

**ATTACHMENT – IV : GLOBAL PRACTICES (EMRE)**

**HPCL Mumbai Regenerator Cyclone Replacement MS-2008-065**

The following referenced Global Practices are attached:

|             |                                                    |
|-------------|----------------------------------------------------|
| GP-03-06-01 | Piping for Instruments                             |
| GP-03-16-01 | Flanged Joints, Gaskets and bolting                |
| GP-03-18-01 | Piping Fabrication Shop or Field                   |
| GP-04-01-04 | Surge Vibration Design Loads                       |
| GP-04-14-01 | Equipment lifts                                    |
| GP-05-01-01 | Pressure Vessels                                   |
| GP-05-03-01 | Pressure Testing of Unified Pressure Vessels       |
| GP-15-02-01 | Temperature Instruments                            |
| GP-15-03-01 | Pressure Instruments                               |
| GP-18-07-01 | Welding Procedures                                 |
| GP-18-10-01 | Additional Requirements for Materials              |
| GP-18-12-01 | Positive Material Identification                   |
| GP-19-01-01 | Paint and Protective Coatings                      |
| GP-19-03-02 | Refractory Linings for Pressure Vessels and Piping |
| GP-20-01-01 | Inspection of Equipment and Materials              |
| GP-20-01-02 | Administrative Procedures for Obtaining Inspection |
| GP-20-01-03 | Quality Programs                                   |

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# Piping for Instruments

## GP 03-06-01

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### Scope

[I] This Global Practice (GP) covers the piping associated with field instrument installations and instrument air systems. Piping for sample transport and conditioning systems of process analyzers are covered by [GP 15-08-02](#).

[I] An asterisk (\*) indicates that either a decision by the Owner's Engineer is required, that additional information is to be furnished by the Owner's Engineer, or that information for Owner's Engineer approval is to be supplied by Vendor or Contractor.

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## 1. Required References

[I] This Section lists Practices and Standards that are generically referenced and assumed to be a part of this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                                         |
|-----------------------------|---------------------------------------------------------|
| <a href="#">GP 03-06-02</a> | Piping at Control and Protective System Valve Stations  |
| <a href="#">GP 03-09-01</a> | Winterizing and Protection Against Ambient Temperatures |
| <a href="#">GP 03-18-01</a> | Piping Fabrication Shop or Field                        |
| <a href="#">GP 04-02-01</a> | Auxiliary Structures for Operation and Maintenance      |
| <a href="#">GP 14-03-01</a> | Fireproofing                                            |
| <a href="#">GP 15-01-03</a> | Instruments for Storage Tanks and Vessels               |
| <a href="#">GP 15-02-01</a> | Temperature Instruments                                 |
| <a href="#">GP 15-03-01</a> | Pressure Instruments                                    |
| <a href="#">GP 15-04-01</a> | Flow Instruments                                        |
| <a href="#">GP 15-05-01</a> | Level Instruments                                       |

### 1.2. API–American Petroleum Institute

|                                 |                                                                                                                                                                                                  |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">API MPMS 14.3.2</a> | Manual of Petroleum Measurement Standards Chapter 14 - Natural Gas Fluids Measurement; Section 3 - Concentric, Square-Edged Orifice Meters; Part 2 - Specification and Installation Requirements |
| <a href="#">API MPMS 5.2</a>    | Manual of Petroleum Measurement Standards Chapter 5 - Liquid Metering Section 2 - Measurement of Liquid Hydrocarbons by Displacement Meters                                                      |
| <a href="#">API MPMS 5.3</a>    | Manual of Petroleum Measurement Standards Chapter 5 - Metering Section 3 - Measurement of Liquid Hydrocarbons by Turbine Meters                                                                  |
| <a href="#">API MPMS 5.4</a>    | Manual of Petroleum Measurement Standards Chapter 5 - Metering Section 4 - Accessory Equipment for Liquid Meters                                                                                 |
| <a href="#">API RP 551</a>      | Process Measurement Instrumentation                                                                                                                                                              |
| <a href="#">API RP 552</a>      | Transmission Systems                                                                                                                                                                             |

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### 1.3. ASME–American Society of Mechanical Engineers

|                                  |                                                                             |
|----------------------------------|-----------------------------------------------------------------------------|
| <a href="#">ASME B1.20.1</a>     | Pipe Threads, General Purpose (Inch)                                        |
| <a href="#">ASME B16.36</a>      | Orifice Flanges                                                             |
| <a href="#">ASME SEC VIII D1</a> | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 1 |

### 1.4. ASTM–American Society for Testing and Materials

|                                   |                                                                                                      |
|-----------------------------------|------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM A 269</a>        | Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service |
| <a href="#">ASTM B 16/B 16M</a>   | Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines          |
| <a href="#">ASTM B 68</a>         | Standard Specification for Seamless Copper Tube, Bright Annealed                                     |
| <a href="#">ASTM B 111/B 111M</a> | Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock        |
| <a href="#">ASTM D 1047</a>       | Standard Specification for Poly(Vinyl Chloride) Jacket for Wire and Cable                            |

### 1.5. ISA–The Instrumentation, Systems, and Automation Society

|                            |                                     |
|----------------------------|-------------------------------------|
| <a href="#">ISA 7.0.01</a> | Quality Standard for Instrument Air |
|----------------------------|-------------------------------------|

## 2. Additional Requirements

\* [I] The following standard shall be used with this GP as specified by Purchaser.

### 2.1. ISO–International Standards Organization

|                            |                                                                                                                                                                            |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ISO 5167-1</a> | Measurement of Fluid Flow by Means of Pressure Differential Devices Inserted in Circular Cross-Section Conduits Running Full - Part 1: General Principals and Requirements |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### 2.2. Other Requirements

- 1) [S] No fluids, except instrument air, potable water, and fresh air from a safe location, shall be piped into the control house. Instrument air that is backed up by nitrogen shall not be piped into control houses or other walk-in enclosed spaces.
- 2) [S] Downstream of the first isolation block valve, all piping, tubing, instruments, and instrument accessories in contact with the process or any purge medium shall have a suitable pressure/temperature rating and material for the service conditions.

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- 3) [S] Valves and their respective control cabling, tubing, and associated field equipment that are required to remain operable during a fire require fireproofing in accordance with [GP 14-03-01](#).
- 4) \* [O] Leak testing of instrument pressure piping and air supply piping shall be in accordance with the requirements of the project specification. Leak testing of signal transmission systems shall be in accordance with [ISA 7.0.01](#).

### 3. Mounting of Instruments and Access Requirements

- 1) [C], [O] The preferred instrument installation is close coupled (line mounted).
- 2) \* [M], [S] All instruments, including thermocouples, shall be accessible for maintenance. Instrument process connections that require maintenance shall also be accessible, including accessories such as rod-out connections, condensate pots, and seal connections. Permanent platforms for instrument maintenance are preferred. In cases where personnel safety is not compromised, alternative methods of access may be approved by Owner's Engineer. All indicating instruments shall be installed to be readable from grade and/or the related operational area. Pressure and differential pressure instruments shall be supported by means other than the process connections.
- 3) [R] When piping or platforms are subject to process or equipment induced vibrations (e.g., fluid solids units, reciprocating compressors, lines in two-phase flow, hydraulic shock from rapid valve action) a more stable location for the instrument mounting shall be selected. In addition, piping/tubing bends shall be used to mitigate vibration.
- 4) [S] Insertion type instruments shall be equipped with a blowout prevention device, such as a mechanical stop or safety chain. This device must prevent the unintentional removal of the instrument while under process pressure. Insertion type instruments that are installed in a toxic or flammable service and rely on a non fire resistant elastomer seal (PTFE, for example) for process pressure containment, shall be equipped with a secondary seal that will prevent the process fluid from being released in the event that the instrument is subjected to a fire.
- 5) [M], [O] In addition to any vendor-supplied nameplate, each installed instrument shall be provided with an identification nameplate containing the tag number and the process service description. These nameplates shall be fabricated from a corrosion resistant material (16 U.S. gauge stainless steel or equivalent is preferred) and shall be permanently and securely fastened to the instrument by either stainless steel wire or drive screws. The identification nameplate shall be readable from grade or the associated maintenance platform. If any process connection is not viewable from its associated instrument, then a separate tag nameplate is required at each such process connection.
- 6) [R] Unless otherwise specified, flow meters shall be installed upstream of the associated control valve(s).

### 4. Take-Off Connections

- 1) [M] A gate valve shall be installed in each instrument take-off connection, and shall be located as close to the vessel or line as possible, consistent with manual opening and closing of the valve. In no case shall the valve outlet be a distance greater than 9 in. (225 mm) from the branch connection. The

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use of elbows between the take-off point and the valve is prohibited. Take-off connections, including the first valve, shall be in accordance with the line service classification.

- 2) [M], [O] Separate process take-off connections shall be furnished for each instrument except as follows, in which case separate block valves shall be provided.
  - a) Dual range installations requiring two instruments
  - b) Pressure measurement associated with flow metering or suppressed range pressure instruments
 All other proposals to use the same set of process take off connections for more than one instrument shall require the approval of the Owner's Engineer.
- 3) [R] For process lines, the minimum size of take-off connections shall be NPS ½ (15 mm). Where the line service classification (including corrosion allowance) will result in an ID of less than 0.466 in. or 12 mm (equivalent of Schedule 160), the connection size shall be increased to NPS ¾ (20 mm). Alternatively, a suitable alloy material with a smaller required corrosion allowance may be used.
- 4) [R] For pressure vessels, a minimum NPS 2 (50 mm) nozzle-sized flanged valve with the same pressure/temperature rating and metallurgy as the vessel shall be used. The outboard side of the valve shall be suitable for connection to the instrument. Thermowells are excluded from this valve requirement.
- 5) [R], [O] Connections to vessel bottom shall be avoided whenever possible. When this is not possible, bottom connection shall extend into the vessel at least 3 in. (75 mm) beyond the inside of the shell or vessel lining. All bottom connections shall be approved by the Owner's Engineer.
- 6) [R], [O] Connections to vessel top shall be avoided whenever possible where the upper fluid is a liquid. When this is not possible, a valved vent connection shall be furnished at the highest point in the instrument piping. All top connections shall be approved by the Owner's Engineer.
- 7) [O] Take-off connections for pressure instruments shall be horizontal except for gauges, which can be vertical.
- 8) [O] Horizontal process takeoff connections for all differential pressure type flow meters are preferred. Gas takeoffs may be installed from horizontal to 90 degrees above horizontal and liquid connections from horizontal to 45 degrees below horizontal.
- 9) [O] The mounting location for differential pressure type flow instruments and pressure instruments with relation to take-off connections shall be as shown in Table 1.

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**Table 1: Mounting Provisions**

| Fluid                                                                                                                                                                                                                                                                                                                                                            | Instrument Location                                                                                                                            |                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                  | Line Mounted                                                                                                                                   | Pedestal Mounted              |
| Liquids                                                                                                                                                                                                                                                                                                                                                          | Level with or below take-off                                                                                                                   | Below take-off                |
| Non-Condensing Gases                                                                                                                                                                                                                                                                                                                                             | Level with take-off                                                                                                                            | Above take-off <sup>(1)</sup> |
| Steam/Condensing Vapors                                                                                                                                                                                                                                                                                                                                          | At least 2 in. (50 mm) below take-off                                                                                                          | Below take-off                |
| Cryogenic Liquids                                                                                                                                                                                                                                                                                                                                                | Level with take-off with the connection to the instrument being beyond the 100% vapor point (usually 12 in. [300 mm]) from the line or vessel) | Above take-off                |
| Note (1): If necessary to mount below take-off connection, make take-off horizontal and:<br>(a) for liquid filled vertical legs, provide fill connections and (for displacement type) seal pots, or<br>(b) for gas filled vertical legs, provide heat tracing, knock-out pots, or drain pots with drain valves as dictated by the amount of condensate expected. |                                                                                                                                                |                               |

## 5. Connecting Piping and Tubing

- 1) \* [R] Connecting piping or tubing, between take-off connection (block valve) and instrument, is as follows:
  - a) Material shall be either carbon steel pipe or stainless steel tubing Type 316 or 304, unless another material is required for the process or utility fluids handled. Tubing is preferred.
  - b) Carbon steel piping shall use threaded or flanged joints. Seal welding of threaded connections, where required, shall be in accordance with [GP 03-18-01](#). Pipe shall be ½ in. NPS (15 mm), seamless, Schedule 80 (3.73 mm) minimum wall thickness. Fittings and valves shall be forged steel.
  - c) Stainless steel tubing shall use compression fittings. Threaded tube fitting connections shall not be seal welded. Tubing shall be seamless, ½ in. OD x 0.049 in. minimum wall thickness (or 12 mm OD x 1.5 mm minimum wall thickness). Double ferrule compression fittings shall be used. Tubing fitting manufacturers shall be approved by the Owner's Engineer.
- 2) [R] If the instrument connection is smaller than the connecting piping, then the connecting piping shall be reduced at the instrument.
- 3) [O] Instrument piping and tubing shall be sloped between the take-off connection and the instrument when the instrument is mounted above or below the connection. The slope shall be at least 1:12 and always in the same direction. Piping and tubing runs shall be designed and installed to prevent fluid pockets or traps.
- 4) [C] Pipe and tubing bends shall be used in place of elbows where practicable.



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- 5) [E], [M] Drain, fill, and blowdown connections shall be provided as follows:
  - a) All sealed installations, including those with condensate legs or pots, shall be provided with fill and drain connections.
  - b) All steam flow meter manifolds shall be provided with a valved blowdown connection.
  - c) All gauge glasses shall be provided with a valved drain connection and a plugged cleanout connection at the top.
  - d) Instruments in hydrocarbon or toxic services shall have a valved drain connection.
- 6) [M] Tees shall be used, to permit rodding, in any service where solids can build up at the take-off connection. Sufficient clearance shall be provided to allow the use of rodout devices.
- 7) [S], [M] The instrument installation shall provide a mechanism for depressurizing piping downstream of the take-off process isolation valve when it is closed.
- 8) \* [O] The minimum flow rates for Purge Systems at process takeoff connections shall be as shown in Table 2.

**Table 2: Minimum Flow Rates**

| Instrument Service                                                                                                              | Minimum Velocity       | Purge        |
|---------------------------------------------------------------------------------------------------------------------------------|------------------------|--------------|
| Liquids                                                                                                                         | 0.25 in./sec, 6 mm/sec | Liquid Purge |
| Gas Solids:                                                                                                                     | 24 in./sec, 600 mm/sec | Gas Purge    |
| Cracking                                                                                                                        | 3 ft/sec, 0.9 m/sec    | Gas Purge    |
| Coking                                                                                                                          | 6 ft/sec, 1.8 m/sec    | Gas Purge    |
| Flame Scanner Connections <sup>(1)</sup>                                                                                        | 2 ft/sec, 0.6 m/sec    | Gas Purge    |
| Note (1): Higher velocities may be required to prevent sensor burnout. Each installation shall be approved by Owner's Engineer. |                        |              |

- 9) \* [O] The use of seal, condensate, and knock out pots shall be approved by Owner's Engineer.
- 10) \* [M] Seal welding of instrument lead line connections downstream of the first block valve shall be approved by the Owner's Engineer.
- 11) \* [S] Quarter-turn valves shall not be used as the final valve to the atmosphere or in isolating applications, unless the Owner's Engineer approves their use for selected services.

## 6. Thermowell Connections

- 1) [S] Thermowells installed in a threaded connection shall be seal welded to prevent removal of the thermowell.
- 2) [O] The minimum pipe size for thermowell installation is NPS 4 (100 mm). For NPS 3 (75 mm) or smaller piping, the line size shall be swaged to NPS 4 (100 mm).

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- 3) [O] Thermowell connections shall be a minimum of 10 pipe diameters downstream of the junction of two streams of different temperatures. For desuperheating stations, the thermowell connection shall be located no closer than 20 pipe diameters downstream of the desuperheater. Where this is impractical, the thermowell connection may be located after the first elbow downstream of the desuperheater.
- 4) [I] When a check thermocouple is required in a separate thermowell, its thermowell connection shall be located within 18 in. (450 mm) of the primary thermowell connection.
- 5) [O] Thermowell connections located in downcomers of towers shall be located in liquid 2 in. to 4 in. (50 mm to 100 mm) from the bottom of the downcomer.
- 6) [O] Thermowells located in vapor spaces of towers shall not be placed in dead spots, or between webs or trusses. They shall be located as close as possible to the tray above.
- 7) [S] Where flange mounted thermowells are required, the flanged thermowell shall be constructed from a single forging or fabricated and certified to meet ASME pressure vessel code requirements.

## 7. Flow Meters

- 1) \* [I] All custody transfer applications and meter prover connections shall be approved by Owner's Engineer.
- 2) [O] All valves used in a prover system that can provide or contribute to a bypass of fluid around the prover of the meter or to leakage between the prover and the meter shall be double block-and-bleed valves, or the system shall be provided with valves and piping that are equivalent. A method for checking valve leakage in the valve system shall be provided.

### 7.1. Orifice Meters

- 1) [I], [O] For liquid or gas service, [API MPMS 14.3.2](#) states the minimum length of pipe upstream and downstream of orifices.
- 2) [O] If static pressure measurement is required for a compressible fluid, it shall be from a dedicated tap whose location shall be in accordance with [GP 15-04-01](#).
- 3) [O] Metering orifices shall be installed in horizontal lines where possible. If installed in vertical lines, flow shall be upward for liquids and downward for gases and for vapors, both condensing and non-condensing.
- 4) [M] Thermowell connections, pressure instrument connections, sample connections, vents, drains, etc. shall not be located within the straight run length requirements of Section 7.1, Item 1.
- 5) [R] Straightening vanes shall not be used.

### 7.2. Positive Displacement Meters and Turbine Meters

- 1) \* [O], [R] Where vapor can occur or air be entrained, an air eliminator shall be installed. A combined air eliminator and strainer assembly may be used with approval of the Owner's Engineer.
- 2) [O] The installation shall be designed to insure a liquid filled meter at all times.

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- 3) [O], [R] Meters shall be provided with strainers to protect the meter from entrained solids. The mesh of the strainers shall meet the requirements of the meter manufacturer. Taps shall be provided to permit differential pressure measurement across the strainer.
- 4) [O], [R] Automatic flow limiters shall be installed where operating conditions might cause the meter to exceed its maximum rated capacity.
- 5) [I] A downstream thermowell connection for temperature measurement shall be provided for all positive displacement and turbine meters in custody transfer or high accuracy applications.

## 8. Pressure Instruments

- 1) [O] Pressure differential instruments in gas service shall be located at or above the highest take-off connection so that both sensing lines will be self-draining. Measurement errors due to condensate in the sensing lines shall be prevented by increasing the take-off connection to NPS 1 (25 mm). Alternatives such as heat tracing, insulation, and purging are also acceptable.
- 2) [O] Pressure take-off connections on towers shall be located in the vapor space.
- 3) [O] Instruments mounted above the take-off connection shall be protected from hot condensable vapors above the instrument's design temperature by installation of a close-coupled siphon or liquid seal.
- 4) [I] Differential pressure instrument manifolds shall comply with the requirements for flow meter manifolds.
- 5) [R] Pressure instruments measuring a pulsating process (such as reciprocating pump or reciprocating compressor discharge) shall be provided with a snubber or similar dampening device. Adequate provisions shall be taken to protect against plugging of the snubber by viscous or corrosive fluids.
- 6) \* [O] Vessel connections for pressure differential transmitters or indicators shall not be used for other purposes, such as drains or pumpout lines, without Owner's Engineer approval.

## 9. Level Instruments

### 9.1. Displacer and Float Type Instruments

- 1) [M] Vents and drains from displacer and float chambers shall be as follows:
  - a) A drain valve shall be installed in the same centerline as the chamber, and shall be a NPS  $\frac{3}{4}$  (20 mm) gate or ball-type valve.
  - b) The top of displacer chamber shall be furnished with a tapped NPS  $\frac{3}{4}$  (20 mm) and valved vent connection. However, for top connected displacers, and for ball float chambers, a NPS  $\frac{3}{4}$  (20 mm) valved vent connection shall be made in the top connecting line, adjacent to the chamber. This vent connection must also be suitable to be used as a fill connection to allow on line testing of float switches when they are in protective system service.

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- 2) [O] When an external chamber is used in services where vaporization of the liquid is possible when exposed to ambient temperatures, precautions like extra thick insulation shall be taken to minimize boiling.
- 3) [O] A stilling well shall be provided for all internally mounted displacer or float type level instruments. The well shall be mounted plumb; shall be open-ended, drilled, or slotted along its entire length; and shall have a smooth interior finish. A bar or rod shall be welded across the bottom of the well to retain the displacer or float, should it become disconnected from the instrument shaft.
- 4) [O] External level instrument vessel connections and internal level instruments shall be oriented to prevent impingement of entering streams. External level instruments shall be mounted plumb.

For displacers or floats subjected to turbulence, provisions shall be made for shielding the connections or guiding the fluid to eliminate the effect of turbulence on the torque tube or float shaft assembly.

## 9.2. Differential Type Instruments

[O] Differential type level instruments in liquid services, except those with remote seals (preferred), shall be installed as follows:

- 1) The instrument shall be installed level with the lower vessel connection. When the temperature of the process fluid is higher than the maximum operating temperature for the instrument, the instrument shall be located 12 in. (300 mm) below the lower vessel connection.
- 2) For upper impulse line dry-leg installations: A drain pot and valved drain at the low point shall be installed. The upper impulse line shall be heated as necessary to ensure a dry leg.
- 3) When upper impulse line is sealed with vessel liquid, a bypass valve between the high and low pressure connections shall be installed at the instrument, and a valved vent using a globe valve at the upper vessel connection. When other seal material is used, the bypass valve is not required.

## 9.3. Gauge Glasses

- 1) \* [R] Horizontal take-off connection length (i.e., vessel connection, vessel isolation valve, and outboard horizontal impulse line) shall not exceed 15 in. (375 mm). If longer lengths are required, they shall be approved by the Owner's Engineer. All take-off connection lines exceeding 15 in. (375 mm), and all take-off connection lines subject to vibration (regardless of length), shall be braced in two planes, per [GP 03-18-01](#).
- 2) [S], [O] Where gauge glasses are specified for use in non-fouling processes where a toxic or flammable vapor cloud may be formed in the event of gauge glass failure, the gauge glass piping shall include a ball type (excess flow) check valve or similar device at each gauge glass column connection. The design shall permit commissioning of the gauge glass column without the need for external bypass piping.
- 3) \* [M], [O] Separate vessel connections shall be installed for gauge glasses and each level instrument. Pipe columns (bridles) may be used to minimize vessel connections when approved by the Owner's Engineer. When a pipe column (bridle) is used, a block valve shall be installed at each pipe column (bridle) to vessel connection and at each instrument to pipe column (bridle) connection. Pipe columns (bridles) shall not be less than NPS 2, Schedule 80 pipe for carbon steel or NPS 2, Schedule 40 pipe for stainless steel.

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- 4) [O] If a pipe column (bridle) arrangement is used for a three fluid system (e.g., interface), a balance line shall be connected between the vessel and the pipe column. The line shall be located so that the point where it connects to the vessel is covered by the middle fluid for all expected fluctuations of the middle fluid levels. If this cannot be achieved with one balance line, additional balance lines shall be used. If the top vessel connection is not always submerged in the top fluid, balance lines will be required for the top fluid also.
- 5) \* [M], [O] Gauge glasses shall be provided to augment level instruments in liquid service, including displacer, float, differential pressure, and hydrostatic head types. The visible range of the gauge glass shall equal or exceed the maximum range of the level instrument. Specifically excluded are fluid solid or tank gauge services. Other exclusions shall be specified by the Owner's Engineer.
- 6) [O] Gauge glass shall, if possible, be installed such that the mid-range of the gauge glass coincides with the mid-range of its associated level instrument.
- 7) [S] Gauge glasses shall be located away from sources of damage such as roadways, work areas, and mobile equipment lanes.
- 8) [M], [O] Gauge glasses shall be oriented with respect to walkways, platforms, ladders, or stairways so that they are conveniently visible to operators and are readily accessible for blocking off, venting, and draining for maintenance. If permanent lighting has not been specified for thru-vision gauge glasses, the gauges shall also be positioned to be accessible for illumination from the rear and simultaneous observation by an operator with a flashlight.

## 10. Instrument Air Systems

### 10.1. Instrument Air Tubing

- 1) \* [R] Single tube runs to field instruments and control valves shall use 0.25 in. diameter 0.035 in. wall thickness stainless steel tubing as a minimum. PVC covered copper tubing may be used where approved by Owner's Engineer.

Individual pneumatic signal lines generally shall not be supported from larger lines. However in remote locations, individual pneumatic signal lines may be supported by lines NPS 2 and larger. Tubing shall be supported in accordance with the recommendations in [API RP 552](#), Sections 21 and 22. The method of support shall be approved. In areas exposed to potential mechanical damage, pneumatic signal lines shall be protected by a continuous support (for example, a structural steel angle or channel).

- 2) [O], [R] Each air consuming instrument shall have a filter, a pressure reducing valve, and a pressure gauge to indicate the reduced pressure. A combination filter regulator with gauge is acceptable for such applications. Instruments on a filtered, regulated panelboard air supply are excepted from having one set per instrument.

Filter body and regulator valve body (or combined filter-regulator body) shall be of metal construction. Downstream tubing shall be stainless steel. Supply lines to instruments shall terminate with shutoff valves not more than 36 in. (900 mm) from the instruments. Supply lines shall be installed with sufficient flexibility to allow for normal piping/equipment movements. Tubing valves in highly corrosive environments, marine (offshore), and chloride bearing environments shall have Type 316 stainless steel bodies. Tubing valves shall have Teflon or graphite packing, stainless steel stems, and TFE stem tips or seats where tight shutoff is required.

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- 3) [O], [R] Pneumatic actuator vents, solenoid valve vents, etc. shall be provided with screens to prevent blockage and shall be installed to prevent the buildup of ice.
- 4) [R] Trays, ladders, separators, their supports, and other fittings shall be made of hot-dipped galvanized steel or corrosion resistant aluminum (0.4% Cu max).

## 10.2. Instrument Air Distribution System

- 1) [M], [R] Instrument air branch supply lines shall be taken from the top of the header. Air supply headers and laterals shall be arranged to allow air to be blown through a full size opening to facilitate final cleaning of the air system.
- 2) Instrument air distribution systems shall have block valves located as follows:
  - a) In each take-off from the main distribution system to a unit, at the process unit area limits
  - b) In each branch line from a unit header
  - c) At each consumer
- 3) No more than six instruments shall be supplied from a valved branch line.

## 10.3. Instrument Air Dryer

[O] Instrument air dryer, prefilters, and afterfilters shall conform to the following:

- 1) \* Air pressure at the exit of the afterfilter shall be 95psig to 100 psig (650 kPa to 700 kPa), and dried to a dew point at least 18°F (10°C) below the minimum specified ambient temperature.
- 2) Prefilters shall be of the coalescing type and be capable of removing 98 percent of oil and water droplets larger than 0.01 µm. Prefilters shall be located downstream of any connections for auxiliary compressors.
- 3) Dryer shall be either adsorptive heatless or heat regenerated type, sized for 110 percent design capacity, and be provided with automatic cyclic operation. Heaters, coils, grids, valves, and similar components shall be readily accessible for maintenance.
- 4) Afterfilter shall remove 98 percent of all particles larger than 0.3 µm.
- 5) Pressure drop through the entire filtering and drying system shall not exceed 10 psi (70 kPa).

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## Record of Change

|                      |               |                                                                                                                                                    |                    |
|----------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b> |               |                                                                                                                                                    | <b>Date: 06/01</b> |
| <b>Location</b>      | <b>Action</b> | <b>Description</b>                                                                                                                                 |                    |
|                      |               | Initial Publish                                                                                                                                    |                    |
| <b>Version 1.0.0</b> |               |                                                                                                                                                    | <b>Date: 12/03</b> |
|                      |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |                    |
| <b>Version 1.1.0</b> |               |                                                                                                                                                    | <b>Date: 06/05</b> |
| General              |               | From this version onward, revision bars in the right margin will be used to identify technical changes from the last version of the GP.            |                    |
| Section 1            | Modification  | Updated reference mnemonic from ASTM B 111 to ASTM B 111/B 111M. Updated reference titles.                                                         |                    |

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## Attachment: Purpose Codes Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C    | Assigned to paragraphs containing specifications whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include Life-Cycle cost considerations. Life-Cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                             |
| E    | Assigned to paragraphs containing specifications whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                              |
| I    | Assigned to paragraphs that provide only clarifying information such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| M    | Assigned to paragraphs containing specifications whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during on-stream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| O    | Assigned to paragraphs containing specifications whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during startups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs containing specifications whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| S    | Assigned to paragraphs containing specifications whose primary purpose is avoidance of personnel or operational safety incidents. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.<br><br><div> <div>Personnel Safety:</div> <div>Refers to the avoidance of recordable personnel injuries; i.e., burns, cuts, abrasions, inhalation, or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</div> </div> <div> <div>Operational Safety:</div> <div>Refers to the prevention and control of process releases, fires, explosions, etc.</div> </div> |

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# Flanged Joints, Gaskets, and Bolting

## GP 03-16-01

### Scope

- 1) **[I]** This Global Practice (GP) covers the design of flanged joints for piping, and the selection of flanges, flange facings, gaskets and bolting for piping, and equipment flanged nozzles and manways.
- 2) **[I]** Orifice flanges, valve bonnets, and elastomeric o-ring gaskets are outside the Scope of this Practice.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------|
| Refining/Chemicals, Downstream<br>Imperial Oil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | For Company Use Only            | Version 3.1.0 |
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## 1. Required References

This Section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                                                       |
|-----------------------------|-----------------------------------------------------------------------|
| <a href="#">GP 03-10-01</a> | Piping Selection and Design Criteria                                  |
| <a href="#">GP 03-16-03</a> | Leak Bands and Heat/Weather Shields for Flanges and Flangeless Valves |
| <a href="#">GP 18-07-01</a> | Welding Procedures                                                    |
| <a href="#">GP 18-10-01</a> | Additional Requirements for Materials                                 |

### 1.2. API–American Petroleum Institute

|                            |                                                                                                                     |
|----------------------------|---------------------------------------------------------------------------------------------------------------------|
| <a href="#">API RP 941</a> | Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants |
|----------------------------|---------------------------------------------------------------------------------------------------------------------|

### 1.3. ASME–American Society of Mechanical Engineers

Unless specific references to the ASME Code are listed, an IHS link to the Introduction is provided to facilitate access to relevant parts of the Code.

|                                  |                                                                               |
|----------------------------------|-------------------------------------------------------------------------------|
| <a href="#">ASME B16.1</a>       | Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250)        |
| <a href="#">ASME B16.20</a>      | Metallic Gaskets for Pipe Flanges Ring-Joint, Spiral-Wound, and Jacketed      |
| <a href="#">ASME B16.21</a>      | Nonmetallic Flat Gaskets for Pipe Flanges                                     |
| <a href="#">ASME B16.47</a>      | Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard       |
| <a href="#">ASME B16.5</a>       | Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard |
| <a href="#">ASME B31.3</a>       | Process Piping                                                                |
| <a href="#">ASME SEC VIII D1</a> | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 1   |

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## 1.4. ASTM—American Society for Testing and Materials

|                                   |                                                                                                                                                                   |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM A 193/A 193M</a> | Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications |
| <a href="#">ASTM A 194/A 194M</a> | Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both                                           |
| <a href="#">ASTM A 320/A 320M</a> | Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service                                                          |
| <a href="#">ASTM F 436</a>        | Standard Specification for Hardened Steel Washers                                                                                                                 |

## 2. Definitions

- 1) **[I]** Hydrogen Service, as used herein, is to be consistent with the definition provided in [GP 18-10-01](#). Equipment is in hydrogen service when the design temperature is greater than the CS curve in [API RP 941](#) for the given hydrogen partial pressure.
- 2) **[I]** Combustible liquids—High flash liquids [flash points 100°F (38°C) or higher] when handled at temperatures 15°F (8°C) below their flash point or lower.
- 3) **[I]** Flammable liquids—Low flash liquids [flash point below 100°F (38°C)]; and high flash liquids [flash point 100°F (38°C) or higher] when handled at temperatures above or within 15°F (8°C) of their flash point.
- 4) **[I]** Flammable materials—Flammable liquids; hydrocarbon vapors; and other vapors such as hydrogen and carbon disulfide that are readily ignitable when released to atmosphere.

## 3. Flanged Joints

- 1) **[R]** The selection of flanged facings and gaskets shall be per Table 3.
- 2) **[S] [A] [R]** Electrically insulated flanged joints require approval by the Owner's Engineer. Insulating flanged joints are required for:
  - a) Isolation of all lines heated by electric impedance heating systems.
  - b) Protection of marine terminal loading stations to electrically isolate on-board (tanker or barge) piping from the pier piping under any of the following circumstances:
    - i) At cathodically protected marine terminals
    - ii) Where loading arms or electrically bonded oil cargo hoses are used
    - iii) For loading and unloading products classified as flammable liquids
- 3) **[\*] [R]** When specified, hot service thermal insulation of flanges is permitted where all of the conditions in the following table are met:

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|                                     |                                                                                                                                                        |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Maximum Fluid Operating Temperature | 550°F (290°C) <sup>(1)(2)</sup>                                                                                                                        |
| Maximum Design Pressure             | 600 psig (4140 kPa) <sup>(2)</sup>                                                                                                                     |
| Flange Material                     | Carbon Steel, or Low Alloy Steel (to 5% Cr) <sup>(3)</sup>                                                                                             |
| Bolting Material                    | Grade B7 or B16 per Section 6, Item <sup>(1)</sup>                                                                                                     |
| Service Restrictions                | Not for hydrogen service, highly corrosive fluids such as concentrated acids, or toxic materials such as phenol or hydrogen sulfide                    |
| Notes:                              |                                                                                                                                                        |
| (1)                                 | For temperatures below 300°F (149°C), consideration shall be given to the possibility of corrosion under the insulation.                               |
| (2)                                 | Steam service flanges may be insulated to a maximum fluid operating temperature of 750°F (400°C) and a maximum design pressure of 650 psig (4480 kPa). |
| (3)                                 | For hydrocarbon services, the flange periphery shall, in addition, be fitted with a leak band.                                                         |

- 4) When weather and heat shields are provided on flanges, they shall be per [GP 03-16-03](#).
- 5) **[S] [A] [R]** For any flammable material or combustible liquid service where the piping system is lined with plastic or low melting point [below 700°F (370°C)] material, flanged joints shall be designed to prevent leakage when exposed to heat sufficient to destroy or melt the lining material (lapped over flange faces). External insulation of the flanges may be considered for this purpose subject to the Owner's Engineer approval and the requirements of Section 3, Item 4 above.
- 6) **[S] [R]** For wafer or lug type valve installations in piping systems with a design temperature greater than 400°F (200°C), flanges and bolting material shall be selected to have the same nominal coefficient of thermal expansion as the body material of the valve.
- 7) **[R]** Steel flanges mating to flat-faced cast iron flanges shall be flat faced. Full-faced gaskets shall be used.
- 8) **[S] [A] [R]** Proprietary flanged piping connectors, quick opening closures, or clamps shall not be used without prior approval by the Owner's Engineer. Equipment that is provided with an approved quick opening closure shall incorporate the following additional design features:
  - a) A vent valve that is located such that vent operation will be outside of the opening path of the quick opening closure or its potential failure path.
  - b) A pressure gauge, easily visible from the location of the quick opening closure and vent valve.

## 4. Flanges

- 1) **[A] [R]** Flanges shall be in accordance with the Standards given in Table 1 and the additional requirements of this Practice and [GP 03-10-01](#). Flanges of materials other than those listed or flanges with special dimensions for mating to equipment shall be per [ASME B31.3](#) or [ASME SEC VIII D1](#) as applicable, and shall be approved by the Owner's Engineer.

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**Table 1: Flange Standards**

| Flange Material                | NPS Size Range                                                                                                                                                                                             |                  | Applicable Standard                                    |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------------------------------------------|
|                                | in.                                                                                                                                                                                                        | mm               |                                                        |
| Carbon Steel                   | 1/2 through 24                                                                                                                                                                                             | 15 through 600   | <a href="#">ASME B16.5</a>                             |
| Ferritic Alloy Steel           |                                                                                                                                                                                                            |                  |                                                        |
| Austenitic Cr-Ni Steel         | 26 through 60                                                                                                                                                                                              | 650 through 1500 | <a href="#">ASME B16.47</a> Series B <sup>(1)</sup>    |
| 3 1/2 percent Ni Steel         |                                                                                                                                                                                                            |                  |                                                        |
| Cast Iron                      | 1 through 48                                                                                                                                                                                               | 25 through 1200  | <a href="#">ASME B16.1</a>                             |
| Nickel; Nickel Copper (Monel)  | 1/2 through 24                                                                                                                                                                                             | 15 through 600   | <a href="#">ASME B16.5</a>                             |
| Nickel-Chromium-Iron (Inconel) |                                                                                                                                                                                                            |                  |                                                        |
| Hastelloy B-2 and C-276        | 26 through 60                                                                                                                                                                                              | 650 through 1500 | <a href="#">ASME B31.3</a>                             |
| Aluminum Bronze                | 1/2 through 24                                                                                                                                                                                             | 15 through 600   | <a href="#">ASME B31.3</a> <sup>(2)</sup>              |
| Aluminum Alloy                 | 1/2 through 24                                                                                                                                                                                             | 15 through 600   | <a href="#">ASME B31.3</a> , Appendix L <sup>(2)</sup> |
| Notes:                         |                                                                                                                                                                                                            |                  |                                                        |
| (1)                            | Except where <a href="#">ASME B16.47</a> Series A flanges may be required to accommodate flangeless or lug type valves or other similar flangeless components, or to mate with existing equipment flanges. |                  |                                                        |
| (2)                            | Dimensions including flange face finish per <a href="#">ASME B16.5</a> .                                                                                                                                   |                  |                                                        |

- 2) **[R]** For ring joint Class 900 or higher flanges, the ring groove corner radius ("R" dimension of [ASME B16.5](#)) shall be 1/8 ±0.03 in. (3 ±0.8 mm) when all of the following apply:
- Size exceeds NPS 3
  - Design Temperature exceeds 500°F (260°C)
  - Flange material is either solid austenitic stainless, or low alloy with austenitic stainless weld overlay
- 3) **[C]** The use of dual certified stainless steel flanges is permitted for the specified grade within the [ASME B16.5](#) pressure-temperature limits as follows:
- Up to 1000°F (540°C), the straight grade pressure-temperature limits may be used per [ASME B31.3](#) Code Cases 8–18 and 8–34.
  - Above 1000°F (540°C), the pressure-temperature limits shall be calculated in accordance with the requirements of [ASME B16.5](#), Annex D, using the L grade allowable stresses per [ASME B31.3](#).
  - Dual certified flanges shall be marked per [ASME B16.5](#) but showing both grades (e.g., 304/304L).
- 4) **[A] [R]** The use of lap joint flanges requires approval by the Owner's Engineer and is subject to the following limitations:
- They shall not be used where the combined longitudinal stress in the pipe where attached to the lap-joint stub-end, resulting from pressure, weight, and thermal expansion, exceeds the [ASME B31.3](#) basic allowable stress at the pipe design temperature.

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- b) The flange may be of a material different from that of the pipe provided the flanged joint will not be subject to galvanic corrosion (e.g., carbon steel flanges may be used on lap-joint stub-ended 18Cr 8 Ni pipe in aboveground services).
  - c) Stub-ends for lap-joint flanges, if fabricated by welding, shall be made with full penetration welds.
- 5) **[R]** The use of slip-on flanges is subject to the following limitations:
- a) **[A]** They shall not be used for Class 400 or higher flanges unless approved by the Owner's Engineer.
  - b) They shall not be used at design temperatures above 750°F (400°C) or where the specified corrosion allowance exceeds 0.125 in. (3 mm).
  - c) **[A]** They shall not be welded directly to welding fittings unless approved by the Owner's Engineer.
  - d) **[A]** They shall not be used in hydrogen service unless properly vented and approved by the Owner's Engineer.
  - e) Aluminum alloy slip-on flanges shall not be used.
- 6) **[C]** Cast iron flanges are permitted only if furnished as integral flanges on cast iron piping or equipment.
- 7) **[R]** Threaded flanges on cast iron or ductile iron pipe shall be of steel.
- 8) **[R]** Aluminum alloy flanges shall be either wrought or forged forms. Castings shall not be used.

## 5. Gaskets

- 1) **[A] [R]** Gasket selection shall be per Table 3 for fluid services compatible with flexible graphite. The use of non-asbestos sheet gaskets and non-asbestos gasket filler materials for services not compatible with flexible graphite shall be approved by the Owner's Engineer.
- 2) **[S] [A]** Asbestos-based gaskets may be used where permitted by local authorities and with the approval by the Owner's Engineer for applications where the use of alternative non-asbestos gaskets is not applicable.
- 3) **[R]** Gasket designs shall be per the following Standards and the additional requirements of this Practice.

| Gasket Type                                       | Standards                                  |
|---------------------------------------------------|--------------------------------------------|
| Compressed Asbestos Fiber (CAF) sheet             | <a href="#">ASME B16.21</a>                |
| Reinforced Flexible Graphite (RFG) sheet          | Dimensions per <a href="#">ASME B16.21</a> |
| Corrugated Metal Flexible Graphite Covered (CMGC) | Dimensions per <a href="#">ASME B16.21</a> |
| Grooved Metal Flexible Graphite Covered (GMGC)    | Manufacturer's Standards                   |
| Double Jacketed (DJ)                              | <a href="#">ASME B16.20</a>                |
| Spiral Wound (SW)                                 | <a href="#">ASME B16.20</a>                |
| Ring Joint (RJ)                                   | <a href="#">ASME B16.20</a>                |

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- 4) [\*] [R] The asbestos content for Compressed Asbestos Fiber (CAF) gaskets shall be a minimum of 70 percent (by weight). The binder shall be NBR polymer ([ASTM D 2000](#) Type B Class F) unless specified otherwise. The grade of asbestos and binders or impregnants used shall be suitable for the service fluids and temperature. Gasket shall contain an anti-stick release agent or be graphited on both sides, and shall have a minimum tensile strength across the grain of 4000 psi (27.6 MPa).
- 5) [A] [R] The design of Reinforced Flexible Graphite (RFG) and Corrugated Metal flexible Graphite Covered (CMGC) gaskets shall be in accordance with Manufacturer standards subject to the Owner's Engineer approval and the dimensions of [ASME B16.21](#). The flexible graphite covering for these gaskets shall contain a minimum of 95 percent pure carbon and have a nominal density of 70 lb/ft<sup>3</sup> (1120 kg/m<sup>3</sup>).
- 6) [\*] [A] [R] Where metal foil reinforcement is specified for Reinforced Flexible Graphite (RFG), it shall be series 300 austenitic stainless steel. The use of nonmetallic reinforcement shall be per the manufacturer's standard and approved by the Owner's Engineer.
- 7) [\*] [R] Metal reinforcement for Corrugated Metal Graphite Covered (CMGC) gaskets and Grooved Metal Graphite Covered (GMGC) gaskets shall be Series 300 austenitic stainless steel unless other materials are specified for the process service.
- 8) [R] The design of Grooved Metal Graphite Covered (GMGC) gaskets shall be in accordance with Manufacturer standards, and as follows:
  - a) [\*] GMGC gaskets shall be supplied with an outer centering ring, loosely attached to the core gasket ring, unless specified otherwise.
  - b) [A] The use of two piece welded cores shall be approved by the Owner's Engineer. When used, welding shall comply with [GP 18-07-01](#). All welds shall be radiographed.
  - c) The thickness of the core shall be maintained across the weld section and confirmed by measurement on the centerline and on each side of the weld.
  - d) The flexible graphite covering for this gasket type shall contain a minimum of 95 percent pure carbon with a nominal density of 45–70 lb/ft<sup>3</sup> (700–1120 kg/ m<sup>3</sup>).
- 9) [R] An inner retaining ring shall be provided for spiral wound (SW) gaskets except as follows:
  - a) Where threaded or slip on flanges are used.
  - b) In applications where the inner ring may project into the pipe bore. For example, certain LWN flanges.
  - c) [\*] [A] Where other means to prevent inward buckling of the spiral windings are provided and approved by the Owner's Engineer.
- 10) [R] Double jacketed (DJ) gaskets of materials other than carbon steel shall be used if the corrosion allowance is greater than  $\frac{1}{16}$  in. (1.5 mm) or if the piping is other than carbon steel. The jacket material selected shall be based on a corrosion rate of less than 0.01 in./yr. (0.25 mm/a) in service.
- 11) [\*] [R] The metal windings (and inner retaining ring where required) of spiral wound (SW) gaskets shall be 300 series stainless steel unless other materials are specified for the process service. For operating temperatures below –50°F (–45°C), the outer centering ring shall also be 300 series stainless steel.
- 12) [C] Soft iron or low carbon content steel oval ring-joint (RJ) gaskets, with hardness limits per ASME B16.20, are satisfactory for carbon steel piping with a maximum corrosion allowance of  $\frac{1}{16}$  in. (1.5 mm).

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- 13) [A] [R] Oval Ring-joint (RJ) gaskets of materials other than soft iron or low carbon content steel shall be used if the corrosion allowance is greater than  $\frac{1}{16}$  in. (1.5 mm), or if the piping is other than carbon steel. The ring material selected shall be based on a corrosion rate of less than 0.01 in./yr (0.25 mm/a). The hardness of the ring shall be lower than that of the flange. Where this is not possible, as in the case of some alloys, the material selection shall be approved by the Owner's Engineer.
- 14) [\*] [R] Ring joint gaskets shall be of "oval" cross section unless otherwise specified by the Owner's Engineer.

## 6. Bolting

- 1) [R] Bolting shall be selected per Table 2.

**Table 2: Bolting Requirements**

| Design Metal Temperature |             | Flange Rating | Bolts |                                                  |                                 | Nuts                              |                            |
|--------------------------|-------------|---------------|-------|--------------------------------------------------|---------------------------------|-----------------------------------|----------------------------|
| Deg F                    | Deg C       | Class         | Type  | ASTM Std.                                        | Grade                           | ASTM Std.                         | Grade                      |
| -40 to 800               | -40 to 427  | Any           | Stud  | <a href="#">ASTM A 193/A 193M</a>                | B7 <sup>(7)</sup>               | <a href="#">ASTM A 194/A 194M</a> | 2H <sup>(1)</sup>          |
| 800 to 1100              | 427 to 593  | Any           | Stud  | <a href="#">ASTM A 193/A 193M</a>                | B16                             | <a href="#">ASTM A 194/A 194M</a> | 4, 7 <sup>(1)</sup>        |
| 1100 to 1200             | 593 to 650  | Any           | Stud  | <a href="#">ASTM A 193/A 193M</a>                | B5                              | <a href="#">ASTM A 194/A 194M</a> | 3 <sup>(1)</sup>           |
| 1100 to 1500             | 593 to 815  | ≤300          | Stud  | <a href="#">ASTM A 193/A 193M</a>                | B8M<br>Class 1 <sup>(2)</sup>   | <a href="#">ASTM A 194/A 194M</a> | 8M                         |
| -150 to -20              | -101 to -29 | Any           | Stud  | <a href="#">ASTM A 320/A 320M</a>                | L7 <sup>(3)(8)</sup>            | <a href="#">ASTM A 194/A 194M</a> | 4 <sup>(1)(6)(3)</sup> , 7 |
| -325 to 1000             | -198 to 537 | Any           | Stud  | <a href="#">ASTM A 320/A 320M</a> <sup>(4)</sup> | B8<br>Class 2 <sup>(5)(8)</sup> | <a href="#">ASTM A 194/A 194M</a> | 8                          |

**Notes for Table 2:**

|     |                                                                                                                                                                                                                              |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) | Nuts larger than $\frac{1}{2}$ in. (12 mm) shall not be machined from bar stock.                                                                                                                                             |
| (2) | Class 1 (low yield) bolts shall not be used for Class 400 or higher flanges nor for flanged joints using metallic gaskets unless supported by appropriate design calculations per <a href="#">ASME B31.3</a> , Par. 309.2.1. |
| (3) | Test temperature for impact testing of all L7 bolts and Grade 4 nuts, per <a href="#">ASTM A 320/A 320M</a> , shall be -150°F (-101°C).                                                                                      |

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**Notes for Table 2:**

|     |                                                                                                                                                                                                                                                                                                                |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (4) | <a href="#">ASTM A 193/A 193M</a> Grade B8 Class 2 bolts with <a href="#">ASTM A 194/A 194M</a> Grade 8 nuts may be used as an alternate. The <a href="#">ASTM A 193/A 193M</a> B8 Class 2 bolts will be marked with the marking listed in the relevant table (Table 5 of the 2001 edition) and not the grade. |
| (5) | Grade B8 bolts shall be strain hardened (i.e., Class 2 of designated ASTM material standard).                                                                                                                                                                                                                  |
| (6) | Grade 4 nuts may be used above -50°F (-46°C) without impact testing.                                                                                                                                                                                                                                           |
| (7) | Grade B7 bolts with a diameter of 2.5 inches or less are appropriate for temperatures ranging from -55°F (-48°C) to 800°F (427°C).                                                                                                                                                                             |
| (8) | Diameter limitations apply as specified by <a href="#">ASME B31.3</a> and <a href="#">ASME B16.5</a> .                                                                                                                                                                                                         |

- 2) **[A] [R]** Ferritic bolting shall be used for all ferritic flanges per the design temperature limits specified by Section 6, Item (1), unless otherwise approved by the Owner's Engineer.
- 3) **[A] [R]** For austenitic stainless steel flanges, the bolting material selection shall be limited to the following:

| Bolting Material                        | Flange Design Temperature                 |
|-----------------------------------------|-------------------------------------------|
| Ferritic Steel (Grade B7)               | Above -40°F up to 1000°F (-40°C to 537°C) |
| Ferritic Steel (Grade B16)              | Above -20°F up to 1100°F (-29°C to 593°C) |
| Austenitic Stainless (Grade B8 Class 2) | Below -20°F (-29°C)                       |

Bolting material and design for temperatures outside these limits shall be approved by the Owner's Engineer.

- 4) **[A] [R]** Bolting, including the use of protective coatings, for highly corrosive services such as concentrated acids shall be approved by the Owner's Engineer.
- 5) **[R]** Stud bolts shall be threaded full length with continuous threads.
- 6) **[R]** Bolts 1½ in. (38 mm) and larger shall be fitted with hardened washers conforming to [ASTM F 436](#) under each nut. Washers fabricated from AISI 4140 material are acceptable. Surface finish shall be 125 microinch (3.2 micrometers) Ra or smoother on both sides.
- 7) **[\*] [R]** For bolt diameters 1½ in. (38 mm) and larger, or when specified, bolt lengths shall be one nut thickness larger than normally required to accommodate the use of bolt-on type stud tensioners.
- 8) **[S]** The use of cadmium coated bolts is not permitted.

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**Table 3: Flange Facings and Gaskets**

| Service Fluid                      | Flange Design Conditions   |                                         | Flange Facing | Gasket Type                                                           |
|------------------------------------|----------------------------|-----------------------------------------|---------------|-----------------------------------------------------------------------|
|                                    | ASME Rating Class          | Temperature Range, Deg F <sup>(1)</sup> |               |                                                                       |
| Hydrocarbon <sup>(3)</sup>         | 150 <sup>(2)</sup> and 300 | -50 to 750                              | RF            | RFG, CMGC <sup>(4)</sup> , GMGC, or SW <sup>(9)</sup>                 |
|                                    |                            | Above 750 to 975                        | RF            | SW, DJ, or GMGC                                                       |
|                                    | 400 and 600                | -50 to 975                              | RF            | SW or GMGC                                                            |
|                                    |                            | Above 975                               | RJ            | RJ                                                                    |
|                                    | 900                        | -50 to 800                              | RF            | SW or GMGC                                                            |
|                                    |                            | Above 800                               | RJ            | RJ                                                                    |
|                                    | 1500 and 2500              | -50 to 800                              | RF            | GMGC                                                                  |
|                                    |                            | Any                                     | RJ            | RJ <sup>(10)</sup>                                                    |
| Hydrogen <sup>(4)</sup> and Helium | 150 <sup>(2)</sup> and 300 | -50 to 750                              | RF            | CMGC <sup>(4)</sup> , GMGC, or SW <sup>(9)</sup>                      |
|                                    |                            | Above 750 to 900                        | RF            | SW, DJ, or GMGC                                                       |
|                                    | 400 and 600                | -50 to 900                              | RF            | SW, or GMGC                                                           |
|                                    |                            | Above 900                               | RJ            | RJ                                                                    |
|                                    | 900                        | -50 to 800                              | RF            | SW, or GMGC                                                           |
|                                    |                            | Above 800                               | RJ            | RJ                                                                    |
|                                    | 1500 and 2500              | -50 to 800                              | RF            | GMGC                                                                  |
|                                    |                            | Any                                     | RJ            | RJ <sup>(10)</sup>                                                    |
| Steam and Steam Condensate         | 150 and 300                | 750 and below                           | RF            | CMGC <sup>(4)(11)</sup> GMGC, or SW <sup>(9)</sup>                    |
|                                    |                            | Above 750 to 975                        | RF            | SW or DJ                                                              |
|                                    | 400, 600, and 900          | 975 and below                           | RF            | SW                                                                    |
|                                    |                            | Above 975                               | RJ            | RJ                                                                    |
|                                    | 1500                       | Any                                     | RJ            | RJ <sup>(10)</sup>                                                    |
|                                    |                            |                                         |               |                                                                       |
| Air or other Oxidizing Media       | 150 and 300                | 600 and below                           | RF            | RFG <sup>(4)</sup> , CMGC <sup>(4)</sup> , GMGC, or SW <sup>(9)</sup> |
|                                    |                            | Above 600 to 750                        | RF            | CMGC <sup>(4)</sup> , GMGC or SW                                      |
|                                    |                            | Above 750 to 875                        | RF            | SW or DJ                                                              |

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| Service Fluid                                            | Flange Design Conditions |                                         | Flange Facing | Gasket Type                                      |
|----------------------------------------------------------|--------------------------|-----------------------------------------|---------------|--------------------------------------------------|
|                                                          | ASME Rating Class        | Temperature Range, Deg F <sup>(1)</sup> |               |                                                  |
| Water <sup>(5)</sup> including Boiler Feed               | 150 or lower             | Any                                     | FF            | RFG                                              |
|                                                          | 150 and 300              | Any                                     | RF            | CMGC <sup>(4)</sup> , GMGC, or SW <sup>(9)</sup> |
|                                                          | 400, 600, 900            | Any                                     | RF            | SW                                               |
|                                                          | 1500                     | Any                                     | RJ            | RJ <sup>(10)</sup>                               |
| Fluid Catalyst <sup>(6)</sup>                            | 150 and 300              | 750 and below                           | RF            | CMGC <sup>(4)</sup> , GMGC or SW                 |
|                                                          |                          | Above 750 to 875                        | RF            | SW or DJ                                         |
| Toxic Materials <sup>(7)</sup>                           | 150 and 300              | 750 and below                           | RF            | CMGC <sup>(4)</sup> , GMGC, or SW <sup>(9)</sup> |
| Refrigerant <sup>(8)</sup> and Refrigerated Hydrocarbons | 150 and 300              | -250 and above                          | RF            | CMGC <sup>(4)</sup> or GMGC                      |
|                                                          | 900 and below            | -400 and above                          | RF            | SW <sup>(9)</sup> <sup>(12)</sup>                |

**Legend for Gasket Types:**

|      |                                                                                     |
|------|-------------------------------------------------------------------------------------|
| RFG  | Nominal $\frac{1}{16}$ in. (1.5 mm) thick Reinforced Flexible Graphite Sheet gasket |
| CMGC | Nominal $\frac{1}{16}$ in. (1.5 mm) thick Corrugated Metal Graphite Covered gasket  |
| GMGC | Grooved Metal Graphite Covered gasket                                               |
| SW   | Spiral Wound (flexible graphite filled) gasket                                      |
| DJ   | Corrugated Double Jacketed (flexible graphite filled) gasket                        |
| RJ   | Ring Joint gasket                                                                   |

**Notes to Table 3:**

|     |                                                                                                                                                                                            |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) | [A] Gasket design temperature shall be the same as the flange design temperature. The Owner's Engineer shall be consulted for temperatures beyond the range specified.                     |
| (2) | Includes Vacuum.                                                                                                                                                                           |
| (3) | Liquid, vapor, or gas, except when in refrigerant service.                                                                                                                                 |
| (4) | [A] The use of CMGC and RFG gaskets in class 300 shall be approved by the Owner's Engineer.                                                                                                |
| (5) | Excludes seawater or other aqueous solution salts where possible electrochemical reactions between the graphite and metallic flange (or gasket) components can lead to galvanic corrosion. |

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**Notes to Table 3:**

|      |                                                                                                                                                                                                                                                             |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (6)  | In suspension in any medium, unless medium is toxic.                                                                                                                                                                                                        |
| (7)  | Includes materials such as acids, caustics, phenol, chlorine, hydrogen sulfide contained in solutions or mixtures. Mineral acids, such as sulfuric and nitric acids, not compatible with graphite are excluded.                                             |
| (8)  | Includes propane, ethylene, ammonia, freon, Nitrogen, LNG.                                                                                                                                                                                                  |
| (9)  | Use of SW gaskets for Class 150 flanges requires review of applied bolt loads for proper seating of the gasket. A review of applied bolt load is not required where acceptable flange sealing performance has been demonstrated by past experience or test. |
| (10) | Raised face flanges (RF) and spiral wound (SW) flexible graphite filled gaskets with inner and outer rings are acceptable up to 800°F (427°C) where the design pressure is below 2700 psig (18600 kPa).                                                     |
| (11) | Use of CMGC gaskets for steam services is limited to Class 150.                                                                                                                                                                                             |
| (12) | <b>[A]</b> Use of spiral wound (SW) gaskets for aluminum alloy flanges requires approval by the Owner's Engineer.                                                                                                                                           |

## Appendix: Acceptable Metric Equivalents for Temperatures

| °F   | °C   |
|------|------|
| 1200 | 650  |
| 1000 | 540  |
| 975  | 525  |
| 900  | 480  |
| 875  | 470  |
| 750  | 400  |
| 600  | 315  |
| -50  | -45  |
| -250 | -160 |
| -400 | -240 |

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## Record of Change

| Version 1.0.0       |              |                                                                                                                                                                                                                                                                             | Date: 02/02 |
|---------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Location            | Action       | Description                                                                                                                                                                                                                                                                 |             |
|                     |              | Initial Publish.                                                                                                                                                                                                                                                            |             |
| Version 1.1.0       |              |                                                                                                                                                                                                                                                                             | Date: 12/03 |
| Section 6           | Modification | Table 3: In the "Gasket Type column, for hydrogen and helium ASME class 150 and 300, the Note at SW was changed from (1) to (9).                                                                                                                                            |             |
| Version 1.2.0       |              |                                                                                                                                                                                                                                                                             | Date: 12/03 |
| Section 3, Item (4) | Modification | Corrected formatting of table in Section 3, Item 4.                                                                                                                                                                                                                         |             |
| Section 6           | Modification | For the Notes for Table 3 table, the title was changed from "* Notes to Table 2" to "* Notes to Table 3."                                                                                                                                                                   |             |
| Version 2.0.0       |              |                                                                                                                                                                                                                                                                             | Date: 07/04 |
| Section 1.2         | Added        | API RP 941                                                                                                                                                                                                                                                                  |             |
| Section 2, Item (1) | Modification | Changed definition of hydrogen service to be consistent with GP 18-10-01.                                                                                                                                                                                                   |             |
| Section 3, Item (3) | Removed      | Item did not provide technical guidance for how flanged joint design could compensate for differential contraction of the flanges                                                                                                                                           |             |
| Section 3, Item (7) | Modified     | Added required design features for safe operation of approved quick opening closures.                                                                                                                                                                                       |             |
| Section (5), Item 1 | Modified     | Reworded for clarity.                                                                                                                                                                                                                                                       |             |
| Section (5), Item 3 | Modification | Under Gasket Type, "Metal" was deleted from Reinforced Flexible Graphite; "profile" was deleted form Flexible Graphite; "Corrugated" was deleted from Double Jacketed.<br><br>Under Standards, "with Corrugated Jacket" and "for Oval Shape" were deleted from ASME B16.20. |             |
| Section 5, Item (7) | Modified     | Added polymer service as requiring inner ring on spiral wound gaskets.                                                                                                                                                                                                      |             |
| Section 5, Item (8) | Modified     | Reworded for clarity/correctness.                                                                                                                                                                                                                                           |             |
| Section 6, Table 2  | Updated      | Updated design metal temperatures of B7 and B8 Class 2 bolts, removed note 4 added note 6 for use of Grade 4 nuts.                                                                                                                                                          |             |
| Section 6, Item (3) | Updated      | Updated Flange Design Temperature in Table.                                                                                                                                                                                                                                 |             |
| Section 6, Item (8) | Added        | Added prohibition of cadmium plated bolts.                                                                                                                                                                                                                                  |             |

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| Version 2.1.0        |              |                                                                                                                                                                                                                                                           | Date: 04/05 |
|----------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Section 1            | Modification | Removed inactive reference and updated a reference title.                                                                                                                                                                                                 |             |
| Version 3.0.0        |              |                                                                                                                                                                                                                                                           | Date: 01/08 |
| Scope                | Modified     | Listed elastomeric o-ring gaskets as outside of the scope.                                                                                                                                                                                                |             |
| Section 1.1          | Removed      | Removed reference to GP 03-12-01                                                                                                                                                                                                                          |             |
| Section 1.1          | Added        | Added reference to GP 18-07-01                                                                                                                                                                                                                            |             |
| Section 3, Item (4)  | Added        | Added weather and heat shield reference to GP 03-16-03                                                                                                                                                                                                    |             |
| Section 4, Item (1)  | Modified     | Added references to GP 03-10-01 and ASME VIII Division 1.                                                                                                                                                                                                 |             |
| Section 4, Item (5)  | Added        | Added item "d" referring to use in hydrogen service.                                                                                                                                                                                                      |             |
| Section 5, Item (1)  | Modified     | Added non-asbestos sheet gaskets.                                                                                                                                                                                                                         |             |
| Section 5, Item (2)  | Modified     | Edited qualifications for asbestos-based gasket use.                                                                                                                                                                                                      |             |
| Section 5, Item (6)  | Added        | Added guidelines for reinforcement for RFG.                                                                                                                                                                                                               |             |
| Section 5, Item (7)  | Removed      | Removed "Reinforced Flexible Graphite (RFG)" and "the grooved profile metal for."                                                                                                                                                                         |             |
| Section 5, Item (8)  | Modified     | Added specifications for GMGC gaskets. Changed from Item 6 to Item 8.                                                                                                                                                                                     |             |
| Section 5, Item (9)  | Modified     | Updated section to require inner retaining ring for spiral wound flexible graphite filled gaskets for all sizes. Added exceptions to this.                                                                                                                |             |
| Section 5, Item (9)  | Removed      | Removed original item 9: "For Class 900 and higher spiral wound gaskets, the inner ring shall be per ASME B16.20, except that the inside diameter of the inner ring shall be equivalent to the inside diameter of Sch 80 pipe for the NPS size involved." |             |
| Section 5, Item (10) | Removed      | Removed original item 10: "The use of alternative spiral wound gasket designs to prevent inward buckling of the spiral windings shall be approved by the Owner's Engineer."                                                                               |             |
| Section 5, Item (13) | Modified     | Removed "Oval." Reworded for clarity.                                                                                                                                                                                                                     |             |
| Section 5, Item (14) | Added        | Added guidelines for "oval" ring join gaskets.                                                                                                                                                                                                            |             |
| Section 6, Table 2   | Modified     | Added note 7 specifying a temperature exception for B7 bolts and note 8 referring to diameter limitations. Replaced 2H with Grade 4 and 7 for temperatures ranging from 800-1100° F.                                                                      |             |

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| Section 6,<br>Table (3)     | Modified      | Removed "oval" RJ from the highest classes for each fluid. Removed "RFG" for classes 150 and 300 for hydrogen, helium, steam, steam condensate and fluid catalyst. Added SW for classes 150 and 300 for fluid catalyst. Removed "oval" from RJ definition. Replaced RFG with CMGC in note 11.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Section 6,<br>Table (4)     | Removed       | Asbestos Based Gasket Table was removed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>All Global Practices</b> | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |
| <b>Version 3.1.0</b>        |               | <b>Date: 10/08</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Table 1                     | Modification  | Added mm range for Aluminum Alloy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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# Piping Fabrication Shop or Field

## GP 03-18-01

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### Scope

[I] This Global Practice (GP) covers the fabrication, inspection, and shop testing of piping.

---

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------|
| Refining/Chemicals, Downstream<br>Imperial Oil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | For Company Use Only            | Version 3.1.0 |
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## 1. Required References

This Section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                                       |
|-----------------------------|-------------------------------------------------------|
| <a href="#">GP 03-19-01</a> | Piping Erection, Leak Testing, Flushing, and Cleaning |
| <a href="#">GP 18-07-01</a> | Welding Procedures                                    |
| <a href="#">GP 18-10-01</a> | Additional Requirements for Materials                 |
| <a href="#">GP 20-01-01</a> | Inspection of Equipment and Materials                 |
| <a href="#">GP 20-01-03</a> | Quality Programs                                      |

### 1.2. ASME–American Society of Mechanical Engineers

|                              |                                             |
|------------------------------|---------------------------------------------|
| <a href="#">ASME B1.20.1</a> | Pipe Threads, General Purpose (Inch)        |
| <a href="#">ASME B16.25</a>  | Buttwelding Ends                            |
| <a href="#">ASME B31.3</a>   | Process Piping                              |
| <a href="#">ASME SEC V</a>   | BPVC Section V - Nondestructive Examination |

## 2. Additional Requirements

- 1) [\*] This Section lists the additional Practices, codes, standards, specifications, and publications that shall be used with this document only where specified. Unless otherwise specified herein, use the latest edition.
- 2) [\*] [I] Fabrication of all piping shall be performed in accordance with [ASME B31.3](#), [ASME B31.1](#), or [ASME SEC I](#) as applicable, and with the additional requirements of this GP and the quality program requirements of [GP 20-01-03](#).
- 3) [I] When compliance with any code or standard by a local jurisdiction is mandatory, the requirements prescribed therein shall also be met.

### 2.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                                                  |
|-----------------------------|------------------------------------------------------------------|
| <a href="#">GP 18-04-01</a> | Postweld Heat Treatment of Equipment Handling Alkaline Solutions |
| <a href="#">GP 18-12-01</a> | Positive Material Identification                                 |
| <a href="#">GP 19-01-01</a> | Paint and Protective Coatings                                    |

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## 2.2. API–American Petroleum Institute

|                            |                                                                                                                     |
|----------------------------|---------------------------------------------------------------------------------------------------------------------|
| <a href="#">API RP 941</a> | Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants |
|----------------------------|---------------------------------------------------------------------------------------------------------------------|

## 2.3. ASME–American Society of Mechanical Engineers

|                            |                                                          |
|----------------------------|----------------------------------------------------------|
| <a href="#">ASME B31.1</a> | Power Piping                                             |
| <a href="#">ASME SEC I</a> | BPVC Section I - Rules for Construction of Power Boilers |

## 2.4. AWS–American Welding Society

|                                    |                                                                       |
|------------------------------------|-----------------------------------------------------------------------|
| <a href="#">AWS D1.1/D1.1M</a>     | Structural Welding Code - Steel                                       |
| <a href="#">AWS D10.10/D10.10M</a> | Recommended Practices for Local Heating of Welds in Piping and Tubing |

## 2.5. CEN–European Committee for Standardization

|              |                                                                                                                                              |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| CEN EN 462-1 | Non-Destructive Testing - Image Quality of Radiographs - Part 1: Image Quality Indicators (Wire Type) - Determination of Image Quality Value |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------|

## 2.6. DIN–Deutsches Institut für Normung

|           |                                                                                                                                 |
|-----------|---------------------------------------------------------------------------------------------------------------------------------|
| DIN 54109 | Non-Destructive Testing; Image Quality of Radiographs; Concepts, Image Quality Indicators, Determination of Image Quality Value |
|-----------|---------------------------------------------------------------------------------------------------------------------------------|

## 2.7. JIS–Japanese Industrial Standards

|            |                                                                |
|------------|----------------------------------------------------------------|
| JSA Z 3104 | Methods of Radiographic Examination for Welded Joints in Steel |
|------------|----------------------------------------------------------------|

## 2.8. PFI–Pipe Fabrication Institute

|           |                                                                     |
|-----------|---------------------------------------------------------------------|
| PFI ES-24 | Pipe Bending Methods, Tolerances, Process and Material Requirements |
|-----------|---------------------------------------------------------------------|

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### 3. Definitions

| Term                            | [I] Description                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Combustible Liquids</b>      | High flash liquids [flash points 100°F (38°C) or higher] when handled at temperatures more than 15°F (8°C) below their flash point.                                                                                                                                                                                                                                                                                                                                 |
| <b>Dangerous Materials</b>      | As used herein, includes the following:<br><br>Toxic materials, such as phenol, hydrogen sulfide, chlorine<br><br>Highly corrosive materials, such as acids, caustic and other similar materials<br><br>Flammable materials (including light hydrocarbons lighter than 68 degrees API)<br><br>Combustible liquids<br><br>Boiler feedwater and steam, in systems requiring ASME Class 300 and higher ratings<br><br>Oxygen in concentrations greater than 35 percent |
| <b>Flammable Liquids</b>        | Low flash liquids [flash point below 100°F (38°C)], and high flash liquids [flash point 100°F (38°C) or higher] when handled at temperatures above or within 15°F (8°C) of their flash points.                                                                                                                                                                                                                                                                      |
| <b>Flammable Materials</b>      | (Including hydrocarbons lighter than 68 degrees API). Flammable liquids; hydrocarbon vapors; and other vapors, such as hydrogen and carbon disulfide, that are readily ignitable when released to atmosphere.                                                                                                                                                                                                                                                       |
| <b>Hydrogen Service</b>         | Equipment is in hydrogen service when the design temperature is greater than the CS curve in <a href="#">API RP 941</a> for the given hydrogen partial pressure.                                                                                                                                                                                                                                                                                                    |
| <b>Inspector</b>                | Refers to the Owner's Representative.                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Non-Dangerous Materials</b>  | As used herein, include all materials not listed as Dangerous Materials.                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Small Piping Connections</b> | Any branch connection NPS 2 (50 mm) or less.                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Toxic Materials</b>          | Fluid may be considered "toxic" when the (Industrial Hygiene) Respiratory Exposure Hazard Class is R-1, R-2, or R-3, as specified in the Environmental, Equipment, Exposure Review (EEER), or as otherwise specified by the Owner.                                                                                                                                                                                                                                  |
| <b>Utility Services</b>         | Category D fluid services as defined in <a href="#">ASME B31.3</a> .                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Wet H<sub>2</sub>S</b>       | Defined as greater than 50 wppm of H <sub>2</sub> S in a water phase (determined by using the total amount of sulfide in the water phase) or ≥ 0.05 psia (0.34 kPa abs) H <sub>2</sub> S partial pressure in the gas phase with liquid water present.                                                                                                                                                                                                               |

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## 4. Small Piping Documentation

[I] The following information for small piping connections shall be shown on the Engineering Drawings:

- 1) Specific location and orientation of small piping connections.
- 2) Connection size and schedule.
- 3) Valve or fitting type.
- 4) Designation of connections to be gusseted, and specifications to be used for gussets.
- 5) Special welding requirements.
- 6) Temporary valves and nipples that are used only during pressure testing shall be indicated on the drawings.

## 5. Attachment Materials

[A] [R] Unless otherwise specified or approved by the Owner's Engineer, lugs, brackets, insulation supports, or other attachments that must be welded to piping shall be of similar nominal chemical composition as the piping component to which they are attached, except for gusseting of small branch connections. P1 material may be used for attachments to P3 through P5 materials that are not in hydrogen service.

## 6. Bends, Miter Bends, and Elbows

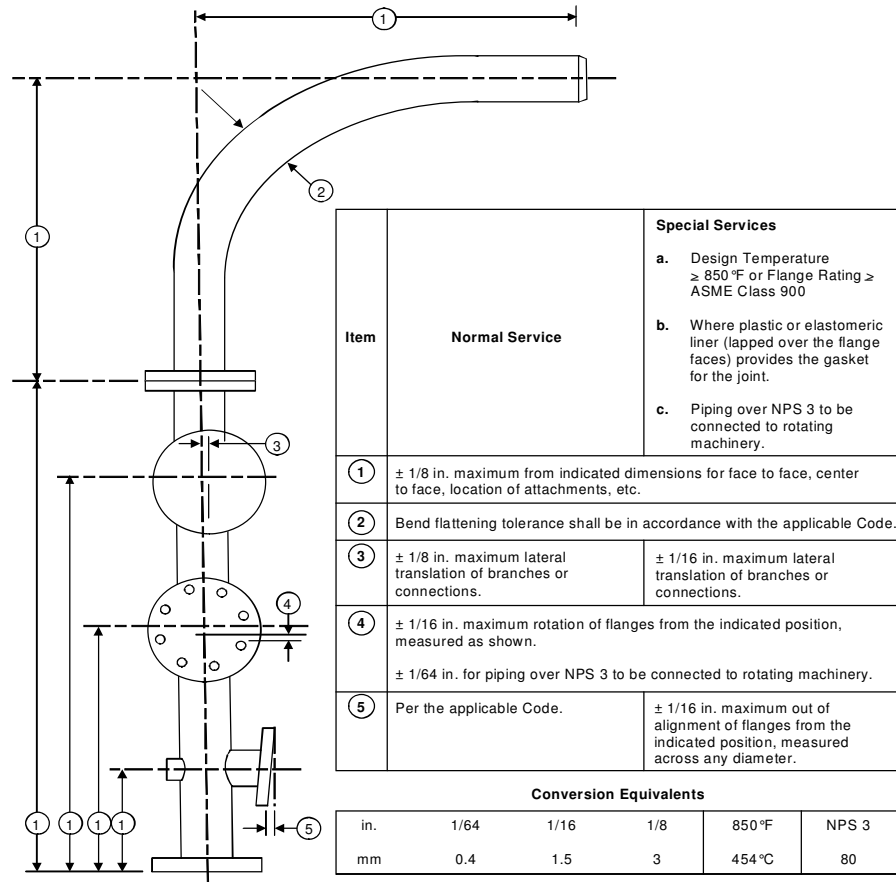
- 1) [R] Pipe bends shall comply with the following requirements:
  - a) Bending shall be in accordance with PFI ES-24.
  - b) [A] The centerline radius of pipe bends shall be equal to at least three times the nominal pipe diameter. Proposals to use smaller radius pipe bends shall be submitted to Purchaser for approval by the Owner's Engineer.
- 2) [R] Miter bends may be used where the pipe diameter exceeds NPS 12 (300 mm) and shall comply with the following:
  - a) Bends exceeding 45 degrees shall be at least three-piece (two miter cuts), with not less than four times the pipe wall thickness between the centerlines of the welds at the crotch, or 1 in. (25 mm), whichever is greater.
  - b) Bends shall have a centerline radius at least equal to the nominal pipe size.
  - c) The maximum miter angle (half the change of directions) shall be 22<sup>1</sup>/<sub>2</sub> degrees up to 200 psig (1380 kPa) design pressure, 15 degrees up to 400 psig (2760 kPa), and 11<sup>1</sup>/<sub>4</sub> degrees over 400 psig (2760 kPa).
- 3) [A] [R] Buttwelding elbows shall be of the long radius type, unless otherwise approved by the Owner's Engineer.

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## 7. Dimensional Tolerances

[R] Tolerances for finished fabricated piping shall conform to Figure 1.

**Figure 1: Dimensional Tolerances**



## 8. Location of Connections

- 1) [O] In gas service, take-off connections shall be from the top of the supply header.
- 2) [O] Condensate line connections into condensate return headers shall be at the top of the header.

## 9. Branch Connections Larger Than NPS 2 (50 mm)

- 1) [A] [R] Integrally reinforced branch welding fittings that abut the outside surface of the run wall, in sizes NPS 4 (100 mm) and larger, are not permitted under any of the following conditions, unless approved by the Owner's Engineer:

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- a) The d/D ratio (branch NPS/run NPS) exceeds 0.8.
  - b) The run piping wall thickness is less than standard schedule.
  - c) The run piping wall thickness is less than 0.75 in. (19 mm) where outside diameter exceeds 36 in. (900 mm).
- 2) [R] Welded support pads and pad-reinforced branch connections are not permitted whenever the piping design temperature is 800°F (427°C) or greater.

## 10. Small Piping Connections

- 1) [R] The minimum schedule of nipples that are used for branch connections NPS 2 (50 mm) or smaller shall be as follows:

| Material                                       | ≤ NPS 1½ (40 mm) | NPS 2 (50 mm) |
|------------------------------------------------|------------------|---------------|
| Carbon and low alloy steel                     | 160              | 80            |
| Carbon and low alloy steel in Utility Services | 80               | 80            |
| Stainless and other high alloy steel           | 80S              | 40S           |

Exception: This requirement does not apply for connections to rotating equipment.

- 2) [R] Nipples that are threaded over their entire length shall not be used.
- 3) [S] [\*] Regarding vibrating service or dangerous materials service: a block valve shall be provided for the purpose of isolating all piping connections NPS ≤ 1½ (40 mm) to main headers of any size.  
Exception: Control valve stations are excluded from this requirement.
- 4) [\*] [R] When a valve is provided for the purpose of isolating piping connections ≤ NPS 1½ (40 mm), the valve centerline shall be located within 9 in. (225 mm) of the branch connection, measured along the branch pipe axis.

[A] In cases where adherence to the 9 in. (225 mm) dimension (pipe wall to valve centerline) is not practicable, the Owner's Engineer shall approve any deviations.

## 11. Bracing of Pipe Connections Less than NPS 2 (50 mm)

- 1) [S] [R] Piping connections NPS ≤ 1½ (40 mm) that connect to a pipe two or more sizes larger shall be braced for the following applications:
- a) For both vibrating and non-vibrating services, bracing is required for piping connections ≤ NPS 1½ (40 mm) that are fabricated using a nipple welded directly to the run pipe without the use of a reinforced fitting, except for Category D fluid services.
  - b) As required for vibrating services per Table 1 below:

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**Table 1: Bracing of Piping Connections in Vibrating Service**

| Primary Equipment or Service Category                                                             | The First Nipple and Valve Shall Be Braced For: <sup>(1)</sup>                                                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reciprocating Compressors                                                                         | Connections to interstage, upstream, and downstream piping and equipment associated with reciprocating compressors (Includes first major piece of equipment upstream and downstream of compressor).                                                                                              |
| Centrifugal Compressors and Steam Turbines                                                        | Connections to piping within the greater of 20 ft (6 m) or 20 pipe diameters, measured along the pipe axis, from the equipment nozzle.<br>[A] Design of all connections to piping equal to or greater than NPS 36 (900 mm) shall be submitted to Purchaser for approval by the Owner's Engineer. |
| Reciprocating Pumps                                                                               | Connections to suction and discharge piping and equipment for reciprocating pumps. (Includes first major equipment upstream and downstream of pump.)                                                                                                                                             |
| Centrifugal Pumps and Rotary Pumps                                                                | Connections to pump piping within the greater of 20 ft (6 m) or 20 pipe diameters, measured along the pipe axis, from the equipment nozzle.                                                                                                                                                      |
| Centrifuges                                                                                       | Connections to centrifuge piping within the greater of 20 ft (6 m) or 20 pipe diameters, measured along the pipe axis, from the equipment nozzle.                                                                                                                                                |
| Machinery where rotating or reciprocating component speed range is 60 to 1000 rpm (1 to 17 rev/s) | Connections to all piping connected to or supported from any type of rotating equipment or its supporting structure. (Includes first major piece of equipment upstream and downstream of machine.)                                                                                               |
| Piping or Equipment subject to Process Induced Vibration                                          | Connections to piping or equipment subject to process induced vibration (e.g., fluid solids units, lines in two-phase flow, hydraulic shock from rapid valve operation, high pressure letdown systems.)                                                                                          |
| Pressure Relieving (PR) Devices                                                                   | Connections to PR device inlet and discharge piping within the greater of 20 ft (6 m) or 20 pipe diameters, measured along the pipe axis, from the PR device                                                                                                                                     |
| Note (1) Bracing of connections on the primary equipment shall be done by the equipment supplier. |                                                                                                                                                                                                                                                                                                  |

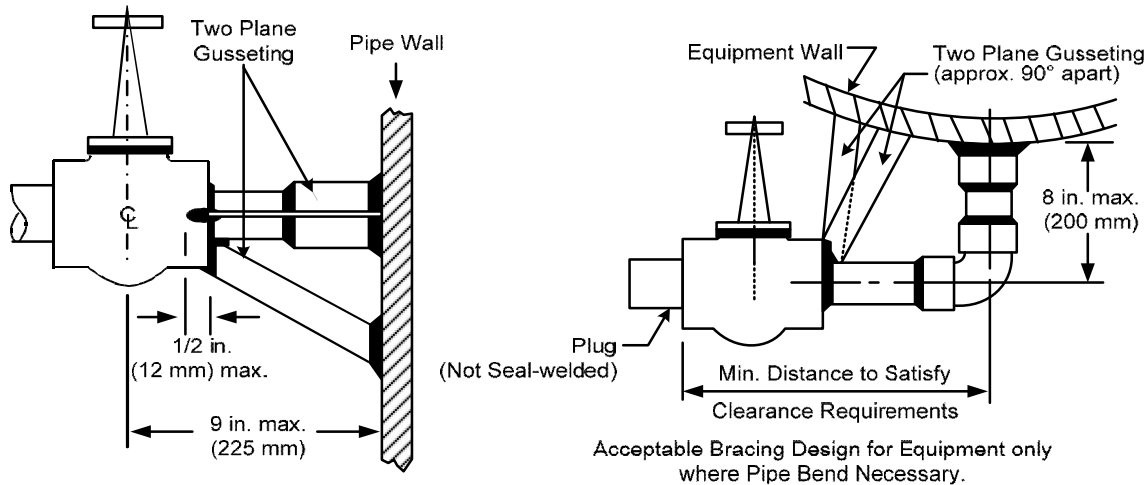
- 2) [S] [\*] [A] [R] Unless specified, bracing is not required for the following small piping connections using integrally or weld reinforced extended body valves or integrally reinforced extended fittings with Class 800 valves. The reinforcement design and weld procedures for the weld reinforced extended body valves shall be approved by the Owner's Engineer.
- a) Pressure gauge connections
  - b) Connections that terminate at the valve or continue as tubing, where the valve centerline is located within 9 in. (225 mm) of the pipe wall.
- 3) [S] [R] Bracing design shall be as follows:

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- a) Material for welded gussets shall be of the same nominal chemical composition as the connected parts except that carbon steel may be used for gusseting P-1, P-3, P-4, and P-5 materials.
- b) Connections shall be braced in two planes with gussets having a minimum thickness of  $\frac{3}{16}$  in. (5 mm) and a minimum width of  $\frac{3}{4}$  in. (19 mm), as shown in Figure 2.

**Figure 2: Bracing Design**



**NOTE:**

Bracing Detail applicable to Extended Body Type Valves, Extended Fittings, or Compact Body Valve plus Nipple (as illustrated).

Alternatively, a single structural 90 degree angle (1 in. x 1 in.) may be used as bracing in one plane, for piping NPS 6 (150 mm) and smaller.

- c) [A] In cases where post-weld heat treatment (PWHT) of structural attachment welds to a pressure boundary is required, gusset stubs (or pads) may be welded to the component prior to PWHT, and then may be used to permit later gusset-to-stub (or pad) attachment without PWHT. Proposals to use special welding procedures in lieu of PWHT shall be submitted to Purchaser for approval by the Owner's Engineer.
- d) [A] Proposals to use clamped or bolted gusset designs shall be submitted to Purchaser for approval by the Owner's Engineer.
- 4) [A] [R] Bracing design for piping connections NPS  $\leq 1\frac{1}{2}$  (40 mm) requiring double block valves shall be submitted to Purchaser for approval by the Owner's Engineer.
- 5) [\*] [A] [R] Unless otherwise specified, all small piping connections in services that are ASME Class 900 and above shall be braced. The bracing design shall be submitted to Purchaser for Owner's Engineer approval.

## 12. Seal Welding Threaded Connections

- 1) [S] [R] All threaded piping connections including threaded thermowells shall be seal welded. However, seal welding is not necessary for the following:
  - a) Category D fluid services as defined in [ASME B31.3](#).

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- b) [\*] Instruments or piping components that require periodic removal for maintenance.
  - c) Union ring threads.
  - d) [\*] Plugs and caps for drain and vent valves. Plugs and caps for drain and vent valves that are used only for hydrostatic testing and are in dangerous materials service shall be seal welded.
  - e) [\*] Miscellaneous other connections identified by the Owner's Engineer.
- 2) [R] If piping assemblies will be PWHT, seal welding shall be given the necessary heat treatment as well. However P-1, P-3, P-4, P-5A, and P-9 materials may be seal welded without subsequent PWHT provided all of the following requirements are met:
- a) The minimum preheat meets either the "required" or the "recommended" preheat listed in [ASME B31.3](#).
  - b) A temper beading technique is employed for all materials except P-1. P-1 material in wet H<sub>2</sub>S service requires multi-pass welds per [GP 18-10-01](#).
  - c) The material is not in alkaline service as defined in [GP 18-04-01](#).
  - d) Low hydrogen electrodes or welding processes are used.
  - e) For all alloy steels, either low carbon electrodes with matching chemistry (i.e., E8018-B2L) or high nickel electrodes (i.e., ENiCrFe-3) are selected.
  - f) P4 and P5A materials are NOT in hydrogen service.
- 3) [S] [R] Connections requiring seal welding shall be made without the use of sealing (anti-seize) compound or PTFE tape. All cutting oil shall be removed prior to assembly. After the joint has been tightened to normal thread engagement per [ASME B1.20.1](#) (hand-tight to 4<sup>1</sup>/<sub>2</sub>–5 threads), seal welding shall cover all exposed threads. A minimum of two weld passes is required.

## 13. Valves, Flanges, and Joints

- 1) [R] Welding is not permitted on valves equipped with soft seats, unless the seats have been removed or precautions recommended by the valve manufacturer have been taken to prevent damage to the soft seats.
- 2) [R] Taper pipe threads (NPT) per [ASME B1.20.1](#) shall be used for all threaded pipe joints, including thermowell nozzles.
- 3) [R] Slip-on flanges shall be positioned such that the distance from the face of the flange to the pipe end is equal to the nominal pipe wall thickness, plus <sup>1</sup>/<sub>8</sub> in. (3 mm).
- 4) [M] Flange bolt holes shall straddle the established centerlines (horizontal, vertical, or layout centerlines), except when required for matching orientation at equipment flanges.
- 5) [R] Stub-ends for lap-joint flanges, if fabricated by welding, shall be made with complete penetration welds.
- 6) [S] Pipe unions between process vessels, lines, or equipment and the first block valve are prohibited.
- 7) [A] [R] The use of proprietary type piping joints shall be approved by the Owner's Engineer.
- 8) [A] [R] Drip rings (bleed rings) shall not be used unless approved by the Owner's Engineer.

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## 14. Welding Joints

- 1) [R] Welding shall be completed per [GP 18-07-01](#).
- 2) [\*] [R] Unless otherwise required by the piping material or welding processes to be used, welding ends shall be prepared per [ASME B16.25](#).
- 3) [R] Radial misalignment at the joining ends of piping components shall be limited to  $\frac{1}{8}$  in. (3 mm) or  $\frac{1}{4}$  of the pipe wall thickness, whichever is less.
- 4) Internal radial misalignment exceeding  $\frac{1}{16}$  in. (1.5 mm) shall be taper trimmed such that the adjoining internal surfaces are flush. However, the resulting thickness of the welded joint shall not be less than the minimum design thickness plus corrosion allowance.
- 5) [R] Minimum spacing of girth butt welds shall be as follows. The clear distance between the edges of adjacent girth butt welds shall not be less than four times the pipe wall thickness, or 1 in. (25 mm), whichever is greater.
- 6) [A] [R] Minimum spacing of branch connections shall be as follows. The clear distance between the edges of attachment welds for adjacent branch connections or reinforcement pads shall not be less than four times the thickness of the run wall, or 1 in. (25 mm), whichever is greater. The Owner's Engineer shall approve deviations from this spacing requirement.
- 7) [M] Backing rings may be used only for the following applications:
  - a) For piping under the jurisdiction of the [ASME SEC I](#).
  - b) For piping in clean steam and air service.
  - c) For castable lined pipe.
  - d) [A] Other applications when approved by the Owner's Engineer.
- 8) [R] If backing rings are used, they shall be fused into the joint for the entire circumference.
- 9) [M] Backing rings are prohibited for the following applications:
  - a) "Pigged" lines.
  - b) Auxiliary piping for machinery. Such piping includes, but is not limited to piping systems such as: jacket cooling water, fuel, lube oil, seal oil, instrument and starting air servicing compressors, turbines, engines, and gears.
  - c) Intake and interstage piping for reciprocating and rotary screw compressors.
- 10) [I] Consumable inserts are not classified as backing rings, and may thus be used for all applications.

## 15. Additional Requirements for Cement-Lined Carbon Steel Pipe and Fittings

- 1) [M] For pipe diameters < NPS 24 (600 mm) the welding arc shall not come into direct contact with the cement lining. This shall be accomplished by the use of partial penetration welding or backing rings.

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[\*] To ensure that a sufficient amount of weld metal is deposited for the integrity of the joint while still maintaining partial penetration, a mockup test, together with joint and welding details, shall be submitted to Inspector for approval, prior to production welding.

- 2) [R] For < NPS 24 (600 mm) pipe joints, sleeve joining method is acceptable. Sleeves shall welded with low heat input and be equipped with  $\frac{1}{4}$  in. (6 mm) threaded tell tale hole for leak testing of cement joint, after completion of fillet welds, but before hydrotesting of system. After testing, tell-tale hole shall be plugged and sleeve shall be wrapped with protective coating system per [GP 19-01-01](#).
- 3) [R] For pipe diameters  $\geq$  NPS 24 (600 mm) the lining shall be cut back 2–4 in. (50–100 mm) from the end prior to welding to permit full penetration welding, with, or without backing rings. This area shall be manually cement lined after welding is completed.
- 4) [M] Cement-lined joints shall be made in accordance with the following procedures:
  - a) For butted joints, the root faces of the adjoining pipe walls shall be tightly butted (no gap for welding), and the ends of the cement linings shall be smooth and flush with the ends of the root faces. No coating or gasketing of the cement lining faces shall be done.
  - b) For sodium silicate coated, gasketed joints, both ends of the lining shall be coated and a  $\frac{1}{16}$  in. (1.6 mm) gasket, installed between the facings of the lining. The gasket shall not extend between the ends of the pipe walls.
  - c) For epoxy cement coated joints, a uniformly applied layer of epoxy cement, approximately  $\frac{1}{16}$  in. (1.6 mm) thick, shall be applied to both ends of the cement lining. Initial set of the epoxy cement shall take place before welding.
- 5) [R] For cement lined carbon steel pipe welding, welding procedure specifications and performance qualifications per [AWS D1.1/D1.1M](#) is an acceptable alternative for butt joints, and may be substituted for the [ASME B31.3](#) requirements.

## 16. Heat Treatment

- 1) [R] Heat treatment requirements shall be per [ASME B31.3](#) and [GP 18-10-01](#), Section on "Additional Requirements for Cr-Mo Steels."
- 2) [A] [R] When PWHT is required, it shall be done in an enclosed furnace or by electrical resistance heating methods. When PWHT is required for environmental cracking control per [GP 18-04-01](#), alkaline services, or when specified by the Owner's Engineer for other applications, the requirements of [AWS D10.10/D10.10M](#) shall be included.
- 3) [A] [R] Any heat treatment proposed for joints involving dissimilar materials shall be approved by the Owner's Engineer.
- 4) [A] [R] Heat treatment requirements for welded joints or bends of materials not covered by [ASME B31.3](#) shall be submitted to Purchaser for approval by the Owner's Engineer.
- 5) [R] Exposed machined and threaded surfaces shall be protected from oxidation during heat treatment.
- 6) [A] [R] Proposals to weld or heat piping after final heat treatment shall be submitted to Purchaser for approval by the Owner's Engineer.
- 7) [R] PWHT of welds on socketweld (SW) and butt weld (BW) valves shall be performed in accordance with the valve manufacturer's recommendations, such that the valve internals are not damaged.

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## 17. Inspection and Testing

- 1) [R] All final inspection and testing shall be performed after any required postweld heat treatment. However, radiographic examination may be performed prior to postweld heat treatment if the following provisions are met:
  - a) Such action does not conflict with the applicable code(s) or regulation(s) and
  - b) The final weld area shall be dye penetrant or magnetic particle inspected after postweld heat treatment, for any materials other than carbon steel (P-1).
- 2) [R] Inspection, examination, and testing of all piping shall be per [ASME B31.3](#) and [GP 20-01-01](#), except as modified in this GP.
- 3) [R] All alloy piping material shall be subject to Positive Material Identification per [GP 18-12-01](#).

### 17.1. Visual Examination

- 1) [M] Maximum allowable projections of weld metal into the pipe bore at welded butt joints shall be per [ASME B31.3](#) and the following:
  - a) The maximum internal projection shall be  $\frac{1}{16}$  in. (1.5 mm) for:
    - i) Piping NPS 2 (50 mm) and smaller
    - ii) "Pigged" lines
    - iii) Plastic or elastomeric lined pipe
    - iv) Orifice flanges
    - v) Intake and interstage piping for reciprocating and rotary screw compressors
  - b) Internal welds for "meter tubes" shall be ground smooth and flush with the pipe ID.
- 2) [R] Undercutting of welds shall not be permitted in intake, recycle, interstage, and start-up bypass piping for reciprocating and rotary screw compressors.

### 17.2. Radiographic Examination

- 1) [R] The minimum required radiographic inspection for girth-butt and miter bend welds, and branch connection welds that are suitable for radiography, shall be per [ASME B31.3](#) and the requirements shown in Table 2. (Category D fluid services shall be solely to [ASME B31.3](#) requirements.)

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**Table 2: Minimum Radiographic Inspection Requirements**

| Material <sup>(1)</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Percentage Shop Welds <sup>(2)</sup> | Percentage Field Welds <sup>(2)</sup> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------|
| Carbon Steel (P-1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 5                                    | 5                                     |
| Low Alloy Steel (P-3, P-4, P-5, and P-9)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 20 <sup>(3)</sup>                    | 50 <sup>(3) (4)</sup>                 |
| Stainless Steels (P-8 and P-10H)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5                                    | 5                                     |
| Nickel Alloys (P-4X)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 20 <sup>(3)</sup>                    | 20 <sup>(3)</sup>                     |
| Aluminum Alloys (P-2X)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 10                                   | 20                                    |
| Notes:<br>(1) [*] For materials that are not listed, the radiographic requirements and acceptance criteria shall be specified by the Owner's Engineer.<br>(2) [*] The percent of specified radiography shall apply to each P-Number and welding process. The first production weld for each welder shall be radiographed. Subsequent inspection selection shall consider the position and accessibility of the production weld.<br>(3) [A] If approved by the Owner's Inspector, once the minimum radiography requirements per <a href="#">ASME B31.3</a> and Note 2 have been met, any additional radiography may be met by the random spot radiography method. |                                      |                                       |

- 2) [R] Progressive sampling (tracer examination), as required by [ASME B31.3](#), shall be in addition to the minimum required radiographic inspection.
- 3) [\*] [R] Radiographic acceptance criteria shall be in accordance with [ASME B31.3](#) for normal fluid service unless severe cyclic service is specified.
- 4) [R] All dissimilar welds (ferritic to austenitic alloys) shall be 100 percent radiographed.
- 5) [R] When permitted, spot radiography shall be in accordance with the following:

| Nominal Pipe Size (NPS) |         | Minimum Number of Spot Radiographs |
|-------------------------|---------|------------------------------------|
| in.                     | mm      |                                    |
| ≤ 18                    | ≤ 450   | 1                                  |
| 20–36                   | 500–900 | 2                                  |
| ≥ 36                    | ≥ 900   | 3                                  |

- 6) [R] The length of film for each spot radiograph shall be 10 in. (250 mm) or half the pipe circumference, whichever is less.
- 7) [S] For girth-butt, miter, and longitudinal welds in piping which is to be pneumatically field tested, the following requirements shall be met:
  - a) Inspection shall meet the acceptance criteria specified by [ASME B31.3](#) for Severe Cyclic Conditions.

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- b) All welded longitudinal joints not previously hydrotested or radiographed shall be radiographed along the entire length of the weld. Ultrasonic examination or eddy current examination may be substituted for radiography.
  - c) [\*] All field girth-butt and miter welds shall be 100 percent radiographed unless otherwise specified. Welds that cannot be radiographed shall be inspected by the liquid penetrant or magnetic particle method.
- 8) [I] Wire type image quality indicators (IQIs) in accordance with CEN EN 462-1, DIN 54109, or JSA Z 3104 may be substituted for those specified in [ASME SEC V](#), provided that an equivalent sensitivity is met.
- 9) [R] A minimum of five percent of all socket welds shall be radiographed to inspect for the following:
- a) The presence of a minimum  $\frac{1}{16}$  in. (1.6 mm) gap after welding.
  - b) Weld defects, such as lack of penetration.
  - c) A minimum insertion depth greater than or equal to the nominal thickness of the inserted pipe or  $\frac{1}{8}$  in. (3 mm).

### 17.3. Ultrasonic Examination

- 1) [A] [R] Ultrasonic examination may be substituted for radiographic examination when approved by the Owner's Inspector.
- 2) [R] All welds where the pipe wall thickness exceeds  $1\frac{1}{4}$  in. (32 mm) shall be 100 percent ultrasonically examined in lieu of radiographic examination when a single wall radiographic technique cannot be used.
- 3) [R] When ultrasonic examination is substituted for spot radiography, the length of the weld joint spot shall be 10 in. (250 mm) or half the pipe circumference, whichever is less.

### 17.4. Magnetic Particle Examination

- 1) [A] [R] For non-magnetic materials, liquid penetrant examination may be substituted for magnetic particle examination. Such substitution may also be used for magnetic materials, with Owner's Engineer approval.
- 2) [R] The D-C prod method shall not be used for P-3, P-4, P-5, and P-9 materials.
- 3) [R] Branch connection welds, not suitable for radiography, shall be in-process magnetic particle examined to the same percentages specified for radiographic examination. In-process inspection shall be performed as follows: the root pass, each 0.25 in. (6 mm) of weld deposit and the final (cover) pass shall be magnetic particle examined.
- 4) [R] All double welded joints in magnetic materials shall be magnetic particle examined prior to back welding.
- 5) [R] All fillet welded connections (magnetic materials only), such as socket welds, seal welds, and slip-on flange welds, shall be inspected as follows:
  - a) Five percent of carbon steel, P-1, welds shall be examined.
  - b) Ten percent of magnetic materials, other than carbon steel (e.g., P-3, P-4, P-5, P-9, etc.), shall be examined.

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## 17.5. Liquid Penetrant Examination

- 1) [\*] [R] When liquid penetrant examination is substituted for the in-process magnetic particle examination of branch connection welds, testing shall be performed as follows: the root pass, each 0.25 in. (6 mm) of weld deposit, and final pass shall be examined by the liquid penetrant method.
- 2) [R] All double welded joints in non-magnetic materials shall be liquid penetrant examined prior to back welding.
- 3) [R] The final pass of fillet welds (non-magnetic materials only), such as socket welds, seal welds, and welds for slip-on flanges, shall be examined by the liquid penetrant method as follows:
  - a) One hundred percent of all welds joining Type 347 SS, Alloy 800, Alloy 825, and Ni based alloys.
  - b) Ten percent for all other non-magnetic materials.

## 17.6. Shop Pressure Testing

- 1) [\*] [C] Hydrostatic testing of individual sections of shop fabricated piping systems is not required, except as specified. If specified, the test shall be per [GP 03-19-01](#) and [ASME B31.3](#).
- 2) [A] [R] Piping that is to be internally coated shall be hydrostatically tested prior to installation of the coating, unless otherwise approved by the Owner's Engineer.

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## 18. Preparation for Shipment

- 1) [R] Protection of openings shall be performed as follows. After completion of inspection, all shop fabricated piping (i.e., piping not fabricated at the job site) shall be prepared for shipment as follows:
  - a) Beveled ends and flange gasket surfaces shall be protected from mechanical damage over their entire surface by firmly attached covers.
  - b) Threaded-end or socket welding-end connections shall be fitted with metal, wood, or plastic plugs or caps.
- 2) [R] Machined or threaded exterior surfaces of carbon steel, and ferrous alloys with a nominal chemistry of 12 Cr and below, shall be protected from corrosion during shipment and subsequent storage by coating with rust preventive. Such preventive shall have the following characteristics:
  - a) It shall provide protection during outdoor storage for a period of twelve months exposed to a normal industrial environment, and
  - b) It shall be removable with mineral spirits or any Stoddard solvent.

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## Record of Change

| Version 1.0.0         |              |                                                                                                                                                    | Date: 07/01 |
|-----------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Location              | Action       | Description                                                                                                                                        |             |
|                       |              | Initial Publish.                                                                                                                                   |             |
| Version 1.0.0         |              |                                                                                                                                                    | Date: 07/03 |
|                       |              | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |             |
| Version 2.0.0         |              |                                                                                                                                                    | Date: 10/05 |
| Section 2, Item (1)   | Addition     | Reference to GP 20-01-03 added.                                                                                                                    |             |
| Section 2.1           | Deletion     | Deleted GP 19-03-02 as an additional requirement.                                                                                                  |             |
| Section 2.3           | Addition     | Added API RP 941 as additional requirement reference.                                                                                              |             |
| Section 3             | Addition     | Added definition of hydrogen service based on GP 18-10-01.                                                                                         |             |
| Section 5             | Addition     | Added the use of PI material for attachments to P3-P5 material in non-hydrogen service.                                                            |             |
| Section 7             | Addition     | Asterisk added.                                                                                                                                    |             |
| Section 9, Item (2)   | Addition     | Welded support pads added to the restriction.                                                                                                      |             |
| Section 10.1          | Modification | Modified requirements for non-braced small piping connections.                                                                                     |             |
| Section 10.1, Table 1 | Modification | Editorial clarification for PR device location.                                                                                                    |             |
| Section 11, Item (2)  | Addition     | Added more requirements to allow for no PWHT after seal welding.                                                                                   |             |
| Section 11, Item (3)  | Addition     | (Anti-seize) added.                                                                                                                                |             |
| Section 13, Item (1)  | Addition     | Welding per GP 18-07-01 requirement added.                                                                                                         |             |
| Section 14, Item (1)  | Addition     | GP 18-10-01 Section 8 added.                                                                                                                       |             |
| Section 15, Item (2)  | Addition     | GP 20-01-01 added.                                                                                                                                 |             |
| Section 15, Item (3)  | Addition     | PMI per GP 18-10-01 added.                                                                                                                         |             |

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| Section 15.1, Table 2         | Addition/Modification | P-10H material added. Percentages reduced to 5% for P-8.                                                                                                                               |
| Section 15.1, Table 2, Note 2 | Addition              | Welder positioning included in determining sampling percentage.                                                                                                                        |
| Section 15.1, Table 2, Note 4 | Deletion              | Note 4 deleted.                                                                                                                                                                        |
| Section 15.3, Item (3)        | Deletion              | Paragraph deleted.                                                                                                                                                                     |
| Section 15.4, Item (3)        | Modification          | In-process inspection requirements further defined.                                                                                                                                    |
| Section 15.5, Item (1)        | Modification          | In-process inspection requirements further defined.                                                                                                                                    |
| Section 15.5, Item (3)        | Modification          | Clarified magnetic material requirements vs. non-magnetic material requirements for liquid penetrant examination.                                                                      |
| <b>Version 3.0.0</b>          |                       | <b>Date: 08/08</b>                                                                                                                                                                     |
| Table of Contents             | Renumbered            | Renumbered for Clarification.                                                                                                                                                          |
| Section 1.2                   | Deletion              | ASME Section VIII D1 reference deleted.                                                                                                                                                |
| Section 2                     | Modification          | GP Reference added.<br>ASME B1.20.1 moved to Section 1 as a required reference.<br>Reference to AWS D10.10 added.<br>ASTM reference deleted.<br>AWS A5 and AWS QC7 references deleted. |
| Section 3                     | Modification          | Modified the definition of Wet H <sub>2</sub> S.                                                                                                                                       |
| Section 3                     | Addition              | Added definition of "Utility Services."                                                                                                                                                |
| Section 3                     | Addition              | Added definition of "toxic materials."                                                                                                                                                 |
| Section 9, Item (1)           | Addition              | Replaced OD with NPS.                                                                                                                                                                  |
| Section 10, Item (1)          | Addition              | Added line in table for Utility Applications.                                                                                                                                          |
| Section 10 Item (1)           | Modification          | Modified "Utility Applications" to "Utility Services."                                                                                                                                 |
| Section 11, Item (1)          | Addition/Modification | Clarification for bracing pipe connections. Moved information from Section 11, Item (2) to Section 11, Item (1).                                                                       |
| Section 11, Item (1a)         | Addition              | Clarification of sentence.                                                                                                                                                             |

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| Section 11, Item (2)           | Addition                  | Rationale Added.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 11, Item (3), Figure 2 | Addition                  | Added Figure 1 from GP 10-01-01.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 12, Item (2f).         | Addition                  | Part (f) added.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Section, Item (2)              | Addition                  | Paragraph added.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 16, Item (2)           | Addition                  | Clarification of sentence.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Section 17 Item (2)            | Modification              | "Visual Examination" covered before "Radiographic Examination."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Section 17.1 Item (4)          | Modification              | Modified "bimetallic" to "dissimilar."<br>Modified "Ferritic to non-ferritic" to "ferritic to austenitic alloys."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Section 17.1, Item (9a & c)    | Modification/<br>Addition | Clarified Item (9a) and added Item (9c).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>All Global Practices</b>    | Modifications             | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |
| <b>Version 3.1.0</b>           |                           | <b>Date: 08/08</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| General                        | Modification              | Rationales were fixed so they don't show when "Hidden Text" is turned off.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Section 10, Item (1)           | Modification              | "in Utility" was removed from "Carbon and low alloy steel" under "Materials."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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| GP 04-01-04 | Surge Vibration Design Loads | October 2004 |
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# Surge Vibration Design Loads

## GP 04-01-04

---

### Scope

[I] This Global Practice (GP) covers the calculation of surge forces for fluidized solids process vessels and support structures that are subject to surge vibration.

[I] An asterisk (\*) indicates that additional information is required. If a job is contracted, this additional information is furnished in the Job Specification.

---

|                                                |                                 |               |
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## 1. Definitions

| Term                               | [I] Description                                                                                                                                                             |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Abnormal Surge Forces</b>       | Those forces corresponding to the most severe combination of fluid-bed height and density in the process vessels and piping during startup or upset of the unit.            |
| <b>Concentrically Braced Frame</b> | A braced frame in which the members are subjected primarily to axial forces.                                                                                                |
| <b>Normal Surge Forces</b>         | Those forces corresponding to the maximum fluid-bed height and density in the process vessels and piping during normal operation of the unit.                               |
| <b>Support Structures</b>          | Any structure supporting or laterally connected to the process vessel, including access structures, such that surge vibrations are transmitted to it by the process vessel. |
| <b>Surge Forces</b>                | As used herein, are equivalent static lateral forces that account for the dynamic loads generated by surge vibration.                                                       |
| <b>Surge Vibration</b>             | Movement induced by the action of fluidized solids contained in process vessels and piping.                                                                                 |

## 2. Symbols

| Symbols used in this GP<br>(All terms are expressed as "force" in consistent units unless noted otherwise.) |
|-------------------------------------------------------------------------------------------------------------|
| C = Weight of fluidized solids specified for a single vessel for a particular design operating condition.   |
| S = Total surge force applied to a single vessel and its support structure.                                 |
| $S_v$ = The portion of S applied directly to the vessel.                                                    |
| $S_s$ = The portion of S applied directly to the support structure.                                         |

## 3. Design

- 1) [R] Surge forces shall be applied to the full length of the process vessel and to any portion of the support structure extending above the support base of the vessel skirt.
- 2) [R] The total surge force, S, applied to a single process vessel and its support structure for selected process units is as shown in Table 1.

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**Table 1: Total Surge Force**

| Type of Process Unit     | S       |
|--------------------------|---------|
| Flexicoking              | 0.15 C  |
| Fluid Coking             | 0.15 C  |
| Gas Conversion FBSG      | 0.15 C  |
| Flexicracking            | 0.075 C |
| Fluid Catalytic Cracking | 0.075 C |

- 3) [I] Weight, C, of fluid-solids to be used for calculating surge shall be as follows, unless specified otherwise:
  - a) For normal surge force: C is the maximum weight of fluid-solids in a single vessel and associated piping during normal operation.
  - b) For abnormal surge force: C is the maximum weight of fluid-solids in a single vessel and associated piping during abnormal (startup or upset) conditions resulting in the most severe combination of fluid-bed height and density in the vessel.
- 4) [R] The total surge force, S, shall be divided between the vessel and the portion of the support structure extending above the base of the vessel skirt according to their relative weights.
- 5) [R] The surge force,  $S_s$ , shall be distributed over the portion of the support structure located above the base level of the vessel support according to the tributary mass weighted by its height above the vessel support level. The surge force for the structure shall not exceed 20 percent of the total surge force, S.
- 6) [R] The surge force  $S_v$  for the vessel shall be calculated as follows:
 
$$S_v = S - S_s$$

Its distribution over the height of the vessel shall be according to the tributary mass weighted by its height above or below the support level of the vessel.
- 7) [R] The total number of levels used to distribute the surge forces shall be sufficient to represent the vertical weight and stiffness distribution of the vessel and of the support structure. The number of levels on the vessel shall not be less than the total height of the vessel divided by its largest outside diameter.
- 8) [R] Surge forces shall be considered to act in any horizontal direction that causes the largest stresses, overturning moments, or deflection.
- 9) [R] Surge forces applied to the vessel and to the support structure shall be considered to act simultaneously in each of the following combinations:
  - a) The surge forces on the vessel and on the support structure acting in the same direction
  - b) The surge forces on the vessel acting in the opposite direction of the surge forces on the support structure
  - c) The surge forces on the support structure and on the vessel above the skirt acting in the opposite direction of the surge forces on the vessel below the skirt to produce the maximum base rotation

|                    |                                     |                     |
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- 10) [R] Relative stiffness of the vessel, the support structure, and vessel to support structure connections shall all be considered when determining how the surge forces are transmitted between the vessel and the support structure.
- 11) [R] If two or more vessels are supported by or connected to a common support structure, all surge forces shall be considered to act simultaneously. However, only feasible combinations of fluid-bed height and density that could simultaneously occur in all the vessels for a particular normal or abnormal condition shall be considered.
- 12) [R] Lateral force resisting systems shall consist of concentrically braced frames in both directions.
- 13) [R] There is no limit on lateral deflections for combinations that include Surge loads.
- 14) [R] Members and connections shall be checked for fatigue assuming two million loading cycles using stresses from normal surge loads only.

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## Record of Change

|                      |               |                                                                                                                                                    |                    |
|----------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b> |               |                                                                                                                                                    | <b>Date: 07/01</b> |
| <b>Location</b>      | <b>Action</b> | <b>Description</b>                                                                                                                                 |                    |
|                      |               | Initial Publish.                                                                                                                                   |                    |
| <b>Version 1.0.0</b> |               |                                                                                                                                                    | <b>Date: 09/03</b> |
|                      |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |                    |
| <b>Version 2.0.0</b> |               |                                                                                                                                                    | <b>Date: 10/04</b> |
| Section 1            | Addition      | Concentrically Braced frame definition                                                                                                             |                    |
| Section 3, Item 4    | Addition      | Rationale                                                                                                                                          |                    |
| Section 3, Item 12   | Addition      | Concentrically Braced Frames requirement                                                                                                           |                    |
| Section 3, Item 13   | Addition      | Clarification on deflection criteria                                                                                                               |                    |
| Section 3, Item 14   | Addition      | Fatigue                                                                                                                                            |                    |

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## Attachment: Purpose Codes Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C    | Assigned to paragraphs containing specifications whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include Life-Cycle cost considerations. Life-Cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                     |
| E    | Assigned to paragraphs containing specifications whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                      |
| I    | Assigned to paragraphs that provide only clarifying information such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| M    | Assigned to paragraphs containing specifications whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during on-stream operations.                                                                                                                                                                                                                                                                                                                                                                             |
| O    | Assigned to paragraphs containing specifications whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during startups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs containing specifications whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                      |
| S    | <p>Assigned to paragraphs containing specifications whose primary purpose is avoidance of personnel or operational safety incidents. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to the avoidance of recordable personnel injuries; i.e., burns, cuts, abrasions, inhalation, or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, explosions, etc.</p> |

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# Equipment Lifts by Cranes

## GP 04-14-01

### Scope

- 1) [I] This Global Practice (GP) covers lifts using cranes associated with the erection and dismantling of plant equipment and structures. It does not cover lifts using other devices such as hydraulic jacks or permanent or fixed lifting equipment, such as overhead trolleys, exchanger hoists, etc.
- 2) [I] This GP is applicable only to onshore applications including inland and near shore terminals.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
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| Refining/Chemicals, Downstream<br>Imperial Oil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | For Company Use Only            | Version 2.0.0 |
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## 1. Required References

- 1) This section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.
- 2) All sections of the Practices, codes, standards, specifications, and publications are to be applicable. All requirements specified in this GP are additions to those of the documents referenced in this section unless specifically noted as exceptions.
- 3) Local codes and standards may be substituted for those referenced herein, provided the following provisions are met:
  - a) The resultant design meets the safety and serviceability criteria attained through this GP.
  - b) [A] Substitution is accepted by the authorities at the facility location and by Owner's Engineer.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                    |
|-----------------------------|--------------------|
| <a href="#">GP 05-01-01</a> | Pressure Vessels   |
| <a href="#">GP 18-07-01</a> | Welding Procedures |

### 1.2. AISC–American Institute of Steel Construction

|          |                                              |
|----------|----------------------------------------------|
| AISC 360 | Specification for Structural Steel Buildings |
|----------|----------------------------------------------|

### 1.3. ASCE–American Society of Civil Engineers

|        |                                                         |
|--------|---------------------------------------------------------|
| ASCE 7 | Minimum Design Loads for Buildings and Other Structures |
|--------|---------------------------------------------------------|

### 1.4. ASME–American Society of Mechanical Engineers

|                             |                                                                                                             |
|-----------------------------|-------------------------------------------------------------------------------------------------------------|
| <a href="#">ASME B30.3</a>  | Construction Tower Cranes                                                                                   |
| <a href="#">ASME B30.4</a>  | Portal, Tower, and Pedestal Cranes                                                                          |
| <a href="#">ASME B30.5</a>  | Mobile and Locomotive Cranes                                                                                |
| <a href="#">ASME B30.6</a>  | Derricks                                                                                                    |
| <a href="#">ASME B30.9</a>  | Slings                                                                                                      |
| <a href="#">ASME B30.10</a> | Hooks - Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings                   |
| <a href="#">ASME B30.20</a> | Below-the-Hook Lifting Devices                                                                              |
| <a href="#">ASME B30.22</a> | Articulating Boom Cranes                                                                                    |
| <a href="#">ASME B30.23</a> | Personnel Lifting Systems Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings |

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|                             |                                                                                                    |
|-----------------------------|----------------------------------------------------------------------------------------------------|
| <a href="#">ASME B30.26</a> | Rigging Hardware Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings |
| <a href="#">ASME BTH-1</a>  | Design of Below-the-Hook Lifting Devices                                                           |

## 1.5. ASTM-American Society for Testing and Materials

|                                 |                                                    |
|---------------------------------|----------------------------------------------------|
| <a href="#">ASTM A 36/A 36M</a> | Standard Specification for Carbon Structural Steel |
|---------------------------------|----------------------------------------------------|

## 1.6. Other Publications

|         |                                                          |
|---------|----------------------------------------------------------|
| TME 233 | ExxonMobil Onshore Crane/Lifting Safety Management Guide |
|---------|----------------------------------------------------------|

# 2. Definitions

[I] Equipment (as used in this Practice) to be lifted is synonymous with structures to be lifted.

| Term                                 | [I] Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Cranes</b>                        | Land-based equipment and machinery used to lift, lower, and swing loads at various radii. These include, but are not limited to: crawler-mounted lattice boom; carrier-mounted lattice and telescope boom; stiffleg and guy derricks; pedestal; rough terrain; all terrain; boom truck and carry deck; tower cranes; overhead and gantry cranes, as well as lift enhancing attachments for these cranes.                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Critical Lifts</b>                | Lifts meeting one or more of the following, unless Owner, through risk assessment, specifies otherwise: <ol style="list-style-type: none"> <li>1) The load is being lifted over or near an occupied building, operating equipment, or electrical power-lines.</li> <li>2) Two or more pieces of lifting equipment are required to work in unison. (This includes using a tailing crane.)</li> <li>3) Special lifting equipment, such as ginpoles or non-standard crane configurations, is used.</li> <li>4) The load is greater than 50 tons (45 metric tons).</li> <li>5) The load represents more than 90 percent of the manufacturer's rated capacity at the working radius.</li> <li>6) The load is greater than 20 tons (18 metric tons) and is also greater than 80 percent of the manufacturer's rated capacity.</li> </ol> |
| <b>Engineered Lifting Components</b> | Rigging hardware designed to meet the requirements of a specific lift or lifts.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

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| Term                               | [I] Description                                                                                                                                                                                                                                                                         |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Non-Standard Lift</b>           | Lifts that do not meet the criteria for a Critical Lift but require the crane to operate at more than 80 percent of its rated capacity for the applicable configuration.                                                                                                                |
| <b>Rated Capacity</b>              | The maximum allowable load as defined by the crane or rigging hardware manufacturer.                                                                                                                                                                                                    |
| <b>Rating Chart</b>                | A document or onboard computer-generated graphic on which the crane manufacturer lists the maximum gross loads at various radii and boom lengths that the crane is capable of safely lifting if operated properly.                                                                      |
| <b>Rigging Hardware</b>            | Detachable lifting components (shackles, links, turnbuckles, spreader bars, lifting beams, etc.) used in conjunction with slings to attach a load to a crane's hook block or overhaul ball. Rigging hardware can be either Standard Lifting Components or Engineered Lifting Components |
| <b>Standard Lift</b>               | Lifts that do not meet the criteria for a Critical Lift or a Non-Standard Lift.                                                                                                                                                                                                         |
| <b>Standard Lifting Components</b> | Rigging hardware designed and tested to verify rated capacities for general purpose use in rigging. These components are typically available "off the shelf."                                                                                                                           |

### 3. Materials

- 1) [A] [R] Lifting components welded directly to the equipment shall be the same material as the equipment, unless an alternate material is approved by Owner's Engineer.
- 2) [R] Lifting components welded to reinforcing pads or attachments to equipment shall be fabricated from A-36 or equivalent steel.
- 3) [S] [R] Cast iron or ductile iron rigging hardware shall not be permitted.

### 4. Design

- 1) [S] [R] Design and use of lifting equipment and components shall comply with Manufacturer's requirements, applicable codes and industry standards, and as specified herein, whichever is most stringent, and:
  - a) Contractor shall verify that all lifting equipment and components can safely perform their intended functions.
  - b) Certified design calculations and drawings shall be submitted for Engineered Lifting Components.

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- 2) [S] [R] Design load or weight (maximum weight of equipment to be lifted) shall be determined as follows:
  - a) Weight determined from manufacturing data or engineering calculations for new equipment to be lifted shall be increased by 10 percent to account for manufacturing tolerances.
  - b) Calculated weight for the removal of existing equipment shall include the weight of all additions since installation and a minimum 25 percent increase factor to account for residual process materials and other unknowns.
  - c) Weight obtained from a certified scale or recently calibrated load cells requires no increase.
- 3) [S] [R] Engineered Lifting Components (except welded Pressure Vessel attachments covered by [GP 05-01-01](#)) and lift lugs, padeyes, trunnions, etc., shall be designed per [ASME BTH-1](#), Design of Below-the-Hook Lifting Devices, with the following additions:
  - a) [\*] Design category B shall be used unless otherwise specified by Owner's Engineer.
  - b) Guy wires shall have a safety factor of at least 3 against failure due to rope breakage and 2 against pull-out of anchorage.
  - c) All potential orientations, load paths, and combined stress conditions that will occur throughout the lift shall be considered, including cable directions out of the principal plane of the components, such as skewed cables.
  - d) Lateral loading that can result from rigging geometry, side-to-side sway and wind during lifting shall also be considered. As a minimum, horizontal forces shall equal 5 percent of the vertical design load.
  - e) All components shall have been tested per [ASME B30.20](#), Below-the-Hook Lifting Devices, prior to use.
- 4) [S] [R] Lifting lugs shall be designed for bending about the weak axis using a force equal to a minimum of 5 percent of the force in the sling.
- 5) [S] [R] Attachment weld details for the lifting lug shall consider local effects such as stress concentrations and lamellar tearing.
- 6) [S] [R] All equipment to be lifted shall be checked to insure that stresses caused by lifting do not exceed code allowable values during all loading conditions of the lift.
- 7) [S] [R] Standard Lift Components shall not be loaded beyond the item's rated capacity.

## 5. Welding Requirements

- 1) [S] [R] The following welds shall be inspected by an approved nondestructive examination method:
  - a) All field welds for a lift in excess of 1 ton.
  - b) All lug attachment welds for a lift in excess of 10 tons.
- 2) Acceptance criteria for any examination performed on a lifting component weld shall be per the manufacturing code to which the equipment was fabricated.

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## 6. Crane Requirements

- 1) [S] No crane shall lift any load in any configuration which exceeds 80 percent of its rated capacity for that configuration unless the requirements of either a Non-Standard or Critical Lift have been met.
- 2) [S] [R] All cranes shall have been inspected by a qualified person (certified by local, regional, or national authorities) within the past 12 months. A copy of the most recent inspection report shall be available for review by Owner's Representative.
- 3) [S] [R] No crane showing evidence of repairs or modifications shall be allowed to begin work without the Manufacturer's written approval of the repair or modification.
- 4) [S] No crane shall lift any load in any configuration unless there is, in or on the crane, a current rating chart.
- 5) [S] All cranes shall be outfitted with the following electronic safety devices (operating aids):
  - a) System which shuts off power to the hoist mechanism (Overhoisting Limiter) and/or activates an alarm (Overhoisting Indicator) when the load block or overhaul ball is hoisted too near the boom or jib tip and
  - b) One of the following:
    - i) System which measures the weight on the hook and displays the load weight (Load Indicating Device), or
    - ii) Electronic system which displays to the crane operator the weight on the hook, radius, and/or percentage of rated capacity [Rated Capacity Indicator, Load Moment Indicator (LMI)], or
    - iii) Electronic system similar to an LMI that is also tied into the crane's control system and will automatically shut off power and set the brakes if an overload condition is reached (Rated Capacity Limiter).
- 6) [S] A minimum boom-to-load clearance of 3 ft (1 m) shall be maintained for all lifting operations unless positive load control systems (tag lines) are being employed to restrict load movement. The minimum boom-to-obstruction clearance is 3 ft. (1 m).
- 7) [S] Any overhead electrical line shall be considered energized unless Owner of the line or electrical utility authority is on the site and verifies that the wire is not energized and the line is visibly grounded.
- 8) [S] [\*] [R] All crane operators shall be fully certified, if a certification procedure exists at location or is required by local regulations.
- 9) [S] [R] All rigging hardware shall be marked, as a minimum, with the manufacturer's name or logo and the rated capacity.
- 10) [S] [R] Operating aids, e.g., Load Indicating Devices, shall not be used as the primary load weight determining mechanism.
- 11) [S] The minimum required clearance between high voltage electrical lines that are not de-energized, and any part of the crane, load, or load line shall be as shown in Table 1. Local codes that are more restrictive shall govern.

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**Table 1: Minimum Clearances between Electrical Lines and Crane and/or Loads**

| During Crane Operation |                     | During Transit (No Load, and Boom or Mast Lowered) |                     |
|------------------------|---------------------|----------------------------------------------------|---------------------|
| Voltage<br>kV          | Clearance<br>ft (m) | Voltage<br>kV                                      | Clearance<br>ft (m) |
| < 50                   | 10 (3.1)            | < 0.75                                             | 4 (1.2)             |
| 50–200                 | 15 (4.6)            | 0.75–50                                            | 6 (1.8)             |
| 201–350                | 20 (6.1)            | 51–345                                             | 10 (3.1)            |
| 351–500                | 25 (7.6)            | 346–750                                            | 16 (4.9)            |
| 501–750                | 35 (10.7)           | 751–1000                                           | 20 (6.1)            |
| 751–1000               | 45 (13.7)           | –                                                  | –                   |

- 12) [S] [\*] [A] [O] [R] Crane shall be supported on firm, stable base or foundation. Loads imposed by the crane shall not exceed the allowable bearing capacity of the soil, per Soil Report, or as specified. Foundations for cranes shall be submitted to Owner's Engineer for review.
- 13) [S] [O] [R] All personnel involved with lifting activities shall be properly trained, qualified, and competent to perform their assigned task.

## 7. Lift Plans

- 1) [S] Standard lifts need to be logged in a daily log prior to each lift. The log should record, at a minimum, the weight of the load, the radius at which it should be handled, and the rated capacity of the crane at that radius for each lift and the maximum weight and radius for a group of repetitive, similar lifts.
- 2) [S] Non-standard lifts require a written lift evaluation. The evaluation should consider the load and rigging weights, crane configuration, crane capacity, crane support conditions, and any nearby hazards.
- 3) [S] [A] Critical lifts require an approved Critical Lift Plan.

### 7.1. Critical Lift Plans

- 1) [A] All critical lifts shall be reviewed by a qualified person.
- 2) All critical lifts require a Critical Lift Plan that shall consist of drawings, specifications, and procedures as necessary to accurately assess all important load and site factors. The Critical Lift Plan shall include, but not be limited to, the following:
- Elevation view drawing(s) of the crane, load, and any nearby structures that could cause interference problems. The drawing shall be to scale and note the following:



|                    |                                  |                   |
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- i) Crane manufacturer(s), model(s), and counterweights
- ii) Boom length(s) and lifting radius (i)
- iii) Maximum load elevation during lifting procedure
- iv) Any jibs or special lifting devices required
- v) Minimum number of parts of crane hoist line required to lift the load
- vi) Minimum boom clearances (load, obstructions, or power lines)
- vii) All required blocks, slings, shackles, and other rigging hardware identified by capacity, size, length, and location.
- b) Plan view drawing(s) of the crane, load, and nearby structures that could cause interference. The drawing shall be to scale and include:
  - i) Route the transport will take to position the load for lifting
  - ii) Initial lifting position of the load, including radius
  - iii) Final placement position of the load, including radius
  - iv) Location of the crane(s), including tail-swing limits
  - v) Location and depth of nearby underground pipes and structures
  - vi) Bearing pressures generated by the crane and the location, thickness, etc., of any required mats or cribbing.
- c) Lift analysis including:
  - i) Tabulation of the gross load weight including all blocks, jib and rigging tackle weight
  - ii) Gross rated capacity of the crane in the configuration specified
  - iii) Net lifting capacity of the crane, detailing any necessary deductions from the crane's gross lifting capacity for all hardware such as jibs, etc.
  - iv) Calculation of the percent of the crane's gross rated capacity for the lift
  - v) Weather limitations, e.g., wind speeds, temperature constraints
  - vi) Determination of crane foundation requirements
  - vii) Emergency procedures and communications plan
  - viii) Details of how the rigging hardware will be removed
  - ix) A narrative of the step-by-step crane movements and load manipulation

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## Record of Change

|                             |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                    |
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| <b>Version 1.0.0</b>        |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Date: 02/02</b> |
| <b>Location</b>             | <b>Action</b>        | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                    |
|                             |                      | Initial Publish                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                    |
| <b>Version 1.0.0</b>        |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Date: 11/03</b> |
|                             |                      | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                    |
| <b>Version 2.0.0</b>        |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Date: 04/07</b> |
| <b>Title</b>                | <b>Modification</b>  | "...by Cranes" was added to the title.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |
| <b>General</b>              |                      | Major and minor changes throughout GP.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |
| <b>All Global Practices</b> | <b>Modifications</b> | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |                    |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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# Pressure Vessels

## GP 05-01-01

### Scope

- 1) [I] This Global Practice (GP) covers the design, fabrication, inspection, and testing of unfired pressure vessels, including all unfired steam generators and non-refrigerated carbon steel pressure storage spheres.
- 2) Additional requirements are found in [GP 09-02-01](#) for spheres, and in [GP 05-01-02](#) for vessels that meet any of the following special criteria:
  - a) Wall thickness is in excess of 2 in. (50 mm) and up to 6 in. (150 mm).
  - b) Material of construction is ferritic alloy steel (Cr-Mo, Mn-Mo, etc.).
  - c) Material of construction is Quenched and Tempered (Q&T) steel.
  - d) Material of construction has a specified yield strength that exceeds 52200 psi (360 MPa).
  - e) Vessel is in cyclic service.
- 3) [I] Small commercial vessels which are not part of process equipment (such as sandblast machines, paint sprayers, and gunite machines) are outside the scope of this practice.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
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| Refining/Chemicals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | For Company Use Only            | Version 3.1.0 |
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## 1. Required References

- 1) [R] This Global Practice requires design, fabrication, inspection, and testing of pressure vessels under the provisions of [ASME SEC VIII D1](#) or [ASME SEC VIII D2](#) and the additional requirements of this practice, except as permitted in Item (2) below.
- 2) [A] Alternatively, pressure vessels may be totally designed, fabricated, inspected, and tested under the provisions of a recognized code which is accepted by the authorities where the vessel is located and by the Owner's Engineer, plus the additional requirements of this practice. Where specific references to ASME requirements are made in this practice, the Owner's Engineer may authorize use of equivalent or more stringent provisions of the applicable recognized code.

### 1.1. Global Practices–ExxonMobil Engineering Practices

This Section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

|                             |                                                         |
|-----------------------------|---------------------------------------------------------|
| <a href="#">GP 03-16-01</a> | Flanged Joints, Gaskets, and Bolting                    |
| <a href="#">GP 04-01-03</a> | Design Loads for Structures                             |
| <a href="#">GP 04-06-01</a> | Reinforced Concrete Foundations, Anchor Bolts and Grout |
| <a href="#">GP 05-03-01</a> | Pressure Testing of Unfired Pressure Vessels            |
| <a href="#">GP 18-07-01</a> | Welding Procedures                                      |
| <a href="#">GP 18-10-01</a> | Additional Requirements for Materials                   |
| <a href="#">GP 20-01-01</a> | Inspection of Equipment and Materials                   |
| <a href="#">GP 20-01-03</a> | Quality Programs                                        |

### 1.2. ExxonMobil Data Sheets

[\*] Complete only the Data Sheet for the specified system of units. Completion of both Data Sheets is required when specified by the Owner's Engineer.

|                            |                                                           |
|----------------------------|-----------------------------------------------------------|
| ExxonMobil Data Sheets     | Data Sheet Home Page                                      |
| <a href="#">T050101C04</a> | Pressure Vessels - Pressure Vessel Data - Customary Units |
| <a href="#">T050101M03</a> | Pressure Vessels - Pressure Vessel Data - Metric Units    |

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## 2. Additional Requirements

[\*] This section lists the additional Practices, codes, standards, specifications, and publications that shall be used with this document only where specified. Unless otherwise specified herein, use the latest edition.

### 2.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                                                  |
|-----------------------------|------------------------------------------------------------------|
| <a href="#">GP 03-18-01</a> | Piping Fabrication Shop or Field                                 |
| <a href="#">GP 04-01-04</a> | Surge Vibration Design Loads                                     |
| <a href="#">GP 04-14-01</a> | Equipment Lifts by Cranes                                        |
| <a href="#">GP 05-01-02</a> | Additional Requirements for Special Criteria Pressure Vessels    |
| <a href="#">GP 05-02-01</a> | Internals for Towers, Drums, and Fixed Bed Reactors              |
| <a href="#">GP 09-02-01</a> | Additional Requirements for Pressure Storage Spheres             |
| <a href="#">GP 18-04-01</a> | Postweld Heat Treatment of Equipment Handling Alkaline Solutions |
| <a href="#">GP 18-12-01</a> | Positive Material Identification                                 |
| <a href="#">GP 19-01-01</a> | Paint and Protective Coatings                                    |
| <a href="#">GP 19-03-02</a> | Refractory Linings for Pressure Vessels and Piping               |
| <a href="#">GP 19-04-01</a> | Glass Reinforced Plastic Tank Bottom Linings                     |
| <a href="#">GP 19-04-02</a> | Natural and Synthetic Rubber Linings                             |
| <a href="#">GP 19-06-01</a> | Facilities for Corrosion Monitoring in Process Equipment         |

### 2.2. API–American Petroleum Institute

|                             |                                                                      |
|-----------------------------|----------------------------------------------------------------------|
| <a href="#">API STD 620</a> | Design and Construction of Large, Welded, Low-Pressure Storage Tanks |
|-----------------------------|----------------------------------------------------------------------|

### 2.3. ASME–American Society of Mechanical Engineers

|                              |                                                                                                                         |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASME 2235</a>    | Use of Ultrasonic Examination in Lieu of Radiography Section I; Section VIII, Divisions 1 and 2; and Section XII (SUPP) |
| <a href="#">ASME B1.20.1</a> | Pipe Threads, General Purpose (Inch)                                                                                    |
| <a href="#">ASME B16.5</a>   | Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard                                           |
| <a href="#">ASME B16.20</a>  | Metallic Gaskets for Pipe Flanges Ring-Joint, Spiral-Wound, and Jacketed                                                |
| <a href="#">ASME B16.47</a>  | Large Diameter Steel Flanges NPS 26 Through NPS 60                                                                      |

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|                                                                                                                                             |                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| <a href="#">ASME SEC I</a>                                                                                                                  | BPVC Section I - Rules for Construction of Power Boilers                                      |
| <a href="#">ASME SEC VIII D1</a>                                                                                                            | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 1                   |
| <a href="#">ASME SEC VIII D1 MA APP 2</a>                                                                                                   | Mandatory Appendix 2 Rules for Bolted Flange Connections with Ring Type Gaskets               |
| <a href="#">ASME SEC VIII D2</a>                                                                                                            | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 2 Alternative Rules |
| Pressure Vessels and Piping, Stresses in Large Horizontal Pressure Vessels, Pressure Vessel and Piping: Design and Analysis, Vol. II: 1977. |                                                                                               |

## 2.4. ASTM–American Society for Testing and Materials

|                             |                                                            |
|-----------------------------|------------------------------------------------------------|
| <a href="#">ASTM F 436</a>  | Standard Specification for Hardened Steel Washers          |
| <a href="#">ASTM F 436M</a> | Standard Specification for Hardened Steel Washers (Metric) |

## 2.5. BSI–British Standards Institute

|                 |                          |
|-----------------|--------------------------|
| BSI BS EN 13445 | Unfired Pressure Vessels |
|-----------------|--------------------------|

## 2.6. WRC–Welding Research Council

|             |                                                                                                            |
|-------------|------------------------------------------------------------------------------------------------------------|
| WRC BUL 107 | Local Stresses in Spherical Cylindrical Shells Due to External Loadings                                    |
| WRC BUL 297 | Local Stresses in Cylindrical Shells Due to External Loading on Nozzles-Supplement to WRC Bulletin No. 107 |

# 3. Definitions

| Term             | [I] Description                                                                                                                                                                                                                                                                                     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| hydrogen service | See <a href="#">GP 18-10-01</a> for definition.                                                                                                                                                                                                                                                     |
| MAWP             | Maximum Allowable Working Pressure (MAWP) is the maximum allowable pressure at the design temperature in the corroded condition. MAWP is determined by calculation, using the actual thickness less the corrosion allowance, in accordance with <a href="#">ASME SEC VIII D1</a> , Paragraph UG-98. |

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| Term                              | [I] Description                                                                                                                                                                                             |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>vessel thickness</b>           | Vessel thickness is defined as the thickness required for strength of the pressure vessel shell, including corrosion allowance but excluding weld overlay, lining, integral cladding or non-integral parts. |
| <b>wet H<sub>2</sub>S service</b> | See <a href="#">GP 18-10-01</a> for definition.                                                                                                                                                             |

## 4. Proposals

- 1) Quotations shall be considered incomplete and shall be rejected if they lack the following:
  - a) Pressure part and major structural part material specifications.
  - b) The location of, and reason for, any local post-weld heat treatment (PWHT) and a description of the proposed procedure.
  - c) When applicable, the proposed method of alloy/clad lining material and general lining procedures (clad or weld overlay).
  - d) Identification of Subcontractors who will be forming and/or welding pressure parts, as well as Suppliers of nonstandard or custom made forgings.
- 2) Each Vendor shall submit to the Purchaser a base proposal for the specified equipment. The base proposal shall comply with the Request for Quotation (RFQ), the applicable project specifications, and the Global Practices. Conflicting requirements in these documents, if any, shall be resolved in writing by the parties prior to submission of the proposal. Technical and commercial questions shall be resolved between the Purchaser and the Vendor prior to award.
- 3) If significant savings or design improvements can be demonstrated, Vendors shall offer alternate proposals in addition to their base bid. A proposal that contains only an alternate bid shall not be considered.
- 4) The Vendor shall furnish all information requested in the RFQ and any accompanying documents. Descriptive literature, drawings, and additional written information necessary to permit a clear understanding of the equipment's design basis, construction, operation, and maintenance shall be furnished with the proposal.

## 5. Documentation

### 5.1. Drawings

- 1) An outline drawing shall be furnished for each vessel, and shall contain the data shown in the appropriate Data Sheet. The location of the vessel marking or nameplate, the size and orientation of all nozzles and connections, and the anchor bolt layout shall also be shown on this drawing.
- 2) A separate outline drawing for each vessel shall be furnished with appropriate markings to cross-reference each component (shell plates, heads, nozzles, flanges, forgings, skirt plates, etc.) to the applicable mill test certificates for the steels used in the construction.

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- 3) Fabrication drawings shall show weld details and shall reference applicable welding procedures. The drawings shall also include impact test requirements, showing (as applicable):
  - a) Component
  - b) Thickness for impact purposes
  - c) Material specification
  - d) Critical Exposure Temperature or Minimum Design Metal Temperature
  - e) Appropriate Charpy impact requirements (average/minimum values)
- 4) [A] Two copies of all required drawings made by the Fabricator shall be submitted for approval prior to the start of fabrication.

## 5.2. Data and Calculations

- 1) A Manufacturer's data report shall be furnished and shall contain the same information as required by form U-1 of [ASME SEC VIII D1](#). Certified material test reports shall be furnished, and they shall represent the properties in the as-fabricated condition. The data report shall be signed by the Manufacturer, by an Authorized Inspector as defined in Par. UG-91 of the ASME Code, or as otherwise required by the applicable code. Other documentation (code papers, etc.) covering the construction of vessels built to the code of another nation shall be signed by the Manufacturer and, where applicable, by others having authority to sign such documentation.
- 2) Six signed copies of data reports and other required documentation shall be submitted to the Inspector prior to shipment of the vessel.
- 3) [C] Welding, PWHT, and weld repair procedures shall be submitted to the Purchaser for review prior to the start of fabrication.
- 4) Two copies of design calculations (including lifting attachments and supports) made by the Fabricator shall be furnished prior to or along with submission of drawings for approval. When calculations are made using a computer, all input data, assumptions, computer program version used, and a summary of the results shall be furnished.
- 5) Fabrication—Upon completion of fabrication, the Fabricator shall supply the Purchaser with:
  - a) Copy of PWHT recording
  - b) Copy of hydrostatic test chart
  - c) Copy of NDE (RT, UT, MT, PT, WFMT, etc.) test records
  - d) Copy of Positive Material Identification (PMI) log
  - e) Copy of results of any required impact tests
  - f) Copy of completed Inspection and Test Plan (ITP).

When weld production test plates are required, the test results shall be forwarded to the Owner no later than 10 working days after the test plates are welded.

- 6) [\*] When specified by the Owner's Engineer, the Vendor shall register all ASME Code stamped vessels with the National Board of Boiler and Pressure Vessel Inspectors in U.S. and Canadian locations.

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## 6. Materials

- 1) [S] [A] Proposals to use materials having a specified minimum tensile strength 90000 psi (620 MPa) or greater at room temperature shall be submitted to the Purchaser for approval by the Owner's Engineer.
- 2) [A] [R] External attachments and supports shall be as shown in Table 1. Proposals to use alternative materials shall be submitted to the Purchaser for approval by the Owner's Engineer.

**Table 1: Materials for External Attachments and Supports**

| Vessel Material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Attachments and Support Material |                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Major Attachments <sup>(1)</sup> | Minor Attachments <sup>(2)</sup>      |
| Carbon steel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Carbon steel <sup>(3)</sup>      | Carbon steel                          |
| Other materials                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Same material as shell           | Same material as shell <sup>(4)</sup> |
| <b>Notes:</b><br>(1) Attachments that are essential to the structural integrity of the vessel, including the top 18 in. (450 mm) of skirts, saddle wear plates, stiffening rings, and supports welded to pressure parts for platforms, piping, and equipment.<br>(2) Includes items that are lightly loaded during operation, such as insulation clips, studs, lifting lugs, and davit clips.<br>(3) For design temperatures over 650°F (343°C), structural quality steels, such as SA-36 and SA-283, shall not be welded to pressure parts.<br>(4) [A] For design temperatures under 450°F (232°C), carbon steel may be welded to non-carbon steel pressure parts with approval by Owner's Engineer. |                                  |                                       |

- 3) [\*] [R] The Owner shall identify any vessels in wet H<sub>2</sub>S or HF acid service. These vessels shall be subject to additional requirements according to [GP 18-10-01](#).
- 4) [R] SA-36, SA-283, and other structural quality steel shall not be used for pressure containing parts.
- 5) [R] Castings shall not be used for pressure parts.

## 7. Design

### 7.1. Design Requirements

- 1) [\*] [R] Unless otherwise specified, all vessels, except spheres designed to [API STD 620](#), operating above 1 psig (7.0 kPa), shall have a minimum design pressure of 16 psig (110 kPa).

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- 2) [\*] The Owner's Engineer shall specify the design pressure and temperature, design liquid level (including fluidized and bulk solids), specific gravity, and/or design pressure at various elevations. The Manufacturer shall design the vessel for the specified design pressure, liquid level, and temperature.
- 3) [\*] [R] All vessels shall be stamped for their MAWP at the design temperature unless otherwise specified by the Owner's Engineer. Nozzle reinforcement, cone-to-cylinder junction reinforcement, and saddle support designs shall not be limiting factors in determining the MAWP.
- 4) [S] [R] Vessels for vacuum service, including those in which a vacuum may be created inadvertently, shall be designed for an external pressure differential of 15 psi (103 kPa) or an external pressure differential 25 percent greater than the maximum operating value, whichever is less.
- 5) [R] Jacketed vessels—Vessel and jacket shall be designed for the most severe condition of coincident pressure and temperature.
- 6) For purposes of determining the applicability of [GP 05-01-02](#), thickness is defined as the thickness "as ordered," provided the plates actually supplied meet the ASTM tolerances on thickness (weight). Vessel pressure components or sections which are greater than 2 in. (50 mm) in thickness shall meet the Examination and Testing requirements of [GP 05-01-02](#). In addition, nozzle forgings for insertion into shell plates greater than 2 in. (50 mm) thick shall also meet the Nozzle and Connections design requirements of [GP 05-01-02](#).

Weld overlay, lining, integral cladding, non-integral parts, flat heads and closures, tubesheets, flanges, nozzle/manway reinforcing pads, areas of reinforcement, and areas of over-thickness up to 12 percent in excess of the specified thickness provided for plate thinning during forming or scale losses during heating, need not be considered in determining the applicability of [GP 05-01-02](#).

## 7.2. Design Loads

- 1) [A] [R] Loadings to be considered in designing a vessel shall be according to ASME SEC VIII and shall include cyclic conditions and erection loadings. If the vessel will be subjected to more than 1000 cycles in which the pressure range is greater than 80 percent of the design pressure, or where the temperature range is greater than 350°F (195°C), an assessment of the need for a fatigue analysis shall be conducted according to the [ASME SEC VIII D2](#), Par. AD-160, or with approval by the Owner's Engineer, according to the recognized code used for design and fabrication. If a fatigue analysis is required, then vessel is considered to be in cyclic service and is subject to additional requirements of [GP 05-01-02](#).
- 2) [R] Additional loadings—Vessels containing circulating suspensions of solids in fluids (fluid-solids processes) shall be subjected to additional horizontal loadings according to [GP 04-01-04](#).
- 3) [S] During erection, testing, startup, or operation, all applicable loads shall be considered as acting simultaneously, including either wind or earthquake, whichever governs. These loads include, but are not limited to:
  - a) Empty dead load of the vessel, attached piping and equipment.
  - b) Empty dead weight of the vessel, trays, insulation, internal attachments, ladder, platforms, and external piping.

See [GP 04-01-03](#) for additional loading requirements.

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### 7.3. Vibration Analysis

- 1) [R] All towers taller than 100 ft (30 m) with a H/D ratio greater than 15 shall be investigated for susceptibility to wind induced vibration (WIV)

Where: H = Overall Height ft (m)

D = Average shell diameter of top 1/3 height of tower ft. (m)

- 2) WIV are unlikely for any of the following conditions and no further analysis is required. These conditions shall be checked for all; erection, empty (shutdown or non-operating) and normal operating conditions.

a)  $V_c < 0.25V$  or  $V_c > 1.2V$

b)  $m' > 1.1$

c)  $m' > 0.8$  and  $f > 1.1$

Where: V = Mean hourly wind speed, mph (km/h)

$V_c$  = Critical Wind Velocity, mph (km/h)

$m'$  = Mass Damping Parameter =  $m\beta/\phi d^2$

m = mass per unit length over the top third of the vessel lb/ft (kg/m)

$\beta$  = Structural Damping Fraction of Critical (0.004 unless other values are justified)

$\phi$  = Density of air (typically 0.078 lbs/ft<sup>3</sup> or 1.25 kg/m<sup>3</sup>)

f = fundamental natural frequency of the tower, cycles/second

d = mean wind diameter over the top third of the tower, ft (m)

- 3) If none of the conditions in Item (2), above, is satisfied, WIV is suspected and the following mitigation steps shall be considered:

a) Flare skirt to increase the natural frequency

b) Increase the thickness of top sections to increase the critical speed.

c) If WIV is suspected in erection condition, only mitigation using temporary guy wires could be considered.

d) If WIV is suspected in operating condition, the permanent mitigation is required. Proposal to allow credit for additional damping due to operating liquid on trays or to adopt a Tuned mass damper method, or other methods shall be discussed with the owner's engineer.

e) If WIV is suspected in empty condition, alternate solutions including fatigue analysis are acceptable.

- 4) [A] Fatigue analysis, if required, shall be performed using method described in Pressure Vessel Design Handbook by H. H. Bednar, 2nd edition (Van Nostrand Reinhold Co. N.Y.) and the following. Any other method of analysis may be used with approval by Owner's Engineer.

The dynamic wind load F shall be applied to the top of the structure as an equivalent static point load, where

$$F = 0.00086(CI \times MF)(D \times H \times V_c^2), \text{ Lbs}$$

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$$F = 0.016(CI \times MF)(D \times H \times Vc^2), N$$

Where: CI = Lift Coefficient (greater than or equal to 0.4)

MF = Magnification factor (greater than or equal to 60)

D= Predominant outside steel shell diameter of the top one-third of the vessel, ft (m)

H = The total height of vessel from base of skirt to top of head, ft.(m)

- a) The maximum single amplitude (deflection) at the top of the vessel due to dynamic wind load, including rotation of the concrete foundation or structure, shall not exceed 0.5 percent of H.
- b) The allowable fatigue stress shall be the lesser of the following:
  - i) Allowable fatigue stress based on [ASME SEC VIII D2 MA APP 5](#) (for the number of cycles to failure as calculated in the wind dynamic analysis)
  - and

$$\text{ii) } S_{\text{allowable}} = \frac{19000 \times T^{1/5}}{k} (\text{psi}) \text{ or } S_{\text{allowable}} = \frac{131 \times T^{1/5}}{k} (\text{MPa})$$

Where: T = natural period (seconds) and k = stress concentration factor.

The value of k shall be no less than 2 for penetration welded joints and no less than 3 for non-penetration welded joints.

- c) [A] All calculations shall be submitted for approval prior to fabrication.

## 7.4. Allowable Stresses

- 1) [A] [R] The alternative higher stresses at temperature for high alloy steels permitted by the ASME Code shall not be used for flanges of gasketed joints, or other applications where slight amounts of distortion can cause leakage or malfunction, unless approved by the Owner's Engineer.
- 2) [R] Vessel supporting skirts—Allowable tensile and compressive stresses for vessel supporting skirts shall be according to the code used for vessel design.
- 3) Anchor bolts—Allowable stress for anchor bolts shall be according to [GP 04-06-01](#).
- 4) [S] In the hydrostatic test condition, the maximum membrane stress in the vessel shell shall not exceed 90 percent of the specified minimum yield strength for ferritic steels, nor 100 percent of the specified minimum yield strength for austenitic and duplex steels or non-ferrous materials.

## 7.5. Vessel Thickness

- 1) [M] [R] The following additional criteria shall be considered in calculating the required thickness of vessels and supports:
  - a) Horizontal drums on saddle supports shall be investigated for buckling, local circumferential bending, and shear stresses.  
L. P. Zic's method in the referenced "ASME: Pressure Vessels and Piping—Stresses in Large Horizontal Pressure Vessels, Pressure Vessels and Piping, Design and Analysis, Vol. II," may be used for this investigation.

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- b) Vessels shall be designed for future field hydrostatic testing with water, with the vessel in the operating position and fully corroded. The appropriate weld joint efficiency factor shall be used in these calculations. Integral cladding, weld overlay, or additional thickness provided in excess of thickness required for strength, may be considered as effective in calculating hydrostatic test stresses only.
- c) [\*] The maximum deflection of vertical vessels for all loadings, except earthquake, shall not exceed  $H/100$ , except level-sensitive equipment, such as fractionating columns, shall be limited to  $H/200$  under normal operating loads, including wind load as specified by the Owner's Engineer. ( $H$  is the overall vessel height from the base of the support ring to the top of the vessel.)
- d) The thickness of any alloy overlay, cladding or other lining shall not be considered when determining required vessel thickness, except as allowed in (b) above.
- e) The minimum thickness of shells and heads, exclusive of corrosion allowance, shall be as shown in Table 2.

**Table 2: Minimum Shell and Head Thickness**

| Material of Construction                                                                                        | Vessel Diameter         | Minimum Thickness                        |
|-----------------------------------------------------------------------------------------------------------------|-------------------------|------------------------------------------|
| Carbon and Low Alloy Steels                                                                                     | $\leq 84$ in. (2130 mm) | $\frac{3}{16}$ in. (5 mm) <sup>(1)</sup> |
|                                                                                                                 | $> 275$ in. (7000 mm)   | $\frac{3}{8}$ in. (10 mm) <sup>(1)</sup> |
| High Alloy Steels                                                                                               | All                     | $\frac{1}{8}$ in. (3 mm)                 |
| <b>Note:</b><br>(1) Thicknesses between values shown may be obtained by linear interpolation based on diameter. |                         |                                          |

- f) The minimum thickness of support skirts shall be 0.25 in. (6 mm) or the vessel wall thickness, whichever is less. Base plates shall have a minimum thickness of 0.50 in. (12.7 mm).
- 2) [R] Corrosion allowances shall be as specified on the Pressure Vessel Data Sheets with the minimum corrosion allowance as shown in Table 3.

**Table 3: Minimum Corrosion Allowance**

| Materials of Construction                                           | Minimum Corrosion Allowance  |      |
|---------------------------------------------------------------------|------------------------------|------|
|                                                                     | in.                          | mm   |
| Carbon, Low Alloy, and Intermediate Alloy Steels <sup>(1)</sup>     | $\frac{1}{16}$               | 1.5  |
| High Alloy Steels <sup>(2)</sup> and All Non-ferrous Materials      | 0.01                         | 0.25 |
| Vessels with Metal Lining or Cladding                               | 0.01<br>(external allowance) | 0.25 |
| Fixed Supports, any material (skirts, legs and lugs) <sup>(3)</sup> | $\frac{1}{8}$                | 3.0  |

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| Materials of Construction                                                                                                                                                                                                     | Minimum Corrosion Allowance |    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----|
|                                                                                                                                                                                                                               | in.                         | mm |
| <b>Notes:</b><br>(1) Includes all steels with an alloy content not exceeding 9Cr 1Mo.<br>(2) Includes all steels with an alloy content of 12Cr or greater.<br>(3) Corrosion allowance indicated is total corrosion allowance. |                             |    |

## 7.6. Heads and Transition Sections

- 1) [R] Cylinder-to-cone transitions shall be toriconical sections when any of the following conditions apply:
- 2) The section is subject to a major support reaction (for example, skirt-to-cone attachment).
- 3) Cone apex angle exceeds 60 degrees.
- 4) [R] Inside radius of knuckles for torispherical heads, toriconical heads, or conical transition sections where knuckles are required, shall be as follows:
- 5) For knuckles  $\frac{3}{4}$  in. (19 mm) thick or less, minimum inside radius shall be not less than 6 percent of the outside diameter of the adjoining cylindrical section.
- 6) For knuckles thicker than  $\frac{3}{4}$  in., minimum inside radius shall be not less than 10 percent of the outside diameter of the adjoining cylindrical section.
- 7) [A] [R] Intermediate heads shall be attached to the shell according to the [ASME SEC VIII D1](#), Figure UW-13.1 (f) with fillet welds, unless otherwise approved by the Owner's Engineer.

## 7.7. Nozzles and Manways

### 7.7.1. General Requirements

- 1) [A] [R] Nozzles NPS 2 (50 mm) and larger shall be flanged or studded, and shall have the same P-number as the vessel shell. Corrosion protection equivalent to that of the vessel shall be provided. Use of studded nozzles shall be approved by the Owner's Engineer.
- 2) [R] All nozzles and connections Class 900 and above shall be flanged or butt welded.
- 3) [\*] [R] Unless otherwise specified, all instrument connections, including thermowell connections, shall be a minimum of NPS 2 (50 mm) flanged.
- 4) [M] Nozzle projection shall be such that all flange bolting clears the vessel and any insulation by at least the distance required to insert and operate a box wrench.
- 5) [A] [O] Connections shall not extend into the vessel beyond the interior surface except as required by Item (6) below when specified or when approved by the Owner's Engineer.
- 6) [M] Nozzles in portions of vessels with gunite shall have internal projections so that the nozzle end is flush with the lining.

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- 7) [\*] [R] When used with spiral wound gaskets, the ID of forged nozzles, including long weldneck flanged nozzles, shall be decreased as necessary to meet the requirements of Table 16 and Table 18 of [ASME B16.20](#). When specified, the ID of the nozzles shall match the ID of mating pipe flanges.
- 8) For skirt supported vessels, the following are not permitted within the skirt:
  - a) [S] Flanged connections
  - b) [M] [R] Bimetallic welds
- 9) [\*] [R] Unlined carbon steel and low alloy (up to and including 9Cr-1Mo) pipe and fittings inside vessel skirts shall be at least one schedule heavier than that required for the MAWP plus corrosion allowance, unless otherwise specified by the Owner's Engineer.
- 10) [R] Nozzle boltholes shall straddle centerlines.
- 11) [A] Nozzles and manways shall be attached to the vessel by full penetration welds. Unless otherwise approved by the Owner's Engineer, full penetration welds shall be used for attaching reinforcing pad plates to nozzle and manway necks.
- 12) [R] Nozzles subjected to large forces and moments shall be analyzed for additional shell and nozzle neck reinforcement requirements. Stresses shall be limited to values listed in Figure 4-130.1 of [ASME SEC VIII D2 MA APP 4](#); the value of  $S_m$  shall be equal to the allowable stress listed in the appropriate Division of ASME SEC VIII or in the recognized code to which the vessel is designed.

### 7.7.2. Connections NPS 1<sup>1</sup>/<sub>2</sub> and Smaller

- 1) [R] Connections NPS 1<sup>1</sup>/<sub>2</sub> (40 mm) and smaller may be threaded, except for pressure relief valve connections. Couplings or integrally reinforced fittings shall be used for threaded connections. Additional thickness shall be provided for corrosion allowance, as required to provide corrosion protection equivalent to that of the vessel. All couplings or fittings shall be installed with complete penetration welds. Half couplings welded to the outer surface of the vessel may be used.
- 2) Threaded connections shall have tapered threads according to [ASME B1.20.1](#).
- 3) Threaded and socketweld connections used as pressure parts shall be Class 6000 forged steel couplings.
- 4) [\*] Connections NPS 1<sup>1</sup>/<sub>2</sub> (40 mm) and smaller shall be braced according to [GP 03-18-01](#) when specified by the Owner's Engineer.
- 5) [S] Plugs and caps for vent and drain connections that are used for hydrostatic testing and that could potentially result in leakage of dangerous material shall be seal welded. Vent and drain connections that are frequently used shall be provided with valves complete with plugs or caps. Refer to [GP 03-18-01](#) for definition of dangerous material.

### 7.7.3. Nozzle Reinforcement

- 1) [R] Nozzle reinforcing pads, or segments thereof, shall be provided with a <sup>1</sup>/<sub>4</sub> in. (6 mm) diameter NPT threaded telltale hole, which shall be filled with grease or plastic sealant after pressure testing.
- 2) [A] [R] Nozzles and their reinforcing pads shall not be located in the knuckle region of a torispherical head without the approval by Owner's Engineer.
- 3) [R] For unlined carbon steel vessels in HF service, integral reinforcement shall be used.

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- 4) [R] Pad reinforced nozzles are not permitted if the vessel shell design temperature is 800°F (427°C) or greater.
- 5) [R] When integral reinforcement is provided on nozzles 6 in. (150 mm) and greater on vessels with design temperatures 800°F (427°C) or greater, the ratio of nozzle wall thickness to shell wall thickness shall not be greater than 2.5, unless a detailed stress analysis has been performed.

#### 7.7.4. Additional Requirements for Manways

- 1) [\*] [M] Manways shall be provided for all process vessels with diameters larger than 36 in. (914 mm). Smaller vessels shall have handholes or flanged heads, or both, as specified. Manway and handhole quantity and locations will be specified. Manways shall have a minimum clear inside diameter of 19 in. (480 mm).
- 2) Manway covers shall be hinged or provided with handling davits. If blind flanges to [ASME B16.5](#) are used for cover plates, corrosion allowance shall be added to the thickness only in the amount that the specified vessel corrosion allowance exceeds  $\frac{1}{4}$  in. (6 mm).
- 3) [A] [R] The design and use of quick opening closures shall be approved by the Owner's Engineer. Detailed drawings and calculations, including safety devices, shall be submitted for approval.

#### 7.7.5. Flanges

- 1) [R] Flanges NPS 24 and smaller (NPS 12 and smaller for Class 2500) shall be according to [ASME B16.5](#).
- 2) [A] [R] Flanges larger than NPS 24 (600 mm) shall be according to [ASME B16.47](#) Series B, unless otherwise approved by the Owner's Engineer. Flanges outside the scope of [ASME B16.47](#) shall be designed according to [ASME SEC VIII D1](#) (with allowable stresses as determined according to that Code), and subject to [ASME SEC VIII D1 MA APP 2](#), Section 14 of that Code. The rigidity index, J, shall be determined for the flange at the seating and design conditions. For carbon steel vessels with design temperature 700°F (370°C) or lower and for low alloy steel (up to and including 5Cr-1Mo) vessels with design temperature 850°F (454°C) or less, J shall be limited to 0.9.
- 3) [R] Flanges for nozzles with attached piping—Flanges that are not according to [ASME B16.5](#) or [ASME B16.47](#) shall be designed to include the applied bending moment from the attached piping.
- 4) [C] [R] The design temperature of uninsulated external flanges and their gaskets may be reduced to 90 percent of the design temperature of the vessel components to which they are attached provided they are located in exposed open areas and this is permitted by the vessel design code. The corresponding bolting design temperature may be reduced to 80 percent of the vessel design temperature. These temperature reductions shall not be applied to flanged shell girth joints.
- 5) [A] [R] Lap type flanges shall not be used unless approved by the Owner's Engineer.
- 6) [R] Slip-on flanges shall be positioned so that the distance from the face of the flange to the pipe end is equal to the nominal pipe wall thickness, plus approximately  $\frac{1}{8}$  in. (3 mm). The welds shall be applied in a manner that will not require refacing of the flange.

#### 7.8. Vents

- 1) [S] [A] A vent shall be provided at or near the top of the vessel on all vessels with manways to facilitate adequate ventilation during vessel entry. Vent shall be sized based on vessel volume and shall not be less than 6 in. diameter. The vent may be another manway or, when approved by the

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Owner's Engineer, a flanged process nozzle which can be disconnected at the vessel and the piping removed to create a clear path. On horizontal vessels, the vent and manway shall be on opposite ends of the vessel.

## 7.9. Vessel Supports and Attachments

### 7.9.1. Horizontal Vessel Supports

- 1) [A] [R] Unless approved by the Owner's Engineer, horizontal vessels shall be supported on two saddles covering at least 120 degrees of the vessel circumference. Saddles and pads shall not cover vessel shell seams. One of the saddle bearing plates shall have slotted holes to allow for thermal expansion of the vessel. If more than two saddles are used, allowable differential settlement shall be determined and actual settlement measurements made periodically to assure the vessel is not overstressed or spring support be considered.
- 2) [M] Horizontal vessels supported on concrete saddles or steel saddles not fully welded to the vessel shall be provided with corrosion plates between the saddle and the vessel. These plates shall be  $\frac{1}{4}$  in. (6 mm) thick, shall extend at least 2 in. (50 mm) beyond the periphery of the bearing area of the saddle, and shall be seal-welded to the vessel. Plates shall have the same nominal chemical composition as the vessel. A  $\frac{1}{4}$ -in. (6-mm) vent hole shall be provided in each corrosion plate, and the hole shall be plugged with a sealant after the vessel has been pressure tested.

### 7.9.2. Vertical Vessel Supports

- 1) [R] Vertical vessels subject to vibration, for example, reciprocating compressor suction drums (that are not machine mounted), shall be skirt-supported on a solid or continuous concrete base.
- 2) [R] Vessels subject to surge vibration design loads according to [GP 04-01-04](#) shall be skirt supported with skirt detail according to the requirements of the Vessel Support Section of [GP 05-01-02](#).
- 3) [R] Vertical vessels shall be provided with one of the following types of supports designed to withstand the loading described in the Design Loads section of this Global Practice.
  - a) [\*] Lugs or legs welded directly to the shell—An analysis of the support-to-shell junctions shall be conducted to determine the need for additional reinforcement of the shell. Maximum stress intensity limits for the load combinations shall be in accordance with AD-150 of [ASME SEC VIII D2](#), except that fatigue life evaluations are not required unless specified by the Owner's Engineer. Stresses listed in Figure 4-130.1 of [ASME SEC VIII D2 MA APP 4](#) shall be limited to the following, unless detailed nonlinear limit load analysis is performed in accordance with [ASME SEC VIII D2 MA APP 4](#):
    - i) The local membrane stress should not exceed  $1.5 S_m$ .
    - ii) The stress due to the sum of membrane and bending stresses should not exceed  $2.25 S_m$ .
 Where  $S_m$  is equal to the allowable stress listed for the material in the appropriate Division of ASME SEC VIII or in the recognized code to which the vessel is designed.
  - b) Support skirts welded to the shell or head—Considerations and general design shall be in accordance with [ASME SEC VIII D1 NMA APP G](#). Joint efficiency of attachment welds shall be according to code requirements.
- 4) [M] A single skirt access manway, of 20 in. (500 mm) diameter, shall be provided if piping is located inside the skirt, unless access is available from below the skirt (e.g., vessels located in a structure). No piping shall pass through access openings.

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- 5) [R] Skirt vents and access shall be provided if the vessel is internally insulated and operated at a fluid temperature above 500°F (260°C). At least four vents shall be provided. The vents shall be minimum NPS 6 (150 mm), Schedule 80 (10.97 mm wall) pipe sleeves, and shall be equally spaced at a maximum of 6 ft (1800 mm) around the skirt circumference.
- 6) [S] [\*] Skirt openings for piping shall have a 1/2 in. (13 mm) maximum clearance between the pipe OD, including insulation, and the skirt, when the inside of the skirt is not to be fireproofed.
- 7) [\*] [M] If the skirt is specified by the Owner's Engineer to be fireproofed, the vents and access hole sleeves shall be of sufficient length so that the ends will be flush with the inner and outer surfaces of the finished fireproofing.

### 7.9.3. Attachments

- 1) [R] Reinforcing pads for internal or external structural attachments to vessel shells shall be provided with a 1/4-in. (6-mm) diameter vent hole for the enclosed space between welds located at or near the low point of the pad. External vent holes shall be plugged with grease or plastic sealant after the vessel has been tested.
- 2) [R] Stiffening and insulation rings on parts of vertical vessels in intermittent service or with normal operating temperatures below 300°F (149°C) shall be designed to allow for drainage.
- 3) [R] When corrosion allowance (CA) is greater than 0.1 in. (2.5 mm), welded non-pressure attachments inside carbon and low-alloy steel vessels shall be completely welded to prevent corrosion behind the attachment. Intermittent welding may be used in non-corrosive services (CA less than or equal to 0.1 in. [2.5 mm]) and in high-alloy and alloy-lined vessels where seal welding is not required.
- 4) [\*] [R] The vessel Fabricator shall provide lifting and tailing lugs as specified. Erection loadings and analysis shall conform to the following for the vessel shell, skirt, and attachments welded to the vessel shell or skirt that are purpose designed for the lift:
  - a) [A] For lifts of 100 tons or less, a lift load factor of 1.7 shall be used along with normal code allowable stress levels, unless otherwise approved by the Owner's Engineer.
  - b) [A] For lifts greater than 100 tons, a lift load factor of 1.35 shall be used along with normal code allowable stress levels, if approved by the Owner's Engineer.  
The above load factors are minimum values and shall be increased as necessary to account for actual lifting procedures and equipment.
  - c) Vessel shells shall be analyzed for local buckling, bending, and shear imposed during erection. Analysis may be performed in accordance with WRC BUL 107 or WRC BUL 297, as applicable.
  - d) The allowable stresses shall be as follows:
    - i) Stresses in the shell and attachments shall be categorized according to [ASME SEC VIII D2 MA APP 4](#) except that the bending stress shall be considered as primary unless detailed nonlinear limit load analysis is performed in accordance with [ASME SEC VIII D2 MA APP 4](#). Basic allowable stress shall be limited to the values listed in the applicable code. Allowable stresses for attachment welds shall be reduced by the applicable joint efficiency factor.
    - ii) No increase in allowable stress is permitted due to the short duration of the erection loads.
  - e) [S] [A] The use of bolted-on tailing frames shall be approved by the Owner's Engineer and shall comply with [GP 04-14-01](#) and the following requirements:

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- i) The fit-up tolerances between the tailing frame and the vessel skirt shall be taken into account in determining the shear loads and load distribution on the attachment bolting during lifting.
- ii) The deflection of the vessel skirt during the lift shall not impose any additional shear loads on the attachment bolting.
- iii) Bolted connections shall be control-bolted to ensure that the loads are distributed to the bolt connections.

## 7.10. Proprietary Construction

- 1) [A] [C] Alternatives to solid wall construction. Certain forms of construction may be used as an alternative to conventional solid wall construction, provided they meet the requirements of this practice, and approval by the Owner's Engineer has been obtained prior to submitting a proposal for such construction.

The alternatives shall be as follows:

- a) Spiral wound
- b) Band reinforced
- c) Multiple layer

## 8. Additional Requirements for Flanged Shell Girth Joints

- 1) [A] [R] Flanged girth joints shall be designed for through bolting. Proposals for alternative joint design shall be submitted to the Purchaser for approval by the Owner' Engineer.
- 2) [R] Flanges for girth joints shall conform to the following:
  - a) Flanges shall be according to [ASME B16.5](#), [ASME B16.47](#) Series B, or designed according to [ASME SEC VIII D1](#) with allowable stresses determined according to that code.
  - b) Welding neck flanges shall be used where the pressure-temperature design conditions require an ASME Class 300 or greater flange.
  - c) Slip-on flanges shall not be used if any of the following conditions are exceeded:
    - i) Pressure-temperature design conditions require an ASME Class 300 or greater flange.
    - ii) Design temperature exceeds 750°F (400°C).
    - iii) Specified corrosion allowance for the vessel is greater than  $\frac{1}{8}$  in. (3 mm).
    - iv) The vessel is in hydrogen service.
  - d) Girth flanges larger than NPS 24 that are not in accordance with [ASME B16.47](#) Series B shall be designed to meet the flange rigidity recommendations in [ASME SEC VIII D1 MA APP 2](#), Section 14. The rigidity index, J, shall be determined for the flange at the seating and design conditions. For carbon steel vessels with design temperature 700°F (370°C) or lower and for low alloy steel (up to and including 5Cr-1Mo) vessels with design temperature 850°F (454°C) or less, J shall be limited to 0.9.
- 3) [\*] [R] Unless otherwise specified, gasket contact surfaces shall have a finish equivalent to 125 to 250  $\mu$ m. (3.2 to 6.3  $\mu$ m) roughness average ( $R_a$ ).

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- 4) [R] Allowable flatness tolerances of gasket contact surfaces for the appropriate service condition shall be as shown in Table 4.

**Table 4: Allowable Flatness Tolerances of Gasket Contact Surfaces**

| Vessel Diameter<br>(nominal size)                                                                                           |               | Normal Service                          |     | Special Service<br>Design Temperature ≥ 850°F (454°C)<br>or Flange Rating ≥ ASME Class 900 |      |
|-----------------------------------------------------------------------------------------------------------------------------|---------------|-----------------------------------------|-----|--------------------------------------------------------------------------------------------|------|
|                                                                                                                             |               | Allowable Tolerances (±) <sup>(1)</sup> |     |                                                                                            |      |
| in.                                                                                                                         | mm            | in.                                     | mm  | in.                                                                                        | mm   |
| ≤ 15                                                                                                                        | ≤ 375         | 1/64                                    | 0.4 | 0.003                                                                                      | 0.08 |
| > 15 to 30                                                                                                                  | > 375 to 750  | 1/64                                    | 0.4 | 0.006                                                                                      | 0.15 |
| > 30 to 45                                                                                                                  | > 750 to 1125 | 1/64                                    | 0.4 | 0.009                                                                                      | 0.23 |
| > 45                                                                                                                        | > 1125        | 1/64                                    | 0.4 | 0.012                                                                                      | 0.30 |
| <b>Note:</b><br>(1) The total tolerance on peripheral gasket contact surfaces shall not occur in less than a 20-degree arc. |               |                                         |     |                                                                                            |      |

- 5) [R] For confined joint construction (peripheral gasket confined on OD):
- Nubbins, if provided, shall be located on the female (grooved) flange.
  - The clearance between flanges after assembly shall be not less than  $3/16$  in. (5 mm). This clearance shall extend from the periphery of the flange to within the bolt circle.
- 6) [M] [R] Bolting shall be according to [GP 03-16-01](#), except that where hydraulic bolt tensioning is specified for girth flange assembly, bolts  $1\frac{1}{2}$  in. (38 mm) and larger in diameter shall be fitted with a hardened washer according to [ASTM F 436](#), under one nut only, located on the side opposite from the extended bolt length.

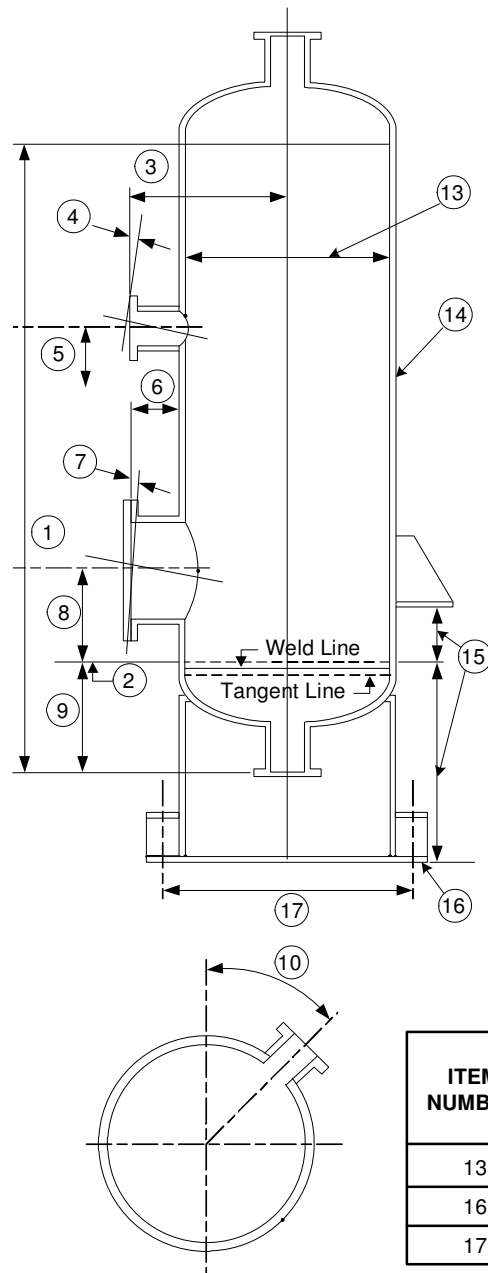
## 9. Fabrication

- 1) [M] Tolerances shall be according to Figure 1.

Vessels that will contain cartridge or pedestal tray assemblies shall be checked with a template to ensure that the assemblies can be inserted and withdrawn without interference or binding. The diameter of the template shall be no smaller than the specified ID of the vessel minus  $1/4$  in. (6 mm).

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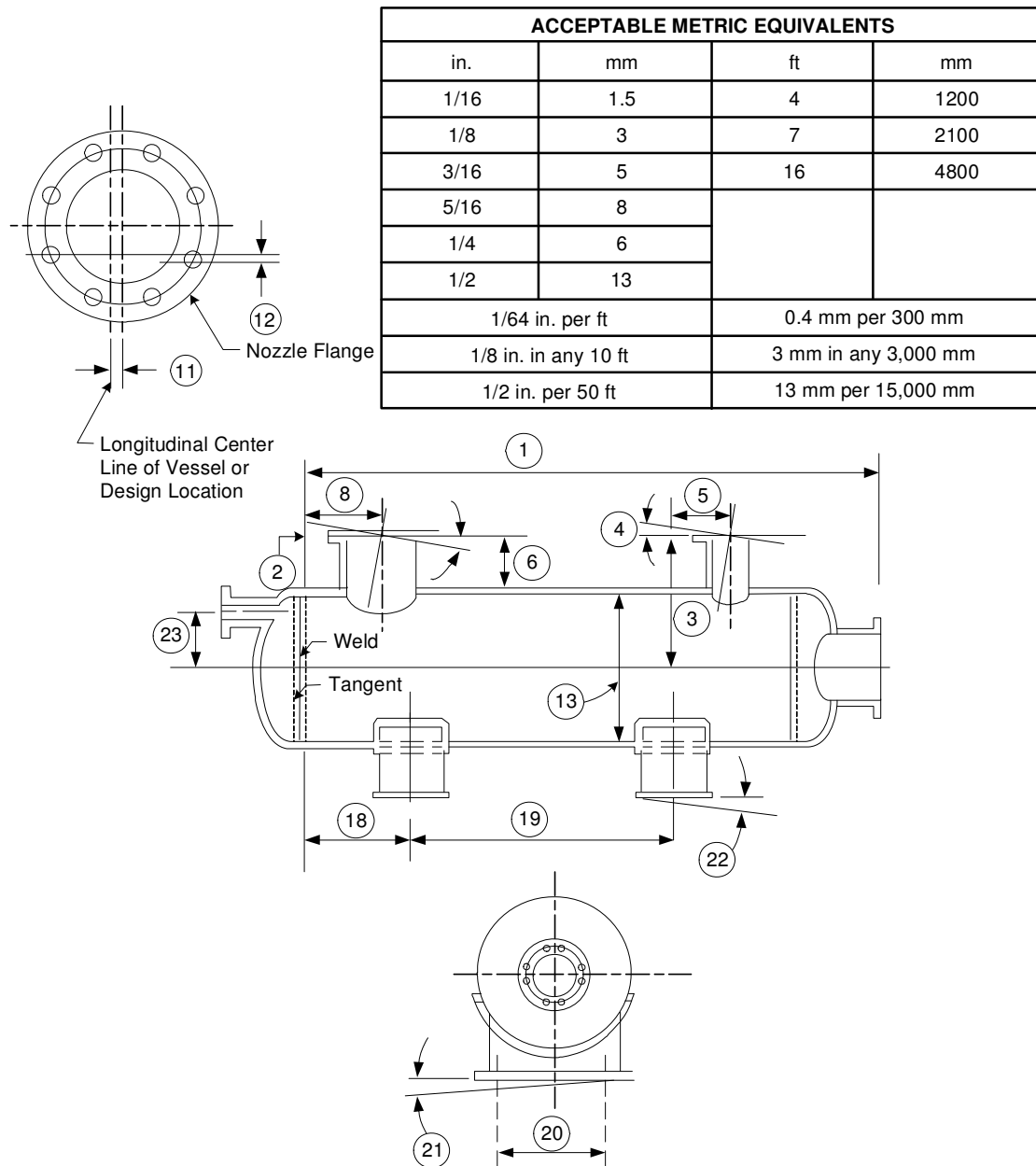


**Figure 1: Pressure Vessel Tolerances**

- 1 Tolerance on longitudinal dimensions from the reference plane shall be the smaller of 1/64 in. per foot of length or 1/2 in., unless noted otherwise.
- 2 Reference Plane punch mark inside and out 3 in. from root land of bottom course.
- 3 Flange face of nozzle from centerline of vessel  $\pm 1/8$  in.
- 4 Flange face of nozzle shall be parallel with the indicated plane in any direction  $\pm 1/2^\circ$ , but not to exceed 3/16 in.
- 5 Location of nozzle from reference plane  $\pm 1/4$  in.; exception shall be liquid level controller nozzles  $\pm 1/16$  in. and nozzles related to tray, draw-off pans, etc., so dimensioned on drawings, distance from support ring  $\pm 1/8$  in.
- 6 Flange face of manhead from outside of tower  $\pm 1/4$  in.
- 7 Flange face of manhead shall be parallel with the indicated plane in any direction  $\pm 1^\circ$ .
- 8 Location of manhead from reference plane  $\pm 1/2$  in.
- 9 Flange face of top or bottom nozzle to reference plane  $\pm 1/4$  in.
- 10 Orientation of nozzle and other attachments shall be within  $\pm 1/8$  in.
- 11 1/8 in. max. lateral translation.
- 12 1/16 in. max. rotation of flanges from the indicated position, measured as shown.
- 13 In addition to ASME code tolerances, tolerances from nominal inside shell diameter as measured by external strapping shall be as given in table below.
- 14 Maximum deviation from straight applied to shell shall be: 1/8 in. in any 10 ft or 1/2 in. per 50 ft of length. In addition, distortion caused by welding of longitudinal or circumferential joints shall not exceed 1/4 in. maximum depth in a 36 in. length of shell centered on the weld.
- 15 Distance from reference plane to base + 0 in., - 1/4 in. or lug + 1/4 in., 0 in.
- 16 Base or support lug out of level over any diameter shall be as given in table below.
- 17 Bolt hole circle tolerance shall be as given in table below.

| ITEM NUMBER | INSIDE DIAMETER SPECIFIED |                                |                                 |                 |
|-------------|---------------------------|--------------------------------|---------------------------------|-----------------|
|             | < 4 ft - 0 in.            | > 4 ft - 0 in. to 7 ft - 0 in. | > 7 ft - 0 in. to 16 ft - 0 in. | > 16 ft - 0 in. |
| 13          | $\pm 1/8$ in.             | $\pm 3/16$ in.                 | $\pm 1/4$ in.                   | $\pm 5/16$ in.  |
| 16          | $\pm 1/8$ in.             | $\pm 3/16$ in.                 | $\pm 1/4$ in.                   | $\pm 1/4$ in.   |
| 17          | $\pm 1/8$ in.             | $\pm 1/8$ in.                  | $\pm 1/4$ in.                   | $\pm 1/4$ in.   |

Figure 1 Continued



- ⑮ Distance from reference plane to the centerline of the saddle 1/8 in. (3 mm).
- ⑰ Distance between the centerline of the saddle 1/8 in. (3 mm).
- ⑳ Distance between the centerline of the support bolt holes across width 1/8 in. (3 mm).
- ㉑ Saddle base plate out of level shall be the same as for item 16.
- ㉒ Saddle base plate out of level slope 1/16 in. (1.5 mm), across the width of the saddle.
- ㉓ Location of nozzle from vessel centerline 1/4 in. (6 mm).

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- 2) [R] When a vessel is insulated for cold service, the vessel nameplate shall be insulated, and a duplicate nameplate shall be provided by the Fabricator for later installation over the outside surface of the insulation system.
- 3) [R] No stamping or indentations shall be made directly on a vessel after PWHT, but may be placed on a plate welded to the vessel before PWHT. The vessel shall be stenciled to show it has undergone PWHT, and that no further welding is to be done on the vessel.
- 4) Vessel nameplates shall be corrosion-resistant and shall extend beyond the vessel by the required insulation thickness. In addition to the information required by the ASME Code, nameplates shall also bear the following as a minimum:
  - a) Corrosion allowance
  - b) Hydrostatic test pressure
  - c) National Registration Number (when applicable)
- 5) [R] Carbon steel vessels in alkaline service shall meet the requirements of [GP 18-04-01](#).
- 6) [R] Temporary attachments that are required as fit-up aids, such as dogs or wedges, shall be removed by grinding or by flamecutting no closer than  $\frac{1}{8}$  in. (3 mm) from the vessel wall. The remaining attachment shall then be ground flush with the vessel wall.
- 7) [S] Cold formed heads fabricated from all grades of type 304, 321, or 347 stainless steel, having inside diameter to nominal head thickness ratio less than 100, shall be solution annealed after forming.

## 9.1. Welding

- 1) [R] Head and shell joints shall be welded with full penetration and full fusion. Welds shall be according to [ASME SEC VIII D1](#), Table UW-12, Type No. 1.
- 2) [R] Non-consumable backing strips may be used for steam or air service when the back side of the weld is not accessible.
- 3) [R] For a welded joint referenced in Table 5 or any other attachment, where one member having thickness greater than  $\frac{3}{4}$  in. is full penetration welded to a plate greater than  $\frac{3}{4}$  in. in thickness to form a corner or T-joint, one of the following requirements shall be met:
  - a) The member subjected to through-thickness tension is a forging.
  - b) The member subject to through-thickness tension is overlaid (buttered) with  $\frac{1}{4}$  in. (6 mm) thick weld metal prior to attachment.
  - c) 100% pulse-echo ultrasonic examination is performed on the weld from the back side of the plate subjected to through-thickness shrinkage stresses.
  - d) [A] If the member subjected to through-thickness tension is a lamellar tearing resistant plate (plate having a sulfur content less than 0.005% and frequently referred to as "Z steels"), requirement of b) or c) above may be waived if approved by company engineer.

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**Table 5: Figure Reference from Indicated Division of the ASME Code Section VIII**

| Joint Configuration                                                | Division 1                                                       | Division 2                            |
|--------------------------------------------------------------------|------------------------------------------------------------------|---------------------------------------|
| Attachment of Pressure Parts to Flat Plates to form a Corner Joint | Fig. UW-13.2 (a), (e-1), (e-2), (f), (h), (i), (j), (k), and (m) | Fig. AD-701.3 (a), (b), (c), (f), (g) |
| Welded Nozzles and Other Connections                               | Fig. UW-16.1 (a), (a-1), (a-2), (a-3), and (b)                   | Fig. AD-610.1 (a), (b)                |

- 4) [R] Skirt and other attachment welds to the pressure boundary of a vessel shall have complete fusion for the full length of the weld, and shall be free from undercut, overlap, or abrupt ridges or valleys. All internal attachment welds shall be continuous.
- 5) [R] Longitudinal and circumferential welds in the skirt shall be full penetration butt joints. The skirt to baseplate joint shall be a continuous fillet weld both inside and out. For skirt base rings constructed in segments, full penetration butt welds shall be used. Such welds shall be ground flush on the bottom side of the ring, and on the top side of the ring where required to avoid interference with the nuts and washers of the anchor bolts. The layout for anchor boltholes shall be such that the holes do not pass through the welds.
- 6) [A] [R] Except for P-1 materials on vessels that are to be PWHT, lifting attachments, gusset stubs for providing small connection gussets, as well as other shell attachments, shall be welded to the vessel before final heat treatment. For P-1 materials, such attachments may be welded after final heat treatment if approved by the Owner's Engineer. Heads that are annealed or normalized shall be freed of any mill scale by sandblasting or pickling prior to inspection.
- 7) [A] [R] Welded attachment of internals to austenitic weld overlay, where approved by the Owner's Engineer, shall be made after PWHT.

## 9.2. Repairs

- 1) [A] [R] Defects found during fabrication shall be removed and re-welded using the qualified welding procedures. Repaired welds shall be re-examined by the original method to ensure freedom from defects. Approval by the Owner's Engineer is required prior to beginning repairs in the following situations:
  - a) Weld repair depth exceeds  $\frac{3}{8}$  in (9.5 mm) or one-half the weld thickness.
  - b) Defects are observed in plates or forgings.
  - c) More than one repair is required of the same defect.
  - d) Repair is required after PWHT.
  - e) Repair is to quenched and tempered material.
  - f) Repair is to material where the specified minimum yield strength exceeds 52000 psi (360 MPa).

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## 10. Inspection and Testing

- 1) [I] The term Inspector, as used in this practice, refers to the Owner's Representative.
- 2) Manufacturer's data reports shall be made available to the Inspector at the time of inspection.
- 3) [A] Manufacturer's Examination and Testing plan—The Vendor shall submit, for the Purchaser's approval, a detailed plan of applicable examinations and tests required for the individual components and weldments of each vessel. Specific examinations applicable to linings or claddings shall be included to the extent of the Vendor's responsibility.
- 4) [I] Appendix Table A–1 summarizes the minimum examination and testing requirements for pressure vessel components and materials.

### 10.1. Examination Methods and Acceptance Criteria

- 1) [R] Spot radiography shall be per the applicable code, except that the acceptance standards shall be per 100 percent radiography requirements.
- 2) [R] Radiographic film—Fluorescent intensifying screens such as calcium tungstate shall not be used.
- 3) [R] Radiographic film length shall be 10 in. (250 mm) minimum, except if the weld is less than 10 in. long. In such cases, film length shall be the full length of the weld.
- 4) [A] [R] For vessels made of materials other than carbon steel, the D-C prod method of magnetic particle examination shall be used prior to final PWHT; the A-C yoke or coil method of magnetic particle examination shall be used after final PWHT. For carbon steel vessels, the A-C yoke method may be used prior to PWHT, when approved by the Owner's Engineer.
- 5) [R] Before welding set-on nozzles, the plate below the nozzle weld shall be ultrasonically examined. Any indications or laminations found within  $\frac{1}{4} \times t$  of the surface of the plate are unacceptable (where  $t$  = plate thickness).

### 10.2. Weld Quality Control

- 1) [R] For vessels or sections of vessels where butt welded seams are 100 percent radiographed or ultrasonically examined, all other pressure containing welds and all attachment welds to pressure containing parts shall be examined as follows:
  - a) [A] Pressure containing welds (such as nozzle-to-shell welds and nozzle welds) shall be examined by the ultrasonic method using either the straight beam or shear wave mode. If ultrasonic examination is not feasible, alternative inspection methods, such as magnetic particle examination for approximately every  $\frac{1}{4}$  in. (6 mm) of weld deposit thickness, may be substituted if approved by the Owner's Engineer.
  - b) Support skirt welds shall be examined by the ultrasonic method using either the straight beam or shear wave mode.
  - c) Lifting lug welds shall be examined by the magnetic particle method.
  - d) All attachment welds to pressure containing parts on materials other than P1, Groups 1 and 2, shall be examined by the magnetic particle method. If the material is non-magnetic, the liquid penetrant inspection method shall be used in place of the magnetic particle method. Accessible welds subject to PWHT shall be inspected after PWHT.

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- e) All locations of temporary attachment welds on materials other than P1, Groups 1 and 2, shall be inspected according to Item (1d) of this Section.
- 2) [R] If 100 percent radiography is not specified, spot radiographs shall be made as follows:
- For cylindrical vessels, one spot shall be examined in each circumferential joint, and in each longitudinal joint between adjacent circumferential joints, at locations designated by the Inspector.
  - For spherical vessels, a spot radiograph shall be taken at each weld intersection, and one for each 20 ft (6 m) of weld seam, at locations designated by the Inspector.
  - For spot-radiographed vessels, 20 percent of the nozzle-to-shell welds (2 minimum) shall be PT examined as follows:
    - The lesser of 12 linear in. (300 mm) or the complete weld length of the backside of the root area after backgouging or grinding, and
    - Both sides of the completed weld shall be examined.
 If cracks are found, two additional nozzles shall be examined.
- 3) [A] [R] Where 100 percent radiography is specified, ultrasonic examination in accordance with [ASME 2235](#) or equivalent procedure in the applicable design code may be used with Owner's Engineer approval. The qualification test required by [ASME 2235](#) (or equivalent) shall be performed "blind" and witnessed by a third party. Owner's Engineer or Owner's designee shall approve the results of the qualification test. Other considerations for the qualification shall include:
- Ultrasonic scan plan shall be submitted and reviewed prior to qualification.
  - Qualification block design: The "qualification block," sometimes referred to as a "mockup," is not equivalent to a "calibration block" (which typically contains flat bottom or side drilled holes). The qualification block shall be designed to include the defect types anticipated by the welding process and consider limitations that may be encountered during UT inspection. Weld bevel, weld process, and weld cap/root geometry shall be representative of field welds, to the extent practical. At least two planar flaws (one OD and one ID) shall be included, representative of weld defects, and be constructed through controlled welding or EDM (electrical discharge machining). Wide machined grooves are not acceptable for these two planar flaws. Weld overlay or cladding on block shall also be consistent with field construction. In addition to the minimum number of qualification defects required by [ASME 2235](#), the inclusion of additional defects should be considered in the event that some operator training is required.
  - Qualification block procurement and testing: It is Contractor's responsibility to ensure that the qualification block is correctly designed and procured.
  - Owner's Engineer or representative (knowledgeable in UT) shall be present for qualification, review of qualification results, and review of final scan plan.
  - [A] Acceptable Performance: Performance shall be based on criteria in [ASME 2235](#) (or equivalent). Assessment of qualification results shall consider both detection and overalls (false positive calls). If initial results from blind qualification are unsatisfactory, retesting may be allowed by Owner's Engineer. Owner's Engineer (or designee) may provide selective technical training and coaching prior to retesting.
  - Qualification block shall be available at fabrication site for performance check or requalification, in event of change to scan plan or equipment.
- 4) [R] Welded joints covered by reinforcing pads shall be 100 percent radiographed prior to installation of the reinforcing pad.

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- 5) [S] If the stress during hydrotest in any Category A seam (per [ASME SEC VIII D1](#)) is not greater than or equal to that seam's stress under

$$\text{Design pressure in the corroded condition} \times \frac{\text{allowable stress at room temperature}}{\text{allowable stress at design temperature}}$$

then the seam shall be subjected to a 100 percent radiographic inspection, or an ultrasonic examination.

- 6) [R] All attachment welds and all areas where fitup bars, etc., were temporarily attached shall be examined by magnetic particle techniques before final PWHT and after hydrostatic testing, for materials having either (a) or (b) below:
- A minimum specified tensile strength of 80000 psi (550 MPa) or greater.
  - A P-number other than P-1, P-4x, or P-8.
- 7) [R] Fillet welds on intermediate heads shall be given a magnetic particle or liquid penetrant examination after hydrostatic testing.
- 8) [R] All reinforcing pad welds shall be tested to at least 15 psig (103 kPa) with dry air or nitrogen (after PWHT, if PWHT is required).
- 9) [R] Vertical vessel support skirts—The finished skirt-to-shell weld shall be examined by the magnetic particle method after any required PWHT.
- 10) [R] Nozzle and communicating chamber butt joints exempt from RT inspection according to Par. UW-11 of [ASME SEC VIII D1](#) shall be visually inspected from the ID. Should this prove impossible or fail to meet the requirements of the Owner's Inspector, these welds shall be RT inspected to the same level as the vessel girth seams.

### 10.3. Materials Testing

- [R] Heat treated plate materials—For all low alloy steels, and carbon steel over 2 in. (50 mm) thickness, specimens for testing shall be prepared from actual vessel material which has been subjected to an equivalent total thermal treatment as the vessel material in the final fabricated condition.
- [\*] When specified, specimens shall be subjected to additional thermal treatment cycles equivalent to those resulting from anticipated shop or field repairs, or field modifications.
- [S] [R] Charpy impact tests are required for deposited weld metal from electroslog, electrogas, and other single pass butt welds through the full thickness of the material. Tests shall be made on weld production impact test plates (run-off tabs). Impact test procedures and values shall meet the requirements in [GP 18-10-01](#).

## 11. Preparation for Shipment

- [R] Cleaning and blanking—Vessels shall be free of loose scale, dirt, and foreign material. Liquid used for testing or cleaning shall be completely drained. Vessel flanged openings shall be blanked with bolted metal, wood, or plastic covers no smaller than the flange OD. Beveled and threaded ends shall be protected with metal or plastic covers or caps. High alloy vessels shall be blown dry with air,

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and all nozzle, manway, vent, and connection openings shall be blanked, plugged, or capped to prevent the entry of moisture and meet the requirements of [GP 18-10-01](#).

- 2) [R] Machined or threaded exterior surfaces of carbon steel, and ferrous alloys with a nominal chemistry of 12Cr and below, shall be protected from corrosion during shipment and subsequent storage by coating with a rust preventive of a type: (1) to provide protection during outdoor storage for a period of twelve months exposed to a normal industrial environment, and (2) to be removable with mineral spirits.

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## Appendix A: Examination and Testing Requirements

**Table A-1: Examination and Testing Requirements**

| Components and Materials \ Examination and Testing Requirements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Chemical Analysis | Tensile, T.S., Y.S., EL., R.A. <sup>(4)</sup> | Charpy Impact <sup>(2)</sup> | Bend Test | Transverse Tensile, T.S. | Radiography <sup>(1)</sup> | Magnetic Particle <sup>(1)</sup> | Brinell Hardness <sup>(6)</sup> | Ultrasonics <sup>(1)</sup> | Liquid Penetrant <sup>(1)</sup> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-----------------------------------------------|------------------------------|-----------|--------------------------|----------------------------|----------------------------------|---------------------------------|----------------------------|---------------------------------|
| I. Base Material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                   |                                               |                              |           |                          |                            |                                  |                                 |                            |                                 |
| A) Plates, shell, and head                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | X                 | X                                             | X                            |           |                          |                            |                                  | X                               |                            |                                 |
| B) Nozzles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | X                 | X                                             | X                            |           |                          |                            |                                  | X                               |                            |                                 |
| C) Internals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | X                 | X                                             |                              |           |                          |                            |                                  | X                               |                            |                                 |
| D) Weld filler metal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | (3)               |                                               |                              |           |                          |                            |                                  |                                 |                            |                                 |
| II. Welding Qualifications <sup>(7)</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | (3)               | (3)                                           | (3)                          |           |                          |                            |                                  | X                               |                            |                                 |
| A) Weld metal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                   |                                               | X                            | X         | X                        |                            |                                  | X                               |                            |                                 |
| B) Weld metal and heat affected zone                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                   |                                               |                              |           |                          |                            |                                  |                                 |                            |                                 |
| III. Shell and Head Seams<br>(Code Category A and B Welds)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                   |                                               | (5)                          |           |                          | X                          | X                                | X                               | X                          | X                               |
| IV. Nozzle Welds                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                   |                                               |                              |           |                          |                            | X                                | X                               | X                          | X                               |
| <b>Notes:</b><br>(1) Extent of requirements for Radiography, Magnetic Particle, Ultrasonics, or Liquid Penetrant Examination shall be as specified in this practice.<br>(2) Impact Testing shall be according to GP 18-10-01.<br>(3) Weld filler metal chemical analysis shall be certified by Weld Filler Metal Supplier. Other weld filler metal testing shall be according to the Standard/Code of Construction.<br>(4) Abbreviations used are:<br>T.S.-Tensile Stress<br>Y.S.-Yield Stress<br>EL.-Elongation<br>R.A.-Reduction of Area<br>(5) Production impact test plates according to Section 10.3, Item 2).<br>(6) Hardness testing shall be according to GP 18-10-01.<br>(7) For weld overlay and back cladding, see Appendix B. |                   |                                               |                              |           |                          |                            |                                  |                                 |                            |                                 |

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## Appendix B: Additional Requirements for Clad Vessels

### B-1. Integral Bonded Cladding

[\*] [R] Cladding thickness shall be not less than 1/8 in. (3.2 mm), unless otherwise specified.

### B-2. Connections and Flanges Attached to Integrally Clad or Weld Overlaid Equipment

- 1) [A] [R] Sleeve lined connections shall not be used unless specifically authorized by the Owner's Engineer. Any request to use sleeve linings shall be accompanied by detailed design information including the provision for differential thermal expansion, a welding procedure (WPS), and a fabrication sequence and inspection plan.
- 2) [R] Connections NPS 2 (50 mm) and smaller shall be one of the following:
  - a) Weld overlaid or integrally bond clad by explosion welding.
  - b) Solid alloys, provided the following conditions are met:
    - i) [A] The mean coefficient of linear thermal expansion of the connection and of the weld metal used for attachment shall fall within  $\pm 20$  percent of the coefficient of the shell or head material at the design temperature. Solid connections, where there is more than a 20 percent difference between the coefficient of expansion of the connection and that of the vessel material, require specific approval by the Owner's Engineer.
    - ii) [A] A description of the materials, welding procedures and installation details shall be submitted to the Purchaser for Owner's Engineer approval.
    - iii) Tests shall be performed using materials representative of the nozzle and vessel materials to demonstrate satisfactory weldability.
    - iv) All ASME P-No. 7 materials (i.e., Type 405 or 410S) shall be postweld heat treated (PWHT).
- 3) [R] Connections over NPS 2 (50 mm) shall be one of the following:
  - a) Weld overlaid.
  - b) Integrally clad by explosion welding.
  - c) Produced from roll-bonded integrally clad plate by forming into a cylinder and welding.
- 4) [R] Flange faces of weld overlaid and integrally clad connections shall be weld overlaid and finish machined in the gasket area, with a minimum  $1/8$  in. (3.2 mm) overlay or cladding thickness after machining.
- 5) [R] Materials used for weld overlay or integral cladding of connections and flanges shall be the same type and thickness as required for cladding the vessel or head to which they are attached.

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## B-3. Inspection and Testing of Integral Bonded Cladding

- 1) [R] Shear strength tests are required on all integrally clad steel plate in accordance with the provisions of the applicable materials specification.
- 2) [R] Prior to fabrication, integrally clad material shall be subject to ultrasonic examination from the clad surface as follows:
  - a) Procedures and records shall be in accordance with ASME SEC II A SA-578/SA-578M Paragraphs 5 and 6 with the following exception: all indications with amplitudes equal to or greater than 50 percent of the initial back reflection and accompanied by a 50 percent loss of back reflection shall be recorded, regardless of plate thickness.
  - b) Acceptance standards shall be ASME SEC II A SA-578/SA-578M, Level A for the backing steel, and Supplementary Level S6 for the cladding bond. For vessels being designed to [GP 05-01-02](#), Level B should be used as well as Supplementary Level S6 for the cladding bond.
  - c) Repair or replacement of the clad product shall be as per agreement between the Vendor and the Owner's Engineer.
- 3) [R] Subsequent to final PWHT, integrally clad vessels and components shall be ultrasonically re-examined in all locations where the tests conducted (per Item (2) above) required recording of indications. Acceptance standards shall be in accordance with ASME SEC II A SA-578/SA-578M, Level A for the backing steel, and Supplementary Level S6 for the cladding bond. Defective areas shall be repaired and re-examined.
- 4) [R] For hydrogen service, integrally clad components shall be ultrasonically examined per Items (2) and (3), above, with the following additional requirements:
  - a) Prior to fabrication, materials shall be scanned along perpendicular grid lines on nominal 6 in. (150 mm) centers and shall cover a path approximately 3 in. (75 mm) wide.
  - b) [\*] When specified, vessels and components shall be scanned along perpendicular grid lines on 12 in. (300 mm) centers after final PWHT.
- 5) [R] Integrally clad surfaces to which minor load bearing attachments are to be welded, and also locations designated for "future attachments," shall be 100 percent ultrasonically examined from the clad side. Clad areas within 4 in. (100 mm) of attachment welds shall be included. Acceptance standards shall be per ASME SEC II A SA-578/SA-578M, Level A for the backing steel and Supplementary Level S7 for the cladding bond.  
 Any indication of lack of bonding between cladding and base metal shall be cause for rejection. Defective areas shall be repaired and re-examined.
- 6) [R] Welding of major load-bearing attachments (maximum tensile stress at the attachment weld is greater than 5 ksi) to the clad side of integrally clad components requires removal of the cladding prior to making the attachment weld(s). Attachment welds shall be weld overlaid to match the composition of the adjacent integral cladding.

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## Record of Change

|                      |               |                                                                                                                                                        |                    |
|----------------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b> |               |                                                                                                                                                        | <b>Date: 07/01</b> |
| <b>Location</b>      | <b>Action</b> | <b>Description</b>                                                                                                                                     |                    |
|                      |               | Initial Publish.                                                                                                                                       |                    |
| <b>Version 1.1.0</b> |               |                                                                                                                                                        | <b>Date: 12/01</b> |
| Section 1.2          | Deletion      | References to non-EMRE data sheets removed.                                                                                                            |                    |
| <b>Version 1.1.0</b> |               |                                                                                                                                                        | <b>Date: 03/03</b> |
| Section 1.1          | Modification  | GP 18-07-01 was removed as a Common reference and marked as Downstream, Chemical, and Pipelines and Terminals Business Sector specific reference only. |                    |
| Section 7.7.4        | Modification  | Section was removed as Common text and marked as Downstream, Chemical, and Pipelines and Terminals Business Sector specific text.                      |                    |
| Section 7.9.2        | Modification  | Item (4) was removed as Common item and marked as Downstream, Chemical, and Pipelines and Terminals Business Sector Specific text.                     |                    |
| <b>Version 2.0.0</b> |               |                                                                                                                                                        | <b>Date: 08/03</b> |
| Section 7.3          | Modification  | Revised WVI scanning criteria.                                                                                                                         |                    |
| Section 7.5          | Modification  | Revised 7.5.1) b) to clarify field test.                                                                                                               |                    |
| Section 9.1          | Addition      | Added new para 2) and renumbered 2)-6) to 3)-7).                                                                                                       |                    |
| Appendix B           | Addition      | New Appendix B added.                                                                                                                                  |                    |
| <b>Version 2.0.0</b> |               |                                                                                                                                                        | <b>Date: 11/03</b> |
|                      |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.     |                    |
| <b>Version 3.0.0</b> |               |                                                                                                                                                        | <b>Date: 04/05</b> |
| Section 1.1          | Modification  | GP references put in numerical order.                                                                                                                  |                    |
| Section 2            | Addition      | Additional references to GP 04-14-01 and BSI BS EN 13445.                                                                                              |                    |
| Section 2            | Deletion      | Deleted reference to GP 19-02-01 (GP was inactivated).                                                                                                 |                    |
| Section 2            | Deletion      | References to AWS and NACE removed.                                                                                                                    |                    |
| Section 4            | Modification  | Reference to GP 18-10-01 for hydrogen service and wet H <sub>2</sub> S service.                                                                        |                    |
| Section 5.2, Item 5) | Addition      | Minor addition.                                                                                                                                        |                    |

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| Section 6                       | Addition      | Minor additions.                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 7.7.3                   | Addition      | Nozzle reinforcement in HF service.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Section 7.8                     | Modification  | Vents.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Section 7.9.1                   | Modification  | Horizontal vessel saddles.                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Section 7.9.2                   | Modification  | Vessel support lugs.                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Section 7.9.3, Item 4e)         | Addition      | Bolted-on tailing frames.                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 9.7                     | Modification  | Cold formed heads.                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Section 10.2, Item 3)           | Addition      | UT qualification blocks.                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Appendix B–2, Item 1)           | Modification  | Thermal expansion.                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Version 3.1.0</b>            |               | <b>Date: 06/07</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Section 6. Item (1)             | Modification  | Wording was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Section 7.7.1, Item (3)         | Modification  | NPS 2 minimum flange size                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 7.7.1, Item (8b)        | Modification  | Split rationale paragraph for clarity                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Section 7.7.2                   | Addition      | Plugs and caps for vent and drain connections                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Section 7.7.5, Item (2)         | Modification  | Link update                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Section 7.8, Item (1)           | Modification  | Rewording of paragraph and rationale statement                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Section 8, Item (2d)            | Addition      | Rigidity Index, J                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Appendix B-3, Item (2b) and (5) | Modification  | Level 1 to Level A                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>All Global Practices</b>     | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> |

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|  |  | <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |
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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| S    | Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.<br><br><div> <div>Personnel Safety:</div> <div>Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</div> </div> <div> <div>Operational Safety:</div> <div>Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</div> </div> |

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# Pressure Testing of Unfired Pressure Vessels

**GP 05-03-01**

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## Scope

- 1) [I] This Global Practice (GP) covers the pressure testing of pressure vessels, including TEMA type, double pipe, and air-cooled heat exchangers.
  - 2) [I] An asterisk (\*) indicates that a decision by the purchaser is required or that additional information is furnished by the purchaser.
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## 1. Required References

[I] This Section lists the Practice and Standards that shall be used with this Practice. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices-ExxonMobil Engineering Practices

|                             |                                       |
|-----------------------------|---------------------------------------|
| <a href="#">GP 18-10-01</a> | Additional Requirements for Materials |
|-----------------------------|---------------------------------------|

### 1.2. ASME-American Society of Mechanical Engineers

|                                  |                                                                                               |
|----------------------------------|-----------------------------------------------------------------------------------------------|
| <a href="#">ASME SEC VIII D1</a> | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 1                   |
| <a href="#">ASME SEC VIII D2</a> | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 2 Alternative Rules |

## 2. Definitions

| Term        | [I] Definition                                                                                                                                                                                                                                                                                    |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>MAWP</b> | Maximum Allowable Working Pressure (MAWP) is the maximum allowable pressure at the design temperature in the corroded condition. MAWP is determined by calculation using the actual thickness less the corrosion allowance in accordance with <a href="#">ASME SEC VIII D1</a> , Paragraph UG-98. |

## 3. Test Procedures

- 1) \* [S] Pneumatic testing with vessels partly or completely filled with air is not permitted unless approved by Owner. When such testing is approved, the test pressure shall meet the minimum requirements specified by ASME ([ASME SEC VIII D1](#) and [ASME SEC VIII D2](#)), and the testing procedure shall be submitted to the Owner's Engineer. The test temperature shall be per [GP 18-10-01](#).
- 2) [R] Vessels with internal non-metallic linings or protective coatings shall be pressure tested before the application of such linings or coatings.
- 3) [R] Vessels shall be pressure tested before external painting of pressure containing welds.
- 4) [R] All vessels with austenitic stainless steel or high alloy materials exposed to test water shall be drained immediately after hydrostatic testing, and dried by blowing with air.

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### 3.1. Pressure Levels

- 1) [R] The hydrostatic test pressure,  $P_T$ , at the top of each section of a vessel shall be no lower than the pressure determined below. A section of a vessel is defined as an area within the vessel where the design pressure or ratio  $t/(t-c)$  varies from that of another area.
- 2) [R] In the hydrostatic test condition, the maximum membrane stress in the vessel in the uncorroded or corroded condition shall not exceed 90 percent of the specified minimum yield strength for ferritic steels, nor 100 percent of the specified minimum yield strength for austenitic steels or non-ferrous materials.
- 3) [R] For vessels designed with ASME ([ASME SEC VIII D1](#)) allowable stresses,  $P_T$  shall be the greater of:

$$P_T = 1.5 \times \text{Design Pressure} \times \frac{S_{rt}}{S_{dt}} \times \frac{t}{t-c}$$

or

$$P_T = 1.3 \times \text{MAWP} \times \frac{S_{rt}}{S_{dt}} \times \frac{t}{t-c}$$

For vessels designed with higher than ASME ([ASME SEC VIII D1](#)) allowable stresses:

$$P_T = 1.25 \times \text{Design Pressure} \times \frac{S_{rt}}{S_{dt}} \times \frac{t}{t-c}$$

Note: For all vessels, the ratio  $S_{rt}/S_{dt}$  shall be the lowest ratio for the vessel, not including bolting. The ratio  $t/(t-c)$  shall not be greater than 1.20 for new uncorroded vessels and 1.0 for fully corroded vessels.

$S_{rt}$  = Allowable design stress at room temperature

$c$  = Corrosion allowance

$S_{dt}$  = Allowable design stress at design temperature

$t$  = Vessel section nominal wall thickness, including corrosion allowance

### 3.2. Duration

[R] The test pressure shall be held for at least one hour per in. (25 mm) of vessel thickness, and in no case for less than one hour. The thickness of either of the heads or the shell, whichever is greatest, shall be used to determine the length of the test period.

### 3.3. Temperature Requirements

[S] When the vessel thickness exceeds  $1/2$  in. (13 mm), the metal temperature of the vessel at time of hydrostatic test shall be as follows:

- 1) For vessel thickness 2 in. (50 mm) or less, the temperature shall be at least 10°F (6°C) above the temperature at which the impact requirements given in [GP 18-10-01](#) are met by the material.
- 2) For vessel thickness greater than 2 in. (50 mm), the temperature shall be at least 30°F (17°C) above the temperature at which impact requirements given in [GP 18-10-01](#) are met by the material.

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|--------------------|-----------------------------------------------------|-------------------|

- 3) When the required vessel temperature during hydrostatic test is greater than 70°F (21°C), this temperature shall be marked on the vessel nameplate.

|                    |                                        |                      |
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## Record of Change

|                               |               |                                                                                                                                                    |                    |
|-------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b>          |               |                                                                                                                                                    | <b>Date: 07/01</b> |
| <b>Location</b>               | <b>Action</b> | <b>Description</b>                                                                                                                                 |                    |
|                               |               | Initial Publish.                                                                                                                                   |                    |
| <b>Version 1.1.0</b>          |               |                                                                                                                                                    | <b>Date: 02/02</b> |
| Section 3.1                   | Addition      | Added Purpose Code [R] to item 3).                                                                                                                 |                    |
| <b>Version 1.1.0</b>          |               |                                                                                                                                                    | <b>Date: 09/03</b> |
|                               |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |                    |
| <b>Version 1.2.0</b>          |               |                                                                                                                                                    | <b>Date: 03/05</b> |
| Section 3.1,<br>Item (3) Note | Modification  | Stress ratio not to include bolting; thickness ratio for corroded and uncorroded vessel specified.                                                 |                    |

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## Attachment: Purpose Codes Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C    | Assigned to paragraphs containing specifications whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include Life-Cycle cost considerations. Life-Cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                     |
| E    | Assigned to paragraphs containing specifications whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                      |
| I    | Assigned to paragraphs that provide only clarifying information such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| M    | Assigned to paragraphs containing specifications whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during on-stream operations.                                                                                                                                                                                                                                                                                                                                                                             |
| O    | Assigned to paragraphs containing specifications whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during startups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs containing specifications whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                      |
| S    | <p>Assigned to paragraphs containing specifications whose primary purpose is avoidance of personnel or operational safety incidents. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to the avoidance of recordable personnel injuries; i.e., burns, cuts, abrasions, inhalation, or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, explosions, etc.</p> |

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# Temperature Instruments

## GP 15-02-01

### Scope

- 1) **[I]** This Global Practice (GP) covers the design and selection of temperature instruments and sensors.
- 2) **[I]** Additional temperature measurement requirements for specific process and equipment items, such as rotating equipment, fired heaters, motors, and storage tanks, may also be covered by the equipment-specific Practices.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------|
| Refining/Chemicals, Downstream<br>Imperial Oil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | For Company Use Only            | Version 2.1.0 |
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## 1. Required References

This Section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                  |
|-----------------------------|----------------------------------|
| <a href="#">GP 18-12-01</a> | Positive Material Identification |
|-----------------------------|----------------------------------|

### 1.2. API–American Petroleum Institute

|                            |                                     |
|----------------------------|-------------------------------------|
| <a href="#">API RP 551</a> | Process Measurement Instrumentation |
|----------------------------|-------------------------------------|

### 1.3. ASME–American Society of Mechanical Engineers

|                               |                                                                                    |
|-------------------------------|------------------------------------------------------------------------------------|
| <a href="#">ASME B1.20.1</a>  | Pipe Threads, General Purpose (Inch)                                               |
| <a href="#">ASME B16.5</a>    | Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard      |
| <a href="#">ASME B31.3</a>    | Process Piping                                                                     |
| <a href="#">ASME B31.8</a>    | Gas Transmission and Distribution Piping Systems                                   |
| <a href="#">ASME PTC 19.3</a> | Part 3: Temperature Measurement Instruments and Apparatus (Performance Test Codes) |

### 1.4. ASTM–American Society for Testing and Materials

|                                   |                                                                                                                    |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM A 249/A 249M</a> | Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes        |
| <a href="#">ASTM A 268/A 268M</a> | Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service |
| <a href="#">ASTM A 276</a>        | Standard Specification for Stainless Steel Bars and Shapes                                                         |
| <a href="#">ASTM A 479/A 479M</a> | Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels           |

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## 2. Additional Requirements

[\*] This Section lists the additional Practices, codes, standards, specifications, and publications that shall be used with this document only where specified. Unless otherwise specified herein, use the latest edition.

### 2.1. Global Practices–ExxonMobil Engineering Practices

|                             |                    |
|-----------------------------|--------------------|
| <a href="#">GP 15-07-02</a> | Protective Systems |
|-----------------------------|--------------------|

### 2.2. API–American Petroleum Institute

|                            |                                                                                  |
|----------------------------|----------------------------------------------------------------------------------|
| <a href="#">API MPMS 7</a> | Manual of Petroleum Measurement Standards - Chapter 7: Temperature Determination |
|----------------------------|----------------------------------------------------------------------------------|

### 2.3. ASTM–American Society for Testing and Materials

|                                     |                                                                                                                               |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM E 230</a>          | Standard Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples                        |
| <a href="#">ASTM E 235</a>          | Standard Specification for Thermocouples, Sheathed, Type K and Type N, for Nuclear or for Other High-Reliability Applications |
| <a href="#">ASTM E 1137/E 1137M</a> | Standard Specification for Industrial Platinum Resistance Thermometers                                                        |

### 2.4. IEC–International Electrotechnical Commission

|                           |                                                        |
|---------------------------|--------------------------------------------------------|
| <a href="#">IEC 60529</a> | Degrees of Protection Provided by Enclosures (IP Code) |
| <a href="#">IEC 60751</a> | Industrial Platinum Resistance Thermometer Sensors     |

### 2.5. NEMA–National Electrical Manufacturers Association

|                          |                                                          |
|--------------------------|----------------------------------------------------------|
| <a href="#">NEMA 250</a> | Enclosures for Electrical Equipment (1000 Volts Maximum) |
|--------------------------|----------------------------------------------------------|

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### 3. Basic Design

- 1) [S] [M] Thermowells are required for all temperature measuring devices used in flammable, toxic, or otherwise hazardous pressurized or vacuum systems. Thermowells are not required for temperature measurement of equipment, such as reactor shell skin, machinery bearings, or motor windings, where there is no risk to personnel from the process fluid during removal of the measuring element, or where radial thermocouples are used. Where a thermowell is not used, a permanent label shall be affixed to the primary element, indicating that there is no thermowell.
- 2) [O] Tip-sensitive elements shall be provided with a mechanical means of ensuring a solid thermal connection with the thermowell tip (spring loaded, compression fitting, etc.).
- 3) [A] [C] [O] For general temperature measurement and control, thermocouples shall be the preferred choice for the primary sensing elements. Alternatively, resistance temperature devices (RTDs) may be used, subject to approval by the Owner's Engineer. The choice would be based on temperature range span and/or accuracy.
- 4) [O] [R] Where specified by the Owner's Engineer, critical temperature control loops that use a thermocouple for the sensing element may be furnished with a second thermocouple as a check sensor. A comparison of measured values can be used as a diagnostic tool to determine possible drift and/or abnormal operations (e.g., start-up, shutdowns, etc.).
- 5) Use of a dual thermocouple in a single thermowell is the preferred method of supplying the check measurement. However, where issues such as intrinsic safety exist, the check thermocouple shall be installed in a separate thermowell within 18 in. (0.46 m) of the control thermocouple. Current applied technology (sheathing and transmitters) essentially eliminates the need for separate thermowells.
- 6) [O] [R] Temperature control loops and other critical loops (Safety Instrument Systems [SIS], etc.) shall use a field-mounted transmitter.
- 7) [R] A single thermocouple shall not be connected to more than one device. A single thermocouple signal needed at more than one receiver device shall first be converted to a standard current or voltage signal.
- 8) [A] [M] [R] The use of filled-system or bi-metallic temperature switches requires approval by the Owner's Engineer. Temperature switches shall be snap-acting type. Other temperature measuring elements may be used subject to approval by the Owner's Engineer.
- 9) [A] [O] [R] Thermocouple/thermowell installations, especially where the measured temperature is higher than 212°F (100°C), shall be designed to reduce the probability for water (condensation or rain) accumulation in the tip of the thermowell. Considerations shall include keeping the tip of the thermowell at or above the horizontal and providing a drain path for condensed water. Designs require approval by the Owner's Engineer.

### 4. Thermocouples

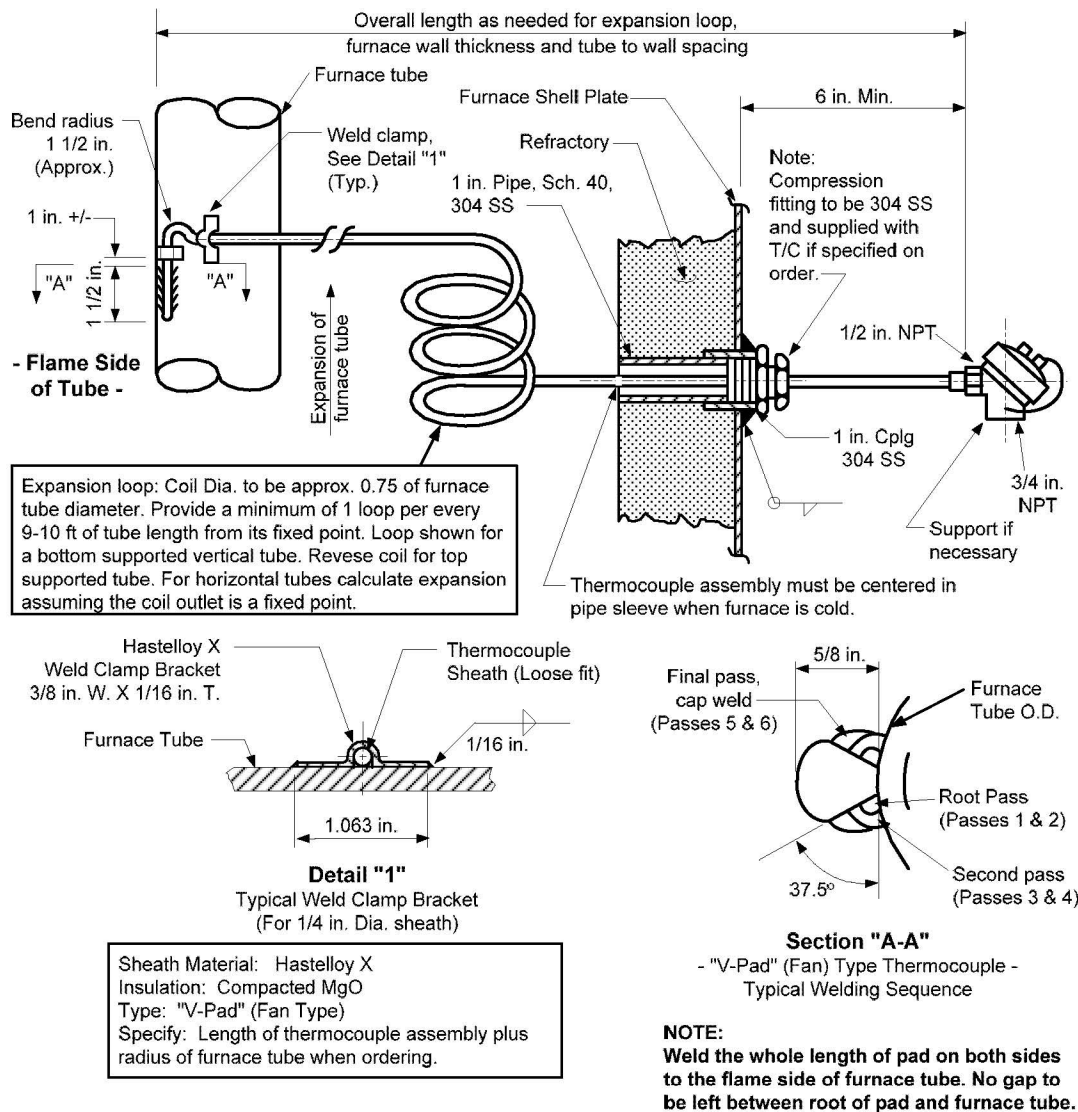
- 1) [R] Thermocouples for general service shall be mineral-insulated, metal-sheathed with the following construction:

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- a) Minimum wire size shall be 20 AWG (0.5 mm<sup>2</sup>).
  - b) [\*] Choice of grounded or ungrounded thermocouple hot junction shall be specified by the Owner's Engineer.
  - c) Sheath shall be 1/4 in. (6 mm) OD, Type 316 stainless steel.
- 2) [M] Thermocouple head (or conduit fitting) shall be as follows:
- a) Enclosure shall be weatherproof to NEMA Type 4 or IP 65 construction and shall meet the electrical area classification.
  - b) Body and cover material shall be cast iron or aluminum.
  - c) Cover shall be threaded and gasketed, with retaining chain attached to body.
  - d) [A] Flexible connection from thermocouple head to fixed wiring system shall be liquid-tight, PVC-jacketed steel conduit or armored flexible cable. These are as shown in Figure 31 "Thermocouple-to-Conduit Connections," of [API RP 551](#), Section 5. Other types of construction may be used, subject to approval.
- 3) [A] [O] [R] For the temperature range 0°F to +2000°F (−20°C to +1090°C), the preferred thermocouple material is chromel-alumel (Type K, per [API RP 551](#)), unless other types of material (such as Type J) are required to connect to existing equipment. Thermocouple extension wire connected to Type K thermocouples shall be Type KX. Use of any other type of thermocouple or extension wire material requires approval by the Owner's Engineer.
- 4) [A] [O] For the temperature range −300°F to +200°F (−195°C to +95°C), the preferred thermocouple material is copper-constantan (Type T). Thermocouple extension wire connected to Type T thermocouples shall be Type TX. Use of Type T thermocouples requires approval by the Owner's Engineer.
- 5) [A] [I] [R] Tube metal thermocouples (TMT) for fired heaters and boilers shall be "V-Pad" fan type, grounded thermocouples in accordance with key elements of Figure 1. Key elements of material selection, installation, and dimensions are shown as "typical" and reflect a historical successful installation. Alternate Vendor recommendations may be considered with the Owner's Engineer approval. The following requirements shall apply to any installation:
- a) Thermocouple material shall be Type K.
  - b) Tube metal thermocouple sheath material shall be Hastelloy X as indicated in Table 1.
  - c) A retaining clip and expansion loop shall be provided to allow for movement of tubes and walls when hot without putting strain on the thermocouple hot junction weld.
  - d) Material selection and installation and/or welding procedures shall be in accordance with Figure 1 and Vendor requirements and must be proven suitable for the environment.
  - e) Sheath material and minimum bend radius shall be selected to avoid stress failure due to movement, sheath diameter, bending stress, temperature, and composition of the combustion products (e.g., heavy metals and sulfur content in fuel oil).
  - f) TMT installation/welding procedures shall be in accordance with Figure 1. These procedures take precedence over any specific Vendor requirements.
  - g) Terminal heads shall project at least 6 in. (150 mm) from heater or boiler furnace walls.
- 6) [A] The design and installation of tube metal thermocouples or the proposed use of any alternative design shall require approval by the Owner's Engineer.

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**Figure 1: Typical Tube Metal Thermocouple Detail****Installation/Welding Instructions:**

- 1) Grind surface of furnace tube in areas of thermocouple pad and clip attachments to remove rust, scale, or other contaminants. Ground area at thermocouple pad location should be approximately 75 mm long by 50 mm wide. Ground area at clip location should be sufficient to ensure attachment welding on a clean surface.
- 2) Locate and clamp thermocouple pad firmly in desired location, centering pad in ground area.
- 3) Select welding filler material from Table 1.
- 4) Deposit root and fill passes using small diameter electrodes, stringer bead technique, and welding sequence shown in Section A-A. Heat input to the Hastelloy X material should be minimized.
- 5) All welds must extend for the full length of the thermocouple pad. Note that, regardless of the number of beads utilized, the final weld bead should be located a maximum of 3 mm from, but not touching, tube surface in order to impart the maximum tempering effect.
- 6) Locate retaining clip in desired position and weld to furnace tube using filler material cited in Table 1.
- 7) [A] Instructions above are typical. Any specific Vendor details or requirements shall be followed, subject to approval by the Owner's Engineer.
- 8) Welders performing work on these thermocouple assemblies shall be fully qualified per ASME SEC IX or equivalent.
- 9) A dye penetrant examination of each completed thermocouple and furnace tube assembly shall be required.

**Table 1: TMT Sheath Materials and Welding Processes**

| Furnace Tube Material                                                                                                              | Filler Material <sup>(1)</sup> | AWS/ASME Filler Material Spec | Welding Process | Preheat (min)             | Interpass Temp. (max) <sup>(2)</sup> | PWHT          | Sheath Material |
|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------|-----------------|---------------------------|--------------------------------------|---------------|-----------------|
| Carbon Steel                                                                                                                       | Inconel 82                     | ERNi Cr-3                     | GTAW            | 300°F–400°F (150°C–205°C) | —                                    | None Required | Hastelloy X     |
| HK-40 Incoloy                                                                                                                      | Inconel 82                     | ERNi Cr-3                     | GTAW            | 50°F (10°C)               | 350°F (175°C)                        | None Required | Hastelloy X     |
| C- <sup>1</sup> / <sub>2</sub> Mo                                                                                                  | Inconel 82                     | ERNi Cr-3                     | GTAW            | 300°F–400°F (150°C–205°C) | 400°F (205°C)                        | None Required | Hastelloy X     |
| 1 <sup>1</sup> / <sub>4</sub> Cr- <sup>1</sup> / <sub>2</sub> Mo                                                                   | Inconel 82                     | ERNi Cr-3                     | GTAW            | 400°F–500°F (205°C–260°C) | 500°F (260°C)                        | None Required | Hastelloy X     |
| 2 <sup>1</sup> / <sub>4</sub> Cr-1 Mo<br>5 Cr- <sup>1</sup> / <sub>2</sub> Mo<br>7 Cr- <sup>1</sup> / <sub>2</sub> Mo<br>9 Cr-1 Mo | Inconel 82                     | ERNi Cr-3                     | GTAW            | 400°F–500°F (205°C–260°C) | 400°F–500°F (205°C–260°C)            | None Required | Hastelloy X     |

Notes:

(1) [A] Filler material shall be as specified, provided that operating temperatures do not exceed 1100°F (595°C) and that high sulfur content is not present in the environment. **Positive Material Identification (PMI) or lot control of filler material is required.** Use of other filler materials must be approved by the Owner's Engineer.

(2) Interpass temperatures shall be controlled no lower than 200°F (95°C) to the maximum shown in the table except that 2<sup>1</sup>/<sub>4</sub> Cr through 9 Cr shall be maintained no lower than 100°F (40°C) of the maximum interpass temperature. Heat input to the Hastelloy X material shall be minimized.

- 7) [S] [A] Design of multi-point thermocouple assemblies shall require approval by the Owner's Engineer. Design features to be considered include the following:
- a) A secondary seal to ensure (1) safe containment of the process if the primary well fails and (2) a means to test for primary well failure where online thermocouple replacement is required.
  - b) A mechanism to prevent pressurizing the junction box assembly by the possible loss of secondary seal.
- 8) [O] For furnace bridgwall temperature measurement, thermocouple installations shall include shielding from flame radiation.

## 5. Resistance Temperature Devices

[A] [C] When approved, RTDs shall be the industrial 100-ohm platinum, three- or four-wire type and shall conform to [ASTM E 1137/E 1137M](#) or [IEC 60751](#). The Owner's Engineer shall specify accuracy requirements. Use of any other type of RTD (such as copper type on existing tank gauging systems) shall require approval by the Owner's Engineer.

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## 6. Other Temperature Measuring Elements

[C] When approved, filled-system type primary elements shall meet the following requirements:

- 1) [A] Maximum bulb temperature shall not exceed 600°F (315°C) unless approved by the Owner's Engineer.
- 2) The filled-system thermal element bulb and capillary tube shall be all-welded stainless steel. The capillary shall be protected from mechanical damage by stainless steel spiral-wound armor and supports. The maximum distance between supports shall be 18 in. (45 cm).
- 3) Capillary length shall not exceed 10 ft (3 m).
- 4) A minimum of 50 percent over-range protection shall be provided for all filled-system devices.
- 5) Compensation for variations in ambient temperature and barometric pressure shall be provided.
- 6) Filled-system temperature elements installed in thermowells shall be specified and supplied as complete assemblies.

## 7. Transmitters

- 1) [O] Transmitters shall have the narrowest available span that covers the anticipated temperatures during start-up, normal operations, and process upset conditions. Where possible, the range shall be selected so that normal temperature will be in the middle third of the range.
- 2) [S] Transmitters shall have a selectable upscale or downscale burnout (open circuit) feature without transient spikes on burnout.
- 3) [\*] For protective systems, sensing element open circuit protection shall be in accordance with [GP 15-07-02](#). For nonprotective control functions, sensing element open circuit protection shall operate to drive the controller output to the final control element failure position. The Owner's Engineer shall specify the direction of open circuit detection in all other applications.

## 8. Temperature-Indicating Gauges

[O] Local temperature-indicating gauges shall be adjustable-angle, bi-metallic or filled-system thermometers with rigid stems.

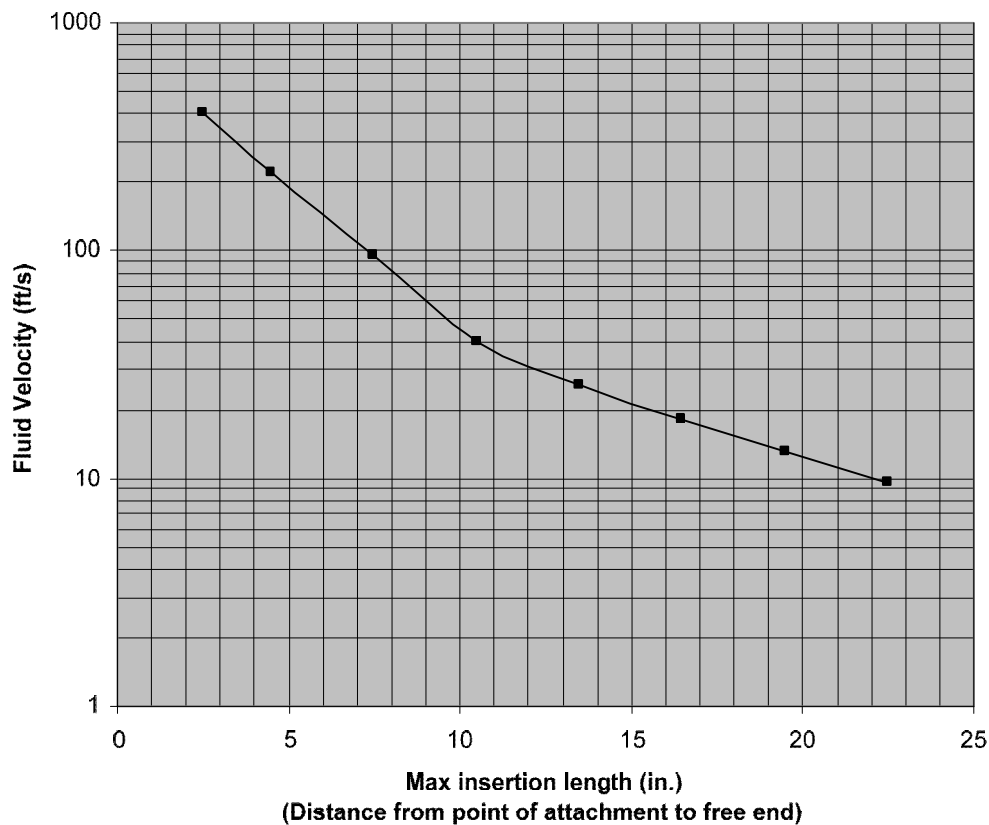
- 1) Minimum dial size shall be 4 in. (10 cm).
- 2) Minimum stem length shall be 9 in. (22 cm).
- 3) [\*] Weatherproof cases shall be used unless otherwise specified.
- 4) Dial thermometers installed in thermowells shall be specified and supplied as complete assemblies.
- 5) If necessary for readability or in vibrating services, a dial thermometer with capillary shall be used. Vapor-filled capillary systems shall not be used.

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## 9. Thermowells

- 1) [C] [O] For pipe-mounted thermowells, immersion length (measured from inside wall of pipe) shall be selected such that the tip is located around one-third of the pipe diameter and does not exceed 10 in. (25 cm) unless the maximum velocity rating of the thermowell requires a shorter length. Vendor standard lengths shall be used to the maximum extent possible.
- 2) [S] [R] The fluid velocity used in calculations per [ASME PTC 19.3](#), or used to select insertion lengths based on Figure 2, shall be the maximum velocity possible based on upstream and downstream equipment and piping configurations. Consideration shall account for possible increases in velocity due to increased throughput and abnormal operations. Thermowell insertion length is the distance between the free end of the well up to, but not including, the external threads or means of attachment to the flange or pipe.

**Figure 2: Maximum Thermowell Insertion Lengths  
as a Function of Fluid Velocity**



**NOTES:**

- 1) To reduce the complexity of presenting this information, the ratings are given based upon thermowells constructed to this GP and operating temperatures of 1000°F (540°C). Slightly higher velocity is possible at lower temperatures.
- 2) The values given represent safe values for water, steam, air, or gas.
- 3) Maximum velocity ratings of thermowells operating at conditions other than 1000°F (540°C) or of thermowells made of materials other than Type 304 or Type 316 stainless steel shall be determined from ASME PTC 19.3.

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- 3) **[O]** A trade-off exists between the length of well for strength and exposure to measurement inaccuracy. Static error can be generated due to conduction to the portion of the well exposed to ambient cooling. Dynamic error can be generated due to the mass of the well between the fluid and the sensing element. Both of these issues are influenced by well length and fluid velocity. Refer to [ASME PTC 19.3](#) for a detailed means of calculating errors and methods of minimizing the effects.
- 4) **[A] [R]** Where flanged thermowells may be subject to damage due to high vibration and the thermowell cannot be relocated (or shortened because of resultant temperature inaccuracies), a velocity collar may be used with approval by the Owner's Engineer. Where used, these velocity collars shall be installed in a machined stand-off where the annular space between the ID of the stand-off and the OD of the thermowell collar is better than 1 mm.
- 5) Thermowell connections for general service applications shall be per the following:
  - a) Flanged connections shall be used in services where any of the following conditions apply:
    - i) The normal operating temperature is equal to or greater than 400°F (205°C).
    - ii) The pressure-to-temperature design conditions require an ASME Class 900 (or greater) flange.
    - iii) Removal of the thermowell for maintenance is expected.
  - b) Threaded connections may be used where flanged connections are not required.
- 6) **[R]** Thermowells for general service shall have the following construction:
  - a) **[A]** Threaded thermowells shall be machined from solid bar stock with a process connection of NPT 1 in. (25 mm) external taper-threaded. Welded thermowell construction for atmospheric storage tanks is acceptable with approval by the Owner's Engineer.
  - b) Connection size for the thermocouple entry shall be NPT 1/2 in. (12.5 mm).
  - c) **[\*]** For flanged connections, the minimum flange size shall be NPS 2 in. (50 mm) [ASME B16.5](#). Flange rating, face, and finish shall be specified. Flanged thermowells may be machined from solid bar stock or, alternatively, may be fabricated from a thermowell and flange similar to panel B, Figure 26, "Thermowell Installation," of [API RP 551](#). The weld must be a full penetration weld as shown.
  - d) Thermowell dimensions shall be as follows:
    - i) **[\*]** Length—insertion length and extension length will be specified.
    - ii) OD—straight taper from 1 1/16 in. (27 mm) OD at the base of thread (or point of flange attachment) to a minimum of 5/8 in. (16 mm) at the tip.
    - iii) Bore—0.26 in. (6.6 mm).
    - iv) Tip Thickness—1/4 in. (6 mm) minimum.
- 7) **[R]** Thermowells in erosive service shall have heavier wall and tip thickness. Thermowells shall taper from 1 1/16 in. OD (27 mm) at base of the thread to 7/8 in. (22.2 mm) at the tip. Tip thickness shall be 5/8 in. (16 mm).
- 8) **[R] [I]** Thermowells in coking and/or erosive service shall be installed from the top of pipe whenever possible.
- 9) **[R]** Test thermowells shall meet all the requirements of thermowells in continuous service and shall be provided with a drilled captive brass plug.
- 10) The thermowell material identification shall be clearly stamped on the body or flange.

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- 11) [R] All alloy thermowells require 100 percent PMI verification per [GP 18-12-01](#).
- 12) [\*] Typical material of construction for thermowells will be 304 or 316 stainless steel. However, the materials of construction shall have corrosion resistance and temperature rating equal to or better than the process piping line classification or vessel materials. Potential stress cracking of stainless steel should also be considered.
- 13) [A] [R] With approval by the Owner's Engineer, two-piece thermowell construction or pipe wells with spun and welded end may be used for gas phase measurement where long insertions are necessary (in firebox and flue gas areas in heaters, boilers, furnaces, stacks, and large vessels).
- 14) [S] Thermowells installed in a threaded connection shall be seal welded to prevent removal of the thermowell.

## 10. Inspection and Testing

- 1) [S] All thermowells shall have ratings clearly above the design pressure of the associated piping, normally no less than 3000 psi (20700 kPa) rated. All thermowells shall be specified on the data sheets as certified pressure tested to confirm their rating by Manufacturer/Vendor.
- 2) [S] Flanged thermowells shall also be certified pressure tested externally, based on the flange rating, under requirements of [ASME B31.3](#) or [ASME B31.8](#) as applicable. Alternatively, if external testing is not readily available, the thermowell may be installed prior to pressure testing of the associated piping and thereby tested with the piping to meet ASME standards.

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## Record of Change

| Version 1.0.0               |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Date: 03/02 |
|-----------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Location                    | Action        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |
|                             |               | Initial Publish.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |             |
| Version 1.0.0               |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Date: 01/04 |
|                             |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |
| Version 2.0.0               |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Date: 07/08 |
| Section 1                   | Deletion      | GP references were deleted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |
| Section 2                   | Deletion      | GP references, except GP 15-07-02, were deleted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |             |
| Section 9<br>Item (1)       | Modification  | Modified requirement from middle third to around first third.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |             |
| Section 9<br>Item (2)       | Modification  | Modified requirement for insertion length requirement to address actual equipment conditions verses design conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |
| Section 9<br>Item (6)       | Addition      | Added requirement for top installation of thermowell for erosive service.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |             |
| Section 9<br>Items (6)–(10) | Modification  | Renumbered Sections 9.6 through 9.9 to 9.7 to 9.10 after addition of new Item (6).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |
| Figure 2                    | Modification  | Figure was corrected with the addition of the 30 ft/s line in the graph.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |
| <b>All Global Practices</b> | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |             |

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| Version 2.1.0                      |              | Date: 10/08                                                                                                                                                                                            |
|------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| General                            |              | From this version onward, revision bars in the right margin will be used to identify technical changes from the last version of the GP.                                                                |
| Section 1.1                        | Addition     | Added reference GP 18-12-02.                                                                                                                                                                           |
| Section 1.3                        | Addition     | Added references ASME B31.3 and ASME B31.8.                                                                                                                                                            |
| Section 3, Items (3), (4), and (5) | Modification | Added wording to clarify intent.                                                                                                                                                                       |
| Section 4, Item (5)                | Modification | Added wording to clarify the use of Figure 1.                                                                                                                                                          |
| Figure 1                           | Modification | Changed Figure 1 and associated installation and welding instructions to reflect best practice installations for TMTs.                                                                                 |
| Table 1                            | Modification | Changed Table 1 and associated notes to reflect best practice installations for TMTs.                                                                                                                  |
| Section 9, Item (2)                | Modification | Modified wording to conform to Figure 2 "velocity vs. insertion length"; also modified rationale wording for clarity.                                                                                  |
| Figure 2                           | Modification | Corrected figure and updated notes.                                                                                                                                                                    |
| Section 9, Item (3)                | Modification | Added wording on required consideration for accuracy versus strength.                                                                                                                                  |
| Section 9, Item (4)                | Addition     | Added restricted use of velocity collars for special circumstances.                                                                                                                                    |
| Section 9, Item (8)                | Modification | Added coking service to erosive service statement.                                                                                                                                                     |
| Section 9, Item (11)               | Addition     | Added requirements for PMI with reference to GP 18-12-01.                                                                                                                                              |
| Section 9, Item (12)               | Modification | Changed wording to include "corrosion resistance and temperature rating equal to or better than the process piping line" and "potential stress cracking of stainless steel should also be considered." |
| Section 9, Item (13)               | Addition     | Added rationale.                                                                                                                                                                                       |
| Section 9, Item (14)               | Addition     | Added seal welding for threaded thermowells.                                                                                                                                                           |
| Section 10, Item (1)               | Modification | Modified pressure rating to 3000 psi.                                                                                                                                                                  |
| Section 10, Item (2)               | Modification | Modified flange testing to conform to ASME B31.3 and B31.8.                                                                                                                                            |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| S    | Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.<br><br><div> <div>Personnel Safety:</div> <div>Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</div> </div> <div> <div>Operational Safety:</div> <div>Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</div> </div> |

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# Pressure Instruments

## GP 15-03-01

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### Scope

[I] This Global Practice (GP) covers the design and selection of pressure instruments.

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------|
| Refining/Chemicals, Upstream,<br>Downstream Imperial Oil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | For Company Use Only            | Version 1.1.0 |
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## 1. Required References

[I] This Section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                      |
|-----------------------------|--------------------------------------|
| <a href="#">GP 03-06-01</a> | Piping for Instruments               |
| <a href="#">GP 15-06-01</a> | Electronic and Pneumatic Instruments |

### 1.2. API–American Petroleum Institute

|                            |                                     |
|----------------------------|-------------------------------------|
| <a href="#">API RP 551</a> | Process Measurement Instrumentation |
|----------------------------|-------------------------------------|

### 1.3. ASME–American Society of Mechanical Engineers

|                              |                                       |
|------------------------------|---------------------------------------|
| <a href="#">ASME B1.20.1</a> | Pipe Threads, General Purpose (Inch)  |
| <a href="#">ASME B40.100</a> | Pressure Gauges and Gauge Attachments |

## 2. Design

- 1) [O] Pressure range shall be such that normal pressure will be in the middle third of the span.
- 2) [S] [R] Instruments shall have over-range protection to the maximum pressure to which they may be exposed. Instruments exposed to vacuum shall have under-range protection to full vacuum.
- 3) [S] Instruments in flammable or toxic service shall not have pressure-containing parts of low melting point materials, such as aluminum or brass.
- 4) [A] [R] All wetted and pressure-containing parts shall meet the material requirements of the process piping to which the instrument is connected. External diaphragm seals may be used with approval by the Owner's Engineer. In process streams containing hydrogen, the use of gold-plated diaphragms shall be considered.
- 5) [O] Scales and displays (local or remote) shall read in engineering units.
- 6) [A] Transmitter design and performance shall meet the requirements of [GP 15-06-01](#) unless otherwise specified by the Owner's Engineer.

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### 3. Indicating Pressure Gauges

- 1) [A] [R] Indicating pressure gauges shall be liquid-filled, and in accordance with [ASME B40.100](#) and this GP. Where other standards are recognized by local jurisdictions, alternate standards may be used (e.g. EN837-1, JIS B 7505, etc.). Vendor and/or Contractor shall submit a list of specific deviations from [ASME B40.100](#) to the Owner's Engineer for approval.
- 2) [O] Accuracy shall be Grade 2A. Liquid-filled gauges shall have a small vapor space for thermal expansion of the liquid fill. Vapor space shall be adequate to allow gauge to satisfactorily operate without leakage under the full range of ambient and process conditions specified.
- 3) [S] [E] [R] Gauges shall be capable of passing the vibration test (A2.5) and the fatigue test (A2.8) specified in [ASME B40.100](#), Nonmandatory Appendix A, "Some Definitions and Suggested Test Procedures Used to Measure New Gauge Performance." A statistically meaningful percentage of all gauges sold shall be sampled to give a confidence factor of at least 90 percent.
- 4) [I] The minimum dial size shall be 4 in. (100 mm).
- 5) [A] Process connection shall be  $\frac{1}{2}$  in. NPT unless otherwise approved by Owner's Engineer.
- 6) [A] [I] Pressure gauge measuring elements shall be the C-type seamless Bourdon tube-type. Proposals to use an alternate type shall be reviewed by Owner's Engineer.
- 7) [\*] [R] The measuring element shall be hardened Type 316 stainless steel, unless process fluid requires the use of other materials. A Monel element is typically required in sea water service.
- 8) [R] [O] The measuring element shall withstand over-ranging to a pressure 1.3 times the maximum scale reading without a permanent set that affects gauge calibration.
- 9) [I] The pressure range of the Bourdon tube and the tube material shall be stamped on the socket.
- 10) [S] [A] The case shall be solid-front, weather-proof, and furnished with a blow-out back or blow-out disk. All cases shall be made of low-copper aluminum (0.6 percent copper maximum), stainless steel, or phenolic. Other case materials require approval by Owner's Engineer.
- 11) [S] [O] A visible stop pin shall be used to restrict the upper limit of the pointer travel. The stop pin shall be located at the 6 o'clock position on the gauge front.
- 12) [S] Gauge window shall be double-strength shatter-resistant safety glass. The window shall be gasketed on the bezel side by means of a resilient gasket and held in place from the case side by means of a threaded retaining ring.
- 13) [S] [A] [O] Fill fluids used in liquid-filled gauges shall be selected carefully, and account for both process and ambient temperature limits. Glycerine or silicone fill fluids shall not be used in applications involving strong oxidizing agents, such as chlorine, nitric acid, or hydrogen peroxide, because of spontaneous chemical reaction, ignition, or explosion. Instead, Fluorolube shall be specified in these cases. Fill fluid shall be reviewed and approved by Owner's Engineer.
- 14) [I] Direct-connected draft measurements shall be slack diaphragm type. Where instruments are remotely mounted, draft measurements shall be made using a pressure transmitter and local receiver gauge.

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## 4. Pneumatic Air Receiver Indicating Gauges

- 1) [S] [O] A stop pin is required on all pneumatic receiver gauges at zero pressure indication.
- 2) [S] Receiver gauges are gauges designed to measure pneumatic signals (e.g., 3 to 15 PSI) and present the pressure in engineering units. This presents a unique hazard when they are directly connected to the process. Receiver gauges must be uniquely and distinctly identified (e.g., unique color, ¼ in. NPT connection, tagged or placarded, or similar method).

## 5. Pressure Switches

- 1) [R] Electrical switch shall have contact rating of 115 VAC, 2 amperes minimum. Any switch that initiates an inductive device, such as a trip coil of a motor starter, shall have a minimum inductance contact rating suitable for that service.
- 2) [S] [R] Switch contacts shall be hermetically sealed.
- 3) [O] Pressure switches shall have an adjustable set point or differential gap with a reference or calibrated scale. Where explosionproof, flameproof or weatherproof housings are used, an internal scale is acceptable; however, an external scale with protective covering is preferred for general-purpose housings.
- 4) [R] For direct process-connected switches, electrical entry and electrical connections shall be completely isolated from process connections and components in contact with the process.
- 5) [R] Where tamper-proof switches are required, they shall have internally adjustable set points or locking devices on the external set point adjustment.

## 6. Process Connections

Instruments shall be mounted and connected to the process in accordance with [GP 03-06-01](#).

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## Record of Change

|                             |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                    |
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| <b>Version 1.0.0</b>        |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Date: 01/02</b> |
| <b>Location</b>             | <b>Action</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                    |
|                             |               | Initial Publish.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |
| <b>Version 1.0.0</b>        |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Date: 07/03</b> |
|                             |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                    |
| <b>Version 1.1.0</b>        |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Date: 10/08</b> |
| Section 1.3                 | Revised       | Updated Referenced ASME B40.1 to current version.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |
| Section 2                   | Modified      | Item (3): Added to Rationale, "...fail during fire that could lead to loss of containment."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |
| Section 3                   | Modified      | Item (1): Modified wording to allow consideration of local jurisdiction standards.<br>Item (3): Added Rationale.<br>Item (5): Added preferred connection size.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                    |
| Section 4                   | Add           | Item (2): Added special precaution regarding 'receiver gauges.'                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                    |
| Section 6                   | Add           | Referenced GP 03-06-01 as requirement for process connections.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                    |
| <b>All Global Practices</b> | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |                    |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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# Welding Procedures

## GP 18-07-01

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### Scope

- 1) [R] This ExxonMobil Global Practice (GP) governs welding and welding qualifications.
  - 2) [I] API RP 582, 1st Edition, March 2001, titled "Welding Guidelines for the Chemical, Oil, and Gas Industries," as amended by this GP, defines the minimum requirements and practices for welding and welding qualification. Unless otherwise noted, all the API paragraphs shall be considered mandatory.
  - 3) [I] Only the paragraphs that are amended are listed in this GP. For convenience, the nature of the amendment is noted in the beginning of each paragraph as follows:
    - a) **Addition** Specifies paragraphs that do not appear in the API RP, and additions to the corresponding API paragraph.
    - b) **Exception** Specifies paragraphs that modify or completely replace the corresponding API paragraph.
  - 4) [I] An asterisk (\*) indicates that a decision by Purchaser is required or that additional information is furnished by Purchaser.
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## 1. Required References

\* This Section lists Practices and Standards that are generically referenced and assumed to be a part of this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                       |
|-----------------------------|---------------------------------------|
| <a href="#">GP 03-18-01</a> | Piping Fabrication Shop or Field      |
| <a href="#">GP 18-10-01</a> | Additional Requirements for Materials |

### 1.2. API-American Petroleum Institute

|                            |                                                              |
|----------------------------|--------------------------------------------------------------|
| <a href="#">API RP 582</a> | Welding Guidelines for the Chemical, Oil, and Gas Industries |
|----------------------------|--------------------------------------------------------------|

## 2. Revisions to API RP 582

[I] All headings contained herein correspond to paragraph numbering within [API RP 582](#) and reflect additions and exceptions to the recommended practice. All provisions not modified or deleted remain in force.

## Revisions to Section 3: Definitions

### 3. Additions: Definitions

|                                 |                                                                                                                                                                                     |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Back cladding</b>            | A localized weld overlay operation between two integrally clad or weld overlaid sections. This process is also known as "clad restoration."                                         |
| <b>Effective depth</b>          | The thickness of weld overlay or back cladding having the specified chemical composition.                                                                                           |
| <b>Total depth</b>              | The total thickness of weld overlay or back cladding.                                                                                                                               |
| <b>Weld overlay (surfacing)</b> | A deposition of one or more layers of a dissimilar weld metal to the surface of a base material in an effort to improve the corrosion or wear resistance properties of the surface. |

## Revisions to Section 4: General Welding Requirements

[R] Basis for rejection of WPS's shall be noncompliance with this practice, failure to meet applicable codes, or violation of industry practice.

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#### 4.4. Addition: General

[I] The Supplementary Essential Variables in ASME Section IX shall apply to all impact tested welding procedure specifications (even if impact testing is not a code requirement).

#### 4.5. Addition: Base Metals

\* [I] Base metals not listed in ASME Section IX QW/QB-422 but having equivalent chemical and mechanical properties as listed materials may be classified in a listed P-Number or S-Number and, where applicable, Group Number subject to the approval of the Owner's Engineer.

#### 4.6. Addition: Documentation

[R] Each base metal within a given P-Number or Group Number having nominally different chemical or mechanical properties (as designated in QW-422 of ASME Section IX) requires:

- 1) A separate WPS. This requirement does not apply to different grades of P-No. 8, Groups 1 and 2, base metal provided the WPS specifies the filler metal required for each different base metal type.
- 2) Separate PQRs whenever a welding related operation satisfactory for one base metal is, in the opinion of the Owner's Engineer, unsatisfactory for another base metal within the same P or Group Number.

---

## Revisions to Section 5: Welding Processes

### 5.1.i. Addition: Acceptable Welding Processes

[I] Electroslag Welding

### 5.2.a. Addition: Limitations of Fusion Welding Processes

[R] Single pass butt welding of pressure containing joints in ferritic steel exceeding 1/4 in. (6 mm) thickness is acceptable only when the joint receives a subsequent grain refining (austenitizing) heat treatment.

#### 5.2.2.c. Addition: GMAW-S

[R] The root pass for any material thickness may be welded with this process.

#### 5.2.2.d. Addition: GMAW-S

[R] Complete butt or fillet welds may be welded with this process provided the wall thickness of no member exceeds 1 in. (25 mm) and either of the following conditions is met:

- Welding is done in any position except vertical-down and the current is not less than 170 A.
- Welding is done in the vertical-up position (3G) and the heat input is not less than 35000 Joules/in. (14000 Joules/cm). Heat input is defined as:

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### Equation 1: Heat Input

$$\frac{\text{amperage} \times \text{voltage} \times 60}{\text{travel speed (in. or cm per minute)}}$$

#### 5.2.6.1 Addition: SAW

[R] Requalification is also required when the welding flux manufacturer is changed.

#### 5.2.7. Addition: Gas Tungsten Arc Welding (GTAW)

- 1) [R] Manual GTAW (TIG) welding shall be used with the addition of filler metal and high frequency starting equipment or equal.
- 2) [R] For GTAW (TIG), the addition or deletion of consumable inserts for single welded butt joints (without backing devices) requires separate WPS(s) and PQR(s).

## Revisions to Section 6: Welding Consumables

#### 6.1.5. Addition: General

For electroslag welding, the AWS electrode-flux classification, and the flux manufacturer and trade name shall be specified in the PQR and WPS.

#### 6.1.6. Addition: General

\* [R] Unless specifically authorized by Purchaser, filler metals and consumables shall be used only for the primary material and process applications recommended in the AWS filler metal specification or by its manufacturer, e.g., filler metals designed for "single pass welding" shall not be used for multi-pass joints. SAW fluxes designated for non-PWHT applications shall not be used for PWHT applications.

#### 6.1.7. Addition: General

[R] When joining similar metals, the deposited weld metal shall match the chemistry and the mechanical properties of the base metal as closely as possible.

\* Whenever the minimum mechanical properties of the deposited weld metal fail to meet the minimum mechanical properties of the base metal, or whenever the nominal chemistry of the deposited weld metal differs from the nominal chemistry of the base metal, the Vendor's proposal to use such weld metal shall be submitted to Purchaser for approval by the Owner's Engineer.

#### 6.1.8. Addition: General

[R] When the thickness of carbon or low alloy steel base metal exceeds  $\frac{1}{2}$  in. (13 mm), groove or fillet welds shall be made with filler metals producing low hydrogen deposits. However, cellulose or rutile-type coated electrodes may be used for the root pass of a groove weld regardless of the base metal thickness. Rutile SMAW electrodes shall not be used for fill and cap passes on pressure vessels and pressure piping.

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### 6.1.9. Addition: General

[R] Requalification is required whenever:

- 1) [R] The wire chemistry for ferritic steels is changed from one AWS classification to any other classification or to a chemical composition not covered by the AWS filler metal specifications.
- 2) [R] Flux cored electrodes are changed from one AWS classification to another, electrodes are not classified by AWS or electrodes are specified with supplementary requirements. Requalification is not required for a change in the position designator from EX0T-X to EX1T-X and vice versa.
- 3) [R] The chemical composition of the weld deposit is changed from one A-Number to any other A-Number in QW/QB 442 of ASME Section IX including a change from A-1 to A-2 and vice versa.

### 6.2.2. Exception: Dissimilar Welding

[R] When joining ferritic steels (P-1 through P-5) to martensitic stainless steels (P-6), ferritic stainless steels (P-7), or austenitic stainless steels (P-8), the filler metal shall be selected based on the following:

- 1) Nickel-based alloy filler metal shall be selected using the design conditions shown in Table 6-1, except the maximum design temperature for AWS Classes ERNiCrMo-3 type filler metals in sulfur environments shall be 900°F (480°C).
- 2) Type 309 and Type 309L may be used for design temperatures not exceeding 600°F (315°C). Type 309Cb shall not be used when PWHT is required, except for weld overlay.
- 3) For design conditions exceeding the limits stated in 6.2.2 items a and b, the filler metal selection shall be reviewed with the Owner's Engineer.
- 4) Type 310 (25 Cr-20 Ni) stainless steel filler metals shall not be used.
- 5) AWS Class ERNiCrFe-6 filler metals shall not be used.

### 6.3.1. Additions: Austenitic Stainless Steel Welding

[I]\*Base metal and filler metal combinations not meeting the recommendations of Appendix A Table A-2 shall be submitted for approval by the Owner's Engineer.

### 6.5.4. Exception: Submerged Arc Welding

[R] Reprocessed flux or re-crushed slag shall not be used for submerged arc welding of pressure-containing parts such as pressure vessels, piping, and atmospheric storage tanks. Use of such materials is permitted for submerged arc welding of structural and non-code components provided all of the following requirements are met:

- 1) Approval by Owner's Engineer.
- 2) Separate and distinct markings identifying the re-crusher and his trade designation.
- 3) Separate WPS(s) and PQR(s).
- 4) Testing per AWS A5.17/A5.17M, AWS A5.23/A5.23M, or equivalent specification.

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### 6.5.5. Addition: Submerged Arc Welding

[R] Active submerged arc fluxes may be used for carbon steel (P-1 Material) welding within all the following limitations:

- 1) Material wall thickness shall not exceed 1 in. (25 mm).
- 2) Voltage ranges are established and equipment is available to monitor that these limits will not be exceeded.
- 3) Welding procedure qualification results indicate that the impact and hardness requirements have been met.

---

## Revisions to Section 7: Shielding and Purging Gases

### 7.5. Addition: Back Purging Gas

- 1) [R] Back purging gas shall be maintained throughout welding of socket, seal, or any attachment welds when the base metal thickness is less than 1/4" (6 mm).
- 2) [R] Deletion of a back purging gas for a butt joints welded from one side only without backing strip shall require a separate PQR.

---

## Revisions to Section 8: Preheating and Interpass Temperature

### 8.1. Addition: Preheating

- 1) [R] ASTM A 105 carbon steel flanges or equivalent shall be preheated to 175°F (80°C), unless welded with low hydrogen processes or consumables.
- 2) [R] All Mn-Mo steels (e.g. SA 302 or SA 533) shall be preheated to 300°F (150°C) minimum.
- 3) [R] Higher temperatures may be required for highly restrained joints (such as closely spaced nozzles).
- 4) [R] For P-No. 9 Group Materials, the guidance provided in ASME Sec. VIII, Appendix R shall remain non-mandatory.

### 8.5. Additions: Preheating

[R] For heavy wall (>2 in. [50 mm]) pressure vessels, the retention of preheat, outgassing (dehydrogenation) and/or intermediate stress relief, if necessary, shall be specified in the WPS or on a supplemental datasheet.

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## Revisions to Section 9: Postweld Heat Treatment (PWHT)

### 9.1. Addition: WPS Requirements

[R] The WPS shall specify whether PWHT shall be performed. (A statement such as "PWHT, if required by ASME code" is not acceptable.)

#### 9.4.1. Exception: Hardness testing

[I] All hardness testing shall be performed per [GP 18-10-01](#).

#### 9.4.2. Exception: Hardness testing

[I] All hardness testing shall be performed per [GP 18-10-01](#).

### 9.5. Exception: Production hardness testing

[I] Production hardness testing shall be performed per [GP 18-10-01](#).

### 9.8. Exception: Repairs without PWHT

[I] Repairing PWHT'd components without PWHT may be proposed for approval by the Owner's Engineer provided the repair meets all requirements of Paragraph UCS-56(f) of ASME Sec VIII Div 1 and:

- 1) All carbon steel repair procedures employ temper beading.
- 2) All P-No. 3, 4, and 5A materials shall be MT or PT inspected after the material has been at ambient temperature for not less than 48 hours.
- 3) Equipment is NOT exposed to alkaline environments that require PWHT for environmental cracking protection.

### 9.10. Exception: Exemption from PWHT

[R] Seal welding for P-1, P-3, P-4, P-5A, and P-9 materials is acceptable without PWHT per paragraph 11.2 of [GP 03-18-01](#).

### 9.11. Exception: Exemption from PWHT

[R] PWHT for P-4 and P-5A piping and tubing shall be per Section 8 of [GP 18-10-01](#).

## Revisions to Section 10: Cleaning and Surface Preparation

### 10.7. Addition: Cleaning

[R] All slag shall be removed from the outside of each completed weld.

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## Revisions to Section 11: Special Procedure Qualification Requirements/Testing

### 11.2.3. Addition: Tube-to-Tubesheet Welding

[R] \* When specified by the Owner's Engineer, tubesheet surfaces require a weld overlay if either of the following conditions exist:

- 1) The root pass is deposited by GTAW (TIG) welding without filler metal.
- 2) The tubesheet material requires PWHT according to the applicable code.

---

## Revisions to Section 12: Other Items

### 12.5.3. Exception: Stud Welding

[R] Arc and resistance stud welding for attaching non-load-carrying studs (such as extended heat transfer surfaces and insulation attachment pins) shall be qualified on materials having the same thicknesses and nominal chemistries as the production welds. Destructive tests of at least 10 consecutively welded studs shall be used to demonstrate the suitability of the WPS including the specified percent fusion. The PQR shall include a record of all welding variables and equipment settings used during qualification. A production test sample of at least 5 consecutively welded studs shall be tested at the beginning of each shift and after performing maintenance operations on automatic equipment.

\* Production welds shall be inspected by hammer testing [2 lb (1 kg) hammer and 20 to 30 in. (500 to 750 mm) stroke] or 15-degree bend tests as agreed between the Owner's Engineer and Fabricator.

---

## Revision to Appendix A: Welding Consumables for SMAW

### Appendix A: Addition: Filler metal selection

[I] \*Tables A-1, A-2 and A-3 shall be considered non-mandatory, unless specified by the Owner's Engineer.

---

## Revision to Appendix B: Weld Overlay and Clad Restoration

### B.1.1. Addition: Weld Overlays

- 1) [R] Weld overlay or back cladding may be deposited in one or more layers. The number of weld layers in production shall not be less than the number of layers deposited for weld overlay procedure qualification tests.
- 2) [R] The "total depth" of overlay and back cladding shall be  $\frac{1}{8}$  in. (3 mm) or greater in thickness, unless otherwise specified.

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- 3) \* [R] The "effective depth" of overlay and back cladding shall be the uppermost  $\frac{1}{16}$  in. (1.5 mm) of the top layer as a minimum, unless otherwise specified. This material shall meet the specified chemical composition where chemical analysis of the production overlay or back cladding is required.
- 4) [R] If multiple-layer overlay or back cladding is required to meet the specified chemistry, and subsequent machining or grinding is necessary to satisfy dimensional requirements, the final machined or ground surface shall retain the specified effective depth. Examples include machining of gasket grooves in flanges and tubesheets, grinding of heat exchanger shell inside diameter to permit insertion of tube bundle.
- 5) [R] Weld overlay thickness shall be verified by actual measurement of the exposed edge at weld joint preparations. Questions regarding overlay thickness shall be resolved by ultrasonic thickness measurements if necessary.

### B.1.3. Addition: PQR Chemical Analysis

[R] The chemical composition at the "effective depth" of the overlay or back cladding shall be reported for welding procedure qualification tests.

### B.1.4. Addition: Production Chemical Analysis

[R] \*Alternatively, the chemical composition at the "effective depth" of the overlay or back cladding shall be reported for production welding, when specified by the Owner's Engineer. The acceptance requirements for production overlay and back cladding are found for the particular alloy(s) in B.3 through B.6.

### B.1.6. Addition: Extent of Chemistry and Ferrite Testing

- 1) [R] The number of samples for chemical analysis for all types of weld overlay and back cladding, and number of ferrite measurements for austenitic stainless steel deposits, shall be as specified below. Test samples shall be removed, or in situ tests shall be conducted, prior to final PWHT at locations selected by the Inspector.
  - a) Automatic weld overlay: One sample or test from each girth section and equipment component (such as head, tubesheet, connection, etc.), and each back clad seam, except as provided in Item B.1.6.c.
  - b) Manual weld overlay: Two samples or tests from each girth section and equipment component (such as head, tubesheet, connection, etc.), and each back clad seam, except as provided in Item B.1.6.c.
  - c) For back clad seams  $\leq 24$  in. (600 mm) in diameter, one sample for each 24 diametral-inch, or part thereof. The 24 diametral-inch measurement shall be cumulative for all back clad seams 24 in. (600 mm) diameter and smaller employing the same welding procedure, process, and filler metal.  
 Example: One 20 in. manway and three 8 in. nozzles  $\cong$  44 diametral-inches; or one 500 mm manway and three 200 mm nozzles  $\cong$  1100 mm diametral measurement. Therefore, two tests are required.

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- 2) \* [R] For repetitive manual and automatic weld overlay operations on components > 24 in. (600 mm) diameter, two tests per welder per week may be substituted for the requirements of Item 1 above. However there shall be no change in welding procedure, filler metal classification, batch number of submerged arc or electroslag flux, or welding position. Authorization shall be at the discretion of the Inspector.

### B.1.8. Exception: Liquid Penetrant Examination

- 1) [R] For multiple-layer weld overlay or back cladding, liquid penetrant examination shall be performed on the first layer as follows:

Automatic welding      5 percent minimum

Manual welding          12 percent minimum.

Examination methods and acceptance standards shall be in accordance with ASME SEC VIII D1 MA APP 8. Any unacceptable indications shall be cause for liquid penetrant examination of the entire surface of the overlay or back cladding.

- 2) \* [R] Unless otherwise specified by the Owner's Engineer, the final surface of weld overlays, back cladding, and welds joining attachments to weld overlays or integral cladding shall be 100 percent liquid penetrant examined with a water soluble penetrant following hydrostatic testing. However, for heat exchangers, 100 percent liquid penetrant examination may be performed prior to hydrostatic testing.

Examination and acceptance standards shall be as per ASME SEC VIII D1 MA APP 8.

Defective areas shall be repaired and reexamined.

### B.2.1. Addition: Back Cladding

[I] Prior to backcladding butt joints, the weld groove in the backing material shall be filled approximately flush with, but not more than  $\frac{1}{16}$  in. (1.6 mm) below the weld overlay fusion line or the clad bond line adjacent to the weld groove prior to back cladding. Care shall be taken to avoid cross-contaminating the cladding and backing material weld metal. Any suspected areas of cross-contamination shall be etched with either a nitric acid or copper sulfate solution to confirm the integrity of the clad surface.

### B.3.2. Addition: Chemical Composition of Austenitic Stainless Steels

[R] The content of individual elements reported in the chemical analysis shall be within the range specified in Table B-2, except for the following:

- 1) For low-carbon austenitic stainless steel deposits (e.g., 308L, 316L), the carbon content shall not exceed 0.04 percent.
- 2) For austenitic stainless steel deposits containing Cb (Nb) (e.g., Type 347 or Type 309Cb), the Cb (Nb) ratio (Cb/C) shall not exceed 16:1.
- 3) For Type 316 and 316L deposits the Mo content shall not be less than 2.25 percent.

### B.3.3. Addition: Ferrite Testing of Austenitic Stainless Steels

[R] The austenitic stainless steel ferrite number shall be as follows:

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- 1) The ferrite content of the first layer and top layer, as described in Table B-1, of the following overlay and back cladding materials shall be in the specified ferrite number (FN) range:
  - a) For Type 304, 304L, 316, 316L and 317L the FN range shall be 4–10.
  - b) For Type 347 the FN range shall be 5-11.
- 2) The ferrite content shall be determined by one of the following:
  - a) The actual, as-deposited chemical composition and the WRC-1988 or the DeLong (FN) Diagram for Stainless Steel Weld Metal (ASME SEC II C SFA-5.9, Figures A1 and A3), or
  - b) Magnetic instrument as listed in AWS A4.2M/A4.2.

### **B.3.5. Exception: Calibration of Magnetic Ferrite Testing Gauges**

- 1) [R] Magnetic gauges shall be calibrated and certified per AWS A4.2M/A4.2. An annual calibration certification shall be available to the Inspector. Prior to use in production, instrument calibration shall be verified on at least two standards (calibration test blocks) with a minimum ferrite spread of 5 FN. At least one of these standards shall have a FN of 4–10.
- 2) These standards shall be one of the following:
  - a) Primary or secondary weld metal standards described in AWS A4.2M/A4.2
  - b) Samples with certified chemical analyses referenced to the WRC-1988 (FN) Diagram or the DeLong(FN) Diagram
  - c) Samples with ferrite content measured by metallographic techniques

### **B.5.2. Addition: Ferricyanide Testing of Ni-Cu (Alloy 400) and Cu-Ni Alloys**

- 1) [R] Ferricyanide testing is required for all Nickel-copper [Alloy 400 (Monel), 67 Ni-30 Cu] and copper-nickel (70 Cu-30 Ni, 90 Cu-10 Ni) alloy overlays and back cladding.
- 2) Ferricyanide tests shall be performed on 100 percent of finished nickel-copper or copper-nickel overlays and back cladding deposits. The results shall not indicate the presence of free iron.

The test procedure shall be as follows:

- a) The surface to be examined shall be prepared by a method that does not cause contamination by free iron. A solvent or detergent solution shall remove oil, grease and dirt. A pickling solution may be used to remove oxides. The surface shall be thoroughly rinsed after pickling or detergent cleaning, using distilled or de-ionized water. If mechanical surface preparation is required, new emery paper or grinding wheels, and non-ferritic buffing wheels and brushes shall be used.
- b) Composition of the test solution shall be as follows:
  - i) 90 percent by volume potassium ferricyanide (4 percent solution)
  - ii) 10 percent by volume solution consisting of 1 part concentrated hydrochloric acid (36-38 percent by weight HCl) and 9 parts distilled water
- c) Fresh test solution shall be prepared immediately before application.
- d) The testing solution's reaction shall be checked on samples of nickel-copper or copper-nickel and carbon steel. A blue color should appear immediately on carbon steel. No color should appear on nickel-copper or copper-nickel within 10 minutes. If color does appear, the solution is too acidic, and new solution shall be formulated.

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- e) Solution shall be applied to the tested surface by spraying (using an atomizer) or drop-by-drop (using an eyedropper). Appearance of a definite blue color within two minutes indicates the presence of free iron. A light blue tint shall be considered insignificant.
- f) Questions regarding determination of iron content based on the degree of blueness shall be resolved by spot chemical analysis. The iron content shall not exceed 6 percent.

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## Record of Change

|                      |               |                                                                                                                                                    |                    |
|----------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b> |               |                                                                                                                                                    | <b>Date: 12/01</b> |
| <b>Location</b>      | <b>Action</b> | <b>Description</b>                                                                                                                                 |                    |
|                      |               | Initial Publish.                                                                                                                                   |                    |
| <b>Version 1.1.0</b> |               |                                                                                                                                                    | <b>Date: 09/02</b> |
| Section 5.1          | Modification  | Item b Rationale: move the last sentence in the paragraph to Item c.<br>Renumber the remaining items in the list.                                  |                    |
| <b>Version 2.0.0</b> |               |                                                                                                                                                    | <b>Date: 08/03</b> |
| Entire GP            | Replacement   | Entire document revised; earlier GP replaced with revisions to API RP 582.                                                                         |                    |
| <b>Version 2.0.0</b> |               |                                                                                                                                                    | <b>Date: 11/03</b> |
|                      |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |                    |

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## Attachment: Purpose Codes Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C    | Assigned to paragraphs containing specifications whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include Life-Cycle cost considerations. Life-Cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                     |
| E    | Assigned to paragraphs containing specifications whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                      |
| I    | Assigned to paragraphs that provide only clarifying information such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| M    | Assigned to paragraphs containing specifications whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during on-stream operations.                                                                                                                                                                                                                                                                                                                                                                             |
| O    | Assigned to paragraphs containing specifications whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during startups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs containing specifications whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                      |
| S    | <p>Assigned to paragraphs containing specifications whose primary purpose is avoidance of personnel or operational safety incidents. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to the avoidance of recordable personnel injuries; i.e., burns, cuts, abrasions, inhalation, or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, explosions, etc.</p> |

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# Additional Requirements for Materials

## GP 18-10-01

### Scope

[I] This Global Practice (GP) covers special materials requirements relating to the fabrication of equipment in the areas of hardness testing, carbon steel chemistry requirements, hydrostatic and wash water quality, impact testing, and protection of equipment.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
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| Refining/Chemicals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | For Company Use Only            | Version 4.0.0 |
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## 1. Required References

This section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                            |
|-----------------------------|----------------------------|
| <a href="#">GP 03-15-01</a> | Pressure Relief Valves     |
| <a href="#">GP 09-04-01</a> | Atmospheric Storage Tanks  |
| <a href="#">GP 09-06-01</a> | Refrigerated Storage Tanks |

### 1.2. API–American Petroleum Institute

|                             |                                                                                                                     |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------|
| <a href="#">API 579-1</a>   | Fitness-for-Service                                                                                                 |
| <a href="#">API RP 941</a>  | Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants |
| <a href="#">API STD 661</a> | Air-Cooled Heat Exchangers for General Refinery Services                                                            |

### 1.3. ASME–American Society of Mechanical Engineers

|                                  |                                                                                                                                  |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASME B31.3</a>       | Process Piping                                                                                                                   |
| <a href="#">ASME SEC II A</a>    | BPVC Section II A - Materials Part A - Ferrous Material Specifications                                                           |
| <a href="#">ASME SEC II C</a>    | BPVC Section II C - Materials Part C - Specifications for Welding Rods, Electrodes, and Filler Metals                            |
| <a href="#">ASME SEC VIII D1</a> | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 1                                                      |
| <a href="#">ASME SEC VIII D2</a> | BPVC Section VIII - Rules for Construction of Pressure Vessels - Division 2 Alternative Rules                                    |
| <a href="#">ASME SEC IX</a>      | BPVC Section IX - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators |

### 1.4. ASTM–American Society for Testing and Materials

|                            |                                                                                                 |
|----------------------------|-------------------------------------------------------------------------------------------------|
| <a href="#">ASTM A 833</a> | Standard Practice for Indentation Hardness of Metallic Materials by Comparison Hardness Testers |
| <a href="#">ASTM A 956</a> | Standard Test Method for Leeb Hardness Testing of Steel Products                                |

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## 1.5. BSI–British Standards Institution

|                                  |                                                                                                      |
|----------------------------------|------------------------------------------------------------------------------------------------------|
| <a href="#">BSI BS EN 1011-2</a> | Welding - Recommendations for Welding of Metallic Materials - Part 2: Arc Welding of Ferritic Steels |
| BSI BS EN 13445                  | Unfired Pressure Vessels                                                                             |
| <a href="#">BSI PD 5500</a>      | Specification for Unfired Fusion Welded Pressure Vessels                                             |

## 1.6. NACE–National Association of Corrosion Engineers

|                                       |                                                                                                                              |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">NACE MR0103</a>           | Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments                                  |
| <a href="#">NACE MR0175/ISO 15156</a> | Petroleum and Natural Gas Industries Materials for Use in H <sub>2</sub> S-Containing Environments in Oil and Gas Production |
| <a href="#">NACE TM0284</a>           | Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking                                |

## 1.7. SNCT and AFIAP

|        |                                                             |
|--------|-------------------------------------------------------------|
| COD AP | French Code for the Manufacture of Unfired Pressure Vessels |
|--------|-------------------------------------------------------------|

## 1.8. STOOMWEZEN (Netherlands)

|            |                                    |
|------------|------------------------------------|
| STOOMWEZEN | Rules for Equipment Under Pressure |
|------------|------------------------------------|

---

## 2. Definitions

| Term                                       | [I] Description                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Critical Exposure Temperature (CET)</b> | [*] Defined as the lowest metal temperature derived from either the operating or atmospheric conditions. The CET may be a single temperature at an operating pressure or an envelope of temperatures and pressures. The CET is determined for different types of equipment including pressure vessels, piping, and machinery as defined herein. |
| <b>CET for Machinery</b>                   | The CET for machinery pressure containing components to be supplied by the Owner's Engineer.                                                                                                                                                                                                                                                    |

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| Term                                                                                     | [I] Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CET for Piping</b>                                                                    | The CET for systems constructed to <a href="#">ASME B31.3</a> is defined as the lowest metal temperature at which a component will be subject to either 30 percent of the maximum allowable working pressure (MAWP) at ambient temperature or a combined total longitudinal stress due to pressure, weight effects, and displacement strains that do not exceed 55.2 MPa (8 ksi). The CET for piping is determined from the anticipated process and atmospheric conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>CET for Pressure Vessels (including heat exchangers and pressure storage spheres)</b> | <p>The CET for pressure vessels is determined from the anticipated process and atmospheric conditions.</p> <p>The CET is defined as the lowest metal temperature at which a component will be subjected to a general primary membrane tensile stress greater than 55.2 MPa (8 ksi). The CET may also be defined according to the following options:</p> <ol style="list-style-type: none"> <li>1. The minimum metal temperature at which a component could be subjected to a pressure greater than 40 percent of the design pressure for vessels constructed to <a href="#">ASME SEC VIII D1</a>.</li> <li>2. The minimum metal temperature at which a component could be subjected to a pressure greater than 35 percent of the design pressure for vessels constructed to <a href="#">ASME SEC VIII D1</a>, with a 3.5 safety factor as recognized in the 1999 addenda.</li> <li>3. The minimum metal temperature at which a component could be subjected to a pressure greater than 30 percent of the design pressure for vessels constructed to <a href="#">ASME SEC VIII D2</a>.</li> <li>4. For pressure vessels designed to a higher allowable stress than that permitted in these codes, the CET may be taken as the lowest metal temperature at which the vessel will be subjected to a pressure no greater than 25 percent of the design pressure or a membrane stress of no greater than 55.2 MPa (8 ksi).</li> </ol> |
| <b>Hardness Test</b>                                                                     | A single hardness reading in the weld metal, base metal, or HAZ.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Heat Affected Zone (HAZ)</b>                                                          | The zone of the base metal affected by the heat input of welding.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Hydrogen Service</b>                                                                  | Equipment is in hydrogen service when the design temperature is greater than the carbon steel (CS) curve in <a href="#">API RP 941</a> for the given hydrogen partial pressure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Inspector</b>                                                                         | As used in this GP, refers to the Owner's Representative.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

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| Term                                                        | [I] Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Stainless Steel</b>                                      | A steel that meets one of the following descriptions: <ol style="list-style-type: none"> <li>1. Martensitic or ferritic chromium stainless steels containing more than 10 percent chromium (typically AISI 400 series).</li> <li>2. Austenitic chromium-nickel stainless steels containing more than 16 percent chromium and more than 6 percent nickel (typically AISI 300 series). This also includes the super austenitic stainless steels (with 6 percent Mo) and the alloys with nominally 20 percent Cr and 35 percent Ni such as Incoloy 825 or Alloy 20.</li> <li>3. Duplex ferritic-austenitic stainless steels containing approximately 15 to 30 percent chromium and 2 to 8 percent nickel (typically the 2205 and 2507 alloys).</li> </ol> |
| <b>Wet H<sub>2</sub>S Service</b>                           | Equipment is in wet H <sub>2</sub> S service when any one of the conditions in <a href="#">NACE MR0175/ISO 15156</a> is met.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Wet H<sub>2</sub>S Service Alternate Downstream Case</b> | Equipment is in wet H <sub>2</sub> S service when any one of the conditions in <a href="#">NACE MR0103</a> , Paragraph 1.3.5.1 is met.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

### 3. Portable Hardness Testing for Fabrication

#### 3.1. Personnel and Procedure Qualification

[R] Personnel performing hardness testing shall demonstrate their capabilities to the satisfaction of the Inspector. Qualification of the hardness testing personnel, including training and experience, shall be made available to the Inspector.

#### 3.2. Testing Equipment

[A] [R] A list of acceptable hardness testers is shown in Table 1. The Owner's Engineer shall approve any hardness tester not listed in Table 1.

**Table 1: Acceptable Hardness Testers**

| Brinell Type Hardness Testers                                               |                                                                                                  | Dynamic/Rebound Type Hardness Tester                                        |
|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Telebrineller<br>Teleweld, Inc.<br>416 North Park St.<br>Streator, IL 61364 | Newage Calibrated Pin Tester<br>Newage Ind., Inc.<br>2300 Maryland Rd.<br>Willow Grove, PA 19090 | EQUOTIP<br>EQUOTIP Associates<br>140 Industry Drive<br>Pittsburgh, PA 15275 |
| Minibrineller                                                               | L.C. Eitzen Brinell Meter                                                                        |                                                                             |
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|                                                                    |                                                                     |
|--------------------------------------------------------------------|---------------------------------------------------------------------|
| Electromechanical Components<br>P.O. Box 159<br>Gillette, NJ 07933 | L.C. Eitzen Co. Inc.<br>P.O. Box 1210<br>Glenwood Springs, CO 81601 |
|--------------------------------------------------------------------|---------------------------------------------------------------------|

### 3.3. Testing Procedure

- 1) [R] Testing procedures using the Brinell Type Hardness Tester shall be as follows:
  - a) Brinell hardness test methods shall be in accordance with [ASTM A 833](#) and Manufacturer recommendations.
  - b) Hardness tests shall be conducted in the center of the weld and in the HAZ and adjacent base metal, when required.
  - c) The diameter of the indentation ball shall not be smaller than 7 mm and not larger than 10 mm.
  - d) If a hardness reference bar is used, the bar hardness shall be within 12.5 percent of the maximum hardness required for the specific material.
  - e) The surface to be hardness tested shall be ground to ensure that the edge of the impression will be clearly defined to permit measurement of the diameter to within  $\pm 0.02$  mm.
  - f) Grinding shall be conducted in such a manner that overheating of the material is prevented.
  - g) Adjacent readings shall be at least 0.25 in. (6.4 mm) apart, edge to edge.
  - h) When hardness testing of the HAZ is required, the weld cap shall be ground so that the indentation ball can be placed in the center of the HAZ. This hardness test shall represent a composite of weld metal, HAZ, and base metal.
- 2) [R] Testing procedures using the Dynamic/Rebound Type Hardness Tester shall be as follows:
  - a) The hardness test method shall be in accordance with [ASTM A 956](#) and Manufacturer recommendations.
  - b) Five hardness tests shall be conducted in the specific zone of the weld joint. The five readings and the average shall be reported. If there is a variation in readings greater than  $\pm 15$  percent, testing with a Brinell-type hardness tester is required.
  - c) The hardness test instrument shall be calibrated in the same position as intended for production testing.
  - d) The minimum wall thickness shall be 0.35 in. (9 mm).
  - e) The surface of the component being tested must be prepared with a fine file or small grinder to the surface finish required in [ASTM A 956](#) or 32 micro-inches, whichever is smoother.

### 3.4. General Requirements and Acceptable Hardness Values

- 1) [R] The hardness of hot-formed bends and of the base metal, weld metal, and the related HAZ of all welds shall not exceed the limits given in Table 2.

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**Table 2: Material Hardness Limits**

| Material P-Number <sup>(1)</sup>                                                                                                                                                                                                                                                                                                                                                           | Brinell Hardness <sup>(2)</sup> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| P-1                                                                                                                                                                                                                                                                                                                                                                                        | 200 <sup>(3)</sup>              |
| CA6NM                                                                                                                                                                                                                                                                                                                                                                                      | 255                             |
| All other P-numbers                                                                                                                                                                                                                                                                                                                                                                        | See <a href="#">NACE MR0103</a> |
| Notes:<br>(1) Material P Numbers per <a href="#">ASME SEC IX</a> .<br>(2) For piping base metal, use the lower of the value shown or the value given in the specific ASTM standard. For weld metal and HAZ, use the lower of the value shown or the value in <a href="#">ASME B31.3</a> .<br>(3) For piping, a Brinell Hardness of 225 is acceptable in the bend area of hot-formed bends. |                                 |

- 2) **[R]** Hardness testing on welds in P-1 material is not required if any of the following conditions are met:
- Shielded Metal Arc Welding (SMAW) process with [ASME SEC II C SFA-5.1/SFA-5.1M](#), Class E60XX and/or E70XX electrodes.
  - Gas Tungsten Arc Welding (GTAW) process or Gas Metal Arc Welding (GMAW) process with [ASME SEC II C SFA-5.18/SFA-5.18M](#), Class ER 70S-2 through ER 70S-4 filler metal.
  - Flux Cored Arc Welding (FCAW) process using filler metal E7XT-1, -5, -9, and -12 with CO<sub>2</sub> or E7XT-1M, -5M, -9M, and -12M with either CO<sub>2</sub> or Ar/CO<sub>2</sub> mixture.
  - [A]** Submerged Arc Welding (SAW) process using filler metal combinations of ELX or EMX wires in accordance with [ASME SEC II C SFA-5.17/SFA-5.17M](#) and a neutral flux approved by the Owner.

### 3.5. Pressure Vessels (Including Heat Exchangers), Pressure Storage Spheres and Storage Tanks

- [R]** Unless otherwise exempted by Section 3.4, Item (2), the Fabricator shall check the weld joint hardness of the initial production weld for each welding process and filler metal used. Once the initial weld hardness is checked, subsequent production hardness testing as specified in Section 3.5, Item (2) shall be conducted. If the clearances are such that it is not possible to check the production weld, a mockup welded under similar conditions shall be used.
- [R]** Production hardness testing shall be conducted as fabrication progresses (not required for welds on P-1 materials that meet the requirements of Section 3.4, Item (2)). The minimum number of welded joints to be tested shall be as follows:
  - For air-cooled heat exchangers the minimum number of welded joints shall be as specified in [API STD 661](#). The hardness tests shall be made after any required PWHT.
  - For pressure vessels, heat exchangers (excluding air-cooled heat exchangers discussed above), pressure storage spheres, and storage tanks, the minimum number of welded joints to be

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examined to verify the specified hardness values of weld components (i.e., base metal, weld metal, and HAZ) shall be determined from Table 3.

- 3) [R] The exact location of hardness testing shall be specified by the Inspector and conducted to verify compliance with the hardness values in Section 3.4, Item (1).

**Table 3: Material Hardness Requirements for Welded Joints of Pressure Vessel, Storage Spheres and Tanks**

| Material P-number                                                                                                                                                                                                                                                                                                                                                                                                   | Weld Component            | Minimum Number of Welded Joints for Hardness Tests <sup>(3)</sup> per Weld Procedure and Appropriate PWHT Category: |                                                                                                            |                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|---------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                     |                           | Materials not requiring PWHT                                                                                        | Materials that have been Locally PWHT                                                                      | Materials that have been Furnace PWHT                                                     |
| P-1                                                                                                                                                                                                                                                                                                                                                                                                                 | Weld <sup>(1)</sup>       | The greater of:<br>$\frac{1}{3}$ of all welded joints<br>or<br>One spot per 50 ft of weld                           | One spot per weld for components $\leq 24$ in. OD<br>or<br>Two spots per weld for components $> 24$ in. OD | The greater of:<br>$\frac{1}{6}$ of all welded joints<br>or<br>One spot per 50 ft of weld |
| P-1                                                                                                                                                                                                                                                                                                                                                                                                                 | Base Metal                | None                                                                                                                | None                                                                                                       | None                                                                                      |
| P-1                                                                                                                                                                                                                                                                                                                                                                                                                 | HAZ                       | None                                                                                                                | None                                                                                                       | None                                                                                      |
| P-3<br>P-4<br>P-5<br>P-6 <sup>(2)</sup><br>P-7<br>P-10A, B, C, and F<br>P-11                                                                                                                                                                                                                                                                                                                                        | Weld, Base Metal, and HAZ | The greater of:<br>$\frac{1}{3}$ of all welded joints<br>or<br>One spot per 50 ft of weld                           | One spot per weld for Components $\leq 24$ in. OD<br>or<br>Two spots per weld for Components $> 24$ in. OD | The greater of:<br>$\frac{1}{6}$ of all welded joints<br>or<br>One spot per 50 ft of weld |
| Notes:<br>(1) See Section 3.4, Item (2) for exception to hardness testing.<br>(2) All areas locally heated for bending or straightening and not receiving a subsequent PWHT shall be hardness tested.<br>(3) For the purposes of this standard, metric equivalents are listed below:<br><div style="text-align: center;"> <b>Acceptable Metric Equivalents</b><br/> <hr/> 24 in. = 600 mm<br/> 50 ft. = 15 m </div> |                           |                                                                                                                     |                                                                                                            |                                                                                           |

### 3.6. Piping

- 1) [R] Unless otherwise exempted by Section 3.4, Item (2), the Fabricator shall check the weld hardness of the initial production weld for each welding process and filler metal. Once the initial weld hardness is checked, subsequent production hardness testing as specified in Section 3.6, Item (2) shall be conducted.

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- 2) [R] Production hardness testing shall be conducted as fabrication progresses. The minimum number of welded joints to be examined to verify the specified hardness values of weld components (i.e., base metal, weld metal, and HAZ) shall be determined from Table 4.
- 3) [R] The exact location of hardness testing shall be specified by the Inspector and conducted in the Inspector's presence to verify compliance with the hardness values in Section 3.4, Item (1).
- 4) [\*] [R] The minimum number of hot-formed bends to be examined, and the extent of the examination, shall be specified by the Owner for P-1 material.

### 3.7. Remedial Measures and Documentation

- 1) [R] When hardness tests exceed the maximum values, the Owner shall be notified before Manufacturer or Fabricator takes corrective action.
- 2) [R] Additional hardness tests (progressive examination) shall be performed for each weld component found to exceed the specified hardness. The Inspector shall select like components from two additional welded joints for such testing.
- 3) [A] A hardness test report shall be prepared by Manufacturer or Fabricator and submitted to the Owner.
- 4) The hardness test report shall indicate the following:
  - a) Type of hardness tester and its last calibration date
  - b) Personnel conducting hardness tests
  - c) Type of material
  - d) Test location
  - e) Reading of each point tested

**Table 4: Material Hardness Requirements for Welded Piping Components**

| Material P-number                                                            | Weld Component            | Minimum Number of Welded Joints for Hardness Tests, per Appropriate PWHT Category: |                                       |                                                    |
|------------------------------------------------------------------------------|---------------------------|------------------------------------------------------------------------------------|---------------------------------------|----------------------------------------------------|
|                                                                              |                           | Materials not requiring PWHT                                                       | Materials that have been Locally PWHT | Materials that have been Furnace PWHT              |
| P-1                                                                          | Weld <sup>(3)</sup>       | $\frac{1}{3}$ of all welded joints                                                 | $\frac{1}{6}$ of all welded joints    | 3 welded joints per furnace charge                 |
| P-1                                                                          | Base Metal                | As required <sup>(1)</sup>                                                         | None                                  | None                                               |
| P-1                                                                          | HAZ                       | None                                                                               | None                                  | None                                               |
| P-3<br>P-4<br>P-5<br>P-6 <sup>(2)</sup><br>P-7<br>P-10A, B, C, and F<br>P-11 | Weld, Base Metal, and HAZ | $\frac{1}{3}$ of all welded joints                                                 | 100 percent of all welded joints      | 10 percent of the welded joints per furnace charge |

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| Material<br>P-number                                                                                                                                                                                                                          | Weld<br>Component | Minimum Number of Welded Joints for Hardness Tests, per Appropriate PWHT Category: |                                          |                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------------------------------------------------------------------------|------------------------------------------|------------------------------------------|
|                                                                                                                                                                                                                                               |                   | Materials not<br>requiring PWHT                                                    | Materials that have been<br>Locally PWHT | Materials that have<br>been Furnace PWHT |
| Notes:                                                                                                                                                                                                                                        |                   |                                                                                    |                                          |                                          |
| (1) When heating and water quenching is used such as for straightening or alignment, testing is required only for piping with nominal wall thickness greater than 3/4 in. (19 mm). All areas treated in this manner shall be hardness tested. |                   |                                                                                    |                                          |                                          |
| (2) All areas locally heated for bending or straightening and not receiving a subsequent PWHT shall be hardness tested.                                                                                                                       |                   |                                                                                    |                                          |                                          |
| (3) See Section 3.4, Item (2) for exception to hardness test.                                                                                                                                                                                 |                   |                                                                                    |                                          |                                          |

## 4. Carbon Steel Chemistry Control

- 1) [R] Control limits of the Carbon Equivalent (CE)—see Equation 1—and Vanadium and Niobium (columbium) content given in Table 5 shall be applied to carbon steel plate and forgings used in the following:
  - a) Pressure vessels, storage tanks, longitudinally welded pipe, and spheres for all pressure components
  - b) Major load-bearing structural attachments welded to the pressure boundary (e.g., tray beam supports, skirts, support lugs, reinforcing pads, annular plates)

### Equation 1: Carbon Equivalent

$$CE = C + \frac{Mn}{6} + \left( \frac{Cr + Mo + V}{5} \right) + \left( \frac{Ni + Cu}{15} \right)$$

Vanadium and Niobium (columbium) shall also meet the limit given in Table 5. Each element is listed in weight percent.

**Table 5: Supplementary Carbon Steel Chemistry Requirements**

| Carbon Content and Plate Thickness                                                                       | Maximum Chemistry Limits (in weight %) |              |              |        |
|----------------------------------------------------------------------------------------------------------|----------------------------------------|--------------|--------------|--------|
|                                                                                                          | Carbon<br>Equivalent (CE)              | Vanadium (V) | Niobium (Nb) | V + Nb |
| For steels with carbon content greater than 0.12 percent and plate and forging thickness less than 2 in. | 0.45                                   | 0.02         | 0.02         | 0.03   |

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| Carbon Content and Plate Thickness                                                                                      | Maximum Chemistry Limits (in weight %) |              |              |        |
|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------|--------------|--------|
|                                                                                                                         | Carbon Equivalent (CE)                 | Vanadium (V) | Niobium (Nb) | V + Nb |
| For steels with carbon content greater than 0.12 percent and plate and forging thickness greater than or equal to 2 in. | 0.48                                   | 0.02         | 0.02         | 0.03   |
| For steels with carbon content less than or equal to 0.12 percent in all plate and forging thicknesses                  | 0.38                                   | 0.04         | 0.04         | 0.07   |

- 2) [R] Plate steel used for pressure vessels shall be fully deoxidized (killed). The plate steel used for storage spheres shall be fully deoxidized (killed) and made to fine grain practice and normalized.
- 3) [A] [C] [R] When approved by the Owner's Engineer, steels that do not meet the requirements given in Table 5 may be used, provided a specified minimum preheat temperature as determined in [BSI BS EN 1011-2](#), Annex C is applied during welding and magnetic particle testing is done 48 hours after welding.
- 4) [A] [R] Steels that contain an intentional addition of Boron may only be used with the prior approval of the Owner's Engineer.

## 5. Hydrostatic Test and Wash Water Quality

- 1) [R] When austenitic stainless steel equipment designed to operate above 1500 psi (105 bar) will be exposed to hydrostatic test water, the water shall have less than 50 ppm (50 mg/kg) chloride ions and a pH between 6 and 9.
- 2) [R] When stainless steel not covered by Section 5, Item (1) or aluminum materials will be exposed to hydrostatic test or wash water, only water having less than 250 ppm (250 mg/kg) chloride ions and a pH between 6 and 9 shall be used. Potable water will meet this requirement.
- 3) [R] All equipment and piping fabricated with stainless steel exposed to hydrostatic test or wash water shall be drained immediately after hydrostatic testing or water washing and dried by blowing with air [less than 140°F (60°C)]. When air-drying stainless steel process stream analyzers, the air used shall be clean and filtered.
- 4) [A] [R] For non-drainable stainless steel equipment, such as vertical fired heater coils and lines with vertical expansion loops, alternative procedures for hydrostatic testing or washing will be developed by mutual agreement among the Owner's Engineer, Vendor, and Purchaser. Such alternatives may include:
  - a) Pneumatic testing.
  - b) Use of a hydrocarbon liquid for testing.
  - c) Use of steam condensate or demineralized water with less than 1 ppm (1 mg/kg) chloride ion. In such cases, the hydrotest or washing shall be delayed until the water can be vaporized out of the coil immediately following the hydrotest (utilizing burners).

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- 5) **[R]** If equipment or piping is subjected to extended hydrostatic test or wet lay-up conditions (greater than 72 hours), the test water shall be treated with a biocide (to minimize the risk of microbiological contamination) and a corrosion inhibitor, when necessary.
- 6) **[A] [R]** Salt or brackish water is permitted for hydrotesting of carbon steel piping and equipment, provided the Contractor's test procedures are approved by the Owner's Engineer and that they include the following:
  - a) Methods for isolating austenitic stainless steel piping and connected equipment from contact with salty water
  - b) Steps to be taken after testing to ensure complete removal of salty water from the system
  - c) Chemical treatment (e.g., inhibitors, oxygen scavengers) to mitigate corrosion if salt water will remain for more than 5 days
- 7) **[A]** If the substitution of pneumatic testing for hydrostatic testing is approved by the Owner's Engineer, pneumatic testing shall be performed at a temperature not less than 60°F (33°C) above the temperature at which impact requirements given in this GP are met by the material, but not greater than 120°F (49°C) for all equipment and piping components where the wall thicknesses do not exceed 2 in. (50 mm). Procedures for testing at lower temperatures or greater wall thicknesses shall be reviewed and approved by the Owner's Engineer.

## 6. Impact Testing Requirements for Materials

- 1) **[S] [\*]** This Section covers impact testing requirements for pressure vessels, piping, and machinery. Impact requirements shall be based on the Critical Exposure Temperature (CET) established by the Owner's Engineer. Impact requirements for atmospheric storage tanks and refrigerated storage tanks are addressed in [GP 09-04-01](#) and [GP 09-06-01](#), respectively. Impact requirements for pressure relief valves are covered in [GP 03-15-01](#).
- 2) **[R]** The following identify impact requirements for equipment and piping covered by this GP:
  - a) **[A]** For pressure vessels, including heat exchangers and pressure storage spheres, the impact requirements shall be as specified by one of the following codes with the exceptions and additions as listed below:
    - i) [ASME SEC VIII D1](#) or [ASME SEC VIII D2](#)
    - ii) BSI BS EN 13445
    - iii) [BSI PD 5500](#)
    - iv) COD AP
    - v) STOOMWEZEN

When one of these codes governs the design of the pressure vessel, the same code shall be followed for impact testing requirements. Other codes covering impact requirements may be permitted provided they are reviewed and accepted by the Owner's Engineer.
  - b) For piping including piping components (e.g., valves, etc.), the impact requirements specified by [ASME B31.3](#) shall be followed with the exceptions and additions listed in Section 6.1 of this GP.
  - c) For machinery equipment, this GP provides the impact requirements.

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## 6.1. Summary of Exceptions and Additions to Impact Requirements

- 1) When using the ASME Code to define the impact requirements, the minimum design metal temperature (MDMT) shall be at least as low as the CET.
- 2) **[R]** Components of equipment to be pneumatically tested shall be normalized and manufactured to a fine grain practice.
- 3) **[R]** Exemptions permitted by [ASME SEC VIII D1](#) A UG, Paragraph UG-20 "Design Temperature," Item (f) are allowed except that Curve B materials are exempt to  $\frac{1}{2}$  in. (13 mm), not 1 in. (25 mm).
- 4) **[A] [R]** If the base metal is exempt from toughness testing, the weld metal shall have a toughness equal to or greater than 20 ft-lbs (27 J) at 0°F (-18°C) or the CET, whichever is lower. The weld metal toughness shall be certified by the manufacturer of the filler metal according to [ASME SEC II C](#), or when approved by the Owner's Engineer, shall be established by testing of the weld procedure qualification test plate.
- 5) **[A] [R]** For CS vessels and piping, only filler metals classifications having minimum specified impact toughness levels at the lesser of 0°F or the CET, shall be used regardless whether the base metal requires impact testing or not, unless approved by the Owner's Engineer.
- 6) When Charpy impact testing is required for base metals, the orientation of the test specimens shall be as follows, unless otherwise specified by the applicable construction code:
  - a) Plate materials: Impact specimens shall be prepared with the base of the notch perpendicular to the plate surface.
  - b) Cylindrical pressure vessels: Impact specimens shall have their long dimensions parallel to the final direction of rolling (longitudinal specimens). Specimens with their long dimensions in the transverse direction are also acceptable.
  - c) Spheres or hemispherical heads fabricated from segments: Impact specimens shall have their long dimensions perpendicular to the final rolling direction (transverse specimens).
  - d) Pipe materials: Impact specimens shall be prepared with their long dimensions oriented in the transverse direction.
    - i) The base of the notch shall be placed perpendicular to the pipe surface and located in the weld (if longitudinally welded) barring constraints as follows:
    - ii) Geometric constraints: When longitudinally welded pipe cannot accommodate a transverse impact specimen, a longitudinal specimen may be used with the root of the notch located in weld metal.
  - e) Forgings: Test specimens shall be prepared in accordance with [ASME SEC II A SA-350/SA-350M](#).
  - f) Castings: Specimens shall be removed from a test block and prepared in accordance with the relevant ASME materials specifications.

## 6.2. Impact Requirements for Machinery

- 1) **[R]** Pressure containing machinery components such as compressor and pump casings, including cast, forged, or welded nozzles, shall meet the requirements in Table 6.

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**Table 6: Impact Requirements**

| CET, °F (°C)                                                                                                                                                                              | Maximum Casing Working Pressure psi (kPa) | Impact Requirement <sup>(1)</sup> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-----------------------------------|
| CET ≤ -20°F (-29°C)                                                                                                                                                                       | All                                       | 15/12 ft-lb (20/16 J)             |
| 60°F (16°C) > CET > -20°F (-29°C)                                                                                                                                                         | > 1000 psi (6900 kPa)                     | 15/12 ft-lb (20/16 J)             |
| 60°F (16°C) > CET > -20°F (-29°C)                                                                                                                                                         | ≤1000 psi (6900 kPa)                      | None                              |
| CET ≥ 60°F (16°C)                                                                                                                                                                         | All                                       | None                              |
| Note:                                                                                                                                                                                     |                                           |                                   |
| (1) In the notation such as 15/12, the first number is the minimum average energy of three specimens while the second number is the minimum for one specimen in the impact determination. |                                           |                                   |

- 2) [C] No impact tests are required if the maximum casing working pressure generates a stress less than 25 percent of the minimum specified yield stress for the casing material, as determined by Manufacturer, for the casing design.

## 7. Materials Requirements for Wet H<sub>2</sub>S and HF Service

- 1) [\*] [R] When a Hydrogen Induced Cracking (HIC) resistant steel plate is specified for pressure vessels or longitudinally welded pipe for wet H<sub>2</sub>S or hydrofluoric acid (HF) service, it shall be tested in accordance with [NACE TM0284](#) Solution A.
  - a) The acceptance criterion is a crack length ratio of less than 10 percent for each of the three sections from each coupon.
  - b) One set of three specimens shall be tested from each thickness of plate from each heat in the as-received or PWHT condition.
  - c) [\*] In addition to the reporting requirements of [NACE TM0284](#), photographs of the examined surface of all test samples showing cracking shall be submitted when requested by the Owner's Engineer. Photographs of the examined surface shall also be submitted un-etched to show the type of inclusions and etched to show the microstructure.
- 2) [\*] [R] Unless otherwise specified, in wet H<sub>2</sub>S or HF service, carbon steel plate and strip used for vessels that are not fully lined shall be supplied in the normalized condition and shall be PWHT. The PWHT procedure outlined in the following industry standards shall be followed:
  - a) [ASME SEC VIII D1](#) B PT UW, Paragraphs UW-40 "Procedure for Postweld Heat Treatment" and UW-49 "Check for Postweld Heat Treatment Practice"
  - b) [ASME SEC VIII D1](#) C PT UHA, Paragraph UHA-32 "Requirements for Postweld Heat Treatment" (notes in Table UHA-32 will not apply)
  - c) [ASME SEC VIII D1](#) C PT UCS, Paragraph UCS-56 Requirements for Postweld Heat Treatment" (notes in Table UCS-56 will not apply)

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All welds, regardless of type or size, that are exposed to wet H<sub>2</sub>S shall be PWHT at a minimum temperature of 1150°F (620°C). External attachments or seal welded threaded connections on P-1 Groups 1 and 2 materials are exempted from this requirement and do not require PWHT.

- 3) **[\*] [R]** Uncoated or unlined carbon and low alloy steel vessels in wet H<sub>2</sub>S or HF service shall be examined as defined in Section 7, Items (3) (a), (b), and (c), unless otherwise specified by the Owner's Engineer.
  - a) All category A, B, and C welds shall be inspected as follows:
    - i) 100 percent radiographically examined. Acceptance criteria shall be as defined in [ASME SEC VIII D1](#) B UW, Paragraph UW-51 "Radiographic Examination of Welded Joints."
    - ii) 100 percent ultrasonic examination of welds not capable of being radiographed is an acceptable alternative to Section 7, Item (3) (a) (i). Acceptance criteria shall be defined by [ASME SEC VIII D1](#) B UW, Paragraph UW-53 "Technique for Ultrasonic Examination of Welded Joints."
  - b) All category D welds (nozzle to shell attachments) shall be inspected as follows:
    - i) Progressive MT of every  $\frac{1}{4}$  in. (6 mm) of weld buildup, using AC yoke or DC prod technique. Where applicable, the backside of the root pass shall be examined after being prepared for welding. Test methods and acceptance criteria shall be defined by [ASME SEC VIII D1](#), Mandatory Appendix 6 "Methods for Magnetic Particle Examination (MT)."
    - ii) 100 percent ultrasonic examination of nozzle to shell welds is an acceptable alternative to Section 7, Item (3) (b) (i). Acceptance criteria shall be defined by [ASME SEC VIII D1](#) B UW, Paragraph UW-53, "Technique for Ultrasonic Examination of Welded Joints."
  - c) Subsequent to PWHT, the inner (wetted) surface of all welds shall be examined as follows:
    - i) Wet fluorescent magnetic particle (WFMT). Testing methods and acceptance criteria shall be defined by [ASME SEC VIII D1](#), Mandatory Appendix 6 "Methods for Magnetic Particle Examination (MT)." The surface shall be prepared by abrasive blasting to a commercial blast quality. Alternatively, flapper wheels or sanding discs (no coarser than 40 grit) may be used.
    - ii) 100 percent ultrasonic examination of welds not accessible from the internal diameter (ID) is an acceptable alternative to Section 7, Item (3) (c) (i). Acceptance criteria shall be defined by [ASME SEC VIII D1](#) B UW, Paragraph UW-53 "Technique for Ultrasonic Examination of Welded Joints."
- 4) **[R]** PWHT is required for all longitudinally welded or seamless carbon and low alloy ferritic steel pipes exposed to wet H<sub>2</sub>S or HF service regardless of the pipe thickness. The minimum PWHT temperature shall be per [ASME B31.3](#) for the material used, but not less than 1150°F (620°C). For carbon steel piping exposed to wet H<sub>2</sub>S service only, the specific types of welds listed in Subitems (a) through (e) below are exempt from the special PWHT requirements of this paragraph. However, this does not exempt these welds from PWHT when required by the applicable code.
  - a) Multipass girth welds in seamless piping, welded from the outside surface only.
  - b) External attachment welds, when the weld metal does not come in contact with wet H<sub>2</sub>S.
  - c) Multipass seal and socket welds.
  - d) Multipass welds for set on branch connections [e.g., see [ASME B31.3](#), Figure 328.4.4 "Preparation for Branch Connections" sketch (a)] provided all welding is performed from the outside.
  - e) Carbon steel piping in HF or wet H<sub>2</sub>S service only, provided that the hardness measurement does not exceed 200 BHN.

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## 8. Additional Requirements for Cr-Mo Steels

- 1) [\*] [R] All P-4 and P-5A welded components in hydrogen service shall be PWHT regardless of the thickness or diameter, unless otherwise specified by the Owner's Engineer.
- 2) [R] For 1 1/4 Cr – 1/2 Mo pressure vessels greater than 1/2 in. (13 mm) thick, only Class 1 materials shall be used at design temperatures greater than or equal to 900°F (480°C), and PWHT shall be performed at a minimum temperature of 1300°F (705°C).
- 3) [R] Seamless or welded 1 1/4 CR – 1/2 Mo piping shall not be used for design temperatures above 900°F (480°C) in applications that have a design pressure greater than 200 psig.

## 9. Protection of Stainless Steel during Shop Handling, Storage, Shipping, and Field Construction

- 1) [R] Stainless steel surfaces shall be protected against contamination by iron-containing dust and fumes from grinding, welding, wire brushing, and other manufacturing operations.
- 2) [R] Nozzles, manholes, vents, and connection openings shall be blanked to prevent moisture from entering. A 6 mm thick, gasketed steel blind shall be used, held in place by a minimum of four bolts.
- 3) [R] Threaded openings in equipment shall be closed with threaded stainless steel pipe plugs. Stainless steel equipment or components shall not be exposed to salt water or salt spray. If this occurs, exposed external surfaces shall be washed with potable water containing less than 250 ppm Cl and dried.
- 4) [R] Stainless steel shall not be stored outdoors in direct contact with or within 12 in. (300 mm) of the soil or in contact with porous or moisture retaining supports such as raw wood.
- 5) [R] During construction, precautions shall be taken to prevent the introduction of water into stainless steel equipment as a result of washing or hydrotesting other connected equipment.

## 10. Preservation and Protection of Equipment during Shipping and Construction

- 1) [R] Preservation shall be provided for fixed equipment to prevent corrosion and deterioration from the effects of environmental conditions during shipping, storage, and construction.
- 2) [A] [R] Procedures for protection shall be submitted to the Owner's Engineer for review. Procedures shall include protective measures, inspection, maintenance, and removal of preservatives. Selection of preservation methods should consider their environmental impact during removal or disposal.
- 3) [R] If preservatives are removed for inspection or testing at any time prior to commissioning, they shall be reapplied upon completion of the work.

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## Record of Change

| Version 1.0.0               |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Date: 03/02 |
|-----------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Location                    | Action       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |             |
|                             |              | Initial Publish.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |             |
| Version 2.0.0               |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Date: 08/03 |
| General                     | Modification | Document sections were renumbered per addition of a new Section 8.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |             |
| Section 1                   | Modification | Modified mnemonics and titles to references as appropriate.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |             |
| Section 1.2                 | Addition     | Added an API reference to read as follows:<br>API RP 941 – Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |
| Section 1.3                 | Modification | Modified ASME reference as follows:<br>ASME SEC II C became ASME SEC IX.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |
| Section 1.9                 | Addition     | Added Section 1.9 to read as follows:<br>EN-European Standards<br>EN 13445 – Unfired Pressure Vessels                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |
| Section 2                   | Addition     | Added definition for Hydrogen Service and Stainless Steel.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |             |
| Section 3.1                 | Deletion     | Deleted asterisk at beginning of sentence.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |             |
| Section 3.2                 | Deletion     | Deleted asterisk at beginning of sentence.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |             |
| Section 3.4, Table 2, Notes | Modification | Modified Notes 1 and 3 to read as follows:<br>(1) Material P Numbers per ASME Section IX.<br>(3) For piping a Brinell Hardness of 225 is acceptable in the bend area of hot-formed bends.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |             |
| Section 3.4, Rationale      | Modification | Modified Rationale paragraph.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |             |
| Section 3.5, Items 1 and 2  | Modification | Modified Items 1 and 2 to read as follows:<br>1) <b>[R]</b> Unless otherwise exempted by Section 3.4, Item (2), the Fabricator shall check the weld joint hardness of the initial production weld for each welding process and filler metal used. Once the initial weld hardness is checked, subsequent production hardness testing as specified in Section 3.5, Item 2 shall be conducted. If the clearances are such that it is not possible to check the production weld, a mockup welded under similar conditions shall be used.<br><br>2) <b>[R]</b> Production hardness testing shall be conducted as fabrication progresses (not required for welds on P-1 materials which meet the requirements of Section 3.4, Item 2). The minimum number of welded joints to be tested shall be as follows: |             |

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| Section 3.5,<br>Second<br>Rationale          | Modification | Modified Rationale.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Section 3.5,<br>Table 3                      | Modification | Modified second column, fifth row, as follows:<br>Weld Base Metal HAZ to Weld, Base Metal, and HAZ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 3.6,<br>Items 1, 2, and<br>Rationale | Modification | Modified Item 1 to read as follows:<br><br>1) <b>[R]</b> Unless otherwise exempted by Section 3.4, Item 2, the Fabricator shall check the weld hardness of the initial production weld for each welding process and filler metal. Once the initial weld hardness is checked, subsequent production hardness testing as specified in Section 3.6, Item 2, shall be conducted.<br><br>2) <b>[R]</b> Production hardness testing shall be conducted as fabrication progresses. The minimum number of welded joints to be examined to verify the specified hardness values of weld components (i.e., base metal, weld metal and HAZ) shall be determined from Table 4. |
| Section 3.7,<br>Item 4                       | Modification | Modified Item 4 to read as follows:<br><br>4) <b>[I]</b> The hardness test report shall indicate the type of hardness tester, its last calibration date, personnel conducting hardness tests, type of material, test location, and reading of each point tested.                                                                                                                                                                                                                                                                                                                                                                                                   |
| Section 3.7,<br>Table 4                      | Modification | Modified second column, fifth row, as follows:<br>Weld Base Metal HAZ to Weld, Base Metal, and HAZ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 4, Item<br>1                         | Modification | Modified Item 1 to read as follows:<br><br>1) <b>[R]</b> The Carbon Equivalent (CE), as defined in Equation 1, of carbon steel plate used in pressure vessels, storage tanks, longitudinally welded pipe, and spheres for all pressure boundary components and major load-bearing structural attachments welded to the pressure boundary (e.g., tray beam supports, skirts, support lug/legs, reinforcing pads, annular plates) as defined by the equation below, shall meet the limits given in Table 5.                                                                                                                                                          |
| Section 4, Item<br>2 and<br>Rationale        | Modification | Modified Item 2 and Rationale to read as follows:<br><br>2) <b>[R]</b> Plate steel used for pressure vessels shall be fully deoxidized (killed). The plate steel used for storage spheres shall be fully deoxidized (killed) and made to fine grain practice and normalized.                                                                                                                                                                                                                                                                                                                                                                                       |
| Section 5, Item<br>4                         | Modification | Modified Item 4 to read as follows:<br><br>4) * <b>[R]</b> For non-drainable stainless steel equipment, such as vertical fired heater coils and lines with vertical expansion loops, alternative procedures for hydrostatic testing or washing will be developed by mutual agreement among the Owner's Engineer, Vendor and Purchaser. Such alternatives may include:                                                                                                                                                                                                                                                                                              |

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| Section 5, Item 7                          | Modification | Modified Item 7 to read as follows:<br><br>7) * <b>[I]</b> If the substitution of pneumatic testing for hydrostatic testing is approved by the Owner's Engineer, pneumatic testing shall be performed at a temperature not less than 120°F (50°C) for all equipment and piping components where the wall thicknesses do not exceed 2 in. (50 mm). Procedures for testing at lower temperatures or greater wall thicknesses shall be reviewed and approved by the Owner's Engineer.                                                                                                                                                                                                                                                                                                                           |
| Section 6, Item 2, Subitem a               | Addition     | Added references to BSI PD 5500 and EN 13445.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Section 6, Item 2, Subitem b               | Modification | Modified Subitem b to read as follows:<br><br>b) For piping including piping components (valves, etc.), the impact requirements specified by ASME B31.3 shall be followed with the exceptions and additions listed in Section 6.1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Section 6.1, Item 2                        | Modification | Modified Item 2 to read as follows:<br><br>2) <b>[R]</b> Components of equipment to be pneumatically tested shall be normalized and manufactured to a fine-grain practice.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Section 7, Item 1                          | Modification | Modified Item 1 to read as follows:<br><br>* <b>[R]</b> When hydrogen induced cracking resistant steel plate is specified for pressure vessels or longitudinally welded pipe for wet H <sub>2</sub> S or HF service, it shall be tested in accordance with NACE TM 0284 Solution A.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 7, Item 1, Subitem c and Rationale | Modification | Modified Subitem c and the Rationale as follows:<br><br>In addition to the reporting requirements of NACE TM0284, photographs of the examined surface of all test samples showing cracking shall be submitted when requested by the Owner's Engineer. Photographs of the examined surface shall also be submitted unetched to show the type of inclusions and etched to show the microstructure.                                                                                                                                                                                                                                                                                                                                                                                                             |
| Section 7, Item 2                          | Modification | Modified Item 2 to read as follows:<br><br>* <b>[R]</b> Unless otherwise specified, in wet H <sub>2</sub> S or HF service, carbon steel plate and strip used for vessels that are not fully lined shall be supplied in the normalized condition and shall be PWHT. The PWHT procedure outlined in ASME Section VIII Division 1 B PT UW, Paragraphs UW-40 and UW-49, ASME Section VIII Division 1 C PT UHA, UHA-32 and ASME Section VIII Division 1 C PT UCS, UCS-56 shall be followed, except that notes in Tables UHA-32 and UCS-56 will not apply. All welds, regardless of type or size, that are exposed to wet H <sub>2</sub> S shall be PWHT at a minimum temperature of 1150°F (620°C). External attachments or seal welded threaded connections on P-1 Groups 1 and 2 materials do not require PWHT. |

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| Section 7, Item 3, Subitem b, Subitem i and ii | Modification | Modified Subitems I and ii to read as follows:<br><br>i) Progressive MT of every $\frac{1}{4}$ in. (6 mm) of weld buildup, using AC yoke or DC prod technique. Where applicable, the backside of the root pass shall be examined after being prepared for welding. Test methods and acceptance criteria shall be defined by ASME Section VIII, Division 1, Appendix 6.<br><br>ii) 100 percent ultrasonic examination of nozzle to shell welds is an acceptable alternative to Section 7, Item 3b.i. Acceptance criteria shall be defined by ASME Section VIII, Division 1 UW, Paragraph UW-53.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 7, Item 3, Subitem c                   | Modification | Modified Subitem c to read as follows:<br><br>Subsequent to PWHT, the inner (wetted) surface of all welds shall be examined by WFMT. Testing methods and acceptance criteria shall be defined by ASME Section VIII, Division 1, Appendix 6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Section 7, Item 4                              | Modification | Modified Item 4 to read as follows:<br><br>4) <b>[R]</b> PWHT is required for all longitudinally welded or seamless carbon and low alloy ferritic steel pipes exposed to wet H <sub>2</sub> S or HF service regardless of the pipe thickness. The minimum PWHT temperature shall be per ASME B31.3 for the material used, but not less than 1150°F (620°C). For carbon steel piping exposed to wet H <sub>2</sub> S service only, the specific types of welds listed in Subitems a through d (below) are exempt from the special PWHT requirements of this paragraph. However, this does not exempt these welds from PWHT when required by the applicable code.<br><br>a) Multipass girth welds in seamless piping, welded from the outside surface only.<br><br>b) External attachment welds, when the weld metal does not come in contact with wet H <sub>2</sub> S.<br><br>c) Multipass seal and socket welds.<br><br>d) Multipass welds for set on branch connections (e.g., see ASME B31.3, Figure 328.4.4(a)) provided all welding is performed from the outside. |
| Section 8                                      | Addition     | Added Section 8, Additional Requirements for Cr-Mo Steels, to read as follows:<br><br>1) * <b>[R]</b> All P-4 and P-5A piping and tubing components in hydrogen service shall be PWHT regardless of the thickness or diameter, unless otherwise specified by the Owner's Engineer.<br><br>2) <b>[R]</b> For 1 $\frac{1}{4}$ Cr-1/2 Mo piping and vessels greater than $\frac{1}{2}$ in. (13 mm) thick, only Class 1 materials shall be used at design temperatures greater than or equal to 900°F (480°C), and PWHT shall be performed at a minimum temperature of 1300°F (705°C).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Version 2.0.0</b>                           |              | <b>Date: 11/03</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                |              | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

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| Version 3.0.0                 |              | Date: 06/05                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| Section 4                     | Addition     | Added chemistry controls for A105 flanges in response to cracking issues reported by Chemicals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 6.1, Item (5)         | Addition     | Added orientation specification for Charpy impact testing.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| General                       | Modification | Renumbering and rewording for conciseness.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Table 2                       | Modification | Altered Brinell hardness requirements for P5, P6, and P7 materials to align with standard practice NACE MR0103.<br><br>Removed owner control of hardness limits for P91 and F91 materials.                                                                                                                                                                                                                                                                                                                                                                                                      |
| Version 4.0.0                 |              | Date: 02/08                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Section 1.5                   | Addition     | Added reference to BSI BS EN1011-2 Annex C.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Section 1.8                   | Addition     | Added reference to ISO 15156 Parts 1, 2, and 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 2                     | Modification | Changed the definition of Wet H <sub>2</sub> S service to align with NACE documents MR0175 and MR0103.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 3                     | Modification | Altered name of section to Portable Hardness Testing for Fabrication for clarification.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Section 3.3 Item (2d)         | Modification | Changed minimum wall thickness to 0.35 in (9 mm) to reflect success in the field at this lower thickness.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Table 2                       | Modification | Altered Brinell hardness requirements of CA6NM material to align with NACE MR0103.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Section 4.1                   | Modification | Placed CE restrictions on CS forgings in addition to plates.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Section 4.2                   | Deletion     | Deleted specific restrictions on A105 flanges by adding CE restrictions to CS forgings in section 4.1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Table 5                       | Modification | Added forgings to the table.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Section 4                     | Modification | Renumbered to reflect removal of item 4.2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Section 4.3                   | Modification | Added reference to EN1011-2 Annex C as guidance to determine preheat temperature.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Section 4, Item (3) Rationale | Modification | Rationale was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Section 5.7                   | Modification | Paragraph revised to read:<br><br>7) * [I] If the substitution of pneumatic testing for hydrostatic testing is approved by the Owner's Engineer, pneumatic testing shall be performed at a temperature not less than 60°F (33°C) above the temperature at which impact requirements given in the GP are met by the material, but not greater than 120°F (50°C) for all equipment and piping components where the wall thicknesses do not exceed 2 in. (50 mm). Procedures for testing at lower temperatures or greater wall thicknesses shall be reviewed and approved by the Owner's Engineer. |

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|-----------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Section 6.5                 | Addition      | New section added that reads:<br><br>5) For CS vessels and piping, only filler metals classification having minimum specified impact toughness levels at the lesser of 0°F or the CET, shall be used regardless whether the base metal requires impact testing or not, unless approved by the Owner's Engineer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Section 6.5 Rationale       | Addition      | Rationale was added.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Section 6.6                 | Modification  | Old Section 6.5 is now Section 6.6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Section 7.3                 | Modification  | Section modified to give alternative inspection guidance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 7.3 Rationale       | Modification  | Rationale was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Section 8.1                 | Modification  | Requirement reworded to include all welded components in hydrogen service not just piping.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>All Global Practices</b> | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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# Positive Material Identification

## GP 18-12-01

### Scope

- 1) **[I]** This Global Practice (GP) applies to metallic alloy materials purchased for use either directly by Owner or indirectly through Vendors, Fabricators, or Subcontractors. It includes the supply, fabrication, and erection of these materials.
- 2) **[I]** This GP covers the procedures and methods to ensure that the nominal chemical composition of alloy materials is in accordance with purchase specifications, and that such materials are properly analyzed and marked to indicate the alloy.
- 3) **[I]** Carbon steels are not within the Scope of this GP.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
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| Refining/Chemicals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | For Company Use Only            | Version 3.0.0 |
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## 1. Required References

This Section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                    |
|-----------------------------|--------------------|
| <a href="#">GP 18-07-01</a> | Welding Procedures |
|-----------------------------|--------------------|

### 1.2. ExxonMobil Data Sheets

|                            |                                                             |
|----------------------------|-------------------------------------------------------------|
| <a href="#">T181201C01</a> | Positive Material Identification - Analysis Mode Data Sheet |
|----------------------------|-------------------------------------------------------------|

### 1.3. API–American Petroleum Institute

|                            |                                                                         |
|----------------------------|-------------------------------------------------------------------------|
| <a href="#">API RP 578</a> | Material Verification Program for New and Existing Alloy Piping Systems |
|----------------------------|-------------------------------------------------------------------------|

### 1.4. ASME–American Society of Mechanical Engineers

|                                     |                                                                                           |
|-------------------------------------|-------------------------------------------------------------------------------------------|
| <a href="#">ASME SEC II A INTRO</a> | Section II A Ferrous Material Specifications (Beginning to SA-450)                        |
| <a href="#">ASME SEC II B INTRO</a> | Section II B Nonferrous Material Specifications                                           |
| <a href="#">ASME SEC II C INTRO</a> | Section II C Specifications for Welding Rods, Electrodes, and Filler Metals               |
| <a href="#">ASME SEC V B SD-129</a> | SD-129 Standard Test Method for Sulfur in Petroleum Products (General Bomb Method)        |
| <a href="#">ASME SEC V B SD-808</a> | SD-808 Standard Test Method for Chlorine in New and Used Petroleum Products (Bomb Method) |

### 1.5. ASTM–American Society for Testing and Materials

|                                   |                                                                                                                                                                   |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM A 193/A 193M</a> | Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications |
| <a href="#">ASTM A 751</a>        | Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products                                                                         |
| <a href="#">ASTM E 353</a>        | Standard Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys                                 |

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|                            |                                                                                                                                          |
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| <a href="#">ASTM E 354</a> | Standard Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys |
|                            | Other ASTM and National Standards, as applicable                                                                                         |

## 2. Definitions

| Term                                               | [I] Definition                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>100% Positive Material Identification</b>       | Each individual component and weld is tested.                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Check (Instrument Performance)</b>              | A test carried out on a known standard alloy to verify the performance of the instrument.<br><div></div>                                                                                                                                                                                                                                                                                                                         |
| <b>Inspection Lot</b>                              | With the exception of bolting, an inspection lot is a group of components from the same heat number or heat treatment batch, from which a sample is drawn. For bolting, a lot is a group of similar components in terms of alloy type and size.                                                                                                                                                                                  |
| <b>PMI Program</b>                                 | A detailed set of instructions defining the order of precedence to be followed for the successful execution of a Positive Material Identification (PMI) Plan. The program shall include the structure, process, and procedure to control operations, manage change, and define how, when and where Positive Material Identification (PMI) is to be employed for compliance with the program objectives.                          |
| <b>PMI Procedure</b>                               | A procedure is defined as a specified series of actions, acts, or operations that have to be implemented in a specific order to continuously obtain the same Positive Material Identification (PMI) results under the same circumstances. It shall include a sequence of activities, tasks, steps, decisions, calculations and processes, that when undertaken in the sequence prescribed will produce the desired PMI analysis. |
| <b>PMIV (PMI Verified)<br/>AV (Alloy Verified)</b> | Markings used to identify components which have been tested and confirmed to be acceptable.                                                                                                                                                                                                                                                                                                                                      |
| <b>Positive Materials Identification (PMI)</b>     | A procedure used to ensure that specified metallic alloy materials are: properly identified as to alloy type, marked according to Owner's procedures, installed as intended.                                                                                                                                                                                                                                                     |

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| Term                              | [I] Definition                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Representative Sampling</b>    | <p>PMI testing of a sample, which consists of one or more pieces (components), selected at random from an inspection lot, which will be examined to determine acceptability of the inspection lot.</p> <p>The size of the representative sample, and the maximum number of defective parts allowed, shall provide 90 percent confidence that not more than 5 percent of the entire lot is defective, with the following minimum sample sizes satisfying this requirement if no defective parts are found:</p> <p>100 percent for a lot of 28 pieces or less; 28 pieces for a lot of 50 pieces or less, 38 pieces for a lot of 150 pieces or less, and 45 pieces for a lot of 3,000 or less.</p> |
| <b>Traceable Mill Certificate</b> | A document that permits each component to be identified according to the original heat or material from which it was produced.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

### 3. Specific Applicability

- 1) [S] [R] The following metallic-alloy-material items require 100 percent Positive Material Identification (PMI):
  - a) All pressure-containing welds. For double welded joints, both weld caps, inside and outside, when accessible. On internally clad or overlaid vessels, the inside weld cap shall be PMI'd before back cladding and the result recorded on an as built and mapped vessel drawing.
  - b) All Pressure-containing piping components, including the following:
    - i) Thermowells
    - ii) Instrument manifolds
    - iii) [\*] Braided alloy-reinforced hoses in the service of hazardous or corrosive materials as designated by the Owner's Engineer
  - c) Pressure-containing components of heat exchangers (to include the plates for plate and frame heat exchangers, except components per Section 3, Item (2)) and other pressure vessels.
  - d) Plate material used as Pressure-containing components.
  - e) Pressure-containing machinery components (e.g., pump casings, compressors, and process expansion drivers).
  - f) Pressure-containing instrument housings in alloy piping circuits that cannot be isolated from the process environment, or housings with a design pressure above 900 psig (e.g., gauge glass housings, orifice meter tubes).
  - g) External valve components (body, flanges, bonnet, plugs, and vents, and associated welds).
  - h) Expansion joints and bellows in Pressure-containing service.
  - i) Pressure-containing tubing which cannot be isolated from the process environment [except as excluded in Section 3, Items (2) and (4)].
  - j) Fired heater coils including all welds on alloy tubes and air-cooled heat exchanger tubes (air fin tubes).

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- k) Except for tubular products covered by Section 3, Item (2a) and bolting covered by Section 3, Item (2c), items designated for representative sampling PMI but which have no alloy type identification (i.e. permanent marking) shall be 100 percent PMI verified.
  - l) Any other components or materials specifically designated for PMI on the Purchase Specification.
- 2) [\*] [R] The following items require PMI on a representative sampling basis, as a minimum, unless specifically exempted on the Purchase Specification:
- a) Tubular products used in the fabrication of equipment, such as heat exchangers and boilers, provided that traceable mill certification is available.
  - b) Fired heater, heat exchanger, and boiler internals (tube hangers, tube supports, and tubesheets).
  - c) All [ASTM A 193/A 193M](#) Grade B16 and alloy stud bolting, except as excluded in Section 3, Item (4j).
  - d) Ring joint flange and clamp type (e.g., Grayloc) connector flange gaskets.
  - e) Sheet products used in the fabrication of equipment, such as welded plate and frame, provided that traceable mill certification is available.
- 3) [R] Internal metallic lining/cladding and weld overlay used for protection against corrosive environments shall be tested as follows:
- a) Integral cladding: 100 percent. One inspection for each clad component.
  - b) Weld overlay, backcladding, and applied linings as specified in [GP 18-07-01](#) shall be tested before postweld heat treatment.
- 4) [C] The following items are exempt, unless specifically designated for PMI on the Purchase Order:
- a) Alloy components, where the alloy is installed for product purity consideration only. Owner shall specify PMI requirements if special alloy requirements are needed for environmental concerns.
  - b) Internal machinery parts.
  - c) Internal instrument parts, including orifice plates.
  - d) Electrical components.
  - e) Non-pressure-containing welds.
  - f) Stainless steel instrument tubing and copper tubing with an outside diameter of  $\frac{3}{4}$  in. and less, when properly identified by paint stencil (exchanger tubing is not included in this exemption).
  - g) Stainless steel instruments installed in carbon steel piping circuits.
  - h) Compression-type ferrules fittings and components (e.g., valves, filters, etc.) for use with  $\frac{3}{4}$  in. outside diameter and smaller tubing.
  - i) Steam tracing, instrument air, and hydraulic tubing.
  - j) All [ASTM A 193/A 193M](#) Grade B7 bolting.
  - k) [\*] All gaskets, except as required by Section 3, Item (2d), or Owner's Representative, based on criticality of service.
- 5) [R] Supplier shall provide a documented PMI program to ensure conformance of components to the specified composition for the following items listed. This program may include segregation procedures for tested material, marking, and/or random sampling. Owner shall approve (in writing) acceptance of the supplier's PMI program for internal non-pressure-containing components (as listed in this paragraph).

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- a) Internal non-pressure-containing parts.
- b) Metallic alloy components for refractory linings (e.g., refractory anchors and hex mesh) shall be covered under this requirement.

## 4. General Requirements

- 1) **[R] [\*]** Fabricator or Vendor shall provide a PMI program (including a detailed PMI procedure) to comply with the requirements of this Practice and/or as specified by Owner's Engineer.
- 2) **[A] [R]** Owner's Engineer approval of the PMI program/procedure shall be obtained prior to the start of fabrication. Owner's Inspector shall witness tests and perform audits to ensure that PMI program requirements are met. It is the Contractor's responsibility to ensure that implementation of the PMI program is in accordance with this Practice. Owner's Engineer approval of the PMI program shall be obtained prior to the start of fabrication. The Owner's Inspector shall witness the first article and 10 percent random sampling of all remaining PMI testing thereafter. It is the Contractor's responsibility to ensure that implementation of the PMI program is in accordance with this Practice.
- 3) **[R]** Records of PMI results shall be provided to Owner's Engineer as part of the As-Built documentation.
  - a) For fabricated or assembled equipment, these records shall include an itemized list of all components and welds on Data Sheet [T181201C01](#), or its equivalent.
  - b) Tabulation of tested items shall be keyed to As-Built drawings through the use of reference numbers.
  - c) Positively identified materials shall be traceable to any required material documentation, such as mill test reports.
  - d) **[A]** Shop fabricated equipment or assemblies that have been PMI tested in the Supplier's shop need not be verified again in the field. The Supplier's report of alloy verification shall be submitted to Owner's Engineer for review upon completion of the equipment.
- 4) **[R]** Materials requiring PMI [per Section 3, Items (1–3)] shall be analyzed using an acceptable method as defined in this Practice.
  - a) Instruments shall be used in an analysis mode. The accuracy of the instrument shall be checked by measurement against a known standard of each alloy type. Measured values shall meet acceptance criteria per Section 5.
  - b) **[A]** Instruments may be used in an alloy identification or alloy matching mode, when approved by Owner's Engineer. Follow-up analysis is required when alloy identification does not comply with the specified alloy.
- 5) **[R]** When 100 percent PMI is required per Section 3, Item (1), PMI testing shall be performed according to one of the following:
  - a) On all components and welds, when the equipment (e.g., pipe spool, vessel, heat exchanger or heater) has been completely fabricated, but may be performed prior to PWHT.
  - b) On individual components prior to fabrication, if physical access is no longer possible during final construction, provided that they are both PMI and alloy type marked. Following fabrication, all welds shall be PMI inspected per Section 4, Item (7). Alloy type marking shall meet the same requirements as described for PMIV marking in Section 6.

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- c) On each individual section of reinforced hose requiring PMI (Section 3, Item (1b.iii)) prior to installation. Sections will be marked AV.
- 6) **[R]** Where representative sampling is allowed, pieces may be tested upon receipt. Such pieces shall be marked PMIV (Positive Materials Identification Verified) or AV (or Alloy Verified). Items from the same lot that are not tested shall be marked PMI.
  - a) If any piece from the representative sample is unacceptable, each piece of the lot shall be examined.
  - b) When a lot is found to contain unacceptable pieces, 100 percent of the next two lots from the same Supplier shall be examined. If both lots are acceptable, or when two successive lots are acceptable, the sampling procedure defined in Section 2 may be resumed.
- 7) **[A] [R]** All welds requiring PMI shall be PMI inspected, identified in the records, and marked PMIV or AV. Prior to heat treatment, painting, or insulating, Owner's Engineer shall verify that materials have been installed in accordance with the Specification. Welds requiring PMI shall be inspected according to the following:
  - a) Automated welding—one sample from each girth or long seam.
  - b) Manual welding—two samples from each girth section  $\geq 24$  in. diameter.
  - c) Manual welding—one sample from each girth seam  $< 24$  in. diameter.
  - d) Autogenous welded pipe and fitting—PMI verification of only the base metal is required.
  - e) Weld repair—one sample PMI testing per 24 in. of length for each weld repair.
- 8) Weld Consumables:
  - a) **[\*]** Prior to use in fabrication, sample buttons shall be welded using each heat of bare wire and lot of covered or flux-cored electrodes, and PMI tested based on the approved Seller's PMI Program and Procedures. A button of bare wire is not necessary if the PMI instrument can examine wire. Button size shall be a minimum 1.0 inch diameter (25.4 mm) with a minimum  $\frac{3}{8}$  inch (.375 inch /9.5 mm) thickness of deposited weld metal.
  - b) After successful PMI qualification, all welding consumables used for fabrication shall be segregated and uniquely identified from all other welding materials in the Seller's shop.
  - c) A list of acceptable material heat, lot, and batch numbers shall be developed and clearly identified on the documentation accompanying each vessel in the Seller's shop.
  - d) If the alloy is incorrect, the entire heat or lot shall be rejected.
- 9) **[\*] [R]** Owner's Engineer shall specify the material composition of bimetallic or duplex stainless steel welds.

## 5. Acceptance Criteria

**[R]** For all materials requiring PMI, acceptance criteria shall be as follows:

- 1) Analysis Mode Examination: the measured value of alloying elements shall be within 10 percent of the specified level or range in the applicable materials standards (example: for 5 Cr, where the allowable range is 4–6 percent, the measured value shall fall within the range 3.6 to 6.6 percent). Requirements for minor alloying elements are defined in Table 1 notes.

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- 2) Alloy Identification or Alloy Matching Mode Examination: the instrument shall confirm that alloys comply with the specified standard, within the accuracy given in Section 5, Item (1).
- 3) Test results shall conform to purchase documents and be properly identified to the applicable materials specifications. Materials shall be color coded in accordance with Owner's Specification, and marked per Section 6, of this Practice.
- 4) For weld metal PMI testing, or joints of similar base metals with matching filler, the acceptance criteria are based on the requirements of ASME Section II, Part C ([ASME SEC II C INTRO](#)).
- 5) **[R]** If PMI test results indicate that the component is not the specified material, the item shall be rejected.
  - a) Whenever materials are identified as incorrect, a rejection note shall be issued indicating unacceptable materials have been supplied.
  - b) Vendor or Fabricator shall be responsible for replacing the material with the correct specified material and for performing PMI on all replacement materials.
  - c) Material rejected by PMI shall be marked to designate rejection using indelible ink or paint. The rejected items shall be held in a designated area to prohibit their re-use.
  - d) If the PMI test results fall outside the acceptable range, using the standard instruments described in this Practice, Vendor may obtain a quantitative check analysis performed by an independent testing laboratory. If no method is referenced in the applicable materials standard, an appropriate method of chemical analysis, as specified in this Practice, shall be used. Results of this analysis shall govern.

## 6. Marking

- 1) **[R]** Each component (or weld) shall be marked immediately after PMI inspection and acceptance. Markings shall be permanent and readily visible. These markings shall be in addition to markings required by applicable Codes.
- 2) **[A]** Each component or weld analyzed shall be marked with the "PMIV" or "AV" code letter symbol, using a low stress stamp or other marking approved by Owner. A permanent dye or paint may be used to mark bolts and tubing. The marking shall be placed as follows:
  - a) Pipe shall have two marks, 180 degrees apart, 75 mm (3 in.) from each end of each length on the outer surface of the pipe.
  - b) Weld marks shall be placed adjacent to the welder's mark, directly on the weld. Welds on tubes in heat transfer shall not be stamped, but marked by either stenciling or vibro-etching.
  - c) Weld overlay and backclad material may have Positive Materials Identification noted on As-Built drawings. Marking of vessel equipment is not required.
  - d) Fittings and forgings shall be marked adjacent to the Supplier's markings.
  - e) Valves shall be marked adjacent to the Supplier's markings on bodies and other pressure parts.
  - f) Plates shall be marked adjacent to the heat numbers.
  - g) Castings shall be marked adjacent to the Supplier's markings and heat numbers.
  - h) Tubes for Heat Transfer Service shall be stenciled—not stamped—300 mm (12 in.) from each end.

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- i) The marking shall be done with a water-insoluble material that contains no harmful substance, such as metallic pigments (aluminum [Al], lead [Pb] and zinc [Zn], sulfur or chlorides), that would attack or harmfully affect austenitic or nickel alloy steels at ambient or elevated temperatures.
- ii) The chloride and sulfur content of water insoluble materials shall be limited to one percent or less as determined by [ASME SEC V B SD-808](#) and [ASME SEC V B SD-129](#), or equivalent.
- iii) Supplier shall submit an analysis of the marking material to the purchaser to demonstrate, by chemical analysis and history of use, that the marking material meets the requirements.
- i) Bolting shall be marked on one end.
- j) Nuts shall be marked on one flat.
- 3) If the material or item is too light, too small, or cannot otherwise be stamped, vibro-etching or color-coding shall be applied in conjunction with the Supplier's standard. Such shall be noted on the Alloy Verification Reports.
- 4) When heat treatment is performed after material verification, the identification marking shall be recognizable after such heat treatments. If the marking is unrecognizable, PMI testing shall be repeated.
- 5) When an alloy pipe or plate is cut after PMI testing and marking, the marking shall be transferred onto the unmarked section as described in this Section.

## 7. Acceptable Methods for PMI

- 1) [\*] [R] Positive Materials Identification (PMI) shall verify that the alloy is as specified. When elemental analysis is carried out, minimum elements to be tested for each alloy type are listed in Table 1. For alloys not included in Table 1, Owner shall submit proposed elements. The instrument employed shall be used to verify the major alloy constituents of the material.

**Table 1: Identification Elements <sup>(1)</sup>**

| Materials             | Identification Elements | Materials               | Identification Elements                   |
|-----------------------|-------------------------|-------------------------|-------------------------------------------|
| C - 1/2 Mo            | Mo                      | Alloy 20Cb-3            | C <sup>(2)</sup> , Cr, Ni, Mo, Cb, Cu     |
| 1 Cr - 1/2 Mo         | Cr, Mo                  | Brass, Admiralty        | Sn                                        |
| 1 1/4 Cr - 1/2 Mo     | Cr, Mo                  | Brass, Naval            | Sn                                        |
| 2 1/4 Cr - Mo         | Cr, Mo                  | Brass, Aluminum         | Zn, Al                                    |
| 5 Cr - 1/2 Mo         | Cr, Mo                  | 90/10 Cu/Ni             | Cu, Ni                                    |
| 7 Cr - 1/2 Mo         | Cr, Mo                  | 70/30 Cu/Ni             | Cu, Ni                                    |
| 9 Cr - 1 Mo           | Cr, Mo                  | Alloy 400               | Ni, Cu                                    |
| 12 Cr (Type 405/410S) | C <sup>(2)</sup> , Cr   | Titanium Grades 1 and 2 | Ti                                        |
| 12 Cr (Type 410)      | Cr                      | Grade 12 Ti             | Ti, Mo <sup>(2)</sup> , Ni <sup>(2)</sup> |
| 17 Cr (Type 430)      | Cr                      | Grade 16 Ti             | Ti, Pd <sup>(2)</sup>                     |

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| Materials        | Identification Elements       | Materials                    | Identification Elements   |
|------------------|-------------------------------|------------------------------|---------------------------|
| 25 Cr (Type 446) | Cr                            | Grade 26 Ti                  | Ti, Ru                    |
| 304              | Cr, Ni                        | Alloy 182                    | Ni, Cr                    |
| 304L             | C <sup>(2)</sup> , Cr, Ni     | Alloy 600                    | Ni, Cr                    |
| 304H             | C <sup>(2)</sup> , Cr, Ni     | Alloy 625                    | Ni, Cr, Mo, Cb, Ti        |
| 309L             | C <sup>(2)</sup> , Cr, Ni     | Alloy 800                    | Ni, Cr, Al, Ti            |
| 309 CbL          | C <sup>(2)</sup> , Cr, Ni, Cb | Alloy 825                    | Ni, Cr, Mo, Cu, Ti        |
| 310              | Cr, Ni                        | AISI 4140                    | C <sup>(2)</sup> , Cr     |
| 316/317          | Cr, Ni, Mo                    | AISI 4340                    | C <sup>(2)</sup> , Cr, Ni |
| 316L/317L        | C <sup>(2)</sup> , Cr, Ni, Mo | Alloy 2205                   | Cr, Ni, Mo                |
| 321              | Cr, Ni, Ti                    | Alloy 2507                   | Cr, Ni, Mo                |
| 347              | Cr, Ni, Cb                    | 3.5, 5 and 9 Ni              | Ni                        |
|                  |                               | Alloy C-276                  | Ni, Cr, Mo, W             |
|                  |                               | ASTM A533 Grades B, C, and D | Ni, Mo                    |

Notes to Table 1:

<sup>(1)</sup> Acceptance criteria for Identification Elements shall be per Section 5, Item (1).

<sup>(2)</sup> Owner's Engineer shall specify requirements for minor alloying elements (e.g., low carbon in Type 304L SS or Type 410S SS, minor alloying elements in various grades of titanium) using guidance in Section 7 Item (4f).

|  |
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- 2) **[R]** Instruments or methods used for examination when used in either the element analysis or alloy identification mode shall include:
  - a) **[A]** Testing shall be performed according to the alloy analyzer Manufacturer's procedures. Owner's Engineer shall approve any modification of such procedures.
  - b) Each analyzer shall be calibrated according to Manufacturer requirements. At the beginning and end of each shift, the instrument shall be checked at least three times against a known standard for each alloy type to be inspected during the shift, using the method to be used during the shift. This check shall be performed under environmental conditions similar to the test location.
  - c) Accuracy as measured against the standard shall meet requirements in Section 5, Item (1).
  - d) When confirming results of alloys not correctly identified in the alloy identification mode, instruments shall provide quantitative, recordable, elemental composition results for positive identification of the alloy elements present.
- 3) **[A] [R]** Persons performing the PMI shall demonstrate their capabilities to the satisfaction of Owner's Engineer. Qualifications of the tester, including training and experience, shall be included in the PMI program required by Section 4, Item (1).



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- 4) **[A] [R]** PMI shall be conducted using equipment approved by Owner's engineer. The following are requirements to obtain approval.
- Equipment shall be one of the following devices suitable for the elements to be determined as required in Table 1.
    - Use of quantitative, portable X-ray fluorescence analyzers per [API RP 578](#) paragraph 5.21
    - Use of portable optical emission analyzers per [API RP 578](#) paragraph 5.22
  - The specific device (manufacturer, model number) shall be identified within the submitted PMI procedure.
  - Equipment shall have demonstrated as per Section 5 Item (1), +/- 10% accuracy of the actual value for all elements analyzed. This shall be documented within the submitted procedure with example data results for alloy element combinations required for the proposed job.
  - [\*]** If the Owner's Engineer is not satisfied with the submitted device information for approval. A procedure for further qualification of instruments may be provided by the Owner's Engineer.
  - Care shall be taken to not damage critical surfaces (e.g., bearings) when using optical emission analyzers.
  - Analytical laboratories using X-ray fluorescence spectrometry, optical spectroscopy, or wet chemical analysis may be used for verification in cases where test results by other methods differ from Mill Certificate data.
  - Suitable methods for identifying minor elements include: specialized laboratory instrumentation, suitable optical emission analyzers, traceable mill certificates, or a combination of traceable mill certificates and chemical analysis using lower measurement sensitivity.
- 5) **[A]** Owner's Engineer may approve PMI methods other than those listed in Section 7, Item (4) (e.g., magnetic) for austenitic stainless steel (e.g., 304SS or 316SS) base metal in cryogenic (and non-corrosive) service.

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## Record of Change

|                        |               |                                                                                                                                                    |
|------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Version 1.0.0</b>   |               | <b>Date: 07/01</b>                                                                                                                                 |
| <b>Location</b>        | <b>Action</b> | <b>Description</b>                                                                                                                                 |
|                        |               | Initial Publish.                                                                                                                                   |
| <b>Version 1.1.0</b>   |               | <b>Date: 12/03</b>                                                                                                                                 |
| Section 1.1            | Deletion      | Deleted reference to GP 19-02-01.                                                                                                                  |
| Section 1.1            | Addition      | Added references to GP 05-01-01 and GP 18-07-01.                                                                                                   |
| <b>Version 1.1.0</b>   |               | <b>Date: 12/03</b>                                                                                                                                 |
|                        |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |
| <b>Version 2.0.0</b>   |               | <b>Date: 06/05</b>                                                                                                                                 |
| Section 3, Item (1b)   | Addition      | [*] Added requirement for material identification of braided hosing in critical services as specified.                                             |
| Section 3, Item (2e)   | Addition      | Added requirement for PMI testing on sampling basis for refractory supports.                                                                       |
| Section 4, Item (8)    | Addition      | Added requirement for weld consumable qualification pre-fabrication.                                                                               |
| Section 7, Item (1)    | Modification  | Table 1: some material identification was modified.                                                                                                |
| Section 7, Item (4)    | Addition      | [*] Added option to permit alternative instruments to be qualified for PMI testing with an approved testing protocol.                              |
| Section 7, Item (4iii) | Addition      | [*] Added Niton XL 800 to approved instruments list.                                                                                               |
| Section 7, Item (4)    | Deletion      | [*] Removed Niton XL 818, 2XL800 and XL 808 from approved instruments list.                                                                        |
| <b>Version 3.0.0</b>   |               | <b>Date: 03/09</b>                                                                                                                                 |
| Section 2              | Modification  | Redefined Representative Sampling to be based on statistical confidence. Added PMI Program and PMI Procedure definitions.                          |
| Section 3, Item (1)    | Addition      | Addition of [S] Purpose Code.                                                                                                                      |
| Section 3, Item (2e)   | Addition      | Added requirement of representative sampling for sheet products.                                                                                   |
| Section 3, Item (5)    | Modification  | Revised wording to clarify intent.                                                                                                                 |

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| Section 4, Item (1)         | Deletion      | Removed [S] purpose code.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Section 4, Item (2)         | Addition      | Added requirements regarding witness of PMI by Owner's Inspector.<br>Added [A].                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Section 4, Item (5b)        | Modification  | Specified requirements on final construction verification.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Section 4, Item (8a)        | Addition      | Added button size requirements.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Section 7, Table 1          | Addition      | Added Alloy C-276 and ASTM A533 to Table 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Section 7, Item (4)         | Deletion      | Removed approved instruments list.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Section 7, Item (4)         | Addition      | Added guidance for qualified PMI instruments.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>All Global Practices</b> | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Process Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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# Paint and Protective Coatings

## GP 19-01-01

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### Scope

- 1) [I] This Global Practice (GP) covers the selection and application of exterior paint and Protective Coating Systems for structures and equipment. Requirements for protective wrapping systems and galvanizing of structures are also covered.
  - 2) \* [I] An asterisk (\*) indicates that a decision by the Purchaser is required, or that additional information is furnished by the Purchaser.
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## 1. Required References

- 1) [I] This Section lists Practices and Standards that are generically referenced and assumed to be a part of this document. Unless otherwise specified herein, use the latest edition.
- 2) \* [I] Other National Standards or Codes may be substituted for those listed as directed by the Purchaser.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                        |
|-----------------------------|------------------------|
| <a href="#">GP 14-01-01</a> | External Insulation    |
| <a href="#">GP 04-07-01</a> | Piles and Sheet Piling |

### 1.2. AWS–American Welding Society

|                           |                                                                                                                      |
|---------------------------|----------------------------------------------------------------------------------------------------------------------|
| <a href="#">AWS C2.18</a> | Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and Their Alloys and Composites |
|---------------------------|----------------------------------------------------------------------------------------------------------------------|

### 1.3. AWWA–American Water Works Association

|           |                                                                                                    |
|-----------|----------------------------------------------------------------------------------------------------|
| AWWA C203 | Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied |
| AWWA C215 | Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines                             |

### 1.4. ASTM–American Society for Testing and Materials

|                                   |                                                                                                                  |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM A 123/A 123M</a> | Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products                         |
| <a href="#">ASTM D 2240</a>       | Standard Test Method for Rubber Property - Durometer Hardness                                                    |
| <a href="#">ASTM D 2583</a>       | Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor                   |
| <a href="#">ASTM D 3363</a>       | Standard Test Method for Film Hardness by Pencil Test                                                            |
| <a href="#">ASTM D 4263</a>       | Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method                             |
| <a href="#">ASTM D 4417</a>       | Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel                            |
| <a href="#">ASTM D 4752</a>       | Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub |
| <a href="#">ASTM D 5402</a>       | Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs                    |

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|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM F 1869</a> | Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|

## 1.5. NACE–National Association of Corrosion Engineers

|                             |                                                                                                                   |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------|
| <a href="#">NACE RP0274</a> | High-Voltage Electrical Inspection of Pipeline Coatings                                                           |
| <a href="#">NACE RP0287</a> | Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using a Replica Tape                |
| NACE RP0188                 | Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates                               |
| <a href="#">NACE RP0198</a> | Control of Corrosion Under Thermal Insulation and Fireproofing Materials - A Systems Approach                     |
| <a href="#">NACE RP0394</a> | Application, Performance, and Quality Control of Plant-Applied, Fusion-Bonded Epoxy External Pipe Coating; Errata |

## 1.6. SSPC–The Society for Protective Coatings

|                    |                                                                                                                              |
|--------------------|------------------------------------------------------------------------------------------------------------------------------|
| SSPC PA 1          | Shop, Field, and Maintenance Painting (Steel Structures Painting Manual, Ch 5 - Paint Application Specs.)                    |
| SSPC PA 2          | Measurement of Dry Coating Thickness with Magnetic Gages (Steel Structures Painting Manual, Ch 5 - Paint Application Specs.) |
| SSPC PA GUIDE 3    | Guide to Safety in Paint Application (Steel Structures Painting Manual, Ch 5 - Paint Application Specs.)                     |
| SSPC PS GUIDE 8.00 | Guide to Topcoating Zinc-Rich Primers                                                                                        |
| SSPC AB 1          | Mineral and Slag Abrasives                                                                                                   |
| SSPC AB 2          | Cleanliness of Recycled Ferrous Metallic Abrasives                                                                           |
| SSPC AB 3          | Newly Manufactured or Re-Manufactured Steel Abrasives                                                                        |
| SSPC SP 1          | Solvent Cleaning (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)                                       |
| SSPC SP 3          | Power Tool Cleaning (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)                                    |
| SSPC SP 5          | White Metal Blast Cleaning NACE No. 1-2000 (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)             |
| SSPC SP 6          | Commercial Blast Cleaning NACE No. 3-2000 (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)              |
| SSPC SP 8          | Pickling (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)                                               |

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|            |                                                                                                                                                                                            |
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| SSPC SP 10 | Near-White Metal Blast Cleaning NACE No.2-2000 (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)                                                                       |
| SSPC SP 11 | Power Tool Cleaning to Bare Metal                                                                                                                                                          |
| SSPC SP 13 | Surface Preparation of Concrete                                                                                                                                                            |
| SSPC VIS 1 | Visual Standard for Abrasive Blast Cleaned Steel (Standard Reference Photographs) Editorial Changes September 1,2000 (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.) |
| SSPC VIS 3 | Visual Standard for Power- and Hand-Tool Cleaned Steel (Standard Reference Photographs)                                                                                                    |

- 3) \* [R] Vendor shall prepare a detailed Painting Schedule including (but not limited to) the information listed below, for approval by the Owner's Engineer.
- Detailed scope
  - Surface preparation
  - Materials
  - Application
  - Inspection procedures and documentation
  - Provisions for handling and storage of paints and coatings at the site
  - Plans for conformance to national, state, and local environmental law

## 2. Definitions

- [I] Bare surfaces as referred to in this GP shall be defined as surfaces, equipment, or structures that are not insulated or fireproofed.
- [I] Marine atmosphere as referred to in this GP shall be defined as containing a high concentration of chlorides and water in the air.
- [I] Intermittent service (see Table 7) is one in which the process temperature cycles on a recurrent basis, into and out of the 25°F to 300°F (–4°C to 150°C) range.

## 3. Documentation

- [R] Coatings application contractor shall submit proof of certification by the Society for Protective Coatings (SSPC) to SSPC QP1 or QP3 as applicable, or equivalent.
- [R] Coatings application contractor shall submit a list of its most recent industrial experience plus names and telephone numbers of people who can verify this experience.
- [R] Coatings application contractor shall submit plans for Quality Assurance and Quality Control, the names of their coating inspectors and the degree of their training.

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## 4. Selection of Paint and Coating Systems

### 4.1. Painting Service Category

- 1) \* [O] The paint system to be used for external surface protection of individually purchased equipment items, shop assembled sections (modular or package units furnished as subassemblies or complete), and other field erected facilities as shown in Table 4 of this GP shall be based on the type of atmospheric exposure. Category designation shall be according to Table 5.
- 2) [I] Selection requirements for other painting and coating systems shall be according to the following Tables and other requirements of this Practice.
  - a) Table 8: Special Service Paint and Coating Systems Carbon Steel Construction
  - b) Table 9: External Coating and Wrapping Systems for Underground and Underwater Piping (to 120°F) - Metallic and Nonmetallic Construction
  - c) Table 10: Coating Systems for Concrete
  - d) Table 11: Coating Systems for Steel Piles and Sheet Piling
  - e) Table 12: Paint and Coating System for Mooring Buoys and Other Floating Structures
  - f) Table 13: Use of Thermal Spray Aluminum

### 4.2. Use of Galvanizing

[I] Hot-dip galvanizing may be substituted for Category I and II painting systems when the evaluated cost is equivalent. Galvanizing on steel products, including fasteners, shall be according to [ASTM A 123/A 123M](#). High strength bolting (>150,000 psi [1100 MPa] ultimate tensile strength) shall not be hot-dip galvanized, but shall be coated by mechanical galvanizing or with an inorganic zinc rich primer.

### 4.3. Types and Brands of Paints and Coatings

- 1) \* [R] A listing of acceptable brands of paints and protective coatings, conforming to the generic descriptions according to Table 3 and Table 4, shall be developed by Contractor and approved by Owner's Engineer. The selection shall take into account the following:
  - a) Paint and protective coating brands selected on the basis of availability and cost per mil per ft<sup>2</sup> per year of life.
  - b) Primers, finish and topcoats for any particular system from the same manufacturer to assure compatibility and to minimize potential liability issues.
  - c) Local or federal legislation concerning pigments, volatile organic content (VOC), or other materials restrictions.
- 2) \* [I] Except where manufacturer standard is permitted, Vendor proposal to use paints and coatings alternative to those specified shall be submitted to Purchaser for approval.

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## 5. Surface Preparation

- 1) [I] Surface preparation methods and materials for carbon steel shall take into account the following:
  - a) Surface preparation, either in the shop or field, may be employed based upon an economic evaluation including local, state, or federal legislation concerning blast cleaning abrasives.
  - b) Equipment and structures to be painted in the field: Where surface preparation alternatives are permitted, Purchaser shall make a surface preparation cost study and specify the optimum method to be used, taking into account:
    - i) Local rules or regulations governing hygiene, environment and safety.
    - ii) Proximity of adjacent structures and equipment liable to damage from abrasives.
    - iii) Proximity of designated operating areas where personnel may be present.
    - iv) Any effect on coating performance.
  - c) Purchaser shall submit the results of evaluations according to Items 1a) or 1b) of this Section to the Owner's Engineer.
  - d) Surfaces contaminated by oil and grease shall be solvent cleaned according to SSPC SP 1 prior to any blast cleaning.
  - e) Blasting abrasive quality shall be according to SSPC AB 1, SSPC AB 2, or SSPC AB 3, as applicable.
  - f) Abrasive material for blast cleaning, consisting solely of steel shot shall not be used for surfaces to be coated with inorganic zinc-rich primers or fusion-bonded epoxy coatings. A mixture consisting of steel shot and at least 25 percent (wt) steel grit is acceptable.
  - g) SSPC SP 11 is suitable surface preparation for small repair areas or for field welds where SSPC SP 10 or better had been originally specified and/or performed. SSPC SP 11 provides good surface cleanliness, roughly equivalent to SSPC SP 10, and it ensures a minimum surface profile of 1.0 mil.
- 2) [I] New concrete surfaces to be coated (other than concrete fireproofing) shall be prepared according to the following:
  - a) Concrete shall have cured for at least 30 days. Surfaces above grade shall be tested according to [ASTM D 4263](#) and have no moisture detected. On-grade slabs and surfaces below grade, shall be tested according to [ASTM F 1869](#) and have a moisture vapor emission of  $\leq 3$  lbs (per 1000 ft<sup>2</sup> over 24 hours).
  - b) Surface preparation of concrete shall be according to SSPC SP 13.
  - c) Surface defects shall be patched with a material recommended by the coating manufacturer to provide a smooth surface suitable for the coating application.

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## 6. Application of Paint, Coating, and Wrapping Systems

### 6.1. Manufacturer's Recommendations

- 1) [R] Manufacturer recommendations for the application of paints and coatings and SSPC PA 1 shall be followed unless modified by this Practice.
- 2) [R] Spray application shall be used with inorganic zinc-rich primers, with the exception of small areas for touch-up.

### 6.2. Underground and Underwater Piping

- 1) \* [R] Table 9 lists acceptable external coating and wrapping systems for underground and underwater piping with operating temperatures up to 120°F (50°C). For higher temperatures, the protective system shall be specified.
- 2) \* [R] Proposals for alternative coating systems shall be submitted to Purchaser for approval by the Owner's Engineer.
- 3) [R] Underground or underwater piping joints (including welded joints) shall not be painted, coated, or wrapped until after completion of field pressure testing.

### 6.3. Waterproof Coatings and Underground Concrete Structures

- 1) \* [R] Underground air ducts for fired heaters: Table 10 lists acceptable coating systems to be applied to external concrete surfaces, for waterproofing purposes. Proposals for alternative coating systems shall be submitted to Purchaser for approval by the Owner's Engineer.
- 2) [R] Underground, liquid retaining, concrete structures: A waterproof coating according to Table 10 shall be applied to the external surfaces of concrete structures that are internally lined. Alternatively, plastic sheeting may be used to prevent ground water permeation of the concrete.

### 6.4. Manufacturer's Standard Painting for Purchased Equipment

- 1) [O] Industrial atmospheres: Purchased equipment (limited to machinery, including drivers and auxiliaries supplied by the equipment vendor, instruments, valves, motors, transformers, and enclosures for switchgear) shall be painted by the manufacturer using its standard paint system. Damaged prime or finish coats shall be repaired with an equivalent coating.
- 2) [O] Marine and corrosive chemicals atmospheres shall be governed by the following:
  - a) Instruments, motors, transformers, and enclosures for switchgear may be coated with the manufacturer standard paint. Manufacturer shall be advised of the environment.
  - b) Purchased equipment (limited to machinery, including drivers and auxiliaries supplied by the equipment vendor and valves) shall have the surface preparation and prime coats completed at manufacturer shop according to Table 7. At the option of the Purchaser, finish coats may also be shop-applied.
  - c) Damaged coatings shall be repaired using the prescribed surface preparation and paint system.

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## 6.5. Steel Piles and Sheet Piling

- 1) \* [R] Land structures: The need for protective coatings on steel piles (pipe or structural), and on sheet piling and structural appurtenances shall be specified. Coating systems shall be according to Table 11.
- 2) [R] Marine facilities (fresh or salt water). Steel piles (pipe or structural), and sheet piling and structural appurtenances, shall be coated. Coating systems shall be according to Table 11.

## 6.6. Surfaces Not Requiring Painting

- 1) \* [I] The following metallic surfaces and materials do not require painting or coating unless otherwise specified:
  - a) Non-ferrous metals
  - b) Austenitic stainless steels
  - c) Galvanized or aluminum-coated carbon steel surfaces
  - d) Carbon steel surfaces to be insulated, where the equipment is in continuous service with (fluid) operating temperatures outside the range of 25°F to 300°F (-4°C to 150°C)
- 2) \* [I] The following non-metallic surfaces and materials do not require painting or coating unless specifically required according to Table 10 or by the Owner's Engineer.
  - a) Building brick, masonry units and wall tile.
  - b) Concrete structures and foundations.
  - c) Plastic and plastic coated materials.
  - d) \* Concrete or gunite fireproofing in mild industrial exposure. When specified, concrete or gunite fireproofing shall be top-coated with two coats of 100 percent acrylic latex paint (Table 3 Code a). Epoxy coatings and silane or silicate waterproofing penetrant treatments are also acceptable with Owner's Engineer approval.

## 6.7. Shielding of Adjoining or Adjacent Equipment

[M] Temporary shielding shall be used during any surface preparation and application of coatings to prevent damage or contamination to adjoining or adjacent equipment from abrasives, water, dust, or paint. Such equipment includes (but is not limited to):

- 1) Exposed machined surfaces (i.e., operating shafts, couplings, lubrication fittings, linkages, valve stems)
- 2) Glass (used for instrument cases, level gauges, lighting fixtures)
- 3) Exposed surfaces of packing glands, seals and bearings
- 4) Equipment openings (i.e., air intakes, vents, cooling air inlets)
- 5) Information and identification labels (i.e., switch plates, instrument dials, nameplates, caution and warning signs)
- 6) Exposed austenitic stainless steel surfaces—contamination resulting from overspray or spillage shall be removed

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## 6.8. Piping and Welded Joints

\* [R], [C] The following aboveground piping joints (including all welds and bonds) shall be left unprimed and unpainted for examination during field pressure testing (leak testing):

- 1) Joints requiring sensitive leak tests
- 2) Joints located in an environmentally sensitive area as specified by the Owner's Engineer
- 3) Where Type M fluids (per [ASME B31.3](#)) are contained

## 6.9. Fireproofed or Insulated Equipment and Structures

- 1) [R] Protective coating systems for use under thermal insulation shall be according to Table 7.
- 2) [R] Bare metal surfaces of piping, vessel nozzles and manways, structural steel extensions and similar attachments extending beyond fireproofing or insulation shall be protected with a complete coating system according to the painting service category for the bare steel at the equipment operating temperature.
- 3) \* [R] Owner's Engineer shall specify protective coatings or wrapped aluminum foil sheathing according to [GP 14-01-01](#), to protect thermally insulated austenitic stainless steel equipment from chloride stress corrosion cracking.
- 4) [I] The minimum operating temperature of a vessel, exchanger or other equipment shall be considered when determining the need for coating beneath insulation.
- 5) \* [M] When specified by the Owner's Engineer, personnel protection cages will be used instead of insulation to minimize the occurrence of corrosion under insulation.

## 6.10. Direct Contact Attachment of Structural Steel

[R], [M] Direct contact surfaces of non-galvanized components which are bolted or attached with intermittent welding, shall be protected according to the following:

- 1) Surfaces shall be painted with the primer system according to the specified painting service category.
- 2) A coating of an elastomeric mastic or petrolatum paste and tape shall be applied to both contact surfaces. Coating shall be  $\frac{1}{8}$  in. (3 mm) wet film thickness.
- 3) After erection, the space between plates and at the outer edges shall be filled with elastomeric mastic before finish coat application.

## 6.11. Repair of Damaged Galvanizing

\* [R], [M] Galvanized steel that is damaged by welding shall be repaired with a suitable coating system as approved by the Owner's Engineer.

## 6.12. Paint System and Safety Equipment Identification

- 1) \* [S] Painting requirements covering number or service identification of equipment, pipelines and structures, and special color identification shall be specified. If not otherwise specified, the identification colors listed in Table 6 shall be used.
- 2) [M] Information regarding the Protective Coating System shall be stenciled on the exterior surface of equipment and structures according to the following:

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- a) Vessels and tankage—shell and roof, interior and exterior as applicable:
  - i) Surface preparation—identify method(s) used (i.e., SSPC SP 6).
  - ii) Identify the manufacturer and product number for each coat—primer, intermediate, and finish coats.
  - iii) Month and year of application.
  - iv) Contractor name.
  - v) Lead, chromium, and or cadmium content of any coating.
- b) \* [I] Other equipment including pipelines, and structures—the need for and extent of identifying information shall be specified.
- c) The location of identifying information according to Items 2a) and 2b) above shall be specified. Stencil lettering shall be approximately 1½ in. (40 mm) high.

## 7. Inspection and Testing

[I] The term Inspector, used in this Practice, refers to the Owner's representative. For marine, severe industrial, chemical, or lining applications, the Inspector shall be a certified NACE International Coating Inspector or equivalent.

### 7.1. Inspection Methods and Acceptance Criteria

- 1) [R], [M] Surface preparation cleanliness shall be evaluated using SSPC VIS 1 or SSPC VIS 3 visual standards. Surface roughness (anchor pattern or profile) shall be determined according to [NACE RP0287](#) or [ASTM D 4417](#).
- 2) [R], [M] Dry film thickness measurement shall be made of each coat and of the total system, according to the procedure established by SSPC PA 2, with the exception that the inspector may inspect any and all areas and make as many measurements as deemed necessary.
- 3) \* [R] Additional inspection of coatings applied to tank and vessel interiors:
  - a) Continuity shall be checked according to NACE RP0188.
  - b) Degree of cure shall be determined using a solvent wipe test and/or a film hardness test. Where a film hardness test is appropriate, the procedure shall be according to [ASTM D 3363](#), [ASTM D 2583](#), or [ASTM D 2240](#) as deemed suitable for the particular coating.  
Test methods and procedures shall be developed with the Owner's Engineer for the specific installation.
- 4) [R] Protective coatings for underground or submarine pipelines shall be inspected according to the appropriate specification listed in Table 9.
- 5) \* [R], [M] Compliance with governing specifications shall be checked by the Inspector during the entire course of surface preparation and application of the paint, coating or wrapping systems.
- 6) \* [R], [M] Work shall not proceed with the next step in the system sequence (i.e., surface preparation, priming, intermediate, finish coat application) until the previous work has been inspected and approved by the Inspector.

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## 8. Use of Thermal Spray Coatings

- 1) \* [R] When specified by the Owner's Engineer, a thermal spray aluminum (TSA) coating shall be applied to the external surfaces of equipment and piping as an alternative to other paints and coatings, as outlined in Table 13.
- 2) [I] Commercially pure grades of aluminum (such as 1100 or 1350) shall be used.
- 3) [R] Field welds made on equipment and piping coated with TSA require a weld topcoat, as specified in Table 13. The weld topcoat shall be applied at the weld and extend at least 1 in. over the TSA coating to ensure continuous protection.
- 4) \* [I] Procedures for qualifying TSA procedures and applicators, plus the actual production TSA procedures and test records, shall be submitted by the TSA vendor to the Owner's Engineer for review prior to the start of the job.

## 9. Metric Equivalents and Alphanumeric Code Descriptions for Use with Tables 7–13

**Table 1: Acceptable Metric Equivalents for Tables 7-13**

| Coatings and Wrapping |     |                          |        | Other Linear |         | Temperature |     | Pressure             |          |
|-----------------------|-----|--------------------------|--------|--------------|---------|-------------|-----|----------------------|----------|
| Film Thickness        |     | Wrapping                 |        |              |         |             |     |                      |          |
| mils                  | μm  |                          |        |              |         | (as shown)  |     |                      |          |
| 1                     | 25  | 12 mils                  | 300 μm | 12 in.       | 300 mm  | 25          | −4  | 2 RVP <sup>(1)</sup> | 13.8 kPa |
| 1.5                   | 40  | 15 mils                  | 380 μm | 2 ft         | 600 mm  | 150         | 65  | 100 psia             | 690 kPa  |
| 3                     | 75  | 40 mils                  | 1 mm   | 5 ft         | 1500 mm | 200         | 93  |                      |          |
| 4                     | 100 | 60 mils                  | 1.5 mm |              |         | 250         | 121 |                      |          |
| 5                     | 125 | 15 lb/100 ft² (730 g/m²) |        |              |         | 360         | 182 |                      |          |
| 8                     | 200 |                          |        |              |         | 400         | 204 |                      |          |
| in.                   | mm  |                          |        |              |         | 500         | 260 |                      |          |
| 1/32                  | 0.8 |                          |        |              |         | 510         | 266 |                      |          |
| 3/32                  | 2.4 |                          |        |              |         | 560         | 293 |                      |          |
|                       |     |                          |        |              |         | 750         | 400 |                      |          |
|                       |     |                          |        |              |         | 900         | 482 |                      |          |

**Note:**

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| Coatings and Wrapping        |    |          | Other Linear | Temperature |    | Pressure |
|------------------------------|----|----------|--------------|-------------|----|----------|
| Film Thickness               |    | Wrapping |              | °F          | °C |          |
| mils                         | µm |          |              |             |    |          |
| 1) RVP (reed vapor pressure) |    |          |              |             |    |          |

**Table 2: Surface Preparation**

| Code | Description                                  |
|------|----------------------------------------------|
| 1    | SSPC SP 5/NACE #1 White Metal Blast Cleaning |
| 2    | SSPC SP 10/NACE #2 Near White Blast Cleaning |
| 3    | SSPC SP 6/NACE #3 Commercial Blast Cleaning  |
| 4    | SSPC SP 11 Power Tool Cleaning to Bare Metal |

**Table 3: Primers**

| Code                                                                                                                                                                                                                                 | Generic Descriptions                | Typical Dry Film Thickness—Mils <sup>(2)</sup> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------------------------------------------|
| Z <sup>(1)</sup>                                                                                                                                                                                                                     | inorganic zinc                      | 3–4                                            |
| A                                                                                                                                                                                                                                    | acrylic latex                       | 1–2                                            |
| S                                                                                                                                                                                                                                    | silicone high-temperature zinc-rich | 1                                              |
| E                                                                                                                                                                                                                                    | epoxy                               | 3–6                                            |
| U                                                                                                                                                                                                                                    | moisture cured urethane             | 3–4                                            |
| <b>Notes:</b><br>1) Manufacturer's requirements and SSPC PS GUIDE 8.00 shall be followed when applying topcoats to inorganic zinc rich primers.<br>2) These are typical dry film thicknesses; use manufacturer's recommended values. |                                     |                                                |

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**Table 4: Topcoats**

| Code                                                                                    | Generic Descriptions                        | Typical Dry Film Thickness (mils) |
|-----------------------------------------------------------------------------------------|---------------------------------------------|-----------------------------------|
| a                                                                                       | 100 percent acrylic latex topcoat           | 1.5–3.0                           |
| b                                                                                       | phenolic aluminum (two-component)           | 1.0                               |
| c                                                                                       | coal tar epoxy (polyamide or amine cured)   | 8–16                              |
| e                                                                                       | epoxy                                       | 4–8                               |
| h                                                                                       | silicone hi-temperature aluminum (or color) | 1.0–1.5                           |
| m                                                                                       | thermal spray aluminum                      | 10–20                             |
| n                                                                                       | epoxy-phenolic (novolac)                    | 5–8                               |
| p                                                                                       | aliphatic acrylic polyurethane              | 2–4                               |
| s                                                                                       | silicone-acrylic                            | 1–2                               |
| t                                                                                       | temperature indicating (silicone-based)     | 1.5                               |
| u                                                                                       | moisture cured urethane                     | 3–5                               |
| v                                                                                       | vinyl anti-fouling                          | 1–2                               |
| w                                                                                       | petrolatum wax tape                         |                                   |
| <b>Note:</b> These are typical dry film thickness; use manufacturer recommended values. |                                             |                                   |

## 10. Coating Selection Tables

**Table 5: Painting Service Categories**

| Category | Description                                                    | Environmental Corrosion Rate   | Table 7 Reference and Special Conditions                                                         |
|----------|----------------------------------------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------|
| I        | Industrial atmospheres:<br>Class I (mild)<br>Class II (normal) | 1 mpy or less<br>3 mpy or less | Sweating pipelines and equipment shall be coated according to requirements of Marine Atmospheres |

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| Category | Description                                           | Environmental Corrosion Rate | Table 7 Reference and Special Conditions                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------|-------------------------------------------------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| II       | Marine atmosphere<br><br>Severe industrial atmosphere | Over 3 mpy                   | 1. Bare steel flare structures, all structural components of fixed platforms, and associated bolting, shall be coated for marine atmosphere, except where the location is designated as Category I, industrial (mild)<br><br>2. Bare steel structures and equipment within 150-ft radius of a salt water or brackish water cooling tower shall be coated for Marine Atmosphere (regardless of other designated atmospheric exposure conditions for the location). |
| III      | Corrosive chemical atmosphere                         | Over 3 mpy                   | As required, modifications of different painting systems may be specified for the specific chemical(s) handled                                                                                                                                                                                                                                                                                                                                                    |

**Table 6: Safety Equipment Identification Colors**

| Equipment                                                                                                                                                    | Identification Colors                       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Fire protection equipment <sup>(1)</sup> , including<br>1. Fire equipment cabinets<br>2. Mounting areas for portable fire extinguishers                      | Red                                         |
| Pressure relief (Pr) devices and associated car sealed block valves:<br>1. Conventional Pr valves<br>2. Bellows type Pr valves<br>3. Car sealed block valves | Yellow<br>Body–Yellow; Bonnet–Red<br>Yellow |
| <b>Note:</b><br>1) Excludes mobile fire fighting equipment (i.e., automotive fire apparatus).                                                                |                                             |

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**Table 7: Paint Systems for External Protection Carbon Steel Construction**

| Service                                                                                               | Surface Preparation and Coating Code <sup>(1)(2)</sup> |                            |                                                                   |                               |                                    |
|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------|----------------------------|-------------------------------------------------------------------|-------------------------------|------------------------------------|
|                                                                                                       | Industrial Atmosphere                                  |                            | Severe Industrial or Marine Atmosphere                            | Corrosive Chemical Atmosphere |                                    |
|                                                                                                       | Class I (Mild)                                         | Class II (Normal)          |                                                                   | Chemical Fumes                | Chemical Liquids Handled or Stored |
| Bare carbon steel surfaces 250°F and below:                                                           |                                                        |                            |                                                                   |                               |                                    |
| 1. Structural steel, equipment (including pressure vessels and exchangers), and piping                | 3Aaa or<br>3Ee                                         | 2Zaa or<br>2Zep or<br>2Uuu | 2Z <sup>(3)</sup><br>2Uuu                                         | 2ee or<br>2nn                 | 2ee or<br>2nn                      |
| 2. Misc. iron and steel work in pump slab areas to 5 ft above grade where corrosive chemicals handled | 2ee or<br>2nn                                          |                            | 2ee or<br>2nn                                                     | —                             | 2ee or<br>2nn                      |
| 3. Structures, equipment, and piping exposed to chemical fumes                                        | 2ee or<br>2nn                                          |                            | 2ee or<br>2nn                                                     |                               | —                                  |
| 4. Tanks and storage vessels<br>a. External surfaces                                                  | 3Aaa<br>or<br>3Ee                                      | 2Zaa or<br>2Zep or<br>2Uuu | (2Z, 2Zaa,<br>2Zep, 2Zuu) <sup>(3)</sup><br>or<br>2Uuu or<br>2Znn | 2ee or<br>2nn or<br>2Znn      |                                    |
| b. Roof of floating roof tanks                                                                        | 2Zee or<br>2Zbb                                        | 2Zee or<br>2Zbb            |                                                                   |                               |                                    |
| 5. Equipment operating below dew point that sweats                                                    | 2Z <sup>(3)</sup>                                      |                            |                                                                   | 2ee or<br>2nn                 |                                    |
| Purchased equipment (individual commodity purchase with painting by Vendor) limited to:               |                                                        |                            |                                                                   |                               |                                    |
| 1. Rotating machinery including drivers, and auxiliary vessels and piping by equipment vendor         | Manufacturer standard                                  |                            | 2Z <sup>(3)</sup>                                                 | 2ee or<br>2nn                 |                                    |
| 2. Valves                                                                                             | Manufacturer standard                                  |                            | 2Z <sup>(3)</sup>                                                 | 2ee or 2nn                    |                                    |
| 3. Instruments, motors, transformers, and enclosures for switchgear                                   | Manufacturer standard                                  |                            | Manufacturer standard suitable for the specified environment      |                               |                                    |

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| Service                                                                                                  | Surface Preparation and Coating Code <sup>(1)(2)</sup> |                   |                                        |                               |                                    |
|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-------------------|----------------------------------------|-------------------------------|------------------------------------|
|                                                                                                          | Industrial Atmosphere                                  |                   | Severe Industrial or Marine Atmosphere | Corrosive Chemical Atmosphere |                                    |
|                                                                                                          | Class I (Mild)                                         | Class II (Normal) |                                        | Chemical Fumes                | Chemical Liquids Handled or Stored |
| Bare carbon steel surfaces above 250°F for equipment, piping, stacks, and tankage:                       |                                                        |                   |                                        |                               |                                    |
| 1. Not over 500°F                                                                                        | 2Z or 2Zss                                             |                   | 2Z or 2Zss                             | 2Zss                          |                                    |
| 2. Not over 750°F                                                                                        | 2Z or 2Zhh <sup>(4)</sup>                              |                   | 2Z or 2Zhh <sup>(4)</sup>              | 2Zhh <sup>(4)</sup>           |                                    |
| 3. Not over 900°F                                                                                        | 2hh <sup>(4)</sup>                                     |                   | 2hh <sup>(4)</sup>                     | 2hh <sup>(4)</sup>            |                                    |
| Refractory lined reactors subject to hydrogen partial pressures greater than 100 psia:                   |                                                        |                   |                                        |                               |                                    |
| 1. Carbon steel construction                                                                             | 2Stt <sup>(5)</sup>                                    |                   | 2Ztt <sup>(5)</sup>                    | 2Ztt <sup>(5)</sup>           |                                    |
| 2. Carbon moly and 1¼ Cr construction                                                                    | 2Stt <sup>(6)</sup>                                    |                   | 2Ztt <sup>(6)</sup>                    | 2Ztt <sup>(6)</sup>           |                                    |
| Externally insulated surfaces:                                                                           |                                                        |                   |                                        |                               |                                    |
| 1. Equipment and piping in continuous service with operating (fluid) temperatures between 25°F and 300°F | 2nn, 2cc, or 2m <sup>(7)</sup>                         |                   |                                        | 2nn or 2cc                    |                                    |
| 2. Equipment and piping in intermittent service between 25°F and 500°F                                   | 2ss or 2m <sup>(7)</sup>                               |                   |                                        | 2ss                           |                                    |
| 3. Equipment and piping in intermittent service above 500°F                                              | 2 m <sup>(7)</sup> or Note <sup>(8)</sup>              |                   |                                        | Note <sup>(8)</sup>           |                                    |
| Surfaces of structures to be fireproofed (bare carbon steel surfaces):                                   |                                                        |                   |                                        |                               |                                    |
| 1. Gunitite or concrete                                                                                  | 3nn or 3cc                                             |                   |                                        |                               |                                    |
| 2. Alternative fireproof coatings                                                                        |                                                        |                   |                                        |                               |                                    |

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**Notes to Table 7:**

- 1) Designations refer to alphanumeric code according to Tables 2, 3, and 4. Two identical coats are applied when code designation is repeated.
- 2) \*Final color shall be specified.
- 3) Inorganic zinc coatings exposed in marine environments require no topcoat. Inorganic zinc coatings exposed in a severe industrial environment shall be topcoated with system aa, ep, or uu as deemed most appropriate by the Owner's Engineer for the local site conditions and service environment.
- 4) This system must be heat cured. Small items may be baked in an oven to obtain cure but with larger pieces of equipment, this heat cure normally takes place as the equipment is put into high temperature service.
- 5) Temperature indicating paint with distinct color change near 370°F.
- 6) Temperature indicating paint with distinct color change near 500°F.
- 7) \*If thermal spray aluminum is specified, the Owner's Engineer shall specify the sealer, if one is to be used.
- 8) \*Coating suitable for expected temperatures shall be specified.
- 9) \*Modifications to this procedure shall be established by mutual agreement between the fireproof coating Contractor, Purchaser, and the Owner's Engineer.

**Table 8: Special Service Paint Systems for Carbon Steel Construction**

| Equipment or Service                                                                                                                                      | Surface Preparation and Coating Code <sup>(1)(2)</sup>                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Interior fired heater casings:<br><br>Where other than castable type linings are used and where fuel fired contains 0.5 percent (mass) or greater sulfur. | Surface preparation: Code 1<br><br>Coating: Protective coating to be flake- filled polyester equal to Carboline 1601 SG, or Plasite 4310.<br><br>Application: Two coats, 40 mils total dry film thickness |
| Internal surfaces of steel storage tanks for demineralized water                                                                                          | 1nnn                                                                                                                                                                                                      |
| Interior surfaces of sulfuric acid tanks (underside of roof, rafters, center spider, etc.                                                                 | 2cc                                                                                                                                                                                                       |
| External bottoms of tanks containing corrosive chemicals on pier type (open) foundations                                                                  | 2cc                                                                                                                                                                                                       |

**Notes:**

- 1) Designations refer to alphanumeric code according to Tables 2, 3, and 4. Two identical coats are applied when code designation is repeated.
- \*2) Final color shall be specified.



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**Table 9: External Coating and Wrapping Systems for Underground and Underwater Piping (to 120°F)–Metallic and Nonmetallic Construction<sup>(1)</sup>**

| Service for Carbon Steel Piping <sup>(4)(7)</sup>                                                                                          | Surface Preparation and Coating Code <sup>(1)(2)(4)</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Underground—sand and loamy soils                                                                                                        | <p>A. Pipeline enamel, single wrap system<sup>(2)</sup> consisting of:</p> <ol style="list-style-type: none"> <li>1. Surface preparation: Code 3<sup>(3)</sup></li> <li>2. Coal tar or asphalt primer</li> <li>3. Hot coal tar or asphalt enamel (<math>\frac{3}{32}</math> in. <math>\pm</math> <math>\frac{1}{32}</math> in. thick).</li> <li>4. Single layer of nominal 15 lb/100 ft<sup>2</sup> felt, saturated and bonded to enamel.</li> </ol> <p>B. Extruded thermoplastic jacket<sup>(5)</sup>, minimum 40 mils thickness; with heat-shrink sleeves to protect field welded piping joints.</p> |
| 2. Underground—high shrinkage clay soil<br><br>(Clay soils which exert pressure against the coated pipe during wetting and drying cycles.) | <p>A. Piping enamel, double coat–double wrap system<sup>(2)</sup> consisting of:</p> <ol style="list-style-type: none"> <li>1. Surface preparation: Code 3<sup>(3)</sup></li> <li>2. Coal tar or asphalt primer.</li> <li>3. Hot coal tar or asphalt enamel (<math>\frac{3}{32}</math> in <math>\pm</math> <math>\frac{1}{32}</math> in. thick).</li> <li>4. Glass fiber wrap.</li> <li>5. Hot coal tar or asphalt enamel seal (<math>\frac{1}{32}</math> in (min).</li> <li>6. Single layer of nominal 15 lb/100 ft<sup>2</sup> Type coal tar or asphalt saturated felt, bonded to enamel.</li> </ol> |
| 3. Underground—soils having ground water continually present (marshy) and underwater piping <sup>(6)</sup>                                 | <p>B. Extruded thermoplastic jacket<sup>(5)</sup>, minimum 60 mils thickness, with heat-shrink sleeves to protect field welded piping joints.</p> <p>C. Fusion bonded epoxy applied according to <a href="#">NACE RP0394</a> at a total film thickness to be determined by the Owner's Engineer.</p>                                                                                                                                                                                                                                                                                                   |

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**Notes to Table 9:**

- 1) \*For temperatures over 120°F, the protective system shall be specified by the Owner's Engineer.
- 2) Coal tar coating shall conform to AWWA C203. Asphalt may be substituted where coal tar is not available or not permitted by local rules and regulations. Asphalt primer and enamel type, or properties, shall be specified.
- 3) Surface preparation Code designation refers to Table 2.
- 4) \*Underground piping used for air ducts to fired heaters shall also be internally coated. Coating type shall be specified.
- 5) Extruded thermoplastic jacket shall conform to AWWA C215.
- 6) Underwater piping requiring negative buoyancy shall have a wire mesh reinforced concrete jacket over the pipeline coating system.
- 7) \*Owner's Engineer shall specify a rock shield when required.

**Table 10: Coating Systems for Concrete**

| Service                                                                                                                                                                                                                                                 | Surface Preparation and Coating Code <sup>(1)(2)</sup>                    |                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------|
|                                                                                                                                                                                                                                                         | (Corrosive)                                                               | (Nonclassified) |
| Corrosive chemical areas:                                                                                                                                                                                                                               | Surface preparation:<br>per Section 5 Item 2)<br>Coatings: ee or nn or cc | —               |
| 1. Pump slabs:<br><br>Concrete surfaces including top and inside faces of curb enclosures, fireproofing up to 5 ft above slab, all foundation and slab surfaces with enclosures.                                                                        |                                                                           |                 |
| 2. Paved areas around process equipment (towers, exchangers, etc.):<br><br>Item 1 above shall apply only where appreciable spillage is anticipated (such as at flanged joints, etc.). Otherwise, concrete or fireproofed surfaces shall not be painted. |                                                                           |                 |
| 3. Tank foundations:<br><br>Foundations for tanks containing corrosive chemicals. External coating on outer vertical surface of foundation downward 12 in. minimum below finished grade.                                                                |                                                                           |                 |

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| Service                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Surface Preparation and Coating Code <sup>(1)(2)</sup> |                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | (Corrosive)                                            | (Nonclassified)                                                                                                                                                                              |
| Underground concrete structures, external surfaces:<br>1. Fired heater air ducts <sup>(3)</sup><br>2. Liquid retaining structures                                                                                                                                                                                                                                                                                                                                                                                            | —                                                      | Surface preparation: according to Section 5 Item 2<br>Coatings: Code cc or a hot applied asphalt or coal tar enamel<br>$(\frac{3}{32} \text{ in.} \pm \frac{1}{32} \text{ in. thick})^{(4)}$ |
| <b>Notes:</b><br>1) Designations refer to alphanumeric code according to Table 4. Two identical coats are applied when Code designation is repeated.<br>2) *Final color shall be specified where a paint series is shown.<br>3) If cast-in-place concrete box construction is used, the concrete foundation mat shall be cast and coated with coal tar-polyamide epoxy before constructing the duct.<br>4) Coating properties:<br>Coal tar according to AWWA C203.<br>Asphalt coating type or properties shall be specified. |                                                        |                                                                                                                                                                                              |

**Table 11: Coating Systems for Steel Piles and Sheet Piling**

| Service                                                                                                                                                                                                                                                                                                                             | Surface Preparation and Coating Code <sup>(1)</sup> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| Land Structures:<br>1. Piles and sheet piling<br><br>Coat from 2 ft below permanent ground water level to top of piles (sheet piling), or from 5 ft below final grade to top of piles (sheet piling), whichever is less.<br>2. Sheet Piling<br>In addition to the above, the groove at sheet piling interlocks shall not be coated. | 1c or 1cc                                           |

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| Service                                                                                                                                                                                                                                                                                                                                                   | Surface Preparation and Coating Code <sup>(1)</sup> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <p>Marine Facilities (fresh or salt water):</p> <p>1. Piles and Sheet Piling</p> <p>Coat piles in zone from 5 ft below harbor bottom to top of piles (sheet piling).</p> <p>2. Sheet Piling</p> <p>In addition to the above, the groove at sheet piling interlocks shall not be coated.</p>                                                               | 1c or 1cc                                           |
| <p><b>Note:</b></p> <p>1) Designations refer to alphanumeric code according to Table 2 and Table 4. Two identical coats are applied when designation is repeated. Suitable coal tar epoxies are available that may achieve the 16 mils nominal dry film thickness required by <a href="#">GP 04-07-01</a> Piles and Sheet Piling in one or two coats.</p> |                                                     |

**Table 12: Paint and Coating System for Mooring Buoys and Other Floating Structures**

| Service                                                                                                                                                                                                                                        | Surface Preparation and Coating Code <sup>(1)(2)</sup> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Submerged area                                                                                                                                                                                                                                 | 1cc or 1Evv                                            |
| Tidal and Splash zones, and superstructure                                                                                                                                                                                                     | 1Z, 1Eee, or 2m                                        |
| <p><b>Notes:</b></p> <p>1) Designation refers to alphanumeric code according to Tables 2, 3, and 4. Two identical coats are applied when designation is repeated.</p> <p>2) *Final color shall be specified where a paint series is shown.</p> |                                                        |

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**Table 13: Use of Thermal Spray Aluminum**

| Service Conditions                                                                                                                                                                                                                                                                                                   | Away from Welds <sup>(1)</sup> | Weld Coating <sup>(1)</sup>    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|--------------------------------|
| Continuous below 25°F (-5°C)                                                                                                                                                                                                                                                                                         | 2m                             | 2m                             |
| Continuous above 300°F (150°C)                                                                                                                                                                                                                                                                                       | 2m                             | 2m                             |
| Continuous from 25–160°F (-5–70°C)                                                                                                                                                                                                                                                                                   | 2m                             | w <sup>(2)</sup> or 2m         |
| Continuous from 160–240°F (70–115°C)                                                                                                                                                                                                                                                                                 | 2m <sup>(3)</sup>              | 2nn or 2m <sup>(3)</sup>       |
| Continuous from 240–300°F (115–150°C)                                                                                                                                                                                                                                                                                | 2m <sup>(3)</sup>              | 2nn, 4nn, or 2m <sup>(3)</sup> |
| Intermittent, maximum temperature 425°F (220°C)                                                                                                                                                                                                                                                                      | 2m                             | 2nn, 4nn, or 2m                |
| Intermittent, maximum temperature 425–1000°F (220–535°C)                                                                                                                                                                                                                                                             | 2m                             | 2m                             |
| <b>Notes:</b><br>1) Designation refers to alphanumeric code according to Tables 2, 3, and 4. Two identical coats are applied when the designation is repeated.<br>2) Most petrolatum wax tape (w) should not be used above 140°F (60°C).<br>3) *The Owner's Engineer shall specify the sealer, if one is to be used. |                                |                                |

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## Record of Change

| Version 1.0.0                |              |                                                                                                                                                                                                         | Date: 03/02 |
|------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Location                     | Action       | Description                                                                                                                                                                                             |             |
|                              |              | Initial Publish.                                                                                                                                                                                        |             |
| Version 2.0.0                |              |                                                                                                                                                                                                         | Date: 09/03 |
| Section 1                    | Addition     | Added reference to AWS C2.18 (created new Section 1.2 for AWS). Subsequent subsections renumbered accordingly.                                                                                          |             |
| Section 1                    | Modification | Reference titles updated.                                                                                                                                                                               |             |
| Section 2, Items 1) and 2)   | Modification | “Used” replaced with “referred to.”                                                                                                                                                                     |             |
| Section 3, Items 1) –3).     | Modification | “Vendor” replaced with “Coatings application contractor.”                                                                                                                                               |             |
| Section 4.1, Item 1)         | Modification | “Painting service category” replaced with “paint system.”                                                                                                                                               |             |
| Section 4.1, Item 2)         | Addition     | Added subitem f), “Table 13: Use of Thermal Spray Aluminum.”                                                                                                                                            |             |
| Section 4.2                  | Modification | Changed title of section from “Use of Galvanized Coatings” to “Use of Galvanizing.”                                                                                                                     |             |
| Section 4.3, Item 1)         | Modification | Deleted “If a job is contracted, a...” from beginning of sentence. Changed table references to Table 3 and Table 4 (resulting from reorganization of tables and addition of new Table 13—see below).    |             |
| Section 6.3, Item 2)         | Modification | Second sentence: Replaced “...for Owner’s Engineer’s approval” with “for approval by the Owner’s Engineer.”                                                                                             |             |
| Section 6.4, Items 1) and 2) | Modification | Commas inserted to replace semicolons in parenthetical list of “purchased equipment.”                                                                                                                   |             |
| Section 6.6                  | Modification | Deleted “or Coating” from title of section.                                                                                                                                                             |             |
| Section 6.6, Item 2)         | Modification | Paragraph following subitem c) now numbered d).                                                                                                                                                         |             |
| Section 6.9, Item 2)         | Modification | Revised end of sentence as follows:<br>Original “specified painting service category” changed to “painting service category for the bare steel at the equipment operating temperature.”                 |             |
| Section 6.9                  | Addition     | Added Item 5) as follows:<br>“5) * [M] When specified by the Owner’s Engineer, personnel protection cages will be used instead of insulation to minimize the occurrence of corrosion under insulation.” |             |

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| Section 6.12           | Modification        | Changed title of section from “Safety Fire Protection and Equipment Identification” to “Paint System and Safety Equipment Identification.”                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Section 6.12, Item 2a) | Addition            | Added “Vessels and” to “Tankage.”                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Section 8              | Addition            | Added new Section 8, “Use of Thermal Spray Coatings.” Original Section 8 became Section 9.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Sections 9 & 10        | Modification        | <p>Tables reorganized. Section 9 became “Metric Equivalents and Alphanumeric Code Descriptions for Use with Tables 7–13.” New Section 10 became “Coating Selection Tables.” The following tables positioned in Section 9:</p> <p>Table 1 (formerly Table 3): Acceptable Metric Equivalents for Tables 7–13<br/> Table 2 (formerly Table 10): Surface Preparation<br/> Table 3 (formerly Table 11): Primers<br/> Table 4 (formerly Table 12): Topcoats</p> <p>The following tables positioned in Section 10:</p> <p>Table 5 (formerly Table 1): Painting Service Categories<br/> Table 6 (formerly Table 2): Safety Equipment Identification Colors<br/> Table 7 (formerly Table 4): Paint Systems for External Protection Carbon Steel Construction<br/> Table 8 (formerly Table 5): Special Service Paint Systems for Carbon Steel Construction<br/> Table 9 (formerly Table 6): External Coating and Wrapping Systems for Underground and Underwater Piping (to 120°F)–Metallic and Nonmetallic Construction<br/> Table 10 (formerly Table 7): Coating Systems for Concrete<br/> Table 11 (formerly Table 8): Coating Systems for Steel Piles and Sheet Piling<br/> Table 12 (formerly Table 9): Paint and Coating System for Mooring Buoys and Other Floating Structures<br/> Table 13: Use of Thermal Spray Aluminum</p> |
| Section 9, Table 1     | Modification        | <p>In “Temperature Column” made the following adjustments:</p> <p>“300” and “150” deleted and replaced with “250” and “121.”<br/> ”238”(°C) replaced with “204.”<br/> ”265”(°C) replaced with “266.”</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Section 9, Table 2     | Addition / Deletion | <p>Added Code 4.</p> <p>Deleted Notes.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Section 9, Table 4     | Modification        | <p>Alphabetized codes.</p> <p>Added code “w” for petrolatum wax tape.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

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| Section 10,<br>Table 7  | Modification | Multiple additions of surface preparation and coating code for various listed services.<br><br>Added the following to Note 3: "Inorganic zinc coatings exposed in marine environments require no topcoat."<br><br>Added new Note 7 as follows and renumbered subsequent notes: "If thermal spray aluminum is specified, the Owner's Engineer shall specify the sealer, if one is to be used." |
| Section 10,<br>Table 8  | Modification | Changed table caption from "Special Service Paint and Coating Systems Carbon Steel Construction" to "Special Service Paint Systems for Carbon Steel Construction."                                                                                                                                                                                                                            |
| Section 10,<br>Table 10 | Modification | Added asterisk (*) to Note 2.                                                                                                                                                                                                                                                                                                                                                                 |
| Section 10,<br>Table 12 | Modification | Added "2m" to surface preparation and coating code for "Tidal and Splash zones, and superstructure."<br><br>Added asterisk (*) to Note 2.                                                                                                                                                                                                                                                     |
| Section 10,<br>Table 13 | Addition     | Added new Table 13, "Use of Thermal Spray Aluminum." Subsequent tables renumbered accordingly.                                                                                                                                                                                                                                                                                                |
| <b>Version 2.0.0</b>    |              | <b>Date: 11/03</b>                                                                                                                                                                                                                                                                                                                                                                            |
|                         |              | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.                                                                                                                                                                                                                                            |
| <b>Version 2.1.0</b>    |              | <b>Date: 02/04</b>                                                                                                                                                                                                                                                                                                                                                                            |
| General                 | Modification | Corrected table references in table notes throughout document.                                                                                                                                                                                                                                                                                                                                |
| <b>Version 3.0.0</b>    |              | <b>Date: 04/04</b>                                                                                                                                                                                                                                                                                                                                                                            |
| Table 7                 | Modification | Corrected column line for "Externally insulated services."                                                                                                                                                                                                                                                                                                                                    |

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## Attachment: Purpose Codes Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C    | Assigned to paragraphs containing specifications whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include Life-Cycle cost considerations. Life-Cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                     |
| E    | Assigned to paragraphs containing specifications whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                      |
| I    | Assigned to paragraphs that provide only clarifying information such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| M    | Assigned to paragraphs containing specifications whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during on-stream operations.                                                                                                                                                                                                                                                                                                                                                                             |
| O    | Assigned to paragraphs containing specifications whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during startups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs containing specifications whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                      |
| S    | <p>Assigned to paragraphs containing specifications whose primary purpose is avoidance of personnel or operational safety incidents. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to the avoidance of recordable personnel injuries; i.e., burns, cuts, abrasions, inhalation, or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, explosions, etc.</p> |

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# Refractory Linings for Pressure Vessels and Piping

**GP 19-03-02**

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## Scope

- 1) [I] This Global Practice (GP) covers requirements for refractory linings in pressure vessels, lines, and piping. It shall apply, but not be limited to, Fluid Catalytic Cracking (FCC), Fluid Coking, FLEXICOKING, and reforming units. This GP addresses the following:
    - a) Material selection
    - b) Testing
    - c) Shipment
    - d) Installation
    - e) Inspection
    - f) Curing and dryout
  - 2) [I] The following are excluded from this GP:
    - a) Shotcrete (Gunit) linings (Portland cement and sand)
    - b) Brick type linings
    - c) Fired Heater, Incinerator, and Sulfur Combustor linings
  - 3) [I] An asterisk (\*) indicates that a decision by Purchaser is required or that additional information is furnished by Purchaser.
- 

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## 1. Required References

[I] This Section lists Practices and Standards that are generically referenced and assumed to be a part of this document. Unless otherwise specified herein, use the latest edition.

[I] These requirements may be superseded by this GP and/or by the Job Specification(s). The requirements set forth in the Job Specification(s) shall supersede the requirements of this GP.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                       |
|-----------------------------|---------------------------------------|
| <a href="#">GP 18-07-01</a> | Welding Procedures                    |
| <a href="#">GP 18-12-01</a> | Positive Material Identification      |
| <a href="#">GP 20-01-01</a> | Inspection of Equipment and Materials |

### 1.2. ExxonMobil Data Sheets

|                            |                                         |
|----------------------------|-----------------------------------------|
| ExxonMobil Data Sheets     | ExxonMobil Data Sheet Home Page         |
| <a href="#">D190302C01</a> | Execution Data Sheet - Castable Linings |

### 1.3. API–American Petroleum Institute

|                            |                                                                                                                       |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <a href="#">API RP 936</a> | Refractory Installation Quality Control Guidelines-Inspection and Testing Monolithic Refractory Linings and Materials |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------|

### 1.4. ASME–American Society of Mechanical Engineers

|                                          |                                                                 |
|------------------------------------------|-----------------------------------------------------------------|
| <a href="#">ASME SEC VIII D1 B PT UW</a> | Part UW Requirements for Pressure Vessels Fabricated by Welding |
|------------------------------------------|-----------------------------------------------------------------|

### 1.5. ASTM–American Society for Testing and Materials

|                                   |                                                                                                                        |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM A 167</a>        | Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip                  |
| <a href="#">ASTM A 176</a>        | Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip                         |
| <a href="#">ASTM A 580/A 580M</a> | Standard Specification for Stainless Steel Wire                                                                        |
| <a href="#">ASTM A 743/A 743M</a> | Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application |
| <a href="#">ASTM C 181</a>        | Standard Test Method for Workability Index of Fireclay and High-Alumina Plastic Refractories                           |

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|                             |                                                                                                                       |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <a href="#">ASTM C 201</a>  | Standard Test Method for Thermal Conductivity of Refractories                                                         |
| <a href="#">ASTM C 704</a>  | Standard Test Method for Abrasion Resistance of Refractory Materials at Room Temperature                              |
| <a href="#">ASTM C 1113</a> | Standard Test Method for Thermal Conductivity of Refractories by Hot Wire (Platinum Resistance Thermometer Technique) |

## 1.6. SSPC–Society for Protective Coatings

|           |                                                                                                                                                  |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| SSPC SP 1 | Solvent Cleaning (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)                                                           |
| SSPC SP 3 | Power Tool Cleaning (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)                                                        |
| SSPC SP 7 | Joint Surface Preparation Standard Brush-Off Blast Cleaning NACE No. 4: 2000 (Steel Structures Painting Manual, Ch 2–Surface Preparation Specs.) |

## 1.7. API RP 936 Certification

In application of this GP, service providers shall have demonstrated knowledge of [API RP 936](#). Individuals requiring certification include:

- 1) Contractor refractory inspectors
- 2) Laboratory test technicians
- 3) Installation field supervisor contractors
- 4) Vendor technical representatives
- 5) OEM/Prime contractor personnel responsible for refractory selection/design

## 2. Definitions

| Term                     | [I] Description                                                                                                                                                                                                                                                                |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Contractor</b>        | The definition in <a href="#">API RP 936</a> shall apply. In cases where a general contractor subcontracts the refractory installation, the Owner shall define the responsible parties in the Execution Data Sheet (EDS).                                                      |
| <b>Job Specification</b> | Developed by the Owner or designated representative(s), this documentation defines in detail all the design/installation requirements that are applicable to a specific job. The Job Specification is in addition to the Practices, Codes, and Standards specified in this GP. |
| <b>Owner's Engineer</b>  | Owner's designated representative to resolve technical refractory lining issues.                                                                                                                                                                                               |

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| Term                                  | [I] Description                                                                                                                                                             |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Pre-installation qualification</b> | The testing of materials, installation personnel and equipment prior to installation work. Its purpose is to demonstrate ability to comply with the specified requirements. |

### 3. Documentation and Responsibilities

- 1) \* [I] Information to be furnished by Owner shall be as follows:
  - a) Provide Job Specification as defined in Section 2.
  - b) Initiate the Execution Data Sheet (EDS) (see Section 1.2).
  - c) Designate the Owner's representative Engineer and Inspector(s).
- 2) [I] Contractor responsibilities include the following. Prior to work execution, Contractor shall:
  - a) \* Prepare and obtain approval for installation and dryout procedures. These include methods and order of execution for refractory installation, and for types of equipment to be used in installation. It also applies to the quality control plan, Dryout Index (as defined in [API RP 936](#)) of products being installed, and method of dryout, including equipment and setup to control and monitor dryout heating.
  - b) List of [API RP 936](#) certified personnel.
  - c) \* Complete the EDS with required signoffs.
  - d) [S] Provide applicable Materials Safety Data Sheets (MSDS) for conditions of purchase and use and furnish information regarding safety precautions to protect personnel during application and dryout.
  - e) Direct pre-installation qualification testing to ensure that the installation quality requirements are met and documented with applicable water ratios.
- 3) \* [I] Equipment Fabricator responsibilities are as follows:
  - a) Equipment Fabricator shall be responsible for lining protection during shipment and erection of equipment with refractory installed prior to arrival at job site. Fabricator shall provide shipping instructions, including details of any structures to support the applied linings, to Purchaser for approval by the Owner's Engineer.
  - b) Equipment Fabricator shall submit the anchor heat-treatment report to Contractor for review prior to anchor installation.

### 4. Refractory Material Preparation Prior to Shipment

- 1) [R] All shipments shall have each batch and refractory type clearly identified on the containers.
- 2) [R] The water ratio used in qualification testing shall be marked on the refractory containers (except for Type 2h).
- 3) [R] For Type 2h lining materials:

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- a) Refractory shall be pre-sliced at a thickness of  $1\frac{1}{4}$ – $1\frac{3}{4}$  in. (30–45 mm) and then packaged in heat-sealed plastic wrap.
- b) The recommended workability index range and that used for the qualification testing shall be marked on the containers and included with the installation instructions.

## 5. Design and Installation of Linings

Refer to details shown on Figures A–1 through A–16 in the Appendix.

### 5.1. Refractories

- 1) \* [R] The EDS shall be approved and pre-installation qualification of materials and applicators shall be satisfactorily completed before installation may commence.
- 2) [R] Installation Contractor shall ensure that installed physical properties are within the limits specified in Tables 3 and 4, with the allowances specified in [API RP 936](#). To this end, Installation Contractor shall specify any additional pre-qualification testing per Section 9.1, Item (2) that is necessary to meet this obligation.
- 3) [R] Refractories containing calcium silicate type binders (Portland cement) shall not be used at temperatures above 800°F (427°C).
- 4) [S] Refractories shall not contain asbestos or asbestos additives.
- 5) [R] Loose rust, scale, and other foreign matter shall be removed from all surfaces in contact with refractory per SSPC SP 3 or SSPC SP 7. Oil and grease shall be removed using solvent wipe per SSPC SP 1.

### 5.2. Metal Fiber Reinforcement

- 1) [R] Fiber reinforcing shall not be used in refractory for Hexmetal linings.
- 2) [R] Unless otherwise specified, metal fibers shall be of 304SS material, 1 in. (25 mm) long fibers that meet the following requirements:
  - a) Cold-drawn fibers shall be 0.013 in. (0.33 mm) diameter with chemical requirements per [ASTM A 580/A 580M](#).
  - b) Melt-extracted fibers shall be 0.013–0.016 in. (0.33–0.41 mm) equivalent diameter with chemical requirements per [ASTM A 743/A 743M](#).
  - c) Fibers made by a "Sheet Chopping" process shall be 0.010 x 0.022 in. (0.25 x 0.56 mm) with chemical requirements per [ASTM A 167](#) or [ASTM A 176](#). Straight, corrugated or zigzag type fibers are acceptable.
- 3) [R] Cold drawn fibers shall be used for casting installations unless otherwise specified or approved. Melt-extracted or chopped fibers shall be used for gunning and hand packed applications unless otherwise specified or approved.
- 4) [R] When metal fiber use is specified, the added fiber content in the refractory shall be 3.5 percent by weight. Material to which metal fibers have been added shall be designated with an "f" following the refractory type. For example, Type 3f is Type 3 refractory to which metal fibers have been added.

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### 5.3. V and Y Anchors

- 1) [R] V-anchors for single component linings shall be as follows:
  - a) Design and layout for single layer linings shall be per Figure A-1 and Figure A-2. Either straight tine or Wave V-anchors are acceptable.
  - b) For cast and gunned installations, anchor tips shall be 0 in. minimum to 1 in. (25 mm) maximum from the refractory lining surface.
  - c) For gunned single layer linings behind shrouds, V-anchor tips shall be flush with the specified lining surface to provide for accurate measurement of the applied lining thickness.
  - d) For cast pipe linings, anchors are not required if the lining ID is 26 in. (660 mm) or less, provided that the lining thickness is 3 in. (75 mm), or more.
- 2) [R] Y-anchors for dual-layer linings shall be per Figure A-3. When installed by gunning, the first layer shall be gunned with the stud-welded threaded stud in place, with tape or plastic caps covering the exposed threads. The "V" portion shall then be attached before the second layer is gunned.
- 3) [R] Anchors shall be of the hand-weldable type. Stud gun weldable anchors shall not be used unless approved by Owner's Engineer.
- 4) [R] Austenitic stainless steel V and Y anchors shall be supplied in the fully solution-annealed condition. Solution annealing shall be performed after the anchor is formed.
- 5) [R] Metallurgy shall be based on the maximum long-term temperature to which the anchor is exposed at a depth of 1 in. (25 mm) from the lining hot face. Selection shall be as listed in Table 1.

**Table 1: V-Anchor Metallurgy**

| Maximum Permissible Anchor Temperature<br>[1 in. (25 mm) from Hot Face]                                                                 |     | Metallurgy <sup>(1)</sup>                |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----|------------------------------------------|
| °F                                                                                                                                      | °C  |                                          |
| 1000                                                                                                                                    | 540 | Carbon Steel 0.30 wt percent Carbon max. |
| 1200                                                                                                                                    | 650 | 12 percent Cr (410S, 405)                |
| 1600                                                                                                                                    | 870 | Austenitic Stainless Steel               |
| Note (1) Metallurgy selection for anchors in high H <sub>2</sub> S service (i.e., reforming) shall be approved by the Owner's Engineer. |     |                                          |

- 6) [R] Anchors shall be color coded per Appendix C of [API RP 936](#).

### 5.4. Hexmetal

- 1) [R] Hexmetal shall meet the general requirements of this Section:
  - a) Hexmetal shall be fabricated from strips of the following thickness:
    - i) Carbon steel = 0.105 ± 0.007 in. (12 Gauge, 2.5 mm metric equivalent).
    - ii) Alloy steels = 0.078 ± 0.004 in. (14 Gauge, 2.0 mm metric equivalent).

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- b) Hexmetal (Figure A-4) shall be 1 in. (25 mm) deep and measure approximately  $1\frac{7}{8}$  in. (48 mm) between parallel sides. Two tabs approximately  $\frac{1}{4}$  in. wide by  $\frac{1}{2}$  in. long (6 mm by 13 mm) shall protrude into each hexagon. The tabs shall be located at the center of the hexagon depth, unless otherwise specified. Hexmetal depths of  $\frac{3}{4}$  in. (19 mm) and/or  $1\frac{1}{2}$  in. (38 mm) may only be used if approved by the Owner's Engineer.
  - c) Hexmetal strips shall be tightly joined at each contact point by double tab clinches so that adjoining strip walls shall not separate by more than  $\frac{1}{16}$  in. maximum (as measured front and backside) when rolled and installed. The mesh shall be resistant to bending and sufficiently rigid so that it will not flex between points of attachment to the shell.
  - d) Flexible Hexmetal, using hinged sections, is permitted only for lined components less than 10 in. (250 mm) diameter or spray shield applications; each cell shall contain at least 2 tabs.
  - e) Hexmetal metal and termination strips shall be austenitic if attached to Austenitic components, such as 300 series stainless steels, and ferritic if attached to ferritic components, such as carbon steel or 12 percent Cr. PMI shall be made at a 5 percent random frequency based on the number of pieces and number of strips in the Hexmetal.
  - f) Hexmetal shall be installed in panels as large as practical to minimize the extent of joints in the applied lining. Joints between panels shall be offset to avoid continuous seams in the direction of process flow.
  - g) Metal fiber reinforcing and organic fiber burnout material shall not be used in refractory for Hexmetal linings.
- 2) [R] Hexmetal attached directly to plate shall conform to the following:
- a) Orientation shall be with strips perpendicular to the direction of process flow.
  - b) Welding and metal termination strips (when used) shall be as shown in Figure A-5.
  - c) Joints between adjacent Hexmetal panels shall have ends welded to the plate with a maximum gap of  $\frac{1}{2}$  in. (13 mm) per Figure A-6.
  - d) Edging for linings in severe erosion applications such as cyclones shall be refractory lined per Figure A-7.
- 3) [R] Hexmetal used in dual-layer linings with stud supports shall conform to the following:
- a) Orientation on curved surfaces shall be with strips parallel to the direction of rolling (i.e., the Hexmetal is rolled in the "hard" direction).
  - b) Stud layout and spacing shall be per Figure A-8, Detail A.
  - c) Stud and heads shall be as shown in Figure A-8, Detail B.
  - d) Hexmetal shall be welded to stud heads along all points of contact with a  $\frac{3}{16}$  in. (4 mm) fillet weld per Figure A-8, Detail C.
  - e) Terminations shall be made using continuous termination strips or a combination of bridging and termination strips as in Figure A-8, Detail D.
  - f) Joints between adjacent Hexmetal panels shall be made using strip tie-ins welded to the Hexmetal as shown in Figure A-9. Tie-ins shall be secured by welding to the adjacent Hexmetal through the full depth of the strips and at any contacting stud supports.

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## 5.5. Hexalt Anchors

- 1) [R] Hexalt anchor alternatives to Hexmetal per the [API RP 936](#) definition are acceptable when repairing areas 2 ft<sup>2</sup> (0.18 m<sup>2</sup>) or smaller. Use in larger areas and/or fit-up between Hexmetal sheets shall be subject to approval by the Owner's Engineer.

- 2) [R] Acceptable Hexalt anchoring includes the following:

|                   |                                          |
|-------------------|------------------------------------------|
| Flexible Hexmetal | Causeway Steel Products Limited          |
| Half Hexcels      | Five Ash Works, Dover Road East          |
|                   | Northfleet, Kent                         |
|                   | DA11 0RF, England                        |
|                   | Tel: +44 (0) 1474 567871                 |
| K-Bar™            | Kraemer Gunite, Inc.                     |
|                   | P.O. Box 305                             |
|                   | Richwood Road                            |
|                   | Pitman, NJ 09071, USA                    |
|                   | Tel: (832) 227-8097                      |
| Hexcel            | Discovery Associates, Inc.               |
|                   | P.O. Box 31                              |
|                   | Fairview Village, PA 19409               |
|                   | Tel: (800) 446-0918, Fax: (610) 631-9365 |

Proposals to use alternative Hexalt anchor designs or suppliers shall be submitted for Owner's Engineer's review and approval.

- 3) \* [R] Hexalt designs, welding, and layout patterns shall be subject to approval by Owner's Engineer.

## 5.6. Welding

- 1) \* [R] Welding procedure(s) for refractory anchorage attachment shall conform to [GP 18-07-01](#) and shall be approved by the Owner's Engineer prior to start of fabrication.
- 2) [R] If postweld heat treatment (PWHT) of the equipment is required, refractory anchorage shall be installed prior to PWHT.
- 3) [R] Surface preparation for anchorage attachment welds shall be:
  - a) Per [ASME SEC VIII D1 B PT UW](#)-32.
  - b) Spot-ground to obtain clean metal for welding. New shells that have been blast-cleaned need not be spot-ground, provided any subsequent accumulation of rust or foreign material may be effectively removed by brushing at weld locations.
- 4) [R] When Hexmetal is to be welded to flat plate and the resulting assembly rolled, one weld per 2 ft<sup>2</sup> (0.25 m<sup>2</sup>) of the attachment welds shall be examined for cracks by the liquid dye penetrant method after rolling.

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- 5) [R] All anchor weld attachments shall be bend tested. Bend testing shall be performed by bending the anchor in the vicinity of the weld. This bending shall be 15 degrees and back in the direction of greatest resistance without evidence of failure. Austenitic stainless steel anchors shall be visually inspected without bending if the bend could be exposed to 1000°F (540°C).
- 6) [R] Qualification tests shall be made for anchor welds per [ASME SEC VIII D1 B PT UW](#)–27, 28, and 29, with anchors considered as load carrying non-pressure parts.

## 5.7. Field Joints in Single Layer Pipe Linings

- 1) [R] Refractory lining and joint makeup details shall be the close-fitting Type A or open Type B joints as shown in Figures A–10 and A–11. Flanged joints shall be per Figure A–12. Alternative methods shall be subject to approval by the Owner's Engineer.
- 2) [R] Type A joints shall be used for all weld connections of refractory lined pipe, except those requiring make-up or deforming for fit-up after refractory installation. For Type A joints, all piping shall be match marked and provided with truing rings prior to refractory installation (Figure A–10). Compliance with alignment tolerances shall be the responsibility of the refractory Installation Contractor.
- 3) [R] Type B joints shall be for welded connections requiring make-up or deforming for fit-up during field erection. The lining shall terminate 8 in. (200 mm) from the end of the pipe as per details shown in Figure A–11. Hammering or deforming fully lined pipe to effect joint fit-up with other lined pipe is not acceptable.
- 4) [R] If the castable is installed in piping nozzles or vessel sections prior to their erection, a gap at the end of each section shall be left unlined until the erected sections have been welded.

## 5.8. Shell Openings

- 1) [R] Linings at manway heads shall be per Figure A–13.
- 2) [R] Manway plugs shall be per Figure A–14.
- 3) [R] Linings at nozzles shall be per Figure A–15. The surrounding lining shall be either cast with connections in place, or with removable dowels before the connections are installed.
  - a) When installing lining with connections in place, the refractory Installation Contractor shall be responsible for the nozzle height protrusions or flush fit with the lining ID as per dimensional requirements given in the drawings.
  - b) Removable dowels shall be used when the lining is installed before the nozzle connections. The dowels shall be machined using hardwood or metal material to an outside diameter equal to the OD of the connection to a tolerance of  $+^{1}/_{16}$  in./–0 in. (+1.5 mm/–0 mm). Dowels shall be coated (waterproofed) or covered with adhesive-backed vinyl tape and then greased prior to lining installation.

---

## 6. Installation

- 1) [R] Material that shows signs of having set (hardness or lumps in the dry mixture) prior to installation shall be rejected and immediately removed from the job site.

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- 2) [R] Horizontal paddle-type mixers shall be used for mixing hydraulic-setting refractories.
- 3) [R] Water used to mix refractories shall have a 50 ppm maximum chloride content.
- 4) [R] The thickness of cold wall linings installed by gunning or hand packing shall be verified during installation with a gauge, at every 4 ft<sup>2</sup> (0.37 m<sup>2</sup>) on center. The thickness tolerances for specified refractory linings shall be as shown in Table 2.

**Table 2: Thickness Tolerances for Refractory Linings**

| Application                                      | Lining Thickness Tolerance          |          |
|--------------------------------------------------|-------------------------------------|----------|
|                                                  | in.                                 | mm       |
| Vessel Shell Linings                             | + <sup>1</sup> / <sub>2</sub> , -0  | +13, -0  |
| Shrouded Linings                                 | + <sup>1</sup> / <sub>4</sub> , -0  | +6, -0   |
| Pipe Straight Sections                           | ± <sup>1</sup> / <sub>8</sub>       | ±3       |
| Pipe Curved Sections                             | ± <sup>1</sup> / <sub>4</sub>       | ±6       |
| Maximum Step at Adjoining Sections               | ± <sup>1</sup> / <sub>16</sub>      | ±1.5     |
| Refractory in Relation to the Retaining Hexmetal | + <sup>1</sup> / <sub>16</sub> , -0 | +1.5, -0 |

- 5) [R] Pneumatic gun application of refractory linings is permitted except when:
  - a) The finished lining inside diameter is less than 48 in. (1220 mm)
  - b) The thickness of the installed lining is less than 2 in. (50 mm)
  - c) The Owner specifies other application methods in the Job Specification
  - d) Hexmetal or Hexalt anchors are used
- 6) [R] The following shall be required when applying refractory with pneumatic gun:
  - a) All tools, equipment and water storage vessels shall be kept clean and free of contamination.
  - b) Rebound material shall not be reused. It shall be removed from the equipment before it hardens. Rebound accumulations shall be completely removed from the installation surface prior to installation.
  - c) The gunning machine shall be either pressurized dual chamber or bottom discharge rotary type. Pressurized chamber guns are preferred for installations of metal fiber reinforced refractory and use of rotary guns shall be subject to Owner's Engineer's approval.
  - d) Bowl discharge type rotary guns are not acceptable.
  - e) Paddle Mixer, transport, and holding bin for pre-wetting of refractory shall be sized to mix about 200–400 lbs (90–180 kg) of refractory at a time.
  - f) The air compressor shall be capable of delivering 330 ft<sup>3</sup>/sec min (9.3 m<sup>3</sup>/sec min) to the gun at 100 psi (7 kg/cm<sup>2</sup>).
  - g) Water supply for nozzle and pre-wetting. Water pressure shall be at least 100 psi (7 kg/cm<sup>2</sup>) at the nozzle. Water shall be potable and at 80°F (27°C) maximum.

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- h) Nozzle and hosing with  $1\frac{1}{4}$  or  $1\frac{1}{2}$  in. ID (32 or 38 mm). The nozzle assembly shall provide for a minimum of 16 in. (400 mm) extension between the water ring and the nozzle outlet to improve the mixing of nozzle water with the castable and, thereby, more fully develop material properties, minimize rebounds, and prevent lamination defects.
  - i) Longitudinal joints of each course shall be at least 8 ft (2.4 m) long, and shall be staggered by at least 2 ft (0.6 m).
  - j) For down-hand work pieces (i.e., bottom heads of vertical vessels, piping, ductwork), the bottom 120 degrees of refractory shall be installed by casting prior to gunning the remaining section of the lining. Hand packing of the bottom 120 degrees for other than thin-wall erosion resistant lining shall be subject to Owner's Engineer's approval.
- 7) [R] The following requirements apply to vibration casting:
- a) Vibrators shall be capable of delivering a total force equal to at least 100 percent of the total weight being vibrated.
  - b) Proposals to vibrate forms or to use immersion vibrators shall be subject to Owner's Engineer's approval.
  - c) The casting of pipe sections may be done in lengths up to 15 ft (4.5 m) maximum per casting. Cold joints between casting are permitted provided refractory is allowed to cure for 24 hours minimum before continuing the casting operation. The number of cold joints shall be minimized. Casting in bends shall be continuous and without joints. Sequential casting and welding of pipe sections is permitted provided provisions regarding cold joints given above are followed.
- 8) [R] For cast installations, Installation Contractor shall check the concentricity and fit-up of the piping, and notify Purchaser of any deviations. Use of mitering on curved sections shall be subject to Owner's Engineer's approval. Styrofoam, if used, shall be  $2 \text{ lb/ft}^3$  ( $32 \text{ kg/m}^3$ ) minimum density. All forms shall be removed after casting and curing. Burnout of forms shall not be permitted.
- 9) [R] All Type 2h chemical setting refractories shall be installed by placing slabs of pre-sliced material on top of the anchors and ramming them roughly perpendicular to the casing shell. Layered application of refractory should be minimized to the greatest extent possible. Trimmings and loose rubble shall be discarded and not reused. Field water addition or re-mixing to recondition a refractory with inadequate workability is unacceptable.
- 10) [R] The full thickness Type 2a/h shall be installed in a single application using a pneumatic bench rammer or by hand packing and then hammering or pounding with a wood mallet or block to ensure that the Hexmetal cells are completely filled. Underfilling and voids shall not be permitted. The material shall be cut back flush with the top of the Hexmetal so that the hex pattern is visible. Maximum overfill of cells shall be  $\frac{1}{16}$  in. (1.5 mm).
- 11) [R] Special attention is required when hand packing refractory material in Flexible Hexmetal to ensure that the refractory is completely packed under the wire and between the wire and the adjacent strip.

## 7. Repair of Linings

- 1) [R] Section 5 of this GP shall apply to the repair of lining systems, in addition to the requirements of this Section.

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- 2) \* [R] Owner's Engineer shall approve all repair procedures and plans before work commences.
- 3) \* [R] Repairs of single layer linings by the overlay method are not permitted unless specifically approved by the Owner's Engineer.
- 4) [R] Refractory repair in defective areas shall be as follows:
  - a) In the case of single layer linings, remove refractory to the shell and laterally to sound refractory. The side of the cut shall be tapered back to provide patch retention (refer to Figure A-16). Replacement of lining metallic components may be necessary if damaged.
  - b) In the case of dual-layer linings, remove to the insulating castable. Removal of the insulating castable is not required unless damaged.

## 8. Curing and Dryout

### 8.1. Curing Procedures

[R] All linings shall be cured as follows before heating:

|              |                                                                                                                                                      |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Types 1, 3-9 | Moisten or seal for 24 hours minimum at 50-90°F (10-32°C).                                                                                           |
| Type 2a      | Air cured uncovered for 24 hours at ambient conditions of 50-90°F (10-32°C). Before heating, water contact is prohibited.                            |
| Type 2h      | Hold for 72 hours minimum at 50°F to 90°F (10°C to 32°C). Before heating, linings shall not be mechanically disturbed or come in contact with water. |

### 8.2. Dryout/Heating Procedures

- 1) [R] All newly installed linings shall be dried out within 30 days of installation. Protection may be required for longer periods, and shall be subject to Owner's Engineer's approval.
- 2) [R] When a metal shroud is required over the refractory, dryout of the refractory lining shall be completed prior to shroud installation.
- 3) [R] Procedures for heating/dryout of refractory linings shall be per Table 5 as applicable. If products with Dryout Indices are used providing a potential opportunity for a faster dryout, that dryout procedure shall be subject to the approval of the Owner's Engineer. When drying out multiple materials/installations at the same time, procedures may be merged using heating rates and holding times for the lining material/design most sensitive to rapid dryout.

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**Table 3: Refractory Property Requirements  
(Customary Units)**

| Castable Type                         | Type No.         | Dry Installed Density lb/ft <sup>3</sup> <sup>(1)</sup> | Minimum Compressive Strength psi <sup>(2)</sup> | Maximum Erosion Loss per <a href="#">ASTM C 704</a> (cm <sup>3</sup> ) | Maximum PLC, % <sup>(3)</sup> | Maximum PLC, % <sup>(4)</sup> | Maximum Allowable Long Term Use Temp. °F | Maximum Thermal Conductivity BTU in./hr ft <sup>2</sup> °F <sup>(5)</sup> | Maximum Reversible Thermal Expansion Coefficient x 10 <sup>-6</sup> in./in. °F |
|---------------------------------------|------------------|---------------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------|-------------------------------|-------------------------------|------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Hydraulic Setting Erosion Resistant   | 1                | As cast<br>135–175                                      | 8000                                            | 7                                                                      | -0.1                          | -0.3                          | 2400                                     | 10                                                                        | –                                                                              |
| Chemical Setting Erosion Resistant    | 2a               | Air-setting                                             | 8000                                            | 3                                                                      | -0.1                          | -0.3                          | 2600                                     | –                                                                         | –                                                                              |
|                                       | 2h               | Heat-setting                                            | –                                               | 3                                                                      | –                             | -0.3                          | 2600                                     | –                                                                         | –                                                                              |
| Erosion Resistant Heat Insulating     | 3 <sup>(9)</sup> | 120 max                                                 | 5000                                            | 12                                                                     | -0.1                          | -0.3                          | 2000                                     | 6.0 <sup>(7)</sup>                                                        | –                                                                              |
|                                       | 3lx              | 120 max                                                 | 3000                                            | 20                                                                     | -0.1                          | -0.3                          | 2000                                     | 8.0 <sup>(7)</sup>                                                        | 0.83                                                                           |
| Special Medium Weight Heat Insulating | 4                | As cast<br>70–82<br>As gunned<br>70–90                  | 1100                                            | –                                                                      | -0.1                          | -0.3                          | 2000                                     | 3.1                                                                       | –                                                                              |
| Medium Weight Heat Insulating         | 5                | As cast<br>70–90<br>As gunned<br>85–95                  | 500                                             | –                                                                      | –                             | -0.3                          | 2000                                     | As Cast<br>2.8<br>As Gunned<br>3.1                                        | –                                                                              |
| Special Light Weight Heat Insulating  | 6                | As cast<br>60–70<br>As gunned<br>60–80                  | 700                                             | –                                                                      | –                             | -0.3                          | 2000                                     | As Cast<br>2.1<br>As Gunned<br>2.3                                        | –                                                                              |
| Light Weight Heat Insulating          | 7                | As cast<br>60–70<br>As gunned<br>65–75                  | 300                                             | –                                                                      | –                             | -0.8                          | 1800                                     | As Cast<br>1.8<br>As Gunned<br>2.4                                        | –                                                                              |
| Extra Light Weight Heat Insulating    | 8                | 60 max                                                  | 150                                             | –                                                                      | –                             | -0.8                          | 1800                                     | As Cast<br>1.4<br>As Gunned<br>2.0                                        | –                                                                              |
| Special Fill <sup>(6)</sup>           | 9                | <35                                                     | 100                                             | –                                                                      | –                             | -0.8                          | 1500                                     | –                                                                         | –                                                                              |

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| Castable Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Type No. | Dry Installed Density lb/ft <sup>3</sup> <sup>(1)</sup> | Minimum Compressive Strength psi <sup>(2)</sup> | Maximum Erosion Loss per <a href="#">ASTM C 704</a> (cm <sup>3</sup> ) | Maximum PLC, % <sup>(3)</sup> | Maximum PLC, % <sup>(4)</sup> | Maximum Allowable Long Term Use Temp. °F | Maximum Thermal Conductivity BTU in./hr ft <sup>2</sup> °F <sup>(5)</sup> | Maximum Reversible Thermal Expansion Coefficient x 10 <sup>-6</sup> in./in.*°F |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---------------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------|-------------------------------|-------------------------------|------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Notes: <ol style="list-style-type: none"> <li>(1) In the installed condition after drying at 220°F for 18 hours (established by specimen and panel tests). For castable with metal fiber reinforcement the value shown for dry installed density shall be modified per the following: Density (with fiber) = Density (without fiber) X 1.035.</li> <li>(2) As determined by test procedures described in <a href="#">API RP 936</a>.</li> <li>(3) Permanent linear change (PLC) from cured to dried at 230°F.</li> <li>(4) Permanent linear change (PLC) from dried at 230°F to fired at 1500°F.</li> <li>(5) As per <a href="#">ASTM C 201</a> at mean temperature of 1000°F.</li> <li>(6) Special mix of perlite and/or vermiculite and calcium aluminate cement.</li> <li>(7) Same as Note 5 above, except that test data shall be taken from initial heat up curve with maximum 1350°F hot face.</li> <li>(8) Shaded areas indicate properties monitored during quality control.</li> <li>(9) Type 3 to be used as equivalent to either of prior Type 3a or Type 3b designations.</li> </ol> |          |                                                         |                                                 |                                                                        |                               |                               |                                          |                                                                           |                                                                                |

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**Table 4: Refractory Property Requirements  
(Metric Units)**

| Castable Type                         | Type No.         | Dry Installed Density kg/m <sup>3</sup> <sup>(1)</sup> | Minimum Compressive Strength MPa <sup>(2)</sup> | Maximum Erosion Loss per ASTM C 704 cm <sup>3</sup> | Maximum PLC, % <sup>(3)</sup> | Maximum PLC, % <sup>(4)</sup> | Maximum Allowable Long Term Use Temp. °C | Maximum Thermal Conductivity W/M °C <sup>(5)</sup> | Maximum Reversible Thermal Expansion Coefficient x 10 <sup>-6</sup> m/m*°C |
|---------------------------------------|------------------|--------------------------------------------------------|-------------------------------------------------|-----------------------------------------------------|-------------------------------|-------------------------------|------------------------------------------|----------------------------------------------------|----------------------------------------------------------------------------|
| Hydraulic Setting Erosion Resistant   | 1                | As cast 2160–2800                                      | 55                                              | 7                                                   | -0.1                          | -0.3                          | 1375                                     | 1.55                                               | –                                                                          |
| Chemical Setting Erosion Resistant    | 2a               | Air-setting                                            | 55                                              | 3                                                   | -0.1                          | -0.3                          | 1425                                     | –                                                  | –                                                                          |
|                                       | 2h               | Heat-setting                                           | –                                               | 3                                                   | –                             | -0.3                          | 1425                                     | –                                                  | –                                                                          |
| Erosion Resistant Heat Insulating     | 3 <sup>(9)</sup> | 1900 max                                               | 24.5                                            | 12                                                  | -0.1                          | -0.3                          | 1095                                     | 0.93 <sup>(5)</sup>                                | –                                                                          |
|                                       | 3lx              | 1900 max                                               | 20.7                                            | 20                                                  | -0.1                          | -0.3                          | 1095                                     | 1.24 <sup>(5)</sup>                                | 1.5                                                                        |
| Special Medium Weight Heat Insulating | 4                | As cast 1120–1315<br>As gunned 1150–1440               | 7.6                                             | –                                                   | -0.1                          | -0.3                          | 1095                                     | 0.45                                               | –                                                                          |
| Medium Weight Heat Insulating         | 5                | As cast 1120–1440<br>As gunned 1360–1520               | 3.4                                             | –                                                   | –                             | -0.3                          | 1095                                     | As Cast 0.40<br>As Gunned 0.45                     | –                                                                          |
| Special Light Weight Heat Insulating  | 6                | As cast 960–1120<br>As gunned 960–1280                 | 4.8                                             | –                                                   | –                             | -0.3                          | 1095                                     | As Cast 0.30<br>As Gunned 0.33                     | –                                                                          |
| Light Weight Heat Insulating          | 7                | As cast 960–1120<br>As gunned 1040–1200                | 2.1                                             | –                                                   | –                             | -0.8                          | 962                                      | As Cast 0.26<br>As Gunned 0.35                     | –                                                                          |
| Extra Light Weight Heat Insulating    | 8                | 960 max                                                | 1                                               | –                                                   | –                             | -0.8                          | 962                                      | As Cast 0.20<br>As Gunned 0.29                     | –                                                                          |
| Special Fill <sup>(6)</sup>           | 9                | <580                                                   | 0.7                                             | –                                                   | –                             | -0.8                          | 815                                      | –                                                  | –                                                                          |

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| Castable Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Type No. | Dry Installed Density kg/m <sup>3</sup> <sup>(1)</sup> | Minimum Compressive Strength MPa <sup>(2)</sup> | Maximum Erosion Loss per <a href="#">ASTM C 704</a> cm <sup>3</sup> | Maximum PLC, % <sup>(3)</sup> | Maximum PLC, % <sup>(4)</sup> | Maximum Allowable Long Term Use Temp. °C | Maximum Thermal Conductivity W/M °C <sup>(5)</sup> | Maximum Reversible Thermal Expansion Coefficient x 10 <sup>-6</sup> m/m*°C |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------------|-------------------------------|-------------------------------|------------------------------------------|----------------------------------------------------|----------------------------------------------------------------------------|
| Notes: <ol style="list-style-type: none"> <li>(1) In the installed condition after drying at 105°C for 18 hours (established by specimen and panel tests). For castable with metal fiber reinforcement the value shown for dry installed density shall be modified per the following: Density (with fiber) = Density (without fiber) X 1.035.</li> <li>(2) As determined by test procedures described in <a href="#">API RP 936</a>.</li> <li>(3) Permanent linear change (PLC) from cured to dried at 110°C.</li> <li>(4) Permanent linear change (PLC) from dried at 110°C to fired at 815°C.</li> <li>(5) As per <a href="#">ASTM C 201</a> at mean temperature of 1000°F.</li> <li>(6) Special mix of perlite and/or vermiculite and calcium aluminate cement.</li> <li>(7) Same as Note 5 above, except that test data shall be taken from initial heat up curve with maximum 1350°F hot face.</li> <li>(8) Shaded areas indicate properties monitored during quality control.</li> <li>(9) Type 3 to be used as equivalent to either of prior Type 3a or Type 3b designations.</li> </ol> |          |                                                        |                                                 |                                                                     |                               |                               |                                          |                                                    |                                                                            |

### 8.3. Additional Heat/Dryout Considerations

- 1) \* [R] Hydrostatic testing or flushing of lined vessels and piping is acceptable subject to the following:
  - a) Types 1, 3–9 either green or fired.
  - b) Types 2a/h shall not contact water unless previously heated to 700°F (370°C).
  - c) The wetted lining shall be re-dried per the procedures for a new lining as per Table 5.
  - d) Approval of Owner's Engineer.
- 2) \* [R] Freezing climates (Climatic Zones B, C, and D). Where it is anticipated that a delay will occur between wet curing/air drying stages and heating to final dryout temperature, and freeze-thaw conditions can occur, refractories other than Type 2h may be allowed to freeze. However, the following steps shall be taken:
  - a) The lining shall be air dried after curing, at a temperature greater than 60°F (16°C), for 24–48 hours.
  - b) All openings shall be sealed to prevent the accumulation of superficial water on the lining.
  - c) The full thickness of the lining shall be raised to 60°F (16°C) before start of heating to final dryout temperature.
  - d) Type 2h refractories shall be installed, held at controlled temperatures for 72 hours, and heat soaked per Table 5 before exposure to freezing climates.

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**Table 5: Procedures for Heating/Dryout of Refractory Linings<sup>(1) (2)</sup>**

| Dryouts Prior to Unit Startup: New Installation and Patches Larger than 30 ft <sup>2</sup> (3 m <sup>2</sup> )                                                                                                                                                                                                                                                                                                                                                                |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Step 1                                                                                   | Step 2                                                                                                     | Step 3                                                                                                                                                                           | Step 4                                                                                                                        | Step 5                                               |
| 1, 3–9                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Start at 150–300°F (65–150°C) and increase at 50°F (30°C)/hour to 400°F (200°C) maximum. | Hold at 250°F (120°C) minimum to 400°F (200°C) maximum for 1½ hours per 1 in. (25 mm) of lining thickness. | Heat at 100°F (55°C) to lesser of either ¾ of the design temperature or 950°F (510°C).                                                                                           | Hold ¾ of the design temperature or 950°F (510°C) minimum for 1½ hours per 1 in. (25 mm) of lining thickness <sup>(2)</sup> . | Cool at 100°F (55°C) per hour maximum.               |
| 2 a/h                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Start at 150–300°F (65–150°C) and increase at 50°F (30°C)/hour to 400°F (200°C) maximum. | Once 400°F (200°C) is achieved, heat at 100°F (55°C)/hour to 700°F (370°C)                                 | Hold 700°F (370°C) for at least one hour, or continue on heating to a higher temperature if warranted by the dryout of other types of refractory within the same dryout heating. |                                                                                                                               | The cooling rate shall not exceed 100°F (55°C)/hour. |
| Dryouts During Unit Startup: New Installation and Patches Larger than 30 ft <sup>2</sup> (3 m <sup>2</sup> )                                                                                                                                                                                                                                                                                                                                                                  |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Step 1                                                                                   | Step 2                                                                                                     | Step 3                                                                                                                                                                           |                                                                                                                               |                                                      |
| All                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Start at 150–300°F (65–150°C) and increase at 50°F (30°C)/hour to 400°F (200°C) maximum  | Hold at 250°F (120°C) minimum to 400°F (200°C) maximum for 1½ hours per 1 in. (25mm) of lining thickness.  | Heat to final operating temperature at 100°F (55°C) per hour.                                                                                                                    |                                                                                                                               |                                                      |
| Dryout Patched Areas 5–30 ft <sup>2</sup> ( 0.46–3 m <sup>2</sup> )                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Step 1                                                                                   | Step 2                                                                                                     | Step 3                                                                                                                                                                           |                                                                                                                               |                                                      |
| 1, 3-9 <sup>(2)</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Start at 150–300°F (65–150°C) and increase at 100°F (55°C)/hour to 400°F (200°C) maximum | Hold at 400°F (200°C) for 1½ hours per 1 in (25 mm) of lining thickness.                                   | Heat to final operating temperature at 200°F (110°C) per hour.                                                                                                                   |                                                                                                                               |                                                      |
| 2 a/h                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Start at 150–300°F (65–150°C) and increase at 50°F (30°C)/hour to 400°F (200°C).         | Once 400°F is achieved, heat at 100°F (55°C)/hour                                                          | Hold 700°F (370°C) for at least one hour, or continue on heating to a higher temperature if warranted by the dryout of other types of refractory within the same dryout heating. |                                                                                                                               |                                                      |
| Heating of Previously Dried Refractory or Patched Areas (not Type 2a/h <sup>(4)</sup> ) < 5 ft <sup>2</sup> ( 0.46 m <sup>2</sup> )                                                                                                                                                                                                                                                                                                                                           |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| All but Type 2a/h                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Heat to final operating temperature at 200°F (110°C) per hour.                           |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| Notes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| (1) A minimum of three thermocouples shall be used to monitor and record circulating gas temperature. A minimum of three thermocouples shall also be used to monitor and record shell temperature. The thermocouples shall be located at the vessel inlet, middle, and outlet. These measurements shall be kept for permanent record.                                                                                                                                         |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| (2) If the dryout requirements for final hold temperature cannot be met, the lining shall be considered dry when outside metal shell temperature has been held at 220°F (105°C) for 6 hours. The use of external insulation to promote dryout, and/or furnace dryout shall be subject to approval by the Owner's Engineer. If external insulation is used to promote dryout, metal shell temperature shall be closely monitored during dryout shall not exceed 250°F (120°C). |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| (3) Local heating devices may be used to complete the initial 400°F (200°C) hold in a separate localized heating prior to startup. In this case, cooling rate shall not exceed 100°F (55°C) per hour following the localized heating.                                                                                                                                                                                                                                         |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |
| (4) Patched areas of Types 2a/h, regardless of size, shall be "heat-soaked" per the procedures for a new lining.                                                                                                                                                                                                                                                                                                                                                              |                                                                                          |                                                                                                            |                                                                                                                                                                                  |                                                                                                                               |                                                      |

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## 9. Inspection and Testing

### 9.1. General

- 1) \* [R] An Owner's Representative Inspector shall monitor application qualification tests and production installations per [API RP 936](#). While Contractor is responsible for the conduct of material qualification, these tests may be subject to spot checks by the Inspector or Owner's Engineer.
- 2) \* [R] All refractories shall be tested to comply with property requirements in Tables 3 and 4. Refractory shall be applied within 4 months of initial acceptance tests, or within 3 months of each succeeding qualification test per the procedures herein. Such testing shall be arranged by Installation Contractor, and shall be conducted in either an independent lab or at the plant of the castable manufacturer with a laboratory technician who is [API RP 936](#) certified. Installation Contractor shall direct testing to ensure conditions (i.e., mix water contents, ambient temperature, mix temperature, etc.) required for applicable installation quality. Installation Contractor shall report results to Purchaser prior to lining installation.
- 3) [R] Satisfactory testing of "as-installed" samples shall re-qualify the batch for an additional 3 months.
- 4) \* [R] In addition to the requirements of [API RP 936](#), the Inspector shall prepare and submit a shift work report to the Owner within 16 hours after the end of the shift. The report shall cover all activities of the Installer during the referenced shift, including [API RP 936](#) certified personnel present at the work site.
- 5) [R] Records shall be kept for positive identification of refractory type, batch, pallet sampled and water ratios used. Samples shall be taken in chronological order to monitor the production schedule. When a shipment of one type of refractory includes different batches (as designated by bag numbering, separate grouping, or other manner), samples, specimens, and test results shall be kept separate for each batch.
- 6) [R] Sample test results shall meet the requirements in Tables 3 and 4. In the event a sample fails to meet these requirements, the production quantity represented shall be rejected.  
Note: If test results are within 10 percent of the acceptable values, Vendor may propose a re-testing program for the rejected batch or production run to Purchaser for approval by Installation Contractor.
- 7) [R] Additional qualification tests are required for all Type 2h refractories. Refractory samples shall be tested for [ASTM C 181](#) workability. In addition, erosion plate specimens shall be sectioned and inspected after erosion tests are completed. Production quantities represented shall be considered acceptable based upon the following:
  - a) Measured workability indices shall be within the Manufacturer recommended range.
  - b) No significant Lamination or Bloating defects > 1 in. (25 mm) parallel to the eroded face or >  $\frac{1}{16}$  in. (1.5 mm) perpendicular to the eroded face are visible in the specimen cross-section.

- 8) [R] During installation, test specimen preparation and testing shall comply with [API RP 936](#). Correlation between the API classifications and the Types specified by Tables 3 and 4 of this GP is shown below.

| Refractory Type per Tables 3 and 4 | API Classification |
|------------------------------------|--------------------|
| 1, 2a, 2h, 3, 3lx                  | Erosion service    |
| 4, 5, 6, 7, 8                      | Other service      |

- 9) [R] Installation Contractor shall maintain records to identify crewmembers, the materials installed during each shift, installed positions in the vessel or pipe, and the related test samples.

## 9.2. Testing of Installed Linings

- 1) [R] Hammer testing shall be per the following:
  - a) The lining shall be struck with a 1 lb. (454 g) ball-point machinist hammer over the entire surface 24 or more hours after installation. Approximate spacing for striking shall be 12 in. (300 mm) for Types 1, 2a, 3 and 3lx castables and 20 in. (500 mm) for Types 4, 5, 6, 7 and 8 castables.
  - b) Note: Type 2h shall not be hammer tested until after heat curing to 700°F (370°C).
  - c) If problems are detected, either visually or by hammer impact sound, closer spacing shall be used to delineate the size of the defect. Voids or hollow sounding areas larger than 6 x 6 in. (150 x 150 mm) and any soft or "dry fill" areas that reduce the effective lining thickness by more than  $\frac{1}{4}$  of the original thickness or more than  $\frac{1}{2}$  in. (13 mm) are considered defective and shall be repaired.
  - d) In addition to the hammer impact sound requirement described above, chemical setting, erosion resistant linings shall be rejected if they indent when tested. Type 2a and 2h linings shall be tested at the following times:
    - i) Type 2a refractory shall be hammer tested 48 hours after installation. If the lining indents, it shall be re-tested 24 hours later, and rejected if it indents at that time.
    - ii) Type 2h refractory shall be hammer tested after heat soaking at 700°F (370°C) per Table 5.
  - e) For cyclones, slide valves and other specified critical surfaces, defective areas are not permitted regardless of size.
- 2) \* [R] Visual inspection. The lining shall be inspected for cracking after dryout. Areas containing cracks wider than  $\frac{1}{16}$  in. (1.5 mm) are considered defective and shall be repaired. The Owner's Engineer shall approve the repair procedure.  
 Note: Random cracking up to  $\frac{1}{16}$  in. wide, spaced, on average, approximately 1 ft. (300 mm) apart is considered normal.
- 3) \* [R] Limits of lining repair. If more than 25 percent of a lining surface area has defects [i.e., voids, "dry fill," cracks wider than  $\frac{1}{16}$  in. (1.5 mm)], or if there are any defects in designated critical surfaces, the entire lining or the affected section of the lining shall be replaced.

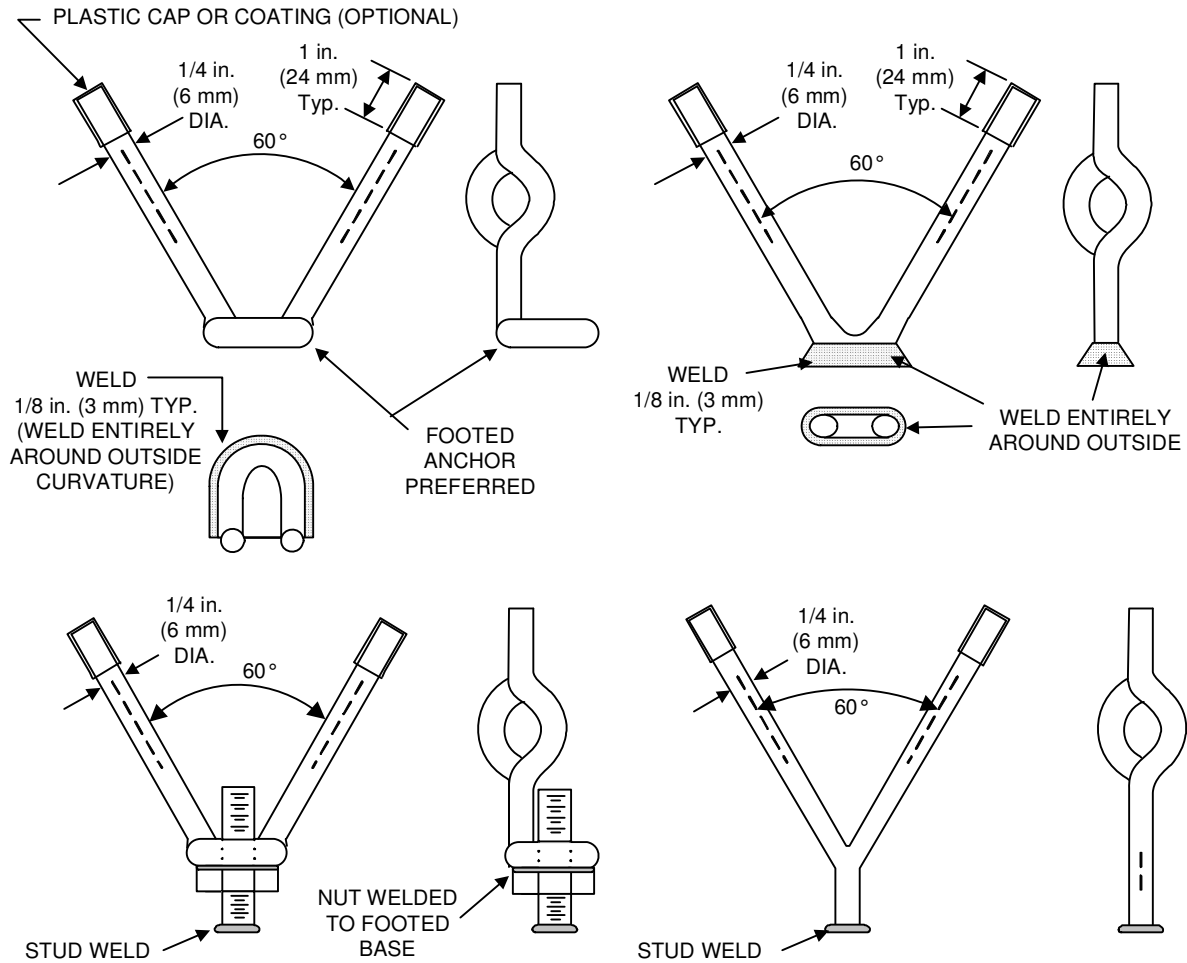
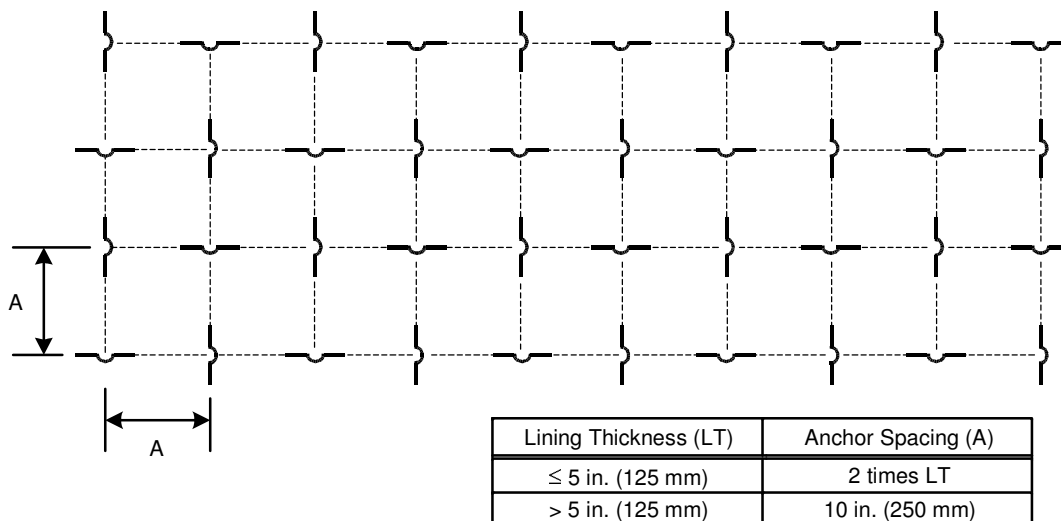


## Appendix: Design and Installation of Lining Details

This Appendix details the design and installation of linings as shown on the following drawings. The acceptable metric equivalents for Figures A-1 through A-16 are shown in Table A-1.

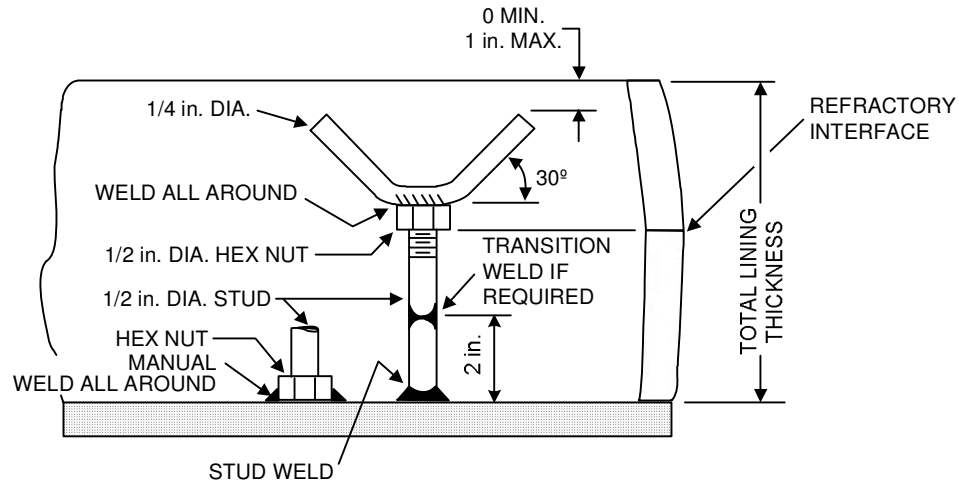
**Table A-1: Acceptable Metric Equivalents**

| Metal Thickness |    | Stud or Round Bar, Diameter |    | Other Linear                                                                                               |     |                |      |
|-----------------|----|-----------------------------|----|------------------------------------------------------------------------------------------------------------|-----|----------------|------|
| in.             | mm | in.                         | mm | in.                                                                                                        | mm  | in.            | mm   |
| $\frac{1}{8}$   | 3  | $\frac{3}{16}$              | 5  | $\frac{1}{32}$                                                                                             | 1   | $1\frac{7}{8}$ | 50   |
| $\frac{1}{4}$   | 6  | $\frac{1}{4}$               | 6  | $\frac{1}{16}$                                                                                             | 1.5 | 2              | 50   |
| $\frac{3}{8}$   | 10 | $\frac{1}{2}$               | 12 | $\frac{1}{8}$                                                                                              | 3   | 3              | 75   |
| $\frac{1}{2}$   | 12 | —                           | —  | $\frac{3}{16}$                                                                                             | 5   | 4              | 100  |
| —               | —  | —                           | —  | $\frac{7}{32}$                                                                                             | 5.5 | 5              | 125  |
| —               | —  | —                           | —  | $\frac{1}{4}$                                                                                              | 6   | $5\frac{1}{2}$ | 140  |
| —               | —  | —                           | —  | $\frac{3}{8}$                                                                                              | 10  | 8              | 200  |
| —               | —  | —                           | —  | $\frac{1}{2}$                                                                                              | 13  | $8\frac{1}{2}$ | 215  |
| —               | —  | —                           | —  | $\frac{5}{8}$                                                                                              | 16  | $9\frac{1}{2}$ | 240  |
| —               | —  | —                           | —  | $\frac{3}{4}$                                                                                              | 19  | 10             | 250  |
| —               | —  | —                           | —  | 1                                                                                                          | 25  | 30             | 750  |
| —               | —  | —                           | —  | $1\frac{1}{2}$                                                                                             | 38  | 60             | 1500 |
| —               | —  | —                           | —  | D, in. (25) x in. = mm<br>65 in. <sup>2</sup> 400 cm <sup>2</sup><br>1 ft <sup>2</sup> 0.09 m <sup>2</sup> |     |                |      |
| —               | —  | —                           | —  |                                                                                                            |     |                |      |
| —               | —  | —                           | —  |                                                                                                            |     |                |      |

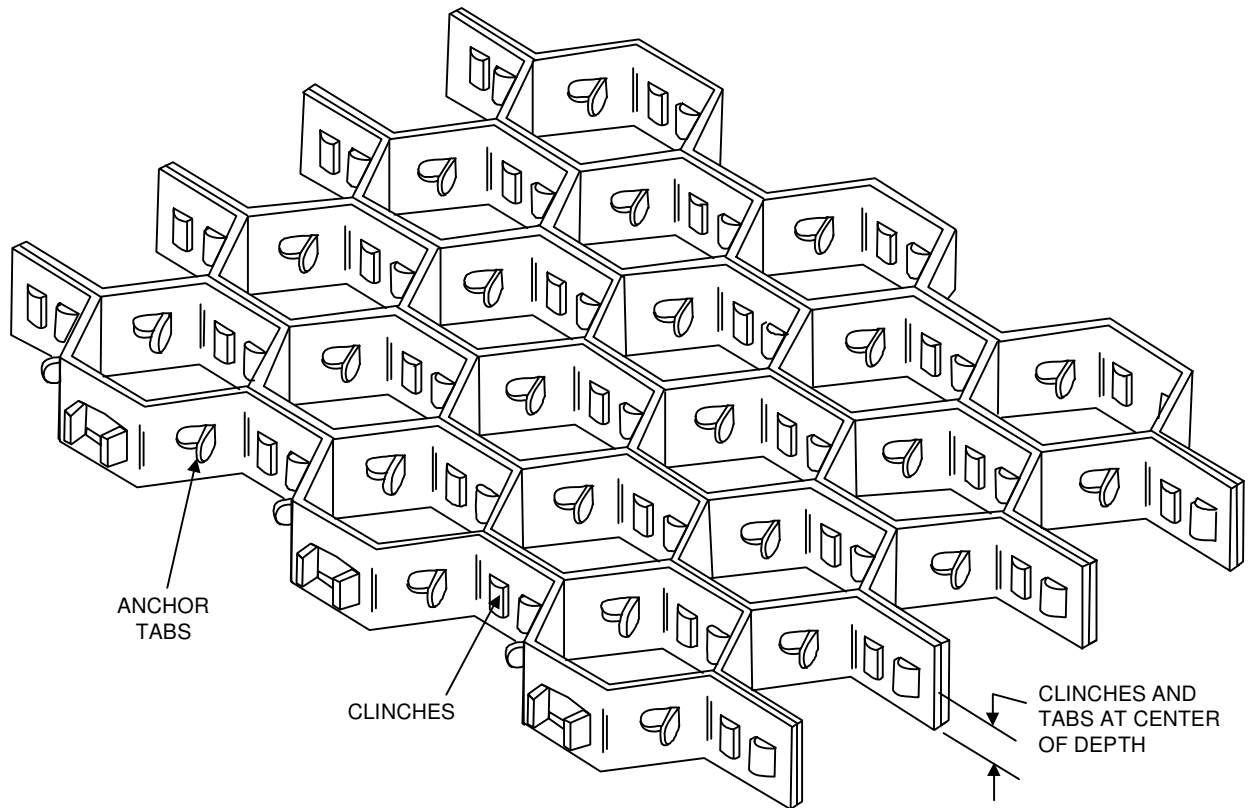
**Figure A-1: V-Stud Anchors, Stick or Stud Welded****Figure A-2: Anchor Layout for Cast or Gunned Linings**

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### Figure A-3: Y-Anchor for Gunned Dual Layer Linings

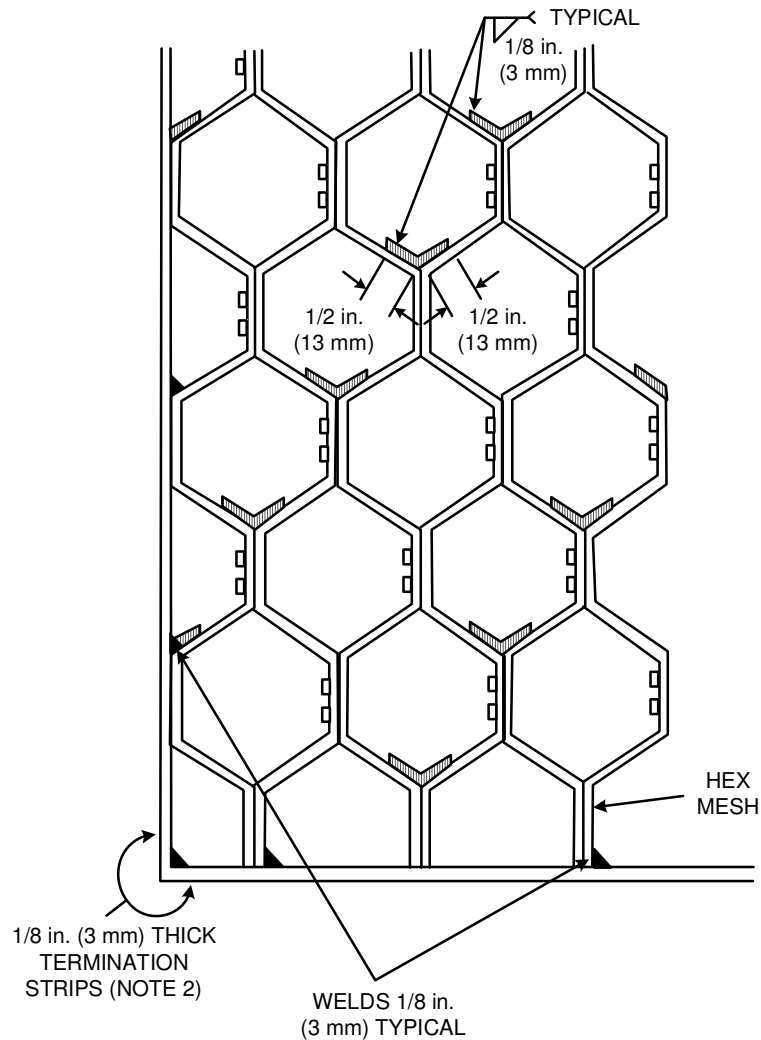


### Figure A-4: Typical Hexmetal Layout



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**Figure A-5: Hexmetal Welding Including Termination Strips for Hexmetal Welded Directly to Plate**



**NOTES:**

- (1) Hexmetal to be welded to backing plate with approximately 21 welds per ft<sup>2</sup> in pattern shown or equivalent layout yielding the same number and length of welds per unit area of hexmetal.
- (2) Termination strips shall be welded continuously to backing plate with a typical 1/8 in. (3 mm) weld on one side.

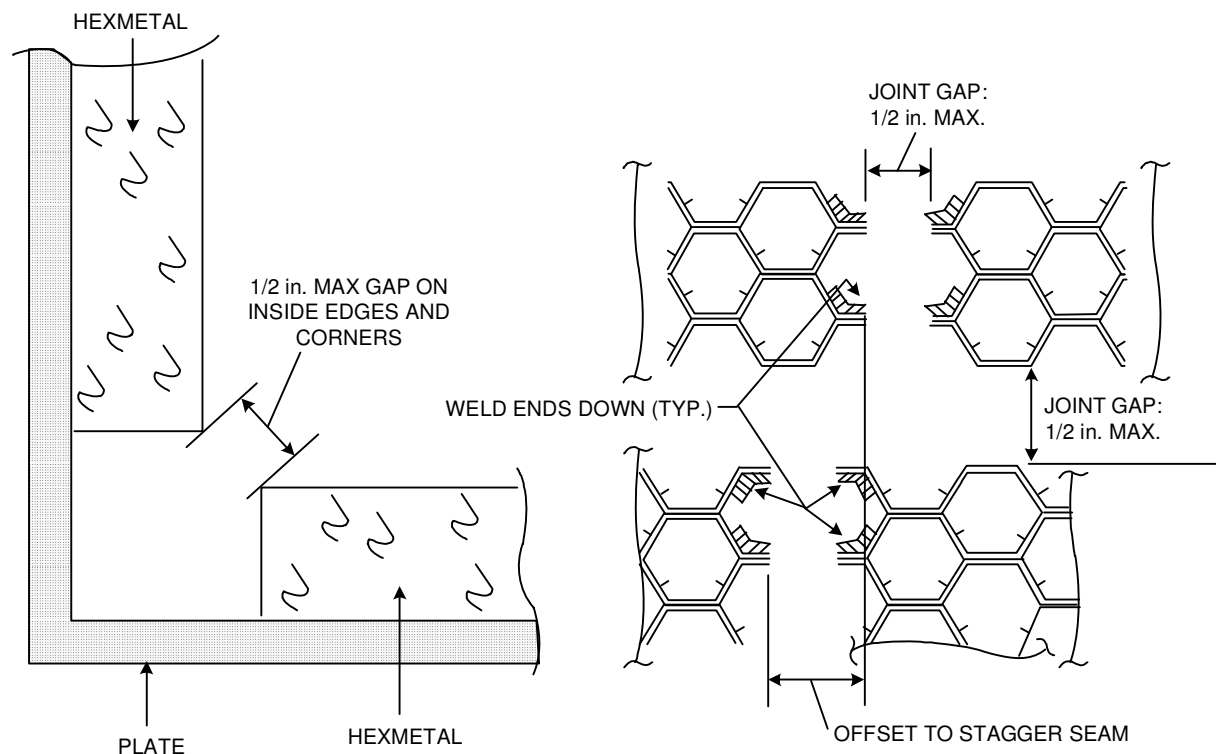
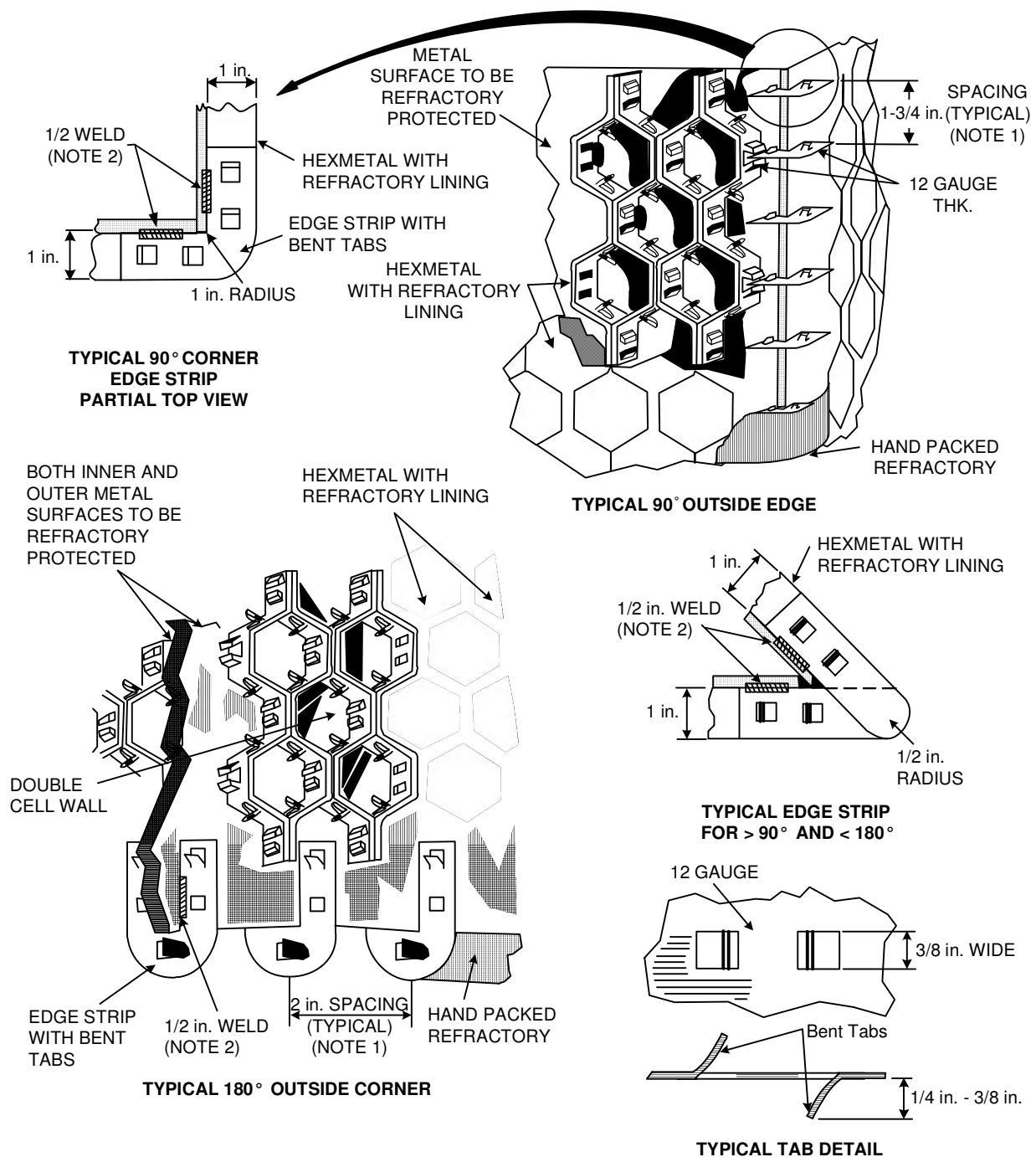
**Figure A-6: Junctions for Hexmetal Attached Directly to Plates**

**Figure A-7: Refractory Lined Edging for Hexmetal Linings Attached Directly to Plate**



**NOTES:**

- (1) Edge strip layout to provide alignment at the center of adjoining open Hexmetal cells. The ends of the strips shall meet and/or overlap the ends of adjoining Hexmetal.
- (2) Edge strips to be attached with 1/2 in. long x 1/8 in. tack welds on alternating sides of connecting surfaces.

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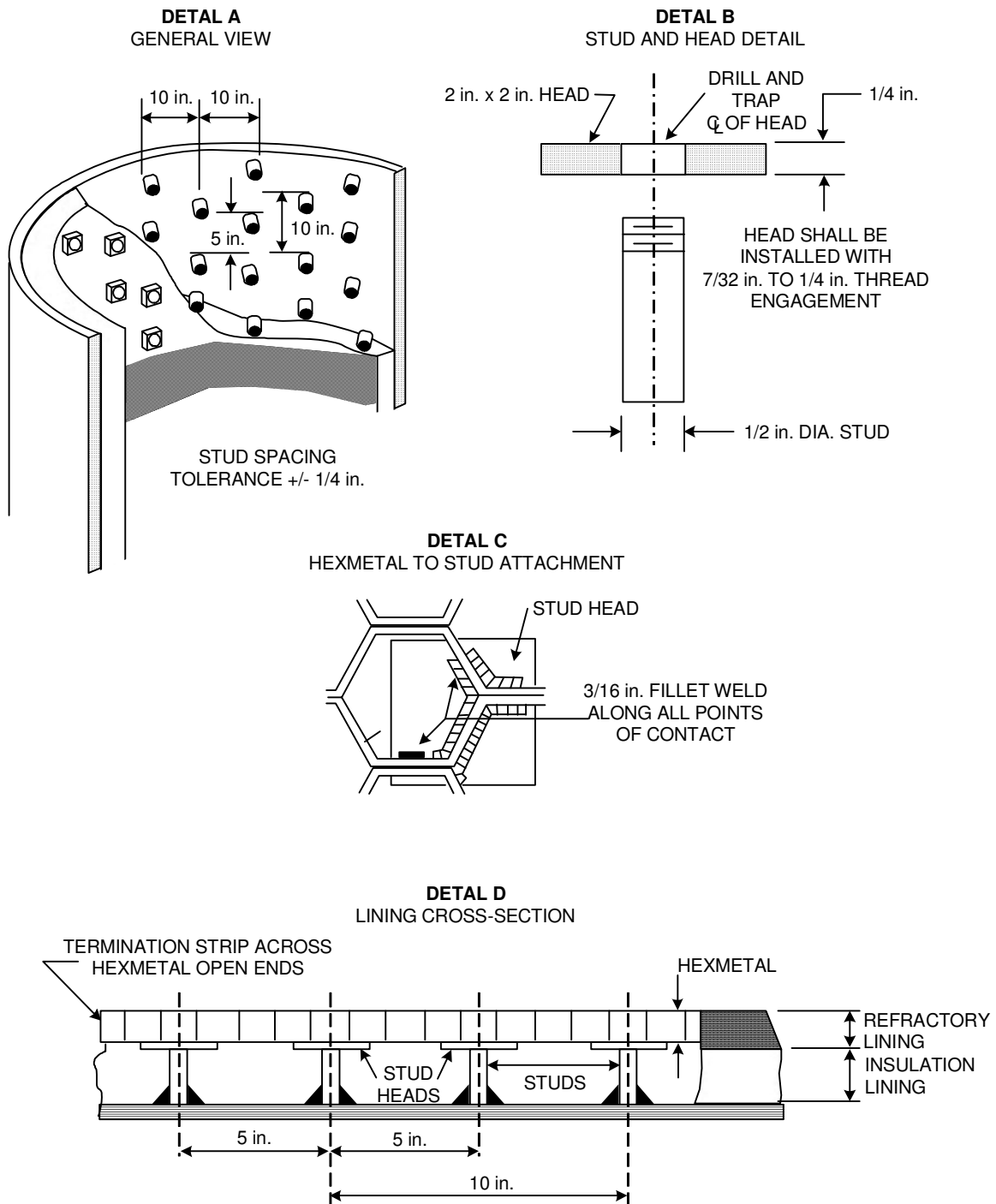
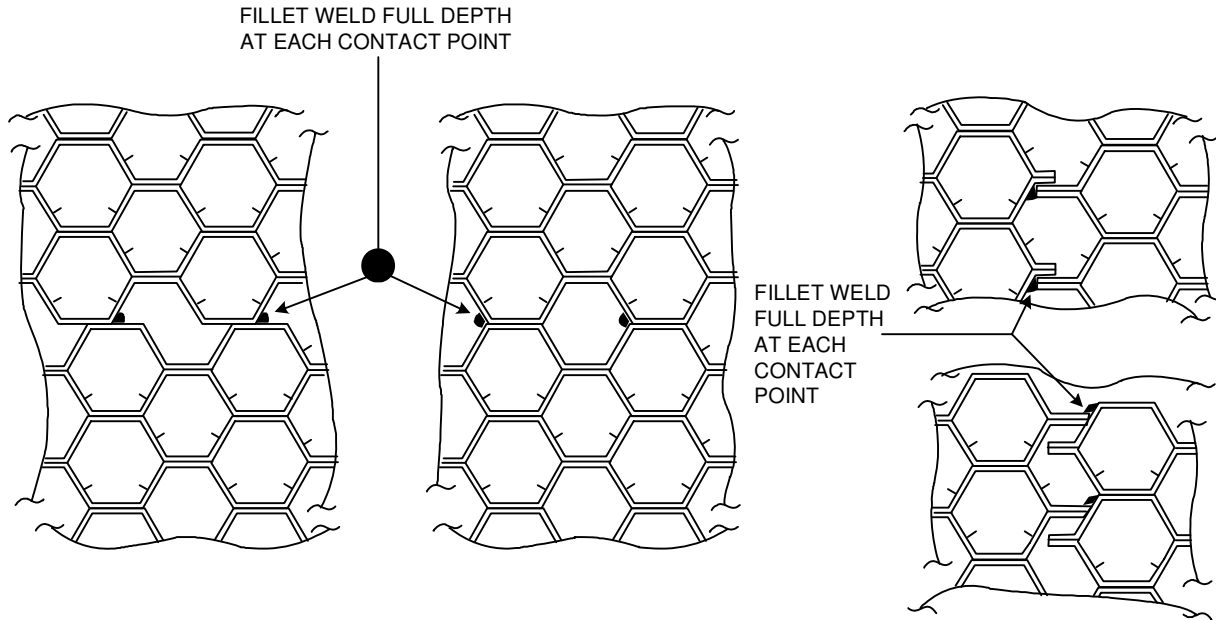
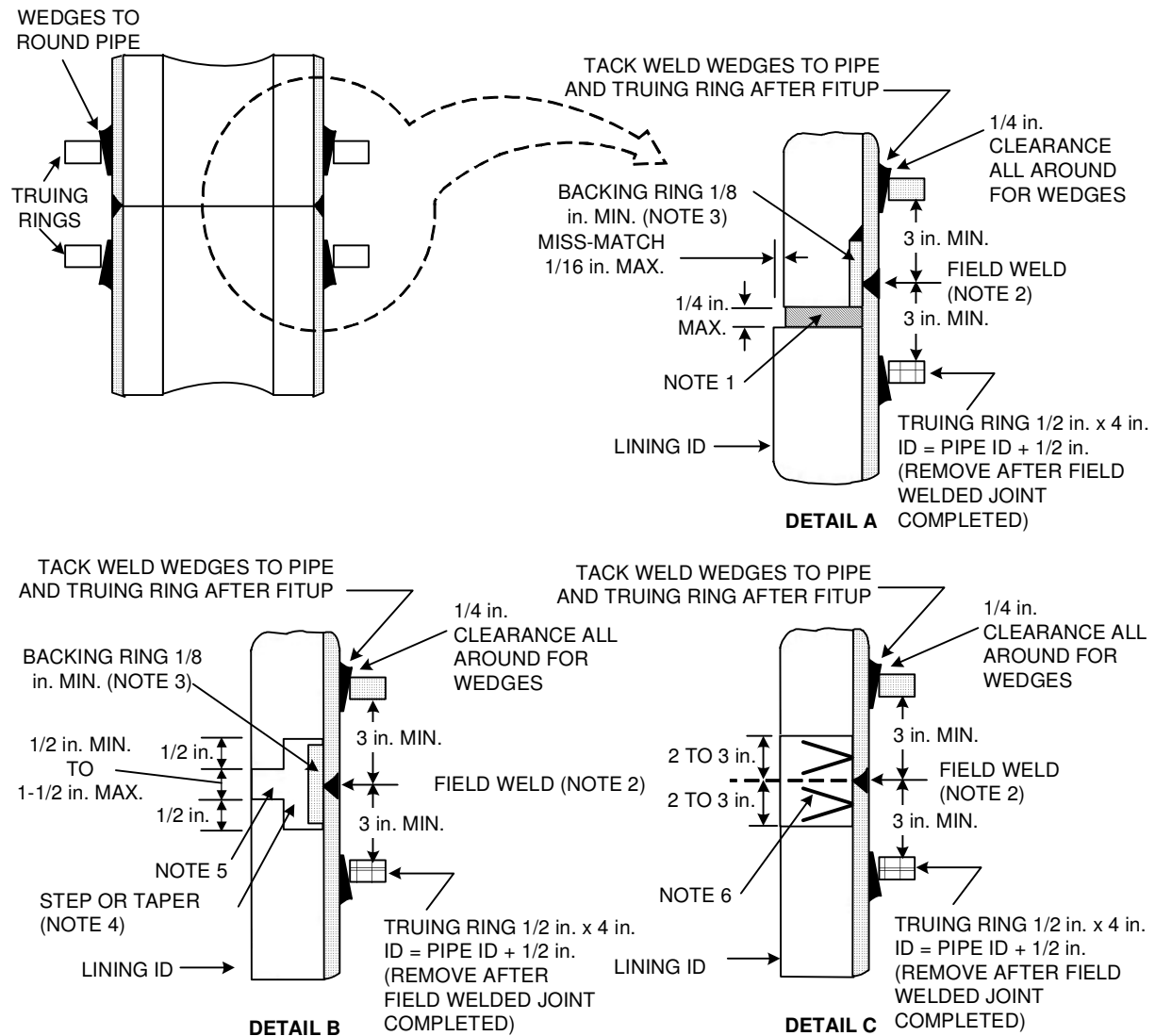
**Figure A-8: Hexmetal Used in Dual Component Linings**

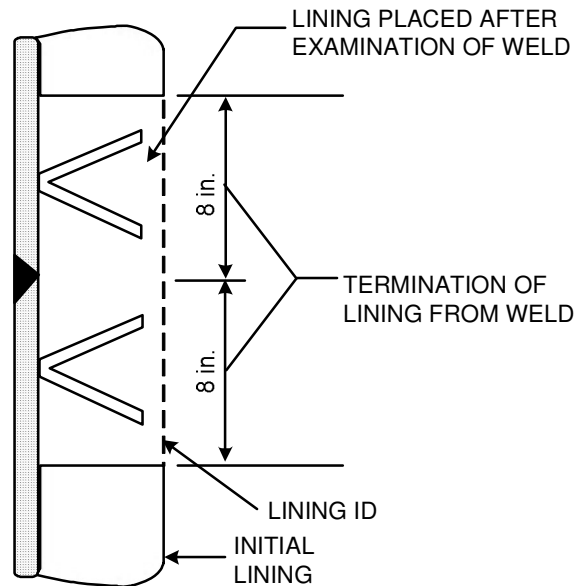
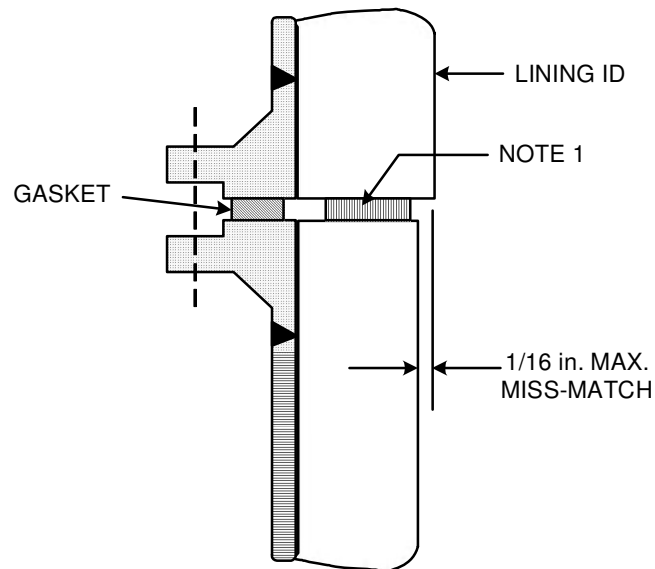
**Figure A-9: Typical Junctions for Hexmetal Attached to Studs**

**NOTE:** All welds are 1/8 in. (3 mm) fillets along full thickness of Hexmetal



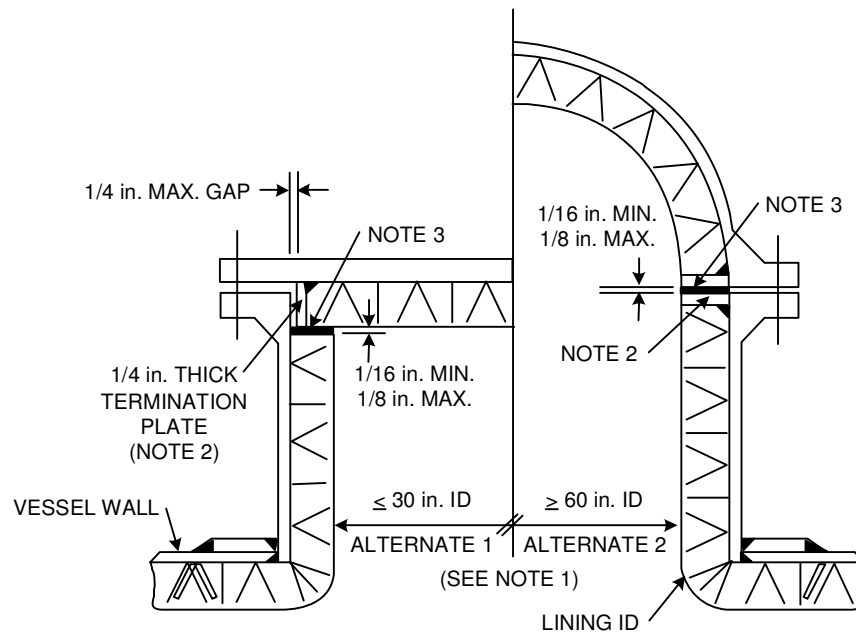
**Figure A-10: Type A, Close-Fitting Lined Pipe Joints****NOTES:**

- (1) Water resisting castable or high temperature mortar coated joint. The coating shall be uniformly applied to both ends immediately prior to fitup for welding.
- (2) Pipe ends shall be cut in one place perpendicular to the axis of the pipe and beveled. Backing rings shall be installed about 5/8 in. above the land at the weld joint bevel, and parallel with the plane of the land within  $\pm 1/32$  in.
- (3) Backing ring to be welded on one side in the pipe before fitting the two ends of the pipe together. This backing ring to be dimensioned and held in position behind the closure weld in the spool sections.
- (4) Refractory ends shall be contoured with a step or 1/2 continuous taper over the lining thickness.
- (5) Refractory to be Type 2a ram packed into the joint enclosure from inside the pipe after completing the closure weld.
- (6) Refractory to be Type 3, the same as that used for the cast lining in the pipe section. Filed joint refractory to be pump cast or vibration cast without metal fibers after completing the closure weld. Details of forming and/or casting nozzles to be included in installation procedures that the Installation Contractor shall submit to the Owner's Engineer for approval.

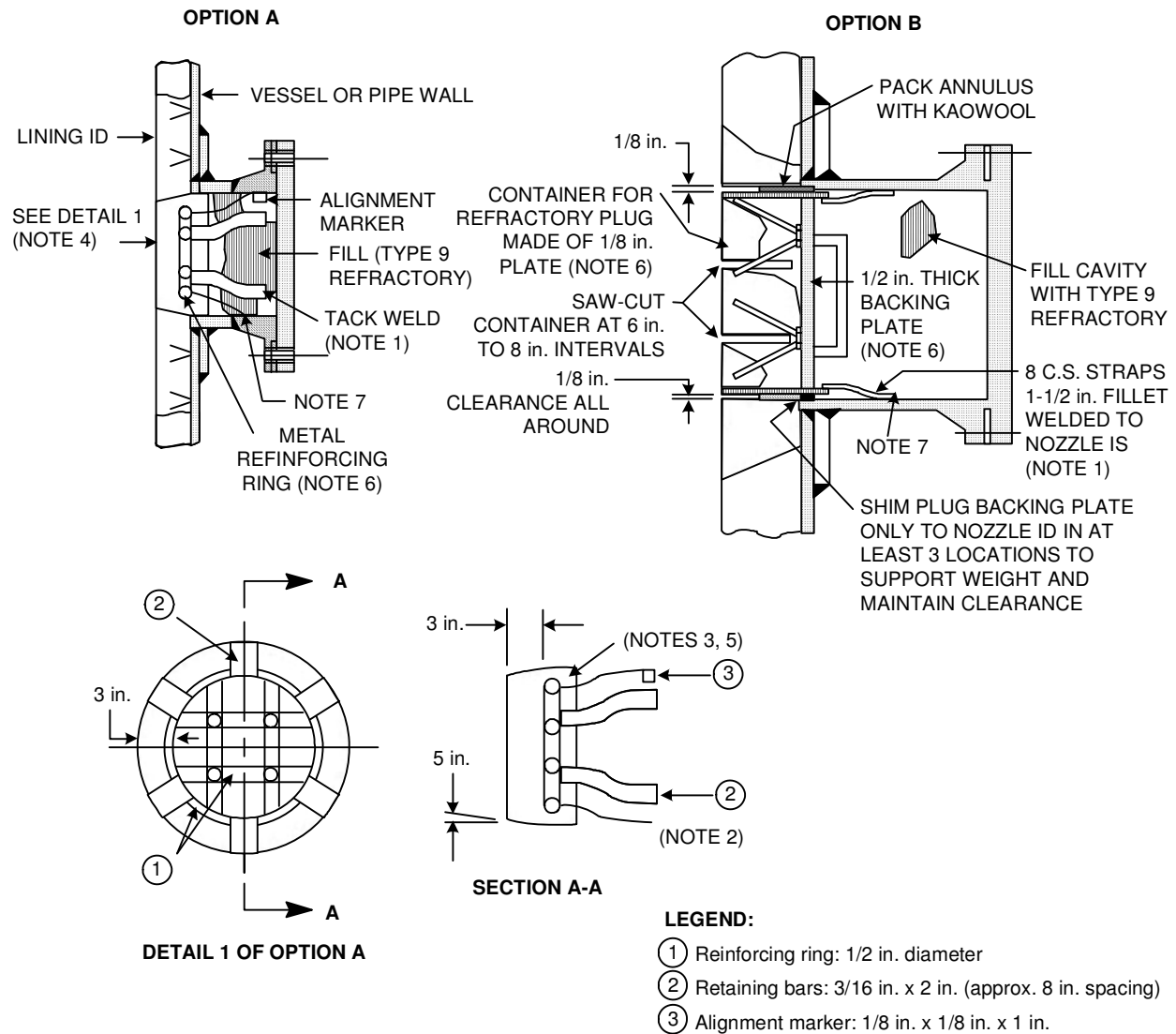
**Figure A-11: Type B Joint for Non-Match-Marked Lined Pipe Spools****Figure A-12: Flanged Joint Detail for Fully Lined Pipe Spools**

**NOTE:** Ceramic fiber tape or cloth coated with high temperature mortar in a gas with a minimum gap equal to the gasket stop ring thickness and a maximum gap of 1/4 in.

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**Figure A-13: Lining Details for Manway Heads****NOTES:**

- (1) Alternate 1 or 2 to be specified for manhole size between 30 in. and 60 in.
- (2) 1/4 in. termination plates: saw cut 3 in. deep at intervals.
- (3) Ceramic fiber tape, cloth or mortar.

**Figure A-14: Details for Manway Plugs****NOTES:**

- (1) As an alternative to welding, retaining bars may be bolted via threaded tap holes at the flange ID.
- (2) Weld retaining bars to reinforcing ring prior to casting the plug.
- (3) Material for cast plug to be same as vessel lining at the manhole location.
- (4) To ensure that the contour of the cast plug matches the contour of the openings in the lining, the plug shall be used as the form. The plug shall be wrapped with two layers of aluminum foil to permit removal of the plug without damaging refractory surfaces. The foil shall be stripped from the plug prior to placing it in service.
- (5) Plug and manhole to be match-marked for fitup when plug is reinserted.
- (6) Metal components to comply with Table 1 requirements.
- (7) Welds to be ground flush to avoid interference with manway plug.

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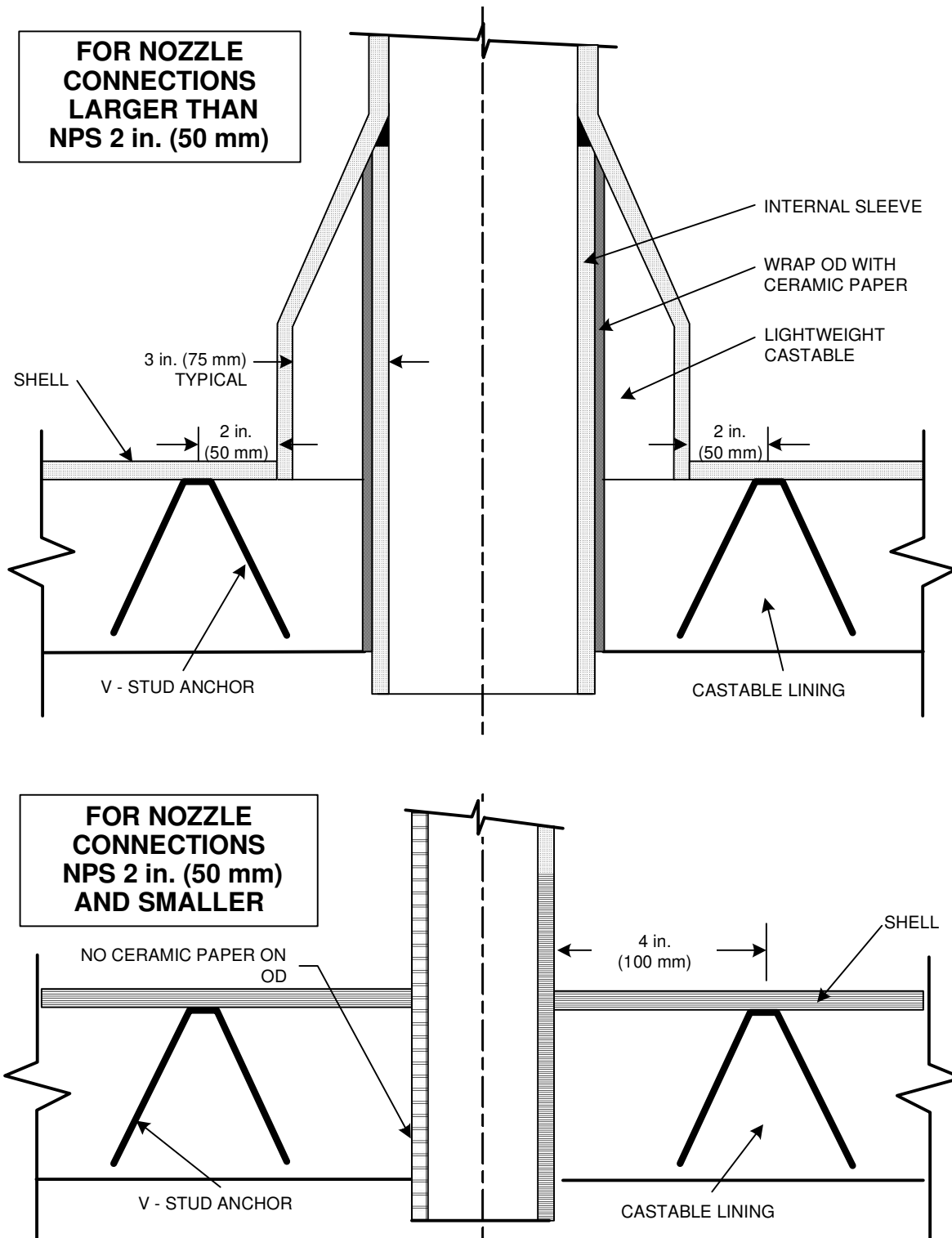
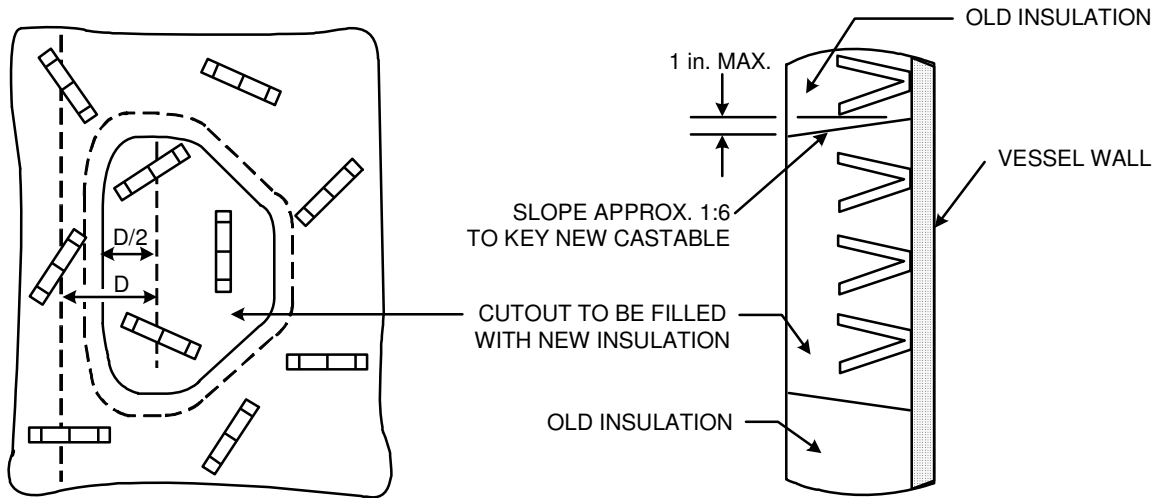
**Figure A-15: Refractory Linings at Nozzle Connections**

**Figure A-16: Repair of Single Layer Lining****NOTES:**

- (1) Repair shown (including 3 studs) is the minimum allowable size.
- (2) The periphery of any repair shall be located midway between studs as shown.
- (3) The cutout should be cleared of all loose insulation and the adjacent material should be thoroughly wetted before new insulation is applied.
- (4) For repair of core sample holes, plugs shall be keyed if practicable (similar to sketch detail), without anchors.

|             |                                                    |          |
|-------------|----------------------------------------------------|----------|
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|-------------|----------------------------------------------------|----------|

## Record of Change

|                       |               |                                                                                                                                                                                 |                    |
|-----------------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b>  |               |                                                                                                                                                                                 | <b>Date: 03/02</b> |
| <b>Location</b>       | <b>Action</b> | <b>Description</b>                                                                                                                                                              |                    |
|                       |               | Initial Publish.                                                                                                                                                                |                    |
| <b>Version 1.0.0</b>  |               |                                                                                                                                                                                 | <b>Date: 07/03</b> |
|                       |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.                              |                    |
| <b>Version 2.0.0</b>  |               |                                                                                                                                                                                 | <b>Date: 05/05</b> |
| Section 1.7           | Addition      | API RP 936 certification requirement for specified service providers.                                                                                                           |                    |
| Section 3, Item (2a)  | Modification  | "... Dryout Index (as defined in API RP 936) of products being installed,"                                                                                                      |                    |
| Section 3, Item (2b)  | Addition      | b) List of API RP 936 personnel.                                                                                                                                                |                    |
| Section 8.2, Item (3) | Modification  | "... For products with Dryout Indices are used providing a potential opportunity for a faster, that dryout procedure shall be subject to the approval of the owner's engineer." |                    |
| Table 3 & Table 4     | Modification  | For Types 2a and 2h, Maximum Erosion Loss per ASTM C 704 (cm <sup>3</sup> ) changed from 4 to 3 cc.                                                                             |                    |
| Section 9.1, Item (2) | Modification  | "... manufacturer with a laboratory technician who is API 936 certified."                                                                                                       |                    |
| Section 9.1, Item (4) | Modification  | "... including API 936 certified personnel present at the work site."                                                                                                           |                    |
| Figure A-1            | Modification  | Added alternate designs for v-stud anchors.                                                                                                                                     |                    |
| Figure A-15           | Modification  | Two separate drawings for nozzles >2" and <2" to replace confusing split drawing.                                                                                               |                    |

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## Attachment: Purpose Codes Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C    | Assigned to paragraphs containing specifications whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include Life-Cycle cost considerations. Life-Cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                     |
| E    | Assigned to paragraphs containing specifications whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                      |
| I    | Assigned to paragraphs that provide only clarifying information such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| M    | Assigned to paragraphs containing specifications whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during on-stream operations.                                                                                                                                                                                                                                                                                                                                                                             |
| O    | Assigned to paragraphs containing specifications whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during startups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs containing specifications whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                      |
| S    | <p>Assigned to paragraphs containing specifications whose primary purpose is avoidance of personnel or operational safety incidents. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to the avoidance of recordable personnel injuries; i.e., burns, cuts, abrasions, inhalation, or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, explosions, etc.</p> |



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# Inspection of Equipment and Materials

## GP 20-01-01

### Scope

- 1) [I] This Global Practice (GP) lists equipment and materials for which the Company requires inspection by a Company Inspector or an appointed Owner's Representative, and this GP defines requirements relating to the inspection activities of this equipment and material.
- 2) [I] This GP shall be applied to any direct or indirect purchase orders or suborders issued on behalf of, or by, the Company.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------|
| Refining/Chemicals, Downstream<br>Imperial Oil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | For Company Use Only            | Version 2.1.0 |
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## 1. Required References

This section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

### 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                                    |
|-----------------------------|----------------------------------------------------|
| <a href="#">GP 20-01-02</a> | Administrative Procedures for Obtaining Inspection |
| <a href="#">GP 20-01-03</a> | Quality Programs                                   |

### 1.2. EMRE–ExxonMobil Research and Engineering

|                                                      |                                                  |
|------------------------------------------------------|--------------------------------------------------|
| <a href="#">Equipment Criticality Rating Process</a> | EMRE Projects Equipment Criticality Work Process |
|------------------------------------------------------|--------------------------------------------------|

## 2. Additional Requirements

- 1) [\*] [I] [R] Table 1 of this GP lists equipment and materials that require inspection by the Company Inspector or Designated Representative unless specifically waived by the Owner.
- 2) [I] The following modifications to the requirements of this GP will be specified in the purchase order:
  - a) Specific Owner requirements
  - b) Compliance with local rules and regulations
  - c) Additions or deletions to Table 1

Note: This does not preclude the Inspector from inspecting material or equipment component parts that are utilized in fabrication/assembly of equipment and materials in Table 1.

- 3) [I] [R] Inspection and test requirements shall include, but not be limited to, those contained in the purchase order.
- 4) This GP makes reference to equipment and material that would require subsequent reference to a large number of additional GPs. To make this GP more efficient, a rationalized listing of all possible GPs will not be provided here. Alternatively, a link to the [ExxonMobil Engineering Practices System \(EMEPS\)](#) is provided for the user's convenience.
- 5) While every effort has been made to provide a link to the applicable GPs in Table 1 of this GP, users are encouraged to reference the specific GP covering the equipment and material in consideration.
- 6) [A] [R] Engineered equipment listed in Table 1 of this GP shall be assigned a Criticality Rating in accordance with EMRE Projects Equipment Criticality Work Process or equivalent as approved by the Owner's Engineer.
- 7) [GP 20-01-02](#) covers the administrative process for securing inspection of equipment and material listed in Table 1 of this GP.

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### 3. Definitions

| Term                   | [I] Description                                                                                                                                                                                                                                             |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Company</b>         | ExxonMobil or ExxonMobil Affiliates.                                                                                                                                                                                                                        |
| <b>Direct Orders</b>   | Purchase orders issued to a Supplier on behalf of, or by, the Company for materials or equipment. (These are also known as "main orders" or "prime orders.")                                                                                                |
| <b>Indirect Orders</b> | Purchase orders issued by a Supplier (who is recipient of a direct order) for mill or foundry materials or component parts or subassemblies for fabrication or assembly. (These are also known as "suborders," "shop orders," "internal work orders," etc.) |
| <b>Inspector</b>       | The Company Inspector, or the appointed Owner's or Purchaser's Representative.                                                                                                                                                                              |
| <b>Owner</b>           | The Company that will receive the equipment or materials.                                                                                                                                                                                                   |
| <b>Purchase Order</b>  | As used in this GP includes the purchase order (or contract) document, its referenced specifications and practices, attachments, codes, standards, other referenced documents, and all agreed amendments thereto.                                           |
| <b>Purchaser</b>       | May be the Company or a Company Designated Representative responsible for procuring equipment, components, materials, systems, or services.                                                                                                                 |
| <b>Supplier</b>        | The Manufacturer, Vendor, Subsupplier, Contractor or Subcontractor, and/or the recipient of the purchase order.                                                                                                                                             |

### 4. Inspection Activities and Data Requirements

- 1) [\*] [C] [R] The scope and extent of inspection may vary depending on the criticality and end use of the equipment. The specific inspection activities will be developed by the Inspector and Owner with the Supplier. Unless otherwise specified, the equipment and materials in Table 1 may be inspected at the source, or at the Supplier or Subsupplier final manufacturing or assembly point as determined by the Inspector and Owner.

- a) The Purchaser shall include reference to this GP in all requisitions/purchase orders for equipment and materials listed in Table 1.
- b) The Purchaser shall include the following inspection clause in all purchase orders for equipment and materials listed in Table 1:

*The goods covered by this purchase order and any subsequent suborders shall be subject to inspection by the Company or its Designated Representative under the guidance of GP 20-01-01. The Supplier/Subsupplier shall notify Company or its Designated Representative and the assigned Inspector at least 5 working days before items are ready for inspection.*

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- 2) [\*] [O] [R] Unless otherwise authorized by the Owner, the Inspector will not release any equipment and materials that have any of the following issues:
  - a) Do not comply with the requirements of the purchase order
  - b) Cannot be identified with applicable specifications, or insufficient data is available to assure compliance
  - c) In the opinion of the Inspector, are of unacceptable workmanship
- 3) [O] [R] Data requirements shall be as follows:
  - a) The Supplier shall provide sufficient documentation to the Inspector at the time of, during, or before the final inspection and prior to shipment, which demonstrates that the requirements of the purchase order or subsequent amendments have been met. This documentation may include a copy of mill test data or other acceptable chemical and physical material data, code forms, charts, certificates, inspection and test reports, and other information required by the purchase order.
  - b) If in-process inspection or final inspection has been waived, the specified number of documents (e.g., copies of mill test data or other acceptable chemical and physical material data, code forms, charts, certificates, inspection and test reports, and other required information and certificates needed to verify compliance with local rules and regulations and requirements of the purchase order) shall be forwarded directly to the Purchaser at, or prior to, shipment.
  - c) [\*] If specified, a "Certificate of Compliance" stating compliance with the purchase order requirements and the applicable specification or standard shall be issued by the Supplier and shall be provided to the Inspector at the time of, or before, final Inspection and prior to shipment.

## 5. Supplier/Subsupplier Obligations and Responsibilities

- 1) [C] [R] Quality Assurance: The Supplier is obligated to assure the quality of the equipment and materials being provided under the purchase order, either directly or indirectly. The Supplier shall provide the following:
  - a) The Supplier shall provide its own quality control and inspection of the materials to ensure that the requirements of the purchase order and its referenced specifications are met.
  - b) The Supplier shall record and maintain records of the quality control inspection activities performed.
  - c) Inspection by the Company or its Designated Representative does not relieve the Supplier of obligations as defined in Item (1). Neither does such inspection relieve the Supplier from guarantees of material, apparatus, workmanship, and/or performance.
  - d) The Prime Supplier shall include all applicable purchase specification requirements in its suborders to lower tier Subsuppliers. This is defined as specific Mechanical Job Specifications, Data Sheets, applicable Company GPs, and any other technical data and documentation relevant to the Supplier's/Subsupplier's scope of work.
  - e) The Prime Supplier shall provide the Company or its Designated Representative with a list of proposed Subsuppliers being considered to provide equipment and materials listed in Table 1 of this GP. The Prime Supplier shall provide this list for Company or Designated Representative review and comment prior to issuing any suborders.
  - f) The Prime Supplier shall provide the Company or its Designated Representative with copies of suborders for equipment and materials listed in Table 1 of this GP.

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- g) [\*] The Company or its Designated Representative will review suborders and develop inspection strategies for the equipment and materials covered therein.
- h) All purchase orders and subsequent suborders for equipment and materials listed in Table 1 of this GP shall include the following inspection clause:
- The goods covered by this purchase order and any subsequent suborders shall be subject to inspection by the Company or its Designated Representative under the guidance of GP 20-01-01.*
- The Supplier/Subsupplier shall notify Company or its Designated Representative and the assigned Inspector at least 5 working days before items are ready for inspection.*
- 2) [C] [R] Free Entry: The Supplier shall afford the Inspector the right of access and free entry to any areas of the Supplier or Subsupplier premises where storage, work, or testing of any equipment or material component is being performed to fulfill purchase order requirements. Unrestricted opportunity shall be provided to the Inspector to verify compliance of equipment and material components with the requirements of direct or indirect purchase orders.
- 3) [S] Inspector's Safety: The Supplier shall provide a safe working environment for the Inspector and shall alert the Inspector of potential hazards. If in the opinion of the Inspector the working conditions are unsafe, then the Inspector will not perform the work.
- 4) [I] [R] Quality Program: When [GP 20-01-03](#) is specified, the Supplier shall follow the approved Quality Program to assure the quality of the equipment and materials that are being provided either directly or indirectly. The Quality Program shall assure that the requirements of the purchase order, its referenced specifications, all attachments, and amendments thereto will be addressed and satisfied during the fabrication and/or manufacturing process.

**Table 1: List of Equipment and Materials to be Inspected**

|                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ([*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 1.                                                                                                                                                                                                                                          | Agitators and mixers: Over 20 hp (15 kW) ( <a href="#">GP 10-09-01</a> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 2.                                                                                                                                                                                                                                          | Boilers and associated parts: ( <a href="#">GP 07-02-01</a> ) <ul style="list-style-type: none"> <li>a. Assembled water walls and superheater</li> <li>b. Boiler tubes after bending, or after fin attachment for water walls</li> <li>c. Drums (<a href="#">GP 05-01-01</a> / <a href="#">GP 05-02-01</a> / <a href="#">GP 05-03-01</a>)</li> <li>d. Headers (<a href="#">GP 03-04-01</a>)</li> <li>e. Installed refractory (shop only) (<a href="#">GP 19-03-01</a>)</li> <li>f. Stacks (<a href="#">GP 04-05-01</a>)</li> <li>g. Steam separation equipment (<a href="#">GP 05-01-01</a> / <a href="#">GP 05-02-01</a> / <a href="#">GP 05-03-01</a>)</li> <li>h. Tube supports (<a href="#">GP 18-03-04</a>)</li> </ul> |
| 3.                                                                                                                                                                                                                                          | Bolting: ( <a href="#">GP 03-16-01</a> ) <ul style="list-style-type: none"> <li>a. Alloy (e.g., A193, A320, A325, etc.)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

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| ([*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.) |                                                                                                                                                                                                                                                         |  |
| b.                                                                                                                                                                                                                                          | Material involving impact tests for services below –50°F (–45°C), including witnessing of impact tests ( <a href="#">GP 18-10-01</a> )                                                                                                                  |  |
| c.                                                                                                                                                                                                                                          | Greater than 2 in. (50 mm) diameter                                                                                                                                                                                                                     |  |
| d.                                                                                                                                                                                                                                          | All coated bolts                                                                                                                                                                                                                                        |  |
| 4.                                                                                                                                                                                                                                          | Burners: For process equipment such as boilers, fired heaters, incinerators, sulfur plants, etc. ( <a href="#">GP 07-04-01</a> )                                                                                                                        |  |
| 5.                                                                                                                                                                                                                                          | Castings other than valve bodies: All ductile iron, carbon steel, and alloy castings (if not part of equipment otherwise listed in this GP) for the following: ( <a href="#">GP 18-03-04</a> )                                                          |  |
| a.                                                                                                                                                                                                                                          | Pressure-containing service                                                                                                                                                                                                                             |  |
| b.                                                                                                                                                                                                                                          | Load bearing, or critical vessel internals such as grid plates cat cracking plants                                                                                                                                                                      |  |
| c.                                                                                                                                                                                                                                          | High temperature service [above 1000°F (538°C)]                                                                                                                                                                                                         |  |
| d.                                                                                                                                                                                                                                          | Foundry for casings for compressors, pumps, turbines, and expanders developing or requiring 5000 hp (3750 kW) or more                                                                                                                                   |  |
| e.                                                                                                                                                                                                                                          | Castings when "first-piece" or "pilot castings" are required                                                                                                                                                                                            |  |
| f.                                                                                                                                                                                                                                          | Castings subject to nondestructive examinations (NDE)                                                                                                                                                                                                   |  |
| 6.                                                                                                                                                                                                                                          | Centrifuges: Over 20 hp (15 kW) (See <a href="#">EMEPS Category 10 - Machinery.</a> )                                                                                                                                                                   |  |
| 7.                                                                                                                                                                                                                                          | Circuit breakers: All circuit breakers (with associated relays and panels) rated above 600 volts ( <a href="#">GP 16-13-01</a> )                                                                                                                        |  |
| 8.                                                                                                                                                                                                                                          | Compressors: ( <a href="#">GP 10-03-01</a> / <a href="#">GP 10-03-02</a> / <a href="#">GP 10-03-03</a> / <a href="#">GP 10-04-01</a> )                                                                                                                  |  |
| a.                                                                                                                                                                                                                                          | Centrifugal, axial, and rotary screw compressors for special purpose applications                                                                                                                                                                       |  |
| b.                                                                                                                                                                                                                                          | Packaged, integrally geared compressors                                                                                                                                                                                                                 |  |
| c.                                                                                                                                                                                                                                          | Reciprocating compressors for process applications                                                                                                                                                                                                      |  |
| d.                                                                                                                                                                                                                                          | Other compressors, including axial, centrifugal, rotary screw, reciprocating and liquid ring compressors over 150 hp (112 kW), except laboratory units, or portable commercial units such as for paint sprayers, sandblast machines, or gunite machines |  |
| 9.                                                                                                                                                                                                                                          | Control Panels for Instruments, where functional tests or specific name brand components are required ( <a href="#">GP 15-11-01</a> )                                                                                                                   |  |
| 10.                                                                                                                                                                                                                                         | Cyclones and trickle valves, including installed refractory linings (shop only) ( <a href="#">GP 05-01-01</a> / <a href="#">GP 19-03-02</a> )                                                                                                           |  |
| 11.                                                                                                                                                                                                                                         | Dryers ( <a href="#">GP 03-06-01</a> )                                                                                                                                                                                                                  |  |
| 12.                                                                                                                                                                                                                                         | Engines: Diesel and gas over 150 hp (112 kW) (does not include drivers for construction equipment)                                                                                                                                                      |  |

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([\*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.)

13. Exchangers and heat recovery units:  
([GP 06-01-01](#) / [GP 06-02-01](#) / [GP 06-03-01](#) / [GP 06-04-01](#) / [GP 06-05-01](#))
  - a. All with over 300 ft<sup>2</sup> (28 m<sup>2</sup>) of service for process services
  - b. All with ASME Class 300 flange rating and above
  - c. All specialty heat exchange equipment, including the following: direct contact, steam surface condensers, spiral type, plate type (brazed aluminum, welded plate, etc.), scraped surface, etc.
  - d. Replacement pressure components for those noted above
14. [\*] Expansion joints: as specified in the purchase order ([GP 03-08-01](#))
15. Extruders and associated equipment
16. Fans: ([GP 10-13-01](#))
  - a. Forced and Induced draft centrifugal flow fans for special purpose applications
  - b. Forced and Induced draft centrifugal flow fans requiring drivers 150 hp (112 kW) and over
  - c. Axial flow fans: witness shop balance of fans greater than 20 ft (6000 mm) diameter
17. Filters and Strainers:
  - a. Rotary filters ([GP 05-01-01](#))
  - b. Belt filter presses
  - c. Permanent line mounted strainers, self-cleaning or basket type, for rotating machinery lube and seal oil or external flushing oil systems; and all pumped product service over 2 in. (50 mm) size ([GP 03-03-10](#))
  - d. Permanent inlet filter and screening for compressor and gas turbine intakes
  - e. Which require PMI, Impact, or Hardness tests ([GP 18-10-01](#) / [GP 18-12-01](#))
18. Fired heaters; combustion air preheaters; and their parts: ([GP 07-01-01](#))
  - a. Assembled tube coils
  - b. Headers, return bends, crossover tubes, and fittings
  - c. Tube guides and anchors
  - d. Tube sheets, tube supports, and hangers
  - e. Tubes, including studded or finned surfaces
  - f. Installed refractory, including ceramic fiber lining, anchors, and wire mesh
  - g. Dampers and associated equipment
19. Fire Protection Equipment ([GP 03-02-03](#))

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| ([*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.) |                                                                                                                                                                                                                                                                                                                                                              |  |
| 20.                                                                                                                                                                                                                                         | Flare Tips ( <a href="#">GP 07-10-01</a> )                                                                                                                                                                                                                                                                                                                   |  |
| 21.                                                                                                                                                                                                                                         | Forgings, Machined: ( <a href="#">GP 05-01-01</a> ) <ol style="list-style-type: none"> <li>For design pressure rating 1000 psi (6900 kPa) and greater, including witnessing of ultrasonic testing</li> <li>For design temperature below –50°F (–45°C)</li> <li>For export to another continent or a remote location</li> </ol>                               |  |
| 22.                                                                                                                                                                                                                                         | Gaskets: ( <a href="#">GP 03-16-01</a> ) <ol style="list-style-type: none"> <li>Metal gaskets (spiral wound, double jacket, solid including graphite coated, etc.), for Class 600 and higher</li> <li>Sheet gaskets:             <p><b>All flat sheet material, and</b></p> <ul style="list-style-type: none"> <li>All precut gaskets</li> </ul> </li> </ol> |  |
| 23.                                                                                                                                                                                                                                         | Gears: ( <a href="#">GP 10-10-01</a> / <a href="#">GP 10-10-02</a> ) <ol style="list-style-type: none"> <li>High speed gears for special purpose applications</li> <li>Other gear units rated at over 150 hp (112 kW)</li> </ol>                                                                                                                             |  |
| 24.                                                                                                                                                                                                                                         | Generators: Electrical generators, including drivers, rated 1340 hp (1000 kW) and larger and all generator sets for instrument power supply service ( <a href="#">GP 16-09-03</a> )                                                                                                                                                                          |  |
| 25.                                                                                                                                                                                                                                         | [A] Hardness tests: Witness a sample of hardness tests on material specified requiring these tests unless Owner approval is granted for acceptance of certified test results ( <a href="#">GP 18-10-01</a> )                                                                                                                                                 |  |
| 26.                                                                                                                                                                                                                                         | [A] Hydrogen Induced Cracking (HIC) tests: Witness portions of testing on materials specified requiring these tests unless Owner approval is granted for acceptance of certified test results                                                                                                                                                                |  |
| 27.                                                                                                                                                                                                                                         | Heads for pressure vessels (including exchangers): ( <a href="#">GP 05-01-01</a> ) <ol style="list-style-type: none"> <li>Alloy steel, clad heads, or aluminum alloy</li> <li>Those requiring impact tests (<a href="#">GP 18-10-01</a>)</li> <li>Those for field fabricated vessels</li> <li>Welded sectional type</li> </ol>                               |  |
| 28.                                                                                                                                                                                                                                         | Hose: Marine hose (Submarine, floating, etc.) ( <a href="#">GP 03-11-01</a> )                                                                                                                                                                                                                                                                                |  |
| 29.                                                                                                                                                                                                                                         | [A] Impact tests: Witness impact tests on material specified requiring these tests unless Owner approval is granted for acceptance of certified test results ( <a href="#">GP 18-10-01</a> )                                                                                                                                                                 |  |

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**([\*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.)**

30. Instruments (See Note):

- a. Process stream analyzers such as boiling point, infrared, sulfur, chromatographs, combustible and toxic vapor detection systems, sample conditioning systems, and analyzer shelters
- b. Custom designed/manufactured electronic or electric systems such as Distributed Control Systems, Protective Instrument Systems, Digital Variable Indicators Systems and Custody Transfer Measurement Systems
- c. Pressure containing equipment fabricated by welding such as seal pots, float/displacer chambers and in-line flow elements [e.g., Venturis, turbine meters, Positive Displacement (PD) meters, etc.]
- d. Custody transfer measurement devices such as flow meters and tank gauges
- e. Thermowells and specially fabricated multipoint thermocouple assemblies such as for reactor service
- f. Instrument power supply packages, including inverters and transfer switches

Note: Standard pneumatic and electronic and other instruments such as controllers, indicators, recorders, transmitters, and pressure gauges are not normally subject to inspection unless purchased in large quantities from one Supplier. (See [EMEPS Category 15 - Instruments and Controls.](#))

31. Inverters: For instrument power systems 27 hp (20 kW) and larger ([GP 16-08-01](#))

32. Insulation: All shop-applied cold and hot service insulation systems

33. Lifting equipment: Hoists, cranes, lifts, and lifting equipment components

34. Linings and protective coatings: (See [EMEPS Category 19 - Corrosion Protection and Linings.](#))

- a. All shop-installed linings and weld overlays (refractory, metallic and nonmetallic, bonded and nonbonded): material or equipment is to be inspected before and after lining, including witnessing of any hydrostatic tests before lining
- b. All pressure-containing components manufactured from integrally clad plate
- c. Cladding and weld overlays: Witness ultrasonic testing of base material before weld overlay and dye check after weld overlay, and ultrasonic bonding check after cladding
- d. Paint and protective coatings for marine or severe industrial or corrosive chemical atmosphere service
- e. Fireproofing installed prior to shipment
- f. Bulk refractory material for equipment to be lined at another location

35. Lubricating oil, sealing oil, and control oil systems purchased in accordance with [GP 10-14-01](#)

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**([\*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.)**

36. Marine and offshore facilities:

- a. Loading arms ([GP 03-11-02](#))
- b. Marine cargo transfer hose ([GP 03-11-01](#))
- c. Hydraulic gangways ([GP 04-04-02](#))
- d. Steel pipe and structural piles; precast concrete piles ([GP 04-04-01](#))
- e. Boats; specially fitted such as life boats and escape capsules and launchers, fire fighting, skimmer barges
- f. Quick connect/disconnect cargo couplers, breakaway couplers and emergency release systems, and other packaged emergency control systems
- g. Single Point Mooring (SPM) swivel joints and universal joints
- h. Hawsers and mooring chains

37. Motors: ([GP 16-09-01](#) / [GP 16-09-02](#))

- a. All motor drivers in operational or safety critical services, including but not limited to special purpose compressors and special purpose centrifugal fans
- b. [\*] Motors for other services 500 hp (375 kW) and larger, unless otherwise specified by the Owner's Engineer

38. Motor control equipment: Rated above 300 volts ([GP 16-12-01](#))

39. "Package units" or "skid mounted units" (plant units for process or utility service supplied as either shop-assembled sections, subassemblies, or complete unit) which:

- a. Are designed and constructed in accordance with a Manufacturer's or industry standard design
- b. Have pressure vessels or fabricated piping as integral parts such as blending units, filters, gas dryers, inert gas generators, chemical injection units, lubrication and seal oil systems, and refrigeration units (does not include ice plants or air conditioners)
- c. Handle hydrocarbons or petrochemicals under pressure or temperature other than ambient

40. Pipe, Fittings, and Flanges: ([GP 03-16-01](#) / [GP 03-18-01](#))

- a. For use within the property limits of a plant site or marine facility, and interconnecting lines:
  1. Any material requiring impact tests, hardness testing, or HIC testing ([GP 18-10-01](#))
  2. Any longitudinal or spiral welded
  3. All pipe from warehouse or supply house
  4. Seamless carbon steel pipe NPS 4 (100 mm) and larger from mill, including any forged and bored
  5. Coated, lined, or wrapped

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>6. All chrome and austenitic stainless pipe</li> <li>7. Plastic and plastic-lined pipe as specified in the purchase order</li> <li>8. Centrifugally cast pipe, tubes, and elbows</li> <li>9. All fabricated piping</li> <li>10. All normal or special pipe fittings, except cast iron, ductile iron, malleable iron</li> <li>11. All flanges NPS 4 (100 mm) and larger</li> <li>12. All flanges not conforming to ASME, ANSI, DIN, BSI, or API Standards</li> <li>13. All with cladding or weld overlay or internal lining</li> <li>14. All metering tube runs</li> <li>b. For use in oil field production: <ul style="list-style-type: none"> <li>1. Casing</li> <li>2. Tubing</li> <li>3. Drill pipe</li> <li>4. Well head assemblies</li> <li>5. Drilling choke manifolds</li> <li>6. Scraper/pig launchers and receivers</li> </ul> </li> <li>c. Pipe, fittings, and flanges not otherwise listed to be inspected: Piping components purchased in large quantities from one Supplier, regardless of source</li> </ul> |
| 41. Plate: Includes plate from steel mills, stockists, or that previously manufactured to established standards, as follows: <ul style="list-style-type: none"> <li>a. Carbon steel plate for pressure vessels and tanks (if required by National Code)</li> <li>b. Plate of alloy steel, or nonferrous material</li> <li>c. Weld overlay or integrally bonded clad plate (<a href="#">GP 05-01-01</a> / <a href="#">GP 18-07-01</a>)</li> <li>d. Plate requiring impact tests, any ultrasonic testing. HIC examination, or special markings or transfer of heat identification markings (<a href="#">GP 18-10-01</a>)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 42. Positive Material Identification (PMI) tests: Witness portions of testing on materials specified requiring these tests, and perform audits of the Supplier's PMI program ( <a href="#">GP 18-12-01</a> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 43. Pressure vessels: ( <a href="#">GP 05-01-01</a> / <a href="#">GP 05-02-01</a> / <a href="#">GP 05-03-01</a> ) <ul style="list-style-type: none"> <li>a. All pressure vessels, including vacuum service and shop-fabricated plate for field assembled vessels</li> <li>b. Drums of field erected boilers to be inspected at place of fabrication</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

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44. Prototype Equipment: New design, significant changes in standard design, or facility has no previous manufacturing experience with the equipment

45. Pumps and liquid turbines: (See [EMEPS Category 10 - Machinery](#).)

- a. All having maximum allowable working pressures above 300 psig (2000 kPag), or pumping temperatures of 500°F (260°C) or higher
- b. All having alloy steel, alloy iron, silicon iron, or ductile iron casing materials
- c. All pumps with nonferrous casing material having discharge flange NPS 4 (100 mm) and larger
- d. All pumps with cast iron casing material having discharge flange NPS 6 (150 mm) and larger
- e. All with lined or weld overlay clad areas
- f. Witness of hydrostatic tests of pumps with Monel cases
- g. Seal-less pumps in hydrocarbon service
- h. All having drivers of 20 hp (15 kW) or more

46. Refractory Materials: ([GP 19-03-02](#) / [GP 19-03-03](#))

47. Solids handling equipment: (See [EMEPS Category 10 - Machinery](#).)

- a. Size reduction equipment (mills, crushers, and grinders): castings, drivers, and power transmission components, witnessing no-load run test
- b. Belt conveyor systems: structural steel, fabric, or steel cable reinforced conveyor belting, pulleys, drivers, and power transmission components
- c. Stacker, Reclaimer, and Stacker/Reclaimer: Structural steel, slew bearings, traversing wheels and rails, power-instrument cable "hose reel" slip rings, drivers and power transmission components, and conveyor components
- d. Ship loader: structural steel, rack and pinion gears, drivers and power transmission components, and conveyor components
- e. Prefabricated dust collection systems, including witnessing vacuum tests if required
- f. Rotary air locks (valves)
- g. Screw conveyors
- h. Feeders, hoppers, storage bins
- i. Elevators
- j. Screens

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| ([*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.) |                                                                                                                                                                                                                                                         |  |
| 48.                                                                                                                                                                                                                                         | Spare parts:                                                                                                                                                                                                                                            |  |
| a.                                                                                                                                                                                                                                          | Major equipment ordered as standby spares such as compressors, and equipment components such as rotors and diaphragms and turbine blades, and other major parts for equipment normally inspected. (See <a href="#">EMEPS Category 10 - Machinery</a> .) |  |
| b.                                                                                                                                                                                                                                          | Long delivery items not normally stocked by the Manufacturer                                                                                                                                                                                            |  |
| 49.                                                                                                                                                                                                                                         | Structures: (See <a href="#">EMEPS Category 04 - Civil</a> .)                                                                                                                                                                                           |  |
| a.                                                                                                                                                                                                                                          | Stacks (self-supporting): Shop-fabricated steel stacks or welded courses for field erection, breechings, and ductwork ( <a href="#">GP 04-05-01</a> )                                                                                                   |  |
| b.                                                                                                                                                                                                                                          | Offshore drilling platforms                                                                                                                                                                                                                             |  |
| c.                                                                                                                                                                                                                                          | Pipe supports (shop fabricated only), purchased in large quantities from one Supplier                                                                                                                                                                   |  |
| d.                                                                                                                                                                                                                                          | Structures supplied as either shop-assembled sections, subassemblies, or complete, unless otherwise covered in this GP                                                                                                                                  |  |
| 50.                                                                                                                                                                                                                                         | Switchgear: All switchgear, associated relays, and control panels ( <a href="#">GP 16-12-01</a> )                                                                                                                                                       |  |
| 51.                                                                                                                                                                                                                                         | Tanks or spheres (atmospheric or pressure storage): ( <a href="#">GP 09-04-01</a> / <a href="#">GP 09-02-01</a> )                                                                                                                                       |  |
| a.                                                                                                                                                                                                                                          | Shop fabrication of shell plates                                                                                                                                                                                                                        |  |
| b.                                                                                                                                                                                                                                          | Complete shop-assembled tanks                                                                                                                                                                                                                           |  |
| c.                                                                                                                                                                                                                                          | Internal floating covers sent to job site in another hemisphere                                                                                                                                                                                         |  |
| d.                                                                                                                                                                                                                                          | Field erection                                                                                                                                                                                                                                          |  |
| 52.                                                                                                                                                                                                                                         | Vessel and tower internals: For shop and field assembly ( <a href="#">GP 05-02-01</a> )                                                                                                                                                                 |  |
| 53.                                                                                                                                                                                                                                         | Variable Frequency Drives: 75 hp (60 kW) and larger ( <a href="#">GP 16-14-01</a> / <a href="#">GP 16-14-02</a> )                                                                                                                                       |  |
| 54.                                                                                                                                                                                                                                         | Transformers: 500 kVA and larger, or with primary windings above 15 kV ( <a href="#">GP 16-10-01</a> )                                                                                                                                                  |  |
| 55.                                                                                                                                                                                                                                         | Trucks: See Vehicles                                                                                                                                                                                                                                    |  |
| 56.                                                                                                                                                                                                                                         | Tube bundles: For exchangers over 300 ft <sup>2</sup> (28 m <sup>2</sup> ) surface area or pressure rating requiring ASME Class 300 flanges or over, including air-cooled heat exchangers ( <a href="#">GP 06-01-01</a> )                               |  |
| 57.                                                                                                                                                                                                                                         | Tubes (exchanger, boiler, and fired heater): (See <a href="#">EMEPS Category 06 - Heat Exchangers</a> and <a href="#">EMEPS Category 07 - Fired Heaters and Boilers</a> .)                                                                              |  |
| a.                                                                                                                                                                                                                                          | All alloy steel                                                                                                                                                                                                                                         |  |
| b.                                                                                                                                                                                                                                          | Nonferrous: e.g., 70Cu 30Ni, titanium, tantalum, Ni based alloys, etc.                                                                                                                                                                                  |  |
| c.                                                                                                                                                                                                                                          | Exchangers, coolers, and reboilers: integral finned, bi-metal, electrical resistance welded, and "U" tubes (including after heat treatment)                                                                                                             |  |
| d.                                                                                                                                                                                                                                          | Boiler tubes: after bending, or after fin attachment for water walls                                                                                                                                                                                    |  |
| e.                                                                                                                                                                                                                                          | Fired heater tubes: before and after centerwelding, stud, or fin attachment                                                                                                                                                                             |  |

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([\*] Unless otherwise specified, the equipment and materials in this table may be inspected at the originating source, or at the Supplier or Subsupplier final manufacturing or assembly points, as determined by the Inspector and Owner.)

58. Turbines and Gas expanders: (See [EMEPS Category 10 - Machinery](#).)

- a. All combustion type gas turbines ([GP 10-08-01](#))
- b. All steam turbines and gas expanders for special purpose applications ([GP 10-03-01](#) / [GP 10-07-02](#))
- c. Other steam turbines and gas expanders over 150 hp (112 kW) ([GP 10-03-01](#))

59. Valves: ([GP 03-12-09](#))

- a. Ball, butterfly (noncontrol) gate, globe, and plug valves (including manual gear operator):
  1. Cast iron and bronze valves, size NPS 14 (350 mm) and larger, any pressure rating
  2. All carbon steel and low Cr (up to and including 5 Cr and 5 Cr-Mo) valves:
    - (a) With pressure rating equal or less than Class 400 sizes NPS 4 (100 mm) through NPS 12 (300 mm)
    - (b) With pressure rating over Class 400
    - (c) In sizes 14 in. and larger
    - (d) All socket welding valves with welded-in stubs requiring postweld heat treatment
    - (e) All valves with bonnets, end flanges, or bodies fabricated or assembled by welding
    - (f) All valves with soft seals
- b. Motor actuated (electric motor, piston, rotary air motor) other than control valves:  
All valves and their operators ([GP 15-09-02](#))
- c. Control valves (including butterfly and valves in protective instrument services):  
All valves and their operators ([GP 15-09-01](#))
- d. Pressure relief valves and devices (including thermal relief valves, pressure-vacuum valves, vacuum relief valves, rupture pin type relief valves, rupture discs):  
All ([GP 03-15-01](#))
- e. Diaphragm valves:  
All ([GP 03-12-09](#))
- f. Check valves:
  1. All valves in sizes 4 in. (100 mm) and larger ([GP 03-12-09](#))
  2. All spring loaded check valves ([GP 03-12-09](#))
- g. Slide valves:  
All ([GP 05-01-01](#))

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|     |                                                                                                                                                                           |
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| h.  | Lined valves:<br>All                                                                                                                                                      |
| i.  | Valves requiring impact or hardness tests or PMI:<br>All ( <a href="#">GP 18-10-01</a> / <a href="#">GP 18-12-01</a> )                                                    |
| j.  | All flanged or welding end valves of the following materials: ( <a href="#">GP 03-12-09</a> )                                                                             |
| 1.  | Ductile iron                                                                                                                                                              |
| 2.  | High alloy (9 Cr and above, 18Cr 8Ni)                                                                                                                                     |
| 3.  | Monel                                                                                                                                                                     |
| 4.  | Aluminum                                                                                                                                                                  |
| 5.  | Hastelloy                                                                                                                                                                 |
| k.  | Valves requiring "fire-safe" certification: ( <a href="#">GP 03-12-08</a> / <a href="#">GP 03-12-09</a> )<br>Witness all tests for certification purposes                 |
| l.  | Valve castings in hydrogen service as per <a href="#">GP 18-03-04</a>                                                                                                     |
| m.  | [*] Valves not otherwise listed to be inspected:<br>Purchaser to consult with Owner's Engineer for special inspection requirements of valves in the following categories: |
| 1.  | Reconditioned valves                                                                                                                                                      |
| 2.  | Materials, construction, or designs requiring special inspection techniques                                                                                               |
| 3.  | Valves purchased in large quantities from one Supplier, regardless of source                                                                                              |
| 60. | Vehicles:                                                                                                                                                                 |
| a.  | Trucks: Specially fitted, such as fire trucks and tank trucks                                                                                                             |
| b.  | Heavy construction and maintenance equipment for export to another continent or remote location                                                                           |
| 61. | Weigh scales: Except laboratory, medical, shipping platform                                                                                                               |
| 62. | Wire and Cable:                                                                                                                                                           |
| a.  | Wire and cable rated 5000 volts and higher                                                                                                                                |
| b.  | Wire and cable rated 3000 volts in sizes 300 MCM (150 mm <sup>2</sup> ) and larger                                                                                        |
| 63. | Wood, for permanent installation:                                                                                                                                         |
| a.  | Timber and Piling                                                                                                                                                         |
| b.  | All incised lumber prior to preservative treatment                                                                                                                        |

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## Record of Change

|                                |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                    |
|--------------------------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b>           |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Date: 07/01</b> |
| <b>Location</b>                | <b>Action</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |
|                                |               | Initial Publish.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |
| <b>Version 1.0.0</b>           |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Date: 07/03</b> |
|                                |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |
| <b>Version 1.0.0</b>           |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Date: 03/05</b> |
|                                |               | Initial endorsement by Chemical. Due to Chemical endorsement of the referenced GP 20-01-02, this version replaces Chemical's previous customized Version 1.0.1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                    |
| <b>Version 2.0.0</b>           |               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Date: 09/06</b> |
| Section 1                      | Modification  | Added additional explanation of references.<br>Added/deleted references as needed per body of GP.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |
| Section 2, Item (4)            | Addition      | Added reference to Projects Equipment Criticality Rating Work Process.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    |
| Section 4, Items (1a) and (1b) | Addition      | Added requirement for Purchaser to reference this GP in requisition.<br>Added requirement for inspection clause in purchaser's responsibilities.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |
| Section 5, Items (1d) to (1h)  | Addition      | Added clarification to Supplier obligations, roles, and responsibilities.<br>Added reference to technical documentation, GPs in suborders.<br>Added requirement for inspection clause in prime/suborders.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    |
| Table 1                        | Addition      | Added references to applicable Global Practices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |
| General                        | Modification  | Added purpose codes throughout GP.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |
| <b>All Global Practices</b>    | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> |                    |

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|               |              | <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |
| Version 2.1.0 |              | Date: 11/08                                                                                                                                                                                                                                                         |
| Table 1       | Modification | Deleted inactive reference GP 10-13-02.                                                                                                                                                                                                                             |

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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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| GP 20-01-02 | Administrative Procedures for Obtaining Inspection | January 2007 |
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# Administrative Procedures for Obtaining Inspection

## GP 20-01-02

### Scope

- 1) [I] This Global Practice (GP) covers administrative procedures applicable when material or equipment is to be inspected by the Company or an appointed Owner's Representative.
- 2) [\*] [R] This Practice shall be applied to any direct or indirect Purchase Orders or suborders issued on behalf of or by the Company when inspection is required by [GP 20-01-01](#), or when specified by the Purchaser.

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| Refining/Chemicals, Downstream<br>Imperial Oil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | For Company Use Only            | Version 2.0.0 |
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# 1. Required References

This section lists the Practices, codes, standards, specifications, and publications that shall be used with this document. Unless otherwise specified herein, use the latest edition.

## 1.1. Global Practices–ExxonMobil Engineering Practices

|                             |                                       |
|-----------------------------|---------------------------------------|
| <a href="#">GP 20-01-01</a> | Inspection of Equipment and Materials |
| <a href="#">GP 20-01-03</a> | Quality Programs                      |

## 1.2. ExxonMobil Research and Engineering (EMRE) Inspection Request

|                                  |                         |
|----------------------------------|-------------------------|
| <a href="#">GP200102 IR FORM</a> | Inspection Request Form |
|----------------------------------|-------------------------|

To engage EMRE Inspection, complete [GP200102 IR FORM](#) and submit to the respective AEO Inspection Coordinator listed in Table 1 of this GP.

- 1) [I] The EMRE Inspection Request Form includes two drop-down "selection" boxes in Section 4 to assist in defining Equipment Criticality. The first drop-down selection is for defining the Criticality Assessment of the Equipment/System. The second is for defining the basis for the Criticality Assessment., using either Table 1 (predefined list) or Table 2, Criticality Assessment Worksheet. If Table 2 is used, the requester is to include a copy with the request.

Note that the EMRE Equipment Criticality Assessment Work Process is based on the corporate risk matrix approach, with SHE and Financial consequences assessed separately.

- 2) The Inspection Request shall include all purchase specification requirements, e.g., copy of Purchase Order, mechanical job specification, and reference to all applicable ExxonMobil Global Practices (GPs), ExxonMobil AML, General ExxonMobil Piping Material Specifications (GEMS), site-specific General Information and Instructions (GIIs), etc., applicable to the Vendor's scope of supply.
- 3) EMRE Inspection will review the data submitted and develop an Inspection Plan commensurate with the purchase specification requirements and the Equipment/System Criticality Rating.
- 4) EMRE Inspection will submit an Inspection Plan to the requester for review and comment before commencing inspection activities.
- 5) **[R] Equipment/Systems with Criticality Rating I:** EMRE Inspection requires owner endorsement of the proposed inspection plan before the work can proceed.

## 2. Definitions

| Term                             | [I] Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Company</b>                   | ExxonMobil or ExxonMobil Affiliates.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Direct Orders</b>             | Purchase Orders issued to a Supplier on behalf of or by the Company, or a Company Affiliate, for materials or equipment. These are also known as Main Orders or Prime Orders.                                                                                                                                                                                                                                                                                                                                                |
| <b>Indirect Orders</b>           | <p>Purchase Orders issued by a Supplier (who is a recipient of a Direct Order) for mill or foundry materials or component parts or subassemblies for fabrication or assembly. These are also known as suborders, shop orders, internal work orders, etc.</p> <p>Indirect orders also include subcontracts issued to a Supplier on behalf of, or by the Company or a Company Affiliate for the design and/or supply of materials, equipment, large special purpose package units, and possible execution at the job site.</p> |
| <b>Inspector</b>                 | As used in this Practice, refers to the Company Inspector, or the appointed Owner's or Purchaser's Representative.                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Owner</b>                     | Company or Company Affiliate organization that will receive the equipment or materials.                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Purchase Order (Contract)</b> | As used in this Practice, includes the Purchase Order (or Contract) document, its referenced Specifications and Practices, Attachments, Codes, Standards, other referenced documents, and all agreed on amendments thereto.                                                                                                                                                                                                                                                                                                  |
| <b>Purchase Order Package</b>    | <p>Includes a direct or indirect Purchase Order with the following attachments:</p> <ul style="list-style-type: none"> <li>a. Applicable Practices or equivalent technical specifications and narrative and Technical Data Sheet specifications, and applicable drawings.</li> <li>b. Copies, or complete identification of applicable Codes, Standards, Specifications, and Publications.</li> <li>c. Applicable transportation and documentation instructions.</li> </ul>                                                  |
| <b>Purchaser</b>                 | May be the Company, a Company Affiliate organization, or a Company designated Representative responsible for procuring equipment, components, materials, systems, or services.                                                                                                                                                                                                                                                                                                                                               |
| <b>Supplier</b>                  | As used in this GP, refers to the Manufacturer, Vendor, Prime Supplier, Subsupplier, Contractor or Subcontractor, and/or the recipient of the Purchase Order/Suborder.                                                                                                                                                                                                                                                                                                                                                       |

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### 3. Procedures

- 1) [\*] [R] Equipment and materials listed in Table 1 of [GP 20-01-01](#) and/or as specified by the Purchase Order or subsequent Suborders are subject to inspection by the Company or its designated Representative.
- 2) [I] The EMRE Inspection Office or its designated Representative shall furnish the Supplier and Subsupplier with a notification of intent to inspect material and equipment at the Supplier's/Subsupplier's works.
- 3) EMRE or its designated Inspection Representative will provide the Supplier/Subsupplier with written notification of their involvement and confirm contact information for the nominated Inspector.
- 4) [I] Direct and indirect Purchase Orders for items to be inspected shall include the inspection clause shown below.

The goods covered by this Purchase Order and any subsequent Suborders shall be subject to inspection by the Company or its designated Representative under the guidance of GP 20-01-01.

The Supplier/Subsupplier shall notify the Company or its designated Representative and the assigned Inspector at least 5 working days before items are ready for inspection.

- 5) [I] Each Purchase Order and any correspondence pertaining thereto shall include the following:
  - a) Contractor Project Identification Number or the Purchase Order number of Company Affiliate, or Client, as applicable
  - b) Any Purchase Order numbers assigned by Contractor, Manufacturer, or Vendor
  - c) Project or Affiliate designation
- 6) [\*] [I] Copies of Purchase Orders/Suborders and all related technical data, documentation, and correspondence shall be sent in electronic format to the nearest EMRE Inspection office listed in Table 1 of this GP, unless Purchaser advises otherwise.  
 If the location of a Fabricator/Manufacturer is unknown, the Purchaser may contact the nearest EMRE Inspection office listed in Table 1 of this GP for advice or instruction.
- 7) [\*] [I] Copies of any follow-up correspondence pertaining to Purchase Orders/Suborders shall be sent in electronic format to the appropriate EMRE Inspection Office listed in Table 1 of this GP or to the Company's designated Representative.
- 8) Correspondence pertaining to drawings, manufacturing data, welding, or test procedures shall include the appropriate document identification number, revision number, and date. This shall assure that the Inspector will have reference to the correct and most recent version of fabrication/manufacturing documents during execution of the inspection activities.

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**Table 1: Administrative Procedures for Obtaining Vendor Surveillance for Procured Equipment/Materials**

| Location of Manufacture                                                  | Regional Inspection Offices, Address, Telephone, Facsimile, E-Mail, or Internet web site at <a href="http://emre.na.xom.com/home/engproj/aeos.htm">http://emre.na.xom.com/home/engproj/aeos.htm</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| North America<br>South America<br>Central America<br>Caribbean Countries | <p><b>A. Jay Weick</b>, Regional Inspection Supervisor</p> <p>ExxonMobil Research &amp; Engineering Company - Americas Regional Engineering Office - Quality Assurance Headquarters<br/>PO Box 2954, 2800 Decker Drive<br/>Baytown, Texas 77522-2954</p> <p>Telephone: (281) 834-3542<br/>Facsimile: (281) 834-3571<br/>E-Mail: <a href="mailto:A Jay Weick/ Baytown/ExxonMobil@xom">A Jay Weick/ Baytown/ExxonMobil@xom</a><br/>Internet: <a href="mailto:a.jay.weick@exxonmobil.com">a.jay.weick@exxonmobil.com</a></p> <p><b>Send Inspection Request and purchase documentation to:</b></p> <p><b>Jenny M. Prasek</b> - Inspection Coordinator, Americas AEO Baytown<br/>E-Mail: <a href="mailto:jenny.m.prasek@exxonmobil.com">jenny.m.prasek@exxonmobil.com</a><br/>Tel: (281) 834-3547</p> <p><b>Mary H. Walker</b> - Inspection Coordinator, BRRF - BRCP Only<br/>Tel: (225) 977-5751<br/>E-Mail: <a href="mailto:mary.h.walker@exxonmobil.com">mary.h.walker@exxonmobil.com</a></p> <p>For additional information and to obtain an Inspection Request Form visit the <a href="#">AAEO Quality Assurance/Source Inspection</a> web site.</p> |

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| Location of Manufacture                                                                                       | Regional Inspection Offices, Address, Telephone, Facsimile, E-Mail, or Internet web site at <a href="http://emre.na.xom.com/home/engproj/aeos.htm">http://emre.na.xom.com/home/engproj/aeos.htm</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Europe<br>United Kingdom<br>Middle East<br>Africa<br>Commonwealth of Independent States (Former Soviet Union) | <p><b>Barry J. Luxton</b>, Regional Inspection Supervisor</p> <p>ExxonMobil Engineering Europe Ltd.<br/>Quality Assurance Group<br/>Epcu Administration Building Room 242<br/>Esso Refinery<br/>Fawley Southampton<br/>SO45ITX</p> <p>Telephone: (44) 02380 88 4556<br/>Facsimile: (44) 02380 88 4542<br/>Mobile: (44) 07841 295149<br/>Or e-mail to:<br/>EMEEL QA GROUP@xom<br/>E-Mail: <a href="mailto:Barry.J.Luxton/UK/ExxonMobil.xom">Barry J. Luxton/UK/ExxonMobil.xom</a><br/>Internet: <a href="mailto:barry.j.luxton@exxonmobil.com">barry.j.luxton@exxonmobil.com</a></p> <p><b>Send Inspection Request and purchase documentation to:</b><br/><b>Richard Zuk</b><br/>E-Mail: <a href="mailto:richard.zuk@exxonmobil.com">richard.zuk@exxonmobil.com</a> or <a href="mailto:emeelqa@exxonmobil.com">emeelqa@exxonmobil.com</a><br/>Tel: (44)-02380-88-4692</p> |
| Far East Area<br>Indonesia<br>Australia<br>India<br>Pakistan                                                  | <p><b>Ooi, Soo-Ken</b>, Regional Inspection Supervisor</p> <p>ExxonMobil Asia Pacific Pte., Ltd.<br/>ExxonMobil Engineering Asia Pacific<br/>Quality Assurance Group<br/>18 Pioneer Road, Jab - 2nd Floor<br/>Singapore 628498</p> <p>Telephone: (65) 6660 6518<br/>Facsimile: (65) 266 4409<br/>Mobile: (65) 9786 0960<br/>E-Mail: <a href="mailto:Soo-Ken.Ooi/Singapore/Mobil-Notes">Soo-Ken Ooi/Singapore/Mobil-Notes</a><br/>Internet: <a href="mailto:soo-ken.ooi@exxonmobil.com">soo-ken.ooi@exxonmobil.com</a></p> <p><b>Send Inspection Request and purchase documentation to:</b><br/><b>Anthea Moon-Ngoh Wong</b><br/>E-mail: <a href="mailto:anthea.mn.wong@exxonmobil.com">anthea.mn.wong@exxonmobil.com</a><br/>Tel: 65-6660-6516</p>                                                                                                                       |

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| Location of Manufacture     | Regional Inspection Offices, Address, Telephone, Facsimile, E-Mail, or Internet web site at <a href="http://emre.na.xom.com/home/engproj/aeos.htm">http://emre.na.xom.com/home/engproj/aeos.htm</a>                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| General Inspection Business | <b>Steven G. Fess</b> , Section Head - Materials and Inspection<br>ExxonMobil Research & Engineering Company<br>Americas Regional Engineering Office - Quality Assurance Headquarters<br>Materials, Inspection And Support Group<br>PO Box 2954, 2800 Decker Drive<br>Baytown, Texas 77522-2954<br>Telephone: (281) 834-7548<br>Facsimile: (281) 834-3571<br>E-Mail: <a href="mailto:Steven.g.fess/Baytown/ExxonMobil@xom">Steven.g.fess/Baytown/ExxonMobil@xom</a><br>Internet: <a href="mailto:steven.g.fess@exxonmobil.com">steven.g.fess@exxonmobil.com</a> |

### 3.1. Inspection Notification

- 1) [\*] [C] [R] Advance notice. Supplier/Subsupplier shall notify the appropriate EMRE Inspection Office and assigned Inspector at least 5 working days before items are ready for inspection. In all cases, notification shall be given prior to painting or preparation for shipment.  
If progressive inspection is to be performed during shop fabrication (e.g., heat exchangers, vessels, tanks, boilers, compressors), Inspector shall be notified of the date that shop fabrication/assembly begins.
- 2) [I] Advance inspection notice should be communicated by e-mail, (letter, telephone, or facsimile may also be used), and shall include the following:
  - a) Contractor Project Identification Number or the Purchase Order number of the Company Affiliate
  - b) Purchase Order numbers assigned by the Company's designated Representative, Supplier, Manufacturer, or Vendor
  - c) Company project or Affiliate designation
  - d) Indication of which portion of the order is ready for inspection
  - e) EMRE assigned Inspection File Number

### 3.2. Waiver of Inspection

- 1) [A] [C] [I] Inspector may waive the inspection of any item, as approved by Owner's Engineer. In this case, written notification of the waiver shall be furnished to both Purchaser and Supplier.
- 2) Waiver of source inspection shall not prejudice the right to reject equipment or materials upon delivery to final destination.

### 3.3. Inspection and Data Requirements

- 1) [O] [R] At the time of final inspection and prior to shipment, Supplier shall furnish the Inspector with sufficient documentation to demonstrate that the requirements of the Purchase Order or subsequent amendments have been satisfied. Such documentation may include the following:

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- a) A copy of certified mill test reports or other acceptable chemical and physical material data,
  - b) Code forms
  - c) Charts
  - d) Certificates
  - e) Inspection and test reports
  - f) Any other documentation required by the Purchase Order.
- 2) Inspector shall not release equipment or materials until he/she has received and endorsed the Supplier's data and documentation and is satisfied that it meets the purchase specification requirements.
- 3) [O] [R] Certified mill test reports/certificates or certified tests of physical and chemical properties may be considered adequate documentation. Further witnessing of tests may not be required unless justified by the experience of EMRE Inspection Office, or as specified below.
- Impact tests shall be witnessed by the Inspector. Witnessing shall include the identification of samples prior to removal from the parent metal. The Inspector shall selectively witness hardness, Hydrogen Induced Cracking (HIC), and Positive Material Identification (PMI) testing. Additionally, the Inspector shall witness all pressure vessel hydrostatic testing.
- 4) [I] The sections above refer to the documentation and testing requirements that must be either endorsed or witnessed by Inspector, and is separate from the data dossier that Supplier shall provide to Purchaser at the conclusion of fabrication.

### 3.4. Surveillance Reports

- 1) [I] Inspector shall issue a Surveillance Report indicating that Supplier is released to ship materials and equipment pending Owner's instructions immediately after receiving required data and after verification of satisfactory compliance with the purchase specification requirements.
- 2) [O] [R] Inspector shall be responsible for reporting details of nonconforming equipment or material in the appropriate section of his/her Surveillance Report after inspection at Supplier's/Subsupplier's works. Equipment and materials shipped to the job site without inspection or release shall not be accepted.

## 4. Supplier/Subsupplier Obligations and Responsibilities

- 1) [C] [R] Quality Assurance: The Supplier is obligated to assure the quality of the equipment and materials being provided under the purchase order, either directly or indirectly. The Supplier shall provide the following:
  - a) The Supplier shall provide its own quality control and inspection of the materials to ensure that the requirements of the purchase order and its referenced specifications are met.
  - b) The Supplier shall record and maintain records of the quality control inspection activities performed.
  - c) Inspection by the Company or its Designated Representative does not relieve the Supplier of obligations as defined in Item (1). Neither does such inspection relieve the Supplier from guarantees of material, apparatus, workmanship, and/or performance.

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- d) The Prime Supplier shall include all applicable purchase specification requirements in its suborders to lower tier Subsuppliers. This is defined as specific Mechanical Job Specifications, Data Sheets, applicable Company GPs, and any other technical data and documentation relevant to the Supplier's/Subsupplier's scope of work.
- e) The Prime Supplier shall provide the Company or its Designated Representative with a list of proposed Subsuppliers being considered to provide equipment and materials listed in Table 1 of [GP 20-01-01](#). The Prime Supplier shall provide this list for Company or Designated Representative review and comment prior to issuing any suborders.
- f) The Prime Supplier shall provide the Company or its Designated Representative with copies of suborders for equipment and materials listed in Table 1 of [GP 20-01-01](#).
- g) [\*] The Company or its Designated Representative will review suborders and develop inspection strategies for the equipment and materials covered therein.
- h) All purchase orders and subsequent suborders for equipment and materials listed in Table 1 of [GP 20-01-01](#) shall include the following inspection clause:

The goods covered by this Purchase Order and any subsequent Suborders shall be subject to inspection by the Company or its designated Representative under the guidance of GP 20-01-01. The Supplier/Subsupplier shall notify the Company or its designated Representative and the assigned Inspector at least 5 working days before items are ready for inspection.

- 2) [C] [R] Free Entry: The Supplier shall afford the Inspector the right of access and free entry to any areas of the Supplier or Subsupplier premises where storage, work, or testing of any equipment or material component is being performed to fulfill purchase order requirements. Unrestricted opportunity shall be provided to the Inspector to verify compliance of equipment and material components with the requirements of direct or indirect purchase orders.
- 3) [S] Inspector's Safety: The Supplier shall provide a safe working environment for the Inspector and shall alert the Inspector of potential hazards. If in the opinion of the Inspector the working conditions are unsafe, then the Inspector will not perform the work.
- 4) [I] [R] Quality Program: When [GP 20-01-03](#) is specified, the Supplier shall follow the approved Quality Program to assure the quality of the equipment and materials that are being provided either directly or indirectly. The Quality Program shall assure that the requirements of the purchase order, its referenced specifications, all attachments, and amendments thereto will be addressed and satisfied during the fabrication and/or manufacturing process.

## 5. Alternative Inspection by Purchaser

- 1) [\*] [I] At Purchasers' discretion, inspection may be arranged through a qualified third party of their choice. All of the administrative procedures, obligations, and requirements detailed in this GP shall apply whether or not the EMRE Inspection Office is involved with the inspection.
- 2) [I] Should Purchaser decide to undertake responsibility for inspection, the following points should be considered:
  - a) Purchaser should complete a criticality assessment of the equipment/commodity to be inspected.

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- b) Purchaser should develop detailed inspection instructions based on the criticality of the equipment/commodity being fabricated.
- c) Purchaser may consult with the nearest EMRE Regional Inspection Office for additional information and assistance.

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## Record of Change

|                                |               |                                                                                                                                                    |                    |
|--------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| <b>Version 1.0.0</b>           |               |                                                                                                                                                    | <b>Date: 01/02</b> |
| <b>Location</b>                | <b>Action</b> | <b>Description</b>                                                                                                                                 |                    |
|                                |               | Initial Publish.                                                                                                                                   |                    |
| <b>Version 1.0.0</b>           |               |                                                                                                                                                    | <b>Date: 07/03</b> |
|                                |               | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |                    |
| <b>Version 1.1.0</b>           |               |                                                                                                                                                    | <b>Date: 03/05</b> |
| Table 1                        | Modification  | Update reflecting changes in organization.                                                                                                         |                    |
| Section 3.4, Items (1) and (3) | Modification  | Minor change to Data Requirements.                                                                                                                 |                    |
| Section 3.5                    | Modification  | Change to Section name and to reporting requirements.                                                                                              |                    |
| Section 5                      | Addition      | New section addressing alternative inspection by Purchaser.                                                                                        |                    |
|                                |               | Initial endorsement by Chemical.                                                                                                                   |                    |
| <b>Version 2.0.0</b>           |               |                                                                                                                                                    | <b>Date: 01/07</b> |
| Section 1.                     | Modification  | Editorial change                                                                                                                                   |                    |
| Section 1.1                    | Addition      | GP 20-01-03 was added as a reference.                                                                                                              |                    |
| Section 1.2                    | Modification  | Added EMRE Inspection Request Form, GP200102IR Form, as a reference.                                                                               |                    |
| Section 1.2                    | Modification  | Added instructions for engaging EMRE Inspection.                                                                                                   |                    |
| Section 2                      | Modification  | Added definition of "Company."                                                                                                                     |                    |
| Section 3.                     | Modification  | Editorial changes.                                                                                                                                 |                    |
| Section 3, Item (4)            | Modification  | Purchase Order Inspection clause wording was changed.                                                                                              |                    |
| Section 3.1                    | Modification  | Editorial change/clarification.                                                                                                                    |                    |
| Section 3.2                    | Modification  | Added instructions for submitting inspection request.                                                                                              |                    |
| Section 3.3                    | Modification  | Title change.                                                                                                                                      |                    |
| Table 1                        | Modification  | Update reflecting changes in organization.                                                                                                         |                    |

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|-----------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Section 4                   | Modification  | Title change and editorial change. Supplier/Subsupplier Obligations and Responsibilities changed to be consistent with GP 20-01-01 requirements.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Section 4, Item (2)         | Modification  | Editorial change.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Section 4, Item (4)         | Modification  | Added reference to GP 20-01-03 Quality Programs.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>All Global Practices</b> | Modifications | <p>To standardize the format of the Global Practices and to meet other requirements, the following changes have been implemented:</p> <p>"For ExxonMobil Use Only" has been replaced with "For Company Use Only."</p> <p>A copyright waiver has been added in the first page Footer.</p> <p>The definition of asterisks in the Scope has been deleted. The asterisk is now defined in the Purpose Code attachment and is used within brackets as other Purpose Codes.</p> <p>Multiple paragraphs within a Section have been numbered.</p> <p>The standard text for Required References has been modified.</p> <p>The standard text for Additional Requirements has been modified.</p> <p>The [S] Purpose Code has been modified.</p> <p>The following Purpose Codes have been added:</p> <p>[*] for additional information or decision required of Owner's Engineer.</p> <p>[A] for approval requirements before beginning work or finalizing design.</p> |

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| GP 20-01-02 | Administrative Procedures for Obtaining Inspection | January 2007 |
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## Attachment: Purpose Code Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *    | Assigned to paragraphs that require the Owner's Engineer to provide additional information or make a decision.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A    | Assigned to paragraphs that require approval from the Owner's Engineer before the work may proceed or the design is finalized.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| C    | Assigned to paragraphs whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include life cycle cost considerations. Life cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| E    | Assigned to paragraphs whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| I    | Assigned to paragraphs that provide only clarifying information, such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| M    | Assigned to paragraphs whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during onstream operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O    | Assigned to paragraphs whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during start-ups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| R    | Assigned to paragraphs whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| S    | <p>Assigned to paragraphs containing specifications/guidance where the primary purpose is the avoidance of incidents impacting personnel safety, operational safety, and the public in general and/or involving responses to emergency situations. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to incident-related personnel injuries or illness, e.g., burns, cuts, abrasions, inhalation of or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, and/or explosions that could result in damage to equipment, process disruption, or personnel injury or illness.</p> |

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# Quality Programs

## GP 20-01-03

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### Scope

- 1) [I] This Global Practice (GP) covers the minimum standards for Quality Programs for specific equipment, components, materials, systems, or services to be provided or furnished to ExxonMobil, or ExxonMobil affiliates. The purpose of the Quality Program is to identify the procedures and controls to be implemented by the affected organization to ensure the equipment, components, materials, systems, or services within the scope of supply meet the specified requirements.
  - 2) [I] When specified, this GP shall be applied to any direct or indirect purchase orders, sub orders, or services agreement for or by ExxonMobil or ExxonMobil affiliates.
  - 3) [I] An asterisk (\*) indicates that a decision by Purchaser is required or that additional information is provided by Purchaser.
- 

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# 1. Required References

This Section lists Practices and Standards that are generically referenced and assumed to be a part of this document. Unless otherwise specified herein, use the latest edition.

## 1.1. ASQ—American Society for Quality

|             |                                                                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| ASQ A8402   | Quality Management and Quality Assurance - Vocabulary                                                                                                     |
| ASQ C1      | Specification of General Requirements for a Quality Program                                                                                               |
| ASQ Q9000-1 | Quality Management and Quality Assurance Standards - Guidelines for Selection and Use                                                                     |
| ASQ Q9000-2 | Quality Management and Quality Assurance Standards - Part 2: Guidelines for Implementing ANSI/ISO/ASQC Q9001, ANSI/ISO/ASQC Q9002 and ANSI/ISO/ASQC Q9003 |
| ASQ Q9001   | Quality Management Systems - Requirements                                                                                                                 |

# 2. Definitions

| Term                         | Definition                                                                                                                                                                                                                                                                 |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Affected Organization</b> | Affected Organization is the individual or organization upon whom this GP is imposed.                                                                                                                                                                                      |
| <b>Auditor</b>               | Auditor is the individual who carries out the audit.                                                                                                                                                                                                                       |
| <b>Direct Orders</b>         | Direct Orders are Purchase orders issued to a Supplier on behalf of, or by ExxonMobil or an ExxonMobil Affiliate, for materials or equipment. (These are also known as main orders or prime orders.)                                                                       |
| <b>External Audits</b>       | External Audits are quality audits performed by Purchaser.                                                                                                                                                                                                                 |
| <b>Indirect Orders</b>       | Indirect Orders are Purchase orders issued by a Supplier (who is recipient of a direct order) for mill or foundry materials or component parts or subassemblies for fabrication or assembly. (These are also known as sub orders, shop orders, internal work orders, etc.) |
| <b>Purchaser</b>             | Purchaser may be ExxonMobil, an ExxonMobil affiliate organization, or ExxonMobil designated representative responsible for procuring equipment, components, materials, systems, or services.                                                                               |
| <b>Quality Assurance</b>     | Quality Assurance includes planned and systematic actions necessary to provide adequate confidence that a product or service or a project shall satisfy given quality requirements.                                                                                        |

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| Term                   | Definition                                                                                                                                                                                                                                                           |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Quality Audit</b>   | The Quality Audit is a systematic and independent examination and evaluation to determine whether quality activities and results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives. |
| <b>Quality Control</b> | Quality Control refers to operational techniques and activities that are used to fulfill requirements for quality.                                                                                                                                                   |
| <b>Quality Plan</b>    | The Quality Plan is the document that sets out specific quality practices, resources, and activities relevant to a particular product, process, service, system, contract, or project.                                                                               |
| <b>Quality Program</b> | The Quality Program includes documented plan(s) for implementing the quality system by the Affected Organization. These plans define the specific scope of supply for the particular inquiry or purchase document.                                                   |
| <b>Quality System</b>  | The Quality System encompasses the organizational structure, responsibilities, procedures, processes, and resources for implementing quality management.                                                                                                             |
| <b>Supplier</b>        | As used in this GP, the term Supplier refers to manufacturer, vendor, sub-supplier, contractor or sub-contractor, and/or the recipient of the purchase order.                                                                                                        |

### 3. Procedures

- 1) \* [O], [R] When this Global Practice is specified, Supplier (Affected Organization) shall provide Purchaser a Specific Quality Program which shall include individual Quality Plans for each piece of equipment, lot of material(s), system(s), or service(s) included in the scope of supply by the specification. Unless otherwise specified, the preliminary Quality Program and Quality Plan shall be submitted to Purchaser with Supplier's initial proposal and/or quotation.
- 2) \* [I] Quality Programs shall generally be structured in accordance with ASQ C1, or ASQ Q9000-2, or other quality standard format that has been mutually agreed upon by ExxonMobil and the Affected Organization.

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- 3) \* [I] Unless otherwise advised, the following are minimum requirements to be addressed in the Quality Program and Quality Plan for the specific scope of supply:
- a) Management Responsibility and Quality Systems utilized
  - b) Quality Assurance plans and actions for scope of supply
  - c) Design Control Procedures for scope of supply
  - d) Document Control Procedures
  - e) Procurement
  - f) Material Control Methods
  - g) Product Identification and Traceability Methods
  - h) Production Process Control Methods
  - i) Quality Control, Inspection, Testing, and Acceptance Criteria
  - j) Inspection, Measuring, and Test Equipment Records
  - k) Inspection and Test Status Identification
  - l) Control of Nonconforming Product
  - m) Corrective Action
  - n) Handling, Storage, Packaging, and Delivery of Products
  - o) Internal and External Audit Plans
  - p) Quality Records Maintenance
  - q) Training and Testing to qualify personnel
  - r) Servicing, Commissioning, and After-Market, when specified
  - s) Statistical Techniques used
- 4) [R], [C] The Quality Program and Quality Plan shall be updated to include ExxonMobil specific requirements and submitted for Purchaser review and approval within four weeks after purchase order/agreement award.
- 5) Any changes to the previously submitted Quality Program or Quality Plan shall be submitted within 10 working days for Purchaser review and approval prior to use. This includes revisions for both Direct Orders and Indirect Orders and agreements.

## 4. Quality Audits

- 1) [R], [C] Purchaser shall have the right to conduct and carry out External Audits for compliance with the approved Quality Program and the intent of this GP.
- 2) [I] External Audits shall be conducted by ExxonMobil or their designated representatives.
- 3) [I] External Audits may cover the complete Quality Program and Quality Plan, or any part, or parts thereof.
- 4) [I] Purchaser or his representative shall have Free Entry to those parts or areas of Supplier or sub-supplier facilities to conduct External Audits, unless prohibited by government security regulations. In such cases, these security regulations must be identified prior to the purchase order, and provisions made to make available all necessary data to Auditor to conduct a comprehensive Quality Audit.

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- 5) [I] Compliance with approved Quality Programs, or major portions of such programs, that is deemed unsatisfactory through External Audits by Purchaser may be cause for withholding acceptance of the product(s).
- 6) [I] Auditor Safety—Supplier shall provide a safe working environment for Auditor(s) and shall alert Auditor to all known potential hazards. If the working environment or conditions are unsafe in the opinion of Auditor, Auditor shall not conduct the Quality Audit. Likewise, Auditor shall be knowledgeable of and comply with Supplier safety rules.

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## Record of Change

|               |        |                                                                                                                                                    |             |
|---------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Version 1.0.0 |        |                                                                                                                                                    | Date: 07/01 |
| Location      | Action | Description                                                                                                                                        |             |
|               |        | Initial Publish.                                                                                                                                   |             |
| Version 1.0.0 |        |                                                                                                                                                    | Date: 07/03 |
|               |        | Global Practice version number and format updated to comply with new process; however, original publish date remains, and no content was modified. |             |

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## Attachment: Purpose Codes Definitions

| Code | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C    | Assigned to paragraphs containing specifications whose primary purpose is reduced costs. Reduced cost in this context refers to initial investment cost and does not include Life-Cycle cost considerations. Life-Cycle cost considerations are captured under reliability, maintainability, or operability purpose codes.                                                                                                                                                                                                                                                                                                                                                     |
| E    | Assigned to paragraphs containing specifications whose primary purpose is driven by environmental considerations. Environmental considerations typically include specifications intended to protect against emissions/leakage to the air, water, and/or soil. Deviations from the specifications contained in such paragraphs require formal review and approval according to local environmental policy.                                                                                                                                                                                                                                                                      |
| I    | Assigned to paragraphs that provide only clarifying information such as Scope statements, definitions of terms, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| M    | Assigned to paragraphs containing specifications whose primary purpose is to provide for maintainability of equipment or systems. Maintainability provisions are those that facilitate the performance of maintenance on equipment/systems either during downtimes or during on-stream operations.                                                                                                                                                                                                                                                                                                                                                                             |
| O    | Assigned to paragraphs containing specifications whose primary purpose is to assure operability of equipment or systems. Operability is the ability of the equipment/system to perform satisfactorily even though conditions are off-design, such as during startups, process swings, subcomponent malfunction, etc.                                                                                                                                                                                                                                                                                                                                                           |
| R    | Assigned to paragraphs containing specifications whose primary purpose is to improve or assure the reliability of equipment or systems. Reliability is a measure of the ability of equipment/systems to operate without malfunction or failure between planned maintenance interventions.                                                                                                                                                                                                                                                                                                                                                                                      |
| S    | <p>Assigned to paragraphs containing specifications whose primary purpose is avoidance of personnel or operational safety incidents. Any deviation from the specifications contained in such designated paragraphs requires formal review and approval according to local safety policy.</p> <p>Personnel Safety: Refers to the avoidance of recordable personnel injuries; i.e., burns, cuts, abrasions, inhalation, or exposure to dangerous substances, etc., that could result in medical treatment, restricted work, lost-time incidents, or fatalities.</p> <p>Operational Safety: Refers to the prevention and control of process releases, fires, explosions, etc.</p> |