

Engineering Procedure

SAEP-325

30 June, 2004

Inspection Requirements
for Pressurized Equipment

Document Responsibility: Inspection Department

Saudi Aramco DeskTop Standards

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1 Scope

- 1.1 This Saudi Aramco Engineering Procedure (SAEP) provides special instructions that are in addition to API STD 510 and the normal T&I requirements for internal inspection, testing, repairing and re-rating of In-service Pressurized Equipment (PE). Excluded from the scope of this document are pressure equipment fabricated in accordance with ASME SEC I (boilers), API STD 650 and API STD 620 (storage tanks), ASME B31.1, B31.3, B31.4 and B31.8 piping, air cooled heat exchangers and fired heaters. When in doubt about the applicability of this procedure for any equipment, contact the Inspection Department, Operations Inspection Division, Dhahran.
- 1.2 The equipment covered by this engineering procedure falls into one of three classes:
- Class 1 Equipment
 - Class 2 Equipment
 - Class 3 Equipment

Commentary Note:

The different equipment types covered under the above classes of equipment are listed in Section 6 under "Definitions". These classes are based on service severity.

2 Conflicts and Deviations

- 2.1 Any conflicts between this procedure and other applicable Saudi Aramco Engineering Procedures (SAEPs), Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Inspection Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this procedure in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Inspection Department of Saudi Aramco, Dhahran.
- 2.3 Nondestructive Testing (NDT) shall be performed only by individuals certified to Level I or II in accordance with [SAEP-1140](#) or [SAEP-1142](#).

3 Purpose

- 3.1 This SAEP is intended to assist the Plant and Equipment (PE) Inspectors of the Plant Inspection Units in their evaluation of PE during an internal inspection (T&I). The following major considerations that should be taken into account are:
- 3.1.1 Environmental related cracking that may develop inside equipment exposed to amine, caustic, wet hydrogen sulfide, or Boiler Feed Water (BFW) deaeration processes.
 - 3.1.2 Assessment of carbon steel pressurized equipment when changing from sweet to sour service.
 - 3.1.3 Assessment of all PE (including carbon steel and low alloy steel) exposed to high temperature/ pressure hydrogen and normal hydrogen service.
 - 3.1.4 High temperature creep and creep fatigue. PE operating at temperatures above 370°C (700°F) as per API RP 571 may be susceptible to creep and creep fatigue depending upon stress level and material composition.
 - 3.1.5 Graphitization of carbon steels operating at temperatures above 800°F for cumulative periods exceeding 30,000 hours may experience embrittlement due to graphitization.
 - 3.1.6 Fatigue service of PE subject to cyclic service as defined by ASME SEC VIII, Div. 2, Section AD-160.
- 3.2 Further defines the responsibilities of the organizations involved in inspecting, testing, repairing, altering, re-rating and maintaining PE records as specified in [SAES-D-008](#).

4 References

References shall be the latest issued revision or edition.

4.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

[SAEP-20](#)

Equipment Inspection Schedule

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*

<u>SAEP-317</u>	<i>Testing and Inspection (T&I) of Shell and Tube Heat Exchangers</i>
<u>SAEP-355</u>	<i>Field Metallography and Hardness</i>
<u>SAEP-1140</u>	<i>Qualification and Certification of Saudi Aramco NDT Personnel</i>
<u>SAEP-1141</u>	<i>Industrial Radiation Safety</i>
<u>SAEP-1142</u>	<i>Qualification and Certification of Non-Saudi Aramco NDT Personnel</i>
<u>SAEP-1143</u>	<i>Radiographic Examination</i>
<u>SAEP-1144</u>	<i>Magnetic Particle Examination of Welds and Components</i>
<u>SAEP-1145</u>	<i>Liquid Penetrant Examination of Welds and Components</i>
<u>SAEP-1146</u>	<i>Manual Ultrasonic Thickness Testing</i>

Saudi Aramco Engineering Standards

<u>SAES-A-004</u>	<i>General Requirements for Pressure Testing</i>
<u>SAES-A-005</u>	<i>Safety Instruction Sheet</i>
<u>SAES-A-007</u>	<i>Hydrostatic Testing Fluids and Lay-up Procedure</i>
<u>SAES-A-206</u>	<i>Positive Material Identification</i>
<u>SAES-D-001</u>	<i>Design Criteria for Pressure Vessels</i>
<u>SAES-D-008</u>	<i>Repairs, Alterations and Re-rating of Pressured Equipment</i>
<u>SAES-E-004</u>	<i>Design Criteria of Shell & Tube Heat Exchangers</i>
<u>SAES-W-010</u>	<i>Welding Requirements for Pressure Vessels</i>

Saudi Aramco Materials System Specifications

<u>32-SAMSS-004</u>	<i>Manufacture of Pressure Vessels</i>
<u>32-SAMSS-007</u>	<i>Manufacture of Shell & Tube Heat Exchangers</i>

Saudi Aramco General Instructions

<i>GI-0002.100</i>	<i>Work Permit System</i>
<i>G1-0002.102</i>	<i>Pressure Testing Safely</i>
<i>GI-0002.600</i>	<i>Plant/Unit Acceptance After T&I Shut Down</i>
<i>GI-0006.102</i>	<i>Isolation, Lockout and Use of Hold Tags</i>

GI-0008.011 Safety Requirements for Scaffolding

Saudi Aramco Inspection Procedures

[00-SAIP-07](#) *Positive Material Identifications*

[00-SAIP-74](#) *Inspection for Corrosion under
Insulation/Fireproofing*

[00-SAIP-75](#) *External Inspection*

[00-SAIP-76](#) *Worksheet Control and Tracking*

[00-SAIP-78](#) *Inspection Records/Filing*

Saudi Aramco Form and Data Sheet

[3060-ENG](#) *T&I Acceptance Report*

4.2 Industry Codes and Standards

American Society of Mechanical Engineers

ASME SEC II Materials

ASME SEC V Nondestructive Examination

*ASME SEC VIII Pressure Vessels
Div. 1 and Div. 2*

American Society of Testing and Materials

*ASTM E10 Standard Test Method for Brinell Hardness of
Metallic Materials*

*ASTM E709 Standard Guide for Magnetic Particle
Examination*

American National Standards Institute

ANSI NB-23 National Board Inspection Code

American Petroleum Institute

API STD 510 Pressure Vessel Inspection Code

*API RP 571 Recommended Practice for Damage Mechanism
Affecting Equipment in Refining Industry*

*API RP 572 Recommended Practice for Inspection of Pressure
Vessels*

API RP 579 Recommended Practice for Fitness-For-Service

API RP 941 Recommended Practice for Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants

API RP 945 Recommended Practice for Avoiding Environmental Cracking in Amine Units

National Association of Corrosion Engineers

NACE RP0472 Recommended Practice for Methods and Controls to Prevent In-Service Cracking of Carbon Steel Welds in P-1 Materials in Corrosive Petroleum Refining Environments

NACE RP0590 Recommended Practice for Prevention, Detection and Correction of Deaerator Cracking

5 Safety

- 5.1 All inspection and testing shall be in full compliance with GI-0006.102, "Isolation, Lockout and Use of Hold Tags".
- 5.2 All inspection and testing shall be in full compliance with GI-0002.100, "Work Permit System".
- 5.3 All pressure testing shall be in compliance with GI-0002.102, "Pressure Testing Safely".
- 5.4 All scaffolds shall be in full compliance with GI-0008.001, "Safety Requirement for Scaffolds".

6 Definitions and Abbreviations

Alteration: A physical change in any component or a re-rating that has design implications that affect the pressure-containing capability of process equipment beyond the scope of the items described in the original Manufacturers' Data Report as defined in [SAES-D-008](#).

Amine Services: All amine solutions including MEA, TEG, DEA, DGA, MDEA and ADIP.

Class 1 Equipment: Process equipment made from carbon steel and low alloy steel, whose internal surfaces are exposed to amine, caustic, or wet hydrogen sulfide service.

Class 2 Equipment: BFW deaeration equipment.

Class 3 Equipment: All other pressurized process equipment, not included or excluded in Class 1 and Class 2 Equipment definitions listed above.

Corrosion Allowance (CA design): The design corrosion allowance is specified metal thickness in excess of the calculated minimum required thickness to achieve a specific service life of equipment in a specific service. If a PE is clad, the cladding must be considered as corrosion allowance.

Corrosion Allowance (CA actual): The actual corrosion allowance is any metal thickness in excess of the calculated minimum required thickness. If a PE is clad, the cladding must be considered as corrosion allowance.

Corrosion, General: Refers to corrosion dominated by uniform thinning that proceeds without appreciable localized attack.

Corrosion, Localized: Describes different forms of corrosion, all of which have the common feature that the corrosion damage produced is localized rather than spread uniformly over the exposed metal surface.

Corrosion Rate: Corrosion rate is the representative rate of metal loss due to corrosion over a period of time for a given service. The corrosion rate is usually measured in mils per year (mpy).

Caustic Services: All sodium hydroxide solutions.

Field: Any location where PE repair work is performed, other than in a Shop.

Hydrocarbon Services: Process streams of liquid or gaseous hydrocarbon (HC) materials. HC streams may contain phenols, carbon dioxide, and ammonia.

Hydrogen Services: Process streams containing relatively pure hydrogen (H₂) and component streams containing hydrogen with a partial pressure of 350 Kpa and higher. $H_2 \text{ partial pressure} = \text{mol \% } H_2 \times \text{Operating Pressure}$.

Inspector: A Saudi Aramco employee qualified and certified to the criteria specified in the Company's Plant and Equipment (P&E) Inspector Job Descriptions recognized by the Organization and Consulting Department (OCD) or a qualified and certified contract P&E Inspector.

Low-Chromium Alloy Steels: Alloy materials with nominal chromium contents of 1% to 9% chromium.

Manufacturer's Data Report: An ASME Code document completed and furnished by the Manufacturer, certifying all materials, construction and workmanship conform to Code requirements.

Minimum Required Thickness (T-min): Minimum thickness is equal to the design thickness as calculated by the applicable ASME SEC VIII, Div.1 and Div 2 code to the temperature, pressure and/or vacuum limits as specified by the Company. The calculated (T-min.) excludes corrosion allowance. In some instances additional thickness is required for mechanical or structural loading.

Natural Resource Services: Includes pressure vessels used for drilling, producing, gathering, and gas-oil separation plants.

Re-rating: Change in the design temperature and/or MAWP of process equipment. The MAWP and design temperature may be increased or decreased because of re-rating, and sometimes a re-rating requires a combination of changes. Re-rating below original design conditions is a permissible way to provide for corrosion as defined in [SAES-D-008](#).

Repair: The work necessary to restore a vessel to a condition suitable for safe operation at the design conditions, without any deviation from the original configuration.

Routine Repair: Repair that does not require "R" stamping in accordance with the ANSI NB-23 and PWHT as defined in [SAES-D-008](#).

Pressurized Equipment: Denotes reactors, columns, drums, exchangers, spheroids and any other pressurized equipment designed and constructed in accordance with ASME SEC VIII. Excluded from the scope of this document are pressure equipment fabricated in accordance with ASME SEC I (boilers), API STD 650 and API STD 620 (storage tanks), ASME B31.1, B31.3, B31.4 and B31.8 piping, air cooled heat exchangers and fired heaters.

Safety Instruction Sheet (SIS): A document that provides the minimum required thickness, test pressure, material, design pressure and temperature that is compiled in accordance with [SAES-A-005](#).

Saudi Aramco Engineer: The Supervisor of the Process Equipment Unit, Consulting Services Department, Dhahran.

Shop: Any Company Maintenance or ASME approved vendor shop engaged in repair, test or alteration of PE.

Steam Services: All steam and condensate services at operating pressures above 15 psig.

Utility Services: Includes: potable water, cooling water, salt water, plant air, instrument air and nitrogen.

Wet Sour Service: Per [SAES-D-008](#) definitions, the following process streams containing water and hydrogen sulfide:

1. Sour water with a hydrogen sulfide concentration above 2 milligrams per liter (2 ppm) with a total partial pressure of 450 kPa absolute (65 psia) or greater.
2. Crude containing hydrogen sulfide when transported or processed prior to completion of stabilization.
3. Gas or hydrocarbon condensate containing hydrogen sulfide with a total partial pressure of 450 kPa absolute (65 psia), when transported or processed prior to completion of sweetening or hydrogen sulfide stripping.
4. Multiphase services when the partial pressure of hydrogen sulfide is above 0.34 kPa absolute (0.05 psia) in the gas phase or a concentration of hydrogen sulfide above 2 milligrams per liter (2 ppm) in the water phase.

Abbreviations:

ADIP	Amino Di Iso Propanol
BFW	Boiler Feed Water
CSD	Consulting Services Department
DEA	Di Ethanol Amine
DGA	Di Glycol Amine
HAZ	Heat Affected Zone
HC	Hydrocarbon
HIC	Hydrogen Induced Cracking
ID	Inspection Department
MDEA	Methyl Di Ethanol Amine
MEA	Mono Ethanol Amine
MSAER	Mandatory Saudi Aramco Engineering Requirements
MSSD	Mechanical Services Shop Department
OED/OEU	Operation Engineering Division/Operations Engineering Unit
OMD	Operation Maintenance Division
OME	Operations, Maintenance and Engineering
PE	Pressurized Equipment
PIU	Plant/Pipeline Inspection Unit
PMI	Positive Material Identification
PT	Penetrant Testing
PWHT	Post Weld Heat Treatment

SCC	Stress Corrosion Cracking
SIS	Safety Instruction Sheet
TEG	Tri Ethylene Glycol
UT	Ultrasonic Testing
VT	Visual Inspection
WFMPT	Wet Fluorescent Magnetic Particle Testing

7 Responsibilities

7.1 The Responsible Plant Inspection Unit (PIU) shall:

- 7.1.1 Establish and revise inspection intervals, in accordance with [SAEP-20](#) limits, based on the conditions found during Testing and Inspection (T&I).
 - 7.1.2 Establish inspection procedures for repair in accordance with API STD 510, and the requirements of this SAEP. Provide the responsible Operation Maintenance Division (OMD) with recommended inspection procedures for routine repair of damaged PE including replacement prior to the start of repair work.

The Saudi Aramco inspectors from PIU shall ensure compliance of repair, routine repair and alteration work with the approved standards and procedures and shall sign and maintain the applicable inspection records in [SAES-D-008](#) and closure form [3060-ENG](#) of GI-0002.600.
 - 7.1.3 Perform all inspections and specify the degree of cleanliness and what tests are required on the PE in accordance with section 8.0, "Detailed Inspection Procedure" of this SAEP.
 - 7.1.4 Witness and evaluate all required tests performed on the PE. The Inspection Unit Supervisor may authorize others to witness certain tests at his discretion.
 - 7.1.5 Verify all repair work on the PE is in compliance with the repair procedure and with the requirements of this SAEP. Inspector shall also verify that the PE is acceptable to return to service for continued operation per original design criteria.
 - 7.1.6 Perform On-Stream Inspection (OSI) and external visual inspection on all PE accessible externally.
 - 7.1.7 Maintain a permanent and progressive set of records for each PE per "Inspection Reports" of this SAEP.
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- 7.1.8 Keep any worksheet covering temporary repair open until it is changed to permanent per [00-SAIP-76](#).
 - 7.2 The Responsible Operations Engineering Division/Operation Engineering Unit (OED/OEU) shall:
 - 7.2.1 Issue/Review T&I packages identifying anticipated work on PE. T&I packages should contain the scope of the inspection and the required testing requirements.
 - 7.2.2 Review and concur with the recommended repair or alteration procedures/worksheets submitted by OED/IU. Issue the authorized repair/alteration procedure for only the repairs of a routine nature.
 - 7.2.3 Develop when needed, special repair procedures for damaged PE per consultation with CSD and ID. The repair procedures should include methods of repair/replacement, approved welding procedures, NDT, materials, positive material identification (PMI) requirements and coating specifications, etc. All procedures shall be approved per [SAES-D-008](#) requirements.
 - 7.2.4 Recommend the requirements of chemical cleaning and/or neutralization procedures as needed for proper cleaning PE before the T&I work.
 - 7.2.5 Prepare and issue a new/revised Safety Instruction Sheet per [SAES-A-005](#) any time a PE is re-rated or other changes (alterations) to the pre-T&I conditions have been made.
 - 7.3 The Responsible Operation Maintenance Division (OMD) shall:
 - 7.3.1 Notify Inspection Unit regarding planned T&I actions to facilitate their pre-shutdown inspection, when a PE is required to be moved to the shop and all T&I work may be performed at the shop.
 - 7.3.2 When a T&I is to be performed in the field, Operations, Maintenance and Engineering (OME) shall proceed with work per sections 7.4.1 through 7.4.5.
 - 7.3.3 OMD shall remove applicable PE from the plant and transport them to the shop for inspection, testing and/or repair per section 7.4 below when T&I is to be performed in the shop.
 - 7.3.4 Transport PE from the shop and install in the plant, when shop T&I work is completed and accepted by inspection.
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- 7.3.5 Remove the isolation blinds and make-up all piping connections after the PE is accepted for service by inspection.
- 7.3.6 Fabricate and install new name plate for re-rated PE as authorized by OED per [SAES-D-008](#) section 11.2. The existing nameplate should also be maintained.
- 7.4 The Responsible Mechanical Services Shop Department (MSSD) shall:
 - 7.4.1 Notify the responsible PIU at least one day prior to start of any disassembly, cleaning, testing or repair work on any PE. One full working day notice will be required for offshore and remote areas.
 - 7.4.2 Clean all internal components of the PE before inspection.
 - 7.4.3 Perform all repair work in accordance with the approved repair procedures.
 - 7.4.4 Perform all pressure tests described in section 10.15, "Pressure Testing".
 - 7.4.5 Notify the responsible OME team when a T&I is complete and the PE is ready for return to the plant.
- 7.5 All non-destructive testing shall follow the applicable Saudi Aramco SAEP requirements as per [SAEP-1140](#) through [SAEP-1146](#).

8 Inspection Procedure Class-1 Equipment

- 8.1 Prioritization
 - 8.1.1 Each PIU should develop an internal inspection action plan for the equipment exposed to amine (MEA, DEA, DGA, ADIP, etc.), caustic (sodium hydroxide) and wet sour service in accordance with this SAEP.
 - 8.1.2 Inspection priorities shall be established based on material type, environment and cracking/corrosion susceptibility, as follows:
 - Priority #1
 - All carbon steel equipment, exposed to caustic or amine service originally without PWHT, and has had a history of cracking and/or subsequent weld repair without PWHT.

Priority # 2

All carbon steel equipment exposed to caustic or amine service originally without PWHT and never internally inspected using WFMPT or existing PE in wet hydrogen sulfide service with high weld hardness.

Priority # 3

All carbon steel equipment, exposed to caustic or amine service originally with PWHT and never internally inspected using WFMPT or existing PE in wet hydrogen sulfide service, where weld hardness is not known and recorded.

Priority # 4

All carbon steel equipment with or without PWHT exposed to wet hydrogen sulfide, caustic, amine (ADIP, MEA, DEA) that have had a history of cracking.

Priority # 5

All carbon steel equipment exposed to wet hydrogen sulfide and never internally inspected using WFMPT.

- 8.1.3 In each of these categories, highest priority should be given to equipment handling liquids that would auto-refrigerate in the event of leakage.

8.2 Inspection Assignment

- 8.2.1 Before this procedure can be applied, particular areas within the equipment subject to cracking must be identified by a corrosion engineer or inspector to ensure repeatability of the inspection. Assigned areas shall be shown in layout drawings to guide the inspector (see section 8.9.2).
- 8.2.2 Specific areas within Class 1 equipment shall be identified and inspected in accordance with "Pressure Vessel Inspection Code" API STD 510, "Inspection of Pressure Vessels" ANSI NB-23 National Board Inspection Code, Part RB-3200, API RP 572 and this SAEP. These areas include, but are not limited to, the following:

All internal welds associated with the pressure containing parts of the vessel, including all seam, circumferential, nozzles, flange, and

attachment welds, arc strikes, crevice areas and welds behind or associated with leaking panels of alloy strip-lined vessels.

Commentary Note:

Removal of stainless steel (SS) lining/cladding or overlay is not required to inspect vessel fabrication welds if the liner attachment welds are confirmed to be good by visual inspection and other NDT methods (e.g., air-soap test and PT) and there is no indication of seepage from behind the lining. Remove mechanically fastened internals that obstruct proper internal inspection and remove SS liner, only if leakage is evident.

8.3 Visual Inspection

Visually inspect weld areas identified in section 8.2 by working thoroughly and systematically.

- 8.3.1 Surface Preparation: The surfaces of all weld areas to be examined by non-destructive testing shall be prepared in accordance with the specific Saudi Aramco SAEP for the NDE test method as referenced in section 4.1 of this SAEP.
- 8.3.2 Visual Aids: Magnification (4X to 10X) with a minimum illumination of 100-foot candles can be used to detect hairline cracks. Remote visual inspection equipment, e.g., video-camera or optical boroscope, or mirror devices can be used to inspect around non-removable obstructions.
- 8.3.3 Imperfection Sites: All sites that contain fabrication related imperfections, such as arc strikes and weld undercut, shall be examined by WFMPT for ferrous metals ([SAEP-1144](#)) and PT for non-ferrous metals ([SAEP-1145](#)) in accordance with the applicable Saudi Aramco SAEP for the test method.
- 8.3.4 Cracked Areas: Wherever cracks or other linear defects are detected, the area within a 6-inch radius extending beyond the outer crack boundaries shall be marked for subsequent WFMPT or PT testing in accordance with the applicable Saudi Aramco SAEP for the test method.

8.4 Hardness Testing

Hardness readings shall be taken on all Class I Equipment after PWHT and weld repairs as follows:

- 8.4.1 Hardness readings shall be taken on surfaces of Class 1 carbon steel equipment in contact with the service fluid using portable Tele-Brinell hardness testers. Proper surface preparation (see NACE RP0472) (flat surface) applicable for the test tool is required.

Commentary Note:

"EQUOTIP" hardness testers are not allowed for field hardness testing. Other portable hardness testers like MICRODUR - MIC 10 and TeleBrinell are acceptable alternatives.

- 8.4.2 Location and Layout: Spot hardness testing shall be conducted in all specified inspection areas per the requirements of [SAES-W-010](#), section 14.0 and NACE RP0472 section 2 as follows:

8.4.2.1 Hardness readings shall be taken on the inside surface where service fluid is coming in contact with the pressure retaining weld seams and on sweep-type nozzle butt welds, at the rate of one (1) reading every 20 ft. (6 m) of each weld seam, with a minimum of one reading per seam. For circumferential welds on 5 ft. and larger diameter, a minimum of two readings per seam located 180 degrees apart shall be taken.

8.4.2.2 Hardness indentations shall be made at or near the middle of the weld reinforcement and heat affected zone (HAZ). The weld reinforcement shall be ground smooth to provide a flat surface for hardness testing.

8.4.2.3 For weld hardness over 200 Brinell (HBW) but not exceeding 210 HBW then a minimum of three (3) additional readings shall be taken near the original high reading. If all three (3) retests are below the specified limit (200 HBW), then the joint is acceptable. If any of the retest readings exceed the specified limit (200 HBW) then the complete weld joint shall be considered unacceptable (see section 8.4.4).

- 8.4.3 Assessment of Carbon Steel Equipment (Weld Hardness) When Changing from Sweet to Sour Environment:

8.4.3.1 A thorough weld hardness assessment shall be performed to establish the average weld hardness on in-service equipment. Figure 1, "Layout for Hardness Testing", provides a method for determining average weld hardness.

- 8.4.3.2 When the average weld hardness exceeds 200 HBW then the equipment shall be subject to PWHT. This PWHT is required when changing equipment to caustic, amine or sour service. PWHT is required when equipment has experienced cracking problems near welded joints.
- 8.4.3.3 Each inspection area may be divided into four sections or quadrants and shall be tested in at least three different spots or test sites.
- 8.4.3.4 For inspection areas containing a weld, each test site shall contain at least nine readings; i.e., three readings on both sides of the weld in the heat affected zone (HAZ) and three within the weld.
- 8.4.3.5 For non-weld inspection areas, each test site shall contain a minimum of three readings.

8.4.4 Hardness Requirements and Documentation

- 8.4.4.1 Hardness readings that exceed 200 HBW are not acceptable and shall be reported to the Materials Engineering and Corrosion Control Division (ME&CCD) of the Consulting Services Department for evaluation and recommendation.
- 8.4.4.2 All hardness readings shall be documented on a vessel layout drawing showing locations for future reference.

8.5 Ferrous Material Testing Methods

WFMPT examination conducted in accordance with Appendix I and II of [SAEP-1144](#) and the additional requirements of this SAEP are required on all equipment included in the scope of this procedure. WFMPT testing shall be used to inspect all areas defined in section 8.2 that are constructed of ferrous material. The wet continuous magnetization method shall be used in testing (i.e., the magnetizing current is kept on throughout the bath application and distillate clearing time).

8.6 Class-1 Equipment

Non-Ferrous Material Testing Methods

- 8.6.1 For non-magnetic materials that may be susceptible to cracking, UT or PT may be performed to inspect for cracks.

- 8.6.2 Attachment welds for stainless steel liner/cladding or overlay shall be tested per commentary note section 8.2.2.

8.7 Supplemental Inspection

Once cracked areas are identified, other supplemental inspection methods may be used to characterize and size the defect (e.g., UT, RT or an electric potential crack depth indicator could be used). For application of supplemental testing, contact the Operations Inspection Division.

8.8 Crack Assessment Removal, Weld Repair and PWHT

- 8.8.1 Cracks Assessment and Removal: Plant Inspection shall obtain ultrasonic wall thickness measurements to determine the remaining actual corrosion allowance and size the cracks. Plant Inspection and Engineering in consultation with CSD and ID shall determine the disposition of the cracks and the monitoring and/or repair strategy using fitness for service as listed in API RP 579. If cracks are to be removed, the cracks shall be excavated by grinding tools (pencil grinder) or milling burrs. Progress in crack removal shall be monitored by WFMPT per [SAEP-1144](#) until all crack indications are removed. Removal of cracks and all associated repairs shall be in accordance with API STD 510.
- 8.8.2 Weld Repair and Heat Treatment: The PWHT required for weld repair or removal of hard spots shall be done in accordance with [SAES-W-010](#) and requirements of this SAEP. PWHT after weld repair is not required for equipment exposed to wet hydrogen sulfide provided the weld hardness is within the acceptable limit per [SAES-W-010](#). PWHT after weld repair will be required for the equipment exposed to hydrogen sulfide only if the weld has an unacceptable high hardness (above 200 BHW) or the vessel was originally PWHT'd. Temper bead technique is not an acceptable alternative for PWHT.
- 8.8.3 Heat treatment shall be performed on equipment as required by [SAES-D-001](#), section 11.3 and all weld hardness after PWHT should be documented and verified in accordance with [SAES-W-010](#), section 14.0 requirements.
- 8.8.4 After PWHT has been completed, the equipment must be inspected using WFMPT per [SAEP-1144](#) before the final hydrostatic test.
- 8.8.5 When equipment requiring weld repair is not heat treated, then the equipment shall be re-inspected per Appendix IV decision tree. Also, an engineering waiver must be generated through the Consulting

Services Department against the applicable standard, e.g., [SAES-E-004](#) for heat exchangers, [SAES-D-001](#) for pressure vessels, etc.

8.8.6 The following sections are general guidelines for determining PWHT required for PE or Equipment after weld repairs. Contact the Operations Inspection Division for any questions or further details prior to proceeding with any guideline listed below.

8.8.7 PE or Equipment Not Originally Stress Relieved

8.8.7.1 If no cracking is found then no repair or PWHT will be required.

8.8.7.2 If significant environmental cracking is found and welding is required to repair the cracks, then the entire vessel should be PWHT. In this instance, extreme care should be taken to avoid vessel distortion. Consult Welding Specialist of CSD/MEU for PWHT issues.

8.8.7.3 When a vessel has a SS lining and requires PWHT, then the liner must be removed before performing PWHT to avoid damaging the liner. Consult Welding Specialist of CSD/MEU for PWHT issues.

8.8.7.4 After weld repairs, localized PWHT may be performed. Any SS liner that would be affected must be removed during PWHT. Contact CSD to obtain approval of PWHT plan and procedure to be followed.

8.8.7.5 No PWHT will be required after re-installation of the SS liner.

8.8.8 Vessel Originally Stress Relieved: When cracks are found that require weld repairs, then PWHT shall be performed as a full band around the vessel per the Code requirements. The exception to this requirement would be a vessel requiring minor weld repair and CSD approves a localized PWHT.

Commentary Note:

Any SS cladding, lining or overlay that would be affected by weld repairs or PWHT must be discussed with CSD/ME&CCD/ Welding Group and any procedures used must be approved by them.

8.8.9 Localized PWHT Area: The localized PWHT area (length) may be calculated using the following equation. Must contact CSD to verify

the length of the area and the procedure to be followed before doing any localized PWHT.

$$\text{Area (Length)} = 5\sqrt{(R*t)} \quad (1)$$

where

R = Inside radius of the vessel in inches.

t = Wall thickness of the vessel in inches.

- 8.8.10 Equipment Cleaning: Equipment exposed to amine, caustic and hydrogen sulfide service that is to be welded and/or PWHT should first be washed and thoroughly cleaned. Abrasive blasting, neutralizing or flushing with generous amount of sweet water shall be used, per API RP 945.

Commentary Note:

Steam-out of non-PWHTed carbon steel piping and equipment in caustic or amine service should be avoided as this may raise the metal temperature above the threshold for cracking.

8.9 Inspection Reports

- 8.9.1 When this procedure is used for equipment during T&I's or unscheduled outages, the inspection results shall be reported as an addendum to the regular worksheet or pre-T&I inspection report written by the PIU. The [SAEP-20](#) interval shall be adjusted accordingly. Refer to Appendix IV of this SAEP for decision tree.
- 8.9.2 The worksheet or inspection report should also include a layout drawing showing:
- 8.9.2.1 Internal features such as all weld seams, nozzles, attachments, etc.
 - 8.9.2.2 All areas identified for special inspection.
 - 8.9.2.3 Inspection results including crack locations, orientation, length, depth, and high hardness locations with values.

9 Inspection Procedure Class-2 Equipment

9.1 Prioritization

- 9.1.1 Each PIU should develop an internal inspection action plan for the Boiler Deaerators in accordance with NACE RP0590 and this SAEP.
-

- 9.1.2 Inspection priorities should be established based on material type, environment and cracking susceptibility as follows:

Priority #1

All BFW Deaerator vessels without PWHT and never internally inspected using WFMPT.

Priority #2

All BFW Deaerator vessels with or without PWHT and which had a history of cracking.

Priority #3

All BFW Deaerator vessels without PWHT, had a weld repair without PWHT and with or without high weld hardness.

Priority #4

All BFW Deaerator vessels with PWHT.

9.2 Inspection Assignment

- 9.2.1 Before implementation of this procedure, particular areas within the equipment subject to cracking must be identified by Inspection to ensure repeatability of the inspection. Assigned areas shall be shown in layout drawings to guide the inspector (see section 8.9.2).

- 9.2.2 Specific areas within Class 2 equipment shall be identified and inspected in accordance with "Pressure Vessel Inspection Code" API STD 510, "Inspection of Pressure Vessels" ANSI NB-23 National Board Inspection Code, Part RB-3200, API RP 572 and this SAEP. These areas include, but are not limited to, the following:

All internal welds associated with the pressure containing parts of the vessel, including all seam, circumferential, nozzles, flange, and attachment welds, inside surface opposite all external attachment welds (such as reinforcement pads and platform support lugs), arc strikes, crevice areas and welds behind or associated with leaking panels of alloy strip-lined vessels. (See commentary note section 8.2.2.)

9.3 Visual Inspection

Visually inspect weld areas identified in section 8.2 by working thoroughly and systematically.

9.3.1 Surface Preparation: Same as Class-1 equipment, section 8.3.1 and that all weld reinforcement shall be ground smooth with the surrounding base metal prior to performing WFMPT for all deaerators.

9.3.2 Visual Aids: Same as Class-1 equipment, section 8.3.2.

9.3.3 Imperfection Sites: Same as Class-1 equipment, section 8.3.3.

9.3.4 Cracked Areas: Same as Class-1 equipment, section 8.3.4.

9.4 Hardness Testing

Spot hardness testing shall be conducted per the requirements of the original vessel fabrication specification and [SAES-W-010](#), section 14 only after PWHT and weld repairs. The acceptable weld hardness limit is per section 8.4.2.3.

Hardness Requirements and Documentation: Same as Class-1 equipment, section 8.4.4.

9.5 Ferrous Material Testing Methods

Same as Class-1 equipment, section 8.5.

9.6 Non-Ferrous Material Testing Methods

Same as Class-1 equipment, section 8.6.

9.7 Supplemental Inspection

Same as Class-1 equipment, section 8.7.

9.8 Crack Assessment Removal, Weld Repair and PWHT

Same as Class-1 equipment, section 8.8 (Section 8.8.10 is not applicable).

9.9 Inspection Reports

Same as Class-1 equipment, section 8.9.

10 Inspection Procedure Class-3 Equipment

10.1 Prioritization

10.1.1 "Pressure Vessel Inspection Code" API STD 510, "Inspection of Pressure Vessels" ANSI NB-23 National Board Inspection Code, Part RB-3200 and API RP 572 should be used as a general inspection guideline for all Class-3 equipment.

- 10.1.2 Inspection priorities should be established based on material type, environment and cracking susceptibility, as follows:

Priority #1

Carbon - ½ Mo materials in high temperature hydrogen service.

Priority #2

All Cr - Mo (air hardening) materials exposed to hydrocarbon at high temperature.

Priority #3

All equipment over 2½ inch wall thickness and PWHT.

Priority #4

All carbon steel material with or without PWHT.

- 10.1.3 In each of these categories, highest priority should be given to equipment handling liquids that would auto-refrigerate in the event of leakage.

10.2 Inspection Assignment

- 10.2.1 Before implementation of this procedure, particular areas within the equipment subject to cracking must be identified to ensure repeatability of the inspection. Assigned areas shall be shown in layout drawings to guide the inspector (see section 8.9.2).

- 10.2.2 Specific areas within Class 3 equipment shall be identified and inspected in accordance with "Pressure Vessel Inspection Code" API STD 510, "Inspection of Pressure Vessels" ANSI NB-23 National Board Inspection Code, Part RB-3200, API RP 572 and this SAEP. These areas include, but are not limited to, the following:

All internal welds associated with the pressure containing parts of the equipment, including all seam, circumferential, nozzle, flange, and tray ring attachment welds, inside surface opposite to all external attachment welds (such as reinforcement pads and platform support lugs, arc strikes and crevice areas, skirt, pipe supports and lifting lugs welded to the equipment). (See commentary note section 8.2.2)

10.3 Visual Inspection

Visually inspect weld areas identified in section 8.2 by working thoroughly and systematically.

10.3.1 Surface Preparation: Same as Class-1 equipment, section 8.3.1.

10.3.2 Visual Aids: Same as Class-1 equipment, section 8.3.2.

10.3.3 Imperfection Sites: Same as Class-1 equipment, section 8.3.3.

10.3.4 Cracked Areas: Same as Class-1 equipment, section 8.3.4.

10.4 Hardness Testing

Applicable Only for P-3 to P-5 Materials: Follow section 8.4.4 Class-1 equipment guidelines.

Hardness Requirements and Documentation

10.4.1 Hardness readings that exceed 200 BHW for P-1 and 225 BHW for P-3 to P-5 materials are not acceptable and shall be reported to the Materials Engineering and Corrosion Control Division (ME&CCD) of the Consulting Services Department for evaluation and recommendation.

10.4.2 All hardness readings shall be documented on a vessel layout drawing showing locations for future reference.

10.5 Ferrous Material Testing Methods

Same as Class-1 equipment, section 8.5.

10.6 Non-Ferrous Material Testing Methods

Same as Class-1 equipment, section 8.6.

10.7 Supplemental Inspection

Same as Class-1 equipment, section 8.7.

10.8 Crack Assessment Removal, Weld Repair and PWHT

Same as Class-1 equipment, section 8.8 (Section 8.8.10 is not applicable).

10.9 Inspection Reports

Same as Class-1 equipment, section 8.9.

10.10 The following is a list of potential causes of material deterioration and corrosion on Class 3 Equipment.

10.10.1 Thermal Aging

10.10.1.1 Graphitization

Longitudinal, circumferential, nozzle-to-shell welds and nozzle-to-flange welds of carbon-steel vessels that have been operated above 425°C (800°F) shall be examined internally or externally by metallography.

10.10.1.2 Temper Embrittlement

Longitudinal, circumferential, nozzle-to-shell welds and nozzle-to-flange welds of vessels made of 1 Cr and 2.25 Cr alloys operating above 370°C (700°F) shall be VT and WFMPPT examined on the outside and inside to check for cracking.

Any cracks shall be further examined using UT (shear wave procedure) to determine the depth and subsurface dimensions of cracks. Contact CSD/ME&CCD to determine necessity of field metallographic examination before returning to service.

10.10.1.3 Creep Embrittlement

Longitudinal, circumferential, nozzle-to-shell welds and nozzle-to-flange welds and all circumferential and longitudinal welds of low alloy steel that have been operated above 400°C (750°F) shall be VT, WFMPPT or PT and hardness examined on the outside and inside to check for cracking.

Any cracks found shall be characterized and sized by appropriate NDT methods. Contact CSD/ME&CCD to determine necessity of field metallographic examination as per [SAEP-355](#) "Field Metallography and Hardness" before returning to service.

10.10.1.4 Sensitization of Austenitic Stainless Steels

Longitudinal, circumferential, nozzle-to-shell welds and nozzle-to-flange welds of austenitic stainless steel vessels, all circumferential and longitudinal welds of FCC

cyclones of austenitic stainless steel, and the internal surfaces of austenitic stainless steel clad vessels that have been operated above 425°C (800°F) or are subject to chloride cracking or polythionic SCC during shutdown shall be VT and PT examined on the outside and inside.

Cracks located as a result of PT shall be further examined using UT (shear wave procedure) to determine the depth and subsurface dimensions of the cracks. Contact CSD/ME&CCD to determine necessity of field metallographic examination before returning to service.

10.10.2 Fatigue

10.10.2.1 Mechanical Fatigue

Longitudinal, circumferential, nozzle-to-shell welds, nozzle-to-flange welds, and all fillet welds of pressure components, such as Pressure Swing Adsorbers and Hydrocracker Reactors, etc., shall be WFMPT or PT examined to check for cracking.

Cracks located as a result of PT shall be further examined using UT (shear wave procedure) to determine the depth and subsurface dimensions of the cracks. Contact CSD/ME&CCD to determine necessity of field metallographic examination before returning to service.

10.10.2.2 Thermal Fatigue

PE that operates under cyclic conditions of temperature, over a wide range may develop cracks due to thermal fatigue.

Cracks start at the surface of the material, progressing slowly at first and then more rapidly with each cycle of temperature change.

Also thermal fatigue is often found at locations where metals that have different coefficient of expansion are joined by welding.

Cracks located as a result of PT shall be further examined using UT (shear wave procedure) to determine the depth and subsurface dimensions of the cracks. Contact

CSD/ME&CCD to determine necessity of field metallographic examination before returning to service.

10.10.2.3 Corrosion Fatigue

Longitudinal, circumferential, nozzle-to-shell welds, nozzle-to-flange welds, and all fillet welds of non-postweld heat treated pressure vessels shall be WFMPT examined.

Cracks located as a result of PT shall be further examined using UT (shear wave procedure) to determine the depth and subsurface dimensions of the cracks. Contact CSD/ME&CCD to determine necessity of field metallographic examination before returning to service.

10.10.3 Stress Corrosion Cracking

Longitudinal, circumferential, nozzle-to-shell welds, nozzle-to-flange welds, and all fillet welds of pressure components of vessels subjected to process environments that are susceptible to stress corrosion cracking including: sulfide stress corrosion cracking of carbon and chrome-molybdenum steels, chloride stress corrosion cracking of austenitic stainless steels, ammonia stress corrosion cracking of carbon steels, and caustic embrittlement of carbon steels shall be WFMPT or PT examined in accordance with section 8.0.

Any cracks located as a result of WFMPT or PT shall be further examined using UT (shear wave procedure) to determine the depth and subsurface dimensions of cracks. Contact CSD/ME&CCD to determine necessity of field metallographic examination before returning to service.

10.10.4 Internal Erosion

Shell surfaces subjected to high velocity streams shall be VT examined to determine the extent of internal erosion.

UT (longitudinal wave process) or RT shall be used to determine the remaining wall thickness of shell sections suspected of having erosion damage.

10.10.5 Hydrogen Attack

10.10.5.1 Hydrogen Blistering

Vessel I.D. surface shall be checked thoroughly for bulging (blisters) and deformations using an appropriate light source (flashlight).

Longitudinal, circumferential, nozzle-to-shell welds and nozzle-to-flange welds of vessels in hydrogen service shall be VT and WFMPT or PT examined on the I.D. surface to detect cracks on blisters.

If cracks are located in the blisters, the areas shall be further examined using UT to determine the remaining sound vessel shell thickness.

10.10.5.2. High Temperature/Pressure Hydrogen Attack (Decarburization)

Longitudinal, circumferential, nozzle-to-shell welds and nozzle-to-flange welds of low-chrome, chrome-molybdenum vessels in hydrogen service that have been operating above 450°C (850°F) or within 28°C (50°F) of the applicable API RP 941, Figure-1 Nelson Curve and for all C-½ Mo. Steel exposed to high temperature hydrogen service shall be WFMPT from the inside surfaces (during T&I).

Any cracks located as a result of WFMPT shall be further examined using UT (shear wave procedure) to determine the depth and subsurface dimensions of cracks. To determine the severity of decarburization and cracking, CSD/ME&CCD shall be contacted for metallographic examination.

Commentary Note:

Other ultrasonic techniques such as backscatter, velocity ratio and spectrum analysis can also be considered for detection and estimation of high temperature hydrogen attack. The Inspection Department should be contacted to provide further guidance.

10.10.6 Creep and Stress-Rupture

Nozzle-to-shell welds and nozzle-to-flange welds of carbon steel vessels that have been operated above 370°C (700°F) low-chrome alloy vessels that have been operated above 425°C (800°F) shall be WFMPT examined from inside surface and stainless steel vessels operated above 480°C (900°F) shall be PT examined from inside surface.

Any cracks located as a result of WFMPT shall be further examined using UT (shear wave procedure) examination to determine the depth and subsurface dimensions of cracks. Contact CSD/ME&CCD for detail metallographic examination before returning equipment to service.

10.11 Defect Inspection Procedure - All Equipment (All Classes)

10.11.1 Visual External Inspection:

Inspection of external parts shall be made while the equipment is in service per [SAEP-20](#) Equipment Inspection Interval and can use [00-SAIP-75](#) for External Inspection and [00-SAIP-74](#) for Inspection for Corrosion under Insulation/Fireproofing. The most important areas that should be covered and conditions to be noted during an on-stream external inspection are as follows:

- 10.11.1.1 Foundation: Spalling, cracking, uneven settlement, leaky flanges and other signs of pipe distortion/stress, which may indicate equipment or foundation settlement.
 - 10.11.1.2 Anchor Bolts: Area of contact between the bolts and any concrete or steel for corrosion.
 - 10.11.1.3. Fire Proofing: Spalling, cracking, corrosion of reinforcement under cracked location.
 - 10.11.1.4. Skirt: Corrosion, weld cracks at joints between skirt and column/vessel, distortion, bonding of weather/fire proofing to the skirt, etc.
 - 10.11.1.5 Saddle Supports: General condition, corrosion of shell and or support, adequacy of expansion provision of floating supports, plugged drains, buckled shell, etc.
 - 10.11.1.6 Ladders/Stairs: Paint condition. General corrosion and cracked lug welds.
-

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- 10.11.1.7 Platforms and Structures: Weld cracks, condition of structural floor plates, toe plates and fasteners.
 - 10.11.1.8 Insulation: Condition of the insulation material and protective covering. In case of damaged wet insulation the corrosion of underlying material should be evaluated. Other NDT methods should be used to assist in determining the extent and severity of corrosion defects.
 - 10.11.1.9 Protective Coating: Condition of external painting, cracks on coating/lining or external FRP lining and corrosion of metal at cracks on lining.
 - 10.11.1.10 Grounding Connections: Damaged grounding cable connection and its electrical continuity.
 - 10.11.1.11 Nozzles: Check for any sign of leakage through flange gasket faces, reinforcing pad tell tale holes and any physical distortion. Particular attention must be given to instrument and small bore connections, if it is covered under external insulation.
 - 10.11.1.12 External Surface of All Pressure Parts: Any indication of excessive vibration/swaying, hot spots (discoloration) on internally lined equipment and any external mechanical damage including dents or buckles. Hot spots due to internal lining failure may be detected (on stream) using Thermographic technique on internally lined equipment.

10.11.2 Internal Inspection During T&I

- 10.11.2.1 All vessels manways and tray manways in the case of columns shall be opened and all internal surfaces of the pressure vessels shall be thoroughly inspected during scheduled T&I. The internal condition of the equipment should be noted, such as distortion of trays, excessive fouling, etc., prior to cleaning the internal surface.
 - 10.11.2.2 Detailed inspection after thorough cleaning shall be performed systematically on all surfaces. A procedure or checklist shall be followed to avoid overlooking important items.
 - 10.11.2.3 All parts of the vessel should be inspected for corrosion, erosion, hydrogen blistering, deformation, bulging,
-

mechanical damage, cracking, etc. A detailed record shall be made of all the observations including the locations.

- 10.11.2.4 The bottom head and shell of the fractionation columns, processing high sulfur crude oils are susceptible to high temperature sulfide corrosion. This type of corrosion will most likely be around the inlet lines.

Random UT surveys from external surface should be performed during each T&I at the shell transition area between the lower clad section (type 410SS) and upper carbon steel section for checking high temperature H₂S attack. This type of attack is very uniform and not readily obvious to visual inspection.

- 10.11.2.5 The shell at the top of the fractionation columns and distillation towers is subject to chloride attack. The liquid retention areas on the columns trays and in the bottom of overhead accumulators are the most likely areas of attack for this type of corrosion in the form of grooving.

- 10.11.2.6 In vessels, corrosion cell concentration occurs where sludge settles out. The areas that are covered by heavy sludge and contain acidic compounds may be susceptible to highly localized metal loss.

- 10.11.2.7 If steam is injected into a vessel, corrosion and erosion are expected to take place directly opposite to the steam inlet line. The bottom heads with low turbulent locations and pockets with stagnant condensate collection point are also vulnerable to highly localized corrosion.

- 10.11.2.8 Check several welded seams and adjacent areas including heat affected zones for any indication of surface cracks on internal surface. Whenever in doubt, other alternative NDT methods shall be employed to verify the initial findings.

- 10.11.2.9 Check all tray support rings to shell fillet welds.

- 10.11.2.10 Perform Ultrasonic Thickness (UT) measurements on all parts of the equipment. Special attention shall be given to the localized deteriorated areas.

- 10.11.2.11 If pitting type of corrosion is suspected, the I.D. surface of the vessel shall be scratched with a pointed scrapper to expose the pits. The scattered or isolated pits shall be evaluated by competent personnel per API STD 510 section 5.7(e) guidelines or if deemed necessary by API RP 579 procedures.
- 10.11.2.12 The I.D. surface of all nozzles shall be visually inspected for internal corrosion, cracks or any distortion, etc. Pay special attention to inside corners on nozzles for cracks in high temperature services. UT measurements shall be taken on all nozzles, and shall be recorded and evaluated.
- 10.11.2.13 Visually inspect all internals (trays, distributor piping or nozzles, tray manway covers, tray clips and missing hardware, etc., and record the condition.
- 10.11.2.14 To locate the hydrogen blisters or bulging on vessel I.D. surface, a flash light beam may be directed across the metal surface. The blisters or bulges on the vessel I.D. surface will create shadows and can be detected.
- 10.11.2.15 Visually inspect all internal refractory linings or coatings and evaluate the condition for continued satisfactory operation to the next T&I.
- 10.11.2.16 Check strip lining on I.D. surfaces of the vessel for bulging, cracking or pinhole leaks (sign of hydrocarbon leakage). If in doubt, carry out PT.

Inspect the vessel wall under any cracked or bulged strip lining after removal for corrosion / deterioration. This will require removal of damaged lining.

Inspect the bare shell I.D. surface just above or below the strip lined or clad areas for accelerated galvanic bi-metallic corrosion.

10.12 Defect Inspection Procedure - Reactors:

The general inspection procedure as outlined in section 10.11 should be followed. The following is the additional brief outline of the inspection procedure for reactors:

10.12.1 External Inspection: During T&I

- 10.12.1.1 Remove insulation as required and provide access for weld inspection at scheduled intervals.
- 10.12.1.2 Grit blast all main welded seams including nozzle welds.
- 10.12.1.3 Perform Wet Fluorescent Magnetic Particle Testing (WFMPT) on all properly cleaned welded seams (Ferro-magnetic material).
- 10.12.1.4 Perform Liquid Penetrant Testing (PT) on all gasket groove areas.
- 10.12.1.5 Perform UT flaw detection on all main welded seams including all nozzle welds and structural supports to the Reactor (skirt, lifting lugs and platform welds).
- 10.12.1.6 Visually inspect the entire surface of the vessel for any bulges or abnormalities.
- 10.12.1.7 Perform both visual and UT surveys during each T&I on all hydrocracker reactor shell sections opposite the catalyst support beds and hydrogen quench piping to monitor for disbonding between the stainless steel clad/welded section and the low alloy steel shell (presence of hydrogen).

10.12.2 Internal Inspection During T&I if Deemed Necessary

- 10.12.2.1 Inspect thoroughly the alloy-lined surface visually for bulging and ultrasonically for disbonding.
- 10.12.2.2 Perform PT on the internal attachment welds.
- 10.12.2.3 Visually inspect internal grids and distributors for distortion and deterioration.
- 10.12.2.4 To evaluate any defect indication found by using a specialized NDT technique, contact ID/OID, Dhahran for assistance.
- 10.12.2.5 In case of any finding that will require repair, modification, alteration or re-rating, follow section 10.14 guidelines.

10.13 Defect Inspection Procedure-Vertical Exchanger (Platformer)

10.13.1 External Inspection: During T&I

Follow the general inspection procedure as applicable in section 10.11. The following is the additional brief outline of the inspection procedure for the Exchanger shell section:

- 10.13.1.1 Perform ultrasonic flaw detection on upper shell section (360 degree) below the feed inlet nozzle up to top of the flange.
- 10.13.1.2 Perform ultrasonic flaw detection on carbon ½ Mo shell section (360 degree, min. 18 inch wide) just below the 1-¼ Cr ½ Mo welded joint.

10.13.2 Internal Inspection during T&I

- 10.13.2.1 Remove bundle and erect internal scaffolding which meets Saudi Aramco construction safety requirements.
- 10.13.2.2 Grit blast all main welded seams.
- 10.13.2.3 Perform Wet Fluorescent Magnetic Particle Testing (WFMPPT) on all properly cleaned welded seams.
- 10.13.2.4 To evaluate any defect indication or require any specialized NDT technique or metallographic examination, contact ID/OID or CSD/ME&CCD, Dhahran for assistance.
- 10.13.2.5 In case of any finding that will require repair, modification, alteration or re-rating, following [SAES-D-008](#) guidelines.

Commentary Note:

For general inspection of Shell and Tube Heat Exchangers, follow [SAEP-317](#) guidelines.

10.14 Routine Repairs, Alteration, Modification and Re-rating - All Equipment (All Classes) shall all be performed in accordance and as specified in [SAES-D-008](#).

10.15 Pressure Testing

The equipment subjected to repairs and alterations as defined in [SAES-D-008](#), shall be hydrostatically tested per [SAES-A-004](#), [SAES-A-007](#), ANSI NB-23 part RC-2050 and API STD 510 section 6.4. With the exception of tube

bundles, equipment need not be pressure tested after installation in the field provided the equipment was pressure tested in the shop.

10.16 Waiver

10.16.1 NDT in-lieu of hydrostatic test is not acceptable unless approved by Manager, Inspection Department.

10.16.2 If PWHT is a requirement after a weld repair per [SAES-W-010](#) and is not feasible for any reason, obtain an engineering waiver against the applicable MSAER per [SAEP-302](#). Also, Appendix IV, Note-3 and Appendix V, Note-6 of this SAEP are applicable.

11 Data Collection and Records

11.1 Data Collection: Use the attached APPENDICES-I, II, & III Weld Cracking and Hardness Testing Inspection Reports and Equipment Data Sheet every time a vessel is inspected per this SAEP in order to collect field data. [00-SAIP-78](#) for Inspection Records/Filing should be used to ensure consistent filing system.

11.2 Data Records: Update the individual equipment record with the data collected using Appendices I, II, and III, and any other records and documentation specified by cross-references in this SAEP section 3. Store the data as specified in the facility record retention form. This data can be hard copy (i.e., paper), electronic (i.e., database) or both, refer to the facility current record retention policy to obtain the requirements.

30 June, 2004

Revision Summary
Major revision.

Appendix I – Weld Cracking Inspection Report
(Equipment Class 1 and 2, SAEP-325)

Equipment Name:	Equipment No.	Date Inspected / /
Location:	Service: ☐ Wet H ₂ S ☐ Amine ☐ Caustic ☐ Deaerator	Inspector's Signature

1. **Area Assigned for Inspection for Cracks (Attach Layout Drawing per sections 8.2.1 and 9.2.1):**

2. **Inspection Method Used:**

- ☐ Wet Fluorescent Magnetic Particle Testing (WFMPT)
☐ Penetrant Testing (PT)
☐ Ultrasonic Testing (UT)
☐ Others

Specify: _____

3. **Findings:**

4. **Recommendations:**

5. **Repair Procedure and Post Repair Test Results:**

Equipment Name:	Equipment No.	Date Inspected / /
Location:	Service: ☐ Wet H ₂ S ☐ Amine ☐ Caustic	Inspector's Signature

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Appendix III – Inspection Data Sheet

Equipment (Class 1 and 2)

Equipment Name:	Equipment No.	Date Inspected / /
Location:	Service:	Inspector's Signature
	☐ Wet H ₂ S	
	☐ Amine (MEA, DEA, DGA, TEG, ADIP)	
Process Unit:	☐ Caustic	
	☐ Deaerator	

Acid gas being scrubbed (e.g., H₂S, CO₂):

Amine/Caustic/H₂S concentration (%):

Solution loading (for amine unit - acid gas vs. amine):

Corrosion inhibitor, if used:

Date of Unit construction:

Date of 1st problem:

Location of problem (attach. details)

Vessel Shell ☐

Vessel Weld ☐

Pipe Weld ☐

No Problem ☐

Metal temperature at location: Normal Operation: _____ Maximum: _____

Material of construction (ASTM designation and grade):

Wall thickness, lining, diameter and/or pipe schedule:

Post Weld Heat Treated (PWHT)

Yes ☐

No ☐

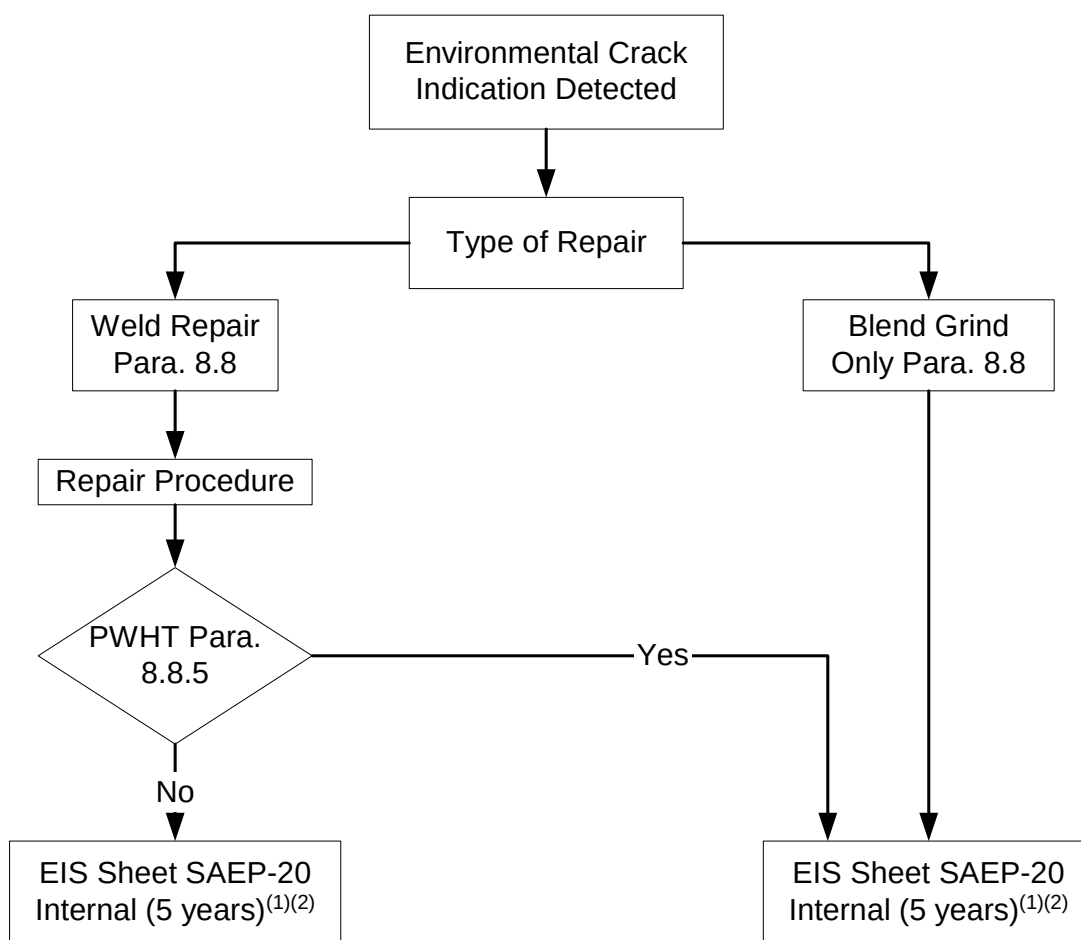
Maximum material hardness and locations:

Is the equipment completely cleaned before any hot work or PWHT Yes ☐ No ☐

If Yes - What Method:

Attach any relevant past inspection records: (e.g., weld repairs with or without PWHT, past records including operation history, etc.)

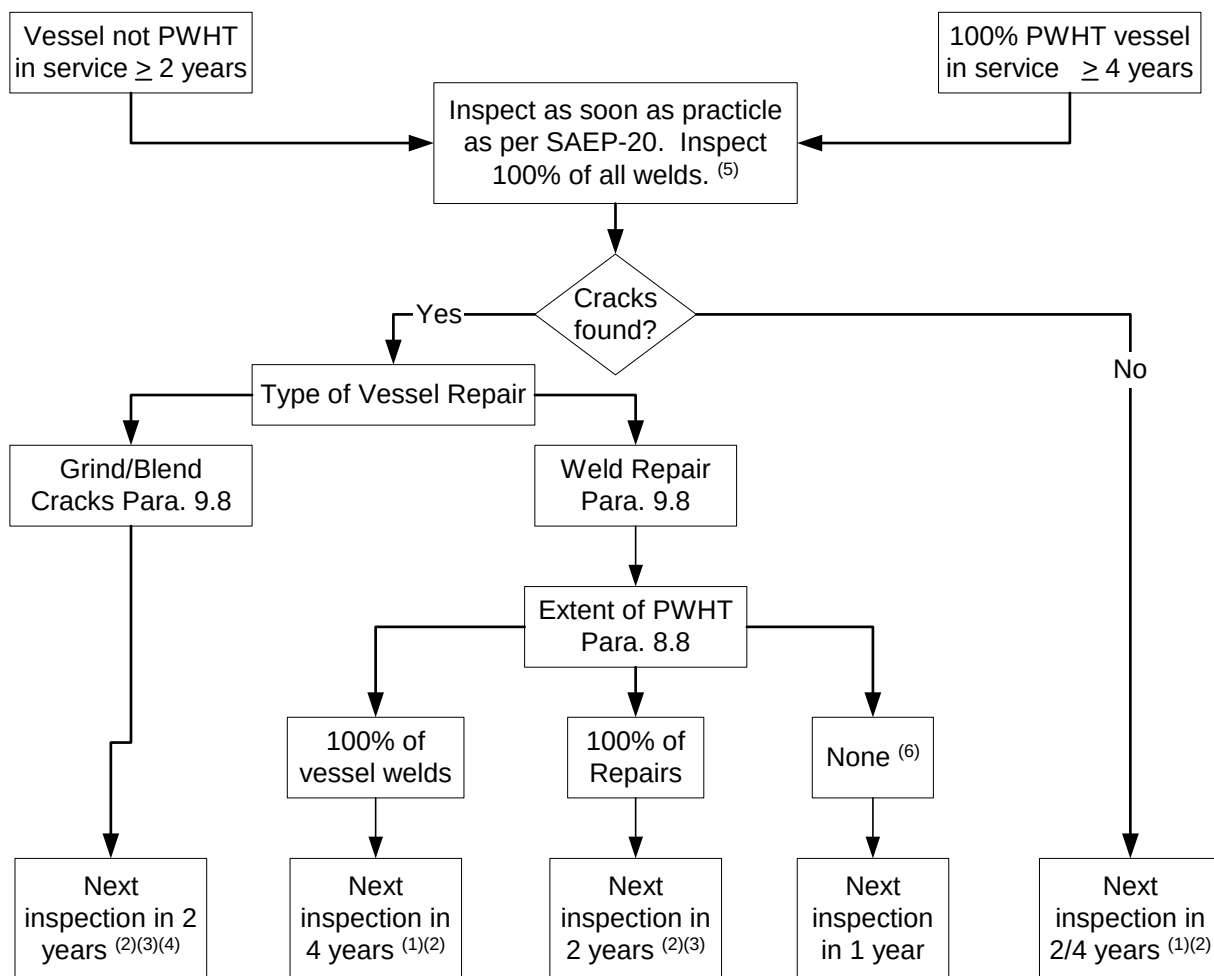
Appendix IV – Class-1 Decision Tree Wet Hydrogen Sulfide, Amine and Caustic Service Equipment Re-inspection Requirements



Notes:

- 1) Inspect sooner if corrosion class is changed or when inspection findings of equipment in similar service dictate inspection.
- 2) Subsequent inspection assignment shall depend on the predictability of cracking locations. More selective inspection areas may be necessary if the cracking tends to concentrate and follow certain patterns. Spot check shall still be done on other locations. For scattered cracking damage, the inspection shall be 100% of initial inspection assignment every T&I.
- 3) Obtain engineering waiver for caustic service and determine if required for other services per the applicable Saudi Aramco Standards.

Appendix V – Class-2 Equipment Decision Tree Deaerator Re-Inspection Requirements



Notes:

- (1) Use the maximum interval set by [SAEP-20](#) for PWHT vessels only. Vessels not PWHT'd shall be inspected after two years.
- (2) Inspect sooner if operation problems persist, i.e.:
 - = Oxygen > 10 ppb
 - = persistent water hammer
 - = frequent pressure/temperature swings
 - = pH > 8.5
- (3) Follow 4 year inspection cycle if cracks are not found in two successive T&I's after repair. (See also [SAEP-20](#), section 3.5.9.2).
- (4) See also [SAEP-20](#), section 3.5.9.2.
- (5) Re-inspection shall be 100% of inspection assignment as per section 7.1 for Class 2 equipment.
- (6) Obtain engineering waiver against [SAES-D-001](#), section 11.3.

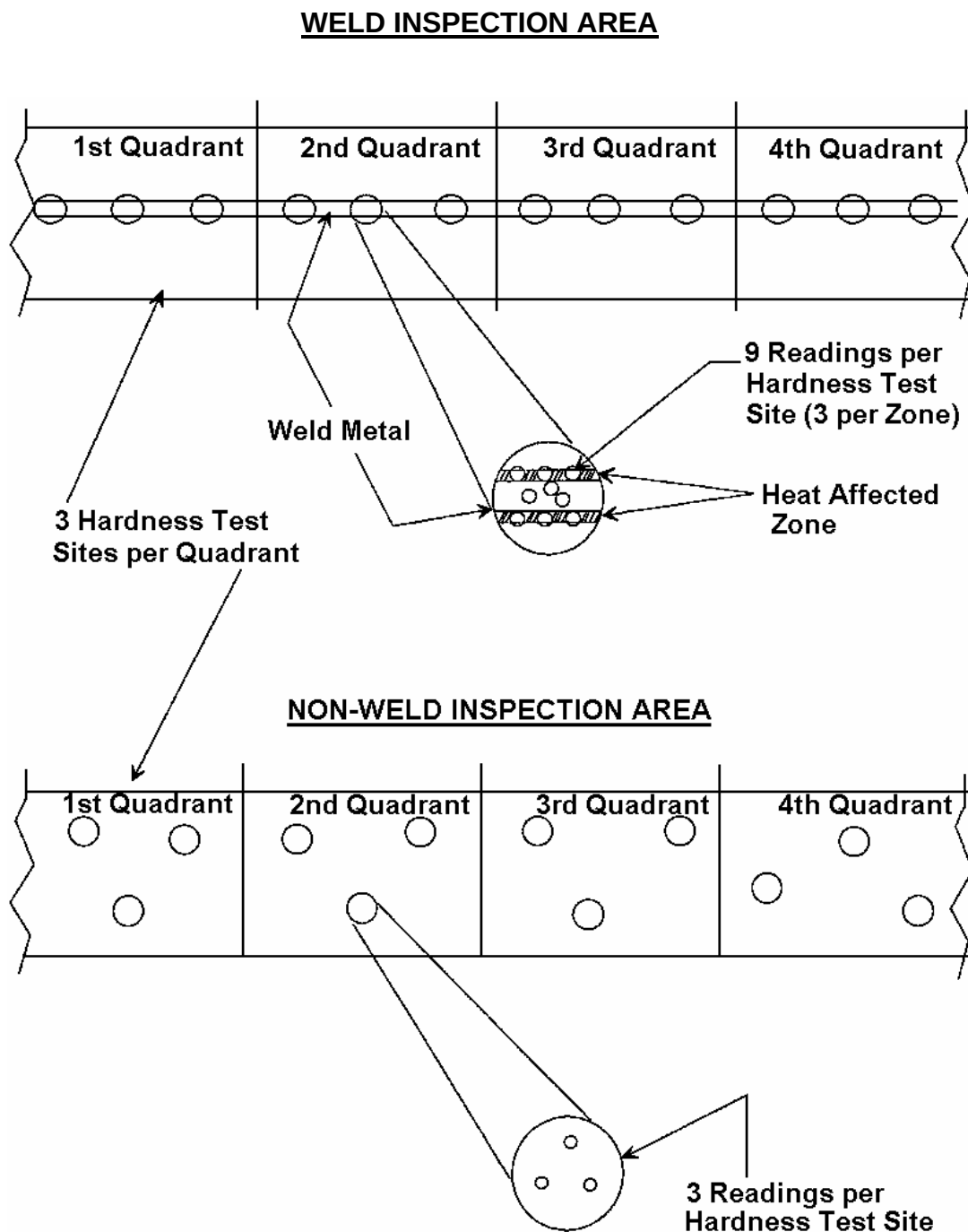


Figure 1 – Layout for Hardness Testing