

GENERAL SPECIFICATION

INSTRUMENTATION

GS EP INS 101

**Instrumentation engineering, supply and
construction general requirements**

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General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 2 of 33

Contents

1. Scope	4
2. Reference documents.....	4
3. Glossary.....	6
4. General requirements	6
4.1 List of Deviations.....	6
4.2 Order of Precedence.....	6
5. Life cycle and obsolescence management.....	7
6. General instrumentation principles.....	9
6.1 Architecture and interconnecting principles	9
7. Utilities	11
7.1 Electricity	11
7.2 Instrument air	11
7.3 Instrument gas	11
7.4 Hydraulic.....	11
8. Instruments general requirements	12
8.1 Instruments definition.....	12
8.2 Instrument standardisation	12
8.3 SIL requirements.....	12
8.4 Instrument earthing	12
8.5 Design and installation of lightning protection	13
8.6 Instruments identification	13
8.7 Area classification/protection.....	13
8.8 Enclosure protection/environmental aspects	14
8.9 Classification requirements for floater application	14
8.10 Heating, winterization and insulation	15
8.11 General instrument characteristics	15
8.12 Units	24
8.13 Instrument accessibility	24



General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 3 of 33

8.14	Instrument installation	25
9.	Tubes, cables, junction boxes, field terminal cabinets, etc.	25
9.1	Tubing and fittings.....	25
9.2	Cables	25
9.3	Wiring	26
9.4	Junction boxes and cable glands	26
9.5	Field Terminal Cabinets (FTC) in technical rooms.....	27
9.6	Identification, tagging and labelling	27
10.	Instrumentation software tools.....	28
11.	Instrument preservation	29
12.	Documents.....	29
	Bibliography.....	30
Appendix 1	Level Instrument Tapping requirements on Pressure Vessels	31

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 4 of 33

1. Scope

This Specification defines the minimum requirements for instrumentation engineering, supply and construction for onshore and offshore installations.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
API RP 551	Process Measurement Instrumentation
ASME PTC 19.3	Part 3: Temperature Measurement Instruments and Apparatus
ASME Section VIII Div. 1	Design and Fabrication of pressure vessels
ASME B16.36	Orifice flanges
ATEX European Directive 94/9/EC	European Directive on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres
European Directive 2004/108/EC	European Directive on the approximation of the Laws of Member States relating to electro-magnetic compatibility (EMC)
IEC 60079-14	Explosive atmospheres - Part 14: Electrical installations design, selection and erection
IEC 60331	Parts related to the Tests for electrical cables under fire conditions - Circuit integrity
IEC 60332	Parts related to the Tests on electric cables under fire conditions
IEC 60529	Degrees of protection provided by enclosures (IP code)
IEC 61000-5	Sections related to the Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines
IEC 62591	Industrial communication networks- Wireless communication network and communication profiles - WirelessHart
IECEX	IEC System for Certification to Standards relating to Equipment for use in Explosive Atmospheres (IECEX System)
ISA 100	Wireless Systems for Automation
ISA-5.1	Instrumentation Symbols and Identification
ISO 4406	Hydraulic fluid power - Fluids - Method for coding the level of contamination by solid particles

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 5 of 33

Reference	Title
ISO 5167	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements - Part 2: Orifice plates - Part 3: Nozzles and Venturi nozzles - Part 4: Venturi tubes
ISO 5168	Measurement of fluid flow - Evaluation of uncertainties
ISO/TR 3313	Measurement of fluid flow in close conduits - Guidelines on the effects of flow pulsations on flow-measurements instruments

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP ECP 103	Process sizing criteria
GS EP ELE 051	Design and installation of lightning protection
GS EP ELE 079	Electrical apparatus for potentially explosive gas atmospheres
GS EP ELE 311	Cable trays/ladders
GS EP INS 000	Minimum Contractor Document Requirements
GS EP INS 102	Instrumentation identification
GS EP INS 103	Instrument Database Management
GS EP INS 104	Design of generation and distribution of instrument air or gas
GS EP INS 107	Design and installation of instrumentation links
GS EP INS 108	Instrumentation for the design of plant rooms and control rooms
GS EP INS 120	Control and Choke Valves
GS EP INS 125	Safety Relief Valves and Rupture Discs
GS EP INS 135	Cyber Security requirements for design and supply of ICSS and Package Systems
GS EP INS 137	On/off valve control panels and actuators functional and construction requirements
GS EP INS 146	Design of generation and distribution of hydraulic energy
GS EP INS 900	Instrument hook-up diagrams
GS EP PVV 112	Piping material classes
GS EP PVV 211	Design and fabrication of pressure vessels according to ASMEVIII
GS EP PVV 771	Thermal insulation (hot service)

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 6 of 33

Reference	Title
GS EP SAF 261	Emergency Shutdown and Emergency De-Pressurisation (ESD & EDP)
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

3. Glossary

BDV	Blow Down Valve
CCR	Central Control Room
HIPS	High Integrity Protection System
IP	Ingress Protection
ITR	Instrument Technical Room
I/O	Input / Output
ICSS	Integrated Control and Safety System
PCS	Process Control System
PLC	Programmable Logic Controllers
SIL	Safety Integrity Level
SIF	Safety Instrumented Function
SSV	Surface Safety Valve
UCP	Unit Control Panel
WV	Wing valve

4. General requirements

4.1 List of Deviations

All deviations, as listed in the mandatory "List of Deviations", attached the technical proposal, shall be reviewed, clarified, approved or rejected one by one before Purchase Order by Company only.

4.2 Order of Precedence

In case a GS specification has been complemented with a project specification, then the project specification will have a higher order of priority than this specification. However, the individual instrument data sheets are considered a derivation of all other documents and any missing or erroneous data on a data sheet, resulting in wrongly sized or wrongly designed valves, shall be corrected under Contractor's responsibility.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 7 of 33

The equipment covered by each GS specification shall satisfy, in descending order of priority, the requirements of:

- The local regulations, when applicable
- The project specification, when existing
- The applicable Company General Specifications and other general specifications referred there-in
- The individual instrument data sheets
- Other standards, codes and professional documents to which the GS specification refers to.

In the event of conflicting requirements between GS and project specifications, rules, codes and standards, then the most restrictive requirement will apply.

The review and approval of instrument data sheets and other related documents by Company does not relieve the Contractor or Vendor to comply with referenced rules, legislation and specifications, and any necessary correction remains therefore the responsibility of the Contractor and/or Vendor.

5. Life cycle and obsolescence management

Facilities are typically designed with an expected design life in the order of 25 years. It is not practical to achieve such a design life for electronic based equipment without the requirement for upgrading.

The design shall therefore take into account the requirement that the electronic based systems and associated software will have to be upgraded during the design life of the facilities. These requirements shall be incorporated in the Basic Engineering requirements.

Level of compliance to those requirements ought to be verified during the CFT stages and cost of obsolescence and resolution costs for obsolete system or main sub system are recommended to be included in the Vendor bid evaluation and selection process.

Strategy for managing obsolescence needs to be regularly updated as an integral part of the core functions

- Design and development
- Sourcing and production
- In-service sustainability
- Vendors support.

The control and instrumentation equipment scope shall be given specific attention to ensure all production and control systems, components, software and individual elements and the respective running tools, test equipment, software and human skills can be maintained or replaced such that the original function and integrity of the whole production system can continue in an uninterrupted manner for the field life.

A project specific dossier shall be developed in accordance with **GS EP TEC 007** requirements during basic engineering and continuously updated during the life cycle time.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 8 of 33

The obsolescence dossier will consider the complete life cycle including:

- Bid stage
- Design phase
- Project delivery phase
- Operation & maintenance phase.

The contents of the dossier shall include as a minimum:

- Equipment Inventory
 - Bill Of Material (BOM)
 - . Comprehensive list with identification of all components up to the card level
 - Software releases
 - Obsolescence status of all main equipment, components and software.
- Dates
 - End of spare parts availability,
 - End of support (i.e. design engineering support, technical after sale support)
 - Product Change Notice (PCN)
 - Product Discontinuance Notice (PDN)
 - End of Life (EOL).
- Vendor support
 - Availability
 - Location.
- Replacement strategy of all components and associated softwares
- Replacement schedule.

All above data shall be tabled in a database or spreadsheet application.

The obsolescence dossier shall be further complemented during the detailed engineering stage and shall detail all aspects of equipment life cycle.

Obsolescence database ought to be required from Contractor/Vendor at CFT stage.

The design will include provisions to allow for an upgrade of all electronic systems to be performed with minimal disturbance to the process and utilities, fixed cabling infrastructure and general facilities infrastructure. Such provisions shall typically include:

- Tie-in points for the future equipment, while the original electronics are still functioning
- Avoidance of common components within the electronic systems for management of duty/stand-by equipment
- Allocation of sufficient space for future equipment/facilities within the ITR's and CCR.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 9 of 33

6. General instrumentation principles

6.1 Architecture and interconnecting principles

6.1.1 Standard architecture

The standard instrument loop architecture consists of field instruments connected to junction boxes which in turn are connected to marshalling cabinets by means of multi-cores cables. Signals are then cross-wired onto control system card-image termination boards inside “system cabinets”.

Marshalling cabinets and system cabinets are normally installed in technical rooms when junction boxes are field located.

6.1.2 Remote I/O's

In order to reduce the number and weight of multicore cables and associated cables-trays as well as the surface of technical rooms by reduction of the number of cabinets to be installed in these rooms, use of field mounted remote I/O's shall be considered.

Remote I/O's installed in hazardous area shall be certified for use in Zone 1 and when used for safety functions shall meet the SIL requirements.

Remote I/O's are considered as “smart junction boxes”. They consist of I/O modules, power supplies, communication bus interface and field terminals enclosed in boxes or cubicles according to the number of sensors or actuators they have to cope with.

RIOs installed in outdoor area shall be suitable for the environmental conditions including vibrations, temperature, humid, salt laden and corrosive atmosphere and all components shall be tropicalized and qualified to withstand the offshore tropical marine environment.

Maintenance facilities shall include:

- Replacement of I/O or power supply modules under power
- Diagnostic data available at the ICSS or UCP maintenance/operator stations in the same way as for standard I/O's
- Parameters of smart transmitters available in technical rooms for commissioning purpose.

Use of such systems shall be submitted to Company approval.

6.1.3 Field buses

Use of field buses is not recommended, but it may be studied on a case by case basis.

However use of fieldbus shall be subject to Company's approval.

Protocol will be as per recognized international standards (i.e. Foundation Fieldbus, Profibus PA).

6.1.4 Wireless Instruments

Use of wireless instruments is prohibited for all control and safety functions (PCS, PSS, ESD, F&G), time critical applications and any other critical safety applications.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 10 of 33

Wireless instruments may only be envisaged for:

- Non essential and non critical monitoring applications
- Non real time services
- Applications which do not require fast response time
- Applications which may withstand unavailability.

The use of wireless instruments shall be subject to a case by case study performed at pre project and basic engineering stages. These studies shall encompass interoperability, interchangeability, cyber security, reliability, availability and sustainability issues and include a risk analysis.

Coexistence between all concurrent wireless networks and radio networks shall be ensured.

Implementation shall comply with **GS EP INS 135** requirements.

The wireless instrument dossier shall be subject to Company approval.

Performances and availability of wireless instrumentation networks shall not be compromised by any other concurrent wireless networks or EM interferences.

Performance and installation study shall address the following topics:

- EMC
- Radio transmission obstructions
- Latency
- Instrument update rate
- Battery lifetime
- Lifecycle duration
- OPEX.

Protocol will be as per recognized international standards.

Equipment compatible with the standards [ISA 100](#) or [IEC 62591](#) are recommended as they offer greater interoperability with the equipment of up and coming generations.

All wireless network components located outdoor shall be certified for zone 1.

All components shall be of an industrial type and suitable for the environmental conditions including vibrations, temperature, humidity, salt laden and corrosive atmosphere. All components shall be tropicalised and qualified to withstand the plants specific environmental conditions.

6.1.5 Building interconnections

Copper links shall not be used to interconnect control, monitoring and safety systems when located in different buildings, whatever their nature: part of ICSS or UCP's for controlling and monitoring packages.

These interconnections will be either fibre optic or radio link according the telecommunications network availability.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 11 of 33

As a general rule, such links shall be redundant and shall run on different cable routings.

6.1.6 Signals segregation

Instrumentation signals shall be segregated according to their nature and the system they belong to. Details are provided in [GS EP INS 107](#).

Special study will be carried out to determine what type of segregation to implement (junction boxes, marshalling cabinets, I/O boards, etc.) when considering redundant instruments attached to the same equipment or instruments attached to redundant equipment in taking into consideration equipment criticality.

7. Utilities

7.1 Electricity

There shall be a distribution board for each type and level of electrical supply: AC, DC, from UPS, etc.

The autonomy time of UPS shall be defined on a case by case basis following the availability required for the overall installation.

Transmitters and actuators shall be powered directly from the control systems or marshalling cabinets.

Transmitters shall be powered at 24 VDC.

Actuators shall be powered at 24 VDC except when long cable runs require 48 VDC.

In specific cases (e.g. system upgrade) when selected voltages exceed 50 VDC, interposing relays shall be used in dedicated cabinet to avoid any ICSS or UCP output module operating such voltages directly.

7.2 Instrument air

The platform/site shall be equipped with a set of air compressors, dryers and buffer vessel.

Air capacity shall be sized to allow autonomy consistent with electrical power supply autonomy on the different sites.

Operating pressure will normally be 7 barg. However, instruments and actuators shall be designed to work in the complete range from 5 barg to 10 barg at instrument inlet.

Instrument Air system requirements are specified in [GS EP INS 104](#).

7.3 Instrument gas

Same design principles as defined for instrument air are applicable (Refer to [GS EP INS 104](#)).

All instruments shall be specified taking into account the actual chemical composition of the gas including injected chemical products.

7.4 Hydraulic

Hydraulic energy will be retained for specific applications such as wellhead valves.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 12 of 33

Use of hydraulic energy shall be studied case by case as per project requirements and installation constraints.

Hydraulic logic modules shall not be used.

Hydraulic generation and distribution shall be designed in accordance with the [GS EP INS 146](#) requirements.

Hydraulic lines shall be cleaned to contamination sensitivity codes 17 / 15 / 12 as per [ISO 4406](#) at start-up.

8. Instruments general requirements

8.1 Instruments definition

The term "Instrument(s)" includes all devices that are used directly or indirectly to measure or control a variable. The term includes primary element, final control elements, computing devices, annunciators, switches and push-buttons, related to process, utilities, safety and fire & gas functions.

8.2 Instrument standardisation

Instrument standardisation requirements shall be addressed during Basic Engineering and shall take into consideration the project contractual strategy (i.e. different EPC Contractors).

Instrument standardisation will be considered for the whole plant, including packaged units, i.e. same technology, Manufacturer and model for the same use.

8.3 SIL requirements

SIL verification calculations shall be carried out for all safety instrumented functions (SIF). All components which contribute to the safety instrumented function (e.g. instrument, relay, Field Termination Assemblies, I.S. barrier etc.) shall be included within the calculation in order that it can be verified that the overall loop meets the required SIL.

Calculations shall be validated by a third party approved by Company.

SIL requirement and test interval for each SIF shall be recorded.

Field devices used for safety functions shall be suitable for SIL 2 applications.

8.4 Instrument earthing

Instrument earthing shall be in accordance with international rules and practices including [IEC 61000-5-2](#), [European Directive 2004/108/EC](#) and with [GS EP INS 107](#).

Instrument earthing principle shall be based on potential equalization principle, achieved by meshing at all possible locations: instruments, junction boxes and technical rooms.

Cable armour shall be earthed at both ends.

Screens will be earthed at a single point in the marshalling/system cabinets or UCP (Unit control panels for packages).

Screen continuity shall be ensured inside the junction boxes.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 13 of 33

8.5 Design and installation of lightning protection

The protection of electrical and electronic equipment against indirect effects of lightning shall be defined through the analysis and evaluation specified as per [GS EP ELE 051](#).

Additional study shall be carried out to evaluate the need for anti-surge devices to protect each I/O individually and/or each transmitter.

The main guideline is to ensure potential equalization all over the facility.

However such devices shall be mandatory for onshore small facilities and remote installations (e.g. wellhead areas).

For maintenance reasons, anti-surge devices shall be of the pluggable type and special attention shall be paid to testing facilities.

Mitigation of indirect effects may be achieved through installation rules such as:

- Grounding of spare conductors within non IS multicore cables on both sides. Whereas within IS cables spare conductors shall be grounded at cabinet side only as per [IEC 60079-14](#)
- Extensive use of underground paths and optical fibres
- Use of metallic cable trays grounded from place to place
- Reduce as much as possible cables loops (at the transmitter location and within the false floor of technical rooms).

8.6 Instruments identification

Instrument identification shall be in accordance with international rules and practices and with the [GS EP INS 102](#) based on [ISA-5.1](#).

8.7 Area classification/protection

All equipment must comply with the requirements of the specific hazardous area where they are installed. Refer to [GS EP ELE 079](#) for detail requirements about hazardous areas definitions and protection methods.

[ATEX European Directive 94/9/EC](#) shall apply in European Countries and associated countries (e.g. Norway, Island).

ATEX European Directive or [IECEx](#) standards shall apply in other countries.

All field instruments shall be certified for zone 1.

Field instrument/equipment not certified for zone 1 shall be de-energized in case of gas detection.

For category 3 equipment as per ATEX European Directive classification, certification by Manufacturer is not accepted. A "Statement of compliance" shall be delivered by a Notified Body.

Preferred protection methods are Ex d, Ex e, Exde, Ex i, Ex m, Ex me according to IEC standards. Use of the protection methods Ex p and Ex n shall be limited to specific applications and subject to Company approval on a case by case basis.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 14 of 33

The project protection method shall be selected during Basic Engineering and shall take account of the context of the overall project (new standalone project, standardisation with other developments or existing facilities, etc.).

The enclosures related certification shall consider all internal components including additional parts for possible extension.

Intrinsically safe circuits shall be installed in accordance with IEC regulations. An IS loop calculation sheet shall be submitted for each installed IS instrument.

Technical rooms shall be pressurized and safe areas consequently.

Concerning the instruments installed outside hazardous areas (e.g. restricted area), it is preferred to select the same type of instruments as those installed in hazardous areas, for standardisation of maintenance and operation, unless their quantity may justify different stock.

8.8 Enclosure protection/environmental aspects

Depending on the location of equipment, one of the following enclosure protection degrees, as described in [IEC 60529](#), shall be selected:

- Indoor: IP21
- Indoor with water mist: IP54
- Outdoor: IP65 or IP66 if subject to marine classification

The equipment shall, in all respects, be suitable for operation in typical gas drilling/operation platform service conditions and in a humid, salt laden and corrosive atmosphere. Any electrochemical coupling and galvanic corrosion shall be avoided and accessories shall be of suitable type. Where necessary, the equipment will be designed to withstand offshore tropical environments.

All field instrument body and their mounting brackets shall be minimum AISI 316.

Instrument technical rooms shall have a controlled environment.

8.9 Classification requirements for floater application

For floaters (FSO, FPSO, FPU) used for the production of oil and gas offshore, instruments, control and safety systems have to be proven for use in marine environment.

Classification Society requires that the control and safety systems equipment is suitable to work with an ambient temperature of 45°C for equipment not located in air conditioned room, and 35-40°C for equipment installed in air conditioned room.

Control and safety systems equipment shall have to be designed for an ambient relative humidity of 95% at 55°C.

Instruments, control and safety systems equipment shall be type approved by the project selected Classification Society.

Factory Acceptance Test of the control and safety systems shall be witnessed by the project selected Classification Society.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 15 of 33

8.10 Heating, winterization and insulation

8.10.1 General

Where heating of impulse lines is necessary and use of the process heat is not possible, the instrument wetted parts and the impulse lines shall be heated by an external source. If steam or hot oil is not available, electric heat tracing shall be considered.

Pre-assembled instrument housings around the instrument body and manifold with heating facilities shall also be provided. The housing material shall be stainless steel or fibreglass reinforced polyester.

Instruments shall be fitted with process separators when fluids characteristics and/or temperature conditions can alter performance and reliability of the system. The measurement capillaries shall be provided with heat insulation and mechanical protection.

8.10.2 Electric heat tracing

The heating equipment shall be selected in accordance with the required working temperature.

The heating tapes shall satisfy the electrical safety requirements in accordance with the area classification.

The arrangement of the electric heat tracing shall be such that the transmitters can be removed for maintenance purpose without disconnecting the electrical block or heater.

8.10.3 Insulation

The parts of the impulse lines which are filled with high pour point fluids shall be insulated. The traced impulse lines shall also be insulated. All fittings in the impulse lines shall be accessible without removing the complete insulation; special markers on the outside of the insulation shall indicate their location. The material used to insulate the impulse lines is described in **GS EP PVV 771**.

8.10.4 Protective shades

Subject to environmental conditions, instruments shall be protected against direct sun radiation by shades. The shades material shall be stainless steel or fibreglass reinforced polyester.

The shades shall be installed in such way that easy installation and removal are guaranteed.

8.11 General instrument characteristics

8.11.1 General

Safety and process control functions shall be performed by independent and autonomous instruments and/or devices.

In the interest of flexibility and standardisation, the components shall be in accordance with following common characteristics:

- All sensors/transmitters and controlled final receivers shall be 4-20 mA 24 VDC, with HART protocol whenever available
- Switches will be avoided. Threshold functions shall be based on analogue signals

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 16 of 33

- All transmitters shall be provided with built-in digital display
- HART safety-related instruments shall be equipped with hardware write protection (i.e. switch or jumper) inside the transmitter
- The use of sensors where the Hart function itself may be enabled / disabled on site is not permitted
- Fire and Gas detectors shall be based on 4-20 mA standard. If Hart is provided, HART configuration shall be fixed at factory. Therefore at site it will only be possible to read the measurement, configuration parameters and diagnostic information. Access to configuration for modifications shall be forbidden. Use of discrete sensors shall be studied on a case by case basis
- In buildings, use of addressable fire detectors shall be considered
- For applications where fast response time is required, dampening or filtering shall be completely disabled inside electronic instruments. This shall be clearly stated on the instrument datasheets and verified
- All instruments when not treated in fail safe configuration (e.g. Manual Call points (MAC), (Emergency) Shut-down, deluge pull handles/buttons...) shall be line monitored.

Instruments using mercury are forbidden.

Due to the potential risk to personnel and the environment, the use of instruments using a radioactive source shall be avoided (e.g. ionic type smoke detectors).

Where all alternatives to a radio-active based instrument have been exhausted, then such technology may be considered (e.g. level profiler or density measurement). However, special attention shall be paid to the required authorisation and local and international regulations. Project specifications shall define all the installation and maintenance aspects of such devices including transportation, storage, handling, source tracking and training.

All inserted instruments (thermowells, vortex, Pitot tubes, etc.) shall conform to [ASME PTC 19.3](#) calculations.

All instruments will be installed with vent and drain facilities and for hazardous and/or polluting fluids the vent/drain of instruments shall be piped to the vent/drain networks.

Instrument wetted parts shall withstand with fluid composition (e.g. Methanol...).

In case of dual transmitters (one for Safety, one for Control) for the same process measurement, they shall have same range and span and the process connections will be fully independent but shall be close enough to allow comparison of measurements.

Instrument technologies listed here below are the most common ones so this list is not exhaustive. Other types of instruments could be used according to the interest or context of the project.

8.11.2 Instrument performance specifications

Figures given for electronic instruments accuracy in the following chapters include the combined linearity, hysteresis and repeatability errors.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 17 of 33

8.11.3 Temperature

Thermowell type shall be one piece thermowell, bored from one piece solid bar stock or forgings without any velocity collar, and shall include a retaining flange. Tapered thermowells with round tip shall be selected.

Thermowells arrangements are given in [GS EP INS 900](#).

The thermowell standard material is SS 316L. Monel is recommended for seawater services. Other materials may have to be selected subject to the relevant piping class.

The cover flange shall always meet the relevant piping material requirements for material selection and dimension.

Thermowells shall be designed and sized in conformity with the [ASME PTC 19.3](#) calculations. Frequency and stress analysis calculations shall be supplied by the thermowell Manufacturer.

Pre-sizing of the well shall be performed by Contractor at an early detailed engineering stage in order to establish the piping nozzle sizing. This pre sizing shall be based on service conditions which shall be included in thermowell data sheets issued by Contractor.

Thermowells shall be sized for process maximum velocities considering all operating modes including steady state, inrush and any future operating conditions.

The maximum velocity limit of the designed thermowell shall be captured on the thermowell data sheet by the thermowell Manufacturer.

Test wells for general use shall be provided with screwed plugs permanently attached by stainless steel chain.

For pipe 4 inches or less, either an increase in pipe diameter to 4 inches shall be made (expander and reducer), or the thermowell shall be mounted in a T which replaces a pipe elbow.

The tip of the immersed well shall be located in the second third of the flowline diameter.

8.11.3.1 Temperature indicators

Bi-metallic temperature indicators shall be supplied as complete assemblies comprising: indicator, extension nipple and thermowell.

Scale graduations, zero adjustment and over-range protection shall be Manufacturer's standard. Accuracy shall be within $\pm 1\%$ of span.

Bi-metallic thermometers in service where vibration may be expected shall be either silicone filled or have other internal dampening means.

8.11.3.2 Temperature transmitters

Thermocouples and resistance temperature detectors shall be supplied as complete assemblies, comprising thermocouple or RTD element, including terminal blocks, terminal head, extension nipple, thermowell, and converter incorporated in thermocouple or in RTD head, with a 4-20 mA output. The RTD/4-20 mA converter shall use a Hart communication protocol.

Thermocouples shall be mineral insulated, stainless steel sheathed execution.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 18 of 33

The performance of the temperature measurement (sensor + transmitter) shall be at a minimum as follows:

- Accuracy $\pm 0.25\%$ of span
- Temperature effect $\pm 0.02\%$ of span/ 10°C variation

8.11.4 Pressure

Over-range protection shall be provided for pressure instruments, pilots, gauges, etc that may be subject to pressures that could damage or change the calibration of the instrument.

Instruments shall be equipped with pulsation dampeners when required by process conditions, capable of being adjusted while instruments are pressurized.

Where capillaries are not used, differential pressure transmitters shall be provided with a 316 stainless steel close coupled 5-valve manifold.

All pressure instruments connections shall be installed with a block and bleed valve assembly. This assembly shall be of AISI 316 stainless steel material including the trim.

8.11.4.1 Pressure gauges

The over-range protection of the gauges shall be at least 25% of the maximum rated pressure flange. The gauges shall have a minimum accuracy of $\pm 2\%$ at half range and $\pm 1\%$ at full scale.

Direct indicating gauges shall be chosen such that the normal operating pressure shall be between 30% and 70% of the full scale measuring range.

All pressure gauges shall be oil filled to avoid vibration.

8.11.4.2 Pressure transmitters

The performance of the instrument shall be at a minimum as follows:

- Accuracy $\pm 0.1\%$ of span
- Temperature effect $\pm 0.1\%$ of span/ 10°C variation

8.11.5 Flow

Measured operating flow range must be between 70% and 80% of calculated maximum flow range.

8.11.5.1 Orifices, Nozzles and Venturi tubes

Generally, square edge orifice plate with concentric entrances and flanged taps will be specified.

Venturi tube will be selected in applications where reduced required upstream pipe length or lower pressure drop are necessary.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 19 of 33

Orifices, Nozzles and Venturis shall be calculated in accordance with international codes, standards and recommendations and mainly with:

- [ISO 5167](#)
- [ISO 5168](#)
- [ISO/TR 3313](#).

Orifice plates flanges shall be minimum 300# rated as per [ASME B16.36](#).

Restriction orifice (RO) flanges shall comply with piping class requirements.

As a minimum, AISI 316 shall be used for orifice plates.

Other materials (e.g. Hastelloy) might be selected subject to the relevant piping class or specific applications.

8.11.5.2 Differential pressure flow transmitters

The performance of the instrument shall be as follows:

- Accuracy $\pm 1\%$ of span
- Temperature effect $\pm 0.1\%$ of span/ 10°C variation

The square root extraction shall be performed inside the ICSS or the UCP PLC.

8.11.5.3 Vortex meters

For the design of the apparatus, the service conditions shall be defined specifically to cover different operating ranges, allowable pressure drop, specifying the physical properties of fluid handled (viscosity, vapour pressure, density, etc.).

The performance of the instrument shall be as follows:

- Accuracy $\pm 1\%$ of flow rate
- Repeatability $\pm 0.25\%$ of flow rate

8.11.5.4 Electromagnetic flowmeters

Electromagnetic flowmeter can be used on low resistivity liquid. Cable selection and electrical connection shall be done following the Manufacturer recommendations.

The performance of the instrument shall be as follows:

- Accuracy $\pm 0.5\%$ of flow rate

8.11.5.5 Variable area meters

The armoured variable area flow meter shall consist of an all metal metering tube with a magnetic type extension attached to the float.

Glass tube types shall not be used.

Float limit stops to be provided for over-range protection.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 20 of 33

The performance of the instrument shall be as follows:

- Calibration accuracy $\pm 2\%$ of span
- Temperature effect $\pm 0.5\%$ of span/ 30°C variation

8.11.5.6 Turbine meters

Turbine meters shall be used only on fluids fully in the liquid phase without solid particles.

The performance of the instrument shall be as follows:

- Signal repeatability $\pm 0.02\%$ or better
- Meter linearity $\pm 0.25\%$ or better

8.11.5.7 Mass flowmeters

Coriolis type flowmeters can be used on test separators liquid outlets or as alternative to turbine meters.

The performance of the instrument shall be as follows:

- Accuracy $\pm 0.15\%$ of flowrate

8.11.5.8 Ultrasonic meters

Use of ultrasonic meters shall be studied on a case by case basis. The measuring principle shall be the "transit time differential method".

The performance of the instrument shall be as follows:

- Accuracy $\pm 0.5\%$ of flowrate

8.11.6 Level

8.11.6.1 Selection criteria for pressurized vessels

- Differential pressure type instrument is the preferred solution on pressurized vessels.
- Torque tube displacer may be used when there is no risk of dry leg (i.e. the displacer shall be fully submerged). However, they shall not be used in case of adhesive type of emulsion, or potential accumulation of solids.
- Capacitive probes are not permitted for applications involving crude oil.
- Guide-wave radar and capacitive probes shall not be used for liquid interface measurements.
- Nucleonic level or interface level measurement may be used.
- All pressure vessels shall be equipped with level gauges providing a visual verification of liquid levels and interface levels to allow for in-situ verification.

8.11.6.2 General Level Instrument Design and Installation Requirements

- The normal operating/alarm/trip settings shall be defined by a combination of process/vessel/instrument criteria in compliance with **GS EP ECP 103** requirements.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 21 of 33

- Level sketches showing all level related instruments (transmitters, gauges, switches) with tapping connections and these normal operating/alarm/trip settings shall be provided before placing any vessel or level instrument purchase order. Limitations included in the Appendix 1 of this specification shall be taken into account.
- Measurement ranges used for control (LT for PCS and LG) and safety functions (LT for SIS) will have the same range, span and process tapping elevations to allow for continuous monitoring of any discrepancy between both measurements.
- However, if for accuracy or sensitivity reasons this requirement can't be achieved, then the measurement range used for safety function (LT for SIS) will be such as correction for discrepancy monitoring will be easy to determine.

In this case:

- Where LSLL (or LSL) for safety function is required, the lower tapping elevation of the safety measurement shall be the same as the lower tapping elevation of the control -related measurement.
- Where LSHH (or LSH) for safety function is required, the higher tapping elevation of the safety measurement shall be the same as the higher tapping elevation of the control -related measurement.
- All level instruments shall be able to be maintained without isolation of the vessel itself. Therefore, level instruments will generally be externally mounted in sensor cages and provided with individual isolation facilities allowing sensor removal and cage cleaning.
- Each level instrument shall have individual process tappings (on vessel or standpipe), not shared with any other instrument, to allow individual isolation of the instrument and to avoid common-mode failures/isolation.
- Stilling wells may be used to cancel / reduce the slopping effects and to protect the sensing element from turbulent process conditions.
- Process tapping are not permitted on flowing outlet connection or piping adjacent to the vessel inlet and outlets.
- For Hull Tank application, only top-mounted (deck-mounted) process tappings are permitted by International Maritime Organization Code.

8.11.6.3 Standpipes and Sensor Cages

Standpipe: is an external extension of the pressure vessel, to which multiple instruments can be connected, but no instrument is installed inside the standpipe itself. There shall be no isolation valves between vessel and standpipe: each instrument shall have individual isolation valves.

Sensor cage: is an individual chamber in which the level sensor is installed, part of a single level instrument. The sensor cage can be installed either on the pressure vessel or on a standpipe. They shall have dedicated process isolation valves and vent/drain facilities, allowing the level sensor to be safely removed without vessel/standpipe shutdown.

The use of standpipes shall be limited as per [GS EP SAF 261](#) and [GS EP PVV 211](#).

Standpipes design shall be in accordance with [GS EP PVV 211](#) requirements.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 22 of 33

8.11.6.4 Level Instrument characteristics

8.11.6.4.1 Level gauges

Magnetic type indicators, with two-coloured flaps are preferred. The reading scale position shall be adjustable.

Level gauges shall be of the transparent type, with illuminators when required by installation conditions. They shall be fitted with off-centred angle taps, with safety ball.

The maximum centre-to-centre distance for level gauges shall be 2000 mm, giving a visibility of 1760 mm. When greater ranges are required, several gauges shall be installed with an overlap of at least 50 mm.

8.11.6.4.2 Level torque tube

If required by process conditions the torque tubes shall have extensions or cooling fins.

The standard ranges of torque tube levels to be used shall be as follows:

- 356 mm (14") and 813 mm (32").

The upper process tapping of a torque tube type transmitter for liquid interface measurement shall be at least 100 mm below the weir plate height.

8.11.6.4.3 Level differential pressure transmitters

When considered for specific services such as viscous fluid or deposit risk, differential pressure transmitters shall be provided with diaphragms and capillaries.

For level measurements in atmospheric pressure tanks, a flanged hydrostatic pressure transmitter can be used, directly mounted on a three inch flange on the tank. A shut-off valve shall be provided for removal of this apparatus.

Particular attention shall be paid to the capillary protection and heat tracing (refer to [GS EP INS 900](#)).

In case of tall measurement range (e.g. above 6 m), calculated differential pressure can be used. In this case, a detailed procedure for the calibration (including the zero shift) shall be issued.

Special care will be paid to the selection of the membrane material, when used in presence of hydrogen ions. Gold plated membrane shall be used to avoid any permeation through the membrane.

Minimum positive pressure at the transmitter (value as per Vendor's datasheet), shall be applied to avoid fill fluid vaporization.

Therefore for applications such as water treatment including de-aerator column, differential pressure transmitter shall be mounted below the lowest tap.

Each differential pressure level transmitter shall be provided with a close coupled 5-valve manifold AISI 316 stainless steel except where capillaries are used.

The performance of the instrument shall be as follows:

- Accuracy $\pm 0.10\%$ of span

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 23 of 33

8.11.6.4.4 Hydrostatic pressure level transmitter

The performance of the instrument shall be as follows:

- Accuracy $\pm 0.10\%$ of span

8.11.6.4.5 Capacitive/Admittance level transmitters

They can be used in some cases mainly on water base fluids or to measure clean fluid interface level between water and oil.

8.11.6.4.6 Radar level transmitters

The performance of the instrument shall be as follows:

- Accuracy $\pm 0.15\%$ of span

8.11.6.4.7 Level threshold detection

This detection is based on vibration technology.

Diagnostic facility shall be provided through the transmitter analogue signal.

8.11.6.4.8 Nucleonic level Instrument

The sources and detectors shall be maintainable and dismountable for calibration without affecting the production. It shall be fitted with sensor supports and dry source well(s).

The process design temperature shall be taken into account. If a cooling system needs to be provided, a reliable and adequate skid mounted cooling water systems for each tank shall be provided. Each skid shall be equipped with adequate redundant pumps and cooler banks for allowing uninterrupted production.

8.11.7 Control and Choke valves

Control and choke valves shall be selected, designed and supplied in compliance with **GS EP INS 120** requirements.

8.11.8 ON/OFF actuated valves

Safety and process ON/OFF valves actuators and control panels shall be selected, designed and supplied in compliance with **GS EP INS 137** requirements.

8.11.9 Pressure Safety Valves and Rupture Disks

Safety relief valves and rupture discs shall be selected, designed and supplied in compliance with **GS EP INS 125** requirements.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 24 of 33

8.12 Units

Unless local rules apply, metric units shall be employed with charts and scales as follows:

Process Variables		Units	Scales
Flow	Liquids	m ³ /D m ³ /hr	Direct reading
	Gases	Nm ³ /hr	Direct reading
Level	General Tank gauge	% meter or %	0-100 Linear 0-100 Linear
Pressure	Above Atmospheric	barg.	Direct reading
	Below Atmospheric	bara	Direct reading
	Differential	mbar	Direct reading
Analysis			Direct reading
Temperature	General	°C	Direct reading

8.13 Instrument accessibility

Each instrument is a working location and as such it is necessary that all intervention on the instrument can be carried out under the best safety and efficient conditions.

Instrument accessibility being able to induce heavy consequence on piping or layout, this problem shall be considered as soon as possible during the detailed engineering stage.

It shall be important to distinguish two kinds of working location:

- Permanent working location
- Non permanent working location.

A working location shall be considered as permanent when visit frequency lower than once a month.

The following instruments and accessories as a minimum shall be considered as permanent working location: Control valves, ON/OFF actuated valves, transmitters, local controllers, local converters, in-line flow meters, level gauges, temperature elements, analyser take off point, sampling loop, pressure taps, pressure gauges, thermocouples or resistance and thermowells

The orifice flanges shall be considered as non permanent working location.

For permanent type, the access shall be easy. Platforms are requested, movable ladder forbidden.

For non permanent type, movable ladder shall be allowed if height in less than 3 meters.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 25 of 33

All permanent work stations and their means of access shall be shown on piping drawings and/or on the models.

Accessories and remote mounting equipment shall be provided to facilitate maintenance for inaccessible detectors (e.g. remote indicators for smoke detectors installed within false floor or HVAC duct, remote transmitters and calibration tubing for gas detectors).

8.14 Instrument installation

Hook-up drawings shall be made by Contractor in accordance with international recommendations, [API RP 551](#) and [GS EP INS 900](#).

For specific instruments Vendor's recommendations will be applied.

Instrument process connections shall be according to [GS EP PVV 112](#).

9. Tubes, cables, junction boxes, field terminal cabinets, etc.

9.1 Tubing and fittings

Fittings and tubing shall be provided in accordance with process piping and instrument general specifications [GS EP INS 107](#) and [GS EP INS 900](#).

The Basic Engineering shall define whether imperial or metric units shall be used. The decision shall take into account the specific context of the project (new standalone project, standardisation with other developments or existing facilities, etc.).

Fittings model shall be standardised throughout the whole plant/installation, including package units. Consideration shall be taken of any existing model already used on site.

All threaded connections will be of NPT type.

9.2 Cables

Interconnecting from technical room to field mounted instruments is made by multicables to junction boxes and then by individual cables.

Electric instrument cable overhead runs shall be protected in accordance with the area classification where they are located, as follows:

- Armoured cables laid on continuous rigid supports or on cable trays
- Metal conduit protected cables only if required by codes.

All cables shall be at least flame retardant ([IEC 60332-3](#)), except for safety related systems (such as fire & gas detectors, emergency/fire push-buttons, CO₂ release, etc.) or when safety loop fail safe principle is not applied for which the cables shall be fire resistant ([IEC 60331](#)).

Cables insulation material will suit with the hydrocarbon environment.

All cables inside accommodation or normally manned rooms shall be halogen free.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 26 of 33

9.3 Wiring

9.3.1 Cable trays / ladders

All cables shall be run on cable trays or ladders.

See **GS EP ELE 311** for cable trays and ladders requirements.

Supports of cable tray and ladders shall be of carbon steel and painted according to the general painting specifications. Cable trays & ladders shall never be fixed to piping.

Cable trays & ladders materials shall be selected according to environmental conditions.

Cable trays & ladders of synthetic materials shall be conductive and fire resistant.

Cable trays shall be edge mounted or covered whenever a risk of mechanical damage exists due to dropped objects, fire or falling incandescent pieces. This shall also apply when cables are exposed to ultraviolet radiation.

9.3.2 Routing

Cable routing system shall be arranged in accordance with the following:

- Electric instrument cable trays/ladders shall be distinctly separated from power and lighting cable trays/ladders
- Cable crossing at the same height is forbidden
- Power cables will pass across signal cables at right angle and on different level.

All cables crossing construction walls shall be sealed with MCT (multi cable transit) suitable for the classified area.

Separate routing shall be selected for redundant data links.

9.4 Junction boxes and cable glands

Junction boxes shall be made of fibreglass reinforced polyester and be as a minimum of safety "Ex e" type. The ingress protection degree for junction boxes and cable glands shall be IP 65.

All out/incoming cabling shall be provided with compression suitable cable glands certified for the classified area.

Cable glands for junction boxes and instruments shall be metallic, nickel plated brass, and covered with heat shrinkable plastic shrouds.

Cable entries shall be designed in such a way that no transmission of stress into the individual terminal shall occur.

All cables cores must be connected on terminals including spare ones which shall be earthed.

When fire resistant cables are used, exposition to fire will be carefully taken into consideration for the lay out of the concerned junction boxes.

All entries shall be at the bottom of the boxes.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 27 of 33

9.5 Field Terminal Cabinets (FTC) in technical rooms

Marshalling cubicles located in technical room shall have bottom cable entry. Technical room shall be equipped with raised floor (see **GS EP INS 108**).

Cables clamping facility shall be provided in the bottom of cabinets.

Marshalling cabinets internal layout shall be such that signals of the same type shall be grouped on contiguous terminal blocks.

Terminal blocks shall be spring clamp type, 2 conductors disconnect ("knife" type) with test points or 4 conductors disconnect. They shall allow plug-in resistor modules for HART communication or fuse modules for outputs to solenoid valves.

All spare conductors shall be connected on terminals and earthed.

9.6 Identification, tagging and labelling

9.6.1 Instruments tagging

All instruments will be labelled in two ways: on the instrument itself and close to the instrument (location label).

The label on the instrument shall be made of an engraved stainless steel plate, attached to the instrument with a SS316 wire. Letters shall be 5 mm high.

The location label shall be an engraved Traffolyte plate screwed on the instrument support. Letters shall be 15 mm high.

Traffolyte plates shall be coloured depending on the part of the control and safety systems they are connected to:

- HIPS instruments: yellow background with red letters
- Fire & Gas System, Safety Shutdown System and Process Shutdown System: red background with white letters
- Process Control System: white background with black letters.

All accessories, screws or rivets shall be in stainless steel.

9.6.2 Cables and tubes

Cables and tubes shall be labelled at both ends and at all wall or bulkhead penetrations.

Marking will be made of punched SS316L labels attached with stainless steel fasteners.

Use of slip-on pre-printed shrinkable sleeves shall be reserved to applications where risk of corruption of marking with dirt is very limited; it shall be submitted to Company approval.

9.6.3 Junction boxes and local cabinets

Junction boxes and field cabinets shall be labelled using engraved Traffolyte plates. Letters shall be 15 mm high.

Plates shall be coloured as follows:

- "Process" junction boxes: white background with black letters

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 28 of 33

- “Safety” junction boxes: red background with white letters
- “Intrinsic Safety” junction boxes: blue background with white letters.

All accessories, screws or rivets shall be in stainless steel.

Inside cabinets, instrument labels shall follow the requirements of chapter 9.6.1 with the exception of letter size which can be reduced to 10 mm.

9.6.4 Radio frequency Identification (RFID)

If required by project specifications, then all tagged equipment will have an electronically readable ID (e.g. RFID embedded in the tag plate).

All tag plates with embedded RFID tags will be provided by one common vendor in order to assure a consistent choice of RFID technology.

Each Contractor will have to make a call off towards this common vendor, and be responsible for fastening the tag plates (and RFID) to their equipment.

9.6.5 Colour coding for instrument connections

Unless local rules apply, colour coding for instrumentation electrical connections will be as follows:

- Power supply 220 VAC:
 - Black (live)
 - Blue (neutral) (compulsory)
 - Yellow/Green (Earth) (compulsory)
- Power supply 48 VCC or 24 VCC:
 - Red (+)
 - Blue (-)
- Analogue signal:
 - Red (+)
 - White (-)
- Pt 100 Temperature:
 - White/Red/Blue.

10. Instrumentation software tools

An Instrument database is required to organize and manage the large amounts of instrument data required to be defined on a project.

It shall be the common source of data used to produce the engineering deliverables (e.g. instrument data sheet, wiring diagrams, cables list, loop diagrams...).

It will be developed in compliance with the **GS EP INS 103** requirements.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 29 of 33

11. Instrument preservation

As soon as any instrument has been unpacked from its original factory-packing and during all construction, test and transportation phases, all necessary measures for protection against mechanical damage, corrosion and foreign material penetration shall be implemented to prevent seizing and contamination (e.g. greasing/lubrication of gaskets, threads and valve shafts, temporary covers or wrapping, etc.).

Free end of cables shall always be protected against water ingress by heat-shrink caps.

12. Documents

Minimum Contractor documents requirements shall be as per **GS EP INS 000**.

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 30 of 33

Bibliography

IEC 60079	Parts related to the Electrical apparatus for explosive gas atmospheres
IEC 60364	Parts related to the Low-voltage electrical installations and Electrical installations of buildings
API RP 521	Guide for Pressure-relieving and Depressuring Systems
API RP 552	Transmission Systems
API RP 554	Parts related to the Process Control Systems
API Std 527	Seat Tightness of Pressure Relief Valves
API MPMS	Manual of Petroleum Measurements Standards
ISA-20	Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves
GS EP SAF 253	Impacted area, restricted area and fire zones

General Specification		GS EP INS 101
Instrumentation engineering, supply and construction general requirements		
Rev.: 11	Effective date: 11/2012	Page: 31 of 33

Appendix 1 Level Instrument Tapping requirements on Pressure Vessels

Tapping limitations for vertical pressure vessels

Side tapping on vertical vessel should keep at least 150 mm distance from the shell/dish weld (often considered the tangent),).

Hence, the maximum tapping distance is the 'tangent-to-tangent' distance minus 300 mm.

Consequently, the maximum measuring range of the level instrument is tapping distance as shown in the figure A1.

Process tapping can also be made from the dish heads (see figure A2). However, making tapping from the dish heads provides additional measured height, but also introduces a dead leg. Such bottom tapplings are often a cause of serious level measurement problem in case solid deposit. In this case of "non-clean" fluid (e.g. production separator) the bottom tapping principle should be prohibited.

Figure A1 - Tapping limitations for vertical pressure vessels

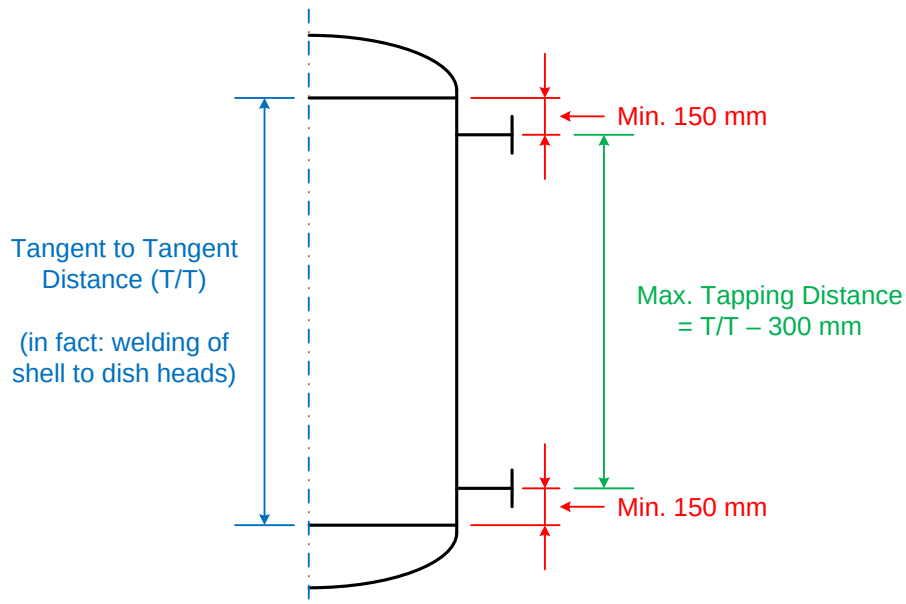
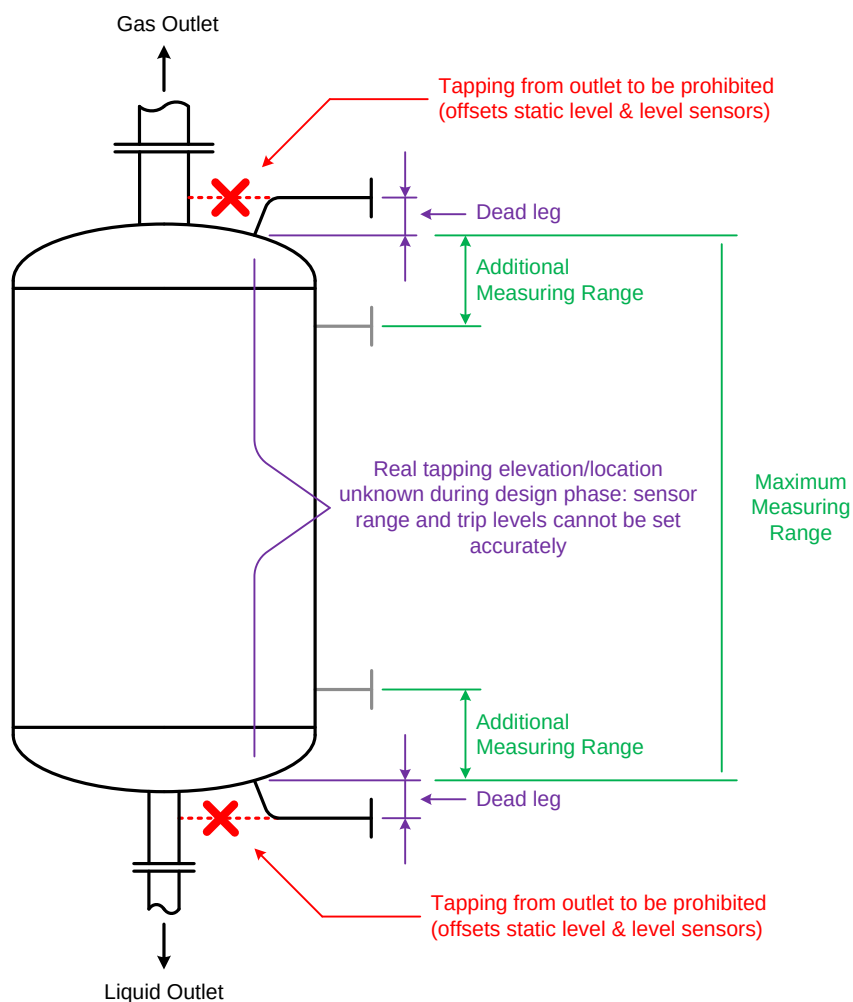


Figure A2 - Tapping limitations for vertical pressure vessels at dish heads


Tapping limitations for horizontal pressure vessels

Horizontal tapplings from horizontal vessels have also fixed limitations as per [ASME Section VIII Div. 1](#) pressure vessel code. The maximum angle for horizontal orientated tapplings should not exceed 55 degrees (which is around $0.9 \times R$ in height).

Consequently, the maximum tapplings distance should be $0.8 \times$ the vessel's diameter (see figure A3).

Figure A3 - Tapping limitations for horizontal pressure vessels

