# TECHNICAL SPECIFICATION

**CLIENT:**

**JOB:**

**AREA:**

**TITLE:** GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS

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**DATE**

**DESIGN**

**EXECUTION**

**CHECK**

**APPROVAL**

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*FORM OWNED TO PETROBRAS N-0381 REV.L.*
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1 INTRODUCTION

1.1 Object

1.1.1 This specification comprehends the minimum general requirements for instruments’ specifications, applicable in Instrumentation projects in E&P Production Units.

1.1.2 The materials here specified, are understood as the minimum required and materials with inferior characteristics shall not be accepted. If operational conditions are more severe, materials with mechanical or chemical characteristics that attend such conditions shall be selected.

1.1.3 This specification includes only the most common instruments used. Other instruments shall be bound to approval by PETROBRAS.

1.1.4 This technical specification shall be used along with specific recommendations of each PACKAGED UNIT.

1.2 About Interdisciplinary Interfaces and Materials Terminology

1.2.1 The application of this document, demands interactions between several disciplines creating interfaces, which are inherent to a production plant. Interfaces can exist in any item of this technical specification. However, where interfaces of great impact were identified, the term [INTERDISCIPLINARY INTERFACE] is used, followed by the abbreviations of the interacting disciplines. Below is a list of all possible discipline abbreviations:

- ARC: Architecture;
- ARR: Arrangement;
- ELE: Electrical;
- MEC: Mechanical;
- PRO: Process;
- SEC: Safety;
- TBM: Turbo Machinery;
- PIP: Piping; 3D: Project Automation and 3D Modeling;
- NAV: Marine Systems

1.2.2 For use within this document, the following terminology is applied:

- Stainless steel AISI 304 refers to UNS S30400;
- Stainless steel AISI 316 refers to UNS S31600;
- Stainless steel AISI 316L refers to UNS S31603;
- Stainless steel AISI 410 refers to UNS S41000;
- Stainless steel AISI 416 refers to UNS S41600;
- Stainless steel AISI 420 refers to UNS S42000.

1.3 Units

In accordance with the International System of Units, the units listed on Table 1 shall be used for the main variables.
Table 1 – SI Units.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Flow</td>
<td>Liquid</td>
<td>m³/h</td>
</tr>
<tr>
<td></td>
<td>Water Vapor</td>
<td>t/h</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>m³/h (20 ºC and 101,325 kPa)</td>
</tr>
<tr>
<td>Pressure</td>
<td>bar or kPa</td>
<td>Pressure measurements refer to manometric pressure, except where clearly specified.</td>
</tr>
<tr>
<td>Vacuum</td>
<td>bar abs or kPa abs</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>% of range, m or mm</td>
<td></td>
</tr>
</tbody>
</table>

2 GENERAL

2.1 Definitions

UNIT FPSO (Floating, Production, Storage and Offloading), FSO (Floating, Storage and Offloading), SS (Semi-Submersible) or Fixed Offshore Unit.

PACKAGED UNIT An assembly of equipment supplied interconnected, tested and operating, requiring only the available utilities from the UNIT for its operation.

MANUFACTURER The responsible for fabrication of equipment

VENDOR System or equipment supplier.

2.2 Abbreviations

ADV Automatic Deluge Valve
AISI American Iron and Steel Institute
API American Petroleum Institute
ASTM American Society for Testing and Materials
BDV Blowdown Valves
CJC Cold Junction Compensation
CNEN National Nuclear Energy Commission (Portuguese: Comissão Nacional de Energia Nuclear)
CSS Control and Safety System
DIN German Institute for Standardization (German: Deutsches Institut für Normung)
ED External Diameter
EMC Electromagnetic Compatibility
EMI Electromagnetic Interference
EN European Norms
ESD Emergency Shutdown
FS Full Scale
HART Highway Addressable Remote Transducer Protocol
ID Internal Diameter
IEC International Electrotechnical Commission
MCP Manual Call Point
ND Nominal Diameter
OD Outside Diameter
3 REFERENCE DOCUMENTS, CODES AND STANDARDS

3.1 External references

3.1.1 International Codes, Recommended Practices and Standards

IEC - INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60529 DEGREES OF PROTECTION PROVIDED BY ENCLOSURES (IP CODE)
IEC 60533 ELECTRICAL AND ELECTRONIC INSTALLATIONS IN SHIPS - ELECTROMAGNETIC COMPATIBILITY (EMC) – SHIPS WITH A METALLIC HULL
IEC 61000 ELECTROMAGNETIC COMPATIBILITY (EMC) SERIES - ALL PARTS
IEC 60079 EXPLOSIVE ATMOSPHERES
IEC 60092 ELECTRICAL INSTALLATIONS IN SHIPS
IEC 60534 INDUSTRIAL PROCESS CONTROL VALVES
IEC 60584 THERMOCOUPLES
IEC 60331-11 TESTS FOR ELECTRIC CABLES UNDER FIRE CONDITIONS - CIRCUIT INTEGRITY - PART 11: APPARATUS - FIRE ALONE AT A FLAME TEMPERATURE OF AT LEAST 750°C
IEC 60331-21 TESTS FOR ELECTRIC CABLES UNDER FIRE CONDITIONS - CIRCUIT INTEGRITY - PART 21: PROCEDURES AND REQUIREMENTS - CABLES OF RATED VOLTAGE UP TO AND INCLUDING 0,6/1,0 KV
IEC 60332 FLAME-RETARDANT CHARACTERISTICS OF ELECTRIC CABLES
IEC 60751 INDUSTRIAL PLATINUM RESISTANCE THERMOMETERS AND PLATINUM TEMPERATURE SENSORS
IEC 61892 MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS

ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO 2715 LIQUID HYDROCARBONS - VOLUMETRIC MEASUREMENT BY TURBINE FLOWMETER
ISO 5167 MEASUREMENT OF FLUID FLOW BY MEANS OF ORIFICE PLATES, NOZZLES AND VENTURI TUBES INSERTED IN CIRCULAR CROSS-SECTION
TECHNICAL SPECIFICATION

TITLE: GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS

CONDUITS RUNNING FULL COMPRESSED AIR - PART 1: CONTAMINANTS AND PURITY CLASSES

API – AMERICAN PETROLEUM INSTITUTE

API RP 520 RECOMMENDED PRACTICE FOR THE DESIGN AND CONSTRUCTION OF PRESSURE-RELIEVING SYSTEMS IN REFINERIES
API STD 527 SEAT TIGHTNESS OF PRESSURE RELIEF VALVES
API RP 551 PROCESS MEASUREMENT
API RP 578 GUIDELINES FOR A MATERIAL VERIFICATION PROGRAM (MVP) FOR NEW AND EXISTING ASSETS
API STD 2000 VENTING ATMOSPHERIC AND LOW-PRESSURE STORAGE TANKS
API MPMS 4.2 MANUAL OF PETROLEUM MEASUREMENT STANDARDS

DIN – DEUTSCHES INSTITUT FÜR NORMUNGEN

DIN 43760 MEASUREMENT AND CONTROL; ELECTRICAL TEMPERATURE SENSORS; REFERENCES-TABLES FOR NICKEL RESISTORS FOR RESISTANCE THERMOMETERS
DIN EN 13190 DIAL THERMOMETERS

AGA – AMERICAN GAS ASSOCIATION

AGA REPORT NUMBER 7 MEASUREMENT OF NATURAL GAS BY TURBINE METERS (2006)

ASME – AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ASME PTC 19.3 TW THERMOWELLS PERFORMANCE TEST CODES
ASME B40.100 PRESSURE GAUGES AND GAUGE ATTACHMENTS
ASME Section VIII, Division 1 RULES FOR CONSTRUCTION OF PRESSURE VESSELS

VDI – VEREIN DEUTSCHER INGENIEURE

VDI / VDE 3513 BLATT 1 VARIABLE-AREA FLOWMETERS - CALCULATION METHODS

ISA – INTERNATIONAL SOCIETY OF AUTOMATION

S 75.08.01 FACE-TO-FACE DIMENSIONS FOR INTEGRAL FLANGED GLOBE-STYLE CONTROL VALVE BODIES (CLASSES 125, 150, 250, 300, AND 600)
S 75.22 FACE-TO-CENTERLINE DIMENSIONS FOR FLANGED GLOBE-STYLE ANGLE CONTROL VALVE BODIES (ANSI CLASSES 150, 300, AND 600)
75.01.01 INDUSTRIAL-PROCESS CONTROL VALVES

3.1.2 Brazilian Codes and Standards

**INMETRO - INSTITUTO NACIONAL DE METROLOGIA, NORMALIZAÇÃO E QUALIDADE INDUSTRIAL**

PORTARIA Nº 179 (18/MAIO/2010) REGULAMENTO DE AVALIAÇÃO DA CONFORMIDADE PARA EQUIPAMENTOS ELÉTRICOS PARA ATMOSFERAS EXPLOSIVAS, NAS CONDIÇÕES DE GASES E VAPORES INFLAMÁVEIS E POEIRAS COMBUSTÍVEIS.


3.1.2.1 All MTE – Ministério do Trabalho regulations (NRs) shall be followed.

3.1.3 Classification Society

3.1.3.1 Detail design phase documentation of the project shall be submitted to approval by Classification Society. The design and installation shall take into account their requirements and comments.

3.1.3.2 The design, installation and operation shall strictly follow the classification society requirements, along with the specific requirements identified in this document, including also all referenced documents’ requirements.

3.2 Internal References

3.2.1 Project Documents

I-ET-3010.00-5520-861-P4X-001 CONTROL AND SAFETY SYSTEM - CSS

I-ET-3010.00-1200-956-P4X-002 GENERAL PAINTING

3.2.2 PETROBRAS Reference Documents

DR-ENGP-M-I-1.3-R.4 SAFETY ENGINEERING

3.3 Brazilian regulation (MTE section) and INMETRO regulation superpose all codes and regulations listed in item 3.2, since they are enforced by Brazilian law.

4 TRANSMISSION AND CONTROL SIGNALS

4.1 Pneumatic Instrumentation

4.1.1 Pneumatic instrumentation range shall be 20 to 100 kPag (0.2 to 1.0 barg). For control valves, if necessary, 40 to 200 kPag (0.4 to 2.0 barg) range shall also be accepted.
4.2 Electronic Instrumentation

4.2.1 4 to 20 mA DC, with addition of digital communication using HART protocol, certified by HART FOUNDATION. Specific signals, such as: RTD (thermoresistance), Thermocouple, Opticals, etc. are exceptions which may be used, but shall be submitted to PETROBRAS’ approval.

4.3 Communication Network Signals

4.3.1 Networking cables shall have exclusive routing with proper protection against mechanical damage. They shall be placed in enclosed trays or in such a way that allows the cable to be inspected without its removal. The minimum separation distance recommended in communication protocol used shall be respected for power cables.

5 POWER SUPPLY SYSTEMS

5.1 Pneumatic system

5.1.1 Air Quality

5.1.1.1 Instrument air shall be in accordance with requirements of ISO 8573-1 (Quality Standard for Instrument Air) standard for particle purity class 2. [INTERDISCIPLINARY INTERFACE] [MEC]

5.1.1.2 For dew point definition, the smallest temperature defined in Metocean data of project shall be adopted and it shall be in accordance with ISO 8573-1. For more information on Metocean Data Acquisition System, see technical specification document of the project entitled REQUIREMENTS OF METOCEAN DATA ACQUISITION SYSTEM – ENV. [INTERDISCIPLINARY INTERFACE] [MEC]

5.1.2 Operating Conditions

5.1.2.1 Typical operation reference values are presented on Table 2, but true values shall be confirmed by Process discipline as defined on the P&IDs of the project.

Table 2 – Operating Conditions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>Maximum</td>
<td>1030 kPa (10.3 bar)</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>686 kPa (6.86 bar)</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>490 kPa (4.9 bar)</td>
</tr>
<tr>
<td>Temperature</td>
<td>Maximum</td>
<td>50°C</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>40°C</td>
</tr>
</tbody>
</table>
5.1.3 Instrument Air Consumption

5.1.3.1 The correct sizing of instrument air compression system capacity shall be based on air consumption calculation according to data given by MANUFACTURERS and elaborated by Process discipline. Equipment from other disciplines also consume instrument air from the same system. For example, pressurization of electrical motors, from Electrical discipline, and seals of compressors, from Turbomachinery discipline. The relative consumption of equipment from other disciplines shall be obtained from each discipline. [INTERDISCIPLINARY INTERFACE] [PRO, NAV, HVAC, ELE, TBM]

5.1.3.2 In case of lack of data from the MANUFACTURER, the estimation of instrument air consumption shall be done considering the consumption of all instruments (of continuous operation) operating simultaneously, plus the consumption of instruments/devices of intermittent operation, according to the criteria established below:

a) Continuous Consumers

The average consumption of continuous operation instruments can be observed on Table 3.

Table 3 – Continuous Consumers of Instrument Air

<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>AVERAGE CONSUMPTION (Nm³/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Valve with Position Indicator</td>
<td>2</td>
</tr>
<tr>
<td>Modulated Damper with Position Indicator</td>
<td>2</td>
</tr>
<tr>
<td>Booster Reles</td>
<td>2</td>
</tr>
<tr>
<td>Analyzer</td>
<td>According to MANUFACTURER</td>
</tr>
<tr>
<td>Pressurized Panels</td>
<td>According to MANUFACTURER</td>
</tr>
</tbody>
</table>

For other instruments, when precise data is not available, a consumption of 1.6 Nm³/h shall be considered.

b) Intermittent Consumers

The consumption of Shutdown Valves (SDV), Blowdown Valves (BDV) and flame arresters, shall not be taken into account, since in normal operating conditions the frequency of events that require their actuation (ESDs) is very low.

For air consumption of pneumatic pumps located in safety panels or in well control racks (production and/or injection) and hydraulic units, needed to pressurize hydraulic lines for actuating valves of Christmas Trees, the average consumption shall be considered, and it cannot be less than 10 Nm³/h. However, the instantaneous consumption shall be used for sizing the pneumatic power lines of pumps.
5.1.3.3 Along with the consumption provided by the sum of continuous and intermittent consumers it shall be added an extra capacity of 43% of the calculated consumption, which contemplates future expansions of the plant (30%) and a reserve to compensate purge from various instruments and possible leakage in air distribution system (10%).

5.1.4 Distribution of Air Supply

5.1.4.1 For each area, skid or PACKAGED UNIT, one air distribution manifold shall be provided, equipped with condensate pot with block and drain valves (AISI 316 stainless steel, ball type), near the manifold inlet, and a block valve (AISI 316 stainless steel, ball type) on each outlet. A local pressure indicator (with block and drain valves) between the manifold inlet and its block valve shall also be supplied.

5.1.4.2 Main instrument air supply distribution line shall be divided into branches, per area/floor, equipped with locked open block valves (AISI 316 stainless steel, ball type). The offshoot of the main distribution line to the branches shall be in superior generating line, to reduce risk of water arrest to branches.

5.1.4.3 Each instrument consumer shall be equipped with a ball or needle block valve, AISI 316 stainless steel made.

5.1.5 Use of natural gas as pneumatic fluid

5.1.5.1 This alternative may only be adopted in unmanned and open areas, and it is subject to prior approval by the involved ASSET/Business Unit. In such cases, natural gas shall be conditioned, and solid residues shall be removed.

5.1.5.2 Conversions of gas into air or vice-versa will not be accepted.

5.1.5.3 Gas-supplied control lines shall not be accepted inside the control rooms.

5.2 Electrical System

5.2.1 Instruments shall be specified to operate in nominal voltage of 24Vcc provided by automation system panels and shall be in accordance with the established limits for powering systems in continuous current determined by IEC-61892-1.

5.2.2 PACKAGED UNITS and skids shall provide a calculation report to establish the minimum voltage necessary on the interface (minimum voltage to be supplied by UNIT to PACKAGED UNIT/skid) so that the minimum voltage required by its instruments is guaranteed.
6 GENERAL REQUIREMENTS FOR INSTRUMENTATION SPECIFICATION

6.1 This chapter describes requirements that shall be applied to all instruments.

6.2 Instruments shall be in accordance with API RP-551.

6.3 Instruments to which the metrological standards of INMETRO and the official regulation (ANP) apply shall, also, be in accordance with the requirements described in the technical specification document of the project entitled FLOW METERING SYSTEM.

6.4 Identification

6.4.1 An AISI 316 stainless steel identification plate with at least, the following information shall be permanently attached to the instrument:

6.4.1.1 Ex Certificate, gas group and temperature class, according to IEC 60079;

6.4.1.2 IP Certificate, according to IEC 60529. If IP68 is defined, the maximum depth shall be explicitly stated on the certificate;

6.4.1.3 Laboratory (who issued the certificate) and certificate numbers;

6.4.1.4 Serial number, model and MANUFACTURER.

6.4.2 Besides the identification plate described in item 6.4.1, a stainless steel plate with the instrument TAG finely engraved shall also be provided. This plate shall have a minimum size of 5 cm x 2.8 cm x 0.5 cm (Width x Height x Thickness), rounded corners and the perimeter shall be smoothly finished so that it does not present a risk of laceration when handled. This plate shall be attached to the instrument by means of a flexible AISI 316 stainless steel wire.

6.5 Dust and Water Ingress Protection (IP) Rating

6.5.1 The enclosure of instruments shall be resistant to weather conditions produced by the process or maritime environment. All instruments and their respective accessories installed in areas that are not sheltered or that are exposed to weather shall have, as a minimum, IP56 ingress protection in accordance with IEC 60529.

Note: An enclosure with only one ingress protection certification with the second IP numeral being 7 or 8 shall not be accepted in replacement of IP56 or IP66, unless it has a double certification (examples: IPX6 / IPX7 and IPX6 / IPX8, where X represents the first digit of the IP rating).

6.5.2 All equipment and instruments to be installed below the damage line, at places such as ballast pump rooms, tunnels, and trunks, shall have ingress protection rating as specified on the following sub-items:
6.5.2.1 Doubly classified as at least IP66 / IP67, i.e. they shall be tested for IP66 AND IP67.

**Note:** An enclosure that has only one (1) IP rating with the second numeral 7 or 8 cannot be considered suitable for exposure to water jets, as recommended by IEC 60529. In order for the instrument to be suitable for both water jets and (both IPX6 / IPX7 and IPX6 / IPX8, where X stands for the first digit of the IP rating).

6.5.2.1.1 When installed inside the tanks they shall be IP68 certified and be resistant to at least 4 meters of water column.

6.5.2.1.2 Display instruments such as ballast/sewage valve position indicators, position indicators for waterproof doors and hatches, position indicators for seawater tank valves, overboard valves, vent dampers and solenoid valves, installed inside or outside of tanks, shall meet IP66 / IP68 ingress protection requirements and be specified to withstand a minimum pressure equivalent to 4 meters of water column.

6.5.3 Cable glands, junction boxes, passage boxes and accessories used for the above applications shall meet the aforementioned ingress protection requirements.

6.5.3.1 All cable glands used in classified areas and in non-sheltered areas shall be specified in order to reduce the effects of the cold-flow characteristic of the cables in accordance with IEC 60079-14, regardless of cable and multicable characteristics.

6.6 **Materials**

6.6.1 The material of cable glands shall be AISI 316 stainless steel.

6.6.2 Boxes or enclosures of field electronic instruments shall be made of ASTM A351 Gr. CF8M stainless steel.

6.6.3 Protective measures shall be provided to avoid direct contact between metals where galvanic corrosion is expected. Painting alone is not considered a sufficient protective measure to avoid direct contact between the metals.

6.6.4 Paint specifications shall follow the color coding requirements of I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING (HOLD).

6.7 **Protection types for classified areas, unclassified areas and unsheltered areas or areas subject to weather conditions**

6.7.1 All electrical / electronic instruments and equipment located in classified areas shall comply and be installed in accordance with IEC-60079 and IEC-61892-7.

6.7.2 All instruments that operate with electric power (transmitters, analyzers, switches, valve positioners and solenoids, fire detectors, gas detectors, beam detectors of gas detectors, manual call points - MCPs etc.) shall be certified to
operate in Zone 1, as required by IEC-61892-7 (item 5.5 of 2014), regardless of the installation location.

6.7.3 The type of protection to be used is Ex db IIA T3. The cases where another type of protection is acceptable are:
   a) Manual call points, MCP;
   b) Instruments installed in Zone 0 (zero) shall have Ex ia IIA T3 certification.
   c) For analyzers, where the only available technology is of the pressurized type, an air reservoir, adjacent and exclusive to the analyzer, shall be provided. It shall allow for a minimum autonomy equal to the operating time of the CSS equipment defined in I-ET-3010.00-5520-861-P4X-001 - CONTROL AND SAFETY SYSTEM - CSS. If the protection type used is for Zone 1, Ex pX, all circuits (DC power, AC power, discrete signal, analog signal etc.) shall pass through the disconnecting device (HOLD).

[INTERDISCIPLINARY INTERFACE] [PRO, MEC, SEG]

NOTE: Any other type of protection shall be submitted to PETROBRAS for evaluation.

6.7.3.1 The respective junction boxes shall also be certified for work in Zone 1 and have an ingress protection rating of at least IP 56.

6.7.4 INMETRO "Certificates of Compliance" to prove compliance with the area classification shall be provided during the technical assessment phase, in accordance with INMETRO Portaria 179 and its amendments, or that which is in force. Technical proposals without this documentation shall not be considered.

6.8 Electrical and electronic characteristics, connections and general installation requirements

6.8.1 All process connections shall have an isolation valve (root valve), double-blocking with drain/vent, according to the technical specification document of the project entitled PIPING SPECIFICATION. Requirement not applicable for temperature measurement.

6.8.1.1 Means shall be provided to depressurize and drain the gap between the isolation valve (root valve) and the instrument. In measurements using impulse lines, this shall be done by using 5-way manifold blocks when the measurement uses 2 impulse intakes and 3-way manifold blocks where the measurement uses 1 impulse intake. In measurements using diaphragm seal, this shall be done by using a flushing ring as defined in item 6.8.8.

6.8.2 Ball valves, whether or not with diameters of less than 2 inches, shall have a bolted and non-threaded body.

6.8.3 Instruments shall not be mounted on handrails and shall not be subjected to vibration beyond the limits specified for the instrument.
6.8.4 Instruments and accessories shall not be installed under the influence of heated surfaces.

6.8.5 Instruments, other than manometers, thermometers, level displays, temperature transmitters and in-line instruments, shall be installed on dedicated support. The brackets shall be located so as not to transmit a vibration level exceeding that specified for the instrument and its electrical, utility, or process connections.

6.8.6 The length of capillaries on remote seals shall be kept close to a minimum in order to minimize response time. To determine this minimum length, the routing shall be planned prior to the capillary connection at the factory. [INTERDISCIPLINARY INTERFACE] [MEC, ARR, ARQ, 3D]

6.8.6.1 For differential pressure transmitters with remote seal, for differential pressure or level measurements, the lengths of both capillaries shall be the same.

6.8.6.2 The capillary shall be protected in its entire routing by covered tray, tied every 2.5 m by metal tape coated with polymeric material. The capillary support shall be designed in such a way as to minimize mechanical stresses in the welding of the capillary with its flange.

6.8.7 Instrument flanges shall be specified in 316L stainless steel or other material with corrosion resistance and superior mechanical strength, such as Duplex and Superduplex. When specifying instruments whose flanges are made from materials different from the flanges of pipe specimens, e.g. 316L stainless steel flange on carbon steel tubing, check whether the pressure class of the instrument flange material meets the pressure conditions of design and tubing temperature. Otherwise, material appropriate to piping conditions shall be specified.

6.8.8 For any flanged process connection in which the instrument is connected through a diaphragm seal, a device shall be provided to allow cleaning and reduce flushing ring. This device shall be supplied with vent valve and drain point with drain plug. The material of the flushing ring and aforementioned valves shall be AISI 316 stainless steel or a more noble material suitable to process conditions.

6.8.9 For any flanged process connection in which an impulse line is used, a device (flange adapter) shall be provided to make the transition between the flange of the process connection and the flange of the impulse line. This flange adapter shall be made of AISI 316 stainless steel and cannot be made of AISI 316L stainless steel. Other more noble materials shall be used if required by process conditions.

6.8.9.1 When measuring differential pressure, an arrangement with tubing and 2-valve manifolds shall be provided to allow pressure equalization between the sockets and drain / vent for each outlet. A 2-valve manifold connected to each flushing ring shall be connected to each outlet.
6.8.9.2 When using differential pressure level measurements, an arrangement with tubing and blocking valves shall be provided to allow pressure equalization between the high pressure and the low pressure chambers, as well as drain for low outlet and vent for high outlet. 1 valve shall be connected for equalization of each flushing ring of each outlet, 1 drain valve in the high pressure (lower) outlet and in the vent of the low pressure outlet (upper) plug can be used.

6.8.10 All circuit boards with electrical / electronic components shall be marinized and tropicalized in order to be adequately protected from the atmosphere to which it will be exposed and fungal attack. VENDOR shall explain in its proposal the methods of marinization and tropicalization used and provide the applicable standards and procedures.

6.8.11 All electronic instruments and equipment shall be immune to electromagnetic and radio frequency interference (EMI / RFI). VENDOR shall state the level of immunity, test procedure and standards used.

6.8.12 Figures Figure 1 through Figure 3 illustrate the definitions used in this document regarding process connections.

6.8.12.1 Using impulse lines

![Diagram](image)

A – Connection to Equipment/Piping  
B – Process Connection  
C – Shut-off Valves

Figure 1 - Nomenclature for instrument mounting with impulse lines
6.8.12.2 Using Remote Diaphragm Seal

A – Connection to Equipment/Piping    B – Process Connection    C – Shut-off Valves

Figure 2 - Nomenclature for instrument mounting with remote diaphragm seal

6.8.12.3 Using Direct Assembly

A – Connection to Equipment/Piping    B – Process Connection    C – Shut-off Valves

Figure 3 - Nomenclature for instrument mounting with single body diaphragm seal.
6.8.13 Pneumatic instrument connections shall be at least ¼" NPT (F). Tubing shall be specified according to Table 11.

6.8.13.1 When process dynamics require a faster response, larger diameter connections shall be provided (e.g. compressor anti-surge valves), respecting VENDOR requirements.

6.8.14 Electrical connections shall be ½" NPT (F).

6.8.14.1 Instruments exposed to weather shall not have electrical connections facing upwards in order to reduce the risk of water ingress into the enclosure.

6.8.14.2 Instrument air intakes shall have a ball-type blocking valve associated with a regulating filter, with a double scaled local indicator (kPa and bar) of the outlet gauge pressure, close to the instrument.

6.9 Functionality and Performance

6.9.1 Transmitters, registers, indicators, controllers and converters shall meet, if not individually specified, the following specifications:

a) The total uncertainty of the instrument shall not exceed 0.5%, including process influences (temperature and static pressure) and combined effects of hysteresis and repeatability;

b) The dead band shall not exceed 0.25% of the measuring range;

c) A change in ambient temperature of up to 50ºC shall not affect the output signal by more than 1% of the measuring range.

6.9.2 Electronic transmitters shall have local indication of the output signal, with alphanumeric display, configurable in engineering units, except for fire and gas detectors.

6.9.3 Intelligent transmitters / positioners / converters (4 to 20 mA, associated with the HART protocol, properly approved by HART FOUNDATION) shall be used. These instruments shall have configuration and calibration tools (one portable device per instrument type), as well as software to perform these functions on PC, via multiplexer).

6.9.4 It shall be possible to configure the instrument in such a way that when the process variable exceeds the limits of the calibrated range, the output signal is limited to 4 mA for subrange, and 20 mA for overrange.

6.10 Ergonomics Requirements for Operation and Maintenance

6.10.1 Display shall be installed at 1.50 meters from the floor and reading direction shall be horizontal.

6.10.2 There shall be sufficient work space around instruments to allow for operation, calibration and maintenance [INTERDISCIPLINARY INTERFACE] [MEC, ARR, ARQ, 3D].

6.10.3 Access shall be provided for all blocking valves of process connections. [INTERDISCIPLINARY INTERFACE] [MEC, ARR, ARQ, 3D]
6.10.4 Operation and maintenance access conditions shall be provided for all instruments, valves, analyzers, fire and gas detectors. The determination of instrument locations, supports and ergonomic access shall be determined after ergonomic studies. [INTERDISCIPLINARY INTERFACE] [MEC, ARR, ARQ, TUB, TBM, 3D]

6.10.5 High temperatures and / or influence of heated surfaces shall be avoided.

6.11 Process Switches

6.11.1 All pre-alarm signals shall be generated internally in the controllers (PLC / DCS, etc.) by using field transmitter signals (4 to 20 mA). The use of process switches (thermostats, pressure switches, flow and level switches) shall be avoided and, when necessary, shall be previously approved by PETROBRAS.

6.11.2 Micro-switches driving process switches shall have a single SPDT contact and their movable parts shall be hermetically sealed.

6.11.3 The micro-switch contacts for pre-alarm, alarm and interlock circuits shall be kept closed under normal process conditions.

7 TEMPERATURE INSTRUMENTS SPECIFICATION REQUIREMENTS

7.1 Sensor elements

7.1.1 The rod that holds the sensor element for insertion into thermowells shall be made of AISI 316 stainless steel with a 6 mm (1/4") outer diameter and shall be of the spring loaded type, sized to have full contact with the bottom of the well.

7.1.2 Thermocouples

7.1.2.1 The thermocouple shall be type K, according to IEC 60584 with tolerance class 2.

7.1.3 RTD (Thermo-resistance)

7.1.3.1 RTDs shall be PT100 type of 3 (or 4) wires, in accordance with IEC 60751 with tolerance class A, if not defined in the design. Attention shall be given to the type of RTD, 3 or 4 wires, when specifying display equipment.

7.1.3.2 RTDs shall be specified in accordance with IEC 60751 (equivalent to DIN 43760) with a temperature coefficient of 0.00385Ω/°C. Callendar-Van-Dusen parameters shall be provided for parameterization on the respective transmitter.

7.1.4 Thermometers

7.1.4.1 Mercury or glass bulb thermometers shall not be used.

7.1.4.2 Thermometers shall be of the bimetallic type.
7.1.4.3 Bimetallic angular type thermometers shall not be used.

7.1.4.4 Bimetallic thermometers shall have the following general characteristics:
   i. Display with minimum nominal diameter of 100 mm;
   ii. A ½" NPT (M) connection to the well;
   iii. AISI 304 stainless steel rod with external diameter (ED) of 6 mm.
   iv. Accuracy class 1 according to DIN EN 13190;
   v. The indication range shall be such that the normal operating temperature is between 30 and 70% of this range, and the minimum and maximum temperatures can still be read within the indication range.

7.1.4.5 The scales shall have a white background with black inscriptions. The ranges shall be chosen among the following, in degrees Celsius: 50/50; 0/100; 0/150; 0/200; 0/300; 0/500. Other ranges shall be presented to PETROBRAS for evaluation.

7.1.4.6 Cases shall be hermetically sealed and made of AISI 304 or AISI 316 stainless steel.

7.1.4.7 The thermometers shall have a zero micrometer pointer adjustment.

7.2 Selection Criteria

7.2.1 Bimetallic thermometers or electronic transmitters shall be used for local indication. Bimetallic thermometers shall not be used where there are vibrations or cryogenic applications.

7.2.2 RTD (thermoresistors) or thermocouples shall be used for telemetry and electronic temperature meshes, usually connected via transmitters to PLC input cards.

7.2.3 In case of temperatures sensor with range within -50 to 450°C, RTD shall be used. If the temperature exceeds 500°C, thermocouple shall be used.

7.3 Installation and Process Connections

7.3.1 Protection and Test Wells

7.3.1.1 All temperature sensing elements for fluid measurement shall be installed with protection wells, equipped with integrally mounted sensors and transmitters (see item 7.4.1), or along with the associated thermometer, whichever is the case.

7.3.1.1.1 The internal bore to accommodate the sensor rod (Item 7.1.1) shall be 6.6 mm in diameter.

7.3.1.1.2 The connection to the well shall be done using union and ½” NPT nipples, in the following sequence: NPT-F well, NPT (MxM), NPT (FxM) union, (MxM) nipple and NPT(F) temperature Instrument (sensor / thermometer / transmitter).
7.3.1.2 The stem of the well shall have a tapered profile, and, if it does not meet the vibration and voltage requirements (see item 7.3.1.8), a stepped profile. Straight profiles may only be used if the tapered and stepped types prove to be incompatible with process conditions.

7.3.1.3 The wells shall be machined from a solid AISI 316 stainless steel bar or, where this material is not suitable for process conditions, from a bar of more suitable material.

7.3.1.4 For flanged wells, materials and construction shall respect the following order to maintain compatibility with connection to pipe or equipment: welded to flange with full penetration weld in accordance with API RP 551 and ASME PTC 19.3 TW, the material of flange and the well being AISI 316L stainless steel. When the AISI 316L stainless steel flange is not suitable for process conditions or line specification, the well shall be made from a single AISI 316 stainless steel piece, without any welds. If this is still not suitable for process conditions or piping specification, another material for the flange and body shall be used as required on item 7.3.1.3.

7.3.1.4.1 Weld certificates shall be provided attesting to procedures, qualification of the performer and penetrating liquid testing of the weld in accordance with the technical specification document of the project entitled PIPING SPECIFICATION.

7.3.1.5 Only when process characteristics require materials other than AISI 316 or AISI 316L stainless steel, lap-joint (Van Stone) type wells may be used. Between different materials, insulation joints shall be used.

7.3.1.6 Well material shall be clearly printed on its flange, if any. In threaded wells, the well material shall be printed on the body.

7.3.1.7 The tip of the protection well shall be inserted in the pipeline as per Table 4.

<table>
<thead>
<tr>
<th>ND of Pipe</th>
<th>Immersion Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>4” to 10”</td>
<td>1/3 to 1/2 of the ID</td>
</tr>
<tr>
<td>greater than 10”</td>
<td>1/4 to 1/3 of the ID</td>
</tr>
</tbody>
</table>

7.3.1.8 The wells shall comply with the requirements established in ASME PTC 19.3 TW, last revision and possible errata, and shall ensure suitability throughout the operational range.

7.3.1.8.1 When the fluid velocity profile is not fully developed at the well installation site, a computational analysis of fluid dynamics shall be carried out to determine the velocity profile at the point of installation.

7.3.1.8.2 When the well is not covered by ASME PTC 19.3 TW, a finite element analysis shall be performed for the proposed well as mentioned in API RP 551.
7.3.1.9 The use of a flange collar is not acceptable.

**Note:** A perfect contact between the collar and the support point on the neck where the well is inserted cannot be guaranteed. This way, the collar does not immobilize the well, which changes the unsupported length, invalidating the vibration calculations, besides constituting a point of fatigue for the well.

7.3.1.10 For temperature measurement after mixing of fluids the wells shall be installed 10 nominal diameters downstream of the liquid mixing point and 25 nominal diameters downstream of the gas mixing point. Smaller distances may be used provided that temperature stabilization is verified through computational simulations. In this case, a simulation analysis report shall also be submitted to PETROBRAS.

7.3.1.11 Thermowell connection to equipment such as vessels, towers and tanks shall be flanged, in the same pressure class as the equipment in which the well is to be installed and shall have the following diameters:

**[INTERDISCIPLINARY INTERFACE] [PRO, MEC]**

i. 1 1/2", for connection to equipment with schedule up to 160 and flange pressure class up to 600 #;

ii. 2", for connection to equipment with schedule greater than 160 or flange pressure class greater than 600 #;

iii. 2", when no 1 1/2" pipe diameter is provided for the respective line specification in the technical specification document of the project entitled PIPING SPECIFICATION;

iv. 3", for vessels with inner coating.

7.3.1.12 Stand-pipe installation is not permitted. **[INTERDISCIPLINARY INTERFACE] [PRO, MEC]**

7.3.1.13 In vessels, tanks and towers the immersion length shall be as per Table 5. **[INTERDISCIPLINARY INTERFACE] [MEC]**

<table>
<thead>
<tr>
<th>Diameter of Vessel or Tower</th>
<th>Immersion Length</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any diameter</td>
<td>300 mm</td>
<td>Liquids</td>
</tr>
<tr>
<td>&lt; 800 mm</td>
<td>200 mm</td>
<td>Gases</td>
</tr>
<tr>
<td>≥ 800 mm &amp; &lt; 1 200 mm</td>
<td>300 mm</td>
<td>Gases</td>
</tr>
<tr>
<td>≥1 200 mm</td>
<td>400 mm</td>
<td>Gases</td>
</tr>
</tbody>
</table>

**NOTE:** In the case of vessels with small diameters, the immersion length shown in the Table 5 shall be reduced so as not to exceed one-half of the inner diameter of the vessel.

7.3.1.14 Minimum sizes for thermowell connection to pipelines are presented in the technical specification document of the project entitled PIPING SPECIFICATION. These sizes can be increased after well design, especially in extreme cases, such as high flow rates and XXS schedules. In
order to avoid the well from bumping into the pipe interior, due to its vibrations and also the uncertainties inherent in the pipe connection, the following formula shall be obeyed: [INTERDISCIPLINARY INTERFACE] [PRO, TUB]

\[
\Phi_{\text{Root well}} + U_{\Phi_{\text{Root well}}} \leq 2 \times \left\{ \frac{(D_{\text{IC}} - U_{D_{\text{IC}}})}{2} - G \right\} - \tan 0.5\theta \times \left[ D_{\text{FTC}} + (E_{T} + U_{E_{T}}) \right] - 1/16
\]

Where

\( \Phi_{\text{Root well}} \) : Nominal diameter of thermowell’s root, on flange side;

\( U_{\Phi_{\text{Root well}}} \) : Positive uncertainty on thermowell’s root diameter, on flange side;

\( D_{\text{IC}} \) : Internal diameter of the connection to pipe;

\( U_{D_{\text{IC}}} \) : Absolute value of the negative uncertainty of the internal diameter of the connection to pipe;

\( G \) : Safety margin. Distance between well and pipe wall at the beginning of the inside diameter of the pipe. Use 6mm;

\( D_{\text{FTC}} \) : Standard distance from the top of the flange of the pipe connection to the outer wall of the pipe. For the values to be used, see project’s technical specification document entitled PIPING SPECIFICATION;

\( E_{T} \) : Process pipe’s wall thickness;

\( U_{E_{T}} \) : Positive uncertainty in the thickness of Process pipe’s wall.
7.3.1.15 For lines and vessels with thermal insulation, the connection to the equipment / piping shall be flanged and shall be of a length necessary for the flange to be external to insulation and so that the union required in item 7.3.1.12 is external to the thermal insulation. [INTERDISCIPLINARY INTERFACE] [MEC, TUB]

7.3.1.16 On lines and vessels with thermal insulation an appropriate extension shall be provided to reduce the temperature of the reading instrument (transmitter) or sensor head to values that meeting the instrument and legislation requirements.

7.4 Transmitters

7.4.1 Transmitters and sensing elements shall be integrally mounted, forming a single body, with 4-20 mA signal transmission + HART with 2 (two) wires with the mesh fed by the reading device.

7.4.1.1 When it is confirmed that the transmitter location will expose it to excessive vibration or temperatures outside the operational range or the ergonomics study indicates that the measuring point has poor access, the sensor part shall be decoupled from the transmitter, installed in the well with the use of a sensor head with passive terminal blocks and interconnected to the transmitter. Support shall be provided for the transmitter and routing shall be provided for the cables. The final assembly shall conform to Ex and IP classification as defined in this technical specification.
7.4.2 Temperature transmitters shall have:

7.4.2.1 Configurable reading range;
7.4.2.2 The ability to read RTDs, thermocouples etc., through configuration;
7.4.2.3 Cold junction compensation (CJC);
7.4.2.4 Full input-output galvanic isolation;
7.4.2.5 Automatic detection of thermocouple input fault (burnout) with configurable fault indication for subrange or overrange;
7.4.2.6 Linearity of the output signal by means of a table and also by the Callendar-van-Dusen coefficients;
7.4.2.7 Dual compartment housing and electrical connections forming a 90° angle between them (one to the side and one to the bottom).

8 PRESSURE INSTRUMENTS SPECIFICATION REQUIREMENTS

8.1 Selection Criteria

8.1.1 Bellows or diaphragm type sensors shall be used for very low pressure or vacuum.
8.1.2 To measure very high pressures, strain-gage sensors can be used.
8.1.3 Electronic pressure transmitters and differential pressure transmitters shall be of the capacitive type, resonant silicon or piezo resistive. They shall be equipped with drain in each chamber.
8.1.4 The selection of the pressure instrument range shall take into account an occasional overpressure of the system and shall be capable of standing, instantly, at least 1.3 times the maximum pressure of the selected work range.
8.1.5 The working range of the pressure instruments shall be chosen so that the maximum value is 75% of the range and the minimum is 15% of the range.
8.1.6 Pressure instruments and differential pressure instruments in the service of crude oil, produced water, fouling fluids, corrosive fluids or toxic fluids shall be installed with a diaphragm seal.

8.2 Manometers

8.2.1 Shall conform to ASME B40.100.
8.2.2 Manometers with bourdon type sensors shall be used.
8.2.3 The manometer shall have a nominal diameter of 114 mm or 100 mm. Other diameters will need prior approval from PETROBRAS.
8.2.4 The color of the manometer display shall be white and the numbers and characters shall be black.

8.2.5 Casing material shall be thermoset phenolic polymer. This material can be modified if required by environmental or process conditions.

8.2.6 Casing display shall be of laminated safety glass with at least 75% transparency.

8.2.7 The manometer housing assembly shall be glycerin filled, with a solid front and with a rupture disc at the rear part.

8.2.7.1 Item 8.2.7 does not apply to pressure gauges used for reading pneumatic signals, such as 3 to 15 psi. Currently, this type of instrument finds little application. Example of use: pressure indicator on control valve positioners.

8.2.8 The material of the components of the moving mechanism of the manometer pointer shall be AISI 304 or AISI 316 stainless steel.

8.2.9 The material of the manometer connection socket shall be the same as the AISI 316 stainless steel sensor element, unless the process fluid requires a more suitable and resistant material.

8.2.10 Manometers with electrical contacts shall not be used and neither shall pointers indicating maximum pressure.

8.2.11 The manometer shall have double scale indication in kPa and bar.

8.2.12 The scales of the differential pressure gauges shall be of the direct reading type.

8.2.13 The operating range shall be between 1/4 and 3/4 of the nominal range and the accuracy class shall be ± 1,0% (full scale), or better, along the whole nominal range.

8.2.14 Pressure gauges shall be adequate for operating with working pressure equal to the upper limit of the nominal range.

8.2.15 Manometers shall not be specified for the types of assembly not accepted in item 8.5.8.

8.3 Transmitters

8.3.1 All differential pressure transmitters shall have both high and low pressure taps ("H" and "L" respectively) clearly and visibly indicated on their bodies. These transmitters shall be connected to the impulse lines through 5-way manifold blocks.

8.3.1.1 The blocking, equalizing and drainage valves of the manifold blocks shall be of the needle type and the obturator shall be non-rotating stem tip, i.e. the obturator is not integral with the rod.
8.3.1.2 Plugs shall be provided in the pressure class of the manifold in the drain and vent.

8.3.2 The accuracy class shall be ± 0.5 FS (full scale), or better.

8.4 Pressure Switches

8.4.1 Pressure switches cannot be used in pulsed flow services. For these cases, a pressure transmitter shall be used. [INTERDISCIPLINARY INTERFACE] [PRO]

8.4.2 The point of actuation of the pressure switch shall be within the second third of the operational range covered by the instrument.

8.4.3 The pressure switches shall be equipped with adjustment of the actuation point. This adjustment shall be weather protected, having no contact with the external atmosphere, except when the adjustment is performed.

8.5 Installation and Process Connection of Pressure Instruments

8.5.1 For differential pressure measurements, also refer to item 6.9.1.

8.5.2 Table 6 presents the connections of Pressure Instruments to Vessels and Towers. [INTERDISCIPLINARY INTERFACE] [PRO, MEC, 3D]

Table 6 – Connection Table of Pressure Instruments to Vessels and Towers

<table>
<thead>
<tr>
<th>INSTRUMENT TYPE</th>
<th>PROCESS CONNECTION &amp; PROCESS TAPPING (Notes 1, 2)</th>
<th>IMPULSE TAPPING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manometer Indicator</td>
<td>2&quot;</td>
<td>1/2&quot; NPT (F)</td>
</tr>
<tr>
<td>Manometer Indicator with sealing</td>
<td>2&quot;</td>
<td>Capillary factory sealing.</td>
</tr>
<tr>
<td>Differential Pressure Gauge</td>
<td>2&quot;</td>
<td>1/2&quot; NPT (F)</td>
</tr>
<tr>
<td>Differential Pressure Gauge With Sealing</td>
<td>2&quot;</td>
<td>Capillary factory sealing.</td>
</tr>
<tr>
<td>Pressure Transmitters or Differential Pressure Transmitters without diaphragm seal</td>
<td>2&quot;</td>
<td>3/4&quot; NPT (F)</td>
</tr>
<tr>
<td>Pressure or Differential Pressure Transmitters with remote or attached to the transmitter diaphragm seal</td>
<td>3&quot;</td>
<td>Capillary factory sealing.</td>
</tr>
<tr>
<td>Pressure Switch</td>
<td>2&quot;</td>
<td>1/2&quot; NPT (F)</td>
</tr>
</tbody>
</table>

Notes:

(1) For vessels with internal coating or when, due to the working pressure, the internal diameter of the process connection is less than 50 mm, the connections and sockets shall be 3".

(2) All process connections to pressure vessels shall be flanged and minimally specified for the pressure class of 150 #.

8.5.3 For piping, piping connection and process connections the requirements presented in the technical specification document of the project entitled PIPING SPECIFICATION shall be followed.
8.5.4 When measuring liquids, impulse lines shall have a downward slope of 1:10 from the impulse tap up to the manifold block of the instrument.

8.5.5 When measuring gas, the impulse lines shall have a rising slope of 1:10 from the impulse tap up to the manifold block of the instrument.

8.5.6 When measuring water vapor, the design of the impulse lines depends on the relative position of the instrument for the impulse tap:

8.5.6.1 It shall have a downward slope of 1:10 from the impulse tap to the manifold block of the instrument when the transmitter is installed below the impulse tap.

8.5.6.2 It shall have an upward slope of 1:10 from the impulse tap to the manifold block of the instrument when the transmitter is installed above the impulse tap with a horizontal syphon (coil syphon).

8.5.7 The material of the parts in contact with the fluid shall be AISI 316 stainless steel, unless the process fluid requires a more suitable and resistant material.

8.5.8 The following pressure gauge assemblies shall not be accepted: bottom connection for panel mounting with holes for fastening and surface mounting with concentric or eccentric rear connection.

9 LEVEL INSTRUMENTS SPECIFICATION REQUIREMENTS

9.1 Level Gauges

9.1.1 Reflective type level gauges shall be used in applications with transparent, clean fluids with melting points below ambient temperature. For high pressure services (above the limit of application of glass displays), vacuum and oil level, magnetic type displays shall be used. For liquid interface monitoring service, level displays of the transparent type with illumination shall be used. For services high pressure and vacuum services, refer to item 9.1.8.

9.1.2 Level gauges shall be of the top-bottom connections type, allowing adjustment of the visual field by turning the display. [INTERDISCIPLINARY INTERFACE] [MEC, 3D]

9.1.3 The lines between the process connection to the vessel and the level display may not form pockets. [INTERDISCIPLINARY INTERFACE] [MEC, TUB, 3D]

9.1.4 Reflective or transparent glass level gauges shall only use glass sections of dimensions 7, 8 or 9 with a maximum height limited to 5 (five) units of size 9 (nine).

9.1.5 The level gauge of any type in each of its process connections shall be fitted with an angular-type ball valve (off-set) to stop a leak if the display is broken.

9.1.6 Level gauges shall have drain / vent valves with ¾" NPT connections to the gauge to allow cleaning of the display during operation.
9.1.7 Installation of level gauges shall always have two ball-type blocking valves.

9.1.8 The magnetic type gauges shall have flag-type indicators and a hermetically sealed measuring tube in AISI 316 stainless steel. Where this material is not suitable for process conditions, other more suitable material shall be used.

9.1.8.1 The enclosure of the flags shall not have contact with the process.

9.1.9 The demagnetizing temperature (Curie temperature) of the magnetic type gauge buoy shall be greater than the upper design temperature of the process fluid by at least 20°C.

9.2 Level Transmitters

9.2.1 Selection by technology and respective assembly constraints

9.2.2 The effectiveness of each technology is intrinsically linked to assembly aspects for operation, maintenance and calibration assurance. To do so, specifications listed on Table 7 shall be followed.

9.2.2.1 Selection between Differential and Capacitive Pressure technologies for vessel water / oil interface services:

Differential pressure: when the specific mass difference between water and oil in the operating conditions is greater than or equal to 100 kg / m³ and when there is no expected variation in density of the fluids involved. It can be implemented through differential pressure cells, in sockets in the body of the standpipe, or device type densimeter, mounted at the top of the standpipe.

Capacitive: when the conditions for use of differential pressure gauges are not met. Mounted on top of standpipe.

9.2.2.2 For water / oil interface services in vessels or tanks, where the project requires greater detail and accuracy in the determination of the internal fluids to the equipment:

- Device of the nucleonic type, which employs the principle of gamma ray absorption, and which guarantees the free area outside the vessel, according to the CNEN Regulatory Standard 3.01 / 004: 2011. Mounted internally.

[INTERFACE INTERDISCIPLINAR] [PRO, MEC, 3D]

9.2.3 The parts of level transmitters that may be exposed to process fluids shall be AISI 316 stainless steel. Where this material is not suitable for process conditions, other more suitable material shall be used.
Table 7 - Selection of Technologies for level transmitters linked to the use of Standpipes (SP) and Hot Tap and Extraction Tool (HT).

<table>
<thead>
<tr>
<th>Technology</th>
<th>Differential Pressure</th>
<th>Radar</th>
<th>Ultrasonic</th>
<th>Capacitive</th>
<th>Wave Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of Liquid (a)</td>
<td>Mandatory: SP</td>
<td></td>
<td></td>
<td>Forbidden</td>
<td>Mandatory: HT</td>
</tr>
<tr>
<td>in case of disturbances that cause level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>variations within the vessel.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only Free Wave</td>
<td></td>
<td></td>
<td></td>
<td>Forbidden</td>
<td>Mandatory: HT</td>
</tr>
<tr>
<td>Conical or Matrix Antenna Type.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parabolic aerial or guided wave are prohibited.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forbidden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandatory: SP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandatory: HT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water - Oil Interface (b)</strong></td>
<td>Mandatory: SP</td>
<td></td>
<td>Forbidden</td>
<td>Forbidden</td>
<td>Mandatory: HT</td>
</tr>
<tr>
<td>Mandatory: SP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Non-structural Tanks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of Liquid (c)</td>
<td>Mandatory: SP</td>
<td></td>
<td>Forbidden</td>
<td>Analyzed upon request</td>
<td>Acceptable (observe tank geometry)</td>
</tr>
<tr>
<td>in case of disturbances that cause level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>variations within the vessel.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyzed upon request</td>
<td></td>
<td></td>
<td></td>
<td>Analyzed upon request</td>
<td>Accepted (observe tank geometry)</td>
</tr>
<tr>
<td>High sensitivity type only (Ceramic)</td>
<td></td>
<td></td>
<td></td>
<td>Analyzed upon request</td>
<td>Accepted (observe tank geometry)</td>
</tr>
<tr>
<td><strong>Service</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Cargo Tank (e)</td>
<td>Forbidden</td>
<td></td>
<td>Acceptable</td>
<td>Forbidden</td>
<td>Forbidden</td>
</tr>
<tr>
<td>Ballast Tank (water only) (f)</td>
<td>Submerged type only</td>
<td></td>
<td>Acceptable</td>
<td>Forbidden</td>
<td>Forbidden</td>
</tr>
<tr>
<td>Void Space (g)</td>
<td>High sensitivity type</td>
<td></td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Forbidden</td>
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<tr>
<td>Structural Tanks</td>
<td></td>
<td></td>
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<tr>
<td>Other Tanks Level of Liquid (h)</td>
<td>Analyzed upon request</td>
<td></td>
<td></td>
<td>Acceptable</td>
<td>Analyzed upon request</td>
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<tr>
<td>(submerged type is prohibited for hazardous or</td>
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<td>flammable fluids)</td>
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<tr>
<td>Acceptable</td>
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<td></td>
<td>Acceptable</td>
<td>Analyzed upon request</td>
</tr>
<tr>
<td><strong>Other Tanks and Water - Oil Interface (i)</strong></td>
<td>Forbidden</td>
<td></td>
<td>Analyzed upon request</td>
<td>Forbidden</td>
<td>Analyzed upon request</td>
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<tr>
<td>9.3 Installing</td>
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<tr>
<td>9.3.1 For differential pressure level</td>
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<tr>
<td>measurements on crude oil, produced water,</td>
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<td>fouling fluids, corrosive fluids or toxic</td>
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<td>fluids, a diaphragm seal shall be used and</td>
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<td>item 6.8.9.2 shall also be followed.</td>
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<td>9.3.2 For level application the installation</td>
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<td>design of the instruments listed below shall</td>
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<td>ensure the feasibility of removal of the</td>
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<td>instrument without the need to interrupt</td>
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<td>the operation of the vessel / tank /</td>
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<tr>
<td>equipment:</td>
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<td></td>
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<tr>
<td>- Differential pressure;</td>
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<tr>
<td>- Radar (for cargo tanks monitoring only);</td>
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<tr>
<td>- Ultrasonic (for bilge systems);</td>
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<tr>
<td>- Capacitive. (HOLD)</td>
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</tbody>
</table>
9.3.3 Use of standpipe is mandatory in the following cases:

9.3.3.1 Instruments used for process control shall have a level gauge installed in the same standpipe to reduce the number of nozzles in the equipment. [INTERDISCIPLINARY INTERFACE] [PRO, MEC]

9.3.3.2 Applications requiring multiple level displays to cover the required range require a minimum overlap of 50 mm in the measuring range.

9.3.3.3 To ensure the feasibility of removing the instrument without the need to interrupt the operation of the vessel / tank / equipment. [INTERDISCIPLINARY INTERFACE] [PRO, MEC]
   i. Radar (for monitoring of cargo tanks only);
   ii. Displacer;
   iii. Capacitive.

9.3.4 The installation of level instruments shall be made in such a way as to mitigate the influence of inclinations of the UNIT. [INTERDISCIPLINARY INTERFACE] [ARR]

9.3.4.1 The lower process connection nozzle for transmitters shall be positioned 200 mm below the minimum value of the range of interest to ensure that the instrument is sensitized throughout the measuring range. [INTERDISCIPLINARY INTERFACE] [MEC]

9.3.5 The heights of the nozzles for installation of the process connections of instruments dedicated to the process level control loops and to interlocking loops shall always be at the same elevation. [INTERDISCIPLINARY INTERFACE] [MEC]

9.3.5.1 Nozzles for level gauges shall be such that their range contains the range of their respective transmitters, i.e. the upper nozzle shall be at a level above the nozzle of the transmitters and the lower nozzle shall be at a position below the nozzles of the transmitters. The nozzles of level gauges shall be located so as to ensure that the level display spans the range from the lower dimension of the lower nozzle of the transmitters and the upper dimension of the upper nozzle of the transmitters. [INTERDISCIPLINARY INTERFACE] [MEC, PRO]

9.3.6 Level instruments shall always be connected to standpipe or equipment (vessel, tank, tower, etc.) and never connected to flow lines, drain lines or vent lines. [INTERDISCIPLINARY INTERFACE] [MEC, PRO]

9.3.7 When placing connections on the lower spherical caps of vases and towers or tank bottoms, they shall never start from the lowest point and shall penetrate the vessel 100 mm to avoid ingress of debris into the instrument. [INTERDISCIPLINARY INTERFACE] [MEC]

9.3.8 The interface instrument stands shall have at least 3 outlets, one lower, one upper and the third in the center of the strip where the phases are supposed to form an emulsion. Other entries shall be used in this emulsion range to ensure
that the distance between them does not exceed 500 mm. Never nest standpipes in series. [INTERDISCIPLINARY INTERFACE] [MEC]

9.3.9 The instrumentation installed in the standpipes shall be mounted at the top, except for the differential pressure device with independent cells. In this case, blind flange shall be provided at the top of the standpipe, in diameter as per Table 8, in order to allow future top installations. [INTERDISCIPLINARY INTERFACE] [MEC]

9.3.10 Resources shall be used to maintain the process temperature within the standpipes. The use of electric heating is recommended. [INTERDISCIPLINARY INTERFACE] [MEC, ELE, PRO]

9.3.11 Standpipes shall have facilities for bottom drainage and gas purging at the top.

9.3.12 Separator vessels shall have a 6” nozzle at the top and 3 nozzles of 3” at the side (one below and one above the emulsion layer, and one at the bottom side for insertion of the rod into the emulsion layer) on the side of the separation chamber, close to the spillway, in order to allow future installations of internal instruments. [INTERDISCIPLINARY INTERFACE] [PRO, MEC]

9.4 Connection of Level Instruments Table

Table 8- Connection of Level Instruments Table

<table>
<thead>
<tr>
<th>INSTRUMENT / ACCESSORIES</th>
<th>PROCESS CONNECTION &amp; PROCESS TAP (Notes 1, 2)</th>
<th>IMPULSE TAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level Gauges</td>
<td>2”</td>
<td>½” NPT (F)</td>
</tr>
<tr>
<td>Level Transmitters mounted on standpipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential Pressure Transmitters (DP) Connected to Process</td>
<td>2”</td>
<td>½” NPT (F)</td>
</tr>
<tr>
<td>Differential Pressure Transmitters (DP) with remote diaphragm seal</td>
<td>3”</td>
<td>Capillary factory seal</td>
</tr>
<tr>
<td>Level Indicator (with external scale)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel Top Level Transmitter (future)</td>
<td>6”</td>
<td></td>
</tr>
<tr>
<td>Standpipe</td>
<td>4”</td>
<td></td>
</tr>
<tr>
<td>Pressure Switches</td>
<td>2”</td>
<td>½” NPT (F)</td>
</tr>
</tbody>
</table>

Notes:

(1) For vessels and tanks with internal coatings or when the internal diameter of the process plug is less than 50 mm due to working pressure, the connections and sockets defined as 2” shall be increased to 3”.

(2) All connections to the pressure vessel process shall be flanged and minimally specified for the pressure class of 150 #.
10 REQUIREMENTS FOR GAS AND FLAME DETECTORS

10.1 Flame Detectors

10.1.1 Installation

10.1.1.1 In order to avoid spurious actions with the flare, the flame detectors shall be installed with their line of sight pointed down, at an angle to the horizontal. The angle to the horizontal shall be determined following the recommendations of the MANUFACTURER in conjunction with the location studies made in 3D models where the position and size of the flare of the flare shall be modeled and the detector viewing cone cannot pick up the flare of the flare. [INTERDISCIPLINARY INTERFACE] [SEG, 3D]

10.1.1.2 Weather protection shall be provided for all open area detectors.

10.1.2 Calibration and testing facilities

10.1.2.1 A calibration kit, one per detector type, shall be provided in order to stimulate the detector at the distances established by the MANUFACTURER.

10.2 Gas Detectors

10.2.1 Installation

10.2.1.1 A hydrophobic filter shall be provided for any sensor installed in an open area to protect against bad weather.

10.2.2 Gas Detector Cell Life

10.2.2.1 In order to maximize the useful life of the sensor cells, the date of delivery by the VENDOR shall be made at a later date than the respective transmitters, being three (3) months before the unit for final rental.

10.2.2.2 In order to perform the loop tests, an additional number of sensors equal to 5% of the number of detectors shall also be delivered after the transmitters but before the period described in 10.2.2.1.

10.2.2.3 The delivery period of the sensors shall be described in the technical reports to enable programming by the Commissioning team the date to start supplying the sensors (HOLD).

10.2.3 Calibration and testing facilities

10.2.3.1 A calibration kit shall be provided, one per detector type.

10.2.3.2 A sufficient number of bottles with standard gas, shall be provided per type of gas sensor, for calibration of each detector at least two (2) times.
11 REQUIREMENTS FOR THE SPECIFICATION OF FLOW INSTRUMENTS AND RESTRICTION ORIFICES

Instruments that shall comply with the INMETRO metrological framework and official regulations (ANP) shall also meet the requirements described in the technical specification document of the project entitled FLOW METERING SYSTEM.

11.1 General Criteria

11.1.1 For instruments that do not need to comply with the FLOW METERING SYSTEM technical specification and when totalization is specified, the flow signal shall be transmitted in one of the following ways, where compatibility with the reading equipment shall be checked in advance:

i) pulses up to 10kHz;
ii) totalized in the instrument transmitter itself and transmitted via non-proprietary field network.

11.1.2 Every meter shall have a shut-off valve and drain / vent valve, upstream and downstream, for maintenance purposes. Follow FLOW METERING SYSTEM technical specification with regard to the locking valve on fiscal measurements, appropriation and transfer of custody.

11.1.2.1 Each meter with an operational purpose shall have, in addition to the locking valves mentioned in item 11.1.2, by-pass valves. This requirement does not apply to fiscal measurements, appropriation and custody transfer as defined by the ANP. [INTERDISCIPLINARY INTERFACE] [PRO, TUB, 3D]

11.1.3 In the installation of turbines, positive displacement meters and Coriolis type mass meters, the piping arrangement and the installation location of the meter shall be designed to avoid vaporization of fluids there through. [INTERDISCIPLINARY INTERFACE] [PRO, TUB, 3D]

11.1.4 The maximum speed to which it can be subjected, and not only the meter itself, e.g. gas filters, which generally have a maximum velocity of 20 m/s, shall be observed for all components. The design of the lines shall maintain these limits and the necessary diameters shall be fed back to the design of the instruments and accessories. [INTERDISCIPLINARY INTERFACE] [PRO, TUB, 3D]

11.2 Restriction Orifices

11.2.1 Application

Used whenever it is necessary to obtain a permanent pressure drop in a straight section of the pipe, or when a restriction is desired for a flow. Examples: Flow limitation in on-off control of condensate in vessels, limitation of gas flow when loss of gas blow-by control and flow limitation in BDVs.
11.2.2 Materials and Constructive Details

11.2.2.1 Restriction orifices shall be made of AISI 316 stainless steel. Where this material is not suitable for process conditions, other more suitable material shall be used.

11.2.2.2 For fluids with subcritical flow, the manufacturing dimensions and tolerances shall be in accordance with ISO 5167. For critical flow a calculation report and a dimensional drawing shall be submitted for analysis by PETROBRAS, according to Annexes A and B.

11.2.3 Installation

11.2.3.1 Restriction orifices shall be installed between flanges, pressure class 150 # minimum.

11.2.4 Calculation of Restriction Orifices

11.2.4.1 For subcritical flow the calculation of restriction orifices shall be in accordance with ISO 5167, taking into account the permanent pressure drop for straight edge bore with 2 ½ D and 8 D pipe (pipe taps).

11.2.4.2 For critical flow a calculation report shall be presented for PETROBRAS analysis, according to annexes A and B. As an example of application, restriction orifices associated with BDVs can be considered.

11.2.4.3 For vessel on-off level control the time of emptying of the liquid is determined by the restriction orifice. In the event of a failure in the control, opening XV, gas migration will occur through the restriction orifice (gas blow by) with a flow being a consequence of the same dimensioning. The Process discipline shall determine the time of emptying as well as the design of the protection devices downstream of the restriction orifice in the blow by gas condition. [INTERDISCIPLINARY INTERFACE] [PRO, TUB, 3D]

11.2.4.4 For vessel-level regulatory control, the calculation of the control valve and the restriction orifice shall be done in an iterative manner. First, the valve for liquid level control is calculated, without considering the orifice. Then the orifice is calculated to restrict the gas flow in a blow by gas condition, considering total opening of the control valve. The valve is then recalculated to the liquid level control condition, this time considering the orifice calculated in the previous step. Orifice and control valve calculations are performed until their respective parameters converge. [INTERDISCIPLINARY INTERFACE] [PRO, TUB, 3D]
11.3 Coriolis Mass Flowmeters and Volumetric Flow Meters of Positive Displacement (PD) Type

11.3.1 Application Criteria

11.3.1.1 A set of meters (parallel installation) shall be specified whenever a single meter cannot cover the entire flow range. [INTERDISCIPLINARY INTERFACE] [PRO, TUB]

11.3.1.2 Where there is vibration in the process line or pulsating flow, mass-type meters (Coriolis) shall be avoided. For the case of line vibration, item 11.3.3.4 can be used as an alternative. [INTERDISCIPLINARY INTERFACE] [PRO]

11.3.2 Materials, Accessories and Construction Details

11.3.2.1 The parts of the meters that have contact with process fluid shall be made of AISI 316 stainless steel. Where this material is not suitable for process conditions, other more suitable material shall be used.

11.3.2.2 Positive displacement (PD) type meters shall be equipped with drain and vent valves or plugs, as well as upstream filters.

11.3.3 Installation

11.3.3.1 Where there is a significant presence of gases or vapors in the fluid, a gas elimination device shall be installed upstream of the meter to ensure continuous immersion of liquids in the meter in operation. [INTERDISCIPLINARY INTERFACE] [PRO, TUB, 3D]

11.3.3.2 For positive displacement type meters, when the flow rate can reach values greater than the maximum flow rate of the meter, the flow measurement shall be made through a setpoint flow control loop at the maximum flow rate of the meter, in order to protect it. [INTERDISCIPLINARY INTERFACE] [PRO]

11.3.3.3 See item 11.1.3.

11.3.3.4 As an alternative to the vibration problem in the line mentioned in item 11.3.1.2, expansion joints upstream and downstream of Coriolis meters shall be installed. [INTERDISCIPLINARY INTERFACE] [TUB, PRO]

11.4 Turbine Type Meters

11.4.1 Application Criteria

11.4.1.1 Turbine-type flow meters shall have their measurement uncertainty of up to 0.6% and the net uncertainty of up to 1%, taking into account the range of viscosity of the fluid and its temperature.

11.4.1.2 For pulsed flow services, turbine type meters shall be avoided. [INTERDISCIPLINARY INTERFACE] [PRO]
11.4.1.3 Pulsed flow services are not suitable for turbines, where the measurement uncertainty increases considerably. One shall opt for another technology, less susceptible to pulsations in the line or eliminate the pulses, installing pulse dampers.

11.4.2 Materials and Constructive Details

11.4.2.1 If used for the measurement of produced oil, turbines with a rotor of the helical type shall be specified.

11.4.2.2 Turbine gas meters shall withstand 25% overspeed without damaging their mechanisms.

11.4.3 Installation

11.4.3.1 Preferably, turbine type meters shall be installed horizontally, in vibration-free lines and distant from electrical equipment radiating electromagnetic fields. [INTERDISCIPLINARY INTERFACE] [TUB, 3D]

11.4.3.2 The installation of turbine-type meters for gas or liquid totalization shall be made in such a way that there is no accumulation of liquid points in the gas measurement or gas (or vapor) accumulation in the liquid measurement. [INTERDISCIPLINARY INTERFACE] [TUB, 3D]

11.4.3.3 A filter sized in accordance with ANSI / ISA-RP31.1 recommendations or a more stringent filtration when specified or recommended by the MANUFACTURER shall be installed upstream of each meter. [INTERCONNECTION INTERFACE] [MEC, PRO, ARR, TUB, 3D]

11.4.3.3.1 When there is no reserve meter, two filters in parallel shall be installed upstream of the turbine meter. These filters shall be sized according to ANSI / ISA-RP31.1 recommendations or more stringent filtration when specified or recommended by the MANUFACTURER. This requirement applies to both liquid and gas flows. This filter shall be installed upstream of the by-pass described in item 11.1.2.1. [INTERDISCIPLINARY INTERFACE] [MEC, PRO, ARR, TUB, 3D]

11.4.3.4 The minimum pipe run lengths upstream and downstream of the meter shall follow the recommendations of the MANUFACTURER and the API-MANUAL OF PETROLEUM MEASUREMENT STANDARDS chapter 5, section 3 and ISO 2715 for liquid operation, and AGA REPORT NUMBER 7 for gas operation. In the latter case, the position of the temperature tap shall also be according to the same AGA report. [INTERDISCIPLINARY INTERFACE] [ARR, TUB, 3D]

11.4.3.5 Follow item 11.1.3 to avoid vaporization of fluids.
11.5 Variable Area Meters

11.5.1 Application Criteria

11.5.1.1 Variable area meters (rotameters) shall be used for local indication only and shall not be used for signal transmission.

11.5.1.2 Rotameters are recommended for services with liquids and gases, both clean and with no great variation of viscosity.

11.5.1.3 In applications with air, inert gases or water and in diameters up to 2”, the rotameter can be constructed with glass tubes.

11.5.1.4 For services with toxic fluids, flammable or in diameters above 2”, the rotameters shall be of metal body.

11.5.2 Materials and Constructive Details

11.5.2.1 Rotators constructed with glass tubes shall be impact resistant, taking into account the pressure and temperature limits of the process.

11.5.2.2 Metal body rotators shall have vertical inlet and side outlet and their floats shall be removable from the top. The indication shall be made by magnetic coupling between the float and the indicating element.

11.5.2.3 For applications where flow is subject to sudden or periodic (pulsed flow) variations, the rotor shall have a guide rod to maintain float alignment.

11.5.2.4 Rotameters may have built-in electrical contacts as long as they are not part of an emergency action. They shall also comply with what was established in item 6 (GENERAL REQUIREMENTS FOR INSTRUMENTATION SPECIFICATION).

11.5.3 Installation

11.5.3.1 Rotameters shall be installed vertically with upward flow.

11.5.3.2 The installation shall avoid points of accumulation of liquid or gas.

11.5.3.3 By-pass valves and locking valves shall be provided.

11.5.4 Performance criteria

11.5.4.1 The minimum uncertainty class shall be 4.0 according to VDI / VDE 3513 BLATT 1.
11.6 Flow Switches

11.6.1 Application Criteria

11.6.1.1 Thermal dispersion type flow switches may be used for interlocking systems in process fluids and utility fluids that serve the process when the use of flow transmitter is not of interest or adequate for the nominal flow rate. [INTERDISCIPLINARY INTERFACE] [PRO].

11.6.1.2 When an orifice plate or similar primary device is used, the same measuring or control loop element may be connected to another flow transmitter for interlocking purposes. The installation shall be immune to a common fault, such as clogging, which makes both measurements, control and interlocking unfeasible.

12 REQUIREMENTS FOR THE SPECIFICATION OF CONTROL VALVES

12.1 Selection of the body type

12.1.1 Subject to applicability limits, the type of valve used for normal services shall be defined according to the following order, and the following option may only be used when the previous option is not technically feasible and formal consultation is made to PETROBRAS for analyze:

a) single seat cage globe valves;

b) butterfly valves.

NOTE: Other types of valves can be used in cases where the types mentioned are not the best solutions.

12.1.2 For cases where the flow coefficients (Cv) of a globe valve are not sufficient and small pressure differential is required, butterfly valves may be used.

12.1.3 The minimum leakage class is Class IV, according to the standard FCI 70-2, including the cases mentioned in item 12.1.2. In special cases (such as for flare relief valves, normally closed valves), the leakage class shall be V or VI.

12.2 Inherent Characteristic of the Valve

12.2.1 The flow characteristic shall be chosen according to the following criteria:

\[ X = \frac{\Delta P}{\Delta P_s} \]

Where:

\( \Delta P \) is the differential pressure in the valve in the normal operating flow condition;

\( \Delta P_s \) is the total differential pressure in the system in which the valve is inserted, including the valve \( \Delta P \) itself, at the normal operating flow. This pressure differential is divided into 3 parts:

1. \( \Delta P \) from the first controlled pressure point or pump discharge to the valve inlet flange;
2. The $\Delta P$ in the valve;
3. The $\Delta P$ from the valve outlet flange to the next controlled pressure point. [INTERDISCIPLINARY INTERFACE] [MEC, ELE, PRO]

**NOTE 1:** Values for static pressure differentials shall not be considered.

So:

A. for $X$ greater than or equal to 0.6 use linear characteristic;
B. for $X$ greater than 0.4 and smaller than 0.6, use modified parabolic characteristic or equal percentage;
C. for $X$ greater than or equal to 0.2 and less than or equal to 0.4, use characteristic equal percentage;
D. avoid $X$ less than 0.2, as the control capacity of the valve is compromised in this range.

Figure 5 - Inherent characteristic of control valves as a function of ratio "X"

12.2.2 For compressor recycling (anti-surge) and flare alignment services, control valves shall have a linear characteristic.

12.3 Installation

12.3.1 Each control valve shall have locking valves. In control meshes where response time is compatible with local manual actuation positioned by operator intervention, manual valve or globe valves shall be provided in parallel for execution of this local manual control. The arrangement of manual globe valves in parallel shall be designed to encompass the entire operational range of the automatic control valves. [INTERDISCIPLINARY INTERFACE] [PRO, TUB, ARR, 3D]

12.3.2 Closed failure type control valves shall have a 3/4 "NPT drain / vent valve upstream and downstream of the valve. Open failure type control valves shall have a 3/4" NPT upstream.

12.4 Constructive Characteristics

12.4.1 Connections

12.4.1.1 The flanges shall conform to ANSI B-16.5 and the face-to-face dimension in accordance with ISA S 75.08.01 - 07 and ISA S 75.22.
12.4.2.1 In cases of medium to high pressure differential, balanced type or pilot operated shutter shall be used. When necessary, anti-cavitation and noise reducing cage or special valves shall be used for severe applications, considering valves for severe applications where the total pressure drop is obtained by means of successive drops of pressure in order to limit the speed of the fluid along the valve, minimizing the noise generated and the pressure of Vena Contracta and consequently the wear caused by excessive speed and cavitation.

12.4.3 Materials

12.4.3.1 The usual material for the control valve body shall be carbon steel, except when the process conditions or the specification of the piping require other material. Cast iron valves may be accepted when so permitted by the pipe specification.

12.4.3.2 The internal (shutters and seats) shall be at least AISI 304 stainless steel. In cases where this material is not suitable for process conditions or pipe specification, other more suitable material shall be used.

12.4.3.3 Seals shall be made of hardened stainless steel when the pressure differential through the valve exceeds 10 bar in flashing services, fluids containing solid particulates in suspension, or when cavitation occurs.

12.4.3.4 The packing material shall be PTFE, unless the process conditions require other material.

12.5 Sizing

12.5.1 The design shall conform to ISA 75.01.01 and shall take into account: rangeability, flow type - subcritical or critical with flashing or cavitation, influence of viscosity, biphasic flow, (limited to 10m / s for services with liquid and 110m / s for services with gases or vapors) and noise level, which shall be limited to 82 dBA measured at 1.0 m downstream of the valve and 1.0 m Tube valves in accordance with IEC 60534. Severe application / service valves shall be used for cavitation, flash (vapor), two-phase flow, flow velocity above the above-mentioned limits or noise above the above limits.

12.5.2 The dimensioning of the actuator shall take into account the largest pressure differential to which the valve will be subjected.

12.5.3 The flow coefficient of the chosen control valve (Cv valve) shall be such that:

12.5.3.1 \( C_v_{\text{min}} \) shall be achieved with an opening greater than or equal to 10%.

12.5.3.2 \( C_v_{\text{max}} \) shall be achieved with aperture less than or equal to 90%.

12.5.3.3 \( C_v_{\text{normal}} \) shall be obtained in openings less than 70%.

12.5.4 The chosen \( C_v \) shall be immediately higher than the calculated theoretical value, extracted from MANUFACTURERS’ catalogs.
12.6 Actuators

12.6.1 The control valve actuators shall preferably be of the diaphragm type. If the ΔP does not allow its use, the piston type shall be used. Other special actuators may be used in specific applications, subject to prior approval by PETROBRAS.

12.6.2 All valves shall be equipped with an indicator of the opening percentage of the rod.

12.7 Valve Positioners

12.7.1 All control valves used in control mesh (PID, etc.) shall be equipped with intelligent electro-pneumatic positioners.

12.7.2 Valve positioners shall be capable of implementing the various flow characteristic curves as a function of valve opening as defined by ANSI / ISA-75.11.01 as well as being capable of working with specific curves for the application or specific points, determined externally and transferred to the positioner or even from set of points fed into the positioner, the curve being generated by it. The positioner shall be able to work with sets of at least 12 pairs of coordinates.

12.7.3 Regulator assemblies (with filter and positioner) shall be provided already installed in the valve. Pneumatic connections and tubing shall be made of AISI 316 stainless steel.

12.7.4 The pressure gauges supplied together with valve filters and positioners shall be made of AISI 304 stainless steel or thermoset phenolic polymer. The mechanism and pointer shall also be AISI 304 stainless steel and AISI 316 stainless steel connection.

12.7.5 Whenever there is a requirement to open or close the valve quickly, a booster or a quick release valve shall be used between the valve and its positioner. To comply with this requirement, item 6.8.14.1 shall be followed.

12.8 Accessories

12.8.1 The use of hand-operated devices (hand wheels) for valves with a diameter equal to or greater than 8" shall be studied on a case-by-case basis. [INTERDISCIPLINARY INTERFACE] [ARQ]

12.9 Minimum Pump Flow

12.9.1 For the control of the minimum flow of centrifugal pumps, a self-operated flow control valve shall be used, except in cases where the control is implemented via frequency drive or speed to the pump drive. [INTERDISCIPLINARY INTERFACE] [PRO, TUB]

12.9.2 When the above solutions are not recommended, a control valve associated with a flow controller shall be used.
12.9.3 If necessary, a restriction orifice in the recirculation line downstream of the minimum flow control valve may be used to reduce $\Delta P$ on the valve.

12.10 Choke Type Valves with Actuators

12.10.1 These valves shall only be used for regulating the pressure of crude oil (before the production collector) and in gas injection services and shall comply with the following minimum requirements:

12.10.1.1 Be of the balanced type;

12.10.1.2 Be of the cage type with outer sleeve or of the plug and cage type;

12.10.2 Valves with nominal diameters greater than 3 "shall have a compensation system aiming at reducing operating torque;

12.10.3 The actuators shall preferably be of the electrical type, and alternatives to the step type actuator are acceptable both with 4-20 mA signal command.

12.10.4 The inherent characteristic of the valve shall be of equal percentage;

12.10.5 All valves shall have a manual override device for opening and closing;

12.10.6 They shall have an electronic position transmitter (4 - 20mA, 2 wire, 24 Vdc) for remote monitoring; the linearity of these devices along the entire range shall be guaranteed. Other position transmission systems will be subject to prior approval by PETROBRAS;

12.10.7 A local position indicator shall also be provided, with a scale covering 0 - 100% aperture, and with an uncertainty less than 0.5% of its total range.

12.10.8 For each code YY (code family) of the coding rule of the piping specification, shall be consulted on technical specification document of the project entitled PIPING SPECIFICATION, valve materials, test requirements and design temperature limits are described in Table 9.

### Table 9 – Choke Valve Requirements

<table>
<thead>
<tr>
<th>YY CODE</th>
<th>BODY MATERIAL</th>
<th>GASKET MATERIAL</th>
<th>SEAT / INTERNALS MATERIAL</th>
<th>TEST REQUIREMENTS</th>
<th>MIN./MAX. DESIGN TEMPERATURE (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>ASTM 995 Gr. 6A</td>
<td>ASTM A479 UNS S32760</td>
<td>TUNGSTEN CARBIDE</td>
<td>API 6A PR2 PSL 3G</td>
<td>-50/+110</td>
</tr>
<tr>
<td>16</td>
<td>ASTM 995 Gr. 4A</td>
<td>ASTM A479 UNS S31803</td>
<td>TUNGSTEN CARBIDE</td>
<td>API 6A PR2 PSL 3G</td>
<td>-50/+100</td>
</tr>
<tr>
<td>30</td>
<td>INCONEL 625 (UNS N06625)</td>
<td>UNS N06625</td>
<td>TUNGSTEN CARBIDE</td>
<td>API 6A PR2 PSL 3G</td>
<td>-100/+150</td>
</tr>
<tr>
<td>31</td>
<td>ASTM A522 Type I</td>
<td>UNS N06625</td>
<td>TUNGSTEN CARBIDE</td>
<td>API 6A PR2 PSL 3G</td>
<td>-100/+93</td>
</tr>
</tbody>
</table>
13 REQUIREMENTS FOR THE SPECIFICATION OF RELIEF DEVICES

13.1 Safety Valves and Pressure and Vacuum Relief

13.1.1 Selection and Sizing Criteria

13.1.1.1 Selection and sizing shall be in accordance with API-526 and API RP 520 standards. Valves intended for atmospheric tanks shall comply with API STD 2000.

13.1.1.2 Pilot-operated valves may only be used conditioned to PETROBRAS approval.

13.1.2 Installation

13.1.2.1 A device for mechanical interlocking between the upstream and downstream shut-off valves shall be provided in order to always ensure that a flow capacity of less than 100% of the design depressurization is never in line. This shall be ensured even during an operation to remove a PSV for maintenance, i.e. the PSV(s) reserve is (are) aligned before PSV(s) to be withdrawn for maintenance.

13.1.2.1.1 The blocking valve downstream of each PSV shall always remain open when installed, even if it is not in operation. The blocking valve downstream of the PSV can only be closed to allow the PSV to be removed for maintenance. The mechanical interlock described in item 13.1.2.1 shall meet this requirement, having a sequence for alignment and a sequence for blockage and withdrawal of PSV for maintenance.

13.1.2.2 The pressure and diameter classes of the inlet and outlet flanges of the PSVs shall be in accordance with the tables of item 11 of API 526 for the specified orifice. The pair of inlet and outlet flanges shall be chosen to provide the desired set pressure at the desired relief temperature. If the pressure class of the inlet or outlet flange is greater than the pressure class of the line that connects to it, it shall be revised to the same PSV flange pressure class. [INTERDISCIPLINARY INTERFACE] [PRO, MEC, TUB]

13.1.3 Materials and Technical Requirements

The materials used in the components of the safety and relief valves shall be adequate to the process conditions, being careful to check the transient conditions, according to the list below. In cases where these materials are not appropriate to the process conditions, other more suitable material shall be used.

- Body and castle: carbon steel;
- Spring: cadmium carbon steel;
- Internal: stainless steel (AISI 304 or AISI 316);
- Rod: stainless steel (AISI 410, AISI 416 or AISI 420);
13.1.3.1 All safety and relief valves shall have capacity certificates in accordance with ASME Section VIII Division I, provided by a qualified and qualified certifying body.

13.1.3.2 The safety relief valve certificates shall show the pressure setting range of the supplied spring. The spring shall allow for adjustment of +/- 10% of the relief pressure for pressures up to 1800 kPa (18 bar) and +/- 5% for pressures above 1800 kPa (18 bar). The adjusting screw shall be protected by a cap or hood (threaded or screwed).

13.2 Rupture Disks

13.2.1 The use of rupture disks as safety and relief devices is defined by the Process discipline. When used, its tolerance shall conform to ASME, Section VIII, Division I, UG-127 (a). The rupture disk shall be specified in order to match the operating pressure, operating ratio, setpoint value and breaking range. [INTERDISCIPLINARY INTERFACE] [PRO]

13.2.2 The 90% minimum operating ratio shall be specified and taken into account in the design of the rupture disk design. Larger operating ratios can be considered for more critical conditions. [INTERDISCIPLINARY INTERFACE] [PRO]

13.3 Buckling Pin Valves

The use of buckling pin valves is acceptable, once the following requirements are considered:

13.3.1 The use of Buckling Pin Valves as safety and relief devices is defined by the Process discipline. When used, they shall be used in accordance with ASME section VIII, Division 1 and Case 2091.3 (Buckling Pin Pressure Relief Devices Section VIII, Division 1). [INTERDISCIPLINARY INTERFACE] [PRO]

13.3.2 Leak tests shall follow API STD 527.

13.3.3 Installation and maintenance procedures shall comply with API RP 520.

14 REQUIREMENTS FOR SPECIFICATION OF EMERGENCY SHUTDOWN (SDV), AUTOMATIC DEPRESSURIZATION (BDV) AND ALIGNMENT AND ON-OFF CONTROL (XV) VALVES

14.1 Emergency Shutdown Valves (SDV) and Automatic Depressurization Valves (BDV)

14.1.1 Concept

14.1.1.1 Shutdown valves or emergency shutdown valves are the final automatic control elements which are actuated by the Production Unit Safety System and / or equivalent unit of the PACKAGED UNIT, with the blocking function certain process circuits and equipment, or opening other circuits to allow the flow of fluid and depressurizing equipment (in this case they are called Blowdown Valves or automatic depressurization valves).
14.1.1.2 These valves are continuously held in the operating position, open for SDVs and closed for BDVs, by signals received from the Safety System or the interlocking (protection) logic of the PACKAGED UNIT.

14.1.1.3 If a trip or emergency shutdown occurs, the signal mentioned in item 14.1.1.1 is interrupted, which brings the valve to its safe position. The travel time from the operating position to the safety position shall be at most 1 second for each inch of nominal valve diameter and shall not exceed 45 seconds.

14.1.2 Characteristics

14.1.2.1 Valves SDVs and BDVs shall be designed following the valve specification level (VSL) and the requirements established on the technical specification document of the project entitled PIPING SPECIFICATION.

14.1.3 BDV Valves - Installation

14.1.3.1 All BDV valves shall have an air sump dimensioned to perform a BDV operation on their own. This vessel shall be calculated from the minimum instrument air distribution pressure after opening the BDV, the remaining vessel pressure is 30% above the minimum pressure of the pneumatic specification of the valve actuator.

14.1.3.2 In order to limit the rate of depressurizing of the unit according to the calculation of aperture sequencing of the various BDVs, whenever there is a need for flow restriction, it shall be done through a calculated restriction orifice and constructed to produce a critical flow.

14.1.4 Actuators

14.1.4.1 The VENDOR of the respective valve shall specify and supply the actuator.

14.1.4.2 Passive protection in actuators shall be applied following the specifications of the Safety Discipline specifications. [INTERDISCIPLINARY INTERFACE] [SEG]

14.1.4.3 These valves shall be driven by pneumatic circuits and the valves shall have rapid exhaust valves. The drive circuit passes through a three-way valve, or other type of valve, depending on the specific needs of the safety function.

14.1.4.4 These valves are continuously supplied by signals received from the Safety System or the interlocking (protection) logic of the PACKAGED UNIT.

14.1.4.5 During normal operation, with the pilot valve energized, the actuation circuit keeps the valve actuator pressurized.

14.1.4.6 If a trip or emergency shutdown occurs, the signal to the pilot valve is interrupted, deenergizing it, initiating the depressurization of the actuator through the pilot and consequently activating the quick escape valve,
depressurizing the actuator completely with reversion of the valve to its safe position.

14.1.4.7 Actuators for the actuation of SDV or BDV shall be pneumatic piston type, with spring return.

14.1.4.7.1 Multi-spring actuators may be used using sets of 2 bagged springs or single springs in configurations of up to three single sets / springs at 120° or two sets / single springs in series.

14.1.4.7.2 Configurations that exceed those mentioned in the item above can only be adopted by submitting test reports that prove its long-term functionality for analysis and release by PETROBRAS.

14.1.4.8 Hydraulic circuits shall be used whenever at least one of the following conditions is satisfied, DN being the nominal diameter:

14.1.4.8.1 Simultaneously DN greater than or equal to 4 "and Pressure class greater or equal to 1500 #;

14.1.4.8.2 Simultaneously DN greater than or equal to 8 "and Pressure class greater than or equal to 900 #;

14.1.4.8.3 Simultaneously DN greater than or equal to 12 "and Pressure class greater than or equal to 600 #;

14.1.4.8.4 DN greater than or equal to 14 ";

14.1.4.8.5 All Pressure Class 10000 #.

14.1.4.9 Sizing

14.1.4.9.1 In both opening and closing, the actuator shall be capable of providing a torque 2 times greater than the torque required by the valve, throughout the actuation stroke thereof. The largest torque supplied by the actuator shall not exceed the maximum torque allowed by the MAST (Maximum Allowable Stem Torque).

14.1.4.9.2 The design of the automatic depressurizing valve actuator, BDVs, shall be done considering the maximum pressure differential, considering the overpressure of the PSV.

14.1.4.9.3 For emergency shutdown valves (SDV) the spring shall be dimensioned to guarantee the closing time according to item 14.1.1.3. For emergency shut-off valves (SDV) with features (system with valves and associated lines) to reduce the difference between the upstream and downstream pressures (closed pressure differential pressure) for opening the SDV, the actuator sizing may consider this differential pressure for valve opening. For emergency shut-off valves without the features for differential pressure reduction in closed condition, the actuator shall be dimensioned by the maximum differential pressure developed after closing the actuator.
14.1.4.9.4 The valve used for differential pressure reduction in closed condition shall also be an SDV and be specified with the same requirements applicable to the main SDV.

14.1.4.9.5 The alternative of installing differential pressure reduction features in closed condition shall be evaluated from the point of view of cost / benefit and safety.

14.1.5 Accessories

14.1.5.1 Actuators shall be equipped with accessories such as position switches, pilot valves, quick release valves, flow regulators and their associated installation materials.

14.1.5.2 When the SDV is closed, there is a possibility of a water hammer, the rapid exhaust valve shall be suppressed and there shall be a fixed restriction in the actuator depressurizing circuit to soften the closing of the VSD.

14.1.5.3 Position switches shall have their contacts actuated by magnetic coupling and shall have a rotating mechanical position visual indication with transparent protection mechanism of the movable part, with open / closed indication by means of different colors and black inscriptions. The current position of the valve shall be easily viewed from the side and top of the indicating device. They shall also allow adjustment of the actuation points without disassembling the valves. The contact of the position indication switches shall be Normally Open (NO) and close when the valve reaches the limit switch.
14.2 Manual And On-Off Control Valves (XVs)

For Valves of Naval Systems, the specifications of the respective discipline shall be followed. **[MULTIDISCIPLINARY INTERFACE] [SNAV]**

### 14.2.1 Concept

14.2.1.1 Valves XVs shall be designed following the valve specification level (VSL) and the requirements presented on the technical specification document of the project entitled PIPING SPECIFICATION.

14.2.1.2 Valves XVs are the end elements for e.g. automatic level control and for directing process fluids. They are driven by the Control Unit of the Production Unit and / or equivalent system of the PACKAGED UNIT.

14.2.1.3 These valves may assume any position depending on the current process demand: open, closed or an intermediate position.

14.2.1.4 Have a failure condition determined by the process, such as failure to open, failure to close or failure of the current position.

14.2.1.5 Where the upper and lower values are not determined by the Process discipline, the opening time as well as the closing time shall be no more than 2 seconds for each nominal inch diameter of the valve.

### 14.2.2 Actuators

14.2.2.1 The VENDOR of the respective valve shall specify and supply the actuator.

14.2.2.2 These valves shall be driven by pneumatic circuits and shall have rapid exhaust valves. The drive circuit passes through a three-way valve, or other type of valve, depending on the specific needs of the function.

14.2.2.2.1 For failure-type XVs, the actuator shall be supplied with an accessory that allows manual mechanical actuation. Electric actuators can be used in fault-type XVs in position, provided they are commanded via the communication network.

14.2.2.3 Passive protection in actuators shall be applied following the specifications of the Safety Discipline specifications. **[INTERDISCIPLINARY INTERFACE] [SEG]**

14.2.2.4 These valves are continuously supplied by signals received from the Control System or control logic of the PACKAGED UNIT.

14.2.2.5 Pneumatic actuators shall be of the piston type. If there is a defined failure condition, the actuator shall be spring loaded.

14.2.2.5.1 Multi-spring pneumatic actuators may be used using sets of 2 bagged springs or single springs in configurations of up to three single sets / springs at 120º or two simple sets / springs in series.
14.2.2.5.2 Configurations that exceed those mentioned in the item above can only be adopted by submitting test reports that prove its long-term functionality for analysis and release by PETROBRAS.

14.2.2.6 Sizing

14.2.2.6.1 In both opening and closing, the actuator shall be capable of providing a torque 2 times greater than the torque required by the valve, throughout the actuation stroke thereof. The largest torque supplied by the actuator shall not exceed the maximum torque allowed by the MAST (Maximum Allowable Stem Torque).

14.2.3 Accessories

14.2.3.1 Actuators shall be equipped with accessories such as position switches, pilot valves, quick release valves, flow regulators and their associated installation materials.

14.2.3.2 When the XV is closed, there is a possibility of water hammer, the quick release valve shall be suppressed and there shall be a fixed restriction in the actuator depressurizing circuit to smooth the actuator closing.

14.2.3.3 Position switches shall have their contacts actuated by magnetic coupling and shall have a rotating mechanical position visual indication with transparent protection mechanism of the moving part, with open / closed indication by means of different colors and black inscriptions. The current position of the valve shall be easily viewed from the side and top of the indicating device. They shall also allow adjustment of the actuation points without disassembling the valves. The contact of the position indication switches shall be Normally Open (NO) and close when the valve reaches the limit switch.

14.3 Multi-directional Valves

14.3.1 When using a multi-directional valve for the production guidance service for test and production separation trains, it shall comply with the following minimum requirements:

- Be actuated remotely by means of a rotary actuator;
- Have position indicators for each of the possible positions of the valve;
- Be able to transmit its position signals via non-proprietary protocol field communication network.

14.3.2 Your electrical components shall be suitable for the classification of the application area and shall meet the IP-56 degree of protection.
15 REQUIREMENTS FOR THE SPECIFICATION OF SOLENOID VALVES

15.1 Pneumatic solenoids

15.1.1 Solenoid valves shall be of integral assembly, whether they are of direct actuation or indirect actuation pilot operated.

15.1.2 Solenoid valves used for compressed air shall be of the compact type, without gaskets, with stainless steel body and housings, rebound seat and resilient seats.

15.1.3 The insulation class of the solenoid valve coil, at least class F.

15.1.4 Solenoid valves used in shutdown or trip systems shall be energized during normal operation and power consumption limited to 5 W per valve. For the special case of CO2 release solenoid valves greater consumption is acceptable. For any solenoid the power consumed by the solenoid added to the power dissipated in the interconnection cables shall be limited to the maximum power that the discrete output channel / channel pair can provide. In this evaluation it shall be demonstrated that the minimum voltage of the solenoid actuation is satisfied.

15.1.5 Valve solenoids shall be fitted with suppression diodes, installed within the solenoid casing.

15.2 Hydraulic solenoids

15.2.1 The requirements of I-ET-3010.00-1210-390-P4X-001 - HYDRAULIC POWER UNIT (HPU) FOR SUBSEA SYSTEM and I-ET-3010.00-5139-390-P4X-001 - HYDRAULIC POWER UNIT (HPU) FOR TOPSIDES VALVES shall be followed.

15.2.2 Solenoid valves shall be fitted with suppression diodes, installed within the solenoid casing.

16 ELECTRICAL INSTRUMENTATION CABLES

16.1 General

16.1.1 The minimum requirements for the design, fabrication and testing of instrumentation cables shall be in accordance with what is established herein and with applicable standards, codes and recommendations, such as IEC 60092-350, IEC 60092-360 and IEC 60092-376.

16.2 Terms of Service

16.2.1 Cables shall be suitable for installation in trays or cable trays in areas exposed to the maritime atmosphere, subject to rain, liquid hydrocarbon spells and exposure to the sun.

16.2.2 All cables and multicables that cross or are contained in areas classified as Zone 0, Zone 1 or Zone 2 or in open areas shall be armored.
16.2.2.1 Cables and multicables fully contained in sheltered and unclassified areas (control rooms, accommodation areas, etc.) shall not be armored. For sheltered areas and when there is a risk of mechanical damage, lidded cable trays or tray beds shall be used.

16.3 Constructive Characteristics

16.3.1 All cables shall be of a marine type with a minimum insulation voltage of 150/250 V (300V), in accordance with IEC 60092-376. Cables for intrinsically safe circuits shall follow the IEC-60079-14.

16.3.2 All materials shall be halogen free and low smoke. They shall be flame retardant and, where specified, flame resistant.

16.3.3 As required by DR-ENGP-M-I-1.3-R.4 - SAFETY ENGINEERING, the following circuits need to operate in a fire condition and therefore shall be interconnected by flame resistant cables in accordance with IEC 60331-11, IEC 60331-21 and IEC 60332. Other circuits shall be analyzed during the project:

   i. ADV, BDV: solenoid and limit switch cables;
   ii. SDV: cables for limit switches;
   iii. Dampers: cables for limit switches;
   iv. Contour SDV for differential pressure reduction of the closed SDV: cable for solenoids and limit switches;
   v. ESV (quick opening valve for flare gas recovery systems): cables for limit switches;
   vi. ESV (quick opening valve for flare staging): cables for solenoids and limit switches;
   vii. Back-up system for ESV (quick opening valves of flare gas recovery systems) - Example: Rupture disk and buckling pin valve: Cables that indicate actuation status / position;
   viii. Cables for gas and flame detectors, as well as cables for the emitters of line-of-sight gas detectors;
   ix. Cables for systems that start or are functional during ESD-3P, ESD-3T and ESD-4;
   x. Cables related to fire-fighting systems (e.g. network fusible plug transmitters, solenoids for CO2 release in hoods, AFDS system cables).

16.3.4 MANUFACTURERS shall provide cable aging curves, where it shall be clear that after the lifetime of the unit design the insulation resistance of the cables is not less than 1 MΩ.

16.3.5 All cables shall allow curvatures with a minimum radius of eight times their outer diameter.

16.3.6 The conductor shall be made of seven strands of soft copper, tinned throughout its length and strung with stranding class 2.

16.3.7 The multicables shall be composed exclusively of pairs or triples or blocks and may not contain different types of units.
16.3.7.1 The number of pairs, triples and quads in a multicable shall be limited to 24 pairs, 16 triples and 12 quads.

16.3.8 At the end of the Acceptance and Performance Tests, there shall be an installed reserve, connected from the junction box terminal strip to the panel, of 10% per signal type on the multicables that interconnect panels and junction boxes. This buffer shall be for each junction box / signal type composition. The type of signal shall be determined by: Analog or Discrete, Input or Output, Intrinsic Safety Circuit or not and subsystem to which it belongs.

16.3.9 Cables and multicables shall have electrostatic shields covering each unit (pair, triple or quad) and made of an aluminum / polyester tape that shall be 0.065 mm to 0.1 mm thick, helically applied with overlapping 25% and with a drain wire in tinned and stranded copper.

16.3.9.1 Cables for discrete signals, cable for analog signals and multicables for discrete signals shall have general shielding and this shall have a drain wire.

16.3.9.2 Multicables (multitriples or multiquads) for analog signals shall have individual shielding per pair (per triple and per quad) and also a general shielding covering the whole set. Each shield shall have a dedicated drain wire.

16.3.9.3 Cables and multicables in accordance with 16.2.2 shall receive on the assembly a metal frame composed of a braid of galvanized steel wire, sufficiently flexible and free of imperfections in galvanization and without discontinuities.

16.3.9.4 Cables shall be provided with a filler between the pairs / triples / quads and the overall shield to ensure circularity of the straight section of the cable along its entire length. The filler shall be of material that will retard flames, not halogen.

16.3.10 There shall be an outer shell on the metal frame made of non-halogenated thermoset material (SHF 2).

16.3.10.1 It shall be ensured that there is no adhesion between the metal frame and the material of the outer layer.

16.3.10.2 The outer layer of the instrumentation cables shall be gray. Intrinsically safe cables shall have a blue outer layer and shall be routed in accordance with IEC 60079. Flame-resistant cables shall have two diametrically opposite red stripes along the entire length.

16.3.11 All pairs, triples and quads shall be twisted with a maximum pitch of 60mm.

16.3.12 When used, see item 7.4.1.1, cables between the thermocouple heads and their transmitters may be of the Extension grade type, provided the cable is specified for the temperature to which it is subjected.
### 16.4 Sizing

16.4.1 The voltage drop in the interconnection cables shall be calculated for all consumers in such a way that the required minimum voltage is guaranteed in the instrument or equipment and higher section cables shall be used when necessary to guarantee this minimum voltage (e.g. signals interlocking logic outputs such as solenoid valves, 4-wire instruments, CO2 flood fire-fighting solenoids, gas-emitting transmitters of the target type, etc.). The minimum nominal sections to be used, even if the sizing referred to earlier comprises lower sections, are described below:

16.4.2 The nominal cross-section of the conductors used in connection with the field shall be 1,0 mm² for the following signals:

- a) analog signals;
- b) end of course;
- c) Discrete signals between panels without power or power supply (e.g. Fault Summary, On - Off Status, Panel Status Information);
- d) control signals to switch electric drawers on or off;
- e) Minimum section of 1,5 mm² shall be adopted for the following signs:
  - A. Solenoid activation within the same module (except main deck, riser balcony and pipe rack);
  - B. Activation of piezoelectric or electronic and visual audible alarms based on LED inside the same module (except main deck, riser balcony and pipe rack).

16.4.3 For the minimum cross-section of 2.5 mm², the following signs shall be used:

- a) Activation of CO2 firing solenoids within the same module (except main deck, riser balcony and pipe rack);
- b) Activation of motorized visual alarms and motorized and / or based on incandescent lamps.

### 16.5 Identification and Polarization

16.5.1 The conductors shall have identifications and be used with the polarity as described below, following IEC 60092-376:

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Signal Type</th>
<th>Conductor 1 (Polarity)</th>
<th>Conductor 2 (Polarity)</th>
<th>Conductor 3 (Polarity)</th>
<th>Conductor 4 (Polarity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pairs</td>
<td>4-20mA</td>
<td>Black (+)</td>
<td>White (-)</td>
<td>N.A.</td>
<td>N.A</td>
</tr>
<tr>
<td>Triples</td>
<td>Power + 4-20mA</td>
<td>Black (+)</td>
<td>White (-)</td>
<td>Red (+, signal)</td>
<td>N.A</td>
</tr>
<tr>
<td></td>
<td>RTD</td>
<td>Black (+)</td>
<td>White (-)</td>
<td>Red (+, signal)</td>
<td>N.A</td>
</tr>
<tr>
<td>Quads</td>
<td>Power + 4-20mA</td>
<td>Black (+)</td>
<td>White (-)</td>
<td>Red (+, signal)</td>
<td>Blue (-, signal)</td>
</tr>
<tr>
<td></td>
<td>RTD</td>
<td>Black (+)</td>
<td>White (-)</td>
<td>Red (+, signal)</td>
<td>Blue (-, signal)</td>
</tr>
</tbody>
</table>

16.5.2 In multicable, conductors of the same group (pair, triple or quad) shall all be identified by the same number printed at intervals as described in IEC-60092-376. The identification within the group is made by the color of the insulation coating as described in item 16.5.1.
16.5.3 All cables and multicables shall be identified externally, indelibly and over their entire length, with data on the type, formation and nominal section of the conductors.

16.5.4 Flame resistant cables shall have identification as required in 16.3.10.2.

16.5.5 Color of the cover and conductors of the thermocouple extension cables shall conform to ASTM E230.

16.6 Tests

16.6.1 The cable VENDOR shall submit a complete report and certification certificate from the Certifying Entity certifying that the cables have been approved in the tests prescribed in IEC-60092-376.

17 INTERCONNECTION

The applicable standards, codes and recommendations that shall be followed are listed in documentation presented in item 2.

17.1 Cable Glands and Clips

17.1.1 The installation of cable glands shall include the use of unions to facilitate handling during maintenance.

17.1.2 Cables and multicables shall be fastened along their routing trays by means of metallic tape-type clips coated with polymeric material.

17.2 Junction Boxes and Passage Boxes

17.2.1 Cables from field instruments shall converge to junction boxes, segregated into 3 (three) types:
- **TYPE 1**: for signals using flame-resistant cables (PSD/HSD/FGS);
- **TYPE 2**: for signals related to safety interlocks (PSD/HSD);
- **TYPE 3**: for signals related to process control (PCS/HCS).

17.2.1.1 Junction boxes interconnecting flame-resistant cables and multicables shall be passively protected to provide the same flame resistance as the cables. The terminal strips shall also be of a flame resistant material, such as ceramic.

17.2.1.2 The junction box shall be internally divided into two regions, one for discrete signals and one for analog signals.

17.2.1.3 Intrinsic safety (IS) signals shall be conditioned in a separate region inside the junction box, segregated from the other regions by means of a separating septum and identified as intrinsically safe signals. The terminal strips and their cable glands shall be blue.

17.2.2 Junction boxes for instrumentation cables in classified or open areas shall have a minimum Ingress Protection rating of IP-56 and shall be "Ex e" or "Ex d" certified and certified for Zone 1.
17.2.3 Cables or multicables that connecting instruments to the junction box may only be attached to the side or bottom of the junction box.

17.2.3.1 Cables and multicables shall be routed so that they lie below their respective junction box connection before entering the junction box, in order to avoid a preferred route for rainwater (e.g. U-shaped routing).

17.2.4 Multicables that connect the junction box to a panel or to another junction box shall be connected to the bottom of the junction box.

17.2.5 Entry of cables through the top of the junction box is not allowed.

17.2.6 In the lower part of the junction boxes, the passage of cables and multicables shall be done using a removable blind plate. No removable blind plate shall be used at the side entrance.

17.2.7 The terminal strips used inside the junction boxes shall be firmly attached and suitable for use under vibrating conditions to avoid poor contact and consequent spark.

17.2.8 Junction boxes and passage boxes shall be made of AISI 316 stainless steel.

17.3 Cable trays

17.3.1 Cable trays shall be made of AISI 316 stainless steel. Cable trays made of galvanized steel may be used in sheltered areas (rooms, etc.). Where the routing of cables along the ground is necessary, cable trays shall be manufactured only in AISI 316 stainless steel, with a bolted cap of the same material.

17.3.2 The occupation of the cable trays, calculated by considering that the cable occupies an area equivalent to the square of its respective diameter, shall be such that the free area at the top of the cable tray is at least 40% of the useful area of the cross section of the cable tray (see Figure 7).

![Figure 7 - Occupation of cable trays.](image)

17.3.3 Carbon steel shall be used in the manufacture of all supports for such trays, and they shall be painted in accordance with the painting procedure adopted in the design for such material. To avoid galvanic cell formation on the contact surface between the trays and the supports, an insulation material shall be used between them. Electrical continuity between tray sections and their proper grounding, as specified, shall be ensured.
17.4 Panels in open areas

17.4.1 To provide maintenance access for cables entering through the bottom of panels, an elevation of 300 mm from the floor shall be provided. The elevation shall be open on all sides to provide access.

17.4.1.1 A platform leveled with the base of the panel shall be installed in front of the panel doors to provide ergonomic access. The platform shall have the width of the panel doors. This platform shall be removable with screw fixing to provide access to the cables.

18 GROUNDING AND ELECTROMAGNETIC COMPATIBILITY (EMC)

18.1 Definitions

18.1.1 The term PE stands for grounding for personal protection and to avoid the formation of static electricity (bonding).

18.1.2 The term IE stands for instrumentation grounding for circuits other than intrinsic safety (Ex i) protection, with the function of providing a path for the flow of electromagnetic noise. The (negative) reference of the control panels shall not be connected to this grounding.

18.1.3 The term IS stands for instrumentation grounding for intrinsic safety circuits (Ex i), in order to provide a path for the flow of electromagnetic noise.

18.2 General requirements

18.2.1 The enclosure of all instruments and panels, junction boxes, cable glands, and multicable armors shall be connected to the PE.

18.2.2 The drain wires of the cable and multicable shields shall be grounded to the IE or IS according to the type of circuit on the side of the panel and insulated on the side of the instrument when the sensor is not grounded (IEC 60533). When the sensor is grounded, the drain wire of the shield shall be grounded on the side of the instrument and insulated on the side of the panel (IEC 60533).

18.2.2.1 In the case of remote mounting for temperature measurement with the sensor installed on the head separately from the respective transmitter, the cable shield drain wire between the head and transmitter shall be grounded to the head and insulated on the side of the transmitter. The shielding of the circuit between transmitter and panel shall be grounded only on the panels in the IE or IS bar, depending on the type of Ex protection used.

18.2.3 In the field, the grounding bars of the panels, PE, IE and IS, shall be connected to the structure with the least cable length possible, which in turn is grounded. It shall be obeyed the distance of 1 to 3 meters between PE and IE, as well as a distance of 1 to 3 meters between PE and IS. Between IE and IS the minimum distance between the connection points in the structure shall be 1.8 meters.
18.2.4 In panel rooms, the grounding bars of the electromagnetic compatibility panels IE and IS shall be connected to the structure with the least cable length possible in order to form an equipotentialization plan. The PE bar shall be interconnected in a ring and connected to the structure in a single point.

18.2.5 The cables used in item 18.2.2 shall have a minimum gauge of 25 mm² and the length shall be as small as possible to minimize the entity parameters.

18.2.6 Design and implementation of grounding systems for automation and instrumentation installations shall follow IEC 60533.

18.2.7 The guidelines given in Chapters 5, 6 and 8 of IEC 61000-5-2 technical report shall be followed in order to optimize the electromagnetic compatibility (EMC) parameters.

18.2.8 Earth connections shall be made using earth bosses. Connections using direct fastening (e.g. Hilti pin) shall not be accepted.

18.3 Protection ground, shield and armor for cables and multicables

18.3.1 For discrete and analog signals shall be carried out according to figures Figure 8 and Figure 9 for discrete signals and according to figures Figure 10 and Figure 11 for analog signals.

Figure 8 - Interconnection of discrete signals
Figure 9 - Interconnection of discrete signals (Ex i circuits)

Figure 10 - Interconnection of analog signals
19 IMPULSE LINES, PNEUMATIC TRANSMISSIONS AND HYDRAULIC TRANSMISSIONS

19.1 General Criteria

19.1.1 All tubing shall have at least the following information marked on their bodies:
- External diameter;
- Wall thickness;
- Material and standard of the material.

19.1.2 Tubing shall be of the seamless type.

19.1.3 Tubing used shall be used in straight sections with a minimum length of 6 meters and maximum length of 12 meters. The use of coils is restricted and the items below determine where straight and coiled tubing shall be used.

19.1.4 Straight tubing shall be used for impulse lines.

19.1.5 Coiled tubings may be used for hydraulic feed between the solenoid rack and the consumers and also between the instrument air distribution manifold and the consumers.

19.1.6 The connections shall be of double ferrule technology for pressures up to 33000 kPa. For greater pressure, double ferrule appropriate for the pressure or cone-screw type connections shall be used. The use of orbital welds is prohibited.

19.1.6.1 The thread of the fittings shall be smooth with a coating to prevent galling from completely covering the thread of the body or the nut.
19.1.6.2 Connections shall have certificate of conformity with ASTM F1387. The certificates shall comprise at least the following Standard Qualification Tests (A) and the following Supplementary Tests (S):

- A3 - Pneumatic test;
- A4 - Hydrostatic test;
- A5 - Impulse Test;
- A6 - Fatigue test;
- A7 - Traction test;
- A8 - Hydrostatic rupture test;
- A9 - Repeated assembly test;
- A10 - Rotational bending test;
- S2 - Thermal cycle test;
- S8 - Vibration test.

19.1.7 For each connection, whether unions, reductions, adapters, OD valves, Flange Adapters etc., all of its components shall be from the same VENDOR. Interchangeability is not allowed.

19.1.8 Each batch of tubing shall have a Positive Material Identification certificate in accordance with API RP 578.

19.2 Pneumatic instrument air transmissions

19.2.1 Tubing shall be made of ASTM A 269 Gr. TP 316L stainless steel with a minimum Molybdenum content of 2.5%.

19.2.1.1 The material of the associated connections and valves shall be made of AISI 316 stainless steel, not requiring a minimum content of 2.5% Molybdenum.

19.2.2 The wall diameters and thicknesses which may be used are presented in Table 11.

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Minimum Wall Thickness</th>
<th>Internal Diameter (mm)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>0.035&quot;</td>
<td>7.7</td>
<td>Compressed air</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>0.083&quot;</td>
<td>5.3</td>
<td>Fusible plug network (Chapter 20)</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>0.035&quot;</td>
<td>10.9</td>
<td>Compressed air</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>0.049&quot;</td>
<td>16.6</td>
<td>Compressed air</td>
</tr>
</tbody>
</table>

19.3 Impulse lines

19.3.1 Tubing for pressures up to 33,000 kPa shall be made of ASTM A 269 Gr. TP 316L stainless steel with a minimum Molybdenum content of 2.5%.

19.3.1.1 The material of the connections shall be made of AISI 316 stainless steel, not requiring a minimum content of 2.5% Molybdenum.

19.3.2 Tubing for pressures above 33,000 kPa shall be made of ASTM A789 UNS S32750 or S32760 super duplex steel.
19.3.2.1 The material of the connections shall be super duplex steel.

19.3.3 The wall diameters and thicknesses that may be used are presented in Table 12.

Table 12 - Tubings for impulse lines

<table>
<thead>
<tr>
<th>External Diameter</th>
<th>Wall Thickness</th>
<th>Internal Diameter (mm)</th>
<th>Working Pressure</th>
<th>Material</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>0,065&quot;</td>
<td>9,4</td>
<td>Up to 33,000kPa</td>
<td>ASTM A 269 Gr. TP 316L</td>
<td>Dry gas/air; Water/Vapor</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>0,095&quot;</td>
<td>14,2</td>
<td>Up to 33,000kPa</td>
<td>ASTM A 269 Gr. TP 316L</td>
<td>Wet gas/air</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>0,065&quot;</td>
<td>9,4</td>
<td>Greater than 33,000kPa</td>
<td>Super Duplex ASTM A789 UNS S32750 or S32760</td>
<td>Dry gas/air; Water/Vapor</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>0,083&quot;</td>
<td>14,8</td>
<td>Greater than 33,000kPa</td>
<td>Super Duplex ASTM A789 UNS S32750 or S32760</td>
<td>Wet gas/air</td>
</tr>
</tbody>
</table>

19.4 Hydraulic Power Transmissions

19.4.1 Tubing for pressures up to 5,000 psig shall be made of ASTM A 269 Gr. TP 316L stainless steel with a minimum Molybdenum content of 2.5%.

19.4.1.1 The connections shall be of double ferrule technology. The material of the connections shall be AISI 316 stainless steel, not needing to have a minimum content of 2.5% Molybdenum.

19.4.2 Tubing for pressures above 5,000 psig shall be made of AISI 316L stainless steel of the medium pressure type manufactured by cold extrusion or super duplex ASTM A789 UNS S32750 or S32760.

19.4.2.1 The material of the connections shall be of the same as the material of the tubing.

19.4.3 The wall diameters and thicknesses that may be used are given in Table 13.

Table 13 - Tubing for hydraulic transmission

<table>
<thead>
<tr>
<th>External Diameter</th>
<th>Wall Thickness</th>
<th>Internal Diameter (mm)</th>
<th>Working Pressure</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>0,065&quot;</td>
<td>9,4</td>
<td>Up to 5,000psig</td>
<td>ASTM A 269 Gr. TP 316L</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>0,095&quot;</td>
<td>14,2</td>
<td>Up to 5,000psig</td>
<td>ASTM A 269 Gr. TP 316L</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>0,065&quot;</td>
<td>9,4</td>
<td>Greater than 5,000psig</td>
<td>Super Duplex ASTM A789 UNS S32750 or S32760</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>0,083&quot;</td>
<td>14,8</td>
<td>Greater than 5,000psig</td>
<td>Super Duplex ASTM A789 UNS S32750 or S32760</td>
</tr>
</tbody>
</table>

19.5 Installation, Assembly, and Manpower Infrastructure Requirements

19.5.1 The assembly and inspection activities of tubing connections shall be performed by trained professionals through training provided by the MANUFACTURER of the connections used in the project. If there are several connection providers, the installation can only be done by a professional who has been trained by the respective connection provider.
19.5.1.1 Qualification certificate issued by the connection provider shall be submitted.

19.5.2 For installation, assembly and labor, item 19.1.7 shall be followed.

19.5.3 Tubing sockets shall not be used to support instruments, which shall be independently supported as required in item 6.8.5.

19.5.4 To avoid the possibility of the embrittlement effect by liquid metal, tubing and its connections shall not be in direct contact or located directly under Zinc or galvanized coated components.

19.5.5 During the installation process, contamination by iron oxide caused by welding or grinding shall be avoided.

19.5.5.1 Any weld splattered on the tubing shall be immediately removed. In the case of damage to the tubing, it shall be replaced.

19.5.6 Where the length of routing of a tubing or group of tubings is greater than that presented in Table 14, routing shall be done using covered trays and provision shall be made to prevent water accumulation.

<table>
<thead>
<tr>
<th>Outside Diameter (OD)</th>
<th>Maximum length without tray (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4&quot;</td>
<td>0.8</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>1.2</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>1.6</td>
</tr>
<tr>
<td>3/4&quot; or greater</td>
<td>2.0</td>
</tr>
</tbody>
</table>

19.5.7 Parallel tubing routing shall be done in lidded trays and provision shall be made to avoid water accumulation.

19.5.8 In union connections, the design shall provide space for connection changes in the intermediate tubing with angles between 30 and 45 degrees (See Figure 12).

19.5.8.1 When tubings are installed in parallel, the installation described in item 19.5.2 shall be lagged in each tubing to allow handling space on the connections with 150 mm of minimum elevation and 200 mm of minimum distance for handling. (See Figure 12).
19.5.9 Tubing support system:

19.5.9.1 When routing more than one tubing in parallel, appropriate insulation shall be provided to avoid contact between them. To avoid corrosion, this insulation cannot create regions that can accumulate water.

19.5.9.2 Support systems that can create crevice corrosion points shall not be used, such as strip-type or clamp-type supports. Tubing support systems shall be designed to minimize the points of contact between the tubing and the support to avoid cracking points.

19.5.10 Support system drawings to be followed are shown in figures Figure 13 and Figure 14. Any other type of support shall be previously submitted to PETROBRAS for evaluation.
19.5.10.1 The metal-to-metal contact shall be eliminated using insulating material for the parts in contact with the tubing.
20 NETWORK OF FUSIBLE PLUGS FOR ADV OPERATION

20.1 Constructive Characteristics

20.1.1 Fusible plugs shall be built and tested, according to the following characteristics:

- Body material: AISI 316 stainless steel;
- Diameter of Connections: 3/8 "OD or 1/4" NPT;
- Melting (actuation) temperature range: 70°C to 77°C.

20.1.2 The following information shall be engraved on the body of the Fusible Plug:

- Name of the MANUFACTURER;
- Operating Temperature;
- Production lot number.

20.1.3 All lots of fusible plugs shall be accompanied by a test certificate covering at least the following aspects:

- Tightness and resistance to extrusion;
- Under pressure softening temperature.

20.2 Network Features and Performance of Fuse Plugs

20.2.1 The Fusible Plug shall work under the same pneumatic air supply and ADV operating pressure.

20.2.2 Each network of Fusible Plugs shall be monitored by a separate pressure transmitter.

20.2.3 Each ADV actuation system shall have a pilot valve directly actuated by a Fusible Plug network. ADVs shall be remotely actuated by an interlock system. The ADV actuation system shall also provide for a local manual reset and shall allow manual opening, as shown in Figure 15 - Fusible Plug Installation Diagram Figure 15.

20.2.4 Each network of Fusible Plugs shall be dimensioned so that the ADV is open within the time determined by the DR-ENGP-M-I-1.3-R.4 - SAFETY ENGINEERING. This time shall be counted from the operation of 1 Fusible Plug to the full opening of the ADV. For this design, the opening of only 1 Fusible Plug located at the most unfavorable point for depressurizing the mains shall be used.

20.2.4.1 For the purpose of commissioning tests, the low pressure detection of the network shall not be used by the pressure transmitter of the respective network of fuses.

20.2.5 The length of the Fusible Plug network in a given scenario of the Fusible Plug depressurizing shall not exceed 300 meters. If more than one scenario is served by the same ADV, check valves can be used to segregate portions that are not part of the claim. However, the number of check valves in series for a given scenario shall not exceed 3.
20.2.5.1 If longer than 300m is required for a given scenario, a dynamic flow simulation shall be performed to verify compliance with item 20.2.4.

20.2.6 The tubings that make up the Fusible Plug network shall be of material according to item 19.2.1 and 3/8" diameter with dimensions as per Table 11 of item 19.2.2.

20.2.7 Connections to be used to create the network of Fusible Plugs shall be of double washer type technology.

20.2.8 Open and closed ADV position monitoring shall be provided to be displayed on the supervisory system screen.

20.2.9 The actuation system shall be installed in a local stainless steel panel, according to Figure 15.

20.2.10 The Fusible Plug system shall conform to DR-ENGP-M-I-1.3-R.4 - SAFETY ENGINEERING.

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Figure 15 - Fusible Plug Installation Diagram
ANNEX A - CALCULATION OF THE DIMENSIONS OF THE RESTRICTION ORIFICE IN ISENTROPIC CRITICAL FLOW REGIME FOR REAL GAS

Table 15 - Calculation of the Restriction Orifice Size in Critical Isentropic Flow Regimen for Real Gas

\[
W = C \cdot \beta^2 \cdot \frac{\pi D^2}{4} \cdot Y \cdot (P_1) \cdot \sqrt{\frac{PM}{8314.3 \cdot Z \cdot T_1}}
\]

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Mass flow [kg/s]</td>
</tr>
<tr>
<td>C</td>
<td>Coefficient of discharge in the conditions of critical flow: ( C = 0.839 ) (ref. Martins, Nelson, &quot;Manual de Medição de vazão&quot;)</td>
</tr>
<tr>
<td>( \beta )</td>
<td>Beta of the orifice at operating temperature</td>
</tr>
<tr>
<td>D</td>
<td>Internal diameter of pipe [m]</td>
</tr>
<tr>
<td>PM</td>
<td>Molecular weight of the gas [kg/kmol]</td>
</tr>
<tr>
<td>Z</td>
<td>Compressibility factor of the gas</td>
</tr>
<tr>
<td>( T_1 )</td>
<td>Gas temperature upstream of the orifice [K]</td>
</tr>
<tr>
<td>Y</td>
<td>Isentropic critical flow coefficient: ( Y = \sqrt{k \left( \frac{2}{k+1} \right)^{k+1}} )</td>
</tr>
<tr>
<td>k</td>
<td>Isentropic gas coefficient</td>
</tr>
<tr>
<td>((P_1))</td>
<td>Total (stagnation) pressure upstream of orifice [Pa] (absolute)</td>
</tr>
<tr>
<td>( P_1 )</td>
<td>Pressure upstream of orifice [Pa] (absolute)</td>
</tr>
<tr>
<td>M</td>
<td>Mach number</td>
</tr>
<tr>
<td>( M = \frac{V_1}{V_S} )</td>
<td></td>
</tr>
<tr>
<td>( V_1 )</td>
<td>Gas velocity in the line upstream of the orifice [m / s]</td>
</tr>
<tr>
<td>( V_S )</td>
<td>Sound velocity in the gas upstream of the orifice [m / s]</td>
</tr>
</tbody>
</table>
ANNEX B - CALCULATION OF THICKNESS OF RESTRICTION ORIFICES

The orifices subjected to stress beyond the permissible range given by the material from which they are made suffer permanent deformation.

a) the formula presented below shall be used for calculating the thickness, considering, at least 2σ:

\[ t_{\text{min}} = \left( \frac{\lambda \times \Delta P \times D^2}{2 \times \sigma} \right)^{1/2} \]

Where:
- \( D \) is the line diameter (mm);
- \( \Delta P \) is the pressure differential on the orifice (kgf/cm²);
- \( \sigma \) is the permissible stress of the material of the orifice (kgf/cm²);
- \( \lambda \) is the factor calculated by the expression below, and that depends on the type of installation;
- \( t \) is the thickness of the restriction orifice (mm).

\[ \lambda = 2.27 - (2.33 \times \beta) \]

b) in the case of stainless steel AISI 304 or AISI 316, up to 500 °C:

\[ \sigma \geq 2109.7 \text{ kgf/cm}^2 \]

c) thickness limits:
- lines up to 14” \( \rightarrow t \geq 1/8” \);
- lines up to 16” a 22” \( \rightarrow t \geq 1/4” \).