PETROBRAS	TECHNICAL SPECIFICATION	N°: I-ET-3010.2Q-1200-800-P4X-005	
	CLIENT: MARLIM LESTE E SUL		SHEET: 1 of 66
	JOB: BASIC DESIGN - REVIT I		
	AREA: MARLIM LESTE E SUL		
	TITLE: **FIELD INSTRUMENTATION**		ESUP
			INTERNAL

INDEX OF REVISION

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL
A	REVISED WHERE INDICATED
B	REVISED WHERE INDICATED, INCLUDING CONSISTENCY ANALYSIS

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E
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1 INTRODUCTION

1.1 Objective

1.1.1 This technical specification, along with I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS, defines the minimum requirements for the field instrumentation to be used in offshore Units (FPSO). Therefore, the two specifications shall be read in conjunction.

1.1.2 For equipment and instruments related to flow metering system, requirements of I-ET-3010.00-1200-813-P4X-001 - GENERAL CRITERIA FOR FLOW METERING SYSTEMS and I-ET-3010.2Q-1200-800-P4X-003 - FLOW METERING SYSTEM (FMS) are also mandatory.

1.1.3 The use of instrument types not covered herein and by aforementioned specifications shall be submitted to Buyer for approval.

1.2 Definitions

1.2.1 Refer to I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

1.3 Abbreviations, Acronyms and Initialisms

Table 1.3-I Abbreviated terminology used in the document

Item	Description
AC	Alternating Current
ADV	Automatic Deluge Valve
A/D	Analog-to-Digital
AEPR	Automation & Electrical Panels Room
AFDS	Addressable Fire Detection System
ALARM	Alarm Management System
ASA	Analyzer System Availability
AST	TAG prefix for Gas detector
ASUT	Analyzer System Unavailable Time
BDV	Blowdown Valve
BS&W	Basic Sediments & Water
CNEN	Comissão Nacional de Energia Nuclear (Portuguese Acronym to National Commission of Nuclear Energy)
CCR	Central Control Room (located in the Hull Accommodation)
CCR-EA	Central Control Room - Equipment Ambiance
CNEN	Comissão Nacional de Energia Nuclear (National Nuclear Energy Commission)
CSS	Control and Safety System
CPU	Central Processing Unit

CSS	Control and Safety System
CV	Valve Flow Capacity
DBB	Double Block and Bleed
D/P	Differential Pressure
DOU	Diário Oficial da União (Official Gazette of the Federal Government)
EMC	Electromagnetic Compatibility
FAT	Factory Acceptance Test
F&G	Fire and Gas
FGS	Fire and Gas System
FMS	Flow Metering System
FO	Restriction Orifice
FPSO	Floating Production Storage and Offloading
FX	Upstream Flanged Spool Metering Straight Run
FY	Doenstream Flanged Spool Metering Straight Run
HART	Highway Addressable Remote Transducer
HC	Hydrocarbon
HFGS	Hull Fire and Gas Subsystem
HMI	Human-Machine Interface
HSD	Hull Shutdown System
IACS	International Association of Classification Societies
I/O	Input/Output
IP	Ingress Protection Ratings
IR	Infrared
JB	Junction Box
LAN	Local Area Network
LED	Light Emitting Diode
LEL	Lower Explosive Limit
LEL·m	LEL·meter
NPT	National Pipe Thread
OD	Outside Diameter
PCS	Process Control System
P&ID	Piping and Instrument Diagram
PSD	Process Shutdown System
PSV	Safety Relief Valve
RTU	Remote Terminal Unit
SDV	Shutdown Valve
SOS	Supervision and Operation System
TCP	Transmission Control Protocol
TDLAS	Tunable Diode Laser Absorption Spectroscopy
TOG	Total Oil and Grease
TP	Test Period (To calculate the ASA)
TSDBO	Temporization Skid for Delaying BDV Opening
UI	Unified Interpretation—A resolution issued by IACS
UR	Unified Requirement—A resolution issued by IACS
UST	TAG prefix for Flame Detector
UV	Ultraviolet

UV-Vis	Ultraviolet-Visible
VDC	Volts Direct Current
XV	ON-OFF Valve

2 REFERENCE DOCUMENTS, CODES AND STANDARDS

2.1 External References

2.1.1 International Codes, Recommended Practices and Standards.

API - AMERICAN PETROLEUM INSTITUTE		
API	MPMS	MANUAL OF PETROLEUM MEASUREMENT STANDARDS - ALL PARTS
API	STD 6FA	STANDARD FIRE TEST FOR VALVES
API	RP 14C	ANALYSIS, DESIGN, INSTALLATION AND TESTING OF SAFETY SYSTEMS FOR OFFSHORE PRODUCTION FACILITIES
API	STD 520-PT I	SIZING, SELECTION AND INSTALLATION OF PRESSURE-RELIEVING DEVICES - PART I - SIZING AND SELECTION
API	STD 520- PT II	SIZING, SELECTION, AND INSTALLATION OF PRESSURE - RELIEVING DEVICES - PART II - INSTALLATION
API	RP 551	PROCESS MEASUREMENT
API	RP 552	TRANSMISSION SYSTEMS
API	RP 554	PROCESS CONTROL SYSTEMS - ALL PARTS
API	RP 555	PROCESS ANALYZERS
API	STD 526	FLANGED STEEL PRESSURE RELIEF VALVES
API	STD 527	SEAT TIGHTNESS OF PRESSURE RELIEF VALVES
API	STD 598	VALVE INSPECTION AND TESTING
ASME - AMERICAN SOCIETY OF MECHANICAL ENGINEERS		
ASME	B 1.20.1	PIPE THREADS, GENERAL PURPOSE (INCH)
ASME	PTC 19.3 TW	THERMOWELLS PERFORMANCE TEST CODES
ASTM – AMERICAN SOCIETY FOR TESTING AND MATERIALS		
ASTM	A351/A351M	STANDARD SPECIFICATION FOR CASTINGS, AUSTENITIC, FOR PRESSURE-CONTAINING PARTS
ASTM	B16.5	PIPE FLANGES AND FLANGED FITTINGS NPS ½ THROUGH NPS 24 METRIC/INCH STANDARD
ASTM	D1142	STANDARD TEST METHOD FOR WATER VAPOR CONTENT OF GASEOUS FUELS BY MEASUREMENT OF DEW-POINT TEMPERATURE
ASTM	D3764	STANDARD PRACTICE FOR VALIDATION OF THE PERFORMANCE OF PROCESS STREAM ANALYZER SYSTEMS
ANSI – AMERICAN NATIONAL STANDARDS INSTITUTE		
ANSI	FCI 70-2	CONTROL VALVE SEAT LEAKAGE
IEC - INTERNATIONAL ELECTROTECHNICAL COMMISSION		
IEC	60068	ENVIRONMENTAL TESTING
IEC	60079	EXPLOSIVE ATMOSPHERES

IEC	60092-350	ELECTRICAL INSTALLATIONS IN SHIPS – PART 350 - GENERAL CONSTRUCTION AND TEST METHODS OF POWER, CONTROL AND INSTRUMENTATION CABLES FOR SHIPBOARD AND OFFSHORE APPLICATIONS
IEC	60092-376	ELECTRICAL INSTALLATIONS IN SHIPS – PART 376 - CABLES FOR CONTROL AND INSTRUMENTATION CIRCUITS 150/250 V (300 V)
IEC	60092-504	ELECTRICAL INSTALLATIONS IN SHIPS - PART 504: AUTOMATION, CONTROL AND INSTRUMENTATION
IEC	60331	TESTS FOR ELECTRIC CABLES UNDER FIRE CONDITIONS - CIRCUIT INTEGRITY
IEC	60529	DEGREES OF PROTECTION PROVIDED BY ENCLOSURES (IP CODE)
IEC	60533	ELECTRICAL AND ELECTRONIC INSTALLATIONS IN SHIPS - ELECTROMAGNETIC COMPATIBILITY (EMC) – SHIPS WITH METALLIC HULL
IEC	60534-8-3	INDUSTRIAL PROCESS CONTROL VALVES – PART 8-3: NOISE CONSIDERATIONS – CONTROL VALVE AERODYNAMIC NOISE PREDICTION METHOD
IEC	60534-8-4	INDUSTRIAL PROCESS CONTROL VALVES – PART 8-4: NOISE CONSIDERATIONS – PREDICTION OF NOISE GENERATED BY HYDRODYNAMIC FLOW
IEC	60945	MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – GENERAL REQUIREMENTS – METHODS OF TESTING AND REQUIRED TEST RESULTS
IEC	61000	ELECTROMAGNETIC COMPATIBILITY (EMC)
IEC	61892-6	MOBILE AND FIXED OFFSHORE UNITS - ELECTRICAL INSTALLATIONS - PART 6: INSTALLATION
IEC	61892-7	MOBILE AND FIXED OFFSHORE UNITS - ELECTRICAL INSTALLATIONS - PART 7: HAZARDOUS AREAS
IEC	62337	COMMISSIONING OF ELECTRICAL, INSTRUMENTATION AND CONTROL SYSTEMS IN THE PROCESS INDUSTRY – SPECIFIC PHASES AND MILESTONES
IEC	62381	AUTOMATION SYSTEMS IN THE PROCESS INDUSTRY- FACTORY ACCEPTANCE TEST (FAT), SITE ACCEPTANCE TEST (SAT) AND SITE INTEGRATION TEST (SIT)
IEC	62382	CONTROL SYSTEMS IN THE PROCESS INDUSTRY – ELECTRICAL AND INSTRUMENTATION LOOP CHECK
IMO - INTERNATIONAL MARITIME ORGANIZATION		
IMO	MEPC 107(49)	REVISED GUIDELINES AND SPECIFICATIONS FOR POLLUTION PREVENTION EQUIPMENT FOR MACHINERY SPACE BILGES OF SHIPS
IMO	MEPC 108(49)	REVISED GUIDELINES AND SPECIFICATIONS FOR OIL DISCHARGE MONITORING AND CONTROL SYSTEMS FOR OIL TANKERS

ISA - INTERNATIONAL SOCIETY OF AUTOMATION		
ISA	RP 42.00.01	NOMENCLATURE FOR INSTRUMENT TUBE FITTINGS
ISA	TR 20.00.01	SPECIFICATION FORMS FOR PROCESS MEASUREMENT AND CONTROL INSTRUMENTS - PART 1: GENERAL CONSIDERATIONS
ISA	18.1	ANNUNCIATOR SEQUENCES AND SPECIFICATIONS
ISA	20	SPECIFICATION FORMS FOR PROCESS MEASUREMENT AND CONTROL INSTRUMENTS, PRIMARY ELEMENTS, AND CONTROL VALVES
ISA	51.1	PROCESS INSTRUMENTATION TERMINOLOGY
ISA	75.01.01	INDUSTRIAL PROCESS CONTROL VALVES – PART 2-1: FLOW CAPACITY – SIZING EQUATIONS FOR FLUID FLOW UNDER INSTALLED CONDITIONS
ISA	75.05.01	CONTROL VALVE TERMINOLOGY
ISA	92.00.01	PERFORMANCE REQUIREMENTS FOR TOXIC GAS DETECTORS
ISA	92.00.02	INSTALLATION, OPERATION, AND MAINTENANCE OF TOXIC GAS-DETECTION INSTRUMENTS
ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION		
ISO	5167-1	MEASUREMENT OF FLUID FLOW BY MEANS OF PRESSURE DIFFERENTIAL DEVICES INSERTED IN CIRCULAR CROSS-SECTION CONDUITS RUNNING FULL - PART 1: GENERAL PRINCIPLES AND REQUIREMENTS
ISO	5167-2	MEASUREMENT OF FLUID FLOW BY MEANS OF PRESSURE DIFFERENTIAL DEVICES INSERTED IN CIRCULAR CROSS-SECTION CONDUITS RUNNING FULL - PART 2: ORIFICE PLATES
ISO	5167-5	MEASUREMENT OF FLUID FLOW BY MEANS OF PRESSURE DIFFERENTIAL DEVICES INSERTED IN CIRCULAR CROSS-SECTION CONDUITS RUNNING FULL - PART 5: CONE METERS
ISO	10497	TESTING OF VALVES - FIRE TYPE-TESTING REQUIREMENTS
ISO	12490	PETROLEUM AND NATURAL GAS INDUSTRIES — MECHANICAL INTEGRITY AND SIZING OF ACTUATORS AND MOUNTING KITS FOR PIPELINE VALVES
ISO	13702	PETROLEUM AND NATURAL GAS INDUSTRIES – CONTROL AND MITIGATION OF FIRES AND EXPLOSIONS ON OFFSHORE PRODUCTION INSTALLATIONS - REQUIREMENTS AND GUIDELINES
ISO	15848	INDUSTRIAL VALVES – MEASUREMENT TEST AND QUALIFICATION PROCEDURES FOR FUGITIVE EMISSIONS – ALL PARTS
ISO	16852	FLAME ARRESTERS – PERFORMANCE REQUIREMENTS, TEST METHODS AND LIMITS FOR USE.
ISO	18453	NATURAL GAS CORRELATION BETWEEN WATER CONTENT AND WATER DEW POINT

ISO	23251	PETROLEUM, PETROCHEMICAL AND NATURAL GAS INDUSTRIES - PRESSURE-RELIEVING AND DEPRESSURING SYSTEMS
ISO	20456	MEASUREMENT OF FLUID FLOW IN CLOSED CONDUITS - GUIDANCE FOR THE USE OF ELECTROMAGNETIC FLOWMETERS FOR CONDUCTIVE LIQUIDS.
NACE - THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS		
NACE	MR0175 / ISO 15156 CIR 1 TO PT 3	PETROLEUM AND NATURAL GAS INDUSTRIES – MATERIALS FOR USE IN H2S – CONTAINING ENVIRONMENTS IN OIL AND GAS PRODUCTION – PART 3: CRACKING-RESISTANT CRAS (CORROSION-RESISTANT ALLOYS) AND OTHER ALLOYS TECHNICAL CIRCULAR 1 TO PART 3
NFPA - NATIONAL FIRE PROTECTION ASSOCIATION		
NFPA	15	STANDARD FOR WATER SPRAY FIXED SYSTEMS FOR FIRE PROTECTION
NFPA	72	NATIONAL FIRE ALARM AND SIGNALLING CODE
NFPA	496	STANDARD FOR PURGED AND PRESSURIZED ENCLOSURES FOR ELECTRICAL EQUIPMENT
OIML – ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE		
OIML	R117	DYNAMIC MEASURING SYSTEMS FOR LIQUIDS OTHER THAN WATER
ANP - AGÊNCIA NACIONAL DO PETRÓLEO, GÁS NATURAL E BIOCOMBUSTÍVEIS		
RESOLUÇÃO CONJUNTA ANP/INMETRO Nº1 (10/JUNHO/2013)		"RESOLUÇÃO CONJUNTA ANP-INMETRO Nº 1", ISSUED ON JUNE, 10th, 2013. NOTE: INCLUDES THE API, ISO, AGA, OIML ETC. STANDARDS MENTIONED IN THAT DOCUMENT.
INMETRO - INSTITUTO NACIONAL DE METROLOGIA, NORMALIZAÇÃO E QUALIDADE INDUSTRIAL		
PORTARIA Nº 115 (21/MARÇO/2022)		REQUISITOS DE AVALIAÇÃO DA CONFORMIDADE PARA EQUIPAMENTOS ELÉTRICOS PARA ATMOSFERAS EXPLOSIVAS - CONSOLIDADO.

2.1.2 All Regulatory Standards (Normas Regulamentadoras-NRs) in force, published in the Official Gazette of the Federal Government (Diário Oficial da União-DOU), shall be followed.

2.1.3 All applicable CNEN Regulatory Standards (Normas Regulatórias) in force, published in the Official Gazette of the Federal Government (Diário Oficial da União-DOU), shall be followed.

2.1.4 Classification Society

2.1.4.1 The detailed design shall be submitted to Classification Society for approval.

2.1.4.2 The Unified Requirements (URs) and Unified Interpretations (UIs) of IACS, applicable and in force in the detailing design, shall be observed and their requirements implemented.

2.1.4.3 The design and installation shall be updated following requirements, comments of Classification Society as well as URs and UIs mentioned in item 2.1.4.2.

2.2 Internal References

2.2.1 PETROBRAS General Specifications

DOCUMENT NUMBER	TITLE
CORPORATIVE DIRECTIVES	
DR-ENGP-M-I-1.3	SAFETY ENGINEERING GUIDELINE
DR-ENGP-I-1.15	COLOR CODING
TYPICAL DOCUMENTS	
I-ET-3000.00-1200-940-P4X-001	TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN
I-ET-3010.00-1200-251-P4X-001	REQUIREMENTS FOR BOLTING MATERIALS
I-ET-3010.00-1200-800-P4X-013	GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS
I-ET-3010.00-1200-800-P4X-015	REQUIREMENTS FOR TUBING AND FITTING (ALIGNED TO IOGP-JIP33 S-716)
I-ET-3010.00-1200-813-P4X-001	GENERAL CRITERIA FOR FLOW METERING SYSTEMS
I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-5140-700-P4X-001	SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-002	SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-003	ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS
I-ET-3010.00-5420-260-P4X-001	WATER / FOAM FIREFIGHTING SYSTEMS
I-ET-3010.00-5520-800-P4X-001	SUPERVISION AND OPERATION SYSTEM (SOS) SCREENS
I-ET-3010.00-5520-888-P4X-001	AUTOMATION PANELS
DOCUMENTS 3010.2Q	
I-DE-3010.2Q-1200-944-P4X-001	GENERAL NOTES
I-ET-3010.2Q-1200-200-P4X-001	PIPING SPECIFICATION FOR TOPSIDES
I-ET-3010.2Q-1200-200-P4X-002	PIPING SPECIFICATION FOR HULL
I-ET-3010.2Q-1200-800-P4X-001	INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS
I-ET-3010.2Q-1200-800-P4X-003	FLOW METERING SYSTEM (FMS)
I-FD-3010.2Q-5400-947-P4X-001	SAFETY DATA SHEET - TOPSIDES
I-FD-3010.2Q-5400-947-P4X-002	SAFETY DATA SHEET - HULL
I-LD-3010.2Q-1200-940-P4X-002	DOCUMENT LIST

DOCUMENT NUMBER	TITLE
I-MD-3010.2Q-1200-940-P4X-011	DESCRIPTIVE MEMORANDUM - AUTOMATION & CONTROL
I-RL-3010.2Q-1200-940-P4X-005	RELIEF AND BLOWDOWN REPORT

NOTE: All P&IDs listed in I-LD-3010.2Q-1200-940-P4X-002 – DOCUMENT LIST are reference documents.

3 MEASUREMENT UNITS

3.1 Requirements with Complementary Internal References

3.1.1 Clarifying flow measuriement units in I-ET-3010.2Q-1200-800-P4X-001 – INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS, I-ET-3010.00-1200-813-P4X-001 - GENERAL CRITERIA FOR FLOW METERING SYSTEMS and I-ET-3010.2Q-1200-800-P4X-003 - FLOW METERING SYSTEM (FMS): flow shall be in m^3/h at 15.6 °C and 101.325 kPa for design purposes and in m^3/h at 20 °C and 101.325 kPa for flow metering system.

4 TRANSMISSION AND CONTROL SYSTEMS

4.1 Overall

4.1.1 Refer to respective section in I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS

5 POWER SUPPLY SYSTEMS

5.1 Pneumatic System

5.1.1 Instrument Air Consumption

5.1.1.1 For air consumption calculation, in addition to requirements of I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS, gastight dampers can be considered as intermittent consumers and, thus, do not need to be taken into account for air consumption calculation.

6 GENERAL REQUIREMENTS FOR THE INSTRUMENTATION SPECIFICATION

6.1 Overall

6.1.1 For operating and environmental conditions refer to I-ET-3010.2Q-1200-800-P4X-001 – INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS.

6.1.2 All instruments that need a power supply higher than 24VDC shall be fed according to I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS. Remote I/O panels are only able to supply 24VDC. For further details, refer to I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

6.1.2.1 Instruments shall operate with floating 24VDC power supply. The instrument shall not galvanically connect the negative pole to ground and also shall not connect the positive pole to ground.

6.2 Preservation and Maintenance related requirements

6.2.1 It shall be foreseen facilities / available space for removal and maintenance of all instruments installed in tanks/vessels during operation phase.

6.2.2 All instruments shall be stored in a room with controlled temperature and humidity while not hooked up to their final position. Some instruments, such as analyzers, shall be stored powered on; others may have a preservation heater that shall remain powered on for as long as the equipment is not operational. Preservation shall be according to manufacturer requirements.

6.3 Installation

6.3.1 Process connection shall not be used for supporting heavier instruments, including manifolds, diaphragm seals etc. In these cases, other means for supporting shall be in accordance with API RP 551.

6.3.2 Instruments installed in high elevation that need support shall be provided with extra safeguarding to prevent them from falling down. As an example: this extra safeguarding may be performed using a stainless steel cable and an additional anchoring point. It shall not be used glue in supports. Special attention shall be given to ASTs and USTs.

6.3.3 All electrical/electronical components subjected to direct sun incidence shall have a cover, in order to minimize damage caused to excessive heating of the component's enclosure.

6.3.4 Temperature, pressure and level gauges shall be positioned so that scale visibility in ergonomic fashion is guaranteed. If proper positioning is not feasible, fixed platforms for Operator's access shall be foreseen. For further details, refer to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

6.3.5 In services where heat tracing is required, see item 22.2 for further details on Heat Tracing.

6.3.6 For cable and multicable installation also refer to item 16 - ELECTRICAL INSTRUMENTATION CABLES.

6.3.7 It is not allowed to install cables, cable trays, conduits, tubing or piping at void spaces.

6.4 Material Selection Requirements

6.4.1 Bolts used in all instrumentation (e.g. but not limited to, instruments, valves, equipment and accessories) shall fully comply with requirements of I-ET-3010.00-1200-251-P4X-001 – REQUIREMENTS FOR BOLTING MATERIALS.

6.4.2 The instruments, valves, devices accessories shall be specified with suitable materials for services with H_2S content as indicated by process data to prevent sulfide stress cracking and corrosion. The following standards, in the latest revisions, shall be reference for material specification in such cases:

I. NACE STANDARD MR0175/ISO 15156 CIR 1 TO PT 3 – PETROLEUM AND NATURAL GAS INDUSTRIES – MATERIALS FOR USE IN H2S – CONTAINING ENVIRONMENTS IN OIL AND GAS PRODUCTION - PART 3:CRACKING-RESISTANT CRAS(CORROSION-RESISTANT ALLOYS) AND OTHER ALLOYS TECHNICAL CIRCULAR 1 TO PART 3.

II. API RP 551 – PROCESS MEASUREMENT INSTRUMENTATION.

6.4.3 All instruments and installation material shall be mounted and installed according to PETROBRAS standards and piping specifications I-ET-3010.2Q-1200-200-P4X-001 – PIPING SPECIFICATION FOR TOPSIDES, I-ET-3010.2Q-1200-200-P4X-002 – PIPING SPECIFICATION FOR HULL and typical hook-up drawings.

6.4.4 All material shall have high quality regarding dielectric rigidity, mechanical, thermal and chemical resistance, following in a strictly manner the standards used for its fabrication.

6.4.5 All material employed shall be non-hygroscopic, flame retardant and resistant to corrosion caused by a saline atmosphere environment with the presence of moisture and contact with hydrocarbons.

6.4.6 All screws, nuts and washers shall be made of bichromatized steel or AISI-316 stainless steel.

6.4.7 In order to avoid electrolytic corrosion, contacts between different metallic materials shall be prevented. Galvanic isolation shall be implemented where contact between different metallic materials is necessary.

6.4.8 Manufacturers shall keep uniformity of components for the same supply. The same model for plugs, junction boxes and all bulk material shall be used in all Unit (FPSO) modules.

6.4.9 For parts of the assembly not specifically detailed by PETROBRAS, the following requirements shall be taken into account:

I. Galvanized bolts and nuts shall not be used.

II. Ductile iron shall not be used without the prior formal approval of PETROBRAS.

III. All proposed plastic components shall be as a minimum flame retardant UV resistant, and non-degradable.

IV. All spindles, bushings, bolting, screws etc shall be manufactured from a suitable grade of stainless steel or other corrosion proof material.

V. All molded polyester parts shall be in an anti-static version for hazardous area locations.

VI. The use of asbestos in any form is prohibited.

VII. The use of aluminum and cast iron is prohibited.

VIII. Whenever there is a need to use different materials in contact, one with another one, which may favor galvanic corrosion, protection procedures shall be foreseen, such as insulation, besides the use of anti-oxidant products.

6.5 Types, Characteristics, Limitations and Interfaces

6.5.1 Instruments of the same type and function interconnected to CSS/SOS, including F&G detectors, and instruments of AFDS shall be of the same manufacturer.

6.5.2 Instrument air-supply regulator filters shall be of coalescent type.

6.5.3 Solenoid valves shall not be used for diameter greater than 1”.

6.5.4 All Ex-p equipment shall send to CSS a “ready to start” signal conditioned to the occurrence of purge after a shutdown. The absence of the confirmation from this signal shall prevent the respective equipment from starting.

6.5.5 Differential pressure transmitters shall have both high and low pressure taps ("H" and "L" respectively) clearly and visibly indicated on their bodies despite of being used as level, flow or differential pressure sensors.

7 REQUIREMENTS FOR SPECIFICATION OF TEMPERATURE INSTRUMENTS

7.1 Requirements with Complementary Internal References

7.1.1 For Temperature elements', gauges' and transmitters', as well as thermowells' requirements refer to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

7.1.2 Minimum accuracy of temperature transmitters shall be ± 0.5 °C, narrowing requirement of I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

7.1.3 Where equipment imposes vibration to the process connection, such as in dynamic equipment discharge line, the sensor shall be of vibration resistant type, even after following all requirements of I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

7.1.4 The length of the spring loaded rod that holds the sensor element shall be designed to have full contact with the bottom of thermowell bore at middle range of the spring for nominal thermowell dimensions (ref.: Figure 7.1-I).

NOTE: This design makes the rod length more resilient to uncertainties in both thermowell dimensions.

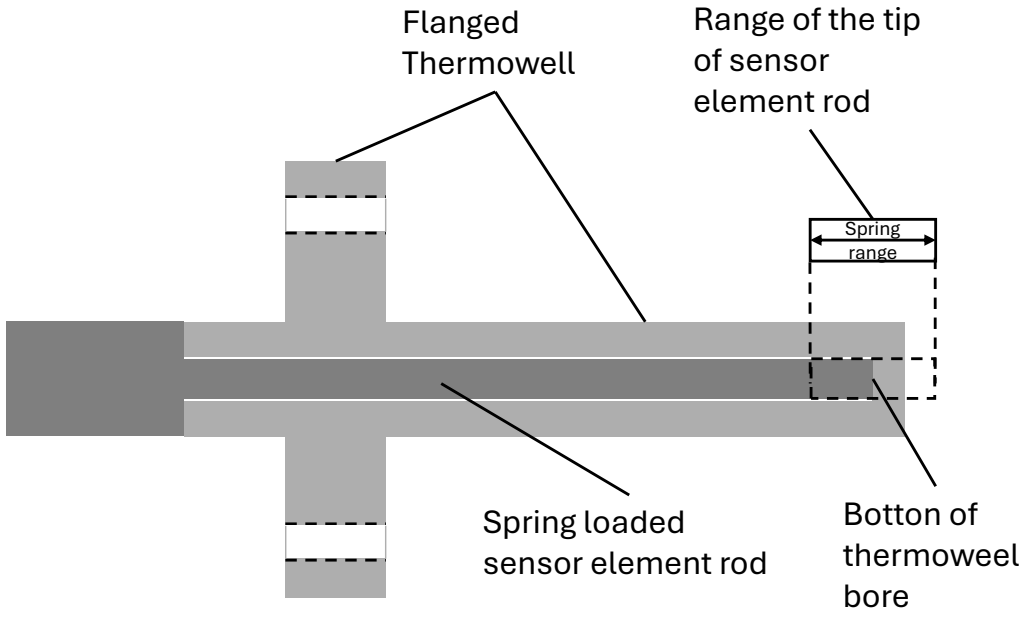


Figure 7.1-I – Spring loaded temperature element inserted into thermowell with spring in the middle of its range

8 REQUIREMENTS FOR SPECIFICATION OF PRESSURE INSTRUMENTS

8.1 Manometers (Pressure Gauges)

8.1.1 Pressure gauges on steam service shall be provided with a siphon coil (pig tail type) connection. Pressure gauges on pulsating service measurements (such as discharge of reciprocating compressors, pumps etc.) shall be provided with a pulsation damper.

8.1.2 In impulse line installation, alternately to the specified at I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS, close-coupled AISI 316 stainless steel 2-valve manifold according to API RP 551 may be used.

8.2 Pressure Transmitters

8.2.1 Pressure instruments in hot condensable gas, vapors and steam service shall be protected from process media by siphons coils or condensate seals.

8.2.2 2-valve manifold (1 blocking and 1 drain) shall be provided for impulse line installation or alternately, close-coupled AISI 316 stainless steel 2-valve manifold according to API RP 551.

8.3 Differential Pressure Transmitters

8.3.1 Differential pressure transmitters shall be provided with close-coupled AISI 316 stainless steel 5-valve manifold.

8.4 Diaphragm Seals

8.4.1 Adherence to the following requirements shall be demonstrated in order to ensure proper selection of the filling fluid:

I. Compatibility with process fluid in case of Diaphragm rupture, exposing the fill fluid to Process fluid, i.e., it does not react or contaminates the Process fluid.

II. Compatibility with the maximum temperature that it can reach, whether from Process or surroundings.

III. Specify a fill fluid that at minimum temperature that it can reach, whether from Process or surroundings, the variation in fill fluid viscosity does not affect the response time defined in item 8.4.3.

IV. The fill fluid vapor pressure shall not be achieved within the pressure and temperature design values.

8.4.2 Diaphragm seals shall be provided with a flushing ring between the process and the instrument connection to facilitate flushing with liquid from an external source, as per I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION

PROJECTS. There shall have 2 (two) flushing connections of ½" NPT(internal thread) located on opposite sides of the ring and provided with vent and drain valves.

8.4.3 The type of capillary (filling fluid, diameter etc.) shall minimize the influence of process and ambient temperature changes on the measurement. Response time—T90—of sealing systems shall be 5 s maximum.

8.4.4 Diaphragm seals shall be of integral design. Where capillary shall be used, it shall be AISI 316 stainless steel with AISI 316 stainless steel armoring and PVC covering. Capillary terminations shall be welded on both diaphragm seal and instrument sides.

8.4.5 If required, provision shall be made to heat tracing the capillary. See item 22.2 for further details on Heat Tracing.

8.4.6 Complementing what is specified in I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS regarding capillary installation.

I. Care shall be taken in routing the capillary to avoid effects of ambient temperature on the thermal expansion of the filling liquid.

II. Minimum curve radios shall be informed and used as base for routing.

8.4.7 Diaphragm seals shall not be used on vacuum services.

8.4.8 The Process Connection shall position the diaphragm seals to prevent deposit of dirt or debris on the seal surface.

9 REQUIREMENTS FOR SPECIFICATION OF LEVEL INSTRUMENTS

9.1 General

9.1.1 For level gauges and level transmitters requirements, as well as level measurement technologies selection and installation guidelines, refer to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS. In addition, the following general and specific requirements are mandatory.

9.1.2 The Process connection shall be designed to make the installation of level instruments not susceptible to the accumulation of dirt on the surroundings of the meter/sensor.

9.1.3 The use of perforated stilling well is mandatory for top mounted internal level measurement. Design, fabrication and installation of stilling wells shall be so as to avoid dirt built-up on its inside and surroundings.

9.1.3.1 Item 9.1.3 is not applicable to non-contacting radars of structural tanks, where stilling wells shall be avoided. The Contractor shall obtain Buyer's prior approval before using stilling wells for these instruments.

9.1.4 Level instruments' process connections shall be hooked up to taps on the sides of the monitored vessels, never to taps on their bottom.

9.1.5 The use of monoflange wafer valves is not allowed.

9.1.6 For services in the presence of gas and applications with potential loss of production, all level instruments shall have double block and bleed valves (DBB) for process connections.

9.1.7 Where electric heat tracing is necessary. See item 22.2 for further details on Heat Tracing.

9.1.8 Whenever the level transmitter uses a capillary with a remote seal and the response time is critical or the installation requires a complex routing of the capillary, it may be considered, as an alternative, the use of a level measurement technology consisting of two absolute pressure sensors, both with diaphragm seal in integral mount, wired to each other, calculating the differential pressure and one of them performing the function of level transmitter, instead of only one D/P cell. For this type of instrument shall be presented, for Buyer approval, the maximum level measurement error due to static pressure.

9.1.9 A document describing a Vessel/Tank sketch of all level instruments connections shall be issued, during Detailed Engineering Design. The Level Sketch document shall be issued according to the following template:

I-DE-3010.XX-XXXXX
_LEVEL_SKETCH.xlsx

9.1.10 For Radar Level Transmitter, it shall be implemented in 3D modeling a cylinder between the bottom of the instrument to the bottom of the tank/vessel in order to avoid any interference of piping or structures in the level measurement.

9.2 Energy Absorption Level Transmitter

9.2.1 Energy absorption transmitter shall be used for oil-water interface level measurement.

9.2.2 These transmitters shall be installed by the side of the vessel. Their communication protocol shall be 4-20mA + HART.

9.2.3 Tools for installation─retraction and insertion─ for maintenance and range adjustment of the transmitters without need to stop the process shall be supplied. Design and sizing shall be according to manufacturer. Special tools for removal, insertion and maintenance shall also be supplied.

9.2.4 For energy absorption level transmitters, the probes process hook up shall be approved by Buyer before respective equipment can be approved for construction since equipment nozzles are the equipment connection which is part of Process Connection (see I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS for connections definitions).

9.3 Nucleonic Profiler Level Transmitter

9.3.1 The transmitter shall be on top of equipment (e.g. vessel).

9.3.2 Each transmitter shall have 2 (two) probes for reception.

9.3.3 Each transmitter is connected to a panel; being those panels located at AEPR. Each panel houses a controller dedicated to performing software actions in the level measurement, such as filter oscillations in the readings. These panels shall communicate through 4-20mA signal with CSS.

9.3.4 Each one of these panels shall send 5 (five) 4-20mA signals to CSS, each one dedicated to:

I. Sand-water interface.
II. Water-emulsion interface (see item 9.3.4.1).
III. Emulsion-oil Interface.
IV. Oil-foam interface.
V. Foam-gas interface.

9.3.4.1 The signal of item 9.3.4-II shall be used to control the Water Level Control Valve.

9.3.5 Each one of these transmitters shall communicate with CSS through Modbus link to provide information related to signal strength and diagnostics to each detector of the 2 (two) probes. The Modbus map shall be able to provide means to configure the densities for 4-20mA by control room SOS HMI.

9.3.6 Each one of these transmitters shall have a dedicated screen configured in SOS according to manufacturer standards. For further details, refer to I-ET-3010.00-5520-800-P4X-001 – SUPERVISION AND OPERATION SYSTEM (SOS) SCREENS.

9.3.7 Nucleonic profiler level transmitters that need isolated area surrounding the vessel are not accepted.

9.3.8 For all radioactive materials and equipment supplied with the Unit (FPSO), Seller shall comply with applicable CNEN (Comissão Nacional de Energia Nuclear, part of Ministry of Science, Technology and Innovation) requirements and is responsible for the collection, management, handling, temporary storage and final disposal of any contaminated waste, including radioactive sources until Unit (FPSO) handover.

9.3.9 It shall be provided a software to be installed at maintenance/engineering workstation to allow calibration and instrument configuration. It shall also provide means to back up instrument configuration.

9.3.10 Radiation sources shall be provided with means to allow their isolation to ensure safety entry at the vessel. The isolation device shall have means for locking devices installation.

9.3.11 Selected instrument shall have factory calibration certification valid for at least 30 years without changing the radioactive source. The calibration certificate shall be revalidated during commissioning phase (offshore).

9.4 Electrical Conductivity Profiler Level Transmitter

9.4.1 This type of level transmitter shall be used for interface measurement control as well as high and low alarms of Pre-Oil Dehydrators and Oil Dehydrators.

9.4.2 Those transmitters shall be mounted at the top of the aforementioned vessels, in a 6” flange. It is recommended to install this instrument so that the flow passes through the rings (rings orthogonal to the flow).

9.4.3 Maintenance space for removal of this instrument during operation phase shall be foreseen. All other provisions necessary for the operation of this transmitter (such as nitrogen supply for pressurization), shall also be foreseen.

9.5 Level Gauge Indicators

9.5.1 Level gauges shall have drain and vent connections with valves and caps included in the instrument.

9.5.2 Level gauges shall have adequate heating when operating with viscous product subject to solidification at environment temperature. See section 22.2 for other requirements.

9.5.3 Concurring with I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS, each level gauge shall have its visible range greater than the range of the correspondent level transmitter. Along with the level gauge, a graduated scale shall be supplied, both in percentage and mm, indicating:

I. Tag of the correspondent LIT.

II. Control set-points (LSL and LSH).

III. Interlocking set points (LSLL and LSHH).

IV. Expected maximum level discrepancy to LIT reading, due to density variations.

9.5.4 Complementing I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS, whenever a level gauge with more than one section, there shall be an overlap between two adjacent sections of visible range, i.e., the top process connection center line of the lower level gauge section shall be above the bottom process connection center line of the upper level gauge of at least 50 mm.

9.5.5 For condensates and applications with viscous and dirty fluids with the possibility of fouling, magnetic type level gauge with sealed buoy shall be used. Means shall be provided to prevent the collapse of the buoy.

9.5.5.1 For oil and gas applications, magnetic level gauges buoy shall be eccentric in relation to chamber center line to improve magnetic influence on the scale by approaching buoy to chamber wall.

9.5.5.2 Buoy shall be coated for slip assistance and shall be sealed.

9.5.5.3 The body of the level gauge shall be 3 inches.

9.5.6 Reflex type level gauges process connections shall be TOP-BOTTOM; Magnetic type level gauges process connections shall be SIDE-SIDE. Level gauges shall allow adjustment of the visual field by turning the display.

9.5.7 Gauges shall be positioned so that scale visibility in ergonomic fashion is guaranteed. If proper positioning is not feasible, fixed platforms for Operator’s access shall be foreseen.

9.5.8 Measuring range of magnetic type level gauges shall be aligned with the Level gauge nozzles center lines, according to following drawing:

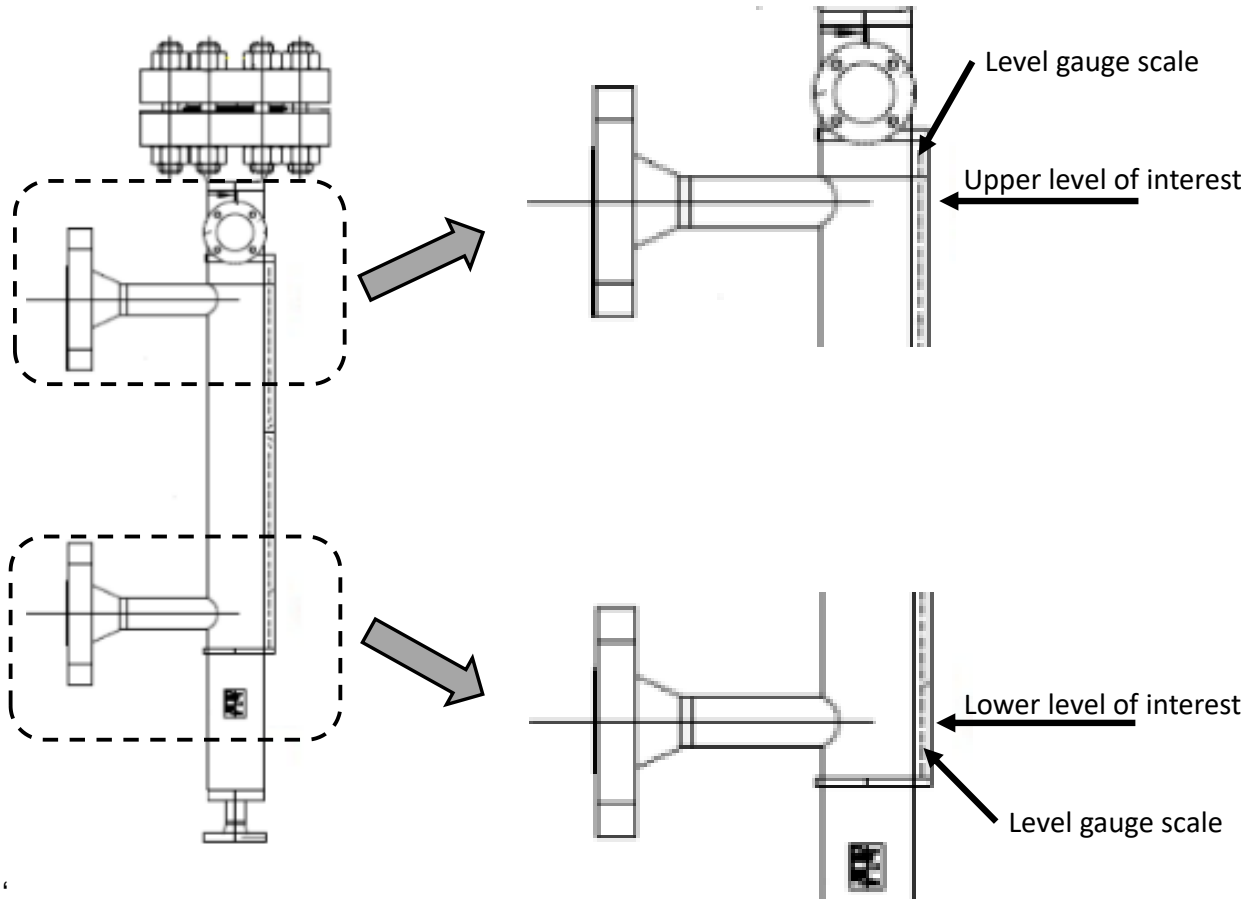


Figure 9.5-I - Magnetic type gauge nozzle vs scale alignment

9.6 Guided Wave Radar Level Transmitter

9.6.1 The probes of guided wave radar level transmitters shall be rigid type.

9.6.2 The probes of guided wave radar level transmitters shall not touch any metallic surfaces.

9.6.3 The Waveguide fixing method shall be evaluated during the detailing phase to avoid pendulum movement caused by process flow or hull sway.

10 REQUIREMENTS FOR SPECIFICATION OF SAFETY INSTRUMENTS

10.1 Gas Detectors

10.1.1 General Requirements

10.1.1.1 Gas detectors shall be type approved and installed according to DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE and Safety Studies requirements.

10.1.1.2 All Gas Detectors, except those integrating AFDS, shall be linked to CSS – FGS (Topsides Detectors) and CSS-HFGS (Hull Detectors), where voting logics and diagnosis shall be carried out.

10.1.1.3 The instrument output shall be 4-20mA + HART. HART shall be the main remote faults and warnings' diagnostics and configuration protocol. The range from 0 to 4 mA can also be used for faults and warnings' indication, as long as every detector has functional HART communication and diagnostic current levels are different from those indicating general fault or absent instrument.

10.1.1.4 All gas detectors of the same type shall be of the same manufacturer.

10.1.1.5 Each gas detector shall be provided with resources to allow calibration without opening its enclosure and shall have protection against outside elements such as rain, dust, water spray etc. Proper accessories shall be provided, including the ones for gas detectors mounting/installation. Gas calibration kits shall be provided in a sufficient quantity for testing each gas detector during commissioning and pre-operation phases.

10.1.1.6 All detectors shall be marine approved and approved by Classification Society.

10.1.1.7 All material and hook-up associated to the installation of gas detectors (O_2 gas detectors, hydrogen gas detectors, CO_2 gas detectors, open path combustible gas detectors and point combustible gas detectors, open path toxic gas detectors and point toxic gas detectors) such as cables, ladders, supports, among others, shall be provided.

10.1.1.8 Open Path detectors location and hook-up shall comply with the following requirements.

I. shall not be hooked up to structures subjected to high vibration nor water droplets.

II. shall be hooked up to a flat plate, to be welded or bolted directly to the structure; 'U' type clamps shall not be used.

III. shall not have the beam crossing permanently congested areas, such as piping, equipment, structures etc.

IV. In the 3D modeling it shall be implemented a cylinder between Transmitter (Tx) and Receiver (Rx) so that no clash happens between the beam and other structures/piping.

V. shall be installed so that the vertical clearance between the beam and any areas subjected to people's circulation is no less than 2.5 meters; hooking up over areas subjected to circulation of people, such as escape routes, shall be avoided.

VI. shall be installed so that parallel beams among two or more Transmitter (Tx) and Receiver (Rx) pairs do not interfere with each other, observing at least the following strategies: (1) parallel beams shall be at least 1m distant from each other; (2) Tx and Rx locations shall be alternated so that Tx from one pair cannot interfere with Rx of the closest parallel pair (anti-parallel assembly).

VII. shall be installed so that the distance between Tx and Rx does not exceed 90% of the maximum recommended distance according the manufacturer for the selected model, or does not exceed 40 meters, whichever is the least.

VIII. shall have the presence of the beam properly signaled by: (1) a line painted on the floor right below, mimicking the projection of the beam; (2) a rope (or the like) linking Tx and Rx hook up supports and (3) a sign fixed in a visible position close to the beam.

10.1.1.9 All detectors shall be supplied with all necessary tools to installation, configuration and calibration.

10.1.1.10 Access for maintenance shall be foreseen during Detail design.

10.1.1.11 Contractor and gas detector manufacturer shall issue during Detailed Engineering Design phase the Parameters List for each type of detector including the setting of all parameters to guarantee the detector performance (detection / diagnostic) and comply with the requirements described on Safety studies and others design documents.

10.1.2 Combustible, O_2 and CO_2 Gas Detectors

10.1.2.1 Combustible gas detectors (point or open path), O2 gas detectors and CO2 gas detectors technology and applications shall comply with DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE definitions.

10.1.2.2 Combustible, O_2 and CO_2 gas detectors shall be suitable for operation in the zone it is installed but shall be rated for "Zone 2, Group IIA, T3" hazardous areas as minimum requirement. The CO_2 gas detectors shall withstand temperatures as low as minus 20 °C (– 20 °C).

NOTE: By minimum requirement it is meant that even if deterctor is installed in a non-classified zone it shall be rated for Zone 2, Group IIA, T3 hazardous area.

10.1.2.3 The main characteristics of the IR point flammable gas detectors are:

I. Detection principle: Infra-red absorption by hydrocarbon gases.

II. Range of detection: 0% to 100% LEL.

III. Accuracy: +/- 5% FULL SCALE (@ 25 °C).

IV. Analogue signal 4-20mA + HART to include 0% – 100%LEL signal and faults.

V. Temperature range shall be –55 °C to +75 °C.

VI. Ingress protection IP56.

VII. Performance certificate and type approval certificate by international agency body, both for sensor and transmitter.

VIII. Equipped with automatic self-testing features of electronics and optical integrity.

10.1.2.4 The main characteristics of the open path IR flammable gas detectors are:

I. Detection principle: Infra-red absorption by hydrocarbon gases.

II. Each detector includes an IR Source and a Receiver (detector with mirror is not acceptable).

III. Range of detection: 0 to 5 LEL·m.

IV. Path length: 5 to 120 meters.

V. Analogue signal 4-20mA + HART to include 0 – 5 LEL·m signal and faults.

VI. Temperature range shall be –40ºC to +60ºC.

VII. Ingress protection IP56.

VIII. Performance certificate and type approval certificate by international agency body, both for sensor and transmitter.

10.1.3 Toxic Gas Detectors

10.1.3.1 Toxic gas detectors technology and applications shall comply with DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE definitions. These detectors shall be suitable for operation in “Zone 1, Group IIB + H2, T1” hazardous areas.

10.1.4 Hydrogen Gas Detectors

10.1.4.1 Hydrogen gas detectors technology and applications shall comply with DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE definitions. These detectors shall be suitable for operation in “Zone 1, Group IIB + H2, T1” hazardous areas.

10.2 Flame Detectors

10.2.1 Flame detectors shall be type approved and in full compliance with DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE and Safety Studies’ requirements.

10.2.2 The instrument output shall be 4-20mA + HART. HART shall be the main remote faults and warnings’ diagnostics and configuration protocol. The range from 0 to 4 mA may also be used for faults and warnings’ indication, as long as every detector has functional HART communication and diagnostic current levels are different from those indicating general fault or absent instrument.

10.2.3 Easy access to clean up the lenses shall be provided. 2 (two) test devices, from the same manufacturer of the detectors, shall be supplied.

10.2.4 Flame detectors shall have effective algorithms to prevent false alarms induced by welding, lightning, x-rays, sparks, lightning, lamps (sodium vapor, fluorescent, LED etc)

and sunlight. Protection accessories against rain and excessive heat shall be provided to flame detectors installed in open areas.

10.2.5 Flame detectors' allocation and hook up:

10.2.5.1 Allocation of flame detectors shall strictly comply with DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE and Safety Studies' requirements.

10.2.5.2 In case optical flame detectors are allocated at top decks of the modules and other areas with straight field of view of flare stack or subject to sensitizing by reflections, special care shall be taken when design and executing detectors' hook up and orientation. The positioning of flame detectors shall be optimized based on the flare position to minimize false detections caused by the flare, either directly or by reflection.

10.2.5.3 Protection accessories against sunlight and high flame flare shall be provided to the flame detectors installed in areas subjected to direct or reflected IR radiation. Painting of reflective surfaces may be considered as a means to mitigate reflections.

10.2.6 Proper installation accessories, such as mounting bracket/support and similar, shall be provided. Mounting brackets/Supports shall have vertical and horizontal orientation indication for assembly reference. Assembly on spots subject to high vibration shall be avoided.

10.2.7 All material and hook-up associated to the installation of flame detectors such as cables, ladders, supports, among others shall be provided.

10.2.8 All detectors shall be supplied with all necessary tools to installation, configuration and calibration.

10.2.9 All detectors shall inform the maximum power consumption in the worst condition (typically actuated with the heating resistance on).

10.2.10 Performance certificates and Classification Societies' approval for each detector model shall be presented for PETROBRAS appraisal.

10.2.11 All flame detectors shall be from the same manufacturer.

10.2.12 Contractor and Flame detector manufacturer shall issue during Detailed Engineering Design phase the Parameters List for each type of detector including the setting of all parameters to guarantee the detector performance (detection / diagnostic) and comply with the requirements described on Safety studies and others design documents.

11 REQUIREMENTS FOR SPECIFICATION OF FLOW INSTRUMENTS

11.1 General

11.1.1 Refer to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS and I-ET-3010.00-1200-813-P4X-001 - GENERAL CRITERIA FOR FLOW METERING SYSTEMS for mandatory technical requirements on flow meters. Elements, transmitters and accessories shall also comply with all requirements under the following items.

11.1.2 Minimum straight upstream/downstream pipe runs length shall comply with, whichever is larger among: manufacturer's recommendation, or:

I. ISO 5167-1 and ISO 5167-2 – for metering by orifice plate.

II. ISO 5167-5 – for metering by cone meter.

III. AGA-9 – for gas metering by ultrasonic flow meter.

IV. API MPMS 5.2 - for oil metering by positive displacement flow meter.

V. API MPMS 5.3 - for oil metering by turbine flow meter.

VI. API MPMS 5.6 – for oil metering by Coriolis flow meter.

VII. API MPMS 5.8 – for oil metering by ultrasonic flow meter.

VIII. ISO 20456 – for magnetic flow meter.

11.1.3 Flow meter signals to CSS shall be originated by Smart transmitters with 4-20mA + HART.

11.2 Orifice Plate Measurements

11.2.1 Multivariable sensors transmitters may be used as an alternative to 3 (three) smart transmitters.

11.2.2 Orifice plate calculations shall be performed according to ISO 5167 requirements.

11.2.3 The orifice plates shall be flange pressure measurement – flange taps.

11.2.4 Drain hole shall not be used on the orifice plates. The separation of the undesired fluid shall be done online or with a drain in the orifice carrier.

11.2.5 The β factor shall comply with I-ET-3010.00-1200-813-P4X-001 - GENERAL CRITERIA FOR FLOW METERING SYSTEMS. In case of divergence, Buyer shall be consulted.

11.2.6 Senior orifice fitting device shall be provided where indicated on P&IDs. Maintenance area and access shall be foreseen by detailed design and used as base for pipe design.

11.2.7 Orifice plates, both spare and the initial plates shall not be assembled in line until the conclusion of pipe cleaning. Until such time, these plates shall be stored in a proper room with controlled temperature and humidity.

11.2.8 Meter Tubes (Straight Pipe Runs)

11.2.8.1 Meter tubes shall be mounted between flanges (spools), and tags shall be FX and FY, according to I-ET-3000.00-1200-940-P4X-001 – TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.

11.2.8.2 Meter tubes mechanical characteristics such as line schedule etc shall comply with the requirements of appropriate pressure class even after the finishing process of machining and polishing to adjust internal roughness. Test certificates in compliance with ISO standard (internal roughness etc) shall be issued and handed over upon delivery in order to allow complete tracking.

11.2.8.3 Upstream and downstream straight pipe runs that are part of a metering point shall have external identification with serial number.

11.2.8.3.1 Straight pipe runs shall be designed taking into account the maximum uncertainty of pipe internal diameter. Refer to both I-ET-3010.00-1200-813-P4X-001 - GENERAL CRITERIA FOR FLOW METERING SYSTEMS and to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS for more details.

NOTE: This requirement is present in both referred specifications and is also referred in the current one given the importance for it to be followed.

11.2.9 A Zanker flow conditioner shall be used in order to reduce requirements to the minimum straight length of the meter tube. Flow conditioner shall only be installed after conclusion of pipe cleaning.

11.2.9.1 For water applications with orifice plate, flow conditioner may be omitted to achieve pressure drop requirements.

11.3 Positive Displacement Flow Meters

11.3.1 Oval Gears Positive Displacement flow meter can be used for liquids of high and low viscosity. The instrument selection shall conform to manufacturer's recommendation for maximum flow rate for continuous service and viscosity rate class. Its construction with special gears teeth profiles and special materials shall be suitable for viscous fluids containing hard solid impurities (sand etc) up to 2% and Ø1 mm.

11.3.2 The Positive Displacement meter can be installed horizontally or vertically; when mounted vertically, flow shall be ascendant.

11.4 Mass (Coriolis) Flow Meters

11.4.1 Coriolis meters shall be configured for pulse signal output. It shall be verified pulse signal compatibility with respective flow computer prior to a purchase order of either.

11.4.2 Coriolis meters may be installed either horizontally or vertically. The preferred installation is vertical with the flow up through the sensor and with the sensor at lowest point of the ascending pipe. If horizontal position is selected, the “U” shape of the Coriolis shall be directed downwards for liquids applications and upwards for gas applications.

11.4.2.1 Coriolis meter shall be installed so that full drainage of tubes is feasible by means of gravity.

11.4.3 Coriolis meters shall not be used on liquid services where cavitation or flashing may occur.

11.5 Magnetic Flow Meters

11.5.1 Magnetic flow meters may be used for water applications and for corrosive or low pressure drop services.

11.5.2 To avoid any risk of damage to meter lining by vacuum, Magnetic flow meters shall not be installed on reciprocating pump suction lines.

11.5.3 Magnetic flow meters shall be installed in a section of piping that remains continuously filled with liquid.

11.6 Ultrasonic Meters

11.6.1 Ultrasonic meters for liquid hydrocarbon applications shall be avoided when BS&W or gas content is high.

11.6.2 Ultrasonic meters shall be selected observing Reynolds number, viscosity and fluid velocity of the application.

11.6.3 Ultrasonic meters for gas application shall be avoided when application has significant content of carried liquid/condensate.

11.6.4 For monitoring gas applications with high flow range and low pressure, preference is to use ultrasonic meters for flare. Ensure there is sufficient clearance around the meter to allow for transducer removal for calibration and maintenance.

11.6.5 Ultrasonic flow meters interconnected to CSS shall have 4-20mA + HART output. Refer to I-ET-3010.00-1200-813-P4X-001 - GENERAL CRITERIA FOR FLOW METERING SYSTEMS for output requirements for flare gas measurement.

11.7 Cone Meters

11.7.1 The pressure taps shall be placed on the upper horizontal section of the pipe, between the 3 (three) or the 9 (nine) o'clock positions.

11.7.2 Whenever a temperature transmitter is required for flow correction, the thermowell shall be installed upstream of the required upstream meter run.

12 CONTROL VALVES, CHOKE VALVES INCLUDED

12.1 General Requirements

12.1.1 Sizing, body type, end to end dimensions, construction and actuators for all control valves to be installed at the Unit (FPSO) shall comply with the requirements of I-ET-3010.2Q-1200-200-P4X-001 – PIPING SPECIFICATION FOR TOPSIDES, I-ET-3010.2Q-1200-200-P4X-002 – PIPING SPECIFICATION FOR HULL, and I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

12.1.2 Control Valve (including self-actuated valves) material shall comply with I-ET-3010.2Q-1200-200-P4X-001 – PIPING SPECIFICATION FOR TOPSIDES, Annex A and I-ET-3010.2Q-1200-200-P4X-002 – PIPING SPECIFICATION FOR HULL, Annex A. In case a cage is necessary, solid tungsten carbide shall be used.

NOTE: Item 12.1.2 is an overlay to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS

12.1.3 Control Valve data sheets shall inform, for each valve, normal, minimum and maximum flowrates. Also, for each flowrate, it shall inform pressure, temperature and all other fluid data required for valve calculations (density, viscosity, molecular weight, specific heat ratio (Cp/Cv), compressibility factor etc).

12.1.4 Control Valve manufacturers shall provide comprehensive calculation sheets for each valve. These sheets shall include, but not limited to, actuator sizing, noise, and flow velocity at the valves for all operational points and process fluid compositions at normal, minimum, and maximum flow rates.

12.1.5 Leakage class:

12.1.5.1 Control valves that share both interlocking and control functions (i.e., control valves for utilities, with a solenoid and a position transmitter) shall have leakage class VI, according to ANSI FCI 70-2.

12.1.5.2 Control valves directly connected to a line that discharges to flare shall have leakage as per I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

12.1.5.3 All other control valves shall have leakage class IV, according to ANSI FCI 70-2.

12.1.6 Control valves shall be built and tested to prevent fugitive emissions according to ISO 15848 – INDUSTRIAL VALVES – MEASUREMENT TEST AND QUALIFICATION PROCEDURES FOR FUGITIVE EMISSIONS' definitions: BH Tightness class and CC1 endurance class. For a list of control valves with such requirements, refer to I-MD-3010.2Q-1200-940-P4X-011 - DESCRIPTIVE MEMORANDUM - AUTOMATION & CONTROL.

12.2 Actuator

12.2.1 The actuator housing material shall be painted carbon steel or stainless steel and shall be adequate to marine environment.

12.2.2 The recommended valve actuator mounting position is vertical to the flow direction.

12.2.3 Actuators shall be sized so that normal throttling control is guaranteed under the minimum instrument air supply pressure condition. The specified air failure position shall be achieved given the stated shut-off differential pressure. Electrical or piston driven actuators may be considered for special conditions and upon Buyer's approval.

12.2.4 Actuator's design shall be such that its bearing requires low lubrication and low intervention under marine atmosphere, such that the actuator output torque is capable of moving the valve throughout its whole travel.

12.3 Positioners

12.3.1 Positioners shall be electro-pneumatic, smart type, with 4-20mA + HART (2 wires, 24 VDC) electronic signal. They shall be sized according to the volume of the actuator they are connected to.

12.3.2 A mechanical pointer and scale type travel indicator, directly coupled to the actuator, shall be provided for local indication of valve travel. Permanent marks for full open and full closed positions shall be provided at the travel limits.

12.3.3 All positioners that require position output to CSS or Package shall feature 4-20mA position feedback output.

12.3.4 Complementing requirements in I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS regarding stroke time and positioner dimensioning, positioners shall be calculated to assure a stroke time of 2 seconds per inch of the control valve or faster. Use of booster for fast action control loops can be considered and applied upon Buyer's approval.

12.4 Limit switches

12.4.1 When required, limit switches shall be of magnetic type (no moving parts).

12.4.2 Enclosures shall be hermetically sealed.

12.4.3 In-place no spark setpoint tuning shall be possible, without disassembling form valve body.

12.4.4 Limit switches shall withstand operation under 1A – 24 VDC condition.

12.5 Control Valves for Severe Service

12.5.1 Control valves for severe service shall be used according to the criteria described in I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

12.6 CHOKE VALVES

12.6.1 General Requirements

12.6.1.1 Choke valves installed at main production lines, between production risers and production/test manifolds, at water injection lines and at gas injection lines shall be pneumatic actuated with position transmitter. The actuation shall be done from the Topsides SOS HMIs through virtual hand switches.

NOTE: Requirement narrows down requirement in I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS regarding choke valve type of actuation (pneumatic vs electric).

12.6.1.2 Choke valves shall be able to receive different cages in order to have different possible CVs with the same valve. These CVs shall be determined for all process conditions, so that in no case the choke needs to be positioned less than 20% of its travel.

12.6.1.3 The Chokes' opening rate shall not exceed a maximum rate to prevent reservoir damage. PETROBRAS shall be queried for the maximum opening rate during the Detailing Engineering Design.

12.6.1.4 Chokes shall be suitable to perform slug control.

12.6.1.5 For further details, see instrumentation diagram in the I-DE-3010.2Q-1200-944-P4X-001 – GENERAL NOTES.

12.6.1.6 Choke Valves Actuator’s design shall be such that its bearing requires low lubrication and low intervention under marine atmosphere, such that the actuator output torque is capable of moving the valve throughout its whole travel.

13 SAFETY RELIEF VALVES (PSV)

13.1 General Requirements

13.1.1 Balanced bellows valve design shall be used for variable backpressures or when backpressure exceeds 10% of the set pressure. Balanced bellows shall also be applied when the PSV operates in services with toxic or corrosive fluids, as per recommended practice.

13.1.2 Pilot operated valves shall be used for high pressures, when backpressure exceeds 50% of the set pressure or where operating pressures are close to the set pressure and narrow blowdown is required. By narrow Blowdown it is meant a small difference between the set pressure and the closing pressure, with closing pressure being about 98% of set pressure. Design shall ensure that the main valve will continue to operate and relieve the required capacity even if the pilot valve fails. The use of pilot-operated valves requires PETROBRAS formal approval.

13.1.3 Selected PSVs shall be configurable so as to allow replacement of parts on site in order to:

I. replace a standard trim to balanced bellows type and vice-versa.

II. replace original nozzle type to a different orifice for a given body size.

13.1.4 All PSVs shall be foreseen with a threaded stem with sufficient stem length in order to allow for the online testing of the PSV. The PSVs placement in the 3D model shall have enough space above the valve in order to allow for the online testing equipment to be inserted.

13.1.5 Thermal relief PSVs shall have inlet diameter of ¾” and outlet diameter of 1”.

14 ON-OFF VALVES

14.1 General Requirements

14.1.1 Valve sizing, body type, valve construction, actuator sizing, actuation fluid, necessary accessories, installation requirements, interface with CSS and other features for all on-off valves (SDV, BDV, XV and ADV) to be installed at Unit (FPSO) shall comply with I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS and, for Topsides, comply with I-ET-3010.2Q-1200-200-P4X-001– PIPING SPECIFICATION FOR TOPSIDES, and for HULL comply with I-ET-3010.2Q-1200-200-P4X-002 – PIPING SPECIFICATION FOR HULL.

14.1.2 Solenoid valve for on-off valve actuation shall be made of AISI 316 stainless steel. Refer to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS other solenoid valves' requirements.

14.1.3 All on-off valve actuators (SDV, BDV, ADV and XV) shall be adequate to marine environment, made of painted carbon steel or stainless steel and their design shall be such that their bearing require low lubrication and low intervention under marine atmosphere, such that the actuator output torque is capable of moving the valve throughout its whole travel.

14.1.4 Actuators of SDVs and XVs shall preferably be pneumatically driven. For BDV, see item 14.3.2. Special cases shall be defined by detailed design documents.

14.1.5 All actuators for on-off valves shall comply with I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS and with ISO 12490. For conflicting requirements, the most restrictive requirement from either specification shall be used.

14.1.6 For all non-piggable valve that is both 600# (or greater) rated and has body size 10" (or greater), a triple eccentric butterfly valve can be considered, provided that the pressure drop does not affect other process equipment.

14.2 Shutdown Valves (SDV)

14.2.1 The data sheets of SDVs shall clearly inform the required actuation time. SDV manufacturer shall inform the actual closing time for each valve, at operation conditions. Deviations of actual closing time from required closing time shall be submitted to PETROBRAS for approval. Refer to I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS for more details.

14.2.2 All platform-limit SDVs (production, gas injection and water injection SDVs) shall have a Partial-Stroke Testing (PST) device. Refer to I-DE-3010.2Q-1200-944-P4X-001 – GENERAL NOTES for more details.

14.2.2.1 The PST shall be triggered by an additional solenoid.

14.2.2.2 The duration time of PST shall be adjustable by a local device, such as an inline needle valve at the pneumatic circuit.

14.3 Blowdown Valves (BDV)

14.3.1 Additionally to I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS definition, each BDV valve shall have 2 (two) check valves in series to keep the BDV closed in case of failure of air supply. Also refer to I-DE-3010.2Q-1200-944-P4X-001 – GENERAL NOTES.

14.3.2 The actuators of BDVs shall be pneumatic-driven. Hydraulic-driven BDV actuators are not accepted.

14.3.3 Mechanical temporization.

14.3.3.1 To avoid all BDVs to open simultaneously due to a blackout scenario/common cause electric failure, each BDV classified in I-RL-3010.2Q-1200-940-P4X-005 – RELIEF AND BLOWDOWN REPORT shall be supplied with a mechanical “Temporization Skid for Delaying BDV Opening” (TSDBO). This works as a backup for logic actuation, in order to determine a fixed period of time that BDV must still be kept closed, allowing it to open only when Flare would have capacity for BDV initial gas flow.

14.3.3.2 The mechanical temporization shall be based solely on pneumatic energy by using a volume to be depressurized from a controlled 4.9 barg to 2 barg, when the final pressure will actuate a pilot valve, depressurizing BDV’s actuator and opening the BDV.

14.3.3.3 The mechanical temporization skid shall be designed to receive three discrete electric signals. Two for open/close signal from CSS logic (BDY-1 and BDY-2). Other signal is a PLC/remote watchdog (KSY) and it shall be kept active (24 VDC) while the FGS system and remote I/O are running, if remote or FGS are down or off-line, (like all redundant CPU are stopped, or without power supply or full network failure on remote I/O etc) this signal shall be deactivated.

14.3.3.4 It shall be used 3-way solenoid valves in the TSDBO, two for the BDV itself (BDY-1 and BDY-2) and another to activate the temporization (KSY).

I. Solenoid BDY-1 shall be energized to close BDV.

II. Solenoid KSY must be energized when temporization is not required.

III. When only BDY-1 is de-energized, BDV shall be commanded to open immediately.

IV. When both BDY-1 and KSY are de-energized, BDV opening shall be delayed by mechanical temporization skid.

V. If KSY is de-energized and BDY-1 remains energized, this indicated a logic error. In such case, the respective BDV shall remain closed and the situation shall be addressed as per item 14.3.3.8.

14.3.3.5 A set of pneumatic accumulators shall be used to retain a volume at 4.9 barg. When a blackout occurs, KSY is activated and the accumulated air will be vented through a calibrated orifice of a metering valve adjusted to make the accumulator pressure to drop from 4.9 barg to 2 barg in the period of time specified for the BDV to open. When pressure reaches 2 barg a piloted valve is commanded, aligning BDV actuator to atmosphere, which starts BDV opening. A schematic of the effect of each valve in BDV state is shown in Figure 14.3-I.

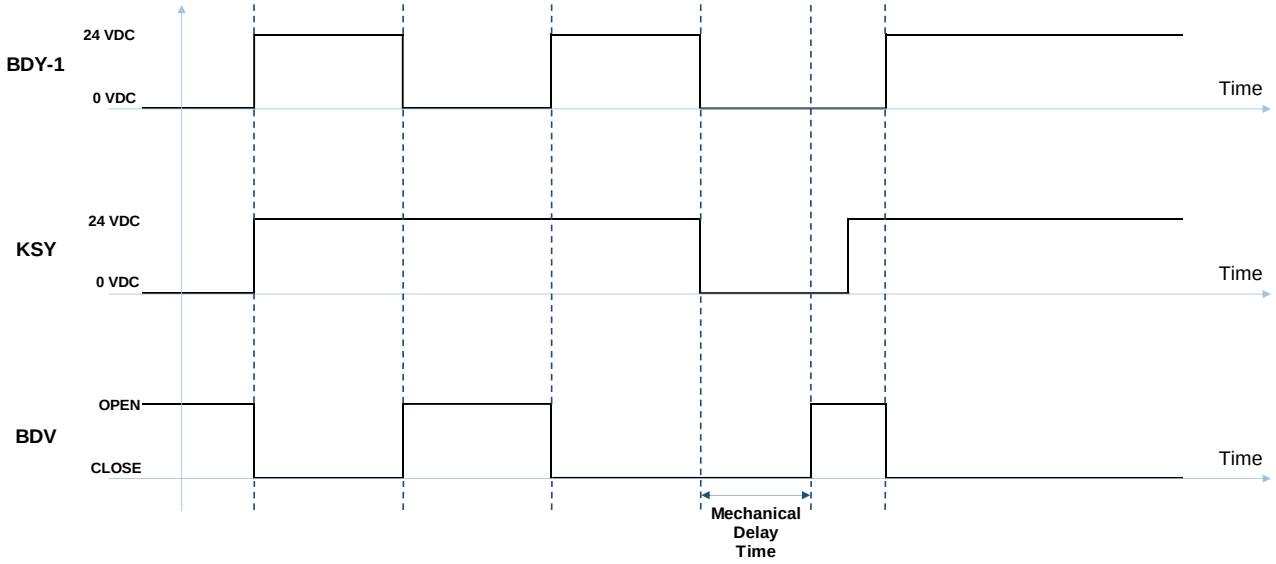


Figure 14.3-I - Solenoids effect on BDV

14.3.3.6 The total volume of pneumatic accumulators described in item 14.3.3.5 shall be dimensioned with the metering valve at 50% to ensure uniformity of all TSDBO in achieving the required delay time with each metering valve adjustment at 50%.

NOTE: Strict adherence is mandatory. Uniform 50% adjustment across all TSDBOs facilitates rapid visual detection of grossly misadjusted metering valves, enhances adjustment sensitivity enabling more precise delay time adjustment, and offers a more robust adjustment window that accommodates variations in accumulator volume and ambient temperature across the entire Metocean-defined range, ensuring system reliability under diverse operating conditions.

14.3.3.7 The second solenoid, BDY-2, shall also be provided, in order to allow the actuation of the BDV in case of failure of the KSY, avoiding, in that case, the mechanical temporization. Its failure mode shall be the opposite of BDY-1, i.e., to open the BDV through BDY-2, BDY-2 shall be energized.

14.3.3.8 The circuit of KSY shall be monitored, i.e., if CSS is commanding KSY to be energized but there is no current in its loop an alarm shall be activated at SOS HMI to inform that BDV temporization is activated and circuit shall be repaired.

14.3.3.9 For further details, refer to I-DE-3010.2Q-1200-944-P4X-001 – GENERAL NOTES and I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

14.4 Automatic Deluge Valves (ADV)

14.4.1 All ADVs shall be supplied in individual skids as defined in DR-ENGP-M-I-1.3 - SAFETY ENGINEERING GUIDELINE and I-ET-3010.00-5420-260-P4X-001 - WATER / FOAM FIREFIGHTING SYSTEMS and I-DE-3010.2Q-1200-944-P4X-001 – GENERAL NOTES. Current section defines requirements regarding Instrumentation discipline.

14.4.2 The actuators of ADVs shall be supplied with a quick exhaust device to minimize actuator venting time (this quick exhaust shall be supplied along with ADV actuator).

14.4.3 The ADVs shall be provided with 2 (two) position limit switches for monitoring of opened and closed statuses.

14.4.4 Each Automatic Deluge Valve (ADV) for water system or foam system shall be provided with a dedicated ADV local panel, installed within the ADV skid.

14.4.5 Signals to open and monitor ADVs positions as well as associated instrumentation of ADV local panel shall be hardwired connected to CSS Topsides Remote I/O Panel installed at AEPR on Module M-17. For further details, see item 20 below, I-DE-3010.2Q-1200-944-P4X-001 – GENERAL NOTES and I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

14.4.6 The circuit to actuate on ADV solenoid valve─ADY─shall be “energize to open” type signal and the circuit shall be line monitored. Refer to DR-ENGP-M-I-1.3– SAFETY ENGINEERING GUIDELINE for requirements on ADVs’ remote manual/automatic operation.

14.4.7 The solenoid valve for ADV─ADY─shall make ADV, once opened, remain opened until closing is locally and manually commanded by operator.

14.4.8 ADVs, when actuated by depressurization of fusible plugs’ network, shall be fully opened within 45s from fusible plug melting (refer to DR-ENGP-M-I-1.3– SAFETY ENGINEERING GUIDELINE).

14.4.9 The valves─ADVs─shall be certified and approved by recognized institutions for offshore application.

14.4.10 Additional requirements (such as fire testing) for ADVs and their accessories shall be addressed during the detailed design phase. Classification Society requirements and safety studies shall be incorporated into the evaluation.

15 SOLENOID VALVES

15.1 Overall

15.1.1 Refer to respective section in I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

15.1.2 See items 6.5.3 and 14.4.7.

16 ELECTRICAL INSTRUMENTATION CABLES

16.1.1 All cables shall be clearly identified for both outdoor and indoor installations.

16.1.1.1 For cables in outdoor installation:

I. The nameplate shall be made of stainless steel.

II. The nameplate shall be fixed with stainless steel or rubber clamps on the outer sheath and in both ends.

III. The nameplate size shall be suitable to the cable diameter.

IV. The wires inside panels or junction boxes shall be identified with plastic or rubberized labels.

16.1.1.2 For cables in indoor installation:

I. The nameplate shall be made of plastic or rubber.

II. The nameplate shall be fixed with plastic or rubber clamps on the outer sheaths and in both ends.

III. The nameplate size shall be suitable to the cable diameter.

IV. The wires inside panels or junction boxes shall be identified with plastic or rubberized labels.

V. It shall not be installed cables in and also not above the cold chamber refrigerated room and similar areas, with the exception of cables and multicables that the interconnection originates or ends for necessary equipment in those spaces.

17 INTERCONNECTION

17.1.1 For criteria related to modeling, sizing and documentation relative to cable trays, except occupation criteria, refer to I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS and I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

17.1.2 Cables/cable trays up to battery limit Junction Box shall be supplied mounted and tested. A calculation memory of the cable trays' occupation, consistent with 3D model and cable tray list, shall be supplied, respecting the occupation requirement defined in I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

17.2 Junction Boxes (JB)

17.2.1 JB tags shall be according to I-ET-3000.00-1200-940-P4X-001 – TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.

17.2.2 Refer to I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS for JB features and requirements.

17.2.3 JBs shall be with ample internal space to accommodate all its capacity of cables and multicables interconnected as well as applicable grounding. This dimensioning shall contemplate a minimum of 20% spare (e.g.: Terminals, cable entries, grounding) for each type of signal.

17.2.4 Mounting brackets, bolts and nuts shall also be of stainless steel material (AISI 316L). Supports shall be in carbon steel and painted according to I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.

17.2.5 All terminals shall be with non-sparking terminations, capable of withstanding vibration and environmental conditions. Number of terminals per instrument junction box shall be standardized. All terminals shall be standardized by type among the Unit (FPSO) (see I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS for terminal type).

17.2.6 According to cables and JBs definitions in I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS there are fire-resistant cables dealt by CSS subsystems PSD, FGS, HSD and HFGS. Additionally to segregations specified in I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS, these cables and the multicables shall be segregated by each subsystem and the JB shall segregate the terminals by subsystem, when installed inside the same junction box.

17.2.7 Where required, the JBs shall have 1 (one) ground bar for grounding the armoring of cables. This bar shall be internally wired to the ground terminal of the box and it shall be provided with sufficient screws for terminating armor grounding wires. Each gland or gland plate shall be electrically bonded to its relevant equipment ground bar or terminal/junction box grounding stud. For further details on grounding of instrumentation circuits, refer to I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

17.2.8 Each outdoor junction box shall have a ground bolt at the outside for bonding to the skid structure. This bolt shall terminate at the inside to provide a grounding means inside the junction box to the safety ground bar.

17.2.9 Instruments installed within the module that should be connected to its respective control panel at AEPR (M-17) or CCR-EA (Hull) shall have their cables routed through a junction box at the battery limit of the Module or Hull area. Routing and connections internal to module shall comply with this specification and I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

17.2.10 Instrumentation cables conveying actuation and position feedback signals to/from ADVs and BDVs, as well as signals from fire and gas detectors throughout the Unit (FPSO), shall be routed to CSS-FGS at AEPR (Module M-17) or to CSS-HFGS at CCR-EA through JBs to be located at the battery limits of the Modules. The criteria for quantifying and locating these junction boxes shall maximize availability of loops; at least one JB per Module level shall be foreseen.

17.2.10.1 Since these JBs are part of Safety System (FGS/HFGS), proper location and integrity protection shall be applied in order to withstand fire conditions.

17.3 Cable Glands

17.3.1 For Instrumentation Junction Boxes:

I. Cable glands for steel sheet enclosures shall have cylindrical thread with locknut.

II. For all other cases, the threaded joints shall be taper type, NPT with standardized tolerances, according to ASME B 1.20.1.

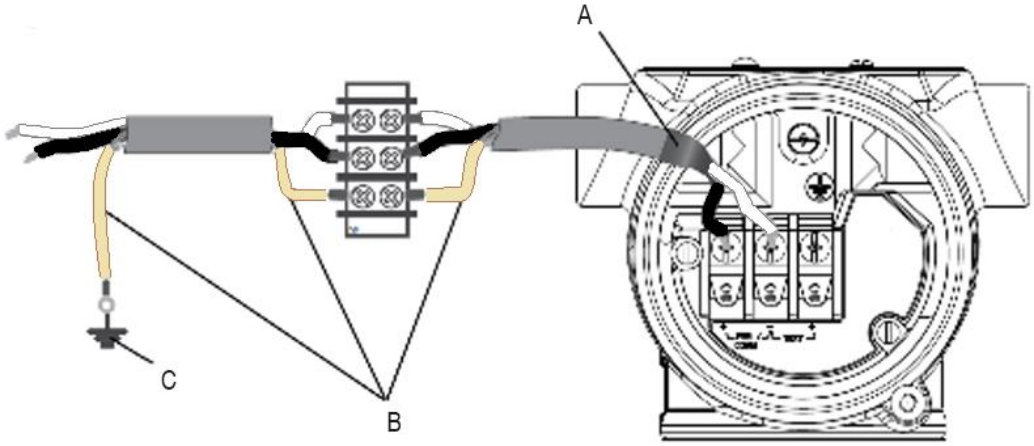
17.3.2 Cable glands connected to equipment installed in hazardous areas or with any type of Ex classification shall comply with IEC-60079-14, especially item 14 - Cable entry systems and blanking elements and its subitems; threads shall comply with IEC-60079-0.

17.3.3 Cable glands sealed with setting compound is not acceptable.

17.4 Electrical Hook-up

17.4.1 For electrical hook-up, special attention shall be given to electrical connections inside electrical terminal compartment of the instrument in order to connect the signal cables properly, do the right insulation for shield drain wire and also to protect the cables against any risks of short circuit (see Figure 17.4-I). For more details see I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

NOTE: This item gives further details of connections in relation to figures of electrical interconnections from I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.



A – Insulate the cable at the stripping point to prevent the drain wire from touching any exposed conductors or metal parts, and to ensure a neat and safe installation.
B – Insulate exposed shield drain wire.
C – Terminate cable shield drain wire to earth ground.

NOTE 1: To not polute the drawing, cable gland, junction box and Panel are not represented.
NOTE 2: Cable Armour, used in defined services, are not represented.

Figure 17.4-I - Electrical Hook-up – Instruments

18 GROUNDING AND ELECTROMAGNETIC COMPATIBILITY

18.1 Requirements from other sections related to current section

18.1.1 Following items have parts related to current section but to avoid repetition they are referred herein: Items 17.2.7, 17.2.8 and 17.4.1

19 IMPULSE LINES, PNEUMATIC TRANSMISSIONS AND HYDRAULIC TRANSMISSIONS

19.1 Overall

19.1.1 Refer to respective section in I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

20 NETWORK OF FUSIBLE PLUGS FOR ADV DRIVING

20.1 General Requirements

20.1.1 Refer to I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS and I-ET-3010.00-1200-800-P4X-015 - REQUIREMENTS FOR TUBING AND FITTING (ALIGNED TO IOGP-JIP33 S-716) for constructive characteristics, features and performance requirements of Fusible Plugs and Fusible Plugs' Networks.

20.1.2 Active and passive resources for protection against fire shall comply with the requirements defined in DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE, including fusible plug detectors quantity and location requirements.

20.1.3 Refer to item 14.4 for ADV features and performance requirements.

20.1.4 The following instrument/equipment shall make part of each fusible plug network:

I. Air supply tubing.

II. Air reservoir to guarantee air supply for at least 2 (two) acting cycles of the ADV in case of air supply failure.

III. Pressure gauge to monitor air supply line, suitable for pressure detection from 0 – 1200 kPa.

IV. Pressure reducing valve (regulator) to provide 500 kPa (fusible plug network) air pressure to the ADV actuators as indicated in the operational conditions of the ADV data sheets.

V. Restriction orifice (FO) with 0.4mm diameter to guarantee the recovery of air pressure in case of spurious leakages in the network. It is not acceptable to substitute the restriction orifice for a valve of any sort.

NOTE: The restriction orifice serves a dual purpose: enabling controlled repressurization for minor leaks to prevent spurious ADV opening, and limiting repressurization during a real fire scenario when the fusible plug melts. The design requirements for the fusible plug network, as specified in document I-ET-3010.00-1200-800-P4X-013 (GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS), are based on simulations using the defined restriction orifice size. A valve has a range of flow capacity that can be adjusted to have a greater or lower flow capacity in comparison to the restriction orifice and this significantly impacts system performance. An adjustment that excessively restricts the valve hinders repressurization of minor leaks, potentially causing spurious ADV opening. Conversely, an adjustment that leads to a valve with excessive flow capacity leads to rapid repressurization in a fire scenario, increasing ADV opening time, invalidating simulations, and may even prevent the BDV from opening, configuring a hazardous scenario. The use of a restriction orifice eliminates the possibility of incorrect flow capacity adjustment.

VI. By-pass valve, spring push-button type. Needle valve shall not be used for this service.

VII. For modules with fire detection made by fusible plugs and flame detectors, in the lower elevations, 2 (two) pressure transmitters with local indication in a 1oo2 voting scheme to monitor the inlet pressure of the ADV actuators and interlocking in case of low pressure shall be used, with a virtual switch set at 450 kPa (signal to FGS/HFGS Logic in order to open the ADV, to carry out actions according to I-FD-3010.2Q-5400-947-P4X-001 – SAFETY DATA SHEET - TOPSIDES and I-FD-3010.2Q-5400-947-P4X-002 - SAFETY DATA SHEET - HULL). In the upper elevations, 3 (three) PITs in a 2oo3 voting scheme shall be used, commanding the ADV directly (without flame detectors voting).

VIII. Areas protected only by fusible plugs network, 3 (three) PITs in a 2oo3 voting scheme shall be used.

IX. Pressure gauges to monitor the inlet pressure of the piloted valve, suitable for pressure detection from 0 – 600 kPa.

X. Pressure gauges to monitor the inlet pressure of the ADV actuator, suitable for pressure detection from 0 – 600 kPa.

XI. Piloted valves directly actuated by the fusible plug network with manual reset.

XII. Manual three-way ball valves for the manual depressurization of the ADV actuator.

XIII. Ball valve with plug.

XIV. ADV (See item 14.4).

XV. For further details and quantities of the items mentioned above, see instrumentation diagram in the I-DE-3010.2Q-1200-944-P4X-001 – GENERAL NOTES.

20.1.5 Certifying requirements for the fire-fighting equipment and materials shall comply with the Classification Society requirements.

20.1.6 Tubing to be used in the fusible plug networks shall be seamless with at 3/8” OD diameter and the connections fittings shall necessarily use the technology of double ferrules 3/8” OD.

21 ANALYZERS

21.1 General Requirements

21.1.1 Analyzers with sensing probes mounted into the process shall be provided with isolation and bypass valves for ease of maintenance. Casings or enclosures shall be ASTM A351 GR CF8M stainless steel made (AISI-316). Deviations shall be submitted to Buyer for approval.

21.1.2 Where required, suitable upstream sample conditioning and sample transportation system shall be designed and installed to provide sample to analyzer specifications. Sample conditioning and transportation system shall be installed on a self-standing panel (AISI 316L stainless steel). Samples shall be returned to the process as far as possible instead of venting or draining. When used, block valves shall be double block and bleed type. Sample systems shall avoid dead legs.

21.1.3 Panels installed in open areas (outdoors) shall be designed for IP-56 protection degree according to IEC-60529, shall be purged and pressurized according to NFPA 496 and IEC 60079-2 and shall comply with the area classification requirements.

21.1.4 Analyzer modules shall be smart microprocessor type. 4-20mA analogue output signal shall be provided for sending the analyzed variable data to CSS (PCS system).

21.1.4.1 Analyzer modules shall feature self-diagnostics tools. Digital output signals (voltage-free contact) shall be used for remote indication of malfunction and emergency stop.

21.1.4.2 HART protocol is required for detailed diagnostics and remote configuration. Other digital protocols such as Modbus RTU can be used, as long as the 4-20mA is still available and connected to CSS. In case the chosen analyzer allows for network connections, then the Analyzer shall be connected to Package Unit LAN, in order to allow for remote configuring / calibration / remote diagnostics.

21.1.4.3 Local alphanumeric display showing the instant measured value is required.

21.1.5 When applicable, the sampling system and all required accessories (such as, but not limited to: sampler pumps, fast loops, thermal insulation, filters, pressure regulator valves, air dryers) shall be supplied totally mounted and tested. All internal materials shall be, at least, AISI 316 stainless steel. Material for sample tubing, tubing and fittings used in sampling system shall also comply with I-ET-3010.00-1200-800-P4X-015 - REQUIREMENTS FOR TUBING AND FITTING (ALIGNED TO IOGP-JIP33 S-716)

21.1.6 If the analyzer has a probe, detailed design shall grant the necessary clearance and access to perform probe extraction and reinsertion. These methods shall thoroughly be detailed in the documentation. If special tools are required for hot removal and hot reinsertion of the probe, then they shall be supplied.

21.1.7 Power supply shall comply with I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

21.1.8 It shall be foreseen available space and access for maintenance/calibration around analyzer according to Manufacturer requirement/recommendation during operation phase.

21.1.9 Regarding analyzers that need to discard any fluid during its operation: Seller shall foresee manners to direct this fluid to the correct drain system.

21.1.10 Analyzers shall be designed and supplied with all the resources needed for onboard calibration and commissioning.

21.1.11 Manufacturers shall have technical support infrastructure in Brazil.

21.1.12 Whenever a sampling system is present, the sampling system shall be supplied by the analyzer vendor. The sample system of the analyzer shall have means to detect an obstruction in the flux of the samples (i.e. no flow condition). The malfunction alarm associated to the analyzer shall be raised at CCR in case this happens.

21.1.13 In case temperature and pressure affect the reading of the analyzer, then the analyzer shall be supplied with measurement and automatic compensation of these variables.

21.1.14 Commissioning of the analyzers in shipyard and during offshore activities shall be supervised by the manufacturer of the analyzer or by third-party certified companies.

21.1.15 For all gas analyzers, means shall be provided in order to remove water/gas condensate.

21.2 Inspection and Tests for all types of analyzers and chromatographs

21.2.1 INSPECTION AND TESTS AT THE FACTORY

21.2.1.1 Factory Acceptance Test (FAT)

21.2.1.1.1 The Analyzers System shall be verified and tested prior to shipment, in order to assure the conformity with the design, and the proper installation and operation.

21.2.1.1.2 Buyer shall be notified thirty days in advance of factory tests.

21.2.1.1.3 The checkout and testing shall include, at least, the following items:

I. Visual inspection of all work to assure mechanical completeness and compliance with all design drawings and specifications.

II. Visual inspection of all nameplates and tags to verify correct identification.

III. Point-to-point check of all wiring and tubing to verify proper interconnection.

IV. Continuity and isolation test of all electrical wiring.

V. Pressure test of all piping and tubing.

VI. Functional test of all electrical equipment, output signals, communications, piping, equipment, sampling system, analyzers and related equipment.

VII. Calibration test of analyzers.

VIII. Functional test of gas detectors, when applicable.

IX. Leakage test.

21.2.2 INSPECTION AND TESTS

21.2.2.1 Site Acceptance Test (SAT)

21.2.2.1.1 Site acceptance test (SAT) is a repetition of the tests listed in item 21.2.1.1, verifying the system operability, after the analyzer system delivery and installation at the definitive site and interconnected to CSS.

21.2.2.2 Performance Test

21.2.2.2.1 The analyzers system shall be ready for this test when it is totally assembled, connected to process/utilities, integrated to plant control system, and all non-conformities found during the Site Acceptance Test (SAT) have been solved.

21.2.2.2.2 This test shall be performed at offshore phase.

21.2.2.2.3 During the performance test period, the following tests shall be executed: Availability test and Validation test.

21.2.2.2.4 The Analyzer System shall be in conformity with requirements if the results obtained during the test run meet or exceed the requirements defined in items 21.2.2.2.6 and 21.2.2.2.7.

21.2.2.2.5 In case one of these requirements is not achieved, the test shall be repeated to verify if the Analyzer System is working satisfactorily, and the Analyzer System final acceptance shall be issued only when the performance criteria have been achieved.

21.2.2.2.6 Regarding Availability Test:

I. The system under test shall be ready and available when all of its parts (sampling system, analyzers, safety systems, controllers and all other associated equipment and systems) are working in conformity with the specification.

II. This test shall include all purchased equipment and software.

III. All the system will be brought into operation for a period of 168 hours. After this period, the Analyzer System Availability (ASA) shall be higher than 95%. The calculations for this index are shown in the Equation 21.2-I.

$ASA = \left(1 - \frac{ASUT}{TP}\right) * 100\%$	ASUT = Analyzer System Unavailable Time, including all equipment which affects the analyzer performance. TP = The total Test Period.

Equation 21.2-I - Analyzer System Unavailable Time Equation.

IV. If this index is not reached within a maximum period of 30 days, including 15 consecutive working days of testing, the system will not be accepted.

V. The period for the following events shall be subtracted from the test observation period to determine the Test Period (TP):

a. Intentional interruption time for downloading file updates, data base modifications and other activities related to system configuration.

b. Utility Failure (Electrical Power, Instrument Air, Steam).

c. Low Utility Quality (AC low voltage, Low Instrument Air Pressure, Low Steam Pressure).

d. Maintenance Time (Preventive Maintenance, Planned Calibration, Planned Modifications or Upgrades).

e. Process Off-Spec (High Dew Point for vapors, Foam or Bubbles in Liquid Sample, Excessive Dirt or Catalyst fines).

f. Process Shutdown (Pump Failures, Plant shutdown).

21.2.2.2.7 Regarding Validation Test:

I. A commercial standard reference material having a certified accepted reference value and a composition similar to the average sample to be analyzed shall be used as a Validation Reference Material (VRM).

II. The analyzers shall be accepted only if their results have variances smaller than or equal to the variances of the laboratory reference samples results and no bias in level, as defined by ASTM D3764.

21.3 Water in Oil Analyzers (BS&W)

21.3.1 The selection of technology to be used shall adhere to the water in oil range required as well fluid characteristics, according to I-ET-3010.00-1200-813-P4X-001 - GENERAL CRITERIA FOR FLOW METERING SYSTEMS.

21.4 Oil-in-Water Analyzers (TOG)

21.4.1 The concentration of oil in water must be continuously and automatically monitored using fluorescence-based analyzers, limited to LIF-Laser Induced Fluorescence Technology. These analyzers are required to have automatic self-cleaning capability achieved through ultrasonic (acoustic) methods.

21.4.2 The TOG analyzer sampling method shall be Side-stream (inline probes are not acceptable).

21.4.2.1 In the only case that oil phase of the water to be monitored is exclusively gas condensate, light scatter technology can be used.

21.4.3 TOG for discharge water applications shall comply with Classification Society requirements.

21.4.4 Automatic cleaning system shall be able to operate over the full operating range of the process; when the process is subject to sudden drops in pressure and flow, which may result in extended wear of the windows, an input of these process parameters shall be available to switch off the cleaning process while these conditions are present.

21.4.5 All sample wetted parts shall be corrosion resistant in accordance with fluid process conditions.

21.4.6 The sampling point shall preferably be in an ascending flow pipe run in order to avoid possible interference from the phase stratification, commonly observed in horizontal multi-phase flows, and more than one point can be monitored from a single analyzer. The intrusive point shall be installed in the center of the pipe, in a 90 degree orientation against the flow.

21.4.7 Manual sampler shall be provided for each TOG analysis point at the process line.

21.4.8 If sample conditioning is necessary for proper operation, all necessary accessories to provide pressure, temperature, flow rate and phase adjustments in order to make the sample compatible with the analyzer shall be designed and supplied.

21.4.8.1 Samples shall be representative, continuous and shall comply with the following requirements:

I. Sample shall not contain solids: suspended solid content < 20 mg/l.

II. Sample shall not contain free gas.

III. Should total iron content be greater than 2.0 mg/l, an acid cleaning system shall be provided.

IV. Flow rate, pressure and temperature of the sample shall also be adjusted for the equipment's operating limits.

21.4.8.2 If Process conditions require a pump to guarantee adequate flow rate during sampling, this pump shall also be supplied. Technical specifications for this pump shall be submitted to PETROBRAS for approval.

21.4.8.3 If probe is installed in a tank, the pump shall be installed on the main deck. Seller shall install a check valve on the suction line of the pump and verify the appropriate position of the check valve, in accordance with the maximum suction lift of the pump.

21.4.9 By-pass arrangement shall only be used in cases where high variation on types of oils and grease at the process line is expected and upon PETROBRAS approval.

21.4.10 Whenever the sample need to be returned to a closed drain, then system counter-pressure shall be used for sizing in order to avoid damaging the analyzer pressurizing system.

21.4.11 Monitor/analyzer maintenance shall be possible of being carried out onboard.

21.4.12 If it is required to install TOG analyzer at a disposal point at the outlet of vessel tanks where open drainage water is present (i.e. slop discharge system), the analyzer shall comply with resolutions IMO MEPC 107(49) and IMO MEPC 108(49).

21.4.13 TOG analyzer shall have a local screen capable of indicating the variables measured in engineering units, viewing, and entering configuration and calibration parameters and showing alarm and fault history.

21.4.14 TOG analyzer shall be supplied with all the resources needed for calibration.

21.4.15 TOG analyzer shall have a local “on/off” pushbutton.

21.4.16 TOG analyzer shall be of the smart microprocessor type, with analogue signal 4-20mA + HART for output.

21.4.17 Side-stream mounted TOG analyzers shall have an automatic shut-off valve on analyzer’s inlet.

21.4.18 In an ESD-2 condition, all analyzers shall be turned off, but kept with fluid inside them.

21.4.19 Spare instruments shall be foreseen to the following oil in water analyzers:

I. Analyzer between Gas Flotation Unit and Produced Water Tanks

II. Analyzer between Produced Water Pumps and Produced Water Filters

21.4.20 All infrastructure required by the spare analyzers, including, but not limited to, sampling conditioning, probes, cables, junction boxes and I/O points interconnection on Remote Panel shall be furnished and assembled. The spare analyzers, however, shall be furnished and kept dismounted in a warehouse.

21.5 Oxygen Analyzer

21.5.1 Oxygen analyzer shall be TDLAS type in gas measurement. The use of advanced thermo-paramagnetic type for gas measurement may be considered upon Buyer's approval. For liquid measurement shall be applied amperometric sensor type. Instrument accuracy shall be better than ± 1% of full scale and repeatability of ± 0.2% of span. Oxygen concentration shall be continuously and automatically monitored.

21.5.2 These analyzers shall always be provided with a sampling system and probe. Analyzers sample system shall be provided with all necessary accessories for local flow indications (rotameter, needle valves, pressure gauges etc).

21.5.3 Instruments shall be supplied with all necessary accessories for operation and maintenance (block valves, pressure regulating valves, sensors, vent, drain etc).

21.5.4 Maximum response time shall be 20 seconds for control/monitoring applications and 10 seconds for interlocking purposes.

21.5.5 When nitrogen purge is required by the manufacturer, then Seller shall check with manufacturer if the available nitrogen at the Unit (FPSO) is adequate. In case Unit (FPSO) Nitrogen purity is not enough, then Seller shall provide other means to purge the analyzer.

21.5.6 Sample system lag time (time between sample extraction from the process line and arrival of the sample at the analyzer) shall be defined during detailed Engineering Design. Sample system lag time shall be no longer than 1 minute.

21.5.7 Connections shall be foreseen in the analyzer sample system in order to connect a cylinder for calibration check of the analyzer. Manufacturer shall inform in the analyzer documentation the connection type of the standard gas cylinder, in order to ease future acquisitions/connections of cylinders.

21.5.8 Manufacturer of the analyzer shall specify the standard gas used for calibration. Cylinders shall be supplied with the specified standard gas, with its certificate of validation, in enough quantity in order to check / calibrate the analyzers during the commissioning and start-up of the plant until handover of the system to the operation team. This quantity also includes all standard gas required for the tests (FAT, SAT, SIT etc).

21.5.8.1 Certificates of validation the standard gas cylinders shall be valid for 6 months after handover of the system to the operation team.

21.5.9 If the analyzer calibration period is more frequent than once per six months, then the sample system shall be supplied with an installed (i.e. fixed) calibration system, with facilities for remote calibration and self-calibration. Calibration system consists of a fixed cylinder, pressure regulators, connections, solenoids, and any other accessories required for remote calibration.

21.5.10 The analyzed gas shall be returned to the process. Detailing engineering shall determine the technology to allow for this return to the process. Chosen Technology shall keep reliability of the system at the same level. In case an ejector is used, the motion gas shall be previously approved by Buyer. In case pumps are necessary in the sampling system, then there shall be means to measure the flow in the sampling lines, so that a reduction of the flow (i.e. low flow alarm) in the pumps may be detected.

21.6 Oxygen Analyzer for corrosion monitoring

21.6.1 Due to the presence of HC Blanketing System in the Unit (FPSO), some residual O2 may be recirculated in the process plant. In order to detect the presence of this residual O2, and to monitor the corrosion that the lines are subjected to, Oxygen Analyzers for corrosion monitoring shall be foreseen in the plant. Oxygen concentration shall be continuously and automatically monitored.

21.6.2 The monitoring point shall be as established at P&IDs.

21.6.3 These analyzers shall always be provided with a sampling system and probe. Analyzers sample system shall be provided with all necessary accessories for local flow indications (rotameter, needle valves, pressure gauges etc).

21.6.4 Oxygen analyzer shall be preferably of optical quench luminescence type. In case range is high enough, TDLAS technology may be used.

21.6.4.1 Each Optical quench luminescence analyzer shall be supplied with at least one additional spare tip/probe/sensor, in order to allow for the correct functioning of the system during all tests and during the first year of operation. Quantity of spares shall be determined by the manufacturer in a calculation report.

21.6.5 Analyzers sample system shall be provided with all necessary accessories for local flow indications (rotameter, needle valves, pressure gauges etc).

21.6.6 Instruments shall be supplied with all necessary accessories for operation and maintenance (block valves, pressure regulating valves, sensors, vent, drain etc).

21.6.7 When nitrogen purge is required by the manufacturer, then Seller shall check with manufacturer if the available nitrogen at the Unit (FPSO) is adequate. In case Unit (FPSO) Nitrogen purity is not enough, then Seller shall provide other means to purge the analyzer.

21.6.8 This analyzer shall be supplied with an installed (i.e. fixed) calibration system, with facilities for remote calibration and self-calibration. Calibration system consists of a fixed cylinder, pressure regulators, connections, solenoids, and any other accessories required for remote calibration.

21.6.9 Sample system lag time (time between sample extraction from the process line and arrival of the sample at the analyzer) shall be defined during detailed Engineering Design. Sample system lag time shall be no longer than 1 minute.

21.6.10 Manufacturer of the analyzer shall specify the standard gas used for calibration. Cylinders shall be supplied with the specified standard gas, with its certificate of validation, in enough quantity in order to check / calibrate the analyzers during the commissioning and start-up of the plant until handover of the system to the operation

team. This quantity also includes all standard gas required for the tests (FAT, SAT, SIT etc).

21.6.10.1 Certificates of validation the standard gas cylinders shall be valid for 6 months after handover of the system to the operation team.

21.6.11 Response time shall be defined during detail engineering design in order to determine spare parts.

21.6.12 The analyzed gas shall be returned to the process. Detailing engineering shall determine the technology to allow for this return to the process. Chosen Technology shall keep reliability of the system at the same level. In case an ejector is used, the motion gas shall be previously approved by Buyer. In case pumps are necessary in the sampling system, then there shall be means to measure the flow in the sampling lines, so that a reduction of the flow in the pumps may be detected prior to the “Clogged line” alarm.

21.7 Salinity Analyzer

21.7.1 The salinity analyzer must be of the conductivity type when used for measurement in water and microwave absorption cell type when used for measurement in oil. Instrument accuracy should be better than 2% of span.

21.7.2 Instruments shall be supplied with all necessary accessories for operation as: block valves, pressure regulating valves, sensors, vent, drain etc.

21.8 Moisture Analyzer

21.8.1 Moisture analyzer shall be quartz crystal type or Tunable diode laser absorption spectroscopy (TDLAS). The probe shall incorporate moisture, temperature and pressure sensing elements. The electronic module shall transmit these signals to the analyzer transmitter unit.

21.8.2 The analyzer/transmitter shall continuously self-check and also check the probe, and signal transmission. Temperature and pressure influence in the moisture measurement shall be continuously compensated.

21.8.3 Sample collecting point shall comply with API MPMS 14.1 standard. Gas sample shall be discharged to the venting system.

21.8.4 Analyzer sample system shall be provided with all necessary accessories including heat tracing in order to avoid sample freezing. See item 22.2 for further details on Heat Tracing.

21.8.5 Instrument uncertainty shall be less than 5% of span.

21.8.6 Analyzer shall be supplied with calibrating kit with certified N_2 cylinder (super dry) with known dew point. The use of correction factor and its specification shall be according to ASTM 1142/95 standard.

21.8.7 Instruments shall be supplied with all necessary accessories for operation/installation as: block valves, pressure regulating valves, interconnecting cables, adapters, sensors fixing brackets and supports etc.

21.9 Dew point Analyzer

21.9.1 Dew point analyzer shall be of high capacitive type with ultra-thin aluminum oxide sensor material and ceramic based.

21.9.2 Analyzer sample system shall be provided with all necessary accessories including heat tracing in order to avoid sample freezing. See item 22.2 for further details on Heat Tracing.

21.9.3 The analyzer/transmitter shall continuously self-check and also check the probe, and signal transmission. Temperature and pressure influence in the moisture measurement shall be continuously compensated.

21.9.4 The analyzer shall have self-diagnostic capability.

21.9.5 Analyzer shall be certified at vibration interferences according to IEC 60068-2-64 test Fh and IEC 60068-2-27 Test Ea.

21.9.6 Analyzer shall withstand operation measurement pressure at least of 206 barg.

21.9.7 All gas-wetted parts shall be in stainless steel (AISI 316L grade) with viton soft parts.

21.9.8 The gas sampling shall be discharged to Unit (FPSO) venting system.

21.9.9 Instrument accuracy shall be less than +/-2% of the span.

21.9.10 Instruments shall be supplied with all necessary accessories for operation/installation (block valves, pressure regulating valves, interconnecting cables, adapters, sensors fixing brackets and supports etc).

21.9.11 The sample system shall have glycol absorption cartridge filter, used on natural gas systems only.

21.9.12 The analyzer shall be provided with temperature control in order to reduce the effects of diurnal (day-night) swings in temperature and prevent measurement errors during periods of temperature change.

21.9.13 Sample system shall be provided with gas purge system. Sample system shall be de-pressurized for maintenance.

21.9.14 Analyzer shall feature natural gas moisture content calculations based on either ISO 18453 or IGT Research Bulletin nº 8.

21.10 CO_2 Analyzer

21.10.1 CO_2 analyzer shall be Tunable Diode Laser (TDL) or Non-dispersive Infrared (NDIR). Other detection method without moving parts, nor consumables are also accepted.

21.10.2 CO_2 analyzer shall be mounted directly onto measurement cells or ASTM 2” flanges.

21.10.3 Measurements shall be performed in real-time.

21.11 H_2S Analyzer

21.11.1 H2S analyzer for gas streams shall be ultraviolet-visible (UV-Vis) or Tunable Diode Laser (TDL) type. For liquid streams, additionally to the ultraviolet-visible (UV-Vis) or Tunable Diode Laser (TDL) type analyzer, a sample conditioning shall be supplied: This sample conditioning system shall be capable of vaporizing the sample through heating. Instrument sensitivity shall be better than 1% full scale. Response time shall be 90% in less than 30 seconds. H_2S concentration shall be continuously and automatically monitored.

21.11.2 Analyzers sample system shall be provided with all necessary accessories to provide pressure, temperature, flow rate and phase adjustments in order to make the sample compatible with the analyzer.

21.11.3 Instruments shall be supplied with all necessary accessories for operation, maintenance and proper cleaning/flushing of the entire system.

21.12 Chlorine Analyzer

21.12.1 Chlorine analyzer shall be amperometric membrane using electrodes to provide a continuous online measurement of residual chlorine concentration.

21.12.2 Chlorine analyzer accuracy shall be better than +/- 0,1 ppm, repeatability better than 2% full scale and response time better than 2 minutes per sample.

21.12.3 Chlorine analyzer power supply shall be 24 VDC.

21.13 Gas Chromatograph

21.13.1 Gas chromatograph system shall comprise: sampling system, sample conditioning system, auxiliary equipment, and accessories, as required to monitor the process stream and to provide the necessary data for the proper process operation. All the related services as technical and engineering, assembly, commissioning, start-up, pre-operation, and training shall be included. The analyzer shall be mounted in the field in a stainless steel cabinet to protect the analyzer, as near as possible of the sampling system.

21.13.2 The sampling system shall be installed in a dedicated AISI 316L panel. Sampling systems inside the analyzer panel shall not be acceptable.

21.13.3 Gas chromatograph shall quantify the concentrations of the main components in the gas composition for the purpose of gas accounting, calculation of calorific value and reference density in fiscal applications. The gas composition shall also be used for check of gas quality conformity with ANP gas quality specifications and as base for calculation of the operating density. Gas chromatograph shall be provided in accordance with the fluid composition, and fluid contaminants. Fluid composition shall be defined by Seller during Detailed Engineering Design phase and shall be sent along with chromatograph's Material Requisition.

21.13.4 Gas chromatograph type shall be Thermal Conductivity Detector.

21.13.5 Analyzer shall comply with the following requirements.

I. The analysis section enclosure shall be separated of the electronic unit enclosure.

II. The analysis section shall have 2 (two) columns of the micro packaged type.

III. Column material shall be in stainless steel with minimum 6 (six) months life duration under normal operation.

IV. If column switching is required, 2 (two) detectors shall be supplied.

V. Analyzer shall have the capability of storing chromatograms in memory for future call up and reference.

21.13.6 Chromatograph controller shall control all the sampling system operation. All program data tables shall locally and remotely (at CCR) configurable.

21.13.7 The chromatograph software and license shall be foreseen to perform the calibration, operation and maintenance though engineering workstation.

21.13.8 Standard calibration gas and carrier gas cylinders shall be supplied, including all regulator valves and standard connector as well.

21.13.8.1 Cylinders shall be supplied in quantity necessary for commissioning, Plant Acceptance Test and Performance Test (Availability, Validation and Stability). The due date of the cylinders shall respect the dates for each of these tests.

21.13.8.2 Cylinders shall be supplied so as to allow 1 (one) calibration per week during 4 (four) months after acceptance. At least 2 (two) cylinders per standard shall be supplied.

21.13.8.3 All calibration standards shall be valid for at least 6 (six) months after the plant start-up.

21.13.8.4 Helium gas purity shall be at least 99.999%.

21.13.9 The analysis time of each stream shall be shorter than 10 minutes. Response time of each stream (fast loop + analyzer cycle time) shall be short as soon as possible.

Response time for each stream is the period between 2 (two) consecutive analyzer results.

21.13.10 The communication protocol shall be Modbus TCP.

21.13.10.1 All chromatographs shall be interconnected to Package Unit LAN. Any media and protocol converters (UTP to fiber and vice versa) shall be supplied and installed at the field (inside the chromatograph's panel) and at EOCP panels. Chromatographs shall be available for maintenance and calibration using the engineering workstation. The chromatograph's software shall also be installed at the engineering workstation.

21.13.11 Chromatographs shall provide the following information:

I. Analyzer identification.
II. Stream identification.
III. Component identification.
IV. Concentration.
V. Date (dd/mm/yyyy).
VI. Time (hh:mm:ss).
VII. All active alarms.
VIII. Analysis validation (if available): Good / Not Good.
IX. Diagnostic: Initialization / Online.
X. Calibration: Auto / Manual.
XI. Maintenance: On / Off
XII. Service: In / Out.
XIII. End of Analysis: Normal / Abnormal
XIV. Stream ID: Tag

21.13.12 Self-Diagnostics

21.13.12.1 Analyzer shall provide quality information on measured values, such as "good / not good" (on-line and off-line diagnostics).

21.13.12.2 Automatic diagnostics routine shall be executed on initialization, checking: CPU, memory, A/D module, clock, communication interfaces and controller boards.

21.13.12.3 The manual diagnostic function shall be activated by operator for: CPU, memory, A/D module, communication interfaces and force outputs to specific value.

21.13.13 Power supply shall be according to I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

21.13.14 Gas Chromatographs supplied shall comply with all legal requirements and ANP standards.

21.14 Potential of Hydrogen (pH) Analyzer

21.14.1 The pH analyzer shall be electrochemical type with electrode sensor.

21.14.2 Analyzer sample system shall be provided with all necessary accessories for operation, maintenance and cleaning of the entire system such as: transmitter, sensors, block valves, needle valves, rotameter, pressure regulating valves, interconnecting cables, adapters, connectors, drain system, fixing brackets and supports, flushing devices and others.

21.14.3 Instrument accuracy shall be better than ± 1% of full scale.

21.14.4 The pH analyzer shall be supplied with temperature compensation and calibration functionality.

21.14.5 If required, the sample conditioning shall be provided with all necessary accessories to provide pressure, temperature, flow rate and phase adjustments to make the sample compatible with the analyzer.

21.15 Density meters

21.15.1 Density elements shall be based on resonant principle.

21.15.2 Density transmitters output shall be 4-20mA + HART.

22 MISCELANEOUS

22.1 Pushbuttons

22.1.1 Electrical loads pushbuttons shall be in accordance with I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

22.2 Heat Tracing

22.2.1 Heat tracing system shall be of electric type.

22.2.2 Thermostats to limit the temperature shall be included in the design.

22.2.3 Heat tracing devices shall be properly assembled, by certified personnel, following the manufacturer instructions and drawings, in order to distribute the heat homogenously through the whole process connection, standpipe (when applicable) and the instrument.

22.2.4 Heat tracing system design is a multidisciplinary task. Thermal demand and temperature range to be maintained shall be defined by respective discipline responsible for the system with eventual support from other disciplines. The design of heat tracing is by Electrical discipline. Seller shall facilitate cross-disciplinary collaboration and integration to ensure a cohesive solution for heat tracing implementation, that shall comprise at least of:

I. Calculation of heat loss, heater power output, developed power ratio, required heater length, determination of heater pitch according to pipe size.

II. Self-regulating heat output in response to changes in temperature.

III. Use of heating metallic over shielded cables approved for use in hazardous areas.

IV. Use of ground fault protective devices.