PETROBRAS	**TECHNICAL SPECIFICATION**	**Nº:** I-ET-3010.2K-1200-813-P4X-001	
	CLIENT: AGP		**SHEET** 1 of 23
	JOB: FPSO BÚZIOS 12		--
	AREA: **CAMPO DE BÚZIOS**		
SRGE	**TITLE:** **FLOW METERING SYSTEM - BOT**		INTERNAL
			ESUP

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INDEX OF REVISIONS

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0	ORIGINAL ISSUE
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B	REVISED WHERE INDICATED

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SUMMARY

1 OBJECTIVE

1.1 This Typical Technical Specification describes the minimum requirements for the project of the Flow Metering System (FMS) on UNIT.

1.2 Definitions

FISCAL MEASUREMENT	Measurement of the gas and oil production volume where the government requires tax payments.
ALLOCATION MEASUREMENT	Measurement to determine the volume of production to be allocated at each field in a group of fields or at each well within the same field.
OPERATIONAL MEASUREMENT	Measurement for production control purposes.
CUSTODY TRANSFER MEASUREMENT	Measurement for totalization of transferred fluids when changed their ownership.
CATEGORY D	Metering systems with installed capacity lower than 5 m³/d (oil) or 5.000 m³/d (gas) – at 20 °C and 101.325 kPa reference conditions.

1.3 Abbreviations and Acronyms

The following abbreviations are used in this document:

ANP	Brazilian National Agency of Petroleum, Natural Gas and Biofuels
BS&W	Basic Sediments & Water
CPL	Correction for the effect of Pressure on Liquid
CSS	Control and Safety System
CTL	Correction for the effect of Temperature on Liquid
DOU	Official Gazette of the Federal Government (in Portuguese: *"Diário Oficial da União"*)
DBB	Double Block and Bleed valve
FAT	Factory Acceptance Tests
FE	Shrinkage Factor (in Portuguese: *"Fator de Encolhimento"*)
FMS	Flow Metering System
FPSO	Floating Production, Storage and Offloading
GCA	Gas Chromatography Analyzer
GSV	Gross Standard Volume
HMI	Human Machine Interface
IACS	International Association of Classification Societies
Inmetro	Brazilian National Institute of Metrology, Quality and Technology

IV Initial Verification per Inmetro
NR Regulatory Standards (in Portuguese: *"Normas Regulamentadoras"*)
NSV Net Standard Volume
PAM *Portaria de Aprovação de Modelo de Instrumentos de Medição* (Inmetro certificate of type approval)
PI Plant Information (software)
RVP Reid Vapor Pressure
RS Solubility Ratio (in Portuguese: *"Razão de Solubilidade"*)
RTM ANP/Inmetro Technical Regulation of Measurement of Oil and Gas
SI International System of Units
UR Unified Requirements – A resolution issued by IACS
UI Unified Interpretations – A resolution issued by IACS
XML Extensible Markup Language

2 REFERENCE DOCUMENTS, CODES AND STANDARDS

2.1 External references

2.1.1 International codes, recommended practices, and standards

ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO	3171	PETROLEUM LIQUIDS – AUTOMATIC PIPELINE SAMPLING
ISO	4267-2	PETROLEUM AND LIQUID PETROLEUM PRODUCTS - CALCULATION OF OIL QUANTITIES - PART 2: DYNAMIC MEASUREMENT
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	5168	MEASUREMENT OF FLUID FLOW - PROCEDURES FOR THE EVALUATION OF UNCERTAINTIES

ISO	6974	NATURAL GAS – DETERMINATION OF COMPOSITION AND ASSOCIATED UNCERTAINTY BY GAS CHROMATOGRAPHY
ISO	6976	NATURAL GAS - CALCULATION OF CALORIFIC VALUES, DENSITY, RELATIVE DENSITY AND WOBBE INDICES FROM COMPOSITION
ISO	7278	LIQUID HYDROCARBONS - DYNAMIC MEASUREMENT - PROVING SYSTEMS FOR VOLUMETRIC METERS - ALL PARTS
ISO	10012	MEASUREMENT MANAGEMENT SYSTEMS - REQUIREMENTS FOR MEASUREMENT PROCESSES AND MEASURING EQUIPMENT
ISO	12213	NATURAL GAS CALCULATION OF COMPRESSION FACTOR - ALL PARTS
ISO	17089-1	MEASUREMENT OF FLUID FLOW IN CLOSED CONDUITS - ULTRASONIC METERS FOR GAS - PART 1: METERS FOR CUSTODY TRANSFER AND ALLOCATION MEASUREMENT
ISO	20456	MEASUREMENT OF FLUID FLOW IN CLOSED CONDUITS - GUIDANCE FOR THE USE OF ELECTROMAGNETIC FLOWMETERS FOR CONDUCTIVE LIQUIDS
ISO	20765	NATURAL GAS — CALCULATION OF THERMODYNAMIC PROPERTIES — ALL PARTS
ISO	GUM	GUIDE TO THE EXPRESSION OF UNCERTAINTY IN MEASUREMENTS

AGA – AMERICAN GAS ASSOCIATION

AGA	REPORT Nº 7	MEASUREMENT OF NATURAL GAS BY TURBINE METERS
AGA	REPORT Nº 8	THERMODYNAMIC PROPERTIES OF NATURAL GAS AND RELATED GASES DETAIL AND GROSS EQUATIONS OF STATE – ALL PARTS
AGA	REPORT Nº 9	MEASUREMENT OF GAS BY MULTIPATH ULTRASONIC METERS

AGA	REPORT Nº 11	MEASUREMENT OF NATURAL GAS BY CORIOLIS METER

API – AMERICAN PETROLEUM INSTITUTE

API	MPMS	MANUAL OF PETROLEUM MEASUREMENT STANDARDS – ALL PARTS
API	MPMS TR 2570	CONTINUOUS ON-LINE MEASUREMENT OF WATER CONTENT IN PETROLEUM (CRUDE OIL AND CONDENSATE)
API	RP 551	PROCESS MEASUREMENT – SECOND EDITION

ASME – AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ASME	PTC 19.3 TW	THERMOWELLS PERFORMANCE TEST CODES

ASTM – AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM	D1945	STANDARD TEST METHOD FOR ANALYSIS OF NATURAL GAS BY GAS CHROMATOGRAPHY

OIML – ORGANISATION INTERNATIONALE DE METROLOGIE LEGALE

OIML	R117	DYNAMIC MEASURING SYSTEMS FOR LIQUIDS OTHER THAN WATER
OIML	R137	GAS METERS – ALL PARTS

2.1.2 Brazilian Codes and Standards

ANP – AGÊNCIA NACIONAL DO PETRÓLEO, GÁS NATURAL E BIOCOMBUSTÍVEIS

RESOLUÇÃO CONJUNTA ANP/INMETRO Nº 1 (10/JUNHO/2013)	REGULAMENTO TÉCNICO DE MEDIÇÃO (RTM) DE PETRÓLEO E GÁS NATURAL, A QUE SE REFERE À RESOLUÇÃO CONJUNTA ANP/INMETRO Nº 1 DE 10 DE JUNHO DE 2013), RETIFICADA EM 17 DE JUNHO DE 2013
OFÍCIO-CIRCULAR Nº1/2020/NFP/ANP (26/MAIO/2020)	ESCLARECIMENTOS DO REGULAMENTO TÉCNICO DE MEDIÇÃO (RTM)
RESOLUÇÃO ANP Nº 52 (26/DEZEMBRO/2013)	REGULAMENTO TÉCNICO DE IMPLEMENTAÇÃO DOS RESULTADOS DE ANÁLISES FÍSICO-QUÍMICAS NAS MEDIÇÕES SUBSEQUENTES DE

	PETRÓLEO E GÁS NATURAL, A QUE SE REFERE À RESOLUÇÃO ANP Nº 52 DE 26 DE DEZEMBRO DE 2013
RESOLUÇÃO ANP Nº 65 (10/DEZEMBRO/2014)	REGULAMENTO TÉCNICO DE ENVIO DE DADOS DE PRODUÇÃO E MOVIMENTAÇÃO DE PETRÓLEO, GÁS NATURAL E ÁGUA, A QUE SE REFERE À RESOLUÇÃO ANP Nº 65 DE 10 DE DEZEMBRO DE 2014
RESOLUÇÃO ANP Nº 737 (27/ JULHO /2018)	ALTERAÇÃO DA RESOLUÇÃO ANP Nº 65 DE 10 DE DEZEMBRO DE 2014

INMETRO - INSTITUTO NACIONAL DE METROLOGIA, NORMALIZAÇÃO E QUALIDADE INDUSTRIAL

NIT-SEFLU-014 (SETEMBRO/2018)	VERIFICAÇÃO INICIAL DE SISTEMAS DE MEDIÇÃO CONFORME A PORTARIA INMETRO Nº 64/2003
PORTARIA Nº 188 (27/ABRIL/2021)	REGULAMENTO TÉCNICO METROLÓGICO CONSOLIDADO PARA CROMATÓGRAFOS A GÁS EM LINHA
PORTARIA Nº 291 (07/JULHO/2021)	REGULAMENTO TÉCNICO METROLÓGICO CONSOLIDADO PARA SISTEMAS DE MEDIÇÃO DINÂMICA EQUIPADOS COM MEDIDORES PARA QUANTIDADE DE LÍQUIDOS
PORTARIA Nº 298 (08/JULHO/2021)	REGULAMENTO TÉCNICO METROLÓGICO CONSOLIDADO PARA OS COMPUTADORES DE VAZÃO E CONVERSORES DE VOLUME
PORTARIA Nº 617 (20/DEZEMBRO/2023)	ALTERAÇÃO DA PORTARIA INMETRO Nº 298, DE 08 DE JULHO DE 2021
PORTARIA Nº 156 (30/MARÇO/2022)	REGULAMENTO TÉCNICO METROLÓGICO CONSOLIDADO PARA MEDIDORES DE VAZÃO DE GÁS NATURAL, BIOMETANO E GÁS LIQUEFEITO DE PETRÓLEO (GLP) EM FASE GASOSA
PORTARIA Nº 236 (14/JUNHO/2022)	ALTERAÇÃO DA PORTARIA INMETRO Nº 156, DE 30 DE MARÇO DE 2022
OFÍCIO CIRCULAR Nº 032/DIMEL (12/SETEMBRO/2017)	VERIFICAÇÕES METROLÓGICAS DE MEDIDORES, SISTEMAS DE MEDIÇÃO E COMPUTADORES DE VAZÃO

2.1.3 All Regulatory Standards (Normas Regulamentadoras – NRs) in force, published in the 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 International Association of Classification Societies (IACS), applicable and in force in the detailing design, shall be observed and their requirements implemented.

2.1.4.3 The design, installation and operation 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 I-ET-3010.2R-1200-941-P4X-002 – GENERAL TECHNICAL DESCRIPTION - BOT

3 INTRODUCTION

3.1 The Flow Metering System (FMS) shall be supplied by one integrator (the scope of supply shall be responsibility of a single vendor).

3.2 The FMS shall comply with Brazilian legislation, including National Agency of Petroleum, Natural Gas and Biofuels (ANP) and Brazilian National Institute of Metrology, Quality and Technology (Inmetro) regulations.

3.3 The FMS shall be designed, selected, installed, commissioned and tested in order to comply with all technical requirements mentioned in the Technical Regulation of Measurement of Oil and Natural Gas, or just “RTM”, approved by “*Resolução Conjunta ANP/Inmetro nº 1 de 10/06/2013*” (or other updated document which substitutes or complements it), with other supplementary regulations issued by ANP/Inmetro and with manufacturer’s recommendations, including all applicable standards and reference technical documents.

3.4 Standards, codes and recommendations that shall be followed in the design of the FMS are listed in RTM-Appendix D (or other updated document which substitutes or complements it) or explicitly referenced in this document.

3.5 A measurement management system shall be included and applied on the FPSO according to ISO 10012 “Measurement management systems - Requirements for measurement processes and measuring equipment” to assure the effectiveness and adequacy to the intended use, besides managing the risk of incorrect metering results. SELLER’s measurement management system shall be submitted for BUYER approval.

3.6 The volume unit for oil and natural gas measurements shall be cubic meter (m^3) under the Brazilian reference conditions of 20 °C for temperature and 101.325 kPa for pressure. The metering system shall consider the International System of Units (SI).

4 FLOW METERING POINTS

4.1 The following requirements for the FMS shall be interpreted as minimum and are in accordance with the RTM. Other metering points may be necessary depending on the plant philosophy adopted on the UNIT and it is SELLER responsibility to correct evaluate the need for additional meters, according to I-ET-3010.2K-1200-941-P4X-001 – GENERAL TECHNICAL DESCRIPTION - BOT. The following table is typical and some of its metering points may not be applicable.

Table 1 - Metering Points

Item	Fluids	Metering points	Duty	Type of meter	Accuracy (note 1)
1	Oil	Cargo pump discharge (offloading)	Custody transfer metering	Ultrasonic or Coriolis (note 2) or turbine meter (note 3); Minimum 1 standby meter	0.3% (system) 0.2% (sensor)
2			Calibration of custody transfer metering	Master meter and Prover (note 2), or only Prover	0.04% (prover) 0.1% (master meter - sensor)
3			BS&W Online	Online analyzer (microwave, RF, capacitive)	0.05% (absolute)
4			BS&W Sampler	Automatic and manual with mixing system (note 4)	
5	Oil	Transference pump discharge (from the process plant to the cargo tanks)	Fiscal metering	Ultrasonic or Coriolis (note 2) or turbine meter (note 3); Minimum 1 standby meter	0.3% (system) 0.2% (sensor)
6			Calibration of fiscal metering	Master meter and Prover (note 2), or only Prover	0.04% (prover) 0.1% (master meter - sensor)
7			BS&W Online	Online analyzer (microwave, RF, capacitive)	0.05% (absolute)
8			BS&W Sampler	Automatic and manual with mixing system (note 4)	
9	Oil	Well injection operations (treated oil)	Operational metering	Positive displacement or Coriolis or turbine meter	1.0% (system) 0.6% (sensor)
10			CANCELLED		
11			CANCELLED		
12	Oil	Test separator	Allocation metering	Coriolis; Minimum 1 spare meter (note 5)	1.0% (system) 0.6% (sensor)
13			BS&W Online	Online analyzer (microwave 0-100%)	5% (measured value)
14			BS&W Sampler	Automatic and manual with mixing system (note 4)	
15	Oil	Production vessels oil outlet	Operational metering	Positive displacement, Coriolis or turbine meter	1.0% (system) 0.6% (sensor)

Item	Fluids	Metering points	Duty	Type of meter	Accuracy (note 1)
16	Diesel	Well injection operations	Operational metering	Positive displacement, Coriolis or turbine meter	1.0% (system) 0.6% (sensor)
17	Gas	Export line	Fiscal metering	Ultrasonic or Coriolis or turbine meter; minimum 1 standby meter (note 6)	± 1.0% (system) ± 0.7% (sensor)
18			Calibration of fiscal metering	Master Meter (Ultrasonic or Coriolis or turbine meter)	± 0.5% (sensor)
19			Gas chromatography Online	Online analyzer (note 7)	± 0.3% (Z factor)
20	Gas	Import line (note18)	Fiscal metering	Ultrasonic or Coriolis or turbine meters; minimum 1 standby meter (notes 6, 8)	± 1.0% (system) ± 0.7% (sensor)
21			Calibration of fiscal metering	Master Meter (Ultrasonic or Coriolis or turbine meter)	± 0.5% (sensor)
22			Gas chromatography Online	Online analyzer (note 7)	± 0.3% (Z factor)
23	Gas	HP fuel gas	Fiscal metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided (note 9)	± 1.5%
24	Gas	LP fuel gas	Fiscal metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided (note 9)	± 1.5%
25	Gas	HP flare	Fiscal metering	Dual path Ultrasonic flare meter	± 5.0%
26	Gas	LP flare	Fiscal metering	Dual path Ultrasonic flare meter	± 5.0%
27	Gas	Vent (note 15)	Fiscal metering	Dual path Ultrasonic flare meter	± 5.0%
28	Gas	Inlet gas to hydrocarbon gas blanket system	Fiscal metering (note 10)	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided	± 1.5%
29	Gas	Outlet gas from hydrocarbon gas blanket system to Vapor Recovery Unit	Fiscal metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided	± 1.5%
30	Gas	Test separator	Allocation metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided (note 11)	± 2.0%
31	Gas	Individual gas lift	Allocation metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided	± 2.0%
32	Gas	Total gas lift	Operational metering	Cone or orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%

Item	Fluids	Metering points	Duty	Type of meter	Accuracy (note 1)
33	Gas	Transferred Gas (note 18)	Operational metering	Cone or orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
34	Gas	Individual injection	Operational metering	Cone or orifice plate meter (single chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
35	Gas	Total injection	Operational metering	Cone or orifice plate meter (single chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
36	Gas	Production separator	Operational metering	Cone or orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
37	Gas	Degasser electrostatic treaters	Operational metering	Cone or orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
38	Gas	Flare pilot	Fiscal metering – Category D	Coriolis; Minimum 1 spare meter (note 17)	± 1.0% (system) ± 0.7% (sensor)
39	Gas	Flare purge	Operational metering (note 12)	Orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided) (note 13)	± 3.0%
40	Gas	Flare assistant	Operational metering (note 12)	Orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
41	Water	Test separator	Operational metering	Orifice plate, magnetic (spool type) or Coriolis meter	1.0%
42	Water	Production separator	Operational metering	Orifice plate, magnetic (spool type) or Coriolis meter	1.0%
43	Water	Electrostatic Pre-Treater (upstream level control valve)	Operational metering	Orifice plate meter, magnetic meter (spool type) or Coriolis meter	1.0%
44	Water	Electrostatic Treater (upstream level control valve)	Operational metering	Orifice plate meter, magnetic meter (spool type) or Coriolis meter	1.0%
45	Water	Individual injection	Operational metering	Orifice plate, cone or clamp-on ultrasonic (note 16)	1.0%
46	Water	Total injection	Operational metering	Orifice plate, cone or clamp-on ultrasonic (note 16)	1.0%
47	Water	Produced (note 14)	Operational metering	Orifice plate, cone or magnetic meter (spool type)	1.0%
48	Water	Disposal	Operational metering	Orifice plate, cone or magnetic meter (spool type); Minimum 1 standby meter	1.0%
49	Condensate	Slug Catcher Outlet	Operational metering	Coriolis or ultrasonic meter	1.0% (system) 0.6% (sensor)

Table 1 - Notes:

(1) Maximum allowable errors for liquid metering; uncertainty for gas metering.

(2) Ultrasonic meter shall have 4-channels as minimum. In case of using ultrasonic or Coriolis meters as duty meter, a master meter and a prover are required, and the master meter shall be a helical turbine meter.

(3) Positive displacement flow meters may be used on fiscal or custody transfer oil applications only when above listed technologies do not comply with expected range of Reynolds number of the flow. In case of using positive displacement meters, gas eliminator device shall be provided.

(4) The mixing system shall be installed upstream of BS&W analyzer and sampling systems to guarantee homogeneity of the mixture (concentration ratio C1/C2 above 0.9, according to ISO 3171) for all expected flow range. The mixing system may be static or dynamic.

(5) The duty meter shall be calibrated against a master meter or a prover at the FPSO facilities. If a master meter is used, it shall be proved against a prover at the FPSO facilities. If the calibration of the duty meter or master meter takes place on the fiscal or offloading metering skid, the calibration pipe run shall be in series with the other pipe runs, so as not to represent a new fiscal measurement point.

(6) If by the time of detail design current RTM explicitly allows for a bidirectional meter, then SELLER may provide a single flow measurement bidirectional skid for export and import gas measurement. In this case, the skid shall comply with ISO 17089-1, AGA 11, AGA 7, or other requirements that may be requested by the ANP, according to the technology applied. The condensate shall be removed upstream the skid, so as to be measured separately. Master and duty meters shall be calibrated on both flow directions.

(7) SELLER shall install one online GCA – Gas Chromatograph Analyzer, according to ISO 6974, for hydrocarbon composition (until C9+), CO_2 and N_2 in the gas import and export lines and linked to the flow computer, which shall inform daily:
a) Gas composition;
b) Total Gas flow rate;
c) Gas flow rate per compound;
d) Gas Higher Heating Value.
The maximum admitted uncertainty shall be ± 0.3% of the compressibility factor.

(8) In case the flow is less than 1,000,000 m³/d (at 20 °C and 101.325 kPa), orifice plate meter with dual chamber orifice fittings and removable straight pipe sections shall be provided instead of linear meters, and the maximum uncertainty shall be ± 1.5%.

(9) In case the flow is equal or greater than 1,000,000 m³/d (at 20 °C and 101.325 kPa), ultrasonic, Coriolis or turbine meter shall be provided instead of orifice plate meter, and the maximum uncertainty shall be ± 1.0% (system) and ± 0.7% (sensor). Also, a master meter with maximum uncertainty ± 0.5%, one online GCA (see note 7) and at least one standby meter run shall be provided assembled on a skid.

(10) If the fuel gas for the Hydrocarbon Blanket Gas System is taken downstream of LP fuel gas fiscal metering, the gas inlet metering of the system shall be classified as “operational”.

(11) There shall be provided means to avoid condensate on gas test separator meter, such as piping thermal coating, meter location as close as possible to the test separator and piping of the flowmeter with upward slope.

(12) Purge, dilution and assist for flare, in case foreseen in the project, shall be individually metered. These streams shall be classified as operational, therefore they shall be fiscally measured by other metering systems (e.g.: flare or fuel gas). Exceptions to classify these meters as fiscal shall be previously approved by BUYER.

(13) Integral orifice and Coriolis meters are acceptable only for operational metering, when lines are smaller than 2". The only exception is the flare pilot.

(14) The produced water meters shall account for all water from the production field. If project foresees the use of dilution water, this shall be discounted of the produced water.

(15) An ultrasonic flare meter shall be provided for the vent posts for operational purposes. The vent post flowmeters do not need to be part of the FMS.

(16) For clamp-on ultrasonic meters, the minimum upstream and downstream straight run lengths and any other installation requirements recommended by the manufacturer shall be complied with.

(17) The gas for flare pilot shall be tapped upstream of the fuel gas fiscal metering point. If the maximum flow rate is equal to or greater than 5,000 m³/d (at 20 °C and 101.325 kPa), it shall be tapped downstream of the fuel gas fiscal metering point and flare pilot metering point shall be classified as operational. In this case, an orifice plate with dual chamber orifice fitting shall be used instead of a Coriolis meter.

(18) Imported gas refers to the treated gas sourced from the export gas pipeline, while transferred gas is the untreated gas transferred from other units.

5 ADDITIONAL REQUIREMENTS

5.1 GENERAL REQUIREMENTS

5.1.1 All metering points, including water measurements, shall include dedicated pressure and temperature transmitters for automatic compensation of static pressure and temperature variations and volume correction to standard conditions.

5.1.2 It is not allowed any kind of bypass at fiscal or custody transfer metering point.

5.1.3 Plant and piping arrangement shall be designed so that no flow stream is fiscally measured twice (e.g., if a gas stream is already measured at the flare fiscal meter, it shall not be accounted on the fuel gas fiscal meter). In case a process unit uses fuel gas and returns it to process, this fuel gas shall be derived upstream the fuel gas fiscal meter.

5.1.4 All fiscal, allocation, operational and custody transfer meters shall be connected to flow computers.

5.1.5 All fiscal, allocation, operational and custody transfer flowmeters (when regulated by Inmetro), flow computers and chromatographs shall have valid Model / Type

Approvals by Inmetro on the date of purchase order placement (procurement). All the technical requirements and constraints inside each of Inmetro Approval Document shall be complied. For flow computers note that it shall comply with *Portaria Inmetro 298/2021* and *617/2023* or any other that complements or replace them.

5.1.6 The Inmetro Initial Verification process shall be carried out for the regulated flow meters applied in metering systems for fiscal, allocation and custody transfer, as per *Portaria Inmetro 291/2021* and *156/2022* or any others that complement or replace them.

5.1.7 The Inmetro Initial Verification process shall be carried out for the regulated flow computers applied in metering systems for fiscal, allocation, custody transfer and operational, as per *Portaria Inmetro 298/2021* and *617/2023* or any others that complement or replace them.

5.1.8 Gas chromatograph analyzers part of the FMS shall be submitted to Inmetro Initial Verification process, as per *Portaria Inmetro 188/2021*.

5.1.9 The Inmetro Initial Verification procedure shall be included in the scope of supply of the fiscal, allocation and custody transfer oil metering systems, according to *Portaria Inmetro 291/2021* and NIT-SEFLU-014 (or any other that may substitute and complement it). The Initial Verification procedure, which is responsibility of the metering system manufacturer, shall be executed on a single-phase basis. The metering systems manufacturer shall submit its Initial Verification procedure for Inmetro approval before its execution. After Inmetro approval of this procedure, a copy of the document and evidence of Inmetro approval shall be presented to BUYER for information only.

5.1.10 Fluid to be used during the Initial Verification test shall be compatible with the final installation fluid (similar density and viscosity) in accordance with RTM criteria.

5.1.11 The initial verification seals installed on the meters and flow computers cannot be voided, unless previously authorized by INMETRO.

5.1.12 Every flow meter shall always comply with nominal flow rate ranges and Reynolds number specified in Inmetro Type Approval. Thus, metering systems shall be envisaged considering flow rates at the beginning of operation (when not all systems will be available), UNIT at full capacity and end of life (lower flow rates and higher BS&W content). Also, the allocation metering system shall be capable of measuring each well individually during their respective life span.

5.1.13 In the installation of flow meters, where required, consideration shall be given to the lengths of straight piping sections specified in the meter model approval and manufacturer's recommendation, whichever is stricter. In cases where the model approval is not required or the length requirement is absent on PAM, the lengths of the runs determined by the meter manufacturer manual or by the relevant standards, whichever is stricter (i.e., larger length for the run), shall be adopted.

5.1.14 All elements of the metering system (including meters, transmitters, analyzers, flow conditioners, straight pipe, mixers, orifice plates, samplers, probes, valves, skids and so on) shall have unique identification code (tag), serial numbers and flow direction engraved on the body for easy visualization and identification on field.

5.1.15 The length of straight pipe runs shall be calculated using internal diameter as D of the multiplying factor. To the multiplying factor, 0.5D shall be added. Example: for minimum straight pipe run of 17D it shall be used 17.5D. This shall also be considered for installation of flow conditioners and sampling probe positioning downstream any disturbance.

5.1.16 Calibration, inspection procedures and maintenance of the metering systems shall not cause any impact (decrease or shutdown) on the UNIT's production.

5.1.17 For operational meters, a bypass line or a standby meter shall be considered to allow calibration or maintenance without system interruption. Exceptions are accepted for individual injection meters. Operational meters without standby meters shall have a spare meter in stock for quick replacement in case of failure. It is acceptable that only one spare meter is provided for each group of identical meters.

5.1.18 All calibration and dimensional requirements: pressure, temperature and flow calibrations (including volume prover calibrations), as well as dimensional inspections (including for flare ultrasonic meters) shall be made through accredited laboratories (Inmetro or ILAC or IAAC).

5.1.18.1 Flow calibrations shall be possible to perform in accredited laboratories in Brazil during the operation phase.

5.1.19 Complete access for installation, maintenance and removal shall be provided (including lifting capacity, if necessary) to all flowmeters and associated components by means of walkways, stairs, or platforms. Temporary access, such as scaffolding, is not acceptable.

5.1.20 Secondary tapings such as pressure and temperature tapings shall be installed in piping or straight run at same diameter as primary meter. Meter flange diameter shall be considered as meter reference diameter.

5.1.21 Impulse lines shall be kept as short as possible. For fiscal, allocation and custody transfer applications, impulse lines tubing shall be 1 meter maximum.

5.1.22 The impulse tap orientation on the horizontal process lines shall be as indicated in Figure 5.1, according to the fluid to be measured, and comply with API RP 551 requirements.

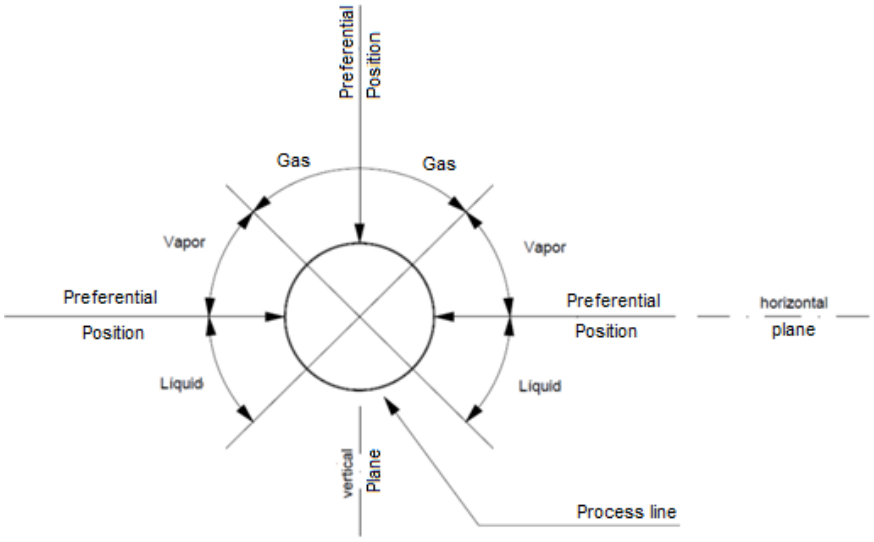

Figure 5.1 - Impulse tap orientation

5.1.23 Double block and bleed valves with drain shall be installed where tightness is required and to guarantee compliance with ANP/Inmetro requirement of periodically check valves for leaks. This includes upstream and downstream alignment stream valves, isolation, and by-pass valves. These valves shall be submitted to leakage performance tests between intervals no longer than 1 (one) year.

5.1.24 Blind spectacles shall be foreseen upstream fiscal, allocation and custody transfer meters (except flare meters) to allow metering point to be put as unavailable for legal requirement purposes.

5.1.25 Installation of any non-leak-tight element between the meter under calibration and the reference (master meter or compact prover) is not allowed.

5.1.26 Fiscal, allocation and custody transfer linear flow meters shall have additional digital communication with the flow computers for diagnostics purposes, additionally to the pulse communication.

5.1.27 The Flow Measurement System shall meet the maximum uncertainty requirements of total oil and gas production. The maximum allowable uncertainty is ± 0.6% for total volume of produced oil, and ± 3% for produced gas.

5.1.28 Uncertainty measurement calculation reports of all metering systems shall be implemented according to the GUIDE TO THE EXPRESSION OF UNCERTAINTY IN MEASUREMENT - ISO GUM, Inmetro, and ISO 5168 - MEASUREMENT OF FLUID FLOW- PROCEDURES FOR THE EVALUATION OF UNCERTAINTIES.

5.1.29 Unless otherwise specifically stated, condensate shall be treated as oil for compliance with ANP and Inmetro requirements.

5.2 OIL METERING REQUIREMENTS

5.2.1 The crude oil to cargo tanks fiscal metering system shall comprise of at least two duty meter runs, each one covering 50% of the maximum flowrate. Moreover, one standby meter run with the same characteristics of the main meter run shall be installed (configuration commonly known as “3 × 50%”).

5.2.2 The custody transfer oil metering system shall comprise of at least three duty meter runs, each one covering 33% of the maximum flowrate. Moreover, one standby meter run with the same characteristics of the main meter run shall be installed (configuration commonly known as “4 × 33%”).

5.2.3 Control valves shall be installed on each meter runs with oil calibration systems so that it is possible to calibrate the flow meters at any flow rate along its full range of flow and to ensure individual flow control during calibrations. Control valves shall be located downstream of the flowmeters.

5.2.4 Routing hydrocarbon volumes directly to cargo tanks without fiscal metering is not acceptable.

5.2.4.1 Any recovered oil volume and condensate streams from Flare K.O Drums, Closed Drain, overflow (oil stream) from hydrocyclones, overflow (oil stream) from the flotation unit, overflow (oil stream) from slop tanks and others shall be collected, treated and routed back to the process plant upstream oil fiscal metering system.

5.2.4.2 Alignments that do not return the oil to process plant from off-spec tanks, settling tanks, produced water tanks, and other tanks that may have crude oil not fiscal metered, shall have removable spools sealed controlled (locked) with open/close register on UNIT’s supervisory system (PI included).

5.2.4.3 The removable spools shall have a nameplate on stainless steel with tag identification.

5.2.4.4 The UNIT shall have operational procedure to guarantee that the above-mentioned alignments are used only in special circumstances and crude oil not fiscal metered is not routed to cargo tanks.

5.2.5 Fiscal, allocation and custody transfer oil metering skids shall be installed at a level below the process line and/or their outlet line shall be at a level above meters so that they operate always filled, with no entrained gas.

5.2.6 Ultrasonic and turbine oil flowmeters shall be specified observing the minimum Reynolds Number limits provided in the Type Approval and in the manufacturer's manual in its most updated version, in order to consider the most restrictive value. If this requirement is not specified in these documents, the minimum Reynolds Number value shall be considered in accordance with API MPMS 5.3 and API MPMS 5.8. If the manuals allow the application of meters in flow regimes below 10,000 Reynolds, without support from Type Approval, the manufacturer shall

issue a technical report proving that the performance for the desired application is not affected. The increase in measurement uncertainty due to operation outside the recommended Reynolds Number range is not acceptable.

5.3 GAS METERING REQUIREMENTS

5.3.1 Fiscal gas metering systems, except for flare applications, designed with capacity above 1,000,000 m³/d (at 20 °C and 101.325 kPa) shall use linear flow meter types (e.g.: ultrasonic, Coriolis or turbine), provided with a standby meter, mounted on a skid. An online GCA shall be foreseen linked to the metering system.

5.3.2 Fiscal gas metering systems designed with capacity below 1,000,000 m³/d and above 50,000 m³/d (at 20 °C and 101.325 kPa) shall use orifice plate flow meters equipped on dual chamber orifice fittings.

5.3.3 Gas meter systems with dual chamber orifice fittings shall allow the change and/or retrieving of the orifice plates during normal operation under pressure. Dual chamber orifice fittings shall be provided with valves for drainage during operation.

5.3.3.1 Gas metering systems with orifice fittings that operate near dew point shall have the drain outlet routed to the closed drainage system, returned back to process or to a safe area, provided there is no by-pass.

5.3.4 Technical design and certifications of all orifice plate metering points shall comply with ISO 5167 standards, meeting a minimum internal pipe diameter of 2". All orifice plate metering points shall use Zanker flow conditioner and shall have the straight pipe runs installed between flanges for dimensional inspection and maintenance.

5.3.5 The piping lengths related to the flare/vent gas flowmeter are based on the minimum number of straight pipe runs: 20 internal diameters upstream and 10 internal diameters downstream. SELLER shall provide technical studies (Computational Fluid Dynamics) to demonstrate that the uncertainties meet ANP/Inmetro requirements and to support uncertainty calculation reports.

5.3.6 For flare/vent gas meters, the flow computation and data storage shall be done at flow computer (Inmetro approved flow computer), using the uncorrected flow rate sent by the meter. Flare meter electronic unit shall communicate with flow computer using field network (MODBUS RTU protocol). PIT and TIT shall communicate directly to the flow computer via 4-20 mA analog signal. If required by manufacturer, PIT and TIT signals may be replicated from flow computer to the flow meter electronic unit via MODBUS-RTU (RS-485). The pressure and temperature compensation to the reference conditions shall be executed exclusively at the flow computer approved by Inmetro.

5.3.7 Ultrasonic flow meters for flare/vent applications shall be provided with 2 channels. Exceptions shall be previously approved by BUYER.

5.3.8 Flare/vent meter shall be supplied in a spool, for easily disassemble for dimensional inspection. Flare/vent sensors shall be of removable type in order to allow the dry calibration procedure.

5.3.9 The use of cone meters shall follow ISO 5167-5 and include means of dimensional verification and calibration. Cone meters shall be initially calibrated on all range of Reynolds number expected for the application.

5.3.10 In cases where process operational pressures are equal to or below 21 bar(a) for gas measurements (e.g.: flare, test separator, etc.), the PIT shall be of absolute pressure type.

5.3.11 The gas lift metering shall be designed to allow the gas lift flow rate measurement of each service riser individually (gas lift and test gas lift risers) and total gas lift flow rate measurement as well.

5.3.12 Fiscal gas metering skids shall be installed at a level above the process line and/or their outlet line shall be at a level below meters to prevent condensate accumulation on the meter streams.

5.3.13 Linear gas fiscal metering systems shall be comprised of duty meters runs, one standby meter run with the same characteristics of the main meter run and a master meter. The number of meter runs shall be such that the master meter can be calibrated in accredited laboratory under operating conditions as required by the RTM, including flowrate range. At least one duty meter run and one standby meter run shall be provided. If by the time of detail design current RTM explicitly allows for a bidirectional meter and SELLER chooses to provide a single flow measurement bidirectional skid for export and import gas measurement, the skid design shall allow to operate and calibrate the duty meters in both directions even if the skid is operating only in exportation or importation direction.

5.3.14 Design for linear gas metering systems shall follow ISO 17089-1, AGA 11, or AGA 7, according to the technology applied.

5.3.15 For gas metering system equipped with linear flowmeters, control valves shall be installed on each meter runs with calibration system so that it is possible to calibrate the meters at any flow rate along its full range of flow and to ensure individual flow control during calibrations. Control valves shall be located downstream of the flowmeters. Evaluate the impact of noise, especially from control valve modulation, on flow measurement. If needed, use noise traps to avoid interference and ensure accurate data.

5.4 SAMPLING REQUIREMENTS

5.4.1 Each gas metering point shall be provided with representative manual sampler devices (flare and vent included), as close as possible to its respective metering point, easily accessible by the operator. Exceptions are accepted for individual gas lift meters, individual gas injection and individual water injection meters which may use their respective total gas lift, total gas injection and total water injection

sampling points. It shall be guaranteed that no significant process change occurs between meter and its respective sampling point. Furthermore, if a flare gas recovery unit is foreseen, the LP and HP flare sampling points shall be installed upstream of the flare recovery system branching to guarantee sample collection even when no gas is flowing on the flare lines.

5.4.2 The gas manual sample points shall comply with the recommendations of the API MPMS 14.1. The probe shall be intrusive, installed on top (12 o'clock position) of a horizontal pipe and at least 5 internal diameters downstream of any disturbing element. For orifice plate and cone meters, the manual sampler shall be installed upstream the meter. Lines that are operating at or near the gas stream's dew point may require special probes designed to overcome the problems of condensation in the gas.

5.4.3 The gas sample points shall be provided with sampling panels, tag labeled, which shall have bottle/cylinder support and means for gas purge before handling collection. Gas purged through sampling points shall be directed to Flare.

5.4.4 Flare and vent sampling system shall be able to collect representative samples even with the low pressure, so devices such as vacuum pumps shall be foreseen.

5.4.5 Fiscal gas metering systems, except for flare applications, designed with capacity above 1,000,000 m³/d (at 20 °C and 101.325 kPa) shall have a dedicated online gas chromatograph analyzer linked to the metering system, for automatic gas proprieties update on the flow computer. The metering system shall have a validation system to discard GC results that are not valid/spurious.

5.4.6 All oil metering points shall have sample collecting points, tag labeled, which can operate at atmospheric pressure aiming to the determination of BS&W and density values. For oil allocation and fiscal oil to cargo tanks metering systems, the sampling points shall also allow the sample collection under the same pressure conditions of the process, aiming to the determination of shrinkage factor (FE) and solubility ratio (RS) values, as well as evaluation of the Reid Vapor Pressure (RVP) of the oil to cargo tanks. Special care shall be given to condensate sampling point, so that the sample is representative of the process conditions.

5.4.7 Oil sampling systems shall be installed downstream of the flow meters and may be installed on the common header of the skid.

5.4.8 Online BS&W oil analyzers shall comply with API MPMS TR 2570.

5.4.9 Sampling probes for automatic sampler and BS&W analyzer on fiscal oil to cargo tanks skid shall be of retrievable type without process interruption.

5.4.10 The manual and automatic oil samplers shall comply with API MPMS 8.1 and 8.2 standards respectively.

5.4.11 Automatic samplers of the intrusive probe type shall be designed in order to avoid the occurrence of vortex-induced vibration and other factors. In the absence of

specific manufacturer criteria, the requirements of ASME PTC 19.3 TW shall be complied with.

5.4.12 The sampling system shall guarantee the oil sample homogeneity on all expected flow range, with concentration ratio C1/C2 above 0.9, according to ISO 3171. During project, SELLER shall submit mixing calculation reports for BUYER evaluation.

5.4.13 In case a fast loop solution is applied, the manual and automatic sampling point shall be installed on the main line. Spares for fast loop pump and rotameter shall be supplied.

5.4.14 Regarding periodicity and procedures for oil and gas analysis and implementation of the results (physicochemical properties) into the flow computers, SELLER shall comply with "*Resolução ANP 52/2013*" (or other updated document which substitutes it), which details and complements "*Resolução Conjunta ANP/Inmetro nº 1/2013*".

5.5 FMS AUTOMATION REQUIREMENTS

5.5.1 The FMS Workstation shall include all necessary functionalities for the full operation and calibration of the flowmeters, including the automatic remote actuation of the valves alignment and calibration flowrate adjustments, besides the generation of metering reports, among others.

5.5.2 An interface with the FMS and Automation System (CSS) of the production UNIT shall be provided to enable the operational data transfer from the flow computers to the supervisory system of the UNIT and to the PI Server. PI data list to be available in onshore servers shall be confirmed during detailed phase.

5.5.3 All log files shall be created based at the actual data from the flow computers simply by uploading, keeping their inviolability; the files shall be kept at the FMS Workstation non-volatile memory / dedicated directory and a backup shall be made at least once per month.

5.5.4 The FMS Workstation shall retain all historical registers and reports for at least 10 years according to RTM item 10.1.6, using hard disks (or solid-state disks) and on an incremental daily basis.

5.5.5 Daily volume production for all metering points shall be closed at 00:00 (midnight).

5.5.6 Metering reports (hourly, daily, and monthly production; calibration; batch for well testing and offloading; alarm and events; audit trail) shall be readily available for ANP and/or BUYER representatives on board, as well as recorded for further internal or authority audit; the measurement data shall also be available at the workstation in BUYER Office onboard.

5.5.7 General log files to be generated by Flow Metering System (minimum):

- Daily Configuration Data Log (for each flow computer);

- Daily Input and Output Data Log (for each flow computer);
- Daily Audit Trail Log (for each flow computer);
- Daily Alarm Log (for each flow computer).
- Daily and monthly production report (for each flow computer);
- Well testing report and batch report (offloading);
- Calibration report.

5.5.8 All log files shall be generated according to the formats defined in (last editions): API/MPMS 21.1, Electronic Gas Measurement; API/MPMS 21.2, Flow Measurement-Electronic Liquid Measurement.

5.5.9 Metering Reports in XML format containing production, configuration and log data extracted from flow computers shall be automatically generated according to ANP specifications (*Resolução ANP 65/2014* and other supplementary regulations issued by ANP/Inmetro). Data flow shall be designed to avoid data tampering, taking measures such as access control.

5.5.10 XML metering daily reports shall also consider operational flare related meters (purge, assist gas, etc.) and custody transfer meters (offloading). Additionally, it shall be provided monthly the volume of each cargo tank.

5.5.11 There shall be provided a communication link between the FMS Workstation and BUYER Corporate Network, to make available the XML files or the necessary data needed for their generation. This communication can be carried out by means of the onboard automation network, not requiring a direct link to the firewall.

5.5.12 In order to set up the better synchronicity between all Flow Computers and the FMS Workstation clocks, there shall be a mean of synchronization of the flow computers with the FMS, considering the FMS clock as reference.

5.5.13 FMS workstation and flow computers shall have control access to avoid inadvertent modifications. Flow computers shall only be configurable through FMS and not via CSS, with traceability to all modifications (audit log).

5.5.14 Fidelity between flow computers, FMS workstation and other automation systems - All production volumes at the FMS workstation shall be based on the variable “Previous Day Net (NSV) Totalizer” of each flow loop.

5.5.14.1 Note: NSV is an acronym to “Net Standard Volume” which means: The total volume of all petroleum liquids, excluding sediment and water and free water, corrected by the appropriate volume correction factor (CTL) for the observed temperature and specific gravity to a standard temperature and also corrected by the applicable pressure correction factor (CPL) and meter factor.

5.5.15 The Flow Metering System shall implement a redundant architecture, with redundant server and network, to ensure data availability for the ICSS and PI, as well as for XML file generation.

5.6 DOCUMENTATION

5.6.1 In the beginning of the UNIT design, within six (6) months' time from Kick-Off-Meeting, SELLER shall provide to BUYER the following documents (in Portuguese language) to be submitted to ANP for approval, according to *Resolução Conjunta ANP/Inmetro* nº 1 de 10/06/2013: (1) "Schematic Diagram for Metering System / *Diagrama Esquemático das Instalações*"; and (2) "Technical description of the production unit metering system / *Memorial Descritivo dos Sistemas de Medição*".

5.6.2 At least six (6) months before UNIT sail way (or four (4) months prior to ANP inspection on shipyard, whichever happens first), SELLER shall provide to BUYER the documentation (in Portuguese language) of the metering system (design and operating description reports, diagrams, and other related documents) to be submitted to ANP for approval, according to *Resolução Conjunta* ANP/Inmetro nº 1 de 10/06/2013. The complete list of required documents will be sent by BUYER on the beginning of the detailed phase.

5.6.3 At least 40 days prior to ANP authorization inspection (with the UNIT on final location, offshore), SELLER shall provide to BUYER the complete documentation of the metering system required on current RTM, including any updates from previous version and including all calibration certificates, dimensional inspection, leak tests, uncertainty reports and flow computer parametrization. All documentation shall be updated and valid for ANP final inspection and for the beginning of the UNIT operation.

5.6.4 SELLER is responsible to provide any additional information or document, as requested by ANP or Inmetro.

5.6.5 All calibration certificates, dimensional inspection, leak tests and uncertainty reports shall be updated and valid for ANP final inspection offshore.

5.6.6 For calibration and dimensional inspections certificates, as well as uncertainty report, additionally to the .pdf of the original document, SELLER shall also send XML files containing the results and relevant information of the documents. BUYER will submit the files templates during detailed design phase.