	TECHNICAL SPECIFICATION		Nº: I-ET-XXXX.XX-1200-813-P4X-001
	CLIENT:		SHEET 1 of 38
	JOB:		--
	AREA:		
SRGE	TITLE: FLOW METERING SYSTEM FOR LEASED UNITS		INTERNAL
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INDEX OF REVISIONS

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C	REVISED WHERE INDICATED IN GRAY
	<p><i>NOTE: The items highlighted in yellow, green and cyan in this document are related to information that may change from project to project. Yellow – project for BOT or Leased unit. Green – project with or without multiphase meters. Cyan – all projects.</i></p>

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
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CHECK	CX2W	CX2W	CX2W	CX2W					
APPROVAL	U4JB	U4JB	CDC1	CDC1					

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FORM OWNED TO PETROBRAS N-0381 REV.L.



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1 OBJECTIVE

1.1 This Typical Technical Specification describes the minimum requirements for the project of the Flow Metering System (FMS) on **LEASED 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, for legal or commercial purpose.
CATEGORY A METERING SYSTEM	Metering systems with installed capacity higher than 5,000 m ³ /d (oil) or 1,000,000 m ³ /d (gas) – at 20 °C and 101.325 kPa reference conditions.
CATEGORY B METERING SYSTEM	Metering systems with installed capacity between 500 m ³ /d and 5,000 m ³ /d (oil) or between 50,000 m ³ /d and 1,000,000 m ³ /d (gas) – at 20 °C and 101.325 kPa reference conditions.
CATEGORY C METERING SYSTEM	Metering systems with installed capacity between 5 m ³ /d and 500 m ³ /d (oil) or between 5,000 m ³ /d and 50,000 m ³ /d (gas) – at 20 °C and 101.325 kPa reference conditions.
CATEGORY D METERING SYSTEM	Metering systems with installed capacity lower than 5 m ³ /d (oil) or 5,000 m ³ /d (gas) – at 20 °C and 101.325 kPa reference conditions.
C1	Water concentration at the top of pipeline
C2	Water concentration at the bottom of pipeline
BLACK OIL	Fluid properties model, based on empirical correlations, used to correct volumetric flow to reference conditions. This is a simplified model, based on the behavior of a standard non-volatile oil.
PVT	Data that describe the fluid and the behavior of its respective phases in relation to the variables pressure, volume and temperature, to correct the volumetric flow for the reference conditions.

1.3 Abbreviations and Acronyms

The following abbreviations are used in this document:

AGA	American Gas Association
ANP	Brazilian National Agency of Petroleum, Natural Gas and Biofuels (in Portuguese: “ <i>Agência Nacional do Petróleo, Gás Natural e Biocombustíveis</i> ”)
API	American Petroleum Institute
BS&W	Basic Sediments & Water
CNEN	National Nuclear Energy Commission (in Portuguese: “<i>Comissão Nacional de Energia Nuclear</i>”)
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: “ <i>Diário Oficial da União</i> ”)
EoS	Equation of State
FAT	Factory Acceptance Tests
FE	Shrinkage Factor (in Portuguese: “ <i>Fator de Encolhimento</i> ”)
FMS	Flow Metering System
FPSO	Floating Production, Storage and Offloading
GCA	Gas Chromatography Analyzer
GLR	Gas-Liquid Ratio
GOR	Gas-Oil Ratio
GUM	Guide to the Expression of Uncertainty in Measurements
GVF	Gas Volume Fraction
HP	High Pressure
IAAC	Inter-American Accreditation Cooperation
IACS	International Association of Classification Societies
ILAC	International Laboratory Accreditation Cooperation
Inmetro	Brazilian National Institute of Metrology, Quality and Technology (in Portuguese: “ <i>Instituto Nacional de Metrologia, Qualidade e Tecnologia</i> ”)
ISO	International Organization for Standardization
IV	Initial Verification per Inmetro
LP	Low Pressure
MCS	Master Control System
MFMS	Multiphase Flow Metering System
MPFM	Multiphase Flow Meter
NR	Regulatory Standards (in Portuguese: “ <i>Normas Regulamentadoras</i> ”)
NSV	Net Standard Volume
OIML	International Organization of Legal Metrology (in French: “ <i>Organisation Internationale de Métrologie Légale</i> ”)



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PAM	Inmetro certificate of type approval (in Portuguese: “ <i>Portaria de Aprovação de Modelo de Instrumentos de Medição</i> ”)
PI	Plant Information (software)
RTU	Remote Terminal Unit
RVP	Reid Vapor Pressure
RS	Solubility Ratio (in Portuguese: “ <i>Razão de Solubilidade</i> ”)
RTM	ANP/Inmetro Technical Regulation of Measurement of Oil and Gas (in Portuguese: “ <i>Regulamento Técnico de Medição</i> ”)
SI	International System of Units
SMPFM	Subsea Multiphase Flow Meter
SPCS	Subsea Production Control System
TMPFM	Topside Multiphase Flow Meter
UI	Unified Interpretation – A resolution issued by IACS
UR	Unified Requirement – A resolution issued by IACS
VOS	Velocity of Sound
XML	Extensible Markup Language
WLR	Water-Liquid Ratio

2 REFERENCE DOCUMENTS, CODES AND STANDARDS

2.1 External references

2.1.1 International codes, recommended practices, and standards

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
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ASTM – AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM	D1945	STANDARD TEST METHOD FOR ANALYSIS OF NATURAL GAS BY GAS CHROMATOGRAPHY
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IEC – INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC	60079	EXPLOSIVE ATMOSPHERES – ALL PARTS
IEC	60529	DEGREES OF PROTECTION PROVIDED BY ENCLOSURES (IP CODE)

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IEC	61000	ELECTROMAGNETIC COMPATIBILITY (EMC) – ALL PARTS
IEC	61892	MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS – ALL PARTS
IEC	62381	AUTOMATION SYSTEMS IN THE PROCESS INDUSTRY – FACTORY ACCEPTANCE TEST (FAT), SITE ACCEPTANCE TEST (SAT) AND SITE INTEGRATION TEST (SIT)

ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO	91	PETROLEUM AND RELATED PRODUCTS - TEMPERATURE AND PRESSURE VOLUME CORRECTION FACTORS (PETROLEUM MEASUREMENT TABLES) AND STANDARD REFERENCE CONDITIONS
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	MEASUREMENT OF FLUID FLOW BY MEANS OF PRESSURE DIFFERENTIAL DEVICES INSERTED IN CIRCULAR CROSS-SECTION CONDUITS RUNNING FULL – ALL PARTS
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

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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

ISO/TS 21354 MEASUREMENT OF MULTIPHASE FLUID FLOW

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)

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 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 44
(15/OUTUBRO/2015)**
REGULAMENTO TÉCNICO DE MEDIÇÃO DE FLUIDO MULTIFÁSICO PARA APROPRIAÇÃO DE PETRÓLEO, GÁS NATURAL E ÁGUA

 RESOLUÇÃO ANP Nº 737
(27/ JULHO /2018)

ALTERAÇÃO DA RESOLUÇÃO ANP Nº 65 DE 10 DE DEZEMBRO DE 2014

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

 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 656
(08/OUTUBRO/2025)

ALTERAÇÃO DA PORTARIA INMETRO Nº 291, DE 07 DE JULHO DE 2021

 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.

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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 All applicable CNEN Regulatory Standards in force, published in the DOU, shall be followed.

2.1.5 Classification Society

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

2.1.5.2 The Unified Requirements (URs) and Unified Interpretations (UIs) of International Association of Classification Societies (IACS), applicable and in force in detailing design, shall be observed and their requirements implemented.

2.1.5.3 The design, installation and operation shall be updated following requirements, comments of Classification Society as well as URs and UIs mentioned in item 2.1.5.2.

2.2 Internal references

2.2.1 I-ET-XXXX.XX-1200-941-P4X-001 – GENERAL TECHNICAL DESCRIPTION

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, such as "Resolução ANP nº 44/2015", 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.
- 3.5.1** CONTRACTOR's measurement management system shall be submitted for PETROBRAS approval.
- 3.6** The volume unit for oil and natural gas measurements shall be cubic meter (m³) under the Brazilian reference conditions of 20 °C for temperature and 101.325 kPa for pressure.
- 3.7** The metering system shall consider the International System of Units (SI).

4 FLOW METERING POINTS

4.1 The Table 1 contains the minimum requirements for the metering points in FMS and are in accordance with the RTM.

4.1.1 The Table 1 is typical and some of its metering points may not be applicable.

4.1.2 **CONTRACTOR** shall evaluate the need for additional meters, depending on the plant philosophy adopted on the UNIT and according to I-ET-XXXX.XX-1200-941-P4X-001 – GENERAL TECHNICAL DESCRIPTION.

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 - sensor) ± 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	
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 - sensor) ± 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	
9	Oil	Test separator	Allocation metering	Coriolis; Minimum 1 spare meter (note 4)	± 1.0% (system) ± 0.6% (sensor)
10			BS&W Online	Online analyzer (microwave 0-100%)	± 5% (measured value)
11			BS&W Sampler	Automatic and manual with mixing system	

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Item	Fluids	Metering points	Duty	Type of meter	Accuracy (note 1)
12	Oil	Production vessels oil outlet	Operational metering	Positive displacement, Coriolis or turbine meter	± 1.0% (system) ± 0.6% (sensor)
13	Oil	Well injection operations (treated oil)	Operational metering	Positive displacement, Coriolis or turbine meter	± 1.0% (system) ± 0.6% (sensor)
14	Diesel	Well injection operations	Operational metering	Positive displacement, Coriolis or turbine meter	± 1.0% (system) ± 0.6% (sensor)
15	Gas	Export line	Fiscal metering	Ultrasonic or Coriolis or turbine meter; minimum 1 standby meter (note 5)	± 1.0% (system) ± 0.7% (sensor)
16			Calibration of fiscal metering	Master Meter (Ultrasonic or Coriolis or turbine meter)	± 0.5%
17			Gas chromatography Online	Online analyzer	± 0.3% (Z factor)
18	Gas	Import line	Fiscal metering	Ultrasonic or Coriolis or turbine meters; minimum 1 standby meter (notes 5, 6)	± 1.0% (system) ± 0.7% (sensor)
19			Calibration of fiscal metering	Master Meter (Ultrasonic, Coriolis or turbine meter)	± 0.5%
20			Gas chromatography Online	Online analyzer	± 0.3% (Z factor)
21	Gas	HP fuel gas	Fiscal metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided (note 7)	± 1.5%
22	Gas	LP fuel gas	Fiscal metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided (note 7)	± 1.5%
23	Gas	HP flare	Fiscal metering	Dual path Ultrasonic flare meter	± 5.0%
24	Gas	LP flare	Fiscal metering	Dual path Ultrasonic flare meter	± 5.0%
25	Gas	Vent (note 8)	Fiscal metering	Dual path Ultrasonic flare meter	± 5.0%
26	Gas	Inlet gas to hydrocarbon gas blanket system	Fiscal metering (note 9)	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided	± 1.5%
27	Gas	Outlet gas from hydrocarbon gas	Fiscal metering	Orifice plate meter; dual chamber orifice fittings and removable	± 1.5%

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Item	Fluids	Metering points	Duty	Type of meter	Accuracy (note 1)
		blanket system to Vapor Recovery Unit		straight pipe sections to be provided	
28	Gas	Test separator	Allocation metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided	± 2.0%
29	Gas	Topside individual gas lift	Allocation metering	Orifice plate meter; dual chamber orifice fittings and removable straight pipe sections to be provided	± 2.0%
30	Gas	Topside total gas lift	Operational metering	Cone or orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
31	Gas	Individual injection	Operational metering	Cone or orifice plate meter (single chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
32	Gas	Total injection	Operational metering	Cone or orifice plate meter (single chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
33	Gas	Production separator	Operational metering	Orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
34	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%
35	Gas	Flare pilot	Fiscal metering – Category D	Coriolis; Minimum 1 spare meter (note 10)	± 1.0% (system) ± 0.7% (sensor)
36	Gas	Flare purge	Operational metering (note 11)	Orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided) (note 12)	± 3.0%
37	Gas	Flare assist	Operational metering (note 11)	Orifice plate meter (dual chamber orifice fittings and removable straight pipe sections to be provided)	± 3.0%
38	Gas	Dilution for Flare	Operational metering (note 11)	Orifice plate, cone or ultrasonic flare meter	± 3.0%
39	Water	Test separator	Operational metering	Orifice plate, magnetic (spool type) or Coriolis meter	± 1.0%

Item	Fluids	Metering points	Duty	Type of meter	Accuracy (note 1)
40	Water	Individual injection	Operational metering	Orifice plate, cone or clamp-on ultrasonic (note 13)	± 1.0%
41	Water	Total injection	Operational metering	Orifice plate, cone or clamp-on ultrasonic (note 13)	± 1.0%
42	Water	Produced (note 14)	Operational metering	Orifice plate, cone or magnetic meter (spool type)	± 1.0%
43	Water	Disposal	Operational metering	Orifice plate, cone or magnetic meter (spool type); Minimum 1 standby meter	± 1.0%
44	Multiphase	Production riser (notes 15,16)	Allocation metering	Multiphase topside flow meter	(note 17)

Table 1 - Notes:

- (1) Maximum allowable errors for liquid metering; uncertainty for gas metering.
- (2) Ultrasonic meter shall have a minimum of four channels. When ultrasonic or Coriolis meters are used 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 for fiscal or custody transfer oil applications only if the previously listed technologies do not comply with the expected range of Reynolds number for the flow. When positive displacement meters are used, a gas eliminator device shall be provided.
- (4) The duty meter shall be calibrated against a master meter or a prover at the FPSO facilities. If a master meter is used for calibration, it shall be proved against a prover at the FPSO facilities.
- (5) If, at the time of the detailed design phase, the current RTM explicitly permits the use of a bidirectional meter, the **CONTRACTOR** may provide a single bidirectional flow measurement skid for both export and import gas measurement.
- (6) If the metering system is not classified as Category A, 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%.
- (7) If the metering system is classified as Category A, ultrasonic, Coriolis, or turbine meters shall be provided instead of orifice plate meter, and the maximum uncertainty shall be ± 1.0% for the system and ± 0.7% for the sensor. Additionally, a master meter with a maximum uncertainty of ± 0.5%, one online gas chromatograph analyzer (GCA), and at least one standby meter run shall be provided, all assembled on a skid.
- (8) An ultrasonic flare meter shall be provided for the vent posts for operational purposes. Vent post flowmeters do not need to be included in the FMS.
- (9) If the fuel gas for the Hydrocarbon Blanket Gas System is sourced downstream of the low-pressure (LP) fuel gas fiscal metering, the gas inlet metering for the system shall be classified as “operational”.

(10) The gas supply for the flare pilot shall be tapped upstream of the fuel gas fiscal metering point. If the metering system is not classified as Category D, the gas shall be tapped downstream of the fuel gas fiscal metering point, and the flare pilot metering point shall be classified as “operational”. In this case, an orifice plate meter with dual chamber orifice fittings and removable straight pipe sections shall be provided instead of Coriolis meter, and the maximum allowable uncertainty shall be $\pm 3.0\%$.

(11) Purge, dilution, and assist for flare, if included in the project, shall be individually metered. These streams shall be classified as operational and, therefore, 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 **PETROBRAS**.

(12) Integral orifice and Coriolis meters are acceptable only for operational metering when the line size is smaller than 2".

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

(14) Produced water meters shall account for all water originating from the production field. If the project includes the use of dilution water, the volume of dilution water shall be deducted from the measured produced water.

(15) One multiphase topside flow meter shall be installed for each production riser slot on the riser balcony.

(16) Topside multiphase meters shall be used in conjunction with subsea multiphase meters for continuous allocation measurement and comparison. Topside meters are especially useful in contingency situations if subsea meters present faulty measurements or even partial or total failure of their functionality.

(17) Multiphase meters shall meet the following uncertainty criteria over the entire operating range:

- Expanded uncertainty in volumetric liquid flow, at actual conditions, shall be less than or equal to $\pm 6\%$ with 95% coverage probability;
- Expanded uncertainty in volumetric gas flow, at actual conditions, shall be less than or equal to $\pm 10\%$ with 95% coverage probability;
- Expanded uncertainty in measured WLR, at actual conditions, shall be less than or equal to $\pm 4\%$ with 95% coverage probability.

5 ADDITIONAL REQUIREMENTS

5.1 GENERAL REQUIREMENTS

- 5.1.1 Metering systems shall be specified to accommodate flow rates at various stages of operation, including: initial start-up (when not all systems may be available), operation of the UNIT at full design capacity, and end of life conditions (lower flow rates and higher BS&W content).
- 5.1.1.1 Each flow meter shall operate within the nominal flow rate ranges and Reynolds numbers specified in the applicable Inmetro Type Approval.
- 5.1.1.2 The allocation metering system shall be capable of measuring the flow from each well individually throughout its respective life span.
- 5.1.2 All fiscal, allocation, operational, and custody transfer flowmeters (when regulated by Inmetro), flow computers and chromatographs shall have valid Model / Type Approvals issued by Inmetro at the date of purchase order placement (procurement).
- 5.1.2.1 All technical requirements and constraints specified in each Inmetro Approval Document shall be fully complied with.
- 5.1.2.2 Flow computers shall comply with *Portaria Inmetro 298/2021* and *617/2023*, or any subsequent regulations that complement or replace them.
- 5.1.3 The Inmetro Initial Verification process shall be carried out for regulated flow meters used in fiscal, allocation, and custody transfer metering systems, in accordance with *Portaria Inmetro 291/2021* and *156/2022*, or any subsequent regulations that complement or replace them.
- 5.1.4 The Inmetro Initial Verification process shall be carried out for regulated flow computers used in fiscal, allocation, custody transfer and operational metering systems, in accordance with *Portaria Inmetro 298/2021* and *617/2023*, or any subsequent regulations that complement or replace them.
- 5.1.5 The Inmetro Initial Verification process shall be carried out for gas chromatograph analyzers (GCA) that are part of the FMS, in accordance with *Portaria Inmetro 188/2021*, or any subsequent regulations that complement or replace it.
- 5.1.6 The fluid used during the Inmetro Initial Verification test shall be compatible with the fluid intended for final installation (similar density and viscosity) in accordance with RTM criteria.
- 5.1.7 The initial verification seals installed on the meters and flow computers shall not be broken or removed unless prior authorization is obtained from Inmetro.
- 5.1.8 All fiscal, allocation, operational and custody transfer meters (except multiphase meters) shall be connected to flow computers.

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- 5.1.9 All metering points, including those for water measurement, shall be equipped with dedicated pressure and temperature transmitters to enable automatic compensation for static pressure and temperature variations, as well as volume correction to standard conditions.
- 5.1.10 The installation of any type of bypass at fiscal or custody transfer metering points is not permitted.
- 5.1.11 For operational meters, a bypass line or a standby meter shall be provided to enable calibration or maintenance activities without interrupting system operation.
- 5.1.11.1 Exceptions to this requirement are permitted for individual injection meters.
- 5.1.11.2 Operational meters without standby meters shall have a spare meter in stock for quick replacement in case of failure. It is acceptable to provide only one spare meter for each group of identical meters.
- 5.1.12 Plant and piping arrangements shall be designed to prevent any flow stream from being measured more than once for fiscal purposes (e.g., if a gas stream is measured at the flare fiscal meter, it shall not be counted again at the fuel gas fiscal meter).
- 5.1.12.1 In case a process unit consumes fuel gas and subsequently returns it to the process, this fuel gas shall be derived upstream the fuel gas fiscal meter.
- 5.1.13 In the installation of flow meters, the lengths of straight piping sections shall comply with the strictest value specified in the meter model approval (PAM) or in the manufacturer's recommendation.
- 5.1.13.1 If PAM is not required, or if no specific length is indicated in the PAM, the lengths of straight runs shall comply with the strictest value specified either in the meter manufacturer's manual or in relevant standards
- 5.1.14 The length of straight pipe runs shall be calculated by considering the internal diameter plus the maximum possible uncertainty, ensuring that the pipe run length always exceeds the actual diameter multiplied by the prescribed multiplying factor.
- 5.1.14.1 An additional length of 0.5D shall be added to the multiplying factor. For example, for a minimum straight run of 17D, a multiplying factor of 17.5D shall be applied.
- 5.1.14.2 This criterion shall also be adopted for the installation of flow conditioners and the positioning of sampling probes downstream of any flow disturbance.
- 5.1.15 All flowmeters and associated components shall have complete access for installation, maintenance, and removal. This access shall be provided through permanent walkways, stairs, or platforms, and shall include adequate lifting capacity where necessary. The use of temporary access solutions, such as scaffolding, is not permitted.

- 5.1.16 Calibration, inspection, and maintenance procedures for the metering systems shall be designed and implemented so as not to cause any reduction or interruption in the UNIT's production.
- 5.1.17 Installation of any non-leak-tight element between the meter under calibration and the reference device (master meter or compact prover) is not permitted.
- 5.1.18 Double block and bleed valves with drain shall be installed wherever tightness is required and to ensure compliance with ANP/Inmetro requirements for periodic valve leak verification. This includes upstream and downstream alignment stream valves, isolation valves, and bypass valves.
- 5.1.18.1 All such valves shall be subjected to leak verification at intervals not exceeding one year.
- 5.1.19 Blind spectacles shall be provided upstream of fiscal, allocation and custody transfer meters (except flare meters) to allow the metering point to be put as unavailable for legal requirement purposes.
- 5.1.20 Secondary tapings, such as those for pressure and temperature measurement, shall be installed on piping or straight runs with the same diameter as the primary meter. Meter flange diameter shall be used as the reference diameter for these installations.
- 5.1.21 Impulse lines shall be kept as short as possible. For fiscal, allocation and custody transfer applications, the length of impulse line tubing shall not exceed 1 meter.
- 5.1.22 The orientation of impulse tap on horizontal process lines shall be as illustrated in Figure 5.1, according to the fluid being measured, and shall comply with the requirements of API RP 551.

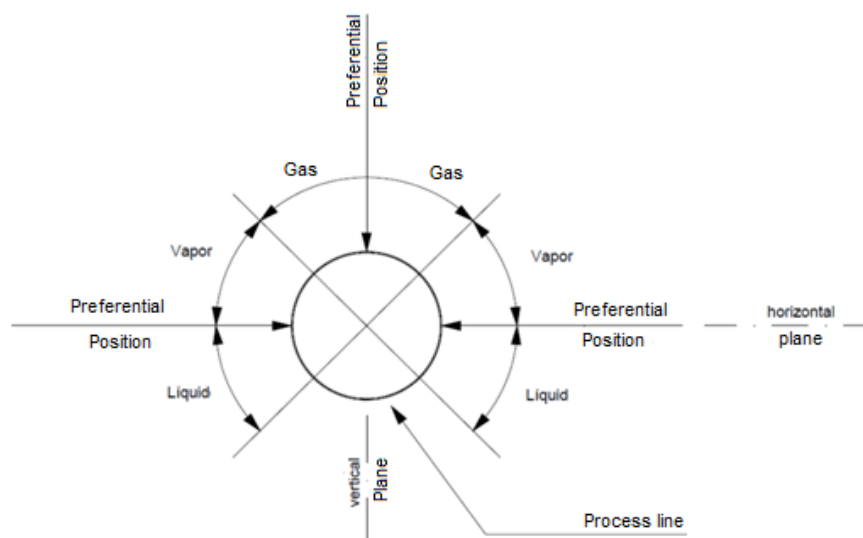


Figure 5.1 - Impulse tap orientation

- 5.1.23 All components of the metering system – including meters, transmitters, analyzers, flow conditioners, straight pipe sections, mixers, orifice plates, samplers, probes, valves, skids, and similar items – shall have a unique identification code (tag), serial number, and flow direction permanently engraved on the body to ensure easy visualization and identification in the field.
- 5.1.24 Fiscal, allocation, and custody transfer linear flow meters shall be equipped with an additional digital communication interface with flow computers for diagnostics purposes, in addition to the pulse communication.
- 5.1.24.1 The diagnostic variables to be monitored shall be defined during the detailed design phase in coordination with the manufacturers and subsequently submitted to **PETROBRAS** for approval.
- 5.1.24.2 For fiscal flare meters, diagnostics shall include, at a minimum, velocity of sound (VOS), signal strength, signal quality, or equivalent parameters. The complete set of diagnostic variables shall be defined and agreed with **PETROBRAS** during the detailed design phase.
- 5.1.25 All calibration and dimensional requirements – including pressure, temperature, and flow calibrations (such as volume prover calibrations), as well as dimensional inspections (including those for flare ultrasonic meters) – shall be performed by laboratories accredited by Inmetro, ILAC, or IAAC.
- 5.1.26 The FMS shall comply with the maximum uncertainty requirements for total oil and gas production. The maximum allowable uncertainty is $\pm 0.6\%$ for the total volume of produced oil and $\pm 3\%$ for produced gas.
- 5.1.27 Uncertainty measurement calculation reports for all metering systems shall be prepared in accordance with the GUIDE TO THE EXPRESSION OF UNCERTAINTY IN MEASUREMENT (ISO GUM), Inmetro guidelines, and ISO 5168 - MEASUREMENT OF FLUID FLOW - PROCEDURES FOR THE EVALUATION OF UNCERTAINTIES.

5.2 OIL METERING REQUIREMENTS

- 5.2.1 The crude oil to cargo tanks fiscal metering system shall comprise of at least two (2) duty meter runs, each one attending 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 (3) duty meter runs, each one attending 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 run equipped with oil calibration systems to enable calibration of the flow meters at any flow rate within their full operating range and to ensure individual flow control during calibrations.
- 5.2.3.1 Control valves shall be located downstream of the flowmeters.
- 5.2.4 Routing hydrocarbon volumes directly to cargo tanks without fiscal metering is strictly prohibited.
- 5.2.4.1 Any recovered oil and condensate from Flare K.O. Drums, Closed Drain, overflow (oil stream) from hydrocyclones, overflow (oil stream) from flotation units, overflow (oil stream) from slop tanks, and similar sources shall be collected, treated and routed back to the process plant upstream of the 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 any other tanks that may contain crude oil not fiscal metered shall be equipped with removable spools that are sealed and controlled (locked), with open/close status registered in the UNIT’s supervisory system (including PI).
- 5.2.4.3 Each removable spool shall have a stainless-steel nameplate with serial number and tag identification.
- 5.2.4.4 The UNIT shall have an operational procedure in place to ensure that such alignments are used only under special circumstances and that 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 with their outlet line positioned above the meters, ensuring that the meters always remain fully filled and free of entrained gas.
- 5.2.6 For fiscal or custody transfer oil metering skids designed with a calibration pipe run intended for calibrating meters from other metering points in the unit against the skid’s prover, the calibration pipe run shall be arranged in series with the duty meters of the skid. This configuration shall ensure that the calibration pipe run does



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not constitute a new metering point to be included in the total measurement of the skid.

- 5.2.7 Ultrasonic and turbine oil flowmeters shall be specified in accordance with the minimum Reynolds number limits stated in the Type Approval and in the most recent version of the manufacturer's manual, with the most restrictive value prevailing.
- 5.2.7.1 If the Type Approval and manufacturer's manual do not specify this requirement, the minimum Reynolds number shall be determined in accordance with API MPMS 5.3 and API MPMS 5.8.
- 5.2.7.2 If the manuals permit the use of meters in flow regimes below a Reynolds number of 10,000 without support from the Type Approval, the manufacturer shall provide a technical report demonstrating that meter performance for the intended application is not compromised.
- 5.2.7.3 Any 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 as Category A (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 and mounted on a skid. An online gas chromatograph analyzer shall be included and integrated with the metering system.
- 5.3.2 Fiscal gas metering systems designed as Category B (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 with dual chamber orifice fittings.
- 5.3.3 Gas meter systems with dual chamber orifice fittings shall allow for the changing and/or retrieval of orifice plates during normal operation under pressure.
- 5.3.3.1 Dual chamber orifice fittings shall be provided with valves for drainage during operation.
- 5.3.3.2 Gas metering systems with orifice fittings operating near the dew point shall have the drain outlet routed to the closed drainage system, returned to the process, or directed to a safe area, provided that no bypass is installed.
- 5.3.4 Technical design and certifications of all orifice plate metering points shall comply with ISO 5167 standards.
- 5.3.4.1 All orifice plate metering points shall have a minimum internal pipe diameter of 2 inches.
- 5.3.4.2 All orifice plate metering points shall use Zanker flow conditioner.
- 5.3.4.3 All orifice plate metering points shall have the straight pipe runs installed between flanges to facilitate dimensional inspection and maintenance.
- 5.3.5 Flare/vent gas metering systems shall be equipped with ultrasonic flow meters for flare/vent applications with 2 channels. Exceptions shall be subjected to prior approval by **PETROBRAS**.
- 5.3.6 Flare/vent gas meter shall be supplied mounted in a spool to facilitate easy disassembly for dimensional inspection.
- 5.3.6.1 The spool shall be provided by the flare/vent gas meter manufacturer, or manufactured under the manufacturer's supervision with certified compliance.
- 5.3.6.2 Flare/vent sensors shall be of the removable type to allow for dry calibration procedures.
- 5.3.7 The piping lengths associated with the flare/vent gas meter shall be based on a minimum of 20 nominal pipe diameters of straight run upstream and 10 nominal pipe diameters downstream of the meter.

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- 5.3.7.1 **CONTRACTOR** shall provide technical studies, including Computational Fluid Dynamics (CFD) analyses, to demonstrate that measurement uncertainties comply with ANP/Inmetro requirements and to support the uncertainty calculation reports.
- 5.3.8 For flare/vent gas meters, flow computation and data storage shall be performed by a flow computer approved by Inmetro, using the **gross** flow rate provided by the meter.
- 5.3.8.1 The flare meter electronic unit shall communicate with the flow computer via a field network using the MODBUS RTU protocol.
- 5.3.8.2 Pressure (PIT) and temperature (TIT) transmitters shall communicate directly with the flow computer via 4-20 mA analog signals. If required by the manufacturer, PIT and TIT signals may be replicated from the flow computer to the flare meter electronic unit via MODBUS-RTU (RS-485).
- 5.3.8.3 Pressure and temperature compensation to reference conditions shall be performed exclusively by the flow computer approved by Inmetro.
- 5.3.9 Flare/vent gas meter shall have a meter service port accessible and available for operation and maintenance, with provision for remote access.
- 5.3.10 The use of cone meters shall comply with ISO 5167-5 and shall include means of dimensional verification and calibration.
- 5.3.10.1 Cone meters shall be initially calibrated on all range of Reynolds numbers expected for the application.
- 5.3.11 The design of linear gas metering systems shall comply with ISO 17089-1, AGA 11, or AGA 7, as applicable to the technology employed.
- 5.3.12 Linear gas fiscal metering systems shall comprise duty meter runs, one standby meter run with the same characteristics as the duty meter runs, and a master meter.
- 5.3.12.1 The number of meter runs shall be sufficient to allow calibration of the master meter in an accredited laboratory under operating conditions, as required by the RTM, including the applicable flowrate range.
- 5.3.12.2 At a minimum, one duty meter run and one standby meter run shall be provided.
- 5.3.13 For export gas metering systems equipped with linear flowmeters, a calibration stream shall be provided to enable calibration of the import gas duty meters when the importation system is not operating, in order to comply with periodic requirements.
- 5.3.13.1 If, at the time of the detailed design phase, the current RTM explicitly allows for a bidirectional meter and the **CONTRACTOR** opts to provide a single bidirectional flow measurement skid for both export and import gas measurement, the skid

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design shall permit operation and calibration of the duty meters in both directions, even if the skid is operating only in the export or import direction.

5.3.14 For gas metering system equipped with linear flowmeters, control valves shall be installed on each meter runs with a calibration system to enable calibration of the meters at any flow rate within their full operating range and to ensure individual flow control during calibrations.

5.3.14.1 Control valves shall be located downstream of the flowmeters.

5.3.14.2 The impact of noise – especially from control valve modulation – on flow measurement shall be evaluated. Where necessary, noise traps shall be employed to prevent interference and ensure accurate measurement data.

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

5.3.16 For gas measurement applications where the process operational pressure is equal to or below 21 bar(a) (e.g., flare, test separator, etc.), the pressure transmitter (PIT) shall be of the absolute pressure type.

5.3.17 The gas lift metering system shall be designed to enable measurement of the gas lift flow rate for each service riser individually (gas lift and test gas lift risers), as well as the total gas lift flow rate.

5.3.18 The gas injection metering system shall be designed to enable measurement of the gas injection flow rate for each well riser individually, as well as the total gas injection flow rate.

5.3.19 Means shall be provided to prevent condensate accumulation in gas meters, such as those installed on the test separator and production separator. Strategies may include thermal insulation of the piping, locating the meter as close as possible to the separator, and installing the flowmeter piping with an upward slope.

5.4 SAMPLING REQUIREMENTS

- 5.4.1 Each gas metering points shall be provided with a representative manual sampler device (including for flare and vent applications). Exceptions are permitted for individual gas lift meters, individual gas injection meters, and individual water injection meters, which may use their respective total gas lift, total gas injection, and total water injection sampling points.
- 5.4.1.1 The manual sampler device shall be installed as close as possible to its respective metering point and easily accessible to the operator.
- 5.4.1.2 It shall be ensured that no significant process change occurs between the meter and its respective sampling point.
- 5.4.1.3 If a flare gas recovery unit is provided, the LP and HP flare sampling points shall be installed upstream of the flare recovery system branching to guarantee sample collection even when there is no gas flow in the flare lines.
- 5.4.2 Gas manual sample points shall comply with the recommendations of API MPMS 14.1.
- 5.4.2.1 The sampling probe shall be intrusive, installed at the top (12 o'clock position) of a horizontal pipe.
- 5.4.2.2 The sampling probe shall be located at least five pipe diameters downstream of any flow-disturbing element.
- 5.4.2.3 For orifice plate and cone meters, the sampling probe shall be installed upstream the meter.
- 5.4.2.4 Lines operating at or near the gas stream's dew point may require special probes designed to address condensation issues in the gas.
- 5.4.3 Gas manual sample points shall be provided with sampling panels, clearly labeled with tags, and provided with bottle/cylinder support as well as means for gas purging prior to sample collection.
- 5.4.3.1 Gas purged through sampling points shall be directed to the flare system.
- 5.4.4 Flare/vent sampling system shall be able to collect representative samples even under low-pressure conditions; therefore, devices such as vacuum pump shall be provided as necessary.
- 5.4.5 Fiscal gas metering systems, except for flare applications, designed as Category A shall be equipped with a dedicated online gas chromatograph analyzer (GCA) integrated with the metering system to enable automatic updating of gas properties in the flow computer.
- 5.4.5.1 GCA shall determine hydrocarbon composition (up to C9+), CO₂ and N₂.

- 5.4.5.2 GCA shall be linked to the flow computer, which shall inform daily, at least: gas composition; gas flow rate per compound, gas higher heating value.
- 5.4.5.3 The maximum allowable uncertainty shall be $\pm 0.3\%$ of the compressibility factor.
- 5.4.5.4 The metering system shall include a validation system to discard invalid or spurious GCA results, before updating the gas properties on the flow computers.
- 5.4.5.5 GCA shall comply with *Portaria Inmetro 188/2021*, ISO 6974 and ASTM D1945 requirements.
- 5.4.6 All oil metering points shall be equipped with sample collecting points, clearly labeled with tags, capable of operating at atmospheric pressure for the determination of BS&W and density values.
- 5.4.6.1 For oil allocation and fiscal oil to cargo tanks metering systems, the sampling points shall also allow the sample collection under process pressure conditions for the determination of shrinkage factor (FE), solubility ratio (RS), and evaluation of the Reid Vapor Pressure (RVP) of oil to cargo tanks.
- 5.4.6.2 Special care shall be taken with condensate sampling point to ensure that samples are representative of 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 samplers and BS&W analyzers on fiscal oil to cargo tanks skids shall be of the retrievable type without process interruption.
- 5.4.10 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 to prevent vortex-induced vibration and other detrimental effects. In the absence of specific manufacturer criteria, the requirements of ASME PTC 19.3 TW shall be complied with.
- 5.4.12 The mixing system shall ensure oil sample homogeneity across the entire expected flow range, with a concentration ratio (C1/C2) above 0.9, in accordance with ISO 3171.
- 5.4.12.1 During the detailed design phase, **CONTRACTOR** shall submit mixing calculation reports for **PETROBRAS** evaluation.
- 5.4.12.2 The mixing system shall be installed upstream of BS&W analyzer and sampling systems.
- 5.4.12.3 The mixing system may be static or dynamic.



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5.4.12.4 If a fast loop solution is applied, the BS&W analyzer and sampling systems (both manual and automatic sampling points) shall be installed on the main line.

5.4.12.4.1 Spares for fast loop pump and rotameter shall be provided.

5.4.13 Regarding periodicity and procedures for oil and gas analysis and implementation of the results (physicochemical properties) into the flow computers, the **CONTRACTOR** shall comply with “Resolução ANP 52/2013” (or any updated document that replaces it), which details and complements “Resolução Conjunta ANP/Inmetro n° 1/2013”.

5.5 MULTIPHASE METERING REQUIREMENTS

5.5.1 Multiphase Flow Metering System (MFMS) is a subsystem of FMS and shall continuously allocate individual well production.

5.5.2 The scope of the MFMS shall include, at least, the following:

5.5.2.1 Topsides Multiphase Flowmeters (TMPFMs), to be provided by CONTRACTOR;

5.5.2.2 Subsea Multiphase Flowmeters (SMPFMs), to be provided by PETROBRAS;

5.5.2.3 Topsides gas lift flow meters, to be provided by CONTRACTOR;

5.5.2.4 Subsea gas lift flow meters, to be provided by PETROBRAS;

5.5.2.5 Flow meters from Test Separator, to be provided by CONTRACTOR;

5.5.2.6 MFMS dedicated panel and workstation, to be provided by CONTRACTOR;

5.5.2.7 Integration of MFMS with Subsea Production Control System (SPCS), by CONTRACTOR;

5.5.2.8 Integration of MFMS with FMS, by CONTRACTOR;

5.5.2.9 Integration of MFMS with Control and Safety System (CSS), by CONTRACTOR;

5.5.2.10 Documentation, by CONTRACTOR;

5.5.2.11 FAT, calibrations (flow testing), SAT, SIT, training, and start-up services, by CONTRACTOR;

5.5.2.12 Metering system approval by national regulation Agencies, by CONTRACTOR;

5.5.2.13 Continuous operation and management of the system for allocation purposes, under national regulation requirements, by CONTRACTOR.

5.5.3 MFMS main objectives as per below:

5.5.3.1 For production wells in subsea manifolds and trunklines, production allocation shall be measured by Subsea Multiphase Flow Meters (SMPFMs), subtracting the injected gas lift flow measured by subsea single-phase gas lift flow meters.

5.5.3.2 For Satellite production wells, production allocation shall be measured by Topsides Multiphase Flow Meters (TMPFMs), subtracting the injected gas lift flow measured by topsides single-phase gas lift flow meters.

5.5.3.3 MFMS shall also include TMPFMs on production risers connected to subsea manifolds and trunklines to verify the performance of the SMPFMs.

5.5.3.4 Additionally, single-phase water, oil, and gas flow meters installed at the Test Separator outlets shall be used to verify the performance of the TMPFMs.

- 5.5.3.5 MFMS shall integrate data from SMPFMs, TMPFMs, subsea single-phase gas lift meters, topside single-phase gas lift meters and single-phase oil, gas, and water meters from Test Separator. The data to be retrieved shall include instantaneous flow rates, totalized volumes, pressure, temperature, and meter diagnostics.
- 5.5.3.6 MFMS shall include all required hardware, software, and accessories to totalize and store metering data, implement standard algorithms for flow calculation, provide a human-machine interface (HMI) for operators and metering technical responsible, ensure data integrity, and comply with all legal requirements.
- 5.5.4 MFMS shall comply with “*Resolução ANP nº 44/2015*” (or any subsequent regulations that complement or replace it), as well as the manufacturer’s recommendations.
- 5.5.5 Each production riser shall have a dedicated Topside Multiphase Flow Meter (TMPFM) installed on topside, including provisions for spare production riser slots. The maximum acceptable pressure loss due to multiphase meters is 400 kPa per production line.
- 5.5.6 Each gas lift/service line shall have a gas lift meter installed on topside (including the gas lift and service lines of the Subsea Gas Lift Manifold).
- 5.5.7 PETROBRAS will install a dedicated Subsea Multiphase Flow Meter (SMPFM) for each production well connected to a manifold or trunkline. Subsea arrangements may include trunklines, manifolds or satellite wells. Integration of these meters into the MFMS shall be the responsibility of the CONTRACTOR.
- 5.5.8 PETROBRAS will install a dedicated subsea gas lift meter for each production well connected to a manifold, trunkline, or the Subsea Gas Lift Manifold. Integration of these meters into the MFMS shall be the responsibility of the CONTRACTOR.
- 5.5.9 CONTRACTOR shall coordinate intercommunication details with subsea flow meter manufacturers (multiphase and gas lift) to ensure proper operation of the integrated system. CONTRACTOR shall also foresee commissioning of subsea meters in conjunction with the meter manufacturers.
- 5.5.10 MFMS shall communicate with the Subsea Production Control System (SPCS) to receive data from the SMPFMs.
- 5.5.10.1 Additionally, MFMS shall be capable of writing to defined registers in the SPCS, to be defined during detailed design phase.
- 5.5.10.2 MFMS shall include supervisory screens for interfacing with the SMPFMs.
- 5.5.11 CONTRACTOR shall provide flow computers to interface with the subsea gas lift flow meters.
- 5.5.11.1 Flow computers shall communicate with the SPCS MCS panel via a network protocol to be confirmed during detailed design phase.

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5.5.11.2 Data from these flow meters shall be available at MFMS.

5.5.11.3 CONTRACTOR shall be responsible for the integration between SPCS MCS and MFMS.

5.5.12 Operation, verification, and parameterization of topside and subsea multiphase meters shall be within the CONTRACTOR's scope.

5.5.12.1 It shall be possible to update the parameters of both topside and subsea multiphase meters from the MFMS.

5.5.13 Operation, verification, and parametrization of subsea gas lift meters shall be within the CONTRACTOR's scope.

5.5.14 MPFMs shall support black-oil and custom PVT models for equation of state (EoS) compatible with the reservoir fluids, which shall be available to the MFMS.

5.5.15 MFMS shall be able to calculate the flow measurements for the entire allocation metering system.

5.5.16 SMPFMs shall be continuously compared to TMPFMs using reconciliation factors to monitor the measurement quality of the subsea meters.

5.5.17 It shall be possible to align the TMPFMs against the Test Separator to verify the accuracy of the multiphase meters, in order to monitor the measurement quality of the topside meters or whenever malfunctions are suspected.

5.5.18 Subsea gas lift measurements shall be continuously compared to gas lift topside meters using reconciliation factors to monitor the measurement quality of the subsea meters.

5.5.19 It shall be possible to test or calibrate an individual subsea gas lift meter against the corresponding topside individual gas lift meter to verify the accuracy of the subsea gas lift meters whenever malfunctions are suspected.

5.5.20 MFMS shall be able to allocate well production by measuring the difference between SMPFMs and their respective TMPFM in contingency situations. This requirement also applies to subsea gas lift meters.

5.5.21 MFMS shall be capable of verifying both topside and subsea multiphase meters, either by performing calibration against a test separator or by continuously monitoring flow between subsea and topside meters.

5.5.22 MPFMs shall have diagnostic capabilities accessible to the MFMS, including operational status indication for every component of the multiphase meter.

5.5.23 MFMS shall receive and store the process data, parameters, and diagnostics from SMPFMs, TMPFMs, and subsea gas lift flow meters.

5.5.23.1 These data shall also be made available to the MFMS workstation, CSS and PI system, and shall include, at a minimum, the following variables:

- Volumetric oil flow at reference conditions (m³/h);
- Volumetric water flow at reference conditions (m³/h);
- Volumetric gas flow at reference conditions (m³/h);
- Volumetric oil flow at actual conditions (Am³/h);
- Volumetric water flow at actual conditions (Am³/h);
- Volumetric gas flow at actual conditions (Am³/h);
- Mass flow of oil (kg/h);
- Mass flow of water (kg/h);
- Mass flow of gas (kg/h);
- Mass flow of liquid (kg/h);
- HC mass flow (kg/h);
- Total mass flow (kg/h);
- Oil hold-up at actual conditions (%);
- Gas hold-up at actual conditions (%);
- Water hold-up at actual conditions (%);
- GLR at reference conditions (%);
- GOR at reference conditions (%);
- WLR at reference conditions (%);
- GLR at actual conditions (%);
- GOR at actual conditions (%);
- WLR at actual conditions (%);
- Static pressure (kPa);
- Differential pressure (kPa);
- Temperature (°C);
- Water salinity (PSU);
- Oil specific mass at reference conditions (kg/m³);
- Gas specific mass at reference conditions (kg/m³);
- Water specific mass at reference conditions (kg/m³);
- Oil specific mass at actual conditions (kg/m³);
- Gas specific mass at actual conditions (kg/m³);
- Water specific mass at actual conditions (kg/m³);
- Oil dynamic viscosity at reference conditions (cP);
- Gas dynamic viscosity at reference conditions (cP);
- Water dynamic viscosity at reference conditions (cP);
- Oil dynamic viscosity at actual conditions (cP);
- Gas dynamic viscosity at actual conditions (cP);
- Water dynamic viscosity at actual conditions (cP).

5.5.24 MFMS shall include software capable of calculating each well's oil, gas, and water production, and generating well production test reports.

5.5.25 MFMS shall be able to convert all measured flow rates in actual conditions to ANP reference conditions. Intermediate conditions may be implemented for TMPFM verification, such as Test Separator actual conditions.



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- 5.5.26 The MFMS Server shall retain all historical records and reports for at minimum of 10 years, using hard disks or solid-state disks and on an incremental daily basis.
- 5.5.27 Metering reports (including well allocation, performance verification, batch metering testing, alarms and events, and audit trails) shall be readily available to ANP and/or PETROBRAS representatives on board, and shall be recorded for future internal or regulatory audits.
- 5.5.28 Oil, gas, and water samples shall be collected from test separators at intervals not exceeding six (6) months for analysis, recombination, and updating as directed by the subsea and topside multiphase meter manufacturers. This interval may be extended only with PETROBRAS authorization, and may be shortened in contingency situations.
- 5.5.29 All TMPFM shall be supplied by the same manufacturer, and the manufacturer shall offer technical support in Brazil.
- 5.5.30 Maintenance of topside multiphase meters shall be the responsibility of the CONTRACTOR, while maintenance of subsea meters shall be the responsibility of PETROBRAS.
- 5.5.31 Maintenance and verification plans to ensure the proper functioning of multiphase meters shall be defined and executed by the CONTRACTOR, subjected to approval by PETROBRAS.
- 5.5.32 The installation of multiphase meters shall be designed to allow maintenance and replacement of the equipment without interrupting FPSO operations.
- 5.5.33 The operating envelope of the multiphase meters shall cover the entire expected flow range throughout the lifetime of the wells.
- 5.5.33.1 If it is not possible to maintain the required measurement uncertainty with the same multiphase meters over operational lifetime, additional parallel streams shall be provided.
- 5.5.34 Each multiphase meter in operation shall have a spare meter in stock for rapid replacement in the event of failure. It is acceptable to provide only one spare meter for each group of identical meters.
- 5.5.35 TMPFMs shall include salinity monitoring of the water phase to enable correction of the Water-Liquid Ratio (WLR).
- 5.5.36 TMPFM shall be equipped with radioactive sources to enhance measurement accuracy. The half-life of the radioactive sources shall be at least 20 years.
- 5.5.37 For all radioactive materials and equipment, CONTRACTOR shall comply with CNEN resolutions throughout all stages of the process, including logistics, handling, storage, manufacturing, and assembly carried out in Brazil, as well as operation, until Unit handover.

5.5.37.1 For activities in other countries, CONTRACTOR shall adhere to the national regulations of the respective country regarding the import, transport, storage, and export of radioactive sources.

5.5.37.2 A comprehensive safety plan addressing all these aspects shall be submitted to PETROBRAS for risk assessment management.

5.5.38 TMPFMs equipped with radioactive sources shall be manufactured to ensure that, during the operation, maintenance, and storage, workers exposure to radiation does not exceed the limits established in CNEN NN 3.01.

5.5.39 CONTRACTOR is responsible for the transfer of ownership of radioactive sources to PETROBRAS and for compliance with all associated legal requirements.

5.5.40 Radioactive sources shall be installed and calibrated when the UNIT is at its final location or during shipyard activities in Brazil, close to the beginning of operation.

5.5.41 For approval of the multiphase metering project, the multiphase meter model shall be subject to performance testing in an independent laboratory to verify compliance with the required uncertainty criteria, as specified in paragraph 3.1 of "Resolução ANP n° 44/2015".

5.5.42 Performance tests shall be conducted using fluids as close as possible to actual process conditions, and shall cover the full operating envelope and flow rates expected during the meter's application.

5.5.43 Factory Acceptance Test (FAT) shall be performed for each TMPFM supplied, covering at minimum the functional tests specified in the technical specification, and individual performance proven through calibration.

5.5.44 PETROBRAS is expected to witness the performance approval test and FAT of the multiphase meters. Notification of the tests shall be provided at least 45 days in advance.

5.5.45 At the beginning of the UNIT design, within six (6) months from the Kick-Off-Meeting, CONTRACTOR shall provide preliminary documents (in Portuguese) for the multiphase metering system to be submitted to ANP for approval, in accordance with "Resolução ANP n° 44/2015". This documentation shall include, at a minimum:

- Schematic Diagram of Flow Metering for Allocation;
- Technical Description of the Allocation Flow Metering System;
- Preliminary performance verification plan for the Multiphases and subsea gas lift flow meters, according to "Resolução ANP n° 44" requirements;
- Multiphase fluid sample collection plan, "Resolução ANP n° 44" requirements;
- PVT data update plan, "Resolução ANP n° 44" requirements;
- MFMS Commissioning plan;



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- TMPFMs performance test procedure.

5.5.46 Twenty (20) months prior to production system start-up, CONTRACTOR shall provide to PETROBRAS the complementary documentation (in Portuguese) for the multiphase metering system to be submitted to ANP for approval, in accordance with "Resolução ANP nº 44/2015". The complete list of required documents will be provided by PETROBRAS during detailed design phase.

5.6 FMS AUTOMATION REQUIREMENTS

- 5.6.1 The FMS Workstation shall include all necessary functionalities for the complete operation and calibration of the flowmeters, including automatic remote actuation of valve alignments and calibration flowrate adjustments, as well as the generation of metering reports (including for gas lift and multiphase meters), among others features.
- 5.6.2 All installed software shall be provided with the necessary licenses and installation media, as well as backups of all implemented configurations and programs. Development versions of these software packages shall also be provided.
- 5.6.3 An interface between the FMS and Automation System (CSS) of the production UNIT shall be provided to enable the transfer of operational data from the flow computers to the supervisory system of the UNIT and to the PI Server. The list of PI to be made available on onshore servers shall be confirmed during detailed design phase.
- 5.6.4 All log files shall be generated based on actual data from the flow computers through direct upload, ensuring data integrity.
- 5.6.4.1 These files shall be stored at the FMS Workstation non-volatile memory / dedicated directory, with backups performed at least once per month.
- 5.6.5 The FMS Workstation shall retain all historical records and reports for a minimum of 10 years, in accordance with RTM item 10.1.6, using hard disks or solid-state disks, with incremental daily backups.
- 5.6.6 Daily volume production for all metering points shall be closed at 00:00 (midnight).
- 5.6.7 Metering reports (hourly, daily, and monthly production; calibration; batch reports for well testing and offloading; alarms and events; audit trail) shall be readily available to ANP and/or PETROBRAS representatives on board, and shall be recorded for future internal or regulatory audits.
- 5.6.7.1 Measurement data shall also be accessible at the workstation in PETROBRAS's office onboard.
- 5.6.8 FMS shall generate, at a minimum, the following general log files:
- 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.



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- 5.6.9 All log files shall be generated in accordance with the formats defined in the latest editions of API MPMS 21.1 and API MPMS 21.2.
- 5.6.10 Metering reports in XML format, containing production, configuration, and log data extracted from flow computers, shall be automatically generated in compliance with ANP specifications (*Resolução ANP 65/2014* and any supplementary regulations issued by ANP/Inmetro). Data flow shall be designed to prevent data tampering, including the implementation of access controls.
- 5.6.11 XML metering daily reports shall also include total gas injection meters (or individual gas injection meters, where classified as fiscal), operational flare related meters (pilot, purge, etc.), and custody transfer meters (offloading). Additionally, the monthly volume of each cargo tank shall be provided.
- 5.6.12 A communication link shall be established between the FMS Workstation and **PETROBRAS** Corporate Network to make XML files and the data required for external XML file generation available. This communication may be carried out via the onboard automation network and does not require a direct connection to the firewall.
- 5.6.13 To ensure proper synchronization between all flow computers and the FMS Workstation clocks, a method shall be provided to synchronize the flow computers with the FMS, using the FMS clock as the reference.
- 5.6.14 FMS Workstation and flow computers shall have access controls in place to prevent inadvertent modifications. Flow computers shall only be configurable through the FMS and not via the CSS, with full traceability of all modifications maintained in an audit log.
- 5.6.15 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..
- 5.6.15.1 Note: NSV stands for "Net Standard Volume", defined as the total volume of all petroleum liquids, excluding sediment and water, and free water, corrected by the appropriate volume correction factor (CTL) for observed temperature and specific gravity to a standard temperature, and also corrected by the applicable pressure correction factor (CPL) and meter factor.
- 5.6.16 FMS 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

5.7 DOCUMENTATION REQUIREMENTS

- 5.7.1 At the beginning of the UNIT design, within six (6) months from the Kick-Off-Meeting, **CONTRACTOR** shall provide to **PETROBRAS** the following documents (in Portuguese) for submission to ANP for approval, in accordance with *Resolução Conjunta ANP/Inmetro* nº 1 de 10/06/2013:
- 5.7.1.1 Schematic Diagram for Metering System (*Diagrama Esquemático das Instalações*);
- 5.7.1.2 Technical description of the production unit metering system (*Memorial Descritivo dos Sistemas de Medição*).
- 5.7.2 At least six (6) months prior to UNIT sail away (or four (4) months before ANP inspection at the shipyard, whichever occurs first), **CONTRACTOR** shall provide to **PETROBRAS** the metering system documentation (in Portuguese), including design and operating description reports, diagrams, and other related documents, for submission to ANP for approval, in accordance with *Resolução Conjunta ANP/Inmetro* nº 1 de 10/06/2013. The complete list of required documents will be provided by **PETROBRAS** at the beginning of the detailed design phase.
- 5.7.3 At least forty (40) days prior to ANP authorization inspection (with the UNIT on final location, offshore), **CONTRACTOR** shall provide to **PETROBRAS** the complete documentation of the metering system required on current RTM, including any updates from the previous version and including valid calibration certificates, dimensional inspection reports, leak tests reports, uncertainty reports and flow computer parametrization.
- 5.7.4 All calibration certificates, dimensional inspection reports, leak tests reports and uncertainty reports shall be updated and valid for ANP final inspection offshore. and for the beginning of the UNIT operation.
- 5.7.5 **CONTRACTOR** is responsible to provide any additional information or documentation as requested by ANP or Inmetro.
- 5.7.6 For calibration and dimensional inspections certificates, as well as uncertainty reports, **CONTRACTOR** shall provide, in addition to the original documents in PDF format, XML files containing the results and relevant information. **PETROBRAS** will provide the file templates during the detailed design phase.