Manual of Petroleum Measurement Standards Chapter 20—Production Measurement and Allocation

Section XX— Full-Range Online Water Cut Analyzers

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Contents

Introduction

The water content from a production stream can be measured by separating the phases in a two-phase, liquid-liquid separator or in a three-phase (oil/gas/water) separator and measuring the flow from the liquid outlets, using single-phase flow meters. However, undersized two-/three-phase separators or inadequate separation internals can lead to poor liquid/liquid separation performance. As a result, significant oil carry-under through the water outlet and water carry-over through the oil outlet will cause inaccurate water fraction measurement. In this scenario, the oil and water streams from the separator can be recombined and a full-range water cut analyzer can be installed downstream of a mixing point to allow for continuous measurement of the water cut. Full-range water cut analyzers can also be installed in the liquid outlet of a two-phase (gas/liquid) separator or in combination with well stream flow measurement devices, such as multiphase flow meters. This standard provides the basis for design and operation of full-range water cut analyzers for production measurement in alignment with other relevant standards.

1 Scope

This standard provides the minimum requirements for design, installation, operation, maintenance, and calibration of online water fraction measurement devices for water cuts from 0-100%.

2 Normative References

The following documents are referred to in the text in such a way that some, or all, of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API MPMS Chapter 8.1 *Manual Sampling of Petroleum and Petroleum Products (ASTM D4057)*

3 Definitions and Abbreviations

For the purposes of this document, the following definitions apply.

water cut analyzer (WCA)
Device that provides an on-line, continuous measurement of water content in a hydrocarbon/water mixture under flowing conditions.

full-range
Percent water in oil, by volume, from 0% up to 100%.

water cut (WC)
The volume percentage of water in a combined hydrocarbon and water stream

water-liquid ratio (WLR)
The water volume flow rate, relative to the total liquid volume flow rate (oil and water), at the actual conditions (operating pressure and temperature), expressed as a percentage.

gas volume fraction (GVF)
The fraction of the total volumetric flow rate at actual condition expressed as a percentage. GVF Qg v Qg v Ql =/(+v)

4 Application in Use

This standard is intended for water cut measurement from a production stream upstream of final separation.

This standard applies to stand-alone water cut analyzers and other stand-alone devices which can provide a water cut output (e.g. Coriolis meters).

5 Overview – Online Water Cut Measurement

5.1 General

5.1.2 There are multiple technologies to measure water cut across different types of applications and ranges. Different measurement principles are described in this section. The device user will need to take into consideration several features such as range, accuracy, fluid characteristic and mechanical configuration to select the most appropriate device for their application, below are some of those features and guidelines to consider before selecting the water cut analyzer best suited for the installation.

5.2 Measurement Approach

5.2.1 Optical

5.2.1.1 An optical water cut analyzer is based on the principle of near infrared wavelength absorption. The difference in near infrared absorption measurements by simultaneously measuring multiple wavelengths that include both water and oil absorption peaks. The difference in energy absorption rates between water and hydrocarbons allow this analyzer to measure water content. The operating principle is not affected by changes of the individual oil and water densities in the stream. The deposition of paraffin and other impurities on the sensor will have less effect on accuracy than with other analyzers.

5.2.2 Microwave

5.2.2.1 An energy absorption water cut analyzer is based on the principle of electromagnetic energy absorption. The difference in energy absorption rates between water and hydro- carbons allows this analyzer to measure water content. The operating principle is not affected by changes of the individual oil and water densities in the stream. The deposition of paraffin and other impurities on the sensor will have less effect on accuracy than with other analyzers

5.2.3 Capacitance

5.2.3.1 The capacitance water cut analyzer operates on the principle that there is a significant difference in the dielectric constants of water and hydrocarbon liquids. By measuring the capacitance (dependent upon dielectric constant) of the hydrocarbon or water emulsion, the water cut in the emulsion can then be determined.

5.2.4 Density

5.2.4.1 A density water cut analyzer is based on the density difference between hydrocarbon liquid and water. By measuring the density of the hydrocarbon/water mixture, the water cut in the mixture can be approximated. Several types of density meters can be adopted for this water cut analyzer application. These include, but are not limited to, vibrating element density meters, Coriolis mass flow meters, differential pressure density meters, and nuclear density meters.

5.3 Key Features

5.3.1

5.3.2 Table *1*provides a list of key features of different water cut measurement approaches.

5.3.3 Users shall consider those features in the selection of the most appropriate water cut measurement approach for a given application.

Table 1. Key Features of Various Water Cut Measurement Approaches

Approach	Key Features
Gamma-ray absorption (Bulk Density Measurement)	— Direct bulk density measurement — Considerations for use with H2S and salinity changes. — Assumes phases are homogenously mixed or are in layers perpendicular to the beam
Dual or Multiple Energy Gamma-ray (Mixture Mass Attenuation Measurement)	— Measures each phase fraction — Not affected by phase inversion — Requires in situ measurement or fluid composition and calculations — Attenuation considerations for use with higher specific gravity fluids
Optical (Near Infra-Red/ Spectroscopy)	— Measures *WLR* — Allows for methanol injection — Window/gap at near wall locations assumes bulk liquid representation — Window/gap cleaning may be required to keep clear — No considerations needed for water salinity, or gas fraction — Considerations for use near phase inversion zone
Low Frequency Electromagnetic <30 MHz Capacitance/Conductance-Inductance Mixture Permittivity/Mixture Conductivity	— Capacitance is suitable for low *water phase fraction* measurement (below oil/water phase inversion) while conductance is suitable above the inversion point — Fluid properties including water conductivity and gas phase fraction are required to evaluate water fraction — Considerations near phase inversion zone and with highly mixed regimes
High Frequency Electromagnetic ~2.4 GHz Microwave Mixture Permittivity/Mixture Conductivity	— *Water phase fraction* derived from the simultaneous measurement of mixture permittivity and conductivity above oil/water inversion point. Only mixture permittivity is needed below the inversion point. — Fluid properties including water conductivity and gas phase fraction are required to evaluate *water phase fraction* — Considerations near phase inversion zone and with high mixing regimes — Considerations of permittivity and conductivity with the continuous oil and continuous water phases respectively
Coriolis meter	— Measures mixture density by the frequency of the pickoff coils signal — Oil and water density measurements at standard conditions are required inputs — The water cut at line conditions is calculated using the measured mixture density and the reference oil and water densities

6 Water Cut Analyzer Selection

6.1 General

6.1.1 This section outlines a process for WCA selection and lists key parameters or conditions to be considered in the selection of WCAs for a given application.

6.2 WCA Selection Process

A flow diagram of the process for selecting WCAs is shown in Figure 1. The main steps in the selection process are as follows:

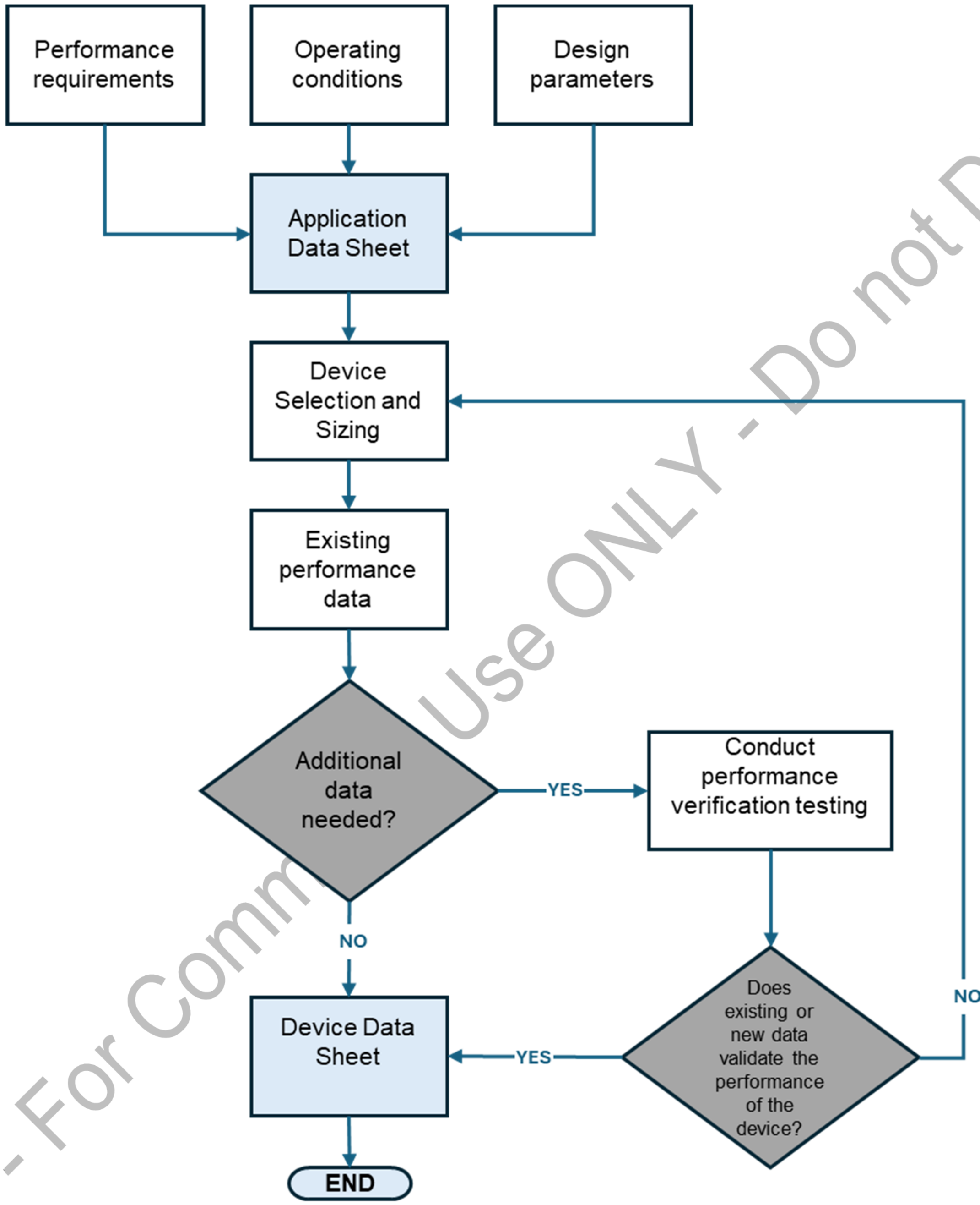

Figure 1. WCA Selection Process

6.2.1 Performance requirements

6.2.1.1 The WCA selection process starts with establishing the measurement performance requirements and process conditions.

6.2.1.2 The user should carefully analyze what performance levels are expected over the variety of process conditions anticipated. Typical performance specifications for full-range water cut analyzers are in the order of 1-2%abs.

6.2.2 Operating conditions

6.2.2.1 Key considerations include anticipated water cut range, the variation in process conditions expected over the life of the system, including variability in water content, flow rate range, and fluid properties. In some production facilities or similar non custody transfer facilities with inefficient separation systems, the water cut, gas content of liquid flow through the WCA may vary widely over time.

6.2.2.2 As such, the data provided to the manufacturer before the selection of the WCA shall not be instantaneous values but data collected over a reasonable period.

6.2.2.3 Any conditions that can impact the WCA performance shall also be identified by the user with guidance from Section 6.3.

6.2.3 Design parameters

6.2.3.1 Once the operating envelope is defined, an application data sheetshould be developed.

6.2.3.2 Relevant design parameters include process pressure and temperature, pipe size, pipe orientation, and wall thickness. Design installation considerations are described in Section 8.

6.2.4 Application Data Sheet

6.2.4.1 WCA manufacturers typically provide an application data sheet to be completed by the end user to provide operating conditions, design parameters, and performance requirements to be used in the selection and sizing of the WCA. Figure 2 shows an example of process conditions information to be included in the application data sheet.

Site Information:

Pipe diameter (units)	
Pipe schedule	
Pipe ID (units)	
ANSI rating	Select
Area classification (Division/Class)	

Flow Conditions:

	Minimum	Normal	Maximum	Units
Water cut				%
Flow rate				
Oil density				
Oil viscosity				
Temperature				
Pressure				
Salinity				

Flow Direction	Select
Is there gas in the process?	Select
If yes, is the gas flow intermittent or continuous?	Select
Max. pressure drop allowed (units)	

Figure 2. Sample Application Data Sheet

6.2.5 Device Selection

6.2.5.1 WCAs can be designed to operate in a multiphase stream (oil/gas/water) while others are designed to operate in liquid only.

6.2.5.2 If gas is normally present, the gas volume fraction shall be determined and WCAs designed to operate in full- range water cut and within the anticipated GVF range shall be identified to be considered in the selection process.

6.2.5.3 The device selection includes consideration of factors that impact performance, for example, fluid velocity, water liquid ratio, density, permittivity, or salinity variations. Selection also includes consideration of proven performance capability in the expected operating conditions.

6.2.5.4 When selecting a water cut analyzer, the application data sheet shall be shared with the manufacturer. Key items to consider include:

- The anticipated range of water cut and expected performance in this range.
- The anticipated range of liquid flow rates (or flow velocity) and expected performance in this operating range.
- The range of operating pressure, pressure losses through the WCA, and consideration whether the pressure in the analyzer is adequate to prevent the liquid from flashing.
- The effect of varying liquid properties (for example, viscosity, oil gravity, and water density) on the performance.
- The operating temperature range and the applicability of automatic temperature compensation.
- The material of construction of the analyzer and the effect of corrosive contaminants on its operating life.
- The quantity and size of foreign solid particles that may be carried in the liquid stream, which can impact performance and integrity of the WCA .
- The location where the water cut needs to be measured, the line size and minimum velocity requirements for the WCA, and the installation configuration of the device. .
- The space required for the installation of the WCA and for retrieving or accessing the device for maintenance and calibration.
- Types of secondary elements (for example, electronic processor unit and readout device) and the acceptable maximum distance between these secondary elements and the water cut analyzer.
- Environmental conditions such as extreme high/low temperatures, vibration, snow and hard freeze conditions, salty moisture and external condensation, and electromagnetic interference.
- The need for external inputs to the WCA, for example, static pressure and temperature inputs or density from another instrument.
- The compatibility of the output electronic signal, if applicable, to other associated devices and the method of adjusting this output signal.
- The class and type of pipe connections.
- Power supply requirements for the WCA and the secondary elements.
- Electrical code requirements.
- Type, method, and frequency of calibration.
- The presence of paraffin, tar, and other impurities that may coat the sensing element, and other adverse conditions that can impact the performance of the WCA (see Section 6.3 for guidance).

6.2.6 Performance verification

6.2.6.1 Once a device is selected, the next step in the process is to review any existing performance data that is available in published literature, from the manufacturer, or other sources.

6.2.6.2 Performance data collected within the operating envelope for the WCA can be used to validate its performance if the absolute error is within the performance specifications provided by the manufacturer or the user specified uncertainty for the application, whichever is highest.

6.2.6.3 The user should determine if the available data provides sufficient evidence of the required performance of the WCA in conditions that are representative of the intended application.

6.2.7 Additional performance verification testing

6.2.8.1 If the user determines that the performance data available is insufficient or is not representative of the intended application, additional testing can be carried out by the user to verify performance of the WCA before a field installation. Guidance on conducting performance verification of WCAs can be found in Section 7.

6.2.8 Device Data Sheet

6.2.9.1 The user shall complete a device data sheet with input from the device manufacturer. A sample of a WCA data sheet can be found in Figure 3.

General	1	Tag Number				
	2	Service				
	3	Application			Equipment Number	
	4	Line Number			P&ID number	
	5	Area Classification	Class			
	6		Division / Zone			
	7		Group			
	8	Protection Type			Temperature Class	
	9	Certification Authority			Certification Number	
Process Data	10	Fluid type				
	11		Units	Minimum	Normal	Maximum
	12	Flow Rate				
	13	Reynolds number				
	14	Temperature				
	15	Pressure				
	16	Density				
	17	Viscosity				
	18	Salinity				
	19	Water Cut				
	20	Gas Volume Fraction				
	21	Contaminant (s)				
	22	Contact Materials				
	23	Tap Conn Size			Type	
	24	Piping Size			Schedule	
	25	Mixer Size			Type	
	26	Verification method				
	27	Calibration method				
Transmitter	28	Tag Number				
	29	Supply	Volts		Amps	
	30	Scale Indicating			Type	
	31	Accuracy				
	32	Mounting			Signal	
	33	Enclosure			Area Class	
	34	Ambient. Temp max			Min	
Element/Sensor	35	Tag Number			Model Number	
	36	Supply	Volts		Amps	
	37	Size			Type	
	38	Oper. Temp max			Min	
	39	Oper. Press max			Min	

Figure 3. Sample Device Data Sheet

6.3 Factors that impact performance

6.3.1 As part of the selection process outlined in Section 6.2, process conditions that can adversely impact the performance of the WCA shall be considered before the WCA selection is finalized. Common parameters that can impact performance of a WCA include:

— Mixing – WCAs rely on a homogeneous mixture of oil and water to measure the WLR within their performance specifications. Inadequate mixing can lead to higher measurement uncertainties and shall be corrected by increasing the mixture flow velocity or by adding mixing device (e.g. static mixer) or flow component (e.g. valve).

— Piping orientation – horizontal piping orientation can lead to phase separation and stratification due to density difference between and oil and water phases while vertical pipe orientation provides a more symmetric distribution of the phases in the cross-section of the pipe. In vertical pipe orientation the flow direction (vertical upward or downward) becomes a relevant parameter. Users shall consider the most appropriate pipe orientation for a WCA based on manufacturer recommendations.

— Water Chemistry—Salinity of water and other water dissolved chemicals that can affect WLR determination.

— Water liquid ratio range – some technologies are designed to operate in a specific range of water fractions.

— Phase Inversion: Fluid parameters in the inversion zone including viscosity changes and temperature dependency (this impacts measurement technology selection for oil-continuous or water-continuous situations)

— Fluid velocity – mixing velocity can affect the WLR determination

— Flow assurance – flow assurance issues (e.g. contaminant buildup on sensors and chemicals impacting fluid properties) can impact performance or direct interfere with the sensor. For example, paraffin buildup on the analyzer decreases its sensitivity and results in erroneous measurement. Remedial practices may include chemical treatment of the liquid stream, heat tracing, and frequent cleaning of the analyzer.

— Solids – the presence of solid, metal and non-metal, particulates can impact the accuracy of the Wand can also cause malfunctioning if the particulates adhere or get stuck in the sensing element of the WCA.

— Environmental considerations, for example extreme temperature, vibration, electromagnetic interference.

— Density – density of the oil and water phases will play a role in the mixing of the two phases. The lower the density difference between oil and water the better the mixing would be and vice versa.

— Free/entrained gas – most WCA are affected by the presence of gas in the liquid phase. Some WCAs are designed to operate in mixtures of oil/water/gas and may provide different performance specifications depending on the volumetric fraction of gas present in the stream (GVF).

6.3.2 The level of impact of these parameters on the performance of WCAs will depend on the measurement approach of the device, advanced compensation or correction algorithms that may be built into the WCA core processor or transmitter, and the frequency and duration of the condition.

6.3.3 The user shall discuss these parameters with the manufacturer to better understand the impact on specific technologies, to factor that into the device selection, and to develop preventive or mitigation measures for the operation of a selected WCA.

6.3.4 Water chemistry and system temperature can be used to assess the potential for scaling and to implement scale buildup of the sensing element of the WCA.

6.3.5 Flow assurance issues (e.g. contaminant buildup on sensors and chemicals impacting fluid properties) can impact performance or directly interfere with the sensor. For example, paraffin buildup on the analyzer decreases its sensitivity and results in erroneous measurement. Remedial practices may include chemical treatment of the liquid stream, heat tracing, and frequent cleaning of the analyzer.

6.3.6 The presence of solid, metal and non-metal, particulates can impact the accuracy of the WCA and can also cause erosion and malfunctioning if the particulates adhere or get stuck in the sensing element of the WCA. Remedial practices may include installing a strainer and/or magnetic element upstream of the WCA and frequent cleaning/inspection of the analyzer.

7 Performance Verification

7.1 General

7.1.1 Accurate water content measurement in hydrocarbon streams is vital for optimizing production, maintaining product quality, and meeting regulatory standards in the oil and gas industry. WCA provide real-time data on water content in oil and gas mixtures by combining direct measurements (see measurement approaches in Section 5.2), with algorithms containing mathematical and empirical models, necessitating a thorough performance verification to ensure accuracy.

7.1.2 Performance data is an integral component of the selection process of WCAs. As described in Section 6.2 the user should review any existing data and identify any potential gaps.

7.1.3 In some cases, additional testing should be carried out to fill in any associated gaps. Performing supplemental or additional tests can be decided for a variety of reasons including:

— For new WCA types with limited or non-existing performance verification data.
— When the test matrix used in previous tests was not broad enough or fluid properties do not match the intended application.
— For applications where facility constraints prevent the installation of the WCA as recommended by the manufacturer, the installation deviation is expected to impact on the performance of the WCA, and performance data on the anticipated installation conditions does not exist.
— When factors that impact performance, as outlined in Section 6.3, exist and cannot be eliminated, and their impact on performance is not sufficiently characterized.

7.1.4 For all new tests or additional tests performed, the following applies:

— Users shall follow the requirements and recommendations provided in this section.
— The user should refer to API MPMS Chapter 22.7, Testing Protocol for Multiphase Flow Meters for guidance on testing protocol, test facility requirements, and uncertainty analysis approach, as applied to WCAs while taking exception to any items specific to multiphase flow meters.

7.1.5 The user shall examine the flow range as predicted by the production profile data decide how to address operating conditions that may fall outside of the minimum flow velocity conditions stated by the WCA manufacturer.

7.1.6 Ultimately, if the selected WCA type and sizing study indicates a portion of the production life will not meet the expected or required performance levels, the user shall estimate a WCA performance level for these areas.

7.1.7 The verification process covers a range of factors that influence the performance of WCAs, that may include:

— Accuracy: The degree to which the WCA's readings correspond to the actual water content in the hydrocarbon mixture. The actual water content should be a well-defined reference value from a test facility or obtained by accurate sampling. Accuracy is typically expressed as the absolute percentage of the measured value (%ABS.).
— Repeatability/Reproducibility: The WCA's ability to produce consistent readings under the same operating conditions over both short term (repeatability) and long term (reproducibility) periods. High repeatability/reproducibility is crucial for ensuring that the WCA can be relied upon for continuous monitoring.
— Response time: The speed at which the WCA can detect and report changes in water content.

A fast response time is essential for applications where water content fluctuates rapidly.

— Process conditions: The WCA's performance under varying process conditions, such as changes in temperature, pressure, and flow rate. The objective is to verify that the WCA maintains accuracy and reliability across the expected range of operating conditions. Abnormal conditions may also be included in the verification process to help understand the response of the WCA under such abnormal conditions.
— Installation Effects: WCA under test must be installed according to manufacturer's recommendations. WCA manufacturers may conduct testing under various installation configurations to fully characterize the performance of their device under abnormal installation conditions. This includes examining how factors such as pipeline orientation, proximity to bends or valves, and the presence of other equipment affect the WCA's readings. The impact of WCA installation effects is closely related to the flow regime, i.e. the degree of mixing of the water and hydrocarbon blend.
— Long-Term Stability: The ability of the WCA to maintain accurate and reliable measurements over extended periods of operation without significant drift or the need for frequent recalibration.

7.1.8 The performance verification can be accomplished by one or both of the following methodologies:

— Laboratory Testing: Controlled testing in a laboratory environment to evaluate the WCA's accuracy and repeatability under specific, known conditions. This includes calibration against known standards, testing under various installation configurations, and testing under a range of controlled variables to mimic process conditions. Laboratory testing is normally performed at steady-state conditions. Evaluating the response time, reproducibility, and long-term stability are not always feasible in a laboratory setting and are best suited for field testing. Additional guidance and requirements for laboratory testing can be found in Section 7.2.
— Field Testing: Evaluation in real-world operating conditions to assess how the WCA performs in situ. This testing is crucial for understanding how the WCA behaves in the presence of complex factors that may not be fully replicated in a laboratory. Field testing also allows for testing the response time, reproducibility, and long-term stability of WCAs.

7.1.9 Data analysis is an essential step in the performance verification of WCAs. Detailed analysis of the data collected during testing to identify any deviations from expected performance. This includes statistical analysis to quantify the WCA's accuracy, repeatability, and response time and may be based on health diagnostics of the WCA when available.

7.1.10 This section details the process for conducting performance verification of WCAs in the lab and in the field and provides guidance for assessing the impact of installation effects, factors that impact WCA performance, and evaluating long-term stability.

7.1.11 A reference water cur and associated uncertainty shall be established and the water cut output from the WCA shall be compared against the reference water cut to assess the WCA's performance.

7.1.12 Acceptance criteria shall be defined by the user considering the uncertainty of the reference water cut and the WCA manufacturer's stated uncertainty.

7.1.13 A field verification method shall be used as the reference to verify the performance of WCAs during field testing and for periodic verification during normal operation. Field verification is expanded in Sections 7.3.

7.2 Laboratory Test

7.2.1 Laboratory testing is instrumental in the development of WCAs and in validating new algorithms and firmware. Laboratory testing is also used to evaluate the accuracy, reliability, and repeatability of WCAs under simulated operational conditions before they are deployed in the field. This test is normally performed in flow loops capable of providing accurate and stable reference conditions at a given flow rate and water cut to test WCA's ability to accurately measure the water content in real-time.

7.2.2 In closed-loop test facilities, two test methods are available for conducting testing of WCAs under flowing conditions:

— Separation method, consists of combining pre-measured pure phases of hydrocarbon liquid and water streams coming from a 3-phase separator or a liquid/liquid separator to create a reference oil/water mixture.
— Premix method, consists of combining premixed volumes of hydrocarbon liquid and water to create a reference oi/water mixture.

7.2.3 In the separation method approach, the test facility injects oil and hydrocarbon liquid and water into the system from their pure, unmixed states. These fluids are introduced separately into the test section, where they are mixed to simulate real-world conditions of varying water cuts. After passing through the WCA, the mixture must be separated back into its oil and water phase for recirculation. This method allows for precise control over the water content, enabling the evaluation of WCA performance across a wide range of conditions. The method relies on proper separation of the phases within the separation time of the flow facility and may therefore only be suitable for hydrocarbon liquids that are easily separable.

7.2.4 The premix method involves the use of a premixed blend of hydrocarbon liquid and water. In this method, the volume of oil and water are measured separately and mixed to achieve a given water cut and the mixture is then circulated through the test section, where the WCA assesses the water content. The premix method eliminates the need for separation while offering less flexibility in adjusting water content during testing. Also, it is necessary to ensure that the hydrocarbon liquid and water mixture remains consistent throughout the facility and no separation in parts of the facility occurs. The premix method may not be feasible for systems with pipe diameters of two inches or larger due to challenges with handling and accurately measuring large volumes of each phase.

7.2.5 Reference water cut value

7.2.5.1 The performance verification is dependent on an accurately defined reference value for the water cut. It is essential to account for the uncertainties associated with the reference water cut. Reference uncertainties refer to the potential errors or variations inherent in the instruments and procedures employed to determine the referenced water content against which the WCA's performance is evaluated. The accuracy and reliability of the WCA's performance verification are directly influenced by the precision of the reference method. Any uncertainty in the reference measurement introduces a corresponding uncertainty in the performance verification of the WCA. If not properly accounted for, these uncertainties can lead to inaccurate conclusions about the WCA's performance.

7.2.5.2 For the separation method, this necessitates precise measurement of the pure phase reference flow rates, as these are utilized to determine the water fraction at the Device Under Test (DUT) location.
— Reference flow meters should be calibrated in accordance with ISO17025 to ensure that measurements are traceable to international standards such as NIST.
— Additionally, the potential cross-contamination of phases (water-in-oil and/or oil-in-water) shall be quantified at the pure phase reference flow meters. This can be achieved by collecting spot samples from the facility's oil and water streams and analyzing the samples to quantify the volume of the second and contaminant phase and the results should be used to correct the reference water cut or to adjust the reference water cut uncertainty.

7.2.5.3 For the premix method, the reference water cut value can be initial established by volume measurement of the pure fluids before the mixing and it shall be verified by spot sampling using the field verification method described in Section 7.3.

7.2.6 Test conditions

7.2.6.1 When conducting performance verification of WCAs in test facilities, the selection of the test conditions should mimic field process conditions.

7.2.6.2 If the flow loop test is part of a technology qualification process for the deployment of WCAs in specific facilities or regions, it is crucial to determine the physical properties of the hydrocarbon liquid and water, as well as the operational conditions such as temperature, pressure, and flow rate, that the WCA will encounter in the field.

7.2.6.3 Those fluid properties and operational conditions shall be used to guide the selection of test fluids with fluid properties that are representative to those in the field and to develop a test matrix covering relevant conditions as closely as possible. This ensures that the test results are representative of the meter's performance in real-world applications.

7.2.6.4 In addition to fluid properties and process conditions, any installation constraints and the presence of contaminants should be considered in the design of the test matrix to incorporate any adverse conditions that cannot be eliminated and which impact in performance is not well understood.

7.2.6.5 While it may not be feasible or practical to replicate all field-specific conditions in a qualification testing, considering all relevant parameters will lead to a more effective selection of test conditions and will help frame the applicability of the test results.

7.2.6.6 Relevant physical properties, process conditions, and installation parameters can be captured using the application data sheet shown in Figure 2. The following subsections expand on the impact of those parameters in the operation of WCAs.

7.2.7 Physical properties

7.2.7.1 Test fluids should be selected based on the purpose of the testing and should be representative of field conditions when testing for a particular application.

7.2.7.2 Viscosity: The viscosity of the hydrocarbon liquid can affect the WCA's ability to accurately measure the water content. Fluid viscosity impacts the segregation of the phases and the droplet size distribution, and therefore the detection of the water phase. Higher viscosity fluids may lead to complex flow dynamics (e.g. emulsions) making it difficult to separate the hydrocarbon and water phases in a separation method of testing. Low viscosity hydrocarbon fluids can lead to segregation of the phases, especially at low flow rates, which can impact the performance of WCAs and the reference water cut in a laboratory testing.

7.2.7.3 Density: Reference density of the hydrocarbon and water phases is a common input to WCAs. Some devices measure the mixture density or require a mixture density input for an accurate determination of the water cut. The density difference between the hydrocarbon liquid and water impacts phase separation and can play a role in the performance of some devices.

7.2.7.4 Water Salinity: The salinity of the water phase affects the conductivity and dielectric properties of the mixture, which can significantly influence the performance of WCAs, particularly those relying on electrical properties for measurement. The test water should have a salinity level comparable to that of the field conditions to accurately assess the WCA's performance.

7.2.8 Process conditions

7.2.8.1 Temperature variations can alter the physical properties of both the hydrocarbon liquid and water, such as viscosity and density and conductivity, thereby affecting the WCA's accuracy. During testing, it is important to replicate the range of temperatures the WCA will experience in the field. This ensures that the WCA's performance is evaluated under realistic thermal conditions, accounting for potential changes in fluid behavior and WCA response.

7.2.8.2 Pressure mildly impacts the compressibility of fluids and the WCA's operational integrity. Test pressures should closely align with the field pressures to ensure that the WCA's performance is not adversely affected by pressure-related phenomena. The flow dynamics of the mixture is not expected to be significantly affected by pressure. At higher pressures there is potential for more gas dissolved in the liquid phase, which can impact the physical properties of the liquid phase.

7.2.8.3 The flow rate of the oil-water mixture is a critical factor in the performance of WCAs. Flow rate affects the mixing behavior of the fluids, the formation of emulsions, and the potential for phase separation. While it may not always be practical to replicate the flow rates expected in the field, the test facility must be able to replicate the range of oil-water mixture velocities expected in the intended application to accurately assess how the WCA responds to different flow conditions. This includes evaluating the WCA's ability to maintain accuracy across low and high flow velocities within the recommended operating limits set by the WCA manufacturer.

7.3 Field Verification

7.3.1 The performance of WCAs can be verified through comparison with manual samples taken from the process stream at specific intervals (spot-sampling).

7.3.2 An accurate sampling procedure relies on two main items: representative sample collection, handling, and analysis. Samples are collected from the process stream at predetermined intervals or during specific operational conditions ensuring that they represent the same flow conditions that the WCA is measuring.

7.3.4 This standard adopts a methodology developed for mixing, handling and analysis in high water cut samples. This methodology was validated under flowing conditions in a controlled laboratory setting and serves as the basis for the field verification of WCAs through spot-sampling and analysis. Design consideration of sample collection ports can be found in section **Error! Reference source not found.** Sample Ports for Verification and the onsite verification recommendations can be found in section 13.3 Onsite verification.

7.4 Assessing the Impact of Gas and Contaminants

7.4.1 The presence of gas and other contaminants in a hydrocarbon stream can affect the performance of WCAs. These factors can introduce errors in measurement, reduce the accuracy and repeatability of the WCA or even result in failure of the WCA, and lead to operational challenges. Understanding how gas and contaminants influence water cut measurement is critical for ensuring the reliability of these instruments in diverse field conditions.

7.4.2 In the context of water cut measurement, gas and contaminants may include:

- Degassing oil: Methane, ethane, and other light hydrocarbons that are naturally present in crude oil and gas production streams and may come out of the liquid due to changes in operational conditions.
- Gas carry under: Gas that becomes mixed with the liquid stream, often due to upsets in certain stages of the processing system.
- Solids, sediments and wax: Particulates such as sand, rust, or other solid materials that may be present in the production stream. Also, long chain hydrocarbons may form wax on the sensing components of the WCA.
- Chemical contaminants: Additives, surfactants, or other chemicals introduced during processing or extraction that can alter the physical properties of the hydrocarbon mixture.

7.4.7 The presence of gas and contaminants can impact WCA performance in several ways and depends on the deployed measurement technology. Gas bubbles, solid particles and wax within the liquid stream can cause the WCA to misinterpret the phase composition, leading to inaccurate water content readings, drifting, and fouling of the WCA sensor.

7.4.8 Conditions such as free gas (from gas carry-under or gas breakout of solution) can be simulated in some flow loop facilities to study the response of the WCA in the presence of gas and to quantify the impact in the water cut measurement accuracy. Replicating flow assurance conditions and other contaminants (e.g. wax deposition, sand, asphaltene precipitation, etc.) in a flow loop may not be feasible or practical.

8 Installation Design Considerations

8.1 General

8.1.1 This standard applies to separator-based metering applications. Typically, allocation metering exists at the outflow of separators. Separators are of two basic configurations: three phase or two phase. For three-phase separators, a single-phase liquid flow meter is located at the outlet of each the water and hydrocarbon streams of the separator and is normally used to determine both the quantity of the liquid hydrocarbon and water being produced. A two-phase separator does not have a produced water leg. On two-phase separators, liquid hydrocarbon and water phases are measured as a single liquid phase using meters like those used on a three-phase separator. A typical piping arrangement is shown in Figure 4.

8.1.2 Installation requirements vary with different types of WCAs as well as what point in the process the WCA is installed.

8.1.3 WCAs shall be installed as per manufacturer recommendations.

8.1.4 Site-specific parameters to be considered and discussed with the manufacturer as part of the design or facility modification for the use of WCAs shall include but not be limited to the following:

— Location and installation approach (e.g. in-line, in a side-stream loop)

— Orientation

— Mixing

— Sample ports for verification

— Environmental conditions

— Power and electrical requirements

— Data communication protocol

8.1.5 A work pack documenting the design and installation requirements shall be prepared by the user for use in the fabrication and installation phase.

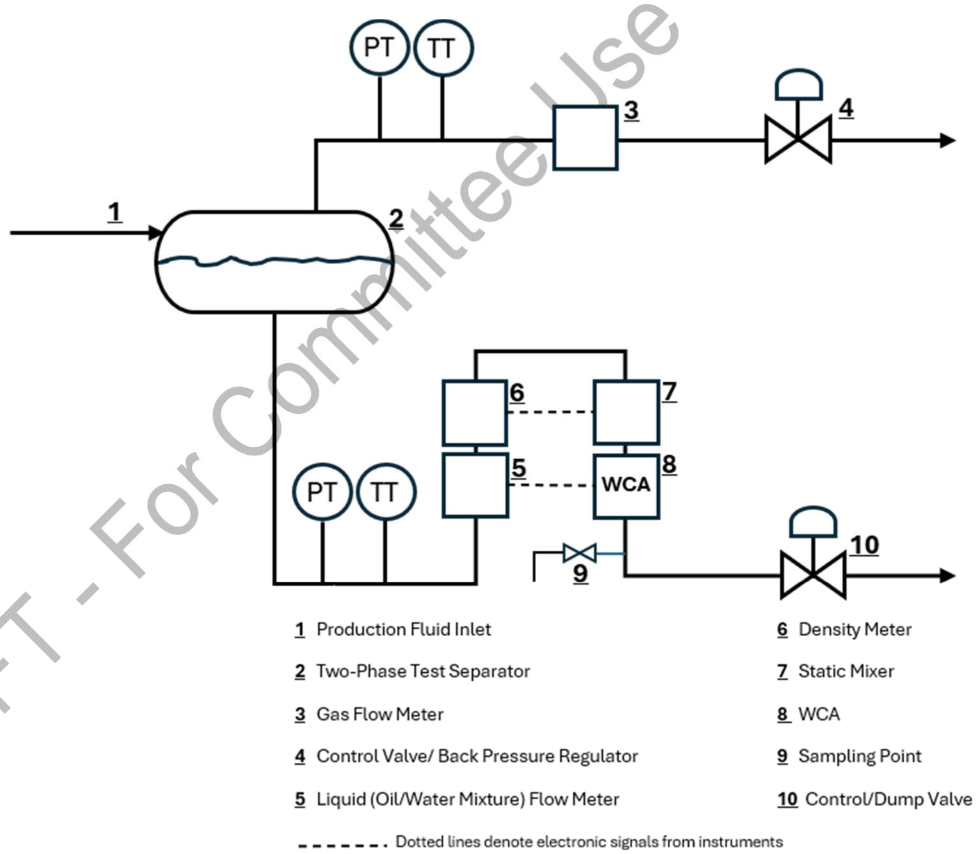

Figure 4. Typical WCA Installation Arrangement in Two-Phase Separator Liquid Outlet

8.2 Location

8.2.1 The WCA shall be at a point where the process fluid is deemed properly mixed. For WCAs with flow direction indication on the body of the device, the installation shall be carried out such that the process flow direction matches the direction indication on the body of the device.
8.2.2 Flashing may occur after pipeline elements (e.g. control valves and inline mixers) due to pressure loss - WCA shall not be installed where this may occur, this is especially relevant to WCAs that are susceptible to the presence of gas.
8.2.3 The mounting position of the WCA is critical. Installation guidelines specified by the manufacturer should be strictly followed. The WCA shall be installed in such a way that it measures the water cut that is representative of the full liquid stream.
8.2.4 The proximity of the WCA to other devices (e.g. flow meter, pressure transmitter, temperature transmitter, densitometer) that can be used to provide input to the WCA shall be considered.
8.2.5 Proximity to flow computers or flow meters that will use the WCA output as an input parameter should also be considered.
8.2.6 To facilitate periodic maintenance or troubleshooting, the WCA should be installed so that it can be conveniently isolated from the process.
8.2.7 Locate the WCA system such that the influence of impurities to include sand, scale, and chemical additives is limited. This will improve the accuracy and repeatability of water cut readings. Maintenance of consistent hydrocarbon density and viscosity through the optimization of separator retention times and dump valve operation will also yield more repeatable water cut readings.
8.2.8 Consideration must also be made for minimizing vibration and bending moments in and around the WCA as these can affect the accuracy of the device.
8.2.9 The selected WCA shall meet the requirements and certifications imposed by the electrical area classification of the location where the WCA will be installed.
8.2.10 The mounting and access of the WCA electronic components shall be considered when selecting a location.
8.2.11 For some of the WCAs, the sensing elements are mounted on a probe that is inserted into the pipe through an available port (insertion type), while others are connected to the piping with the full stream flowing through the device (inline type).
8.2.12 WCAs can be installed directly on the main pipe (see Figure 5) or in a slip stream (see Figure *6*).
8.2.13 In the slip stream approach, a representative sample stream is drawn from the main line into a circulation path. The slip stream can help in improving mixing and creating representative samples. A pump is used to draw a sample of the fluid flow in the main line into the slip stream where the WCA is installed. The flow through the loop is recirculated to the main line upstream of the suction line, creating additional mixing in the line and improving the homogeneity of the flow. This is recommended for applications and WCAs requiring further mixing for more homogenous sampling and where the pipeline and facility configuration allows for it.
8.2.14 For insertion type WCAs, the device shall be installed such that the opening of the probe faces upstream of the fluid flow. The body of the device shall be marked with a flow direction signal if not originally marked by the manufacturer. The WCA shall be installed such that the probe opening is located at a point with maximum mixing of the fluid as recommended in API MPMS Chapter 8.2.
8.2.15 For large pipelines, some insertion type WCAs can be installed using hot tap with isolation valves. This can save costs by avoiding lost production opportunities that will be incurred in shutting down the pipeline and the cost of draining the pipeline. Insertion type WCA probes can be installed through NPT ports or flanged ports. The manufacturer’s recommendation should be adhered to, and the operational conditions of the facility should also be considered before a hot tap is used.

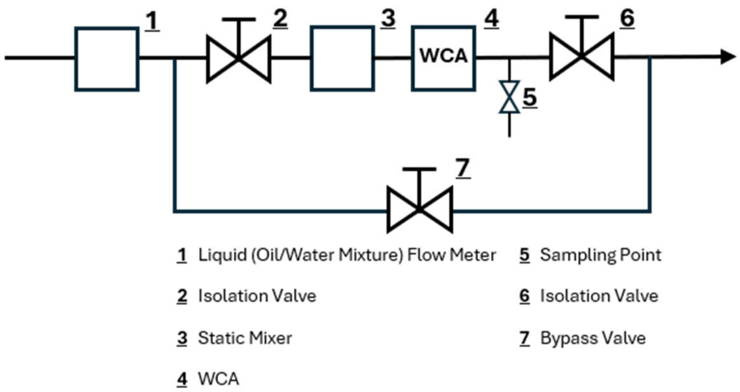

Figure 5 –WCA installed in the main pipe upstream of the metering station

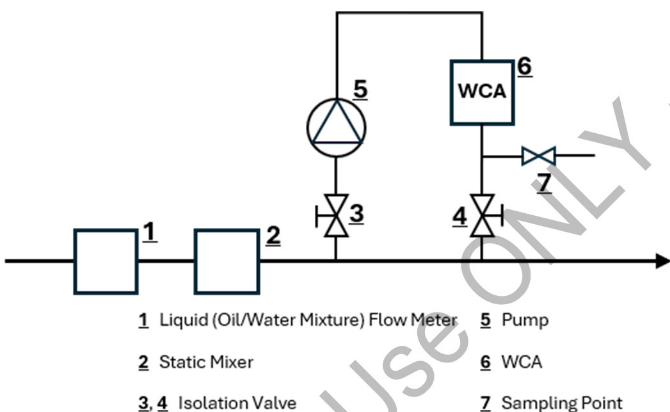

Figure 6 –WCA installed in a slip stream downstream of the metering station

8.3 Orientation

8.3.1 For installation in new facilities and piping systems under design, the manufacturer's recommendation on the orientation of installation shall be strictly adhered to, to ensure proper operation of the system.

8.3.2 For most inline and insertion type WCAs, vertical installation is preferred because of the additional mixing it confers on the fluid. Some manufacturers recommend different positions and locations for the installation of WCAs based on the expected water cut of the application.

8.3.3 For installation in an existing piping system, all efforts shall be made to meet the manufacturer's recommendation on the orientation of the WCA.

8.4 Mixing

8.4.1 Care must be taken to ensure homogeneous mixing in the liquid stream. Mixing may be achieved through the maintenance of minimum velocities through the pipe immediately upstream of the WCA or with the installation of an inline mixer immediately upstream of the analyzer.

8.4.2 When selecting an inline mixer, the added pressure loss should be considered.

8.4.3 Installation of the WCA in a vertical position, with pipe size selected for higher velocities will promote exposure to a homogeneous mixture and may be required in applications where there is the potential for free gas flowing with the liquid phase.

8.4.4 All samples for evaluating the water content of a hydrocarbon mixture generally require mixing. Additional mixing promotes the homogeneity of the mixture, ensuring representative samples are collected for analysis. The presence of additional mixing elements on the line will improve the results from water cut measurement with WCAs. Some WCAs require mixers for flow below certain thresholds for acceptable results. Mixing can be achieved with static mixers, a blind T, multiple bends or other instruments upstream of the WCA. API MPMS Chapter 8.2.9 provides further guidance on mixing.

8.4.5 While a control valve installed immediately upstream of a WCA can help with mixing of the liquid hydrocarbon and water phases, the pressure drop through the control valve can cause gas breakout of solution, especially in high pressure applications, and the gas can impact the performance of the WCA. Also, it may be difficult to assess the level of mixing provided by the control valve and the mixing will vary will the opening of the control valve making it an ineffective and unpredictable mixer for the WCA.

8.4.6 WCA manufacturers may supply the WCA alone or in a pipe spool containing any required mixing elements, the sampling port, and the port for installing the WCA.

8.4.7 Piping fabrication should be within the piping design specification for the facility.

8.5 Manual Sample Verification Point

8.5.1 A spot sampling point shall be available close to the location of the WCA to provide reference for the initial Performance Acceptance Test (PAT) and for ongoing calibration of the WCA.

8.5.2 The manual sampling point shall be as close as possible to the WCA to ensure that samples collected from the sampling spots and sample passing through the WCA are the same.

8.5.3 For WCAs installed in a slip stream, the manual sample port shall be located inside the slip stream. The manual sampling point shall be installed and operated as specified in the API MPMS Chapter 8.1 *Manual Sampling of Petroleum and Petroleum Products (ASTM D4057)*.

8.3.4 Access to sampling ports shall be considered in the design to ensure adequate space is available for the collection of samples in a safe manner.

8.3.5 The manual sample point shall be located ina homogeneous stream.

The manual sample point design should accommodate the following (see Figure 7):

— Sample take off probe; refer to API MPMS Ch 8.2 Automatic Sampling of Petroleum and Petroleum Products (ASTM D4177) for design considerations
— Isolation valve (pressure isolation)
— Needle valve (control rate of extraction)
— A purge line (to purge before collecting the sample)
— Sample container

8.5.6 Other considerations:

— Distance/location sample port and WCA (see API MPMS Ch10.10 for reference), WCA and mixer (per WCA and mixer manufacturer recommendations)
— For vending and vibration issues due to potential vortex shedding see API MPMS Ch. 8.2 and Ch. 10.10 On-Line Measurement of Water Content in Petroleum and Petroleum Products (EI HM 56).

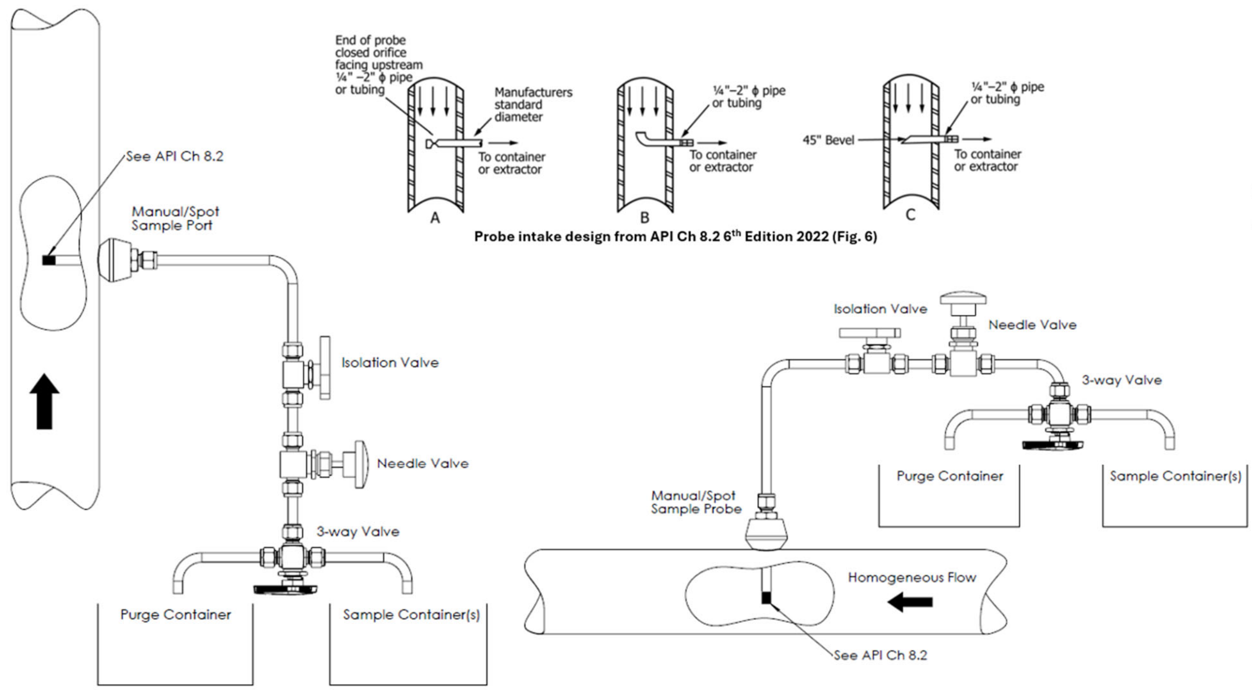

Figure 7. Example of a sample port for verification in horizontal and vertical lines

8.6 Environmental Conditions

8.6.1 The environmental conditions identified during the WCA selection phase in 6.7 should be reviewed during the WCA installation design.
8.6.2 The review should take into consideration the proposed physical WCA location and ensure that any new, previously unknown, or environmental conditions that have changed are addressed. Results from this assessment may lead to a re-evaluation of the WCA that was selected for this installation due to changes in the environmental conditions.

8.7 Power and electrical requirements

8.7.1 The WCA must meet electrical area classification requirements.
8.7.2 Power requirements, power source availability at the facility, and length and routing of power cables, shall all be considered in the design.

8.8 Data communication protocol

8.8.1 Develop a data architecture schematic to clearly identify the communication protocol, required mapping and configuration of input/output signals, and to define the interface with the data acquisition system or any other form of data access.

8.9 Connection of Flow Meter to a WCA

8.9.1 The output from a flow meter can be connected to an WCA for various purposes. For some specific applications, the flow rate signal from the flow meter can provide an input to the electronic component of the WCA to extend the capabilities of the WCA. Where required, a Coriolis meter can be installed upstream of the WCA to provide real time fluid density input which the WCA will use for auto-zero calculations. The WCA will compensate for any changes in the relative dielectric constant of the crude oil with respect to the mixture by feeding continuous live density data to the WCA. A Densitometer can alternatively be used to provide live density data required by the WCA to perform auto-zero.

9 Factory Acceptance

9.1 General

9.1.1 The requirements in this section shall take place prior to the WCA shipping to final installation site.

9.2 Factory Calibration and Configuration

9.2.1 The factory configuration of the device shall be provided to the end user, and the end user shall be provided with the opportunity to review the factory configuration prior to shipping from the factory.

9.3 Factory Acceptance Test (FAT)

9.3.1 A Factory Acceptance Test (FAT) is a functional test which takes place prior to shipping the individual WCA from the factory to verify that the device has been manufactured, assembled, and configured according to the manufacturer procedure and the user requirements. It is typically the final step of the manufacturing process.

9.3.2 The manufacturer shall provide a concise FAT procedure which includes the functional testing and acceptance criteria

9.3.3 The manufacturer shall prepare a report documenting the findings of the FAT and highlighting gaps, if any.

9.3.4 The user shall be given the opportunity to review the FAT report prior to WCA leaving the manufacturer's custody.

9.3.5 The FAT is a functional test and may include factory calibration and configuration in a small-scale flow loop. If a laboratory test is required, refer to Section 7 for guidance.

9.3.6 Example of functional tests often included in FAT are:

— visual inspection confirming physical assembly and markings are per assembly drawings

— dimensional checks

— correct cable connector type, pin configuration and orientation

— mechanical integrity testing i.e. pressure tests

— verification of proper wiring and settings of power and communication as per interconnection diagram

— power-up test

— verification of configuration

— software and user interface checks

— software version check and update if required

— verification of calibration and associated documentation

— verification of communications interface setup

— verification of units of measure

— alarm checks

— packaging and preservation of equipment checks

10 Installation

10.1 General

10.1.1 The WCA shall be installed in accordance with manufacturer recommendations, as well as design, operating, and facility requirements. This section describes the key steps that must be taken before and during the installation of a WCA to ensure that the device is installed in alignment with manufacturer recommendations, as well as design, operating, and facility requirements.

10.2 Pre-installation checks

10.2.1 Before installation, current process conditions shall be compared with the process conditions used in the selection and sizing of the WCA to ensure that current conditions are still within the expected range. Key parameters to confirm include the operating pressure, temperature, flow rate and flow velocity at the WCA location, and water cut range.
10.2.2 Ensure that all aspects outlined in section 8 have been considered, investigated, and documented in a work pack.
10.2.3 Review the work pack prepared as per section 8.1 to ensure all necessary equipment is available and identify and address any potential gaps.

10.3 Installation checks

10.3.1 Confirm the location and installation configuration (e.g. inline, in a slip stream).
10.3.2 WCAs shall be installed as far away from sources of vibration as possible.
10.3.3 Confirm the orientation, flow direction, and probe tip placement (when applicable).
10.3.4 Ensure mixing elements, when needed, are installed according to the manufacturer's recommendations.
10.3.5 Perform wiring per manufacturer recommendations and ensure any required connections between the WCA and other instrumentation (e.g. pressure or temperature transmitters, flow meters, densitometers) are established.
10.3.6 Ensure power and electrical area classification area requirements are met and ensure the WCA can be powered on.
10.3.7 Ensure a sample port is installed per recommendations in section **Error! Reference source not found.**.
10.3.8 For WCAs with matched pairs –the measurement section and associated electronics for example, - it is very important that the pairs are checked and confirmed before installation. The manufacturers' numbers indicating the matched pairs should be used for confirmation. This is usually stamped on the bodies of the pairs.

11 Commissioning and Calibration

11.1 General

11.1.1 Commissioning WCAs after installation provides the opportunity to confirm that the mechanical installation and electrical connections to the device are properly carried out in a way that ensures accuracy, reliable operation, appropriate communication with flow computer and ease of maintenance of the equipment. During commissioning, the diagnostic and operational functions of the WCA is checked to ensure proper function before the WCA is considered ready for use. A commissioning checklist either supplied by the OEM or worked out by qualified technicians is recommended to ensure that all the steps are followed.

11.2 Commissioning Checklist

11.2.1 The commissioning check list shall be completed and used to record the data obtained during this exercise as these will serve as the baseline data for subsequent calibrations and maintenance of the WCA.
11.2.2 Verification of the mechanical installation points shall be carried out to confirm and note the

orientation of installation – vertical or horizontal. Also confirm the probe alignment with the flow and the insertion depth. (for probe type WCAs).

11.2.3 Verification of the electrical connections to confirm correct power supply (voltage and frequency), correct wiring (positive and negative terminals) and the use of the correct wire gauge.

11.2.4 Verification of the instruments where applicable to confirm analog or digital communications.

11.2.5 Confirm any necessary grounding is in place.

11.2.6 Confirm that the wiring is connected and terminated in accordance with manufacturers' recommendations and applicable electrical code.

11.2.7 Confirm that all required accessories, including transmitters, have been installed and tested.

11.2.8 Confirm communication has been established. This verification shall be carried out both on the WCA and in the control room to ensure the fidelity of data transmitted to the control room.

11.2.9 Input signals from other devices (e.g. pressure transmitter, temperature transmitter, flow meter, densitometer) into the WCA shall also be verified.

11.2.10 Verification of the WCA software application functions. The version of the software/firmware shall be confirmed to be up to date.

11.3 In-situ Calibration of the WCA

11.3.1 Calibration procedures from the manufacturer shall be followed and implemented by a trained technician or manufacturer representative.

11.3.2 Calibrations may be static (i.e. by dipping an insertion type WCA in a container filled with a relevant fluid) or dynamic (i.e. under flowing conditions with the WCA installed in a flow loop or facility).

11.3.3 In addition to factory calibrations, WCAs may require in-situ calibrations to ensure their accuracy. In-situ calibration of the WCA may also be required periodically (typically yearly). This period may be adjusted in accordance with specific company, legal or regulatory requirements. The results from the in-situ calibration carried out during the SAT shall be compared with the results from the calibration carried out during the Factory Acceptance Test (FAT).

11.3.4 Results from subsequent calibrations shall also be compared with results from previous calibrations to ensure that they fall within allowable limits. This will provide additional diagnostic function as significant deviations in accuracy may indicate malfunctioning of the WCA.

11.3.5 The in-situ calibration is carried out by comparing the instantaneous results captured on the WCA with analysis obtained from samples taken from the spot sample.

11.3.6 Time shall be allowed for the flow to stabilize before instantaneous readings are taken from the WCA.

11.3.7 The reading shall be taken while samples are being collected from the spot sample point.

12 Site Acceptance Test (SAT)

12.1.1 A Site Acceptance Test (SAT) should be carried out to ascertain the suitability of the WCA for the application for which it is deployed.

12.1.2 The SAT will compare the average water cut from the WCA with average water cut from analysis carried out on samples collected at the spot sampling point.

12.1.3 The water injection test (per API 8.2) for verifying autosamplers is not recommended for full-range water cut measurements.

12.1.4 Before the Site Acceptance Test is carried out, all the project specifications and process data provided to the OEM for the fabrication of the WCA shall be re-verified to ensure that the process conditions are still within the allowable limit and range for the WCA.

12.1.5 Ensure that the calibration parameters in the WCA match the specific parameters for the application it is being deployed for. Carry out any required changes in the parameter using the software provided by the OEM in accordance with the direction provided by the OEM.

13 Operation, Onsite Verification, and Maintenance

13.1 General

13.1.1 This section provides the requirements for the operation, on-site verification, and maintenance of the WCAs.

13.2 Operation

13.2.1 A WCA system should be capable of providing an audit trail including configuration and out-of-range operation to support analysis and estimation efforts.
13.2.2 Monitoring:

— Monitor sensitivities (technology dependent) for factors that can impact performance (refer to section 6.3 for example).

— Ways to collect surveillance data: diagnostics, fluid properties, material balance.

— Monitoring may result in an action: verification or calibration, repair or other.

13.2.3 On-site Verification:

— Spot sample

— If pass fail acceptance criteria are not met, additional steps should be taken to understand why.

— Calibration may be required.

13.2.4 Calibration shall be done according to manufacturer recommendations.
13.2.5 Users should keep a record of all calibration documents as found and as left. For example, configuration, date, fluid properties or profile, and identify any changes that were made.

13.3 On-site Verification

13.3.1 This section provides the requirements for ongoing, onsite verification for WCAs that have been put into service and calibrated.
13.3.2 An onsite WCA verification process is used to validate the device is operating as expected and to identify the need for maintenance or recalibration.
13.3.3 The WCA verification data should be logged. Refer to Table 2 as an example. Any changes to the calibration or where maintenance is performed shall be clearly recorded in the table.
13.3.4 Retain the WCA verification data log per the industry's accepted practices or operator requirements and make them available upon request by interested parties.
13.3.5 Manufacturer's specific verification requirements shall be followed in addition to the guidance provided in this section. After the site acceptance testing, establish a frequency of verification based on the application.
13.3.6 Additional data and diagnostics may be collected from the WCA to help troubleshooting.
13.3.7 Condition-based monitoring can be incorporated to monitor other related measurements such as sensor health, density, gas content, salinity to provide predictive validation.

Table 2 Example WCA Verification Table

Sample ID	Time / Date	Flowing Density	Temperature	WCA Water %	Manual Sample %	WCA Offset	% Difference	Comments / Changes / Maintenance

13.4 Manual Spot Sampling Method

13.4.1 Refer to section **Error! Reference source not found.** *Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products (ASTM D5854)* for sample port design considerations.
13.4.2 Refer to the following documents for guidance in using one or more of these approved methods to determine water content:

— API MPMS Chapter 10.4, Centrifuge Method (Field Procedure)

— It must be noted that the above standards do not cover high water cut sample handling and analysis and therefore should only be used as a guideline.

13.4.3 The average WCA value should be recorded at the same time as the manual spot sample is taken.

13.4.4 Care must be used when handling high water cut samples. It is recommended that the sample handling and analysis method follows the improved method for high water cut described in [3].

13.4.5 Performance expectation of the water cut determination should consider the discrimination interval of the centrifuge tube scale.

13.4.6 Centrifuge tubes with detailed markings from 0-100 mL shall be used to allow adequate measurement of water cuts above 20% (see photograph in Figure 8).

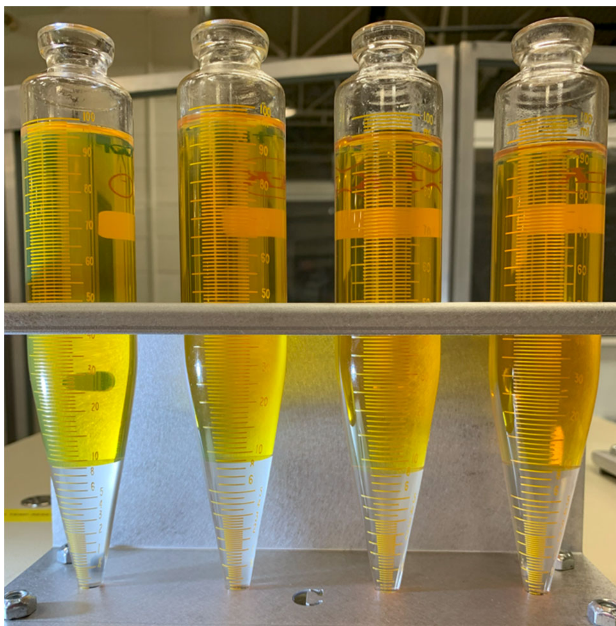

Figure 8. 8-inch centrifuge tubes with detailed markings for the entire scale (0-100 mL)

13.5 Maintenance

13.5.1 Refer to manufacturer recommendations for maintenance and recalibration. This section provides general requirements and recommendations for when to perform maintenance and recalibration of the WCA.

13.5.2 Typical Maintenance

— Maintenance may include periodic probe extraction and cleaning, and possible replacement of eroded components.

— Maintenance frequency can be established based on the results from verification, available WCA self-diagnostic parameters.

— Maintenance shall be performed if there is any suspected fouling, obstruction, or integrity issues of the WCA. Some diagnostic signals may be used to detect any issues with the WCA.

— Maintenance shall be performed before any recalibration.

13.5.3 Recalibration

— Recalibration intervals shall be initially established based on manufacturer recommendations.

— Recalibration may be required when there are changes in the well production (e.g. changes in fluid properties or normal water cut range).
— May be trigger based on on-site verification results.
— Confirm with manufacturer on onsite recalibration capabilities versus recalibration in a lab.
— Frequency depends on fluid composition.
— Before and after calibration parameters shall be recorded in a system of records.
— Fauling and environmental conditions should be considered.
— Onsite verification using spot samples shall be done before and after recalibration.

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