Manual of Petroleum Measurement Standards

Chapter 10.10

On-Line Measurement of Water Content in Petroleum and Petroleum Products

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Introduction

The purpose of this standard is to provide guidance for the installation and operation of a WCA (water cut analyzer) for on-line measurement of water content in petroleum and petroleum products in real-time for use in conjunction with an automatic sampling system that is compliant with API MPMS Chapter 8.2 for the purpose of custody transfer. The WCA shall be used in conjunction with a sampling system compliant with API MPMS Chapter 8.2. Identical installations of a WCA in the same process conditions and of the same installation and design of a proven WCA may preclude the field acceptance testing.

Guidance is also provided for the collection of consistent data to allow for long term performance assessment.

This standard also provides useful guidance in the use of WCA's for non-custody applications, although the burden of requiring acceptance and ongoing verification testing is likely to be less stringent. Operation with different crude oils or different process conditions to those originally tested requires additional testing and verification. This technology shall be viewed as one of several methods to determine the water in petroleum and petroleum products. The method for measuring water in petroleum shall be selected with consideration given to installation, application, and properties of the product(s) being measured.

Where the WCA flow-weighted average readings can be deemed to be within acceptable reproducibility of the automatic samples for a specified liquid under identical process conditions, by agreement between parties such WCA readings may be considered for use as a fallback in lieu of the automatic samples.

1.0   Scope

To provide requirements for application, installation, operation, initial testing and ongoing verification for the use of water cut analysers (WCA) for custody transfer of petroleum and petroleum products which shall be used in conjunction with an automatic sampling system that is compliant with API MPMS Chapter 8.2.

2.0   References

API Manual of Petroleum Measurement Standards:

- API MPMS, Chapter 8.1, "Standard Practice for Manual Sampling of Petroleum and Petroleum Products"

- API MPMS, Chapter 8.2, "Standard Practice for Automatic Sampling of Petroleum and Petroleum Products"

- API MPMS, Chapter 8.3, "Standard Practice for Handling and Remixing Samples of Petroleum and Petroleum Products"

- API MPMS, Chapter 10.4, "Standard Determination of Water and/or Sediment in Crude Oil by the Centrifuge Method (Field Procedure)"

- API MPMS, Chapter 10.9, "Standard Test Method for Water in Crude Oils by Coulometric Karl Fischer Titration"

- API MPMS, Chapter 13.3, "Measurement Uncertainty"

- API MPMS, Chapter 21.2, "Flow Measurement Using Electronic Metering Systems, Addendum to Section 2 -- Flow Measurement Using Electronic Metering Systems, Inferred Mass"

3.0 Definitions

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

auxiliary measurement device
Additional measurement (devices) required to allow the primary measure to be made. Typically for a WCA this may be density, temperature, salinity, or other properties that may influence the primary measurement.

flow-weighted average (FWA)
The average of a variable over a volume weighted by the reading over an incremental volume. It can be the average of the variable values sampled at uniform volume intervals, or it can be the average of variable values sampled at uniform time intervals and weighted by the incremental volume that occurred during that time interval.

performance acceptance testing (PAT), initial acceptance testing, water injection proving
Performance testing that allows the WCA system to be qualified for use in a specific application (see also verification testing). Also known as proving.

representative sample
A portion extracted from a total volume that contains the constituents in the same proportions that are present in that total volume.

WCA verification testing
Ongoing monitoring using the comparison of results from the automatic sampler to the WCA that confirms that the WCA system is within operating specifications.

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

WCA system
A WCA system may be composed of one or more WCAs, stream conditioning, other measurement devices (e.g., temperature, pressure, density, flow, etc.), and a computer to assimilate, compile, and report the data.

4.0 Significance and Use

The WCA provides instantaneous water percent readings. When coupled with a metering device, the total amount of water can be determined.

5.0 Operating Criteria

5.1 General

To determine the total water content, the WCA may be provisioned with a flow input to allow local calculation of the total water volume and water cut percentage or a WCA weighted average is calculated as described in API MPMS Chapter 21.2 within another device.

The standard does not preclude any technology that meets the scope.

A WCA may require additional auxiliary measurement equipment or instruments such as temperature, pressure, or density.

A WCA may be a full bore or an insertion type device; the WCA may be installed directly in the main pipeline or within a slip stream sample loop.

The WCA system installed shall be ranged/scaled to allow optimal accuracy for normal service recognizing that excursions beyond the normal range may have significant influence on the overall accuracy, for example, where slugging occurs.

An example for a worst-case scenario, any high "out of range" readings may be considered to be fully saturated (100% water); therefore, the volume of metered product during such periods shall be considered pure water and accounted for as such by any net oil calculation made. The total volume that has passed through the pipeline for which the WCA is out of scale shall be recorded.

To use a WCA, it is recommended that the instrument be evaluated with respect to section 6.0 and 8.0. Annex A, Figures A.1 and A.2, shows two typical WCA installations.

To improve the confidence in the WCA system, it is recommended that an overall uncertainty evaluation be made. The evaluation shall include the uncertainties of the measurement system, to include the WCA and the auxiliary measurement devices used within the system. An example of uncertainty calculations can be found in API MPMS Chapter 13.3.

All auxiliary measurement devices and equipment associated with the WCA system shall be verified at a frequency that is consistent with the calibration verification frequencies recommended by the manufacturer, contract, regulatory agencies and/or company policy or procedures, whichever is more stringent, used for other measurement instrumentation.

The following are potential influences on the performance of the WCA. The impact of these may depend on the instrument technology and the manufacturer of the WCA. Consult the manufacturer for additional information.

- Non-homogeneity of the flow in the main process and, when applicable, in the sample loop

- Cavitation

- Free gas

- Liquid composition: Chemicals including additives, sand, wax, scale, salinity, asphaltenes, etc.

- Ambient and process temperature variation

- Density and viscosity of oil

- Pressure variation

- Installation effects, including orientation of measurement elements, vibration, etc.

6.0 Installation Requirements

6.1 General

Within a typical water analysis system (WCA) there are two additional water measurement devices which assist in the performance acceptance and diagnostic evaluation.

- The reference device is the automatic sampler which shall be tested and meet the performance criteria as defined in API MPMS Chapter 8.2. The WCA FWA (flow-weighted average) results will be compared on an ongoing basis to this device to allow development of a level of confidence in its performance.

- In addition, a manual spot sample point should be installed in systems to allow troubleshooting/diagnostics of the WCA.

The WCA system shall be installed to obtain a representative measurement taken from a homogenous flowing stream as described in API MPMS Chapter 8.2 and per the manufacturer's recommended installation guidelines.

For a WCA installed in a sample loop, the flow through the sample loop shall be representative of the main flowing stream, refer to Annex A Figure A.1. Where possible a manual sample point should be fitted to the sample loop.

When used direct in line the WCA should be ideally installed upstream of the automatic sample extractor probe, refer to Annex A Figure A.2. Due to change in flow profile, a sample extractor fitted upstream of the WCA can affect the WCA reading.

A means of recording the WCA instantaneous and FWA readings shall be provided for calibration/verification/diagnostics.

6.2   Manual Spot Sampling Point

To allow for diagnostics/verification of the WCA and to ensure representivity, the manual sample point should be as close as practical to the WCA. The manual sample point should be designed and operated in compliance with API MPMS Chapter 8.1 and optimized for the proposed analytical method. If practical, other take-offs (for example a wall tapping) may be used, provided that said manual sample point is tested during the performance acceptance testing (water injection test) to determine if it adequately tracks the WCA and can be useful for diagnostic evaluation.

The manual sample point design shall consider the following additional constraints;

a. Where water is fully entrained, it separates slowly from the oil and therefore a volume collected may be easily and reproducibly subsampled. However, this is not the case when water has been injected or for light viscosity products. Therefore, it is critical that the manual sample process allows for the required volume of sample to be taken in a controlled manner.

b. A manual sample point will normally comprise a primary isolation valve and a second valve that can be used to control the flowrate. A local pressure gauge between the primary and secondary isolation valve will prove useful.

The interconnecting tubing between the manual sample extraction point and the sample receptacle (or glassware, whichever is used) shall be as short as possible and flushed at a rate high enough to clear any residual fluids before and between when samples are collected.

The adjustment of flowrate used through the manual sample point can be influential on the repeatability/ reproducibility of the result. Once adjusted, this flowrate shall not be changed during the acceptance testing process. Be sure to record the nominal sample flowrate used.

It is recommended that an estimate is made of the volume between the tip of the manual sample probe (if used) and the end of the tubing entering the collection vessel; and that typically between 6-10 times this volume is flushed in-between each sample collected for analysis.

The flowrate through the manual sample point shall be adequate to prevent any water fallout, the flowrate will therefore be determined by the size of the tubing used.

7.0   Performance Acceptance Testing (PAT)

This section describes the method for performance acceptance testing of WCA systems in conjunction with the automatic sampling system.

7.1   General

The basis of the performance acceptance testing procedure is described in API MPMS Chapter 8.2, "Water Injection Volume-Balanced Tests" which is a direct comparison of the primary measure of metered oil and metered injected water passing the automatic sampling system. These same primary measures can be used to evaluate the performance of the WCA system.

After a WCA system is installed and commissioned, the WCA system performance shall be tested prior to using it for custody transfer measurement and also at intervals that shall follow the recommendations used for the automatic sampler outlined in API MPMS Chapter 8.2.

The test procedure for a WCA is described in this section and within the flowchart Figure 2.

If a manual sample point is installed, this shall also be tested as part of the performance acceptance testing procedures according to the procedure described in Figure 2. It is recommended that the manual sample point is adjusted for flowrate (per 6.2) before the main testing is undertaken.

Generally, WCA readings within +/- 0.03% water by volume are considered as stable; manual samples should not be taken if the WCA readings are not stable.

It may be desirable to increase, for a few minutes, the mainline flowrate before starting a Performance Acceptance Test sequence and after each water injection test period (before the automatic sample collection/WCA FWA period is stopped) to clear any low spots of residual water that may have collected and are held up during the water injection phase.

All components of the WCA system shall be verified or calibrated per manufacturer's guidelines prior to, or in conjunction with, installation and **before** the execution of any performance acceptance testing.

Adjustments shall not be made to WCA calibration after step 6 of flowchart Figure 2. during the performance acceptance test. During subsequent operations if the WCA calibration values require adjustment, these shall be recorded in such a way as to allow direct comparison of WCA all batch values to a single calibration point.

Raw WCA data should be collected only under flowing conditions.

All WCA readings taken during the testing process shall be compensated by any applicable auxiliary measurements as required (for example, density, temperature, pressure) so that the WCA readings are a direct representation of the calculated water content. Raw (uncompensated) data should also be recorded, if available.

7.2 Test Procedure for Field Performance Acceptance Test (PAT, also known as proving)

The Performance Acceptance Test comprises water injection in accordance with API MPMS Chapter 8.2, if the system has a manual sample point to assist in diagnostics for the WCA, this shall be verified during this testing process.

Two sequential performance acceptance tests are required as per API MPMS Chapter 8.2: Reference is made to "baseline", in this case it refers to the water concentration present in the crude oil being tested. API MPMS Chapter 8.2 defines limits for a shift in baseline across each individual test. The overall acceptance criteria depend upon the assumption that if the baseline water concentration changes, it will do so linearly over the duration of the test and therefore an average value may be used. Because the measurement output from a WCA is continuous and manual spot samples are general taken at a specific point in time, it is also desirable to consider the short-term stability of the baseline water concentration.

Section 7.2.1.6 shows the test comparisons used for PAT and summary of acceptance criteria.

7.2.1.1 The baseline shall be "stable" over the duration of the performance acceptance test. API MPMS Chapter 8.2 defines acceptance criteria. It does not define the difference between baseline stability and baseline shift.

7.2.1.2 Under API MPMS Chapter 8.2 (18.6.9.3) baseline sampling, there are two methods available to determine the baseline shift over the overall performance acceptance test. Composite or Spot Sample.

a. Composite Sample - A sample is taken directly from the outlet of the automatic sample extractor into a separate intermediate sample container. If a baseline composite is taken, the WCA result is to be flow-weighted averaged over the same volume [i.e., the FWA shall be initiated simultaneously with the start of the sample and end when the sample is stopped].

b. Spot Sample - A minimum of three (3) consecutive spot samples are taken directly from the outlet of the automatic sample extractor into a separate intermediate sample container which is then analyzed. These samples may also comprise a volume collected of a number of sample grabs over a period of time, typically 5-10 minutes. Where, as in this latter example, the sample collection period is extended, if possible, the WCA readings shall be flow-weighted averaged. If this is not possible, note the WCA reading several times during the sample collection period and average the WCA result. The results of each of these three sets of analyses shall be within the allowances in API MPMS Chapter 8.2 Performance Acceptance Test.

The spot sample method of baseline sampling in many cases has an advantage in that the overall volume of oil passing through the main

pipeline used for the performance acceptance testing is typically lower, less sample processing and container cleaning is required and the short-term shift (stability) in baselines is quickly determined.

7.2.1.3 Within this testing, baseline stability is defined as a reading that within a period of 10 seconds or less does not change by more than +/- 0.03%Manual Sample Point Verification

If a manual sample point is fitted, this shall be verified during the Performance Acceptance Tests. Verifying the manual sample point requires checking the repeatability and reproducibility of the analysis of manual samples drawn against both the results from the automatic sampler and from the WCA system.

The testing of the manual sample point requires comparison of samples taken during the baseline sample collection periods AND during the water injection phases of the test.

a. Baseline Manual Sample Point Samples

Each set of baseline manual sample point samples shall comprise the collection of three separate "spot" samples. The WCA readings shall be recorded at the same points in time as the manual sample point samples are collected.

In accordance with the processes described under 7.2.1.2a at either one or more intervals during which a composite baseline is being collected (where for example this composite sample collection may take perhaps up to an hour).

In accordance with the process described under 7.1.1.2b a set of three "spot" samples may be collected from the manual sample point described concurrent with the collection of samples from the sample extractor.

b. Water Injection Manual Sample Point Samples

Manual samples may not be drawn from the sample extractor during the performance acceptance test water injection phase as this would destroy the integrity of the composite sample collected. Manual samples may only be collected from the Manual sample point, if one is available.

For each set of manual samples, a minimum of three (3) consecutive spot samples are taken directly from the manual sample point into a separate sample container which is then analyzed. These samples may also comprise a volume collected from a number of sample grabs over a period of time, typically 5-10 minutes. Where, as in this latter example, the sample collection period is extended, *if possible*, the WCA readings shall be flow-weighted averaged. If this is not possible, note the WCA reading several times during the sample collection period and average the WCA result.

If the opportunity exists to take more than one set of test samples during the water injection phase, the results derived shall improve the confidence in the overall repeatability of the manual sample point.

The results of each of these three sets of analyses shall be within the allowances in API MPMS Chapter 8.2 Performance Acceptance Test when compared to the calculated water injection values.

Normally, each spot sample taken shall have a minimum of two aliquot samples analyzed, the results of which shall be within the repeatability of the testing method.

Note:
Where a spot sample is taken from a manual sample valve or directly from the outlet of an automatic sample extractor, there will be a tendency for water to settle in the container and unless the aliquots can be drawn immediately (as opposed to minutes later), it is recommended that the container is re-homogenised using an insertion shear mixer.

7.2.1.4   For each water injection run, at the start of each Test Period (Figure 1) the WCA FWA readings shall be initiated at the same time as the oil volume measurement is registered and the automatic sample collection is started. At the end of the Test Period, the WCA FWA is read at the same time as the oil volume is registered, and the automatic sampling system is stopped.

Note:
The WCA trend (i.e., water values returning to baseline levels) can normally be utilized to monitor the passing of the last of the injected water through the system (shown as "end of test period" in).

Figure 1 shows the timing of one of the tests, and Figure 2 and Figure 3provide a flow diagram of the test procedures for both baseline and water injection phases including the procedure required to validate a manual sample point.
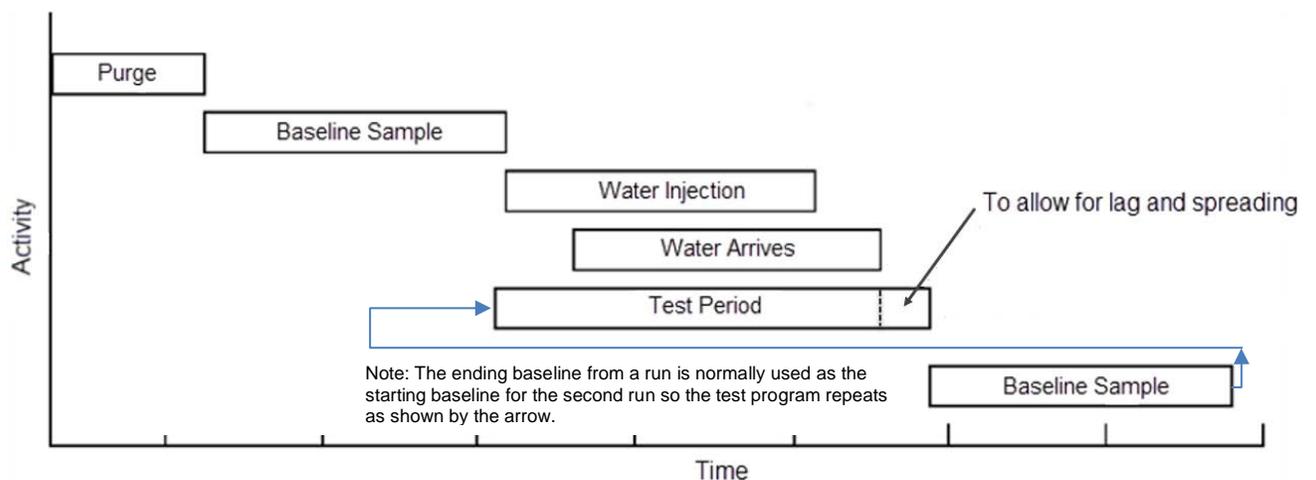
Note: Times are calculated based on minimum oil flow rate and distance between the injection and the sample point.

Figure 1.   Typical timing diagram for one WCA system test run (of 2 required)

7.2.1.5   Evaluation of Results

This section defines acceptance criteria for the use of the WCA as a fallback to the proven automatic sampling system and, where fitted, for the use of a manual sample point for ongoing diagnostics for the WCA.

The evaluation criteria for the standard Performance Acceptance Testing (water injection testing) for the automatic sampler are defined within API MPMS Chapter 8.2 and are not covered here.

a. Evaluation of WCA as fallback to proven Automatic Composite Sample.

The WCA recorded baseline results shall be compared, and within, the baseline tolerances allowed by API MPMS Chapter 8.2 in terms of each composite sample baseline, or the average of each spot sample baseline set and the deviation (drift) of baselines over the testing process.

In addition, the WCA FWA result for the water injected sample shall meet the same acceptance criteria as required for an automatic sampler as denoted in API MPMS Chapter 8.2 by direct comparison with the metered percentage water in oil over the baseline values.

b. Evaluation of manual sample point suitability for diagnostics

Where the manual sampling point and sampling process is being validated during the water injection testing, there are several comparison points to be made. The results shall meet the criteria below. Even a manual sample point evaluation that does not pass may still prove useful for diagnostics provided that it is quantified for both repeatability and bias.

1. Baseline samples

Each set of baseline sample results (collected by Method A or Method B) shall be directly compared with the averages of each set of manual sample point baseline results and to the WCA readings taken.

Under Method A. "Composite", the result being the average of three aliquots from the mixed composite sample that will be compared with the average of at least three sets of manual samples taken during the period over which the composite sample has been taken.

Under Method B. "Spot Samples", ideally manual samples will be extracted from the manual sample point synchronized with the samples drawn directly from the sample extractor.

Each individual sample analysed shall be within the acceptable repeatability of the analytical method. There is no allowance for deviation beyond the repeatability allowances of the analytical method.

2. Water Injected samples

The manual samples taken from the manual sample point during the water injection phase shall be compared to the Calculated Instantaneous Water injection (CIW) percentage (Water Injection Flowrate (WIF)/Total Flowrate (TF)) plus the prior Baseline Water Cut percentage average. (BWC)

$$CIW = [(WIF / TF) * 100] + BWC]$$

Where:

CIW Calculated Instantaneous Watercut (%)
WIF Water Injection Flow Rate (bph)
TF Total Flow Rate (bph)
BWC Baseline Watercut (%)

The manual sample analytical results shall be within the acceptable limits for the water concentration as defined in API MPMS Chapter 8.2 to the Calculated Instantaneous Watercut (CIW) for the average of each set of manual samples taken at a point in the water injection phase.

The manual sample results may also be compared to the WCA instantaneous readings. Such comparison is recommended but it shall not be used for verification of the manual sample point.

7.2.1.6   Summary of testing and acceptance criteria for PAT (see Table 1)

Per API MPMS Chapter 8.2, the primary reference for this testing is the metered oil/water.

Method	Sample Extractor (Auto Sampler)	WCA	Manual Sample Point
Baseline Test			
Method A Composite	Container, mixed. 3 aliquots removed and averaged.	FWA Reading.	Spot samples averaged, 2-3 sets (3 per set) over duration of baseline.
Acceptance Criteria	Per API MPMS Chapter 8.2	Per API MPMS Chapter 8.2	Per Section 7.2.1.5 item b 1
Method B Sample from Extractor	Small container or direct to lab glassware, 2-3 sets of samples from extractor until repeatable results derived.	FWA reading or observation average of readings.	Spot samples averaged, synchronized with samples drawn from extractor. (at least one set of 3)
Acceptance Criteria	Per API MPMS Chapter 8.2	Per API MPMS Chapter 8.2	Per Section 7.2.1.5 item b 1
Water Injection Test			
Water Injection Test (Metered Oil/Water)	Container, mixed. 3 aliquots removed and averaged.	FWA Reading.	Spot samples averaged, synchronized with CIW readings. 2-3 sets (3 per set) over duration of water injection test.
Acceptance Criteria	Per API MPMS Chapter 8.2	Per API MPMS Chapter 8.2	Per API MPMS Chapter 8.2

Legend

Reference – MPMS Chapter 8.2
Comparison

Table 1. Performance Acceptance Criteria

All results shall be recorded as per API MPMS Chapter 8.2 and the additional data for the WCA and Manual Spot samples per Annex B.

Manual Sample Point Testing

WCA Testing

Start
Performance Acceptance Test

Are devices available to calculate WCA FWA?

No → Test cannot be performed

Yes

1
Follow "Preparations before Acceptance Test" procedures of MPMS Chapter 8.2.
Purge and establish test flow rate

Identify and Correct problem, restart baseline

2
Adjust WCA per Fig. 4. and manufacturers procedures, record settings.

3
Determine start baseline watercut using either Method A or Method B

4
Observe and wait until WCA readings are stable (within ± 0.03%)

If Manual Sample Point is available for verification, follow this process concurrently with applying Method A or Method B

Identify and Correct problem

Method A

Method B

5M
Simultaneously collect spot samples from the Manual Sample Point

5A
Simultaneously start test and sample collection into a clean/empty container

5B
Collect Samples directly from sample extractor and record WCA readings for each sample

6M
Record and compare results of the Manual Sample Point with instant WCA results.

6A
Simultaneously stop test and sample collection (allow sufficient sample volume)

6B
Each set of Spot Extractor Point Samples and WCA readings shall agree to guidelines of MPMS Chapter 8.2

7M
Record and compare Manual Sample Point AVG to Method A or B results

7A
Record calculated WCA FWA and Composite Sample analysis;
Compare the two results

7B
Record calculated WCA AVG and Extractor Point Samples AVG;
Compare the two results

No

Do results meet the pass criteria of Section 7.2.1.5 item b 1

Do results meet the pass criteria of API MPMS Chapter 8.2 (Section 7.2.1.5 item a)

No

Yes

Baseline Testing

End Manual Sample Baseline Run

Yes

End WCA Baseline Run

**Figure 2.   Flowchart for WCA System Acceptance Testing (Baselines)**
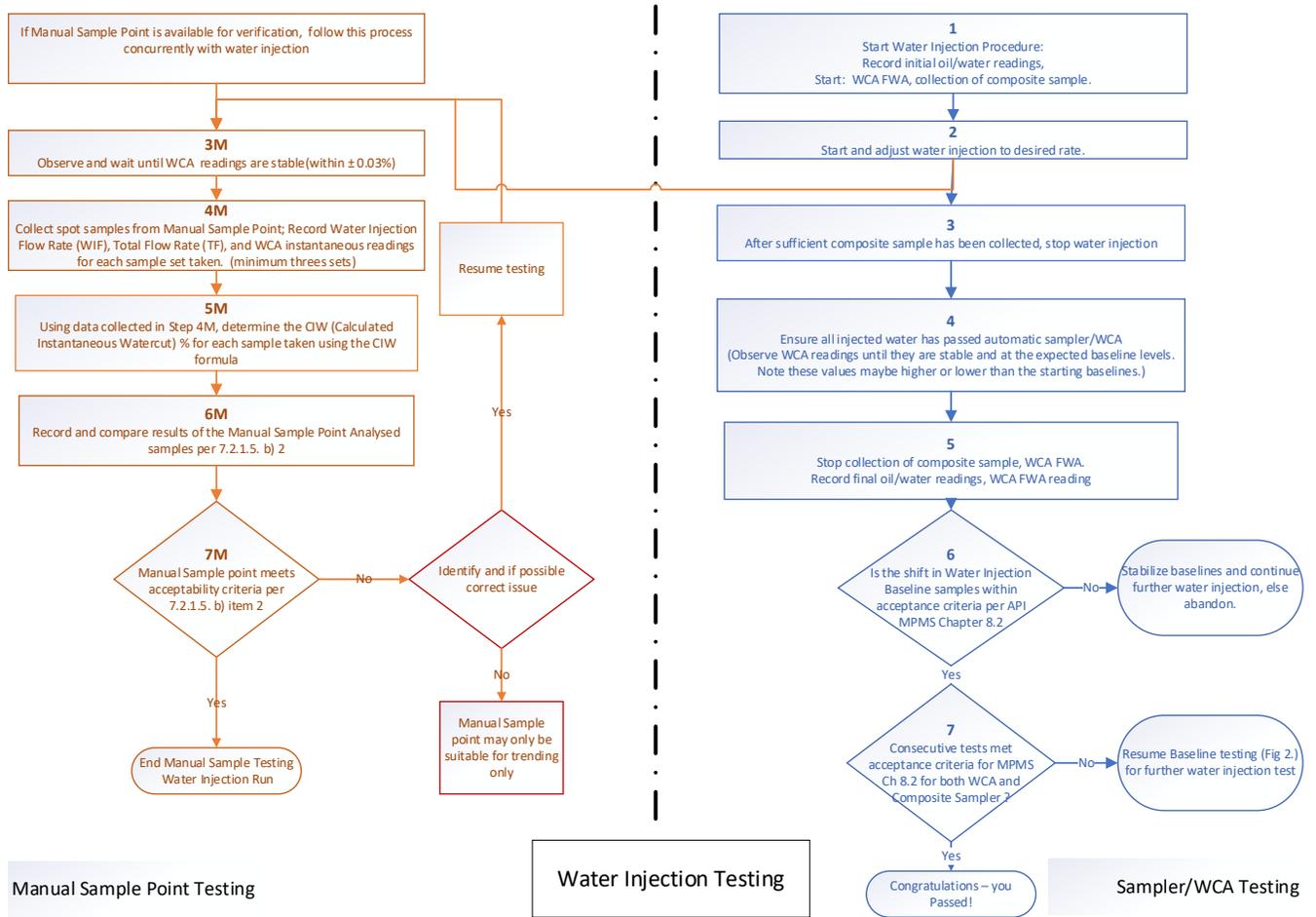
Figure 3.   Flowchart for WCA System Acceptance Testing (Water Injection)

Refer to Annexes for examples of control charts that could be used to document the WCA performance.

8.0   Ongoing Verification

8.1   General

This section discusses ongoing verification of the WCA in general terms.

Manufacturer's specific verification requirements shall be followed in addition to the guidance provided in this section. After the initial setup and acceptance testing, establish a routine frequency of verification.

In-situ verification shall be performed on an ongoing basis by the collection and comparison of data, batch by batch against a sampling system, that has met the requirements of the Water Injection Volume-Balanced Tests (API MPMS Chapter 8.2 – performance acceptance) and continues to meet the requirements of Performance Monitoring as outlined in API MPMS Chapter 8.2.

Additional data collection and diagnostics may be derived by comparing spot samples taken from a manual spot sampling point against the instantaneous WCA readings.

Correlation of data is simplified if the data collected from the WCA is of a form where any changes in calibration offsets can be reversed. Any changes to the calibration, for example for different product or crude types shall be clearly recorded, retained per industry accepted/operator practices, and readily available upon request by interested parties.

8.2 Verification by Comparison to Automatic Sampler

The sampling system design, installation and operation shall meet the requirements of API MPMS Chapter 8.2 and shall have successfully been proven.

Verification shall be by comparison of FWA water values reported by the WCA under test with the water content reported for an automatic sample taken over the same period (volume/batch/time; refer to Figure 4.) This analysis of the automatic sample shall only be for water; therefore, analysis method shall be distillation or Karl Fischer titration. The Centrifuge (field or laboratory) methods are also acceptable if agreed upon by all interested parties and the net water concentration can be accurately determined. The WCA FWA results shall be verified against automatic sample results.

Note: API MPMS Chapter 10.4 Does not currently contain a precision or bias statement

The allowable deviation shown in API MPMS Chapter 8.2 Table 3, shall **not** be used when comparing a WCA with an automatic sample. The table may only be used to compare the water injected values with the WCA system results.

To determine that the FWA is within acceptable tolerance of the automatic sample, the results shall be compared as follows:

1. The automatic sampler is the reference on an ongoing basis.

2. At least 10 batch (or more) results shall be averaged for long term comparison. The FWA WCA result, and the automatic sample result shall show no bias. The averages of the two sets of results shall show no more than +/-0.05% deviation.

3. The comparison of a single pair of results from the FWA WCA and a composite (automatic) sample shall not exceed the repeatability/ reproducibility limits of the method used for the composite sample analysis.

4. When adequate data has been collected and analysed that validates that the WCA meets the acceptance criteria above for a specific product/crude type, the WCA result may be considered if there is no automatic composite result available.

Control charts or other company documentation shall be used to compare and document the performance of the WCA against the continuous automatic sampling system.

Annex D gives an example of a control chart that is also downloadable as a spreadsheet from API. There are several benefits to your using this data form and uploading your data. All data received will be "blinded" i.e., not identifiable to specific installations.

- The collection of data will be used to enhance community knowledge and improve the performance/calibration of this type of equipment.
- By uploading your data, you will be provided access to aggregated results to allow you to benchmark your installations performance against installation type and product type.

START
WCA Ongoing Verification Test
(vs Composite Sample)

Are devices available to calculate WCA FWA?

NO → **Test cannot be performed**

YES

1-Simultaneously start batch and sampling system; Collect samples into a clean/empty container

2-Simultaneously stop batch and sample collection
(allow sufficient sample volume)

3-Record calculated WCA FWA and compare to Composite Sample Analysis

Do results meet the criteria of Section 8.2 of this document?

NO → **4-Make and record WCA adjustments**

YES

4-Maintain record of WCA performance

END
WCA Ongoing Verification Test
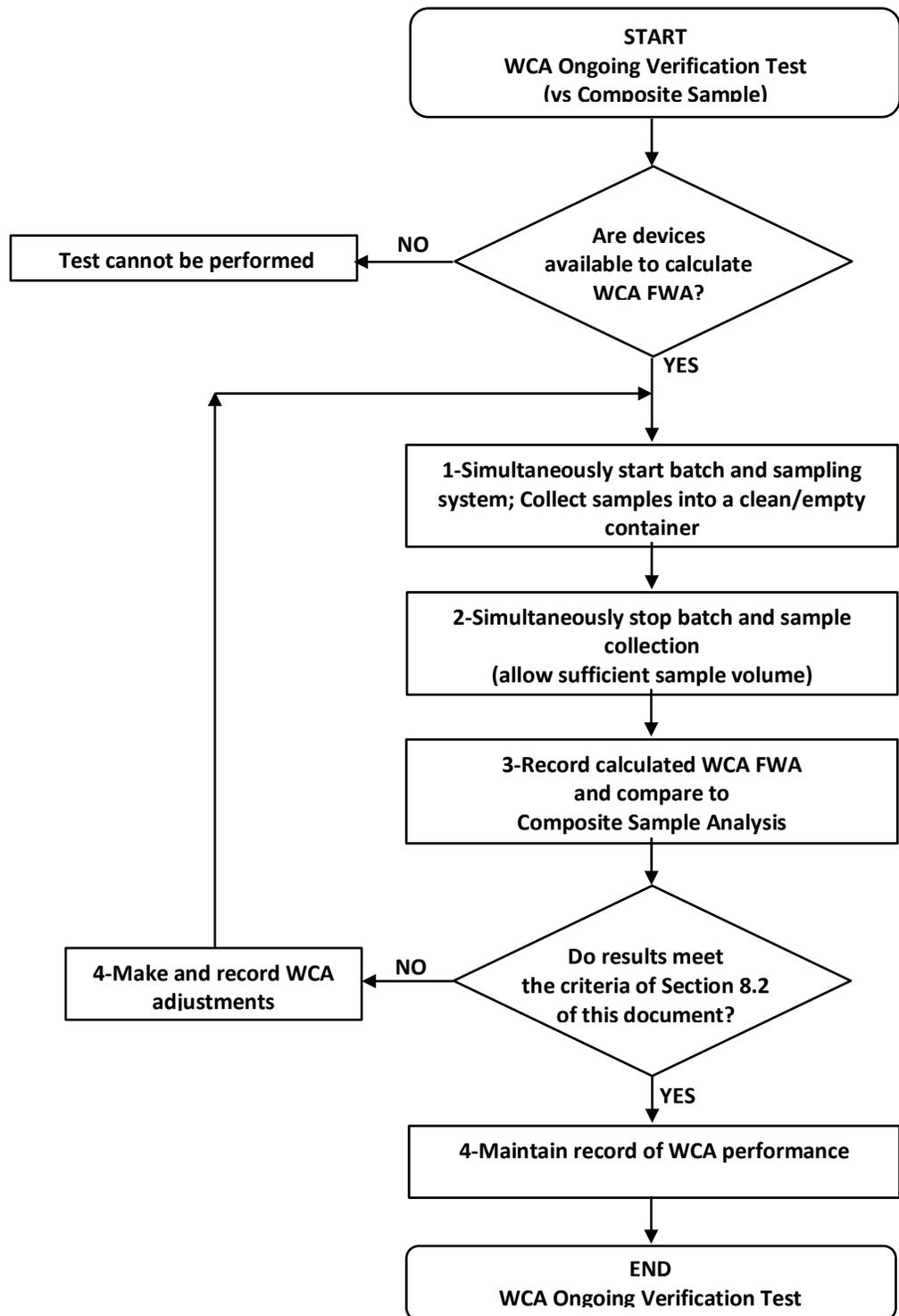
Figure 4.   WCA FWA Reading Compared to Automatic Samples

8.3 Verification of a WCA by Comparison to Manual Spot Sampling

The design and operation of the manual sample point shall meet the requirements of API MPMS Chapter 8.1 and as stated in section 6.

Note: The manual spot sample point shall be designed to ensure that the flow is adequate to prevent separation of hydrocarbon/water. The sample point shall be verified per Section 7 Manual Sample Point Verification test criteria.

The manual sample point may be used as a diagnostic tool to trend or check the instantaneous performance of a WCA. This does not supersede the use of automatic sample versus WCA FWA control charts as the primary verification method.

Diagnostics shall be by comparison of the instantaneous water value recorded by the WCA when each manual spot sample is taken, allowing for any timing as the sample is collected, shall the WCA be volume offset from the manual sample point or the value changes. Figure 4 reflects a typical diagnostic process.

A minimum of three values shall be recorded from the WCA during spot sampling.

It is recommended that the WCA output be averaged during each manual spot sample period.

The manual sample point used shall be verified as described in the Initial Verification section number 7.2.1.3

Pulling the sample: WCA results shall be monitored (or logged in the WCA) and averaged during the time the sample was taken. It is recommended that a minimum of 3 consecutive samples be taken. The variation in the WCA reading during the sampling period determines the uncertainty of the measurement (see Table 2).

Sample ID	Date/Time	Operator	Flowing Density kg/m3	Fluid Temp. Deg F	Analyzer Cal Adjust	Analyzer W/C%	Lab W/C%	Analyzer – Lab = Error%
1	2/21/2020 8:21		826	126	0	0.16	0.16	0
2	2/21/2020 8:23		827	125	0	0.17	0.15	-0.02
3	2/21/2020 8:24		825	126	0	0.14	0.15	0.01
							Average	-0.003

Table 2. Example of Manual Spot Sample Verification of WCA

It is recommended a historical trend of the manual sample diagnostic data is kept relevant to the WCA. The data may be recorded as shown in the example in Annex D.

Calculate the Error by taking the Laboratory analysis result for the water percentage (water cut) of the manual sample and subtracting the observed water percentage (water cut) on the analyzer. Determine the average error by summing the Error column and dividing by the number of samples.

If the average error is within the repeatability of the manufacturers claimed performance, and the data shows no bias then no changes are required.

In the event the average of the manual samples is outside of the WCA manufacturer's stated uncertainty, continue to take manual samples. If the trend persists, contact the WCA manufacturer for troubleshooting assistance.
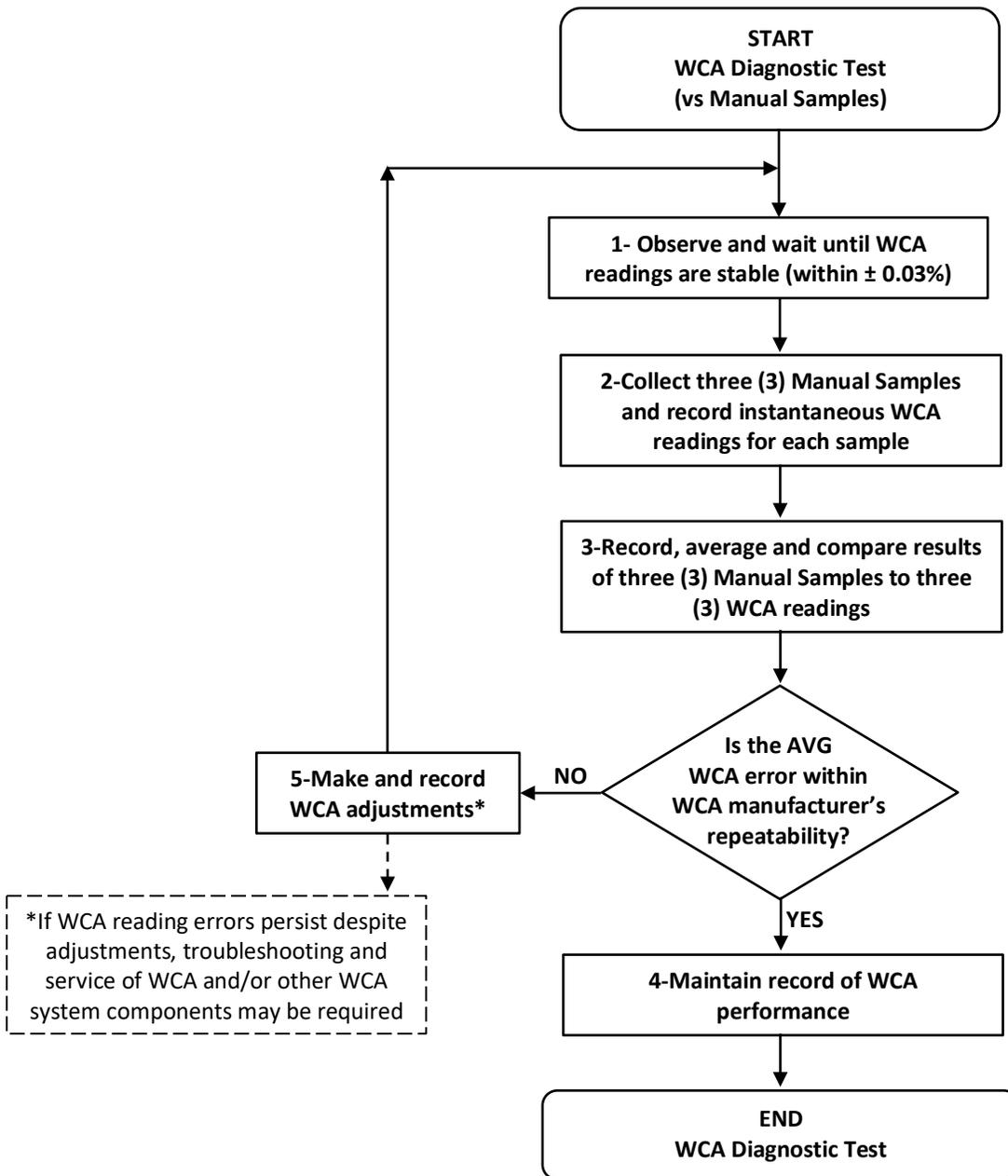
Figure 5.   WCA Diagnostics Compared to Manual Samples

8.4   WCA Records and Documentation

Regardless of the method of verification, the difference between the WCA and the verification value (sample test result) shall be retained.

For systems that handle different commodity grades, separate documentation for each grade and varying operating condition (temperature, pressure, etc.) may be required to show how the WCA responds to the different conditions.

All verification and performance records for the WCA system shall be available for review by all interested parties.

Refer to Annexes B, C and D for examples of control charts that could be used to document the WCA performance.

9.0   Audit Trail and Security

9.1   Audit Trail

The evaluation of operating criteria shall be properly documented with all information necessary for audit. Proper evaluation requires references to sources, background material and a detailed outlining of the evaluations made with respect to sections 7.0 and 8.0.

A WCA system shall be capable of establishing an audit trail by compiling and retaining sufficient information to verify the WCA results. Since the accuracy of a WCA system is affected by the verification and calibration of the device and the commodity characteristics the device is registering, the audit trail shall include the quantity of transaction, configuration logs, and event, alarm, and test records. All changes to the WCA and access shall be documented.

A WCA system shall be capable of alarming and logging error and/or failure. This log is used to note any system alarm or user-defined alarm or error conditions (for example, "out of range") that occur. This includes a description of each alarm condition and the times and totalized volumes when the condition occurred and cleared. This log is primarily used by providing the user with process information and information on equipment failure. At a minimum, an alarm shall be logged whenever any input exceeds its defined span of operation.

9.2   Security

Consideration shall be given to either physically sealing or password protecting as necessary the WCA and/or auxiliary devices to prevent unauthorized access, changes to calibration and setup functions.

WCA's used for custody transfer may be subject to regulatory security requirements.

Annex A. Typical WCA Installation Diagrams (Informative)
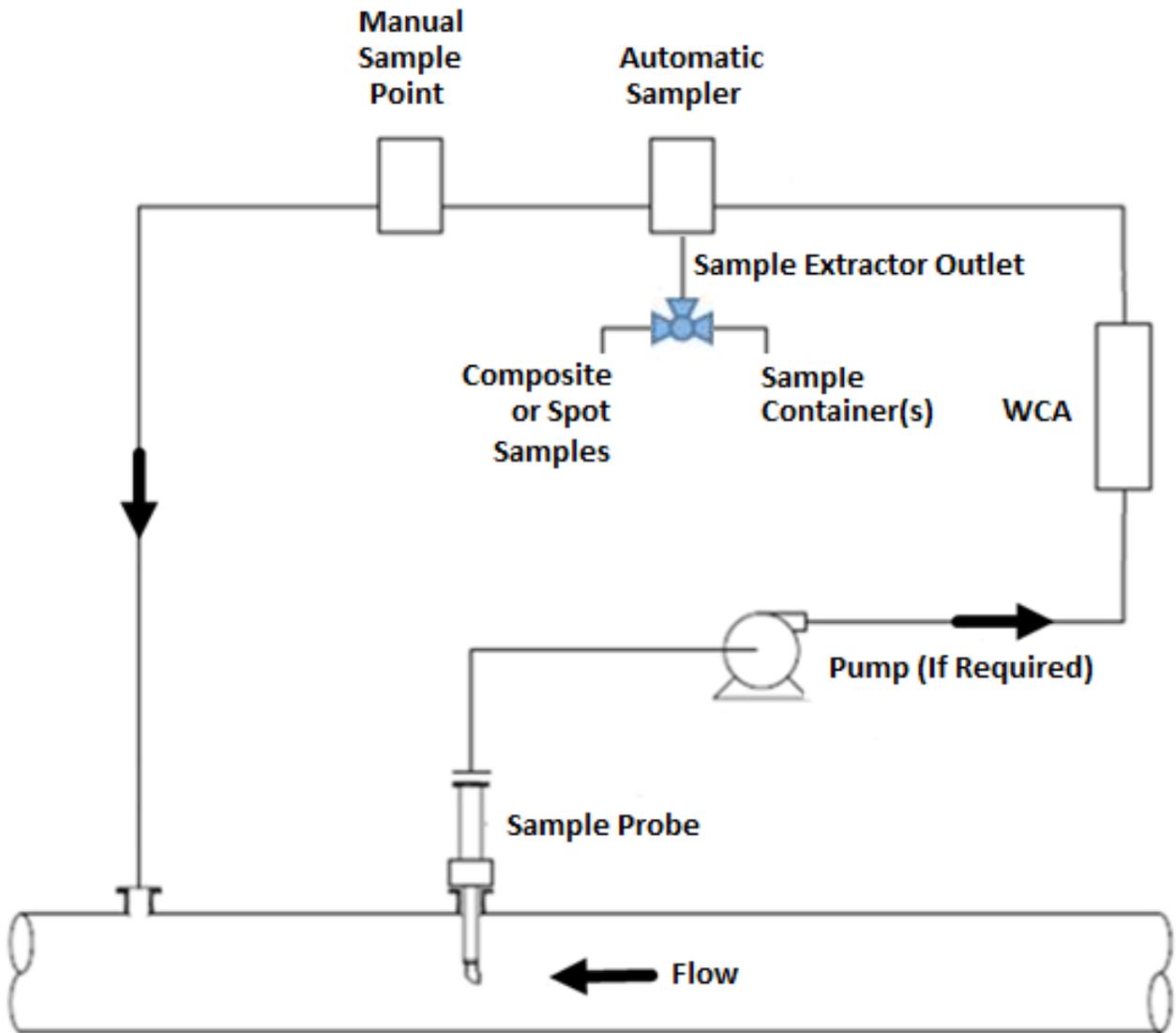
Figure A.1.   Typical Fast Loop WCA Installation

Refer to vendor recommendations for further detail.
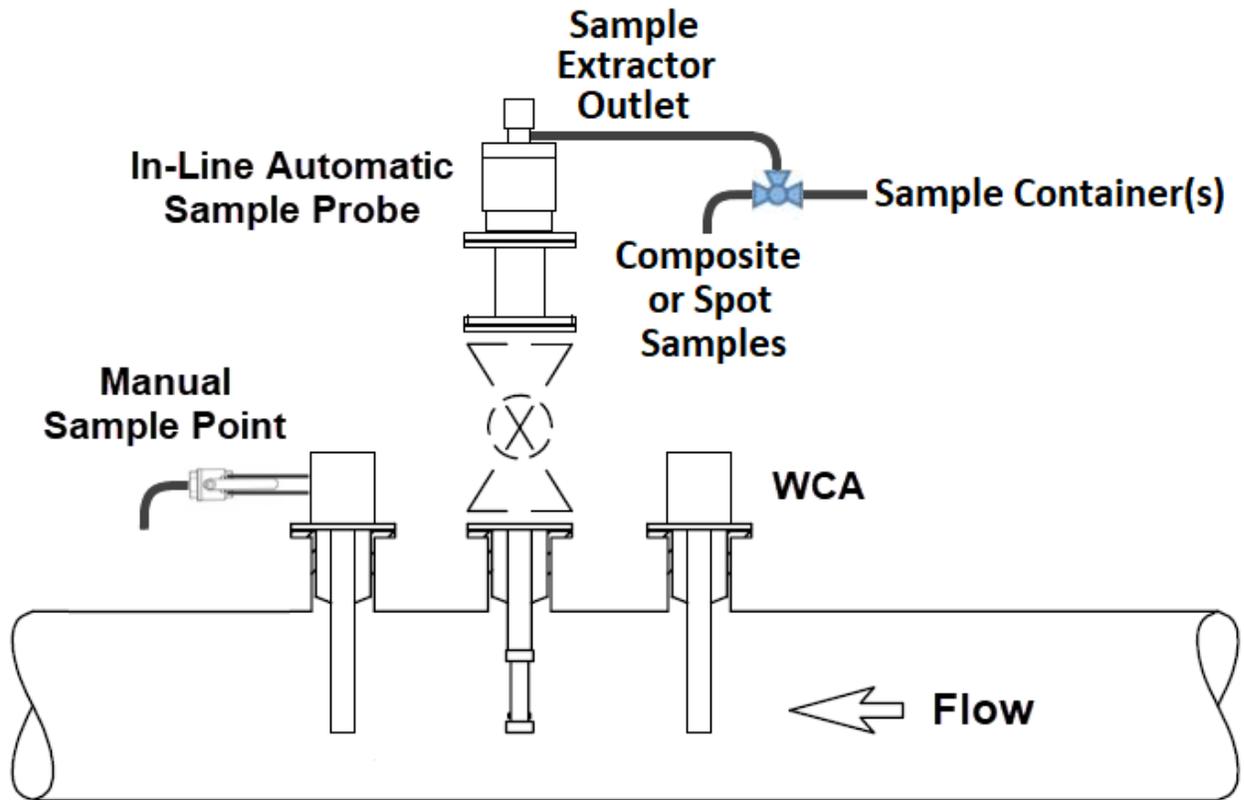
Figure A.2.   Typical In-line WCA Installation

Refer to vendor recommendations for further detail.

Annex B.　　　Example Worksheet for WCA Acceptance Testing Using an Average of Instantaneous Samples (Informative)

Equipment Functional Tag: _____

Location:_____

Date: _____ Start Time: _____ Stop Time: _____

Average Temp: _____ Average Gravity/Density: _____

Water Analysis Method: _____

Baseline Number …

Sample #	Time (hh:mm:ss)	Sample Result (Vol % Water)	WCA Result (Vol % Water)	Manual Spot sample (Vol % Water)
1				
2				
3				
4				
5				
6				
Baseline Average				

Water Injection Test Run …

Sample #	Time (hh:mm:ss)	Sample Result (Vol % Water)	WCA Result (Vol % Water)	Manual Spot sample (Vol % Water)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
12				
Averages				

Annex C. Example WCA Automatic Sample Verification Data Sheet (Informative)

Sample ID	Date / Time	Crude Type / Grade	WCA Cal Factor	Density Comp value		WCA Water %		Automatic Lab Water Cut %		Error
1										
2										
3										
Summary results					WCA Average		Lab Average		Avg Error	
1										
2										
3										
Summary results					WCA Average		Lab Average		Avg Error	
1										
2										
3										
Summary results					WCA Average		Lab Average		Avg Error	
1										
2										
3										
Summary results					WCA Average		Lab Average		Avg Error	
1										
2										
3										
Summary results					WCA Average		Lab Average		Avg Error	

Annex D. Example of downloadable verification data to compare WCA and Composite Sample results

Sample ID	WCA Technology (Type)	Service (Loading, Unloading, Pipeline, Truck, Barge, LACT, Alllocation, Platform Export)	Batch Size — Not Used For Diagnostics	Insertion/Bypass/Other	Manual Sample Point Validated	Batch Duration — Not Used For Diagnostics	PAT	Average Error (Manual Sample)	Date/Time Sample was taken	Type of Sample Extractor	Product Type / Grade	Fluid Density	Line Temp	Date	Product Type/Grade	WCA Initial Offset	WCA Current Offset	WCA Water Cut %	Flowrate	Average Error of runs (Composite Sample)	Composite / Spot Sample (Lab) Water Cut %	Linesize	Lab Analytical Method

Note:
Use for the comparison of composite sample results to the WCA FWA results and for comparison of manual samples against WCA reading, in this case batch size/duration are irrelevant and each reading and each analytical result shall be recorded and averaged in groups as they are "taken" as required.