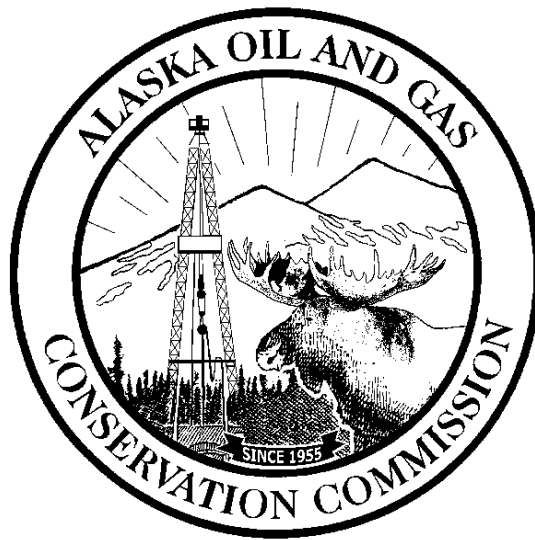


GUIDELINES

For

QUALIFICATION OF MULTIPHASE METERING SYSTEMS FOR WELL TESTING

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Alaska Oil & Gas Conservation Commission

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Prepared by:

Parviz Mehdizadeh, Ph.D.

Production Technology Inc.

Jane Williamson, P.E.

Alaska Oil and Gas Conservation Commission

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Guidelines for Qualification of Multiphase Metering Systems for Well Testing

1.0 Purpose

- 1.0.1 The use of multiphase meters for well testing is gaining increased support within petroleum production operations. It is anticipated that Alaskan operators will be pursuing their use in well testing and field production allocation.
- 1.0.2 Multiphase meters are devices that measure oil, gas, and water flow rates of a well stream with or without partial separation of these components into individual phases. Multiphase metering techniques were developed as an alternative to measurement methods using two and three phase gravity based test separators.
- 1.0.3 The Alaska Oil and Gas Conservation Commission (AOGCC) is authorized to evaluate and approve methodology and equipment utilized for well testing and allocation of production in Alaska per regulation (20 AAC 25.230) and Alaska Statute (Sec 31.05.030(d)(6)).
- 1.0.4 Industry standards and recommended practices are in place for test separator based single-phase gas or liquid metering. However, there are no standards and few guidelines available for multiphase meters.
- 1.0.5 Considering that the multiphase metering technology is relatively new and that accurate well test metering has both financial and reservoir management importance, the AOGCC will require approval prior to use of mutiphase meters to satisfy requirements of 20 AAC 25.230. These guidelines are provided to train and direct the operator and AOGCC on how to qualify these new measurement techniques.
- 1.0.6 These guidelines address both wet gas and multiphase metering systems for use in well testing. Custody transfer applications are regulated under 20 AAC 25.228 and are outside the scope of these guidelines.
- 1.0.7 The materials described in the “Guidelines for Qualification of Multiphase Metering Systems for Well Testing” were developed to serve the following objectives:

- 1.0.7.1 As a guide for the operator in submitting a request to apply new multiphase metering techniques for well testing and allocation of production,
- 1.0.7.2 As a guide and process tool for reviewing operators' requests for qualifying a multiphase metering system for well testing, and
- 1.0.7.3 As a training tool for AOGCC personnel who will be involved in the assessment of the multiphase technology for well testing.

1.1 Organization of the AOGCC Guidelines

The remaining sections of this document are organized as follows:

- Section 2 AOGCC Administrative Process: This section outlines the overall administrative process that will be followed for certification of a multiphase metering system.
- Section 3 Qualifying Multiphase Metering Systems for Well Testing: AOGCC expectations of documentation to accompany the application for pre-certification or certification of the proposed multiphase metering system are described.
- Section 4 Validation of Meter Performance in Field: In some instances, the AOGCC may require field verification of meter performance prior to approving use. This section provides recommendations and requirements for conducting these field tests to gather information required by the AOGCC for qualification of the multiphase metering systems and outlines requirements for documentation of the field test results.

1.2 "Principles of Multiphase Measurements"

A separate document, "Principles of Multiphase Measurements", is concurrently issued with these guidelines. This document provides basic information on multiphase meters, a list of references for further education on multiphase meters, a list of terms and definitions, and installation suggestions for multiphase meters. It is recommended that the novice review the "Principles of Multiphase Measurements" document in conjunction with these guidelines.

2.0 AOGCC Administrative Process

- 2.0.1 This section describes the AOGCC review and decision process that will be used in processing requests and summarizes required application contents. Section 3 provides further detail on required application content.
- 2.0.2 AOGCC approval will be required prior to use of multiphase meters in well rate determination to satisfy requirements of 20 AAC 25.230.
- 2.0.3 AOGCC approval will not be required for minor changes (such as meter size or minor technical upgrades that will not deteriorate performance) of previously approved meter systems. However, if production characteristics change significantly (such as large changes in GVF and water cut) from the initial approved application, a new application must be submitted. Approval will not be required for use of multiphase meters if the well test results are not used to satisfy monthly production reporting and well test allocation requirements of 20 AAC 25.230.
- 2.0.4 The AOGCC will only approve use of a multiphase meter system by Commission order adopting or amending pool rules under 20 AAC 25.520 or, in the Commission's discretion, by administrative approval where provided under an existing order. However, in the case of a pool for which pool rules have not been adopted and for which the applicant demonstrates that pool rules are not yet needed, the Commission will consider an *ad hoc* application for an order under 20 AAC 25.540 approving use of a multiphase meter system.

2.1 Application Contents-General

The application must include a cover-letter request with a summary description of the proposed meter system, discussion of how the proposed meter will be used for the determination of well production within the allocation system, reference to the conservation orders which prescribe the rules for development and operation of the pool, requested changes to the conservation order, and other documentation described in Section 3.

2.2 Review Process

- 2.2.1 It is recommended that the applicant contact the AOGCC early in the evaluation process to decrease the ultimate time to process applications and to reduce the risk of later costly revisions to plans.

2.2.2 If the application is deemed complete, AOGCC will notice the application for public comment and potential hearing, unless handled by administrative approval. By regulation, a minimum of 30 days is required for public comment from the date notice is issued. In some cases an oral hearing may also be held. Applicants should expect the full approval process, from submittal of a complete application to AOGCC decision, to take 30 to 60 days.

2.3 AOGCC Decision

2.3.1 If sufficient information is provided, the AOGCC may approve the system either unconditionally, or conditionally upon field testing and subsequent reporting of meter performance. Any approval is conditioned upon maintenance of the multiphase meter to provide accurate and reliable measurement, and will require periodic calibration of the multiphase meter and records to be kept to verify the calibration of the meter.

2.3.2 An applicant that is dissatisfied with the AOGCC's decision has the option to request reconsideration ("rehearing").

3.0 Qualifying Multiphase Metering Systems for Well Testing

The operator shall submit a proposal to the AOGCC for deploying the multiphase meter or meters in a designated application as a well testing system.

3.1 Application Contents

A complete application must address the following:

3.1.1 Discuss the intended application, proposed location and projected timing of installation of the meter.

3.1.2 List fields, pools, and wells affected by the proposal. Are multiple pools commingled? If so, provide details.

3.1.3 Outline any differences in working interest, royalty interest, and tax treatment for leases or for commingled pools.

3.1.4 Ensure that all working interest owners, royalty owners (e.g. Alaska Department of Natural Resources), and state revenue department (Alaska Department of Revenue) are notified.

3.1.5 Describe the meter make, model, type and measurement

methodology for the intended applications.

- 3.1.6 Describe plans for field-testing the meter (see Section 4). If no field-testing is planned, provide justification.
- 3.1.7 Provide data on the performance of metering systems obtained from laboratory or field tests. Discuss the expected effect of the proposed meter system upon the quality of the well test data measurement accuracy and overall production allocation in the planned application.
- 3.1.8 Provide information on expected precision, repeatability, and bias over the range of conditions for which the meter is planned for use. Accuracy must be evaluated across the full range of expected production flow rates, water cut (WC), gas volume fraction (GVF) and process conditions for which the system will be used (see also Section 4.3).
 - 3.1.8.1 Review accuracy for each phase.
 - 3.1.8.2 The method of accuracy description must be clearly defined. It is preferred that the accuracy be expressed as the percentage (+/-) uncertainty in the flow rates for each phase – i.e. oil, water, and gas flow rates. Other methods may be accepted by the AOGCC on a case-by-case basis if sufficient justification is provided.
 - 3.1.8.3 A numerical degree of confidence in the accuracy estimate must be provided and method of determining the confidence level must be discussed. In general, accuracy must be evaluated at a 90% or higher level of confidence. Other confidence levels or statistical analysis of confidence may be accepted by the AOGCC on a case-by-case basis if the methodology for determining confidence level is explained and sufficient justification is provided.
- 3.1.9 Summarize the production allocation methodology currently being used and explain how the meter will be incorporated into the existing methods of well production allocation.
- 3.1.10 Describe the contingency plan in the event the meter system does not meet the expected performance. Can the meter be changed out if the system does not meet expected performance, or if the well conditions change such that the production is outside the

original designed operating envelope of the meter system? How will this be accomplished?

3.1.11 Submit plans for quality assurance of long-term accuracy.

3.1.12 Describe the proposed systematic maintenance of the measurement system, including methods and frequency of periodic calibration. Describe the proposed record keeping and reporting format.

3.2 Accuracy Expectations

3.2.1 Generally, the AOGCC will expect accuracy for the pay fluid (oil or gas) from the multiphase meter to be within $\pm 5\%$ over the full range of rates, GVF and WC that the meter will measure when in service. It should be noted that this 5% is relative to the reference equipment.

3.2.2 When a multiphase meter is tested against a reference test separator in the field, the accuracy of fluid measurement by both the test separator and multiphase meter will affect the accuracy of the data obtained by the process. Using a root mean square (RMS) approach, the total probable error (accuracy) of the process is determined by:

$$\text{TPE} = (\text{E}^2\text{TS} + \text{E}^2\text{MP})^{1/2}$$

Where:

TPE = total probable error in the measurement

E TS = error due to the Test Separator measurement

E MP = error due to the Multiphase Meter measurements

As an example, if the test separator accuracy is 5% and the multiphase meter accuracy is 5%, the total probable error will be 7%. To obtain a meaningful multiphase meter accuracy, it is critical that the error of the reference equipment be less than 5%. (See also 4.2.2)

3.2.3 Some circumstances may warrant the use of multiphase metering for production allocation even if the meter accuracy is outside the ranges noted above. The AOGCC will consider applications on a case-by-case basis if thorough justification is provided with the application to the AOGCC.

- 3.2.4 The applicant shall provide justification for use of a meter system that will operate outside the above stated accuracy criteria. The following are examples where the AOGCC may determine it to be appropriate to relax these criteria.
- 3.2.4.1 If the meter is used solely for reservoir management and there are no significant financial impacts resulting from well test allocation with multiphase meter systems, less accuracy may be acceptable.
 - 3.2.4.2 Relaxation of accuracy criteria may be appropriate if agreed to by all parties that are financially impacted by inaccuracies of the meter system.
 - 3.2.4.3 It may be very difficult to obtain valid, accurate well tests with conventional separator based systems. As an example, some produced fluids may be extremely difficult to separate and lack of adequate separation will cause large errors in readings. In such instances, use of multiphase meters operating outside of the stated accuracy targets may provide better accuracy and may be preferable to use of separator based systems.
 - 3.2.4.4 Multiphase meters often reduce the measurement system footprint and visits by on-site personnel compared to gravity based separation systems. Multiphase meters may therefore provide an environmental advantage in new, remote drillsite developments and may improve chances of development approval from other regulatory agencies with authority over land use and environmental conservation.
 - 3.2.4.5 Multiphase meter systems may facilitate more frequent well tests as compared to a gravity separator based system. The stability of production during the non-test times will greatly affect the overall allocation accuracy. With more frequent testing and the resulting greater certainty in well test production, overall production allocation may be improved even if the absolute accuracy of the multiphase meter is less than that of the gravity based test separator.

4.0 Validation of Meter Performance in Field

- 4.0.1 The AOGCC will generally require field validation of meter performance prior to final approval. This section provides a guide to the operator in planning a field test to verify the performance of the measurement system and required documentation of these tests. It is strongly encouraged that the field test plan be reviewed with the AOGCC prior to actual field-testing to ensure required data is obtained and to help speed the approval process.
- 4.0.2 In determining whether to waive the requirement of field testing in a particular situation, the AOGCC will consider such factors as other performance validation options, including prior successful field tests for similar types of fluids and flow conditions, the purpose to which the multiphase metering system will be put, and the practicability of field testing.
- 4.0.3 Situations where the AOGCC may choose to waive requirements of a field test include but are not limited to the following.
 - 4.0.3.1 Field validation may be unnecessary if the meter system has been successfully tested in a field with similar fluids, flow regimes, operating conditions, rates, GVF and WC. Results of the prior testing must be provided.
 - 4.0.3.2 If the meter is used solely for reservoir management purposes and other lab or field tests are available at similar conditions, a field test may be unnecessary.
 - 4.0.3.3 Field validation of multiphase meters may be difficult, logistically impossible or highly impractical in some instances, particularly for new, remote drill sites. In lieu of a field test, the AOGCC may accept other lab or field tests conducted at similar operating conditions
- 4.0.4 If the AOGCC determines that a field verification of the proposed multiphase metering system is required, the processes described in the remainder of this section must be followed.

4.1 Field Verification

- 4.1.1 The field tests must be conducted under normal field operating conditions.
- 4.1.2 Field tests require comparison to reference field measurements. Options used to determine the reference flow are:

- 4.1.2.1 Capturing fluids that flow through the system during the test and measuring them with secondary equipment. This option requires extra equipment that must be calibrated per appropriate standards.
- 4.1.2.2 Indexing the performance of the new system against an established well test measurement system such as a conventional gravity based test separator.
- 4.1.2.3 A combination of the above.
- 4.1.3 There may be a large uncertainty in the reference measurements. Pre-calibration and maintenance of the reference measurement system must be performed prior to conducting the field trial.

4.2 Field Test Plan

The following is a guide for planning of field tests and may be revised to suit specific conditions.

- 4.2.1 Establish performance expectations that are within the design and tested constraints of the system.
 - 4.2.1.1 Multiphase metering accuracy degradation typically occurs for wells that have operating liquid rates, gas rates, water cut, or gas volume fractions outside the system's designed accuracy range.
 - 4.2.1.2 The multiphase metering system must be sized and designed to handle the flow range, pressure, and temperature (ambient and production) conditions existing in the field.
 - 4.2.1.3 Multiphase meter performance is also related to the fluid composition such as salt content of the liquids, impurities in the gases etc, which can change over the field life.
- 4.2.2 In a majority of qualification tests, 2-phase or 3-phase gravity based test separators are used to verify the performance of other multiphase measurement systems. Since these systems are used as the reference, the test plan must document the procedures used to calibrate and establish the accuracy of the liquid and gas measurement devices, the water cut analysis and monitoring, and the data acquisition and recording.
- 4.2.3 Full separation is rarely achieved and the procedures must make

an allowance for reduced instrumentation accuracy of the reference under field conditions.

- 4.2.4 Multiphase meters must be calibrated initially to accommodate the properties of the field fluids. The calibration procedures to be used prior to the field tests must be described. The calibration procedures must cover both the multiphase metering system as well as the reference systems.
- 4.2.5 Quite often the multiphase meter, the reference test separator, and the tanks used for fluid measurements are operating at different pressures and temperatures. Measurements made by these systems must be converted to rates at standard conditions (14.65 psia and 60 °F). Actual test measurements, prior to conversion to standard conditions, must be retained. Procedures used to determine shrinkage and conversion of volumes to standard conditions must be addressed.
- 4.2.6 Once the initial calibration is done, the field test results must be obtained without further intervention in the settings of the multiphase meter. If repair, resetting, or recalibration is required during the field tests, the nature and frequency of these interventions must be recorded and reported.
- 4.2.7 One of the major objectives of the field test is to evaluate the performance of the multiphase metering system over the full range of gas volume fraction and water cut since these are the two principal factors in determining the accuracy of the multiphase metering systems. To accomplish this, an outline of the test matrix to be used in the field tests is needed, noting the range of flow rates, GVF, and WC to be covered in the field tests. It is recognized that this matrix may be limited by the flow rates of the wells available, however the test matrix must cover a wide enough range to allow for practical evaluation of the performance.
- 4.2.8 The testing program must cover enough data points to allow a statistical evaluation of the accuracy performance such as the number of points in the tests that can meet the acceptance criteria of Section 3.2.
- 4.2.9 The proposed method for reporting the field test results must be described (see Section 4.3).

4.3 Reporting the Field Results

- 4.3.1 Thorough documentation will be required if field verification is required by the AOGCC prior to final approval of the multi-phase meter system. A report must be submitted to the AOGCC describing the results of such field trials, including accuracy results. The guidelines described in this section are recommended for formatting the report of the field test results. Alternate formats may be used. Regardless, it is required that evaluation of performance be provided as a function of factors (rates, fluid properties, operating conditions, GVF, WC, etc.) found to significantly affect accuracy.
- 4.3.2 All flow performance data for the metering system must be described in conventional oilfield units at standard conditions.
- 4.3.3 Individual well test results as measured by the multiphase meter and the reference measurement system must be provided and include the following:
- 4.3.3.1 **Flowing pressure** – measured at the meter in pounds per square inch absolute (psia).
 - 4.3.3.2 **Flowing temperature** – measured at the meter in degrees Fahrenheit (°F)
 - 4.3.3.3 **Oil rate** – Stock Tank Barrels of Oil per Day (STBD) corrected to standard conditions, at 14.65 psia and 60°F.
 - 4.3.3.4 **Water rate** – barrel per day (BPD).
 - 4.3.3.5 **Gas rate** – thousand standard cubic feet per day (MSCFD), at 14.65 psia and 60°F.
 - 4.3.3.6 **Gas-oil-ratio (GOR)** – (SCF/STB) the gas volume flow rate, relative to the oil volume flow rate, both converted to volumes at standard pressure and temperature.
 - 4.3.3.7 **Gas Volume Factor (GVF)** – gas volume flow rate, relative to the multiphase volume flow rate (oil, gas, water), at the pressure and temperature prevailing at the meter. The GVF is normally expressed as a percentage
 - 4.3.3.8 **Water cut (WC)** – the water volume flow rate, relative to the total liquid volume flow rate (oil and water), both converted to volumes at standard pressure and temperature. The WC is normally expressed as a percentage.

4.3.3.9 **Water-in-liquid ratio (WLR) (optional)** – the water volume flow rate, relative to the total liquid volume flow rate (oil and water) at the pressure and temperature prevailing at the meter. The WLR is normally expressed as a percentage.

4.3.3.10 **Fluid properties** including:

- Oil volume factor (Barrels at meter conditions/STB)
- Gas volume factor (Cubic feet at meter conditions/SCF)
- Water salinity
- Oil gravity (°API)
- Gas specific gravity

4.3.4 Figure 1 shows an illustrative graphical method that may be used to display accuracy results as a function of oil, water, and gas flow rates, WC, GVF or other important factors. In this figure the y coordinate represents flow rate error relative to the reference measurements.

4.3.5 Repeatability of the measured data and confidence level (see 3.1.8.3) must be stated. The repeatability is expressed by the following relationship:

$$repeatability = \frac{(\max \text{ error}) - (\min \text{ error})}{\sqrt{\text{number of tests}}}$$

Fig. 1 - An illustrative graphical method of reporting the accuracy performance of multiphase metering systems. These plots should be provided for each phase compared to GVF, water cut, and other important parameters.

