

OWNER

# FAT, SAT and Witness Testing of Measurement Systems

Procedure



Document No.: [REDACTED] MEA-PRC-003

Rev. A, Issued for Review

Date: September 29, 2026

Project: [REDACTED] [REDACTED]



TORUS

[REDACTED], [REDACTED] County, [REDACTED]

---

## N O T I C E

---

This document was prepared by TORUS for the use of the client named on the cover, under the terms of the agreement between TORUS and the client. It reflects the information available and the scope agreed at the date of issue. Information supplied by the client or by vendors has been used as received unless this document states that it was checked. Codes, site data and vendor information change over time, and conclusions may need to be revisited when they do. A document that is not issued for construction, or that is not sealed where a seal is required, shall not be used for construction. Use of this document by anyone other than the client is at that party's own risk.



ISSUE SUMMARY AND APPROVAL

This page records each issue of MEA-PRC-003. The preparer, reviewer and approver sign for each revision.

| Rev. | Date       | Issue purpose     | Description |
|------|------------|-------------------|-------------|
| A    | 2026-09-29 | Issued for Review | First issue |
|      |            |                   |             |
|      |            |                   |             |

Contributors

| Rev. | Discipline  | Prepared by | Reviewed by | Approved by |
|------|-------------|-------------|-------------|-------------|
| A    | Measurement |             |             |             |
|      |             |             |             |             |

C O N T E N T S

1. INTRODUCTION .....1

1.1. PURPOSE AND SCOPE.....1

1.2. REFERENCES .....1

1.3. INSPECTION CODES .....1

2. HOLD AND WITNESS POINTS.....2

3. FACTORY ACCEPTANCE TESTS.....4

3.1. METERS .....4

3.2. FLOW COMPUTER .....4

3.3. ANALYZER SHELTER B-101.....5

4. SITE ACCEPTANCE AND COMMISSIONING.....6

5. RECORDS .....7

F I G U R E S A N D T A B L E S

Table 2-1: Hold and Witness Points .....2

Table 3-1: Meter Factory Acceptance Tests .....4

Table 3-2: Flow Computer Factory Acceptance Tests.....4

Table 3-3: Analyzer Shelter Factory Acceptance Tests.....5

## 1. INTRODUCTION

### 1.1. PURPOSE AND SCOPE

This procedure defines the factory acceptance tests (FAT), the site acceptance tests (SAT) and the hold and witness points for the custody measurement systems at the . It covers the meter tube assemblies MR-110 and MR-120 (meters FE-111 and FE-121, flow conditioners FC-111 and FC-121, spools and thermowells), the measurement items on meter skid SK-110, flow computer FQI-110, analyzer shelter B-101 with analyzers AT-141 to AT-144, composite sampler SMP-146 and sample probe SP-141.

The purpose of the test sequence is to find problems where they are cheapest to fix. Dimensional and calibration faults in a meter tube are found at the fabricator and the laboratory, configuration faults in the flow computer are found against a simulator, and only the installation and the live data link are left for site. Each test that bears on custody is open to the receiving pipeline operator, so that both parties accept the system on the same evidence.

### 1.2. REFERENCES

1. AGA Report No. 9 (2022), Measurement of Gas by Multipath Ultrasonic Meters.
2. API MPMS Chapter 21.1, Flow Measurement Using Electronic Metering Systems.
3. GPA 2261, Analysis for Natural Gas and Related Gaseous Mixtures by Gas Chromatography.
4. MEA-SPC-001, Multipath Ultrasonic Meters, Flow Conditioners and Meter Tube Fabrication.
5. MEA-DS-001 to DS-010, measurement datasheets.
6. MEA-RPT-001, Measurement System Design Basis and Philosophy (notice periods).
7. MEA-CAL-001, CAL-003 and CAL-004, meter run, AGA 8 and sampling calculations.
8. MEA-PRC-001, PRC-002 and PRC-004, verification, chromatograph and data procedures.
9. MEA-DWG-001 and DWG-002, meter run fabrication drawing and meter skid general arrangement.

### 1.3. INSPECTION CODES

A hold point (H) stops the work until the Owner, and where marked the receiving pipeline operator, releases it. A witness point (W) requires notice; the work may proceed if the witness does not attend. A review point (R) is a review of documents. The receiving pipeline operator's participation is set by the Interconnect Agreement (HOLD H-01).

## 2. HOLD AND WITNESS POINTS

Table 2-1 lists every inspection point in the order it occurs, with the party that holds or witnesses it and the reference that sets its acceptance.

**Table 2-1: Hold and Witness Points**

| No. | Activity                                                                               | Location   | Owner | Receiving operator | Acceptance                                   |
|-----|----------------------------------------------------------------------------------------|------------|-------|--------------------|----------------------------------------------|
| 1   | Laboratory scope and calibration capability, installation-effects test report          | Office     | R     | R                  | MEA-SPC-001                                  |
| 2   | Meter tube spool bore map, steps, dowels and weld profiles                             | Fabricator | H     | W                  | MEA-SPC-001 tolerances                       |
| 3   | Hydrostatic test at 2,160 psig for 8 h                                                 | Fabricator | H     | -                  | No leaks, chart signed                       |
| 4   | Thermowell dimensions against DS-010 and the vendor's ASME PTC 19.3 calculation        | Fabricator | W     | -                  | Root 1.25 in, tip 0.875 in, U length 8.84 in |
| 5   | Flow calibration, as-left (and as-found for recalibrations)                            | Laboratory | H     | W                  | MEA-SPC-001                                  |
| 6   | Zero-flow test at the laboratory                                                       | Laboratory | W     | W                  | Below 0.04 ft/s on each path                 |
| 7   | Meter FAT: electronics, diagnostics, Modbus map, frequency outputs, write-protect seal | Vendor     | W     | W                  | Table 3-1                                    |
| 8   | FQI-110 FAT against a simulator                                                        | Integrator | H     | W                  | Table 3-2                                    |
| 9   | B-101 FAT: chromatograph, analyzers, sample system, ventilation and gas detection      | Integrator | H     | W                  | Table 3-3                                    |
| 10  | Meter tube installation on the skid: match marks, orientation, supports, no welding    | Site       | H     | W                  | MEA-DWG-001, DWG-002                         |
| 11  | Loop checks of pressure, temperature, analyzers and valves to FQI-110 and the RTU      | Site       | W     | -                  | Site acceptance tests                        |
| 12  | Zero-flow verification in place                                                        | Site       | H     | W                  | MEA-PRC-001                                  |
| 13  | Chromatograph calibration and verification with both standards                         | Site       | H     | W                  | MEA-PRC-002                                  |
| 14  | First series comparison at first gas                                                   | Site       | H     | W                  | MEA-PRC-001                                  |

Owner

Project No.: [REDACTED]

FAT, SAT and Witness Testing of Measurement Systems

[REDACTED] MEA-PRC-003

Rev. A

September 29, 2026

| No. | Activity                                                                      | Location | Owner | Receiving operator | Acceptance             |
|-----|-------------------------------------------------------------------------------|----------|-------|--------------------|------------------------|
| 15  | Point-by-point test of the data link to the receiving pipeline operator's RTU | Site     | H     | H                  | Point list, HOLD H-14  |
| 16  | Configuration baseline freeze for FQI-110, meters and chromatograph           | Site     | H     | W                  | [REDACTED] MEA-PRC-004 |



### 3. FACTORY ACCEPTANCE TESTS

#### 3.1. METERS

Each meter is tested after flow calibration, so that the configuration checked at FAT is the one the calibration certificate describes. Table 3-1 sets out the tests.

**Table 3-1: Meter Factory Acceptance Tests**

| Test                   | Method                                                               | Acceptance                                                                  |
|------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Visual and dimensional | Check tag, nameplate, transducer ports, taps and body bore           | MEA-DS-001                                                                  |
| Power and start-up     | Supply 24 VDC at 20.4 V and at 28.8 V                                | Operates with no alarm                                                      |
| Communications         | Read the full Modbus map from a test master; check scaling and units | Map matches the vendor submittal and the FQI-110 configuration              |
| Frequency outputs      | Simulated flow; count pulses against the volume register for 10 min  | Within 1 pulse in 10,000                                                    |
| Diagnostics            | Confirm every diagnostic register updates; disconnect one transducer | Status alarm; meter continues on the remaining paths per the vendor's logic |
| Configuration          | Compare parameters with the as-left calibration file                 | Identical; write-protect sealed                                             |

#### 3.2. FLOW COMPUTER

FQI-110 is tested against a simulator that supplies meter volumes, pressure, temperature and composition. The calculation checks compare against the project calculations, which were made with an independent implementation of the same equations of state. Table 3-2 sets out the tests.

**Table 3-2: Flow Computer Factory Acceptance Tests**

| Test                           | Method                                                                       | Acceptance                                                                              |
|--------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| AGA 8 calculation              | Lean, design and rich compositions at the meter conditions of cases C1 to C7 | Compressibility and density within 50 ppm of MEA-CAL-003, for both Detail and GERG-2008 |
| Volume and energy              | Simulated volume, pressure, temperature and composition over 1 h             | Base volume and energy within 50 ppm of an independent calculation                      |
| AGA 10 speed of sound          | Compare with MEA-CAL-003                                                     | Within 0.01 %                                                                           |
| Speed of sound alert and alarm | Offset the simulated meter SOS by 0.30 % and by 0.45 %                       | Alert at 0.25 %, alarm at 0.40 %                                                        |
| Composition fallback           | Fail chromatograph communications; hold 24 h, time accelerated               | Last good, then fixed composition, with flags and events                                |

| Test            | Method                                                                                                                      | Acceptance                                                                                                                                                                                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Run switching   | Simulate 85 ft/s for 60 s, then 25 ft/s per run for 10 min; simulate a meter failure; command both valves of one run closed | Standby inlet valve opens (outlet already open); return to one run by closing an inlet valve only; make-before-break failover; blocked-in alarm and inhibit without the maintenance permissive |
| Sampler control | Simulate volume; check bite pulses and the cylinder-full input                                                              | One pulse per set volume; sampling stops when full                                                                                                                                             |
| Records         | Hourly and daily quantity transaction records, events, alarms, audit trail, power failure and restore                       | API MPMS 21.1 content; no data lost on a power cycle                                                                                                                                           |
| Security        | Role permissions and write-protect                                                                                          | Unauthorized change rejected and recorded                                                                                                                                                      |
| Interface       | Modbus to the RTU and to the receiving operator's demarcation, simulated                                                    | Point list per HOLD H-14                                                                                                                                                                       |

### 3.3. ANALYZER SHELTER B-101

The shelter is tested complete at the integrator's shop, with the chromatograph, the analyzers and the sample conditioning panel installed and the calibration gases connected. Table 3-3 sets out the tests.

**Table 3-3: Analyzer Shelter Factory Acceptance Tests**

| Test                                                                             | Acceptance                                                                         |
|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Chromatograph, 10 consecutive analyses of the calibration standard               | Repeatability within GPA 2261; heating value within 0.5 Btu/scf of the certificate |
| Chromatograph, independent verification standard                                 | MEA-PRC-002 verification criteria                                                  |
| AT-142, AT-143 and AT-144, zero and span with certified gases                    | Within datasheet accuracy                                                          |
| Sample system leak test at 1.5 times the set pressure of each section            | No leaks by bubble test or pressure decay                                          |
| Sample flows: GC 0.10, moisture 1.00, H2S 0.50, O2 0.50 and speed loop 1.50 SLPM | Rotameter settings recorded                                                        |
| Sample system relief valves                                                      | Set and tagged                                                                     |
| Heating, ventilation fan with FSL-208, gas detectors GD-205 and GD-206           | Functional, with alarms to the RTU                                                 |

---

## 4. SITE ACCEPTANCE AND COMMISSIONING

---

Site acceptance follows installation and precedes first gas. The steps are taken in this order:

1. **HOLD POINT.** Installation check of the meter tubes (item 10 of Table 2-1), including confirmation that no support is welded to a calibrated spool and that insulation is complete except for the removable flange covers.
2. Loop checks from each field device to FQI-110 and the RTU.
3. Heat-trace circuits HT-1080 and HT-1139: insulation resistance and current at the design values.
4. Leak test and purge of the sample lines. Confirm the transport lag by switching to calibration standard at the probe outlet and timing the analyzer response; the expected transport lag is 15 s plus the analyzer's own response.
5. Close sample shutoff valve SDV-141 from the emergency shutdown test and confirm that FQI-110 holds the last good composition. Reopen it and confirm the 2.5 min purge hold before live composition is accepted.
6. **WITNESS POINT.** Zero-flow verification of both meters at line pressure (item 12).
7. **WITNESS POINT.** Commissioning calibration of the chromatograph (item 13).
8. **HOLD POINT.** At first gas, series comparison of FE-111 and FE-121 (item 14) before custody data are declared final.
9. **HOLD POINT.** Configuration freeze and baseline archive (item 16).

---

## 5. RECORDS

---

Every test is recorded on a signed test sheet that carries the item, the tag, the test, the method, the acceptance criterion, the result, pass or fail, the signatures and the date. The complete record comprises the test sheets, the punch list, the calibration certificates, the configuration baselines and the witness signatures of the Owner and the receiving pipeline operator. Records are retained under ME-PRC-004.

