

OWNER

Multipath Ultrasonic Meters, Flow Conditioners and Meter Tube Fabrication

Specification



Document No.: [REDACTED] MEA-SPC-001

Rev. A, Issued for Review

Date: September 29, 2026

Project: [REDACTED] [REDACTED]



TORUS

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

ISSUE SUMMARY AND APPROVAL

This page records each issue of MEA-SPC-001. 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			

SECTION EA-SPC-001

MULTIPATH ULTRASONIC METERS, FLOW CONDITIONERS AND METER TUBE FABRICATION

PART 1 GENERAL

1.01 SUMMARY

- A. This section covers the supply, fabrication, flow calibration, testing and documentation of the two custody-transfer meter runs MR-110 and MR-120 at the :
1. Multipath ultrasonic meters FE-111 and FE-121, with electronics FT-111 and FT-121.
 2. Perforated-plate flow conditioners FC-111 and FC-121.
 3. Meter tube spools, with thermowells and pressure taps.
- B. Motor-operated valves, headers, the crossover and the skid structure are supplied under the mechanical package. They shall meet the interface requirements stated in this section.
- C. The meter, conditioner and meter tube spools of each run form one calibrated assembly. The assembly shall be fabricated, flow calibrated, shipped and installed as one unit, because the calibration is valid only for the exact combination of meter, conditioner and upstream piping that was tested.
- D. Related documents:
1. MEA-DS-001, Multipath Ultrasonic Meters FE-111 and FE-121.
 2. MEA-DS-002, Flow Conditioners FC-111 and FC-121.
 3. MEA-DS-010, Meter Tubes MR-110 and MR-120.
 4. MEA-DWG-001, Meter Run Fabrication Drawing.
 5. MEA-CAL-001, Ultrasonic Meter Sizing and Meter Run Design.
 6. MEA-CAL-004, Sampling System Design and Thermowell Evaluation.
 7. MEA-PRC-003, FAT, SAT and Witness Testing of Measurement Systems.

1.02 REFERENCES

- A. The following codes and standards apply at the edition current on the date of the purchase order unless an edition is stated:
1. AGA Report No. 9 (2022), Measurement of Gas by Multipath Ultrasonic Meters.
 2. AGA Report No. 8 Parts 1 and 2 (2017) and AGA Report No. 10 (2003), for the flow computer calculations and the speed of sound check.
 3. API MPMS Chapter 21.1, Flow Measurement Using Electronic Metering Systems.
 4. ASME B31.8-2022, Gas Transmission and Distribution Piping Systems.
 5. ASME B16.5, B16.9, B16.20 and B16.25, flanges, fittings, gaskets and weld ends.

6. API Specification 5L, 46th edition, Line Pipe, X52 PSL2.
7. ASME Boiler and Pressure Vessel Code Section IX, and API 1104, welding qualification.
8. ASME PTC 19.3 TW-2016, Thermowells.
9. ISO/IEC 17025, General Requirements for the Competence of Testing and Calibration Laboratories.
10. NFPA 70 and API RP 500, electrical equipment in classified locations.
11. NEMA 250 and IEC 60529, enclosure protection.

B. Where this section and a referenced standard differ, the more stringent requirement shall apply. The Supplier shall refer conflicts to the Owner in writing before proceeding.

1.03 DEFINITIONS

- A. Calibrated assembly: the upstream spool U1, the flow conditioner, the upstream spool U2, the meter and the downstream spool DS of one run, as tested at the flow laboratory.
- B. D: the meter bore, 9.562 in, equal to the inside diameter of NPS 10 Schedule 80 pipe.
- C. q_{min} , q_t and q_{max} : the minimum, transition and maximum flow rates of the meter as defined in AGA Report No. 9.
- D. CMC: the calibration and measurement capability stated in a laboratory's scope of accreditation, expressed as an expanded uncertainty at approximately 95 % confidence ($k = 2$).

1.04 DESIGN CONDITIONS

- A. Each calibrated assembly shall be designed for the conditions in Table 1-1.

Table 1-1: Design and Operating Conditions

Parameter	Value
Design pressure and temperature	1,440 psig; -20 °F to 150 °F
Operating pressure at the meter	887 psig to 1,137 psig
Operating temperature at the meter	44 °F to 119 °F
Flow per run	10 MMSCFD to 120 MMSCFD; 5,012 acf/h to 68,973 acf/h
Velocity in the 9.562 in bore	2.8 ft/s to 38.4 ft/s
Gas	Dry, sweet pipeline-quality natural gas; speed of sound 1,130 ft/s to 1,461 ft/s
Ambient	-5 °F to 110 °F; solar 1,000 W/m ² ; meters installed under a canopy
Hydrostatic test	2,160 psig for 8 h

Note 1: Operating conditions are from MEA-CAL-001.

1.05 SUBMITTALS

A. The Supplier shall submit the documents in Table 1-2 at the stages shown.

Table 1-2: Submittals

Stage	Documents
With the bid	Datasheet compliance, qmin, qt and qmax, path configuration, installation-effects test report, flow laboratory scope and CMC, list of deviations
After award (HOLD H-15)	General arrangement drawings with weights and nozzle loads, electrical drawings, ASME PTC 19.3 thermowell calculation, inspection and test plan, welding procedure specifications and qualification records
Before shipment	Material test reports, NDE and hydrostatic test records, bore map, calibration certificates, configuration files, FAT report, manuals, spare parts list

1.06 QUALITY ASSURANCE

- A. The flow laboratory shall be accredited to ISO/IEC 17025 for high-pressure natural gas flow, with a CMC of 0.25 % ($k = 2$) or better over the calibration range. The laboratory's scope, traceability chain and CMC statement shall be submitted before the purchase order is placed. The project uncertainty analysis, MEA-CAL-002, assumes 0.23 %; a CMC of 0.30 % would raise the volume uncertainty at case C5 from 0.40 % to 0.44 %.
- B. The receiving pipeline operator may witness the flow calibration, the FAT and the configuration of the meters, as set out in MEA-PRC-003 and the Interconnect Agreement (HOLD H-01).

1.07 DELIVERY, STORAGE AND HANDLING

- A. Each calibrated assembly shall be shipped fully assembled on its calibration dowels, with end blinds, desiccant and a nitrogen purge or vapor corrosion inhibitor, and with flange faces and transducers protected.
- B. Each spool shall carry a tag with the tag number, the flow arrow and the calibration identification. Every joint shall carry the label "DO NOT DISASSEMBLE - CALIBRATED ASSEMBLY".

PART 2 PRODUCTS

2.01 ULTRASONIC METERS

A. Construction:

1. The meter shall be a multipath transit-time meter with at least four chordal paths. An eight-path meter (two independent sets of four paths) is preferred because it keeps measuring on one set while the other is diagnosed. Reflective single-bounce paths are acceptable only if the installation-effects test in Article 2.02 covers them.

2. The body shall be NPS 10, ASME B16.5 Class 600 RF, with a bore of 9.562 in within ± 0.5 %, forged or cast carbon steel impact tested at -20 °F. The face-to-face length is typically 30.0 in and shall be confirmed by the Supplier (HOLD H-15).
3. Transducers shall be removable under pressure with the Supplier's extraction tool, or with isolation that does not require depressuring the run. Replacement shall not require recalibration beyond the Supplier's documented delay-time procedure and a zero-flow verification.
4. The body shall carry a pressure tap, 1/2 in with a root valve, for PT-111 or PT-121, and a second tap for a test gauge.
5. The electronics shall be mounted on the meter, powered at 24 VDC, and certified for Class I Division 2 Group D, T3.
6. The nameplate shall show the tag, serial number, size, rating, bore, design pressure and temperature, calibration facility and date, body material and hydrostatic test pressure.

B. Performance: after flow calibration and application of the calibration factors, each meter shall meet the requirements in Table 2-1.

Table 2-1: Meter Performance Requirements

Requirement	qt to qmax	qmin to qt
Maximum error before calibration	± 0.7 %	± 1.4 %
Repeatability	0.1 % or better	0.2 % or better
Velocity resolution	0.003 ft/s	0.003 ft/s
Zero-flow reading, each path	Below 0.04 ft/s	Below 0.04 ft/s
Velocity sampling interval	1 s or less	1 s or less
Typical limits (HOLD H-15)	qt 5.0 ft/s (8,976 acf/h), qmax 100 ft/s (179,526 acf/h)	qmin 1.5 ft/s (2,693 acf/h)

Note 1: The Supplier shall state qmin, qt and qmax for the offered meter and confirm that qt does not exceed 0.1 qmax and qmin does not exceed 0.05 qmax.

C. Diagnostics: the meter shall report on its serial and Ethernet interfaces, for use by flow computer FQI-110:

1. Velocity, speed of sound, gain and signal-to-noise ratio for each path in each direction, and the percentage of accepted pulses.
2. Turbulence, profile factor, symmetry, crossflow and swirl indication, and path velocity ratios.
3. The average speed of sound, for comparison with AGA Report No. 10 in FQI-110. The flow computer alerts at a deviation of ± 0.25 % and alarms at ± 0.40 % (MEA-CAL-003).
4. An alarm on path-to-path speed of sound spread above a limit stated by the Supplier, typically 0.2 %.
5. Meter status, alarm flags and a log of configuration changes.

- D. Communications: Modbus RTU (RS-485) and Modbus TCP; two phase-shifted frequency outputs of 0 to 5 kHz for totalizer checking; one status output; diagnostic software with licence and cable. Time shall be synchronized from FQI-110.
- E. Security: the configuration shall be protected by password and by a hardware write-protect switch that can be sealed. The meter shall keep a non-volatile, time-stamped log of configuration changes. The as-left configuration after calibration shall be delivered as a file and a printed report, and becomes the configuration baseline.

2.02 FLOW CONDITIONERS

- A. Each flow conditioner shall be a perforated plate, NPS 10, for installation between Class 600 RF flanges 47.75 in (5D) upstream of the meter inlet face, with 47.75 in of straight pipe upstream of the plate.
- B. The Supplier shall submit an AGA Report No. 9 installation-effects test report, or an equivalent third-party report, showing that the offered meter model and path configuration, with this conditioner and 10D of total upstream length, meets the AGA 9 performance requirements downstream of each of the following:
 - 1. A single elbow.
 - 2. Two elbows out of plane.
 - 3. A header tee.
 - 4. A partially closed valve.
- C. Material shall be 316 stainless steel or duplex stainless steel. Thickness, bore and hole pattern shall be the Supplier's design; thickness is typically 0.13D. The plate inside diameter at the flange shall match the pipe inside diameter within 1 %. The plate shall be centered on the flange bolts by an integral tab or ring and shall not be able to rotate or shift.
- D. The pressure loss coefficient is typically 2.0 on the pipe velocity head, which gives 1.13 psi at case C5 (MEASCAL-001). The Supplier shall state the actual coefficient.
- E. The handle or tab shall be marked with the tag, flow direction, serial number and rating.

2.03 METER TUBE MATERIALS

- A. Pipe shall be API 5L X52 PSL2, SMLS (preferred) or ERW, NPS 10, with the wall selected so that the finished bore is 9.562 in within ± 0.5 %, machined if necessary. The nominal wall is Schedule 80 (0.594 in).
- B. Flanges shall be ASTM A105 or A350 LF2, Class 600 RF weld neck, bored to match the meter bore, and impact tested at -20 °F.
- C. Welding procedures shall be qualified to ASME Section IX with impact tests at -20 °F.

2.04 THERMOWELLS

- A. Thermowells TW-111, TW-112, TW-121 and TW-122 shall be one-piece 316 stainless steel bar stock, flanged NPS 1-1/2 Class 600 RF, tapered from a root diameter of 1.25 in to a tip diameter of 0.875 in, with a 0.26 in bore for a 1/4 in RTD, a 0.25 in tip thickness and a U length of 8.84 in. The flange face shall be 5.0 in above the pipe outside diameter.
- B. The more common tapered stem of 1.00 in root and 0.75 in tip shall not be supplied. At case C5 its vortex shedding frequency reaches 0.405 of its natural frequency, above the 0.4 limit of ASME PTC 19.3 TW-2016. The specified stem reaches 0.271 (MEA-CAL-004).
- C. The Supplier shall submit an ASME PTC 19.3 TW-2016 calculation for the final dimensions, including the actual nozzle stiffness.
- D. Velocity collars shall not be used.

PART 3 EXECUTION

3.01 METER TUBE ARRANGEMENT

- A. Each calibrated assembly shall be arranged as shown on MEA-DWG-001 and in Table 3-1. The upstream length of 10.14D, with the plate at 5D from the meter, is the configuration covered by the installation-effects test; the 5D downstream spool keeps both thermowells inside the calibrated assembly.

Table 3-1: Calibrated Assembly Arrangement, Each Run

Item	Length (in)	Length (D)
Upstream spool U1, inlet flange face to conditioner	47.75	4.99
Flow conditioner including gaskets	1.50	0.16
Upstream spool U2, conditioner to meter inlet face	47.75	4.99
Meter (typical, HOLD H-15)	30.00	3.14
Downstream spool DS	47.75	4.99
Total calibrated assembly	174.75	18.28

- B. Connections on each run shall be located as follows:
1. TW-111 and TW-121 on the DS spool, 3.0D (28.69 in) downstream of the meter outlet face, at the 12 o'clock position, for TT-111 and TT-121.
 2. TW-112 and TW-122, test wells, on the DS spool, 4.0D (38.25 in) downstream of the meter outlet face, at 12 o'clock.
 3. PT-111 and PT-121 on the meter body pressure tap.
 4. No vent or drain connection on a calibrated spool. Bleeds are on the motor-operated valves.
- C. Thermowell nozzles shall be NPS 1-1/2 weldolets with weld neck flanges. The inside edges of each weldolet shall be ground smooth, with no intrusion into the bore.

3.02 FABRICATION TOLERANCES

A. The Supplier shall fabricate each spool within the tolerances in Table 3-2. The project tolerances are tighter than the AGA Report No. 9 limits because the installation effect between laboratory and field is the second-largest term in the meter uncertainty (MEA-CAL-002).

Table 3-2: Meter Tube Tolerances

Requirement	Limit
Spool inside diameter against meter bore, measured at 4 diameters in 2 planes at each end and every 1D	Within $\pm 0.5\%$ (9.514 in to 9.610 in); AGA 9 limit $\pm 1\%$ (9.466 in to 9.658 in)
Step at any joint (spool to plate, spool to meter)	0.3 % of D maximum (0.029 in)
Out-of-roundness	1 % of the mean inside diameter maximum
Flange alignment	Two dowel pins per joint, or self-centering machined flanges; concentricity 0.02 in
Flange face perpendicularity to the tube axis	0.5 degree maximum
Overall length of each spool	± 0.06 in
Internal weld profile, flange to pipe	Ground flush and smooth in U1, U2 and DS
Internal surface	Clean, free of mill scale, grit-blasted or honed; roughness recorded; no internal coating unless applied before calibration and identical in service

3.03 TESTING AND FINISHING

- A. Each spool, or the complete assembly if the meter Supplier permits, shall be hydrostatically tested at 2,160 psig for at least 8 h before flow calibration, then dried immediately with dry air or nitrogen to a dew point of -20 °F or lower.
- B. All butt welds shall be examined by 100 % radiography or automated ultrasonic testing, and all weldolet fillet welds by 100 % magnetic particle testing.
- C. External coating shall be the Owner's above-grade system (zinc-rich epoxy, epoxy and polyurethane), applied before calibration, with the flange faces protected.
- D. No welding, grinding, drilling or coating repair shall be done on any calibrated component after calibration. Any such work voids the calibration.
- E. The assembly shall be supported only by clamp-type saddles, S1 to S5 on MEA-DWG-001. No attachment shall be welded to a calibrated spool.

3.04 FLOW CALIBRATION

- A. Configuration:
 - 1. The complete calibrated assembly, with its own thermowells installed, shall be calibrated as delivered.

2. Upstream of U1 the laboratory shall install piping representative of the station inlet, a tee or elbow followed by a full-bore valve length, as agreed with the Owner.
 3. Flange orientation and dowel positions shall be match-marked and photographed.
- B. Test conditions: the laboratory pressure shall be 600 psig or higher, so that the Reynolds number exceeds 10^6 across the calibration band, close to the field range of 1.0×10^6 to 1.3×10^7 . The test gas shall be natural gas.
- C. Flow points: the meter shall be calibrated at the nine points in Table 3-3, with at least 3 repeat runs at each point. The two points below qt are required because the turndown case C3 runs at 2.8 ft/s.

Table 3-3: Calibration Flow Points

Point	Nominal velocity (ft/s)	Fraction of qmax	Purpose
1	2.0	0.02	Low band, near case C3
2	3.0	0.03	Case C3 (2.8 ft/s)
3	5.0	0.05	qt
4	10	0.10	
5	20	0.20	
6	25	0.25	Cases C1, C2, C6 and C7
7	40	0.40	Cases C4 and C5 (38.4 ft/s)
8	60	0.60	Capacity reserve
9	80	0.80	Run switching set point

- D. The repeatability at each point shall be within 0.1 %, and within 0.2 % below qt. The laboratory shall record its pressure, temperature, speed of sound and Reynolds number, and every meter diagnostic, at each point.
- E. For a recalibration, an as-found test shall be run with the existing configuration before any adjustment, followed by the as-left test. Both shall be reported.
- F. Correction and acceptance:
1. The correction shall be a multipoint piecewise-linear interpolation programmed in the meter, or a polynomial agreed with the Owner. A single weighted factor shall not be used.
 2. The as-left residual at every point shall be within ± 0.1 % from qt to qmax and within ± 0.2 % below qt.
 3. The meter average speed of sound at each point shall be within 0.2 % of the value calculated from the laboratory gas composition with AGA Report No. 10.
 4. With the run blocked in at pressure and 30 min allowed for temperature to stabilize, the zero-flow reading of each path shall be within 0.04 ft/s.

- G. The calibration certificate shall give the laboratory reference, the uncertainty statement, the as-found and as-left data at each point, the correction factors entered, a diagnostic snapshot at each point, the configuration file, and photographs of the assembly and its match marks.

3.05 FACTORY ACCEPTANCE TEST

- A. The factory acceptance test shall be performed under MEA-PRC-003 and shall include at least:
1. Dimensional check of the spools against the bore map, dowels and flange alignment.
 2. Review of the hydrostatic test certificate.
 3. Functional test of the meter electronics.
 4. Diagnostics and communications test against a flow computer simulator.
 5. Zero-flow verification.
 6. Audit of the configuration against the as-left calibration file, and sealing of the write-protect switch.
 7. Inspection of coating and insulation supports.
 8. Inspection of marking and packing.

3.06 SPARES

- A. The Supplier shall provide, for each meter model:
1. One spare transducer pair for each path type.
 2. One set of electronics boards.
 3. Gasket sets for the conditioner joints.
 4. The diagnostic software.

END OF SECTION

