

ISO 17089-1:2019 (E)

Measurement of fluid flow in closed conduits — Ultrasonic meters for gas — Part 1: Meters for custody transfer and allocation measurement

Contents

	Foreword
	Introduction
1	Scope
2	Normative references
3	Terms, definitions and symbols
3.1	Terms and definitions
3.1.1	Quantities
3.1.2	Meter design
3.1.3	Thermodynamic conditions
3.1.4	Statistics
3.2	Symbols and subscripts
3.3	Abbreviations
4	Principles of measurement
4.1	Basic formulae
4.2	Factors affecting the performance
4.3	Description of generic types
4.3.1	General
4.3.2	Transducers
4.3.3	Meter body and acoustic path configurations
4.3.3.1	General
4.3.3.2	Basic acoustic paths types
4.3.3.3	Commonly used multi-path cross-sectional configurations
4.3.4	Average velocity calculation
4.4	Contributions to the uncertainty in measurement
4.5	Reynolds number
4.6	USM classification
5	Meter characteristics
5.1	Operating conditions
5.1.1	Flow rates and gas velocities
5.1.2	Pressure
5.1.3	Temperature
5.1.4	Gas quality
5.2	Meter body, materials, and construction
5.2.1	Materials
5.2.2	Meter body
5.2.3	Connections
5.2.4	Dimensions
5.2.4.1	General
5.2.4.2	Geometrical parameters of the measuring section
5.2.5	Ultrasonic transducer ports
5.2.6	Pressure tappings
5.2.7	Anti-roll provision
5.2.8	Flow conditioner
5.2.9	Markings
5.2.10	Corrosion protection
5.3	Transducers
5.3.1	Specification

- 5.3.2 Rate of pressure change
- 5.3.3 Transducer characterization
- 5.3.4 Path configuration
- 5.3.5 Marking
- 5.3.6 Cable
- 5.3.7 Robustness
- 5.4 Electronics
- 5.4.1 General requirements
- 5.4.2 Display
- 5.4.3 Power supply
- 5.4.4 Signal detection method
- 5.4.5 Sampling or pulsating flow
- 5.4.6 Signal-to-noise ratio
- 5.4.7 Alarm signal
- 5.4.8 Processing of data
- 5.4.9 Output
- 5.4.10 Cable jackets and insulation
- 5.4.11 Marking
- 5.5 Software
- 5.5.1 Firmware
- 5.5.2 MODBUS communication data specification
- 5.5.3 Discontinuity
- 5.5.4 Marking and version management
- 5.5.5 Monitoring and recording of measuring and diagnostic data
- 5.5.6 Correction functions and parameters
- 5.5.7 Inspection and verification functions
- 5.6 Exchange of components
- 5.7 Secondary measurements
- 5.7.1 General
- 5.7.2 Pressure measurement
- 5.7.3 Temperature measurement
- 5.8 Performance requirements
- 5.8.1 General
- 5.8.2 Accuracy requirements
- 5.8.3 Influence of pressure, temperature, and gas composition
- 5.9 Operation and installation requirements
- 5.9.1 General
- 5.9.2 Operational requirements
- 5.9.2.1 Sound, noise, and pressure-regulating valves
- 5.9.2.2 Contamination
- 5.9.2.3 Ambient temperature
- 5.9.2.4 Vibration
- 5.9.2.5 Electrical noise
- 5.9.2.6 Non-steady flow
- 5.9.3 Installation requirements
- 5.9.3.1 General
- 5.9.3.2 Distance to perturbations, upstream and downstream straight pipe length requirements
- 5.9.3.3 Protrusions and diameter step
- 5.9.3.4 Thermowells and density cells
- 5.9.3.5 Flow conditioners
- 5.9.3.6 Internal surface and wall roughness
- 5.9.3.7 Bidirectional use
- 5.9.3.8 Orientation of meter
- 5.9.4 Manual handling and transportation
- 5.10 Documentation
- 5.10.1 General
- 5.10.2 Generic meter documentation
- 5.10.3 Particular meter documentation
- 6 Test and calibration
 - 6.1 Pressure testing and leakage testing
 - 6.2 Individual testing — Static testing
 - 6.2.1 General
 - 6.2.2 Timing and time delays

- 6.2.3 Zero flow verification test
 - 6.3 Individual testing — Flow calibration
 - 6.3.1 General
 - 6.3.2 Laboratory flow calibration
 - 6.3.2.1 General
 - 6.3.2.2 Duration of the calibration
 - 6.3.2.3 Uncertainty of the calibration facility
 - 6.3.2.4 Flow conditions
 - 6.3.2.5 Thermal stratification at a calibration facility
 - 6.3.2.6 Bidirectional calibration
 - 6.3.3 Judging the measurement performance of the meter
 - 6.3.4 Adjustment and records
 - 6.3.4.1 General
 - 6.3.4.2 Results
 - 6.3.4.3 Meter identification and description of the facility
 - 6.3.4.4 Conditions of the test
- 7 Type testing
 - 7.1 General
 - 7.2 Accuracy
 - 7.3 Installation conditions
 - 7.4 Path failure simulation and exchange of components
 - 7.5 Electronics design testing
- 8 Audit trail and diagnostics for meter verification
 - 8.1 General
 - 8.2 USM Lifecycle Process
 - 8.3 Production and Factory Acceptance Test
 - 8.4 Initial Flow Calibration
 - 8.5 Site installation and site acceptance test
 - 8.6 Operation
 - 8.7 Diagnostic warning and alarm levels in operation
 - 8.7.1 MSOS and MSOS ratios warning & alarm levels
 - 8.7.2 Velocity ratios warning & alarm levels
 - 8.7.3 S/N ratios warning & alarm levels
 - 8.8 Service and recalibration
 - 8.8.1 General
 - 8.8.2 Service Related Diagnostics
 - 8.9 Diagnostic parameters
 - 8.9.1 Speed of sound
 - 8.9.1.1 Measured speed of sound (MSOS)
 - 8.9.1.2 Theoretical speed of sound (TSOS)
 - 8.9.2 Automatic gain control
 - 8.9.3 Signal-to-noise ratio (S/N)
 - 8.9.4 Acoustic signal acceptance
 - 8.9.5 Flow profile
 - 8.9.6 Standard deviation/turbulence
- 9 Operational practice
 - 9.1 Temperature and pressure correction
 - 9.1.1 Correction for the temperature
 - 9.1.2 Correction for the pressure
 - 9.1.2.1 General
 - 9.1.2.2 General simplified expression for any body type
 - 9.1.2.3 Refinement in initial estimate to account for different meter body designs
 - 9.1.2.4 Refinement in initial estimate for effects of end loading and end support or constraint
 - 9.1.2.5 Effects of transducer ports
 - 9.1.2.6 Total metering error
 - 9.1.2.7 Detailed calculation procedure
- Annex A (informative) Registration of error bands
- A.1 General
- Annex B (informative) Derivation and correction of USM errors

- B.1 Methods for correcting flow measurement error of a USM
- B.2 Calculation of flow-weighted mean error (FWME)
- B.2.1 General
- B.2.2 Example of a flow-weighted mean error calculation

Annex C (informative) Valve characterization and noise in a metering and regulating station

- C.1 Introduction
- C.2 Calculation method
- C.2.1 General
- C.2.2 Generation of noise by the control valve
- C.2.3 Practical determination of the valve weighting factor N_v
- C.2.4 Theoretical determination of the valve weighting factor N_v
- C.2.5 Propagation of noise from the valve to the USM using attenuation factor, N_d
- C.2.6 Signal strength of the USM, P_s
- C.2.7 Signal-to-noise ratio at the USM
- C.3 M&R station design

Annex D (informative) The calibration time of ultrasonic flow meters

- D.1 Introduction
- D.2 Comparing turbine meters and ultrasonic meters
- D.3 The minimum calibration time
- D.4 Determining the value of u_d

Annex E (informative) Detailed calculation of geometry-related temperature and pressure corrections

- E.1 General background
- E.2 Direct calculation
- E.2.1 Step 1 — Body temperature effect
- E.2.2 Step 2 — Body pressure expansion
- E.2.3 Step 3 — Correction for body style effect or proximity to flanges
- E.2.4 Step 4 — Combined pressure correction effect
- E.2.5 Step 5 — Expansion effects in the transducer ports
- E.2.5.1 General
- E.2.5.2 Port temperature correction
- E.2.5.3 Port pressure correction
- E.2.5.4 Combined port correction
- E.2.6 Step 6 — Combined flow correction
- E.3 Guidance on the use of finite element models
- E.3.1 General
- E.3.2 Note on intentional use of thin-wall equations beyond their normal limit
- E.4 Calculation of an initial estimate for the body pressure effect
- E.5 Worked example
- E.5.1 Meter details
- E.5.2 Initial flow error estimate
- E.5.3 Common elements to detailed calculation
- E.5.4 Direct single stage detailed calculation
- E.5.5 Three stage detailed calculation
- E.5.5.1 Stage 1 — Static calibration to dynamic calibration
- E.5.5.2 Stage 2 — Static calibration to field operation
- E.5.5.3 Stage 3 — Dynamic calibration to field operation flow correction factor
- E.6 Observations on the example calculation
- E.6.1 General
- E.6.2 Initial body pressure estimate
- E.6.3 Meter end-loading conditions
- E.6.4 Body pressure effect
- E.6.5 Body temperature effects
- E.6.6 Port effects
- E.6.7 Comparison against the results of an FE model
- E.6.8 Conclusion

Annex F (normative) MODBUS communication data specification

- F.1 General
- F.2 Example

Annex G (informative) Disturbance tests