

ISO/TR 12748:2015-10 (E)

Natural Gas - Wet gas flow measurement in natural gas operations

Contents		Page
Foreword		vi
Introduction		vii
1	Scope	1
2	Terms and Definitions	1
3	Symbols	10
4	Objectives of wet gas flow measurement	13
4.1	Common production scenarios	14
4.2	Production allocation	15
4.3	Flow assurance aspects	16
4.4	WGFM considerations	16
4.5	Reliability in remote WGFM installations	16
5	Flow regimes	17
5.1	Horizontal wet gas flow regimes	17
5.1.1	Stratified flow	18
5.1.2	Slug flow	18
5.1.3	Annular mist flow	18
5.2	Vertical up wet gas flow regimes	18
5.2.1	Churn flow	18
5.2.2	Annular mist flow	19
5.3	Vertical down wet gas flow regimes	19
5.4	Inclined flow	19
5.5	Examples of wet gas flow regimes	19
5.6	Flow regime maps	20
5.7	Different wet gas flow parameters	21
5.8	Water in wet gas flow	21
6	Wet gas flow metering principles	22
6.1	General	22
6.2	In-Line wet gas flow meters	23
6.2.1	Single-phase gas flow meter with correction factor	23
6.2.2	Two-phase wet gas flow meter	24
6.2.3	Multiphase wet gas flow meter	24
6.3	Single-phase gas differential pressure meters with wet gas flow	24
6.3.1	DP Meter design influence on wet gas over-reading	25
6.3.2	Lockhart-Martinelli parameter influence on DP meter wet gas flow over-reading	25
6.3.3	Gas to liquid density ratio influence on DP meter wet gas flow over-reading	25
6.3.4	Gas densimetric Froude number influence on DP meter wet gas flow over-reading	26
6.3.5	DP meter orientation influence on DP meter wet gas flow over-reading	26
6.3.6	Influence of β on DP meter wet gas flow over-reading	28
6.3.7	Fluid property influence on DP meter wet gas flow over-reading	28
6.3.8	Meter size/diameter influence on DP meter wet gas flow over-reading	28
6.3.9	Applying DP meter wet gas flow correlations	28
6.4	General discussion on DP meter wet gas correlations	29
6.4.1	Wet gas flow performance characterization vs. published wet gas correlations	29
6.4.2	Horizontally-installed orifice plate meter	29
6.4.3	Horizontally-installed Venturi meter	31

6.4.4	Horizontally-installed cone meter	32
6.5	Generic two-phase wet gas meter designs	33
6.5.1	Multiple single-phase meters in series	33
6.5.2	Differential pressure meter classical DP/permanent pressure loss wet gas meters	35
6.5.3	Fast response sensor system	36
6.6	Multiphase wet gas flow meters	37
6.6.1	Trace water metering with multiphase wet gas flow meters	38
6.6.2	Multiphase wet gas flow meter subsystems	38
6.6.3	Phase fraction device choices	39
6.6.4	Gas volume fraction vs. gas void fraction measurement	41
6.6.5	Semi-empirical multiphase flow calculation -- Slip model	41
6.6.6	PVT (pressure volume temperature) models	42
6.6.7	Multiphase wet gas flow meter required fluid property inputs	42
6.6.8	Multiphase wet gas flow meter phase fraction measurement	42
6.6.9	Measurement of water salinity	43
6.6.10	Multiphase wet gas flow meter redundant subsystems and diagnostics	43
6.6.11	Selection of multiphase wet gas flow meter technologies	44
6.7	Wet gas flow meter performance testing	44
6.8	Virtual metering system (VMS)	45
7	DP Meter Wet Gas Correlation Practical Issues	45
7.1	DP meter wet gas flow installation issues	46
7.1.1	Liquid flow rate estimation techniques	46
7.1.2	Monitoring wet gas liquid loading with a DP meter downstream port	47
8	Design and Installation Considerations	49
8.1	Design considerations	49
8.1.1	Meter orientation and fluid flow	49
8.1.2	Meter location relative to other piping components	50
8.1.3	Use of two-phase flow rate and composition maps	50
8.1.4	Fluid sampling	52
8.1.5	Redundancy and external environmental considerations	52
8.1.6	Security	53
8.1.7	Cost and project schedule implications	54
8.2	Performance specifications	54
8.3	Wet gas flow measurement uncertainty	55
8.3.1	Uncertainty evaluation methodologies	55
8.3.2	Additional factors affecting wet gas flow measurement uncertainty	55
8.3.3	Expressing uncertainty of wet gas flow rates	56
9	Testing, Verification and Calibration	56
9.1	Meter orientation	56
9.2	Comments on flow regimes and mixers	57
9.3	Installation requirements	57
9.4	Wet gas flow characterization tests -- Single-phase DP meter baselines	57
9.5	Wet gas flow facility operational considerations	58
9.5.1	Test facility operational issues -- Achieving thermodynamic equilibrium	58
9.5.2	Test facility operational issues -- Phase flow rate stability	60
9.5.3	Test facility operational issues -- Witnessing of tests	61
9.6	Meter testing in a wet gas flow facility	62
10	Operational and Field Verification Issues	65
10.1	Laboratory reference vs. field hydrocarbon flow composition estimates	66
10.2	Laboratory reference vs. field calibration of phase fractions	66
10.3	Comparisons of multiphase wet gas flow meter and single-phase meter requirements	66
10.3.1	The challenge of supplying multiphase wet gas flow fluid properties	66
10.3.2	Confidential slip models	67
10.4	The importance of correct fluid property predictions	67
10.4.1	The importance of gas properties when metering small liquid flow rates	70
10.4.2	Preparation for fluid property variations during meter service	71
10.4.3	Fluid property sensitivity investigation	71

10.5	The benefit of an initial wet gas flow facility test	73
10.6	Line size limitations for some multiphase meters	73
10.7	In situ wet gas flow meter verification	73
10.7.1	Reconciliation factors and meter output confidence	74
10.8	Operation and maintenance	74
10.8.1	System redundancy and diagnostics	74
10.8.2	Operating WGFM diagnostics	75
10.9	Miscellaneous operational issues	76
10.9.1	Wet gas flow and DP transmitters	76
10.9.2	Software and fluid property update procedures	77
10.9.3	Long term trending comparisons with test facility/factory characterization	77
11	Common Field Issues	77
11.1	Inefficient separator systems	77
11.2	Separator systems -- An adverse environment for single-phase meters	78
11.2.1	Separator Outlet deployment	79
11.2.2	Gas Measurement at the separator outlet	79
11.2.3	Liquid Turbine Meter	80
11.2.4	Practical limitations of wet gas flow metering with separator technology	80
11.3	Wet gas flow meter practical problems	81
11.3.1	Considerations for wet gas flow metering	81
11.3.2	The adverse effects of contamination, hydrates, scale, and salts	82
11.3.3	Theoretical, laboratory and actual wet gas flow conditions	84
11.3.4	Undisclosed WGFM calculation procedures	84
11.3.5	Differential pressure measurement and wet gas flows	85
11.3.6	Problems due to lack of long time operating experience of WGFMs	86
	Annex A (informative) WGFM design checklist	87
	Annex B (informative) Wet gas parameters equations	89
	Bibliography	90