

Fiscal measurement systems for hydrocarbon gas

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Foreword	2
Introduction	2
1 Scope	3
2 Normative and informative references	3
2.1 Normative references	3
2.2 Informative references	4
3 Terms, definitions and abbreviations	4
3.1 Terms and definitions	4
3.2 Symbols	5
3.3 Abbreviations	5
4 General requirements	6
4.1 General	6
4.2 Uncertainty	7
4.3 Sampling and analysis equipment	7
4.4 Calibration	7
4.5 Computer design	7
5 Sales and allocation measurement	7
5.1 Functional requirements	7
5.2 Technical requirements	10
6 Fuel gas measurement	18
6.1 Functional requirements	18
6.2 Technical requirements	20
7 Flare gas measurement	23
7.1 Functional requirements	23
7.2 Technical requirements	24
8 Gas samplers systems	25
8.1 Functional requirements	25
8.2 Technical requirements	26
9 Gas chromatograph	27
9.1 Functional requirements	27
9.2 Technical requirements	31
Annex A (Normative) Requirements for automated condition based maintenance	34
Annex B (Normative) Testing and commissioning	35
Annex C (Informative) System selection criteria	39
Annex D (Informative) Example of performance calculation of online gas chromatograph (OGC) result	40

Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are, as far as possible, intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF) and Federation of Norwegian Manufacturing Industries (TBL).

NORSOK standards are administered and published by Standards Norway.

Annexes A and B are normative. Annexes C and D are informative.

Introduction

This revision replaces the version from 1998. The basis for this NORSOK standard has been the version from 1998 combined with general industry experience over the last years. The metering industry still needs this NORSOK standard to be effective as a system standard for design and procurement. The structure from the 1998 version has been kept and the main changes are related to the following topics:

- included reference to last version of relevant standards and included reference to new relevant standards;
- modifications of the technical and functional requirements;
- improved clarification of technical requirements;
- included reference to standard for Coriolis meter;
- technical performance for on-line gas chromatograph when used in allocation and when used for gas density calculation is clarified and also shown in a detailed calculation example.

This update have been carried out by the NORSOK expert group Eg IM with members from end users (oil companies), authorities, contractors, consultants and metering system vendors.

1 Scope

This NORSOK standard describes the functional and technical requirements for fiscal measurement systems for gas. Further this NORSOK standard provides criteria for selection of such systems or main components thereof.

2 Normative and informative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements and guidelines of the standards referenced below.

2.1 Normative references

AGA 7,	<i>Measurement of gas by turbine meters - AGA Transmission Measurement Committee Report No. 7.</i>
AGA 8,	<i>Compressibility factors of Natural Gas and other related hydrocarbon gases, AGA Transmission Measurement Committee Report No. 8.</i>
AGA 9,	<i>Measurement of Gas by Multipath Ultrasonic Meters; AGA Transmission Measurement Committee Report No. 9.</i>
AGA 10,	<i>Speed of sound in Natural Gas and Other Related Hydrocarbon Gases</i>
AGA 11,	<i>Measurement of Natural Gas by Coriolis Meter</i>
AGA 2001,	<i>A model for estimation of the ultrasonic acoustic noise level emitted by pressure regulating valves and its influence on ultrasonic flowmeters</i>
ASTM D1945,	<i>Analysis of natural gas by gas chromatography</i>
BIPM et.al. *)	<i>Guide to the Expression of Uncertainty in Measurements (GUM)</i>
IEC 60751,	<i>Industrial Platinum Resistance Thermometer sensors</i>
IP PMM Part VII,	<i>Continuous Density Measurement</i>
ISO 1000,	<i>SI units and recommendations for use of their multiples and of certain other units</i>
ISO 5024,	<i>Measurement - Standard reference conditions</i>
ISO 5167-1,	<i>Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements</i>
ISO 5167-2,	<i>Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 2: Orifice plates</i>
ISO 5167-3,	<i>Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 3: Nozzles and Venturi nozzles</i>
ISO 5167-4,	<i>Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 4: Venturi tubes</i>
ISO 6551,	<i>Petroleum Liquids and Gases - Fidelity and Security of Dynamic Measurement - Cabled Transmissions of Electric and/or Electric Pulsed Data</i>
ISO 6976,	<i>Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition</i>
ISO 9000-3,	<i>Guidelines for the application of the ISO 9001 to the development, supply and maintenance of software</i>
ISO 9951,	<i>Measurement of gas flow in closed conduits - Turbine meters</i>
ISO 10715,	<i>Natural Gas Sampling Guidelines</i>
ISO 10790,	<i>Measurement of fluid in closed conduits - Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurement)</i>
ISO 12213-1,	<i>Natural gas - Calculation of compression factor – Part 1: Introduction and guidelines</i>
ISO 12213-2,	<i>Natural gas - Calculation of compression factor – Part 2: Calculation using molar-composition analysis</i>
ISO TR 9464,	<i>Guide to the use of ISO 5167</i>
NFOGM 2003,	<i>Handbook of uncertainty calculations; Ultrasonic fiscal gas metering stations</i>
NFOGM 2001,	<i>Handbook of uncertainty calculations, Fiscal orifice gas and turbine metering stations</i>

*) On behalf on BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML.

2.2 Informative references

ISO 6974-1,	<i>Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 1: Guidelines for tailored analysis</i>
ISO 6974-2,	<i>Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 2: Measuring-system characteristics and statistics for processing of data</i>
ISO 6974-3,	<i>Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 3: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns</i>

3 Terms, definitions and abbreviations

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1

accreditation

official recognition to the effect that an organisation is operating in accordance with a documented quality assurance system and that it has demonstrated competence to carry out specified tasks

3.1.2

allocation

distribution of sold/produced quantities of hydrocarbons between licensees and owner companies

3.1.3

can

verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.4

carrier gas

gas used to transport sample through the columns, normally helium, hydrogen or mixture of helium and hydrogen

3.1.5

column

tubes inside the temperature controlled oven of the OGC packed with material suitable for separating the components of natural gas when flowing the sample through using carrier gas

3.1.6

fiscal quantity

measured quantity of hydrocarbons used for sale, custody transfer, ownership allocation or calculation of royalty or tax

Note The term "fiscal" refers to the function of the measurement system, not its level of measurement uncertainty.

3.1.7

group of component

group of components with so low concentrations that their measurement as individual would be difficult or require excessive time

NOTE Hydrocarbons heavier than pentanes (denoted as C6+) is example of such a group.

3.1.8

may

verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.9**online gas chromatograph (OGC) calibration**

determination of the response of the detector for a given component with known concentration given on the certificate of the calibration gas or comparing the reading from OGC with values given on the certificate of the WGM

NOTE The gas chromatograph is fed continuously and automatically with process gas.

3.1.10**quantity**

measure of the hydrocarbon medium, by volume, mass or energy

3.1.11**shall**

verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.12**should**

verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.2 Symbols

U_{Cxi} is the expanded uncertainty of X_i in the WGM ($k = 2$). Expressed in mole percentage.

U_{Lxi} is the expanded uncertainty of X_i , due to lack of linearity of OGC ($k = 2$). Determined from linearity test of OGC and expressed in mole percentage.

U_{Rxi} is the expanded uncertainty of X_i , due to lack of repeatability of OGC ($k = 2$). Determined from stability test of OGC and expressed in mole percentage.

U_{xi} is the total expanded uncertainty of X_i determined by OGC ($k = 2$). Expressed in mole percentage.

X_i is the concentration of component i expressed in mole percentage.

3.3 Abbreviations

AGA	American Gas Association
ANSI	American National Standards Institute
ASME	The American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BIPM	International Bureau of Weight and Measure
CD-ROM	compact disc - read only memory
CEN	The European Committee for Standardization
CMR	Christian Michelsen Research
EN	European Standard
FAT	factory acceptance test
GCV	gross calorific value
GRP	glass reinforced plastics
ID	internal pipe diameter
IEC	International Electrotechnical Commission
IFCC	International Federation of Clinical Chemistry
IP PMM	Institute of Petroleum, Petroleum Measurement Manual
ISO	International Organization for Standardization
IUPAC	International Union of Pure Applied Chemistry
IUPAP	International Union of Pure Applied Physics
NFOGM	Norwegian Society for Oil and Gas Measurement
NPD	Norwegian Petroleum Directorate
OD	outer pipe diameter
OGC	on-line gas chromatograph

OIML	International Organization of Legal Metrology
P&ID	process and instrument diagram
Pt-100	platinum resistance thermometer
RAM	read access memory
SAS	safety and automation system
SI	System Internationale
USM	ultrasonic meter
VDU	visual display unit
WGM	working gas mixture

NOTE WGM is also called calibration gas, used for regular calibration of the OGC. Normally prepared by gravimetric method and supplied with a certificate listing the concentrations of all component and the uncertainty of the concentrations.

4 General requirements

4.1 General

The measurement system which fulfils the functional and technical requirements and has the lowest life cycle cost shall be selected.

Fiscal measurement systems for hydrocarbon gas include all systems for

- sales and allocation measurement of gas,
- measurement of fuel and flare gas,
- sampling,
- gas chromatograph.

All systems shall give readings and reporting in SI-units according to ISO 1000, except for pressure and differential pressure where the units bar and mbar shall be used respectively and for dynamic viscosity where the unit mPa·s shall be used.

The standard reference condition shall be 15 °C, 1,01325 bara, see ISO 5024.

The normal reference condition is defined as 0 °C, 1,01325 bara.

For calculation of gross calorific value (superior) and Wobbe index the standard reference condition shall be used in addition to combustion temperature of 25 °C and metering temperature of 15 °C.

For system concepts with no system specific requirements in this NORSOK standard, the design shall when standards are available, be based on (in order of priority):

- international standards, preferably ISO or CEN;
- the manufacturer's recommendations.

4.2 Uncertainty

Table 1 specifies normally applied uncertainty limits.

Table 1 - Measurement system uncertainty limits

MEASUREMENT SYSTEM	UNCERTAINTY LIMITS (Expanded uncertainty with a coverage factor $k = 2$)	CLASS
Sales and allocation measurement	$\pm 1,0$ % of mass ^a	Class A
Fuel gas measurement	$\pm 1,8$ % of standard volume	Class B
Flare gas measurement	$\pm 5,0$ % of standard volume	Class C
Simplified measurement system for gas	$\pm xx$ % of standard volume ^b	Class D
^a The uncertainty is given in mass, but other units may be requested (project specific) e.g. standard volume, energy etc.		
^b Any other uncertainty limit may be applicable for fiscal measurement systems if validated by a cost-benefit analysis performed and accepted by the operator (see Annex C)		

The uncertainty figures shall be calculated for each component and accumulated for the total system in accordance with the following reference documents:

- "Guide to the Expression of Uncertainty in Measurement (GUM)", (BIPM et. al.);
- a practical implementation is shown in handbooks of uncertainty calculation (including spreadsheet), issued by CMR, NPD and NFOGM (NFOGM 2001 and NFOGM 2003).

4.3 Sampling and analysis equipment

Automatic sampling or analysis equipment shall be installed. For dry gas, on-line gas chromatography shall be used if suitable for the process. Automatic sampling or analysis equipment is not required for fuel and flare metering systems.

Manual sampling point shall also be installed.

4.4 Calibration

All instruments and field variables used for fiscal calculations or comparison with fiscal figures shall be traceable calibrated to international/national standards. Calibration by an accredited laboratory fulfils these requirements. Test requirements prior to start-up are given in Annex B.

All geometrical dimensions used in fiscal calculations shall be traceable measured and certified to international/national standards. The material constants shall be documented. Implemented constants shall be available for verification, see 5.2.4.15.

4.5 Computer design

The vendor shall develop a functional specification for the computer part. This document shall clearly specify all functions and features, e.g. the applied algorithms, the sequences of the system, operator responses and error handling.

5 Sales and allocation measurement

5.1 Functional requirements

5.1.1 General

The measurement system shall measure gas flow rates and accumulated quantities. Where applicable, approval by the national authorities is required for the measurement system.

5.1.2 Products/services

The quality of the gas to be measured shall be evaluated. To obtain the required measurement uncertainty, single-phase condition is required.

5.1.3 Equipment/schematic

The measurement system shall consist of

- a mechanical part, including the flow meter,
- an instrument part,
- a computer part performing calculations for quantity, reporting and control functions. The computer part shall be dedicated computer(s). However, the supervisory computer may be a dedicated part of SAS.

A compact design is encouraged to reduce space requirements and weight.

5.1.4 Performance

5.1.4.1 Capacity

The measurement system shall be capable of measuring the full range of planned quantities of hydrocarbon gas through the measurement system. The flow rate in each meter run shall not exceed limits which result in total uncertainty exceeding the uncertainty limits for systems, listed in 5.1.4.2.

NOTE NPD regulation requires one spare meter run for a multi-run sales gas metering station.

5.1.4.2 Uncertainty

Class A system.

5.1.4.3 Lifetime

The lifetime is application specific.

5.1.4.4 Availability

The measurement system shall be designed for continuously measurement of all expected flow rates.

5.1.5 Process/ambient conditions

See process data sheet (project specific).

5.1.6 Operational requirements

5.1.6.1 General

The measurement system shall be operated from the computer part. It shall be possible to operate the measurement system from SAS, see 5.2.4.3.

It shall be possible to measure the gas flow and accumulate even if the supervisory computer fails completely.

It shall be possible to operate all valves locally.

The gas flow measurement function shall not be affected during regular calibration of the field instruments or if a field instrument of any type fails.

5.1.6.2 Measurement systems with multiple meter runs

In automatic mode, the measurement system shall control opening and closing of meter runs that are in service mode, as required by the amount of gas flow being measured.

The meter runs inlet valves shall have remotely operated electrical actuators. These shall not be part of the automatic operation.

The closing of the last open meter run shall only be possible in manual mode.

5.1.7 Maintenance requirements

5.1.7.1 General

The field instrumentation shall be selected to reduce need for maintenance and calibration activities.

The maintenance requirements for automated condition based maintenance in Annex A shall apply. In addition, it should be easy access to the instruments and flow elements for maintenance.

5.1.7.2 Calibration

Locations where checking and calibration take place shall be protected against environmental influences and vibrations so that the requirements given in this NORSOK standard can be fulfilled.

It shall be possible to calibrate all instruments and separate components in the electronic loop either without moving them from their permanent installations, without disconnecting any cables, or by using transmitters fitted with quick connectors (for removal for calibration/ maintenance). An exception to this will be a flow meter that requires off-line calibration.

If it is impossible to calibrate the meter at the relevant process conditions, the meter shall at least be calibrated for the specified flow velocity range (m/s). For differential pressure device equivalent Re-number range will apply.

Densitometer cables shall be equipped with quick connectors for easy retrofit.

The computer part shall be designed so that during calibration the quantities shall be registered separately and independently of measured quantities. In calibration mode, the flow time shall be registered and displayed by the flow computer/computer system.

5.1.7.3 Maintenance

There shall be easy access to any part that requires regular calibration and maintenance. Facilities to ease the calibration shall be included in the system or offered as an option.

The software shall provide means of calling up live transducer values (one at a time) onto the operator workstation for purpose of calibration. The input shall be displayed in engineering units. Input shall be displayed on VDU with the same time period as read by the input/output system, i.e. no average.

5.1.7.4 Isolation and sectioning

It shall be possible to maintain and inspect the mechanical part of the system, including internal surface of the meter run, without dismantling the manifolds (or similar).

5.1.7.5 Thermal insulation

The insulation/heat trace shall be removable for test and field calibration of instruments in the measurement system.

5.1.8 Layout requirements

Bypassing of the measurement system is not permitted.

Sufficient upstream and downstream length of pipe shall be installed. If the measurement system has an inlet manifold, it shall be in the same plane as the meter tubes

Ultrasonic flow meters shall not be installed in the vicinity of pressure reduction systems (valves etc.), which may affect the signals, see note below.

NOTE A model for estimation of the ultrasonic acoustic noise level emitted by pressure regulating valves and its influence on ultrasonic flowmeters" MARCEL J.M. VERMEULEN, GEEUWKE DE BOER and JIM BOWEN, Paper was presented during the AGA Operations Conference (Washington) in year 2001

The metering system shall not be installed in locations where any liquid may be accumulated.

5.1.9 Interface requirements

The computer part shall be interfaced to

- SAS (if dedicated computer),
- sampling system and/or on-line gas chromatograph,
- production database and allocation systems (information management system).

The remaining interfaces, if any, are application specific, e.g. water dew point, hydrocarbon dew point, hydrogen sulphide (H₂S).

5.1.10 Testing and commissioning requirements

The testing and commissioning requirements in Annex B shall apply.

5.2 Technical requirements

5.2.1 General

The requirements below are only relevant if the specified component is part of the measurement concept.

5.2.2 Mechanical part

5.2.2.1 Sizing

The measurement system shall be designed to measure any expected flow rate within 80 % of maximum capacity.

5.2.2.2 Meter run pressure setting/equalising

Each meter run shall have

- a connection to flare for depressurizing the meter run,
- a connection for nitrogen purging,
- a small bore by-pass across the inlet or outlet valve for pressure setting/equalizing the meter run.

5.2.2.3 Meter runs and header design

Meter run and header design shall ensure adequately developed flow profile at the flow meter. This can be achieved when the cross sectional area of inlet manifold is, as a minimum equal to the area of the meter runs in operation. For large measurement stations, placing the inlet pipe in the centre of the manifold may reduce the inlet manifold diameter. This is valid unless it is verified and documented that the flow meter is not influenced by the layout of the meter runs and header in such a way that the overall uncertainty requirements are exceeded.

Orifice:

The orifice meter runs shall be designed in accordance with ISO 5167-1 and ISO 5167-2.

Ultrasonic:

The ultrasonic meter runs shall be designed in accordance with AGA 9 with the following clarifications:

- the meter shall, either by its own design or by necessary piping arrangements always be available for necessary maintenance;
- for the meter run, the minimum straight upstream length shall be 15 ID. The minimum straight downstream length shall be 3 ID. Flow conditioner of a recognized standard shall be installed. If it is documented that the ultrasonic meter is not influenced by the layout of the piping upstream in such a way that the overall uncertainty requirements are exceeded other designs based on computerized flow modelling can be allowed.
- Ultrasonic meters may be used bi-directionally. In this case both ends of the meter shall be considered as upstream.

Coriolis:

Upstream piping configuration may affect the gas velocity profile entering a coriolis sensor. The upstream piping configuration will have to be based on an evaluation of recent test results for similar type of meters.

5.2.2.4 Flow meter designsOrifice meters:

The orifice meter shall be designed in accordance with ISO 5167-1 and ISO 5167-2. Orifice plate carrier of single chamber type shall be applied.

Ultrasonic meters

The ultrasonic meter shall be designed in accordance with AGA 9 with the following clarifications:

- the number of paths for ultrasonic meters shall be determined by required uncertainty limit. In order for the ultrasonic meter to be accepted and considered to be of acceptable quality the maximum deviation from the reference during flow calibration shall be less than $\pm 1,5 \%$. The linearity shall be better than $1,0 \%$ (band) and the repeatability shall be better than $\pm 0,2 \%$. These requirements are applicable after application of factory zero flow point calibration but before application of any correction factors, for flow velocities above $1,5 \text{ m/s}$,
- the meter shall be designed and installed such that any accumulation in the form of liquid or solid particles in the vicinity of the transducers is avoided,
- the ultrasonic flow meter shall be designed such that measurements of acceptable quality can be achieved when one transducer pair is out of service.

Coriolis:

The coriolis meter shall be designed according to AGA 11, and ISO 10790, Annex E.

Other types of meters:

Project specific.

5.2.2.5 Block valves

The meter run inlet and outlet valves shall be of double block and bleed type. The valves shall be equipped with a body vent and the leakage control shall be automatic or manual monitored.

Outlet on/off valves at multiple meter runs shall be equipped with remotely operated actuators with failsafe "stay in position". Flow direction shall be clearly stated on valve bodies.

Remotely operated electrical actuator shall be used, In addition the valves shall be equipped with limit switches for open and closed position.

5.2.2.6 Vent systems

The system shall have vent system with single connection at system limit. Double block and bleed valve arrangement in the vent lines.

5.2.2.7 Thermal insulation

The meter including critical flanges and downstream spool, temperature measurement point, density, OGC, sampling system etc. shall be thermally insulated and/or heat traced.

There shall be no heat tracing of meter runs between flow meter and temperature measurement nor on the density tubings.

5.2.3 Instrument part**5.2.3.1 General**

Pressure and temperature shall be measured in each meter run. Density shall be measured or calculated based on input from OGC. Density determination shall be duplicated, either by two densitometers, one OGC and one densitometer, or dual OGC.

5.2.3.2 Location of sensors

Pressure: When ultrasonic meters are utilised, pressure shall be measured at the USM body or downstream the flow meter.

Temperature: Temperature shall be measured downstream of the flow meter.

Density: If densitometers are used, the density measurement device shall be installed so that representative measurements are achieved. Pressure and temperature measurement shall be measured as close as possible to the density measurement.

When orifice meters are utilised the upstream flange tap position shall be used for pressure measurement and the density shall be measured or calculated to the upstream flange tap condition.

5.2.3.3 Instrument panel and supplies

Field instrument cable entry shall be metric threads. The electrical supply for field instrumentation used for fiscal measurement systems including the computer system, shall be powered from instrument panels supplied from uninterrupted power supply.

5.2.3.4 Signal types

For measurement systems instrument field bus/digital communication shall be entirely implemented, i.e. so it can be utilised for diagnostic purposes. All transmitters shall be of smart type where available.

5.2.3.5 Stability for smart transmitters

For smart pressure and smart differential pressure transmitters the stability shall be equal or better than $\pm 0,1$ % of upper range limit for 12 months. For smart temperature transmitters the stability shall be equal or better than $\pm 0,1$ °C for 24 months.

5.2.3.6 Temperature loop

For fiscal measurement applications the smart temperature transmitter and Pt-100 element should be two separate devices where the temperature transmitter shall be installed in an instrument enclosure connected to the Pt-100 element via a 4-wire system. Alternatively, the Pt-100 element and temperature transmitter may be installed as one unit where the temperature transmitter is head mounted onto the Pt-100 element (4-wire or 3-wire system).

The Pt-100 element should as a minimum be in accordance with EN 60751, tolerance Class A.

The temperature transmitter and Pt-100 element shall be calibrated as one system where the Pt-100 element's curve-fitted variables shall be downloaded to the temperature transmitter before final calibration, see 4.4. The total uncertainty for the temperature loop shall be better than $\pm 0,15$ °C.

5.2.3.7 Thermowells

All thermowells shall at least be inserted 1/3 ID into the pipe, but less than 1/2 ID. Further details and principles are given in ISO/TR 9464, 12.3.4. A second thermowell shall be installed within 2 ID of the primary thermowell.

For horizontal pipes thermowells shall be installed in clock position between 10 and 2 to allow for liquid filling of the well. For vertical pipes thermowells shall be installed to allow for liquid filling of the well.

The design shall avoid critical vibration in the thermowell. The vibration calculation shall be done for 20 % above maximum design flow rate, see ANSI/ASME Performance Test Code 19.3 - 1974, Chap. 1, section 8-19 thermowells.

Thermowells inner diameter suitable for elements of 6 mm should be used.

Thermowells shall be mounted in such a manner that the temperature element can be installed and removed from the well for maintenance reasons.

5.2.3.8 Direct density measurement

The gas shall at the density measurement point be in a measurable form i.e. well above the hydrocarbon dew point. The density shall be measured by the vibrating element technique and according to IP PMM Part VII. Density calculation and calibration shall be in accordance with company practice. The density shall be corrected to the conditions at the fiscal measurement point.

The transducer pulse/frequency signal shall direct or via smart communication be transmitted to the computer, see 5.2.3.4. If the density is of the by-pass type, temperature compensation shall be applied.

The uncertainty (expanded uncertainty with a coverage factor $k = 2$) of the complete density circuit, including drift between calibrations shall not exceed $\pm 0,30$ % of measured value.

The measured density shall be compared against a calculated density.

5.2.3.9 Calculated density

Calculated density shall be by AGA 8, detailed characterization method, or ISO 12213-1 and ISO 12213-2. For special applications, other methods may be considered. When an OGC is a part of the fiscal measurement system, composition data from this unit shall automatically be used in the standard and line/operating density calculation. However, if online compositional data is not available, operator entered composition data shall be used.

5.2.3.10 Ultrasonic flow meter

For the ultrasonic flow meter, critical parameters relating to electronics and transducers shall be documented. It shall be possible to verify the quality of the electric signal, which represents the acoustic pulse, by automatic monitoring procedures in the instrument or by connecting external test equipment.

The transducers shall be marked by serial number or similar to identify their location in the meter body etc. A dedicated certificate stating critical parameters shall be attached.

5.2.3.11 Differential pressure transmitter

Smart differential pressure transmitters for orifice measurement systems shall be installed in parallel for mutual surveillance, i.e. if the duty transmitter fails the hot stand-by shall be used automatically until the duty transmitter is repaired.

5.2.3.12 Local indicators

Where local indicators are required, local indicators on the smart transmitters can be used as alternative to local gauges.

5.2.3.13 Local pressure indication

For meter tubes/runs, which require pressure or depressurisation system for maintenance purposes, a local indication of pressure shall be installed on the high-pressure side.

5.2.3.14 Instrument ball valves

For fiscal measurement applications, ball valve manifold block or an assembly of ball valves shall be applied (3/5-valve). Final valve arrangement shall be installed in instrument enclosure and be service friendly. In general, the valves shall be full bore with respect to instrument impulse tubing. However, the equaliser-, test-valves and tubing (typically $\frac{1}{4}$ in) may be reduced bore. The test port shall be equipped with quick connector.

5.2.3.15 Instrument tubing

For fiscal measurement systems the instrument impulse tubing shall not be less than 12,7 mm ($\frac{1}{2}$ in) OD. The tubing length should be kept as short as possible.

The slope of the impulse lines should be no less than 1:12. All instrument tubing shall be installed so that "liquid traps" are avoided.

Instrument tubing for differential pressure transmitters should be kept symmetrical with respect to pipe/instrument interface, where tubing diameter changes and isolation valves are installed.

5.2.3.16 Enclosures

Enclosures shall be used for stream differential pressure, pressure and temperature transmitters. The type shall be fire retardant GRP or equivalent. If the instruments are installed in exposed area, enclosure shall be insulated, heated and temperature controlled.

For densitometers a clamp on enclosure, type fire retardant GRP or equivalent, shall be utilised.

5.2.4 Computer part

5.2.4.1 General

The computer part shall consist of a sufficient number of computers performing the functions specified in 5.2.4.2 to 5.2.4.16, VDUs, printers for reporting, and communication possibilities for transferring signals to other systems.

This subclause specifies the requirements for "A Class" system.

5.2.4.2 Computer design

The software for calculation of fiscal quantities shall be stored in a secure manner, see ISO 9000-3.

Version number shall identify the present software program version(s). Change of version number shall be implemented every time permanent program data is altered. It shall be possible to determine the present program version directly from VDU and/or printouts.

The update time shall be less than 2 s for the VDU update and the resolution shall be sufficient to verify the requirement for calculation accuracy. Any displayed value shall be presented by eight significant digits, if necessary. This shall be valid in the normal range of any parameter and $\pm 10\%$ of this value.

Change of fiscal day will be project specific, e.g. 00:00 or 06:00 each day.

The flow computers shall be equipped with battery supported RAM, this shall ensure safe warm start after 1 year power off.

Input signals:

Signals from all instruments in one meter run shall be read during 1 s, except for temperature and density, which shall be read at least every 5 s. Analogue to digital conversion shall be by 14 bits minimum. The system shall accept any manual inputs necessary to perform calculations mentioned below for any measured value. The manual input values shall be verifiable without rounding off or truncation of digits.

Output signals:

Digital to analogue conversion for fiscal purposes shall be by 14 bits minimum.

5.2.4.3 Process operator interface

The process operator interface shall as a minimum comprise

- graphic user interface,
- meter run control,
- security control of operator entered parameters,
- alarm handling.

The graphic user interface shall include a simplified P&ID with process variables and valve status. It shall be possible to operate all valves from the graphics.

5.2.4.4 Measurement computer system

The computer system functions and interface shall as a minimum comprise

- graphic user interface,
- meter run control,
- security control of operator entered parameters,
- alarm and event handling,

- system monitoring,
- trouble shooting,
- software updates,
- tape drive and/or CD-ROM.

The graphic user interface shall include a simplified P&ID with process variables and valve status. It shall be possible to operate all valves from the graphics.

5.2.4.5 Calculations

The computer shall calculate flow rates and accumulated quantities for

- a) actual volume flow,
- b) standard volume flow,
- c) mass flow, energy flow (application specific).

All calculations shall be performed to full computer accuracy (no additional truncation or rounding).

The interval between each cycle for computation of instantaneous flow shall be less than 10 s.

Where the interval between the calculations extends over several updates of input data, the average value of input data shall be used in the computations.

For ISO 5167 (all parts) calculation, the average values for density and differential pressure shall be calculated from square roots of the field values.

The iteration procedure shall ensure that a new iteration of flow coefficient is carried out if the difference between the two last flow coefficient computations exceeds ten to the power of minus five (0,00001).

Algorithm and truncation/rounding errors for computations in the computer part shall be less than $\pm 0,001$ %. This requirement shall be verifiable.

The computer part shall include electronic means for storing accumulated fiscal quantities for each meter run and the total measurement system. These figures shall also be stored in back up files (non resetable counter function). The figures shall be stored for the time period that is regarded as necessary. The files/records shall be secured in such a way that they can not be zeroed or altered unless a special procedure is followed.

The computer part shall be capable of calculating the following figures based on the compositional data normalised values X_i :

- compressibility factor at reference condition according to ISO 6976;
- gross calorific value (superior) according to ISO 6976 and 4.1;
- Wobbe-index according to ISO 6976 and 4.1;
- relative density (real/ideal) according to ISO 6976;
- density at reference condition according to ISO 6976.

It shall be possible to enter the project specific relevant properties of the C6+ fraction in the computer part.

The following calculated values shall as a minimum be available for reports and VDU:

- hourly and daily totals and maintenance mode totals;
- average flow rates;
- average process values, all average values shall be flow-weighted by mass.

The resolution on the VDU shall be sufficient to verify the requirements for calculation accuracy.

5.2.4.6 Check

Comparisons shall be implemented between duplicated instruments measuring the same process value. Comparisons shall also be implemented between instruments measuring the same process value in different