

NORSOK STANDARD

**FISCAL MEASUREMENT SYSTEMS FOR
HYDROCARBON GAS**

I-104
Rev. 2, June 1998

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FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and eliminate unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Standards Institution).

The purpose of NORSOK standards is to contribute to meet the NORSOK goals, e.g. by replacing individual oil company specifications and other industry guidelines and documents for use in existing and future petroleum industry developments.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of a NORSOK standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, the NORSOK standard will be withdrawn.

Annexes A and B are normative. Annex C is informative.

INTRODUCTION

This standard is a replacement of the previous NORSOK standards with respect to fiscal measurement systems for hydrocarbon gas: I-CR-100 Fiscal measurements systems, I-SR-101 Automatic gas sampler, I-SR-102 Fuel gas measurements, I-SR-103 Flare gas measurements, I-SR-104 Fiscal metering for gas, all revision 1, January 1995 and I-SR-106 On-line gas chromatograph, revision 1, January 1996. This new standard has been subject to a total change in contents and structure.

The NORSOK standards for instrumentation shall be read in conjunction with this standard for supplementary requirements. However, if there are any inconsistency in relevant NORSOK standards, priority shall be given to this standard, Fiscal measurement systems for hydrocarbon gas, I-104.

1 SCOPE

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

2 NORMATIVE REFERENCES

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

AGA 7	Measurement of gas by turbine meters -AGA Transmission Measurement Committee Report No. 7.
AGA 8	Compressibility factors of Natural Gas and other related hydrocarbon gases, AGA Transmission Measurement Committee Report No. 8.
API MPMS	Chap. 13
ASTMD 1945	Analysis of natural gas by gas chromatography
BIPM et.al. *)	OIML P17, Guide to the expression of Uncertainty in Measurements.
ECMA-TR25	OSI sub-network interconnection scenarios permitted within the framework of ISO-OSI ref. model.
EN 60751	Industrial Platinum Resistance Thermometer sensors
IP PMM Part VII	Continuous Density Measurement
ISO 1000	SI units and recommendations for use of their multiples and of certain other units.
ISO IEC 3309	Telecommunication and information; exchange between systems; high level datalink control (HDLC) procedure; frame structure.
ISO 5024	Measurement - Standard reference conditions
ISO 5167-1	Measurement of fluid flow by means of pressure differential devices – Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full
ISO 6551	Petroleum Liquids and Gases - Fidelity and Security of Dynamic Measurement - Cabled Transmissions of Electric and/or Electric Pulsed Data
ISO 6568	Natural gas - Simple analysis by gas chromatography
ISO 6976	Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 9000-3	Guidelines for the application of the ISO 9001 to the development, supply and maintenance of software.
ISO 9951	Measurement of gas flow in closed conduits - Turbine meters
ISO 10715	Natural Gas Sampling Guidelines
ISO 10723	Performance evaluation of on line analytical systems
ISO 12213-1	Natural gas - Calculation of compression factor – Part 1: Introduction and guidelines
ISO 12213-2	Natural gas - Calculation of compression factor – Part 2: Calculation using molar-composition analysis

ISO 12213-3	Natural gas - Calculation of compression factor – Part 3: Calculation using physical properties
NORSOK Z-010	Electrical, Instrumentation & Telecommunication installation

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

3 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

Allocation	Distribution of sold/produced quantities of hydrocarbons between licensees and owner companies.
Carrier gas	Gas used to transport sample through the columns, normally Helium, Hydrogen or mixture of Helium and Hydrogen.
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.
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.
Group of component	Group of components with so low concentrations that their measurement as individual would be difficult or require excessive time. Hydrocarbons heavier than Pentanes (denoted as C6+) is example of such a group
ID	Internal pipe diameter.
Informative references	Shall mean informative in the application of NORSOK standards.
May	Verbal form used to indicate a course of action permissible within the limits of the standard.
Normative references	Shall mean normative (a requirement) in the application of NORSOK standards.
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.
Quantity	Measure of the hydrocarbon medium, by volume, mass or energy.
Shall	Verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties.
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.
U _{xi}	Uncertainty of Xi in the WGM
U _{LXi}	Uncertainty of X, due to lack of linearity. Determined from linearity test. Expressed in mole fraction and calculated as one standard deviation taken every average results from MLC.

U_{RXi}	Uncertainty of X, due to lack of repeatability. Determined from repeatability test. Expressed in mole fraction and calculated as one standard deviation from the repeatability test.
U_{Xi}	Total uncertainty of X_i , $U_{Xi} = (U_{RXi}^2 + U_{CXi}^2 + U_{LXi}^2)^{0.5}$.
X	Non-normalised concentration in mole fraction (X, is concentration of component i).
X^x	Normalised concentration in mole fraction.
% REL	Number given as % relative to the concentration.

3.2 Abbreviations

ANSI	American National Standards Institute
AGA	American Gas Association
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BIPM	International Bureau of Weight and Measure
CEN	The European Committee for Standardization
ECMA	European Association for Standardizing Information and Communication Systems
EN	European Norm
FAT	Factory Acceptance Test
GC	Gas Chromatograph, a device which separates the components in a gas mixture and measure them individually with a detector.
IEC	International Electrotechnical Commission
IFCC	International Federation of Clinical Chemistry
IP	Institute of Petroleum
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
MLC	Multi Level Calibration. Calibration using several WGMs to either determine the uncertainty due to linearity of the GC for all components within actual range or to determine the response curves of the detector of each component. MLC may only be performed before installation or during commissioning.
MPMS	Manual of Petroleum Measurement Standard
NPD	Norwegian Petroleum Directorate
NTS	Norwegian Technology Standards Institution.
OGC	On-line Gas Chromatograph, GC fed continuously and automatically with process gas.
OIML	International Organization of Legal Metrology
OLF	The Norwegian Oil Industry Association.
OSI	Open system interconnections
Pt-100	Platinum resistance thermometer
SAS	Safety and Automation System
SPC	Single Point Calibration. Calibration using only one WGM with concentration as close as possible to the process gas or as close as necessary found by multi-level calibration.
TBL	Federation of Norwegian Engineering Industries.
TCD	Thermal Conductivity Detector, most commonly used detector to measure the main components in natural gas.
VDU	Visual Display Unit

WGM Working Gas Mixture, 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 15,0 °C, 1,01325 bar absolute, ref. ISO 5024.

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

For calculation of Gross Calorific value and Wobbe Index [MJ/Nm³] the normal reference condition shall be used in addition to combustion temperature of 25 °C and metering temperature of 0 °C.

For system concepts with no system specific requirements in this NORSOK standard, the design shall to the greatest possible extent, be based on (in order of priority):

- International standards, preferably ISO or CEN.
- The manufacturer's recommendations.

4.2 Uncertainty

Table 1 below 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	± 1,0 % of standard volume Note 1	Class A
Fuel gas measurement	± 1,8 % of standard volume	Class B
Flare gas measurement	± 5,0 % of standard volume	Class C
Simplified measurement system for gas	± xx % of standard volume Note 2	Class D

Note 1) The uncertainty is given in standard volume, but other units may be requested (project specific) e.g. mass energy etc.

Note 2) 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 document: Guide to the Expression of Uncertainty in Measurement.

4.3 Sampling equipment

Automatic sampling equipment shall be installed. However, for dry gas, on-line gas chromatograph should be used if they are found to be more cost-effective than automatic sampling and subsequent laboratory analysis, and if required by any agreement.

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 traceably calibrated by an accredited laboratory to international/national standards.

All geometrical dimensions used in fiscal calculations shall be traceably measured and certified to international/national standards.

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

Not applicable.

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 from the total uncertainty limits for the measurement system, listed in subclause 5.1.4.2.

Note: NPD regulation requires one spare meter run for a multi-run 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

Ref. to 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. The measurement system shall also be operable from SAS.

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.

Continuity in measurement of the gas flow, during regular calibration of the field instruments and whenever a field instrument of any type fails, is required.

5.1.6.2 Measurement systems with multiple meter runs

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

The meter runs inlet valves shall be manually operated (i.e. shall not be part of the automatic operation). Optionally these valves may only be locally operated (project specific).

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 should be chosen to ensure long maintenance and calibration intervals.

The maintenance requirements for automated condition based maintenance in Annex A shall apply. In addition, it should be easy to retrofit 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 such that the requirements given in this 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 and 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.

Density meter 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 require regular calibration and maintenance. Facilities to ease the calibration shall be included in the system or offered as an option.

It shall be possible to maintain the mechanical part of the system without dismantling the manifolds (or similar).

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

If orifice fittings are utilised inspection flanges shall be included downstream of the flow elements.

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.

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

5.1.9 Interface Requirements

Computer part interfaces:

- If dedicated computer: SAS.
- Sampling system and/or On-line gas chromatograph.
- Production database and allocation systems.

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 with the meters operating within 80% of their standard range (not extended).

5.2.2.2 Meter run pressure setting/equalising

Each meter run shall have:

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

5.2.2.3 Meter runs and header design for orifice meters

If the measurement system has an inlet manifold it shall be in the same plane as the meter tubes. The interpretation of ISO 5167-1, table 3, shall be in accordance with the following: (Minimum straight lengths at beta 0,6). The inlet pipe to the inlet manifold shall be in the same plane as this for a length of 20 ID. Alternatively, the additional 20 ID could be added upstream of the orifice. The minimum straight upstream length refers to the length between the inlet valve and the orifice plate and shall be at least 32 ID. This length shall, by definition, be the length from the last upstream disturbance to the orifice plate.

Use of flow conditioners will reduce the requirements to the minimum straight upstream lengths. By use of flow conditioners the flow conditions at the orifice plate with respect to swirl and asymmetric flow shall be documented equal to or better than the general requirements in ISO 5167. If e.g. K-lab flow conditioner is used, the straight upstream length can be reduced from 32 ID to 15—17 ID (6—5 ID upstream of the flow conditioner in combination with 9—12 ID between the flow conditioner and the orifice plate).

The cross sectional area of inlet manifold shall as a minimum be 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, and therefore the manifold area shall be the minimum sum of meter runs/area from the inlet pipe to the manifold end.

5.2.2.4 Flow meter designs

Orifice meters:

Orifice plate carrier of junior type shall be applied.

Note: Requirement in conflict with NPD regulation.

Ultrasonic meters

The number of paths for ultrasonic meters shall be determined by required uncertainty limit.

All geometric dimensions of the ultrasonic flow meter that affect the measurement result shall be measured and certified using traceable equipment, at known temperatures. The material constants shall be available for corrections.

In order for the ultrasonic meter to be accepted and considered to be of good enough quality the maximum deviation from the reference during flow calibration shall be less than $\pm 1,50\%$. The linearity shall be better than $1,0\%$ (band) and the repeatability shall be better than $0,50\%$ (band). These requirements are applicable after application of zero flow point calibration but before application of any correction factors, for flow velocities above 5% of the maximum measuring range.

The meter shall be designed and installed so that any accumulation in the form of liquid or solid particles in the vicinity of the transducers is avoided.

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 10 ID. The minimum straight downstream length shall be 3 ID. Flow conditioner of a recognized standard shall be installed, unless it is verified that the ultrasonic meter is not influenced by the layout of the piping upstream or downstream, in such a way that the overall uncertainty requirements are exceeded.

Ultrasonic meters may be used bidirectionally. In this case both ends of the meter shall be considered as upstream, and thermowells shall be placed outside the 10 ID on either ends.

Any diameter step between two sections shall be in accordance with ISO 5167 within the meter run. Gaskets between meter run and pipe section shall not protrude into the meter run.

Other types of meters:

Project specific.

5.2.2.5 Block valves

The meter runs inlet and outlet valve shall be of double block and bleed type. The valve balls shall be trunnion mounted, and independent up and downstream seals and firesafe. The valve shall be equipped with a body vent and the leakage control shall be by automatic or manual monitoring.

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

Electrical positioner shall be used for remote control, in addition to limit switches for on or off positions. Any flying leads shall be protected with a flexible conduit.

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

If exposed to ambient conditions, the meter runs including temperature, density, OGC, sampling system etc. may be thermally insulated and/or heat traced. There shall be no heat tracing of meter runs between flow meter and temperature measurement.

The ultrasonic flow meter with associated meter tube should be thermally insulated upstream and downstream including temperature measurement point, in order to reduce temperature gradients.

5.2.3 Instrument Part

5.2.3.1 Location of sensors

Pressure and temperature shall be measured in each of the meter runs. Density shall be measured by at least two densitometers in the metering station. 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.

5.2.3.2 Instrument panel and supplies

Field instrument cable entry shall be metric threads. The electrical supply for field instrumentation used for fiscal measurement systems shall be powered from instrument panels. The instrument panels shall be supplied from UPS. All flow passing a fiscal measurement system shall be measured. The power supplies to the measurement system shall be designed for this operation philosophy.

5.2.3.3 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.

5.2.3.4 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 $\pm 0,1\text{ }^{\circ}\text{C}$ for 24 months.

5.2.3.5 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- or 3-wire system).

The Pt-100 element should as a minimum be in accordance to EN 60751 tolerance 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 accredited calibration. The total uncertainty for the temperature loop shall be better than $\pm 0,15\text{ }^{\circ}\text{C}$.

5.2.3.6 Thermowells

For fiscal measurement systems, thermowells for pressure class equal or below class 2500 shall be of threaded/screwed type.

All thermowells shall at least be inserted $\frac{1}{3}$ ID into the pipe, but less than $\frac{1}{2}$ ID.

A reference thermowell shall be installed within 2 ID of the primary thermowell.

Thermowell shall be installed in 10 - 2 o'clock position to allow for liquid filling of the well.

The design shall avoid vibration to flow meter maximum extended range. The vibration calculation shall be done for normal flow rate, in addition to 10% increased flow rate with respect to maximum flow rate. Ref. 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.

5.2.3.7 Direct density measurement

Continuous measurement of density is required. 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. Density calculation and calibration shall be in accordance with company practice. The density shall be corrected to the conditions at the fiscal measurement point.

There shall be direct transmission of transducer pulses/frequency signal to the computer part or via smart communication. Reference is made to subclause 5.2.3.3 Signal types. 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.

Station Back-up density shall be calculated by AGA 8 latest revision, detail characterization method or ISO 12213-2.

5.2.3.8 Calculated density

Calculated density shall be by AGA 8, detailed characterization method or ISO 12213-2. 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 the OGC is not a part of the fiscal measurement system, operator entered composition data shall be used.

5.2.3.9 Ultrasonic flow meter

For the ultrasonic flow meter, critical parameters relating to electronics and transducers shall be determined. 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.

5.2.3.10 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 fail the hot stand-by shall be used automatically until the duty transmitter is repaired.

5.2.3.11 Local indicators

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

5.2.3.12 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.

5.2.3.13 Instrument ball valves

For fiscal measurement applications, ball valve manifold block or an assembly of discrete components 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 not be less than 9 mm full bore, however the equaliser valves and test valve may be 4 mm bore. The test port shall be equipped with quick connector.

5.2.3.14 Instrument tubing

For fiscal measurement systems the instrument impulse tubing shall not be less than 9 mm ID. 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.

5.2.3.15 Enclosures

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

For by-pass densitometer a clamp on type fire retardant GRP enclosures should 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 below, VDUs, printers for reporting, and a communication system for transferring signals to other systems.

This clause specifies the requirements for Class A system.

5.2.4.2 Computer design

The software for calculation of fiscal quantities shall be stored in a secure and resident manner.

Reference is made to 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 seconds for the VDU update and the resolution shall be sufficient to verify the requirement for calculation accuracy. Any displayed value shall be presented by 8 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, certified EEx ia, to safeguard warm start after minimum 1 year power off.

Input signals:

Signals from all instruments in one meter run shall be read during 1 second, except for temperature and density, which may be read every 5 seconds. Signals from duplicated instruments shall be read within 0,5 second. A/D conversion shall be by 14 bits minimum. The system shall accept any manual input 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:

D/A 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.

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 Computer system interface

The computer system (supervisory) interface shall as a minimum comprise:

- Graphic user interface.
- Meter run control.
- Security control of operator entered parameters.
- 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

- i) actual volume flow,
- ii) standard volume flow,
- iii) mass flow and
- iv) 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 seconds.

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

The mean 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. The figures shall be stored for the time period that is regarded as necessary. The files shall be secured in such a way that they can not be zeroed or altered unless a special security method is followed.

Calculation of Gross Calorific value (superior) and Wobbe index shall be done according to ISO 6976 with a combustion temperature of 25 °C and metering temperature of 0 °C.

Calculation of all required values for reports and VDU shall be implemented:

- Hourly and daily totals and maintenance mode totals,
- average flow rates,
- average K-factors and 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 meter runs. Comparisons shall be based on values averaged over a moving time window to be operator selectable between wide intervals (that is from 1 second to 10 minutes).

Facilities shall be included to enable user verification of functions, parameters and accuracy for input values, calculated values and output values.

Auto selection of back-up density in the event of a densitometer failure.

Ultrasonic check:

All parameters relevant for verifying the condition of the meter shall be included in the self-check or user verification of the meter. The computer shall be prepared for zero flow point check of the transducers, e.g. by using an external test cell.

5.2.4.7 Alarms

The alarm system shall raise alarms, print out alarms and/or save alarms to external file, if any comparison check exceeds operator selected limits or if any measured value is outside predetermined limits or in case of indication of instrument failure, computer failure or failure in valve operation.

The alarm system shall be designed in a flexible way, fulfilling as a minimum the following requirements:

- For all alarms it shall be possible, under password/key-switch protection,
 - to suppress or enable the alarm and
 - apply time delay for filtering purposes.
- A list of all suppressed alarms shall be available on screen and printer and external file.
- Grouping of alarms shall be considered in order to reduce the number of alarms to a minimum.
- Hardware and software watchdog alarm shall be implemented.

5.2.4.8 Events

The system shall log all events as a result of system or operator action to external file and printer.

The events shall include manually entered parameters on the computer part that may be changed by an operator.

5.2.4.9 Reporting of data

The computer shall generate quantity reports containing as a minimum:

- current flow rates and process values,
- all totals, and
- average K-factors and process values, all average values shall be flow-weighted by mass.

Reports for the following intervals shall be available: current status (no average values), hourly and daily.

The reports shall also contain gas quality parameters as measured by on-line equipment or manually entered.

The reports above shall be printed automatically but it shall also be possible to suppress the printing of the reports. The reports shall also on request be shown on VDU. When fixed values or fallback values are used instead of the live signals sometime during the report interval, this shall be visually identified on the print out and on the VDU.

The reported data shall be for each meter run and with totals for the measurement system.

If the reporting computer is down across change of hour or day, the quantities thus not reported for the expected time period shall be automatically recovered and reported with the first report that is generated when the computer comes back in service.

Printing of measurement reports shall be on a separate fast laser printer.

Trend curves shall be available on VDU and printers as well as in tabular form, showing values representing measured and calculated flow and process values, for user selectable time periods (that is from one hour to 62 days). The displayed values shall represent the measured and calculated values for a time interval adapted to the selected time period, using data reduction. For each measured and calculated value, the data reduction shall as a minimum produce the minimum, maximum, current and average values for the time interval. For the last hour the time interval shall be maximum 10 seconds. There shall be continuous updating of a live trend curve for the last hour, for all values. Zoom facilities shall be available in both x and y direction. Screen dump facility shall be available.

5.2.4.10 Storing of data

1-hourly reports to be stored to computer file for 62 days, daily reports for 1 year.

All measured and calculated values averaged over the moving time windows shall be stored in computer file for 62 days.

Alarm and event reports to be stored to computer file for 10 days.

5.2.4.11 Availability

The computer shall have fault tolerant design to maintain fiscal measurement, calculations and file storage during error conditions.

The computer part shall be designed in such a way that maximum gas flow can be measured even if failures occur within any level of the computer part.

The availability of the fiscal computer system shall be documented and better than 99,5% availability.

The ultrasonic flow meter shall be designed such that measurements of acceptable quality can be achieved when one transducer pair is out of service.

5.2.4.12 Network Protection/Security

If the flow computers or supervisory computer(s) are connected to a network appropriate security and protection shall be applied, i.e. only dedicated computers shall have access to the measurement computers. Network communication shall utilise a protocol where protection and security is a part of the protocol. Recognized standards are ISO IEC 3309 and ECMA-TR25 or equivalent.

The computer system shall in addition include an efficient security system using system features, utilities and hardware.

Self-check and self-diagnostics at cold start, warm start and continuously during normal operation.

The algorithms and fixed parameters important for accurate computation of fiscal quantities shall be secured in a way that makes direct access impossible, unless an established security routine is followed. There shall be protection against unauthorised data entry by password or key switch. The selection of automatic or manual operation shall be protected by password or key switch.

5.2.4.13 Expandability

For future computer expandability a maximum limit at maximum load to the following computer parts shall be:

- The software, including programs and data shall not occupy for more than a maximum 50% of the computer memory, at any time.
- No more than 50% of the computer disk capacity shall be utilised.
- The system, application and communication software shall require less than 50% of the CPU capacity.
- Input data from the field must be equipped to handle 25% extra points.
- The system must be able to handle 25% extra flow per station or flow computers.

5.2.4.14 Time Synchronisation

A secure handling of daylight saving time and time through day, month and year shall be included.

The fiscal measurement computer system shall be synchronised from a Radio Clock, either directly or via the SAS system.

The system shall operate correct i.e. calculate and report correct regardless of change in day, month, year, decade etc.

5.2.4.15 Downloading of Constants and Ranges

Last versions of constants and ranges are to be downloaded to the flow computer upon initiation, restart or on operator request. In addition, it shall be possible in a secure manner, to download single constants or ranges to the flow computer. Some data consisting of several data items shall be downloaded as complete data sets. This applies to e.g. densitometer constants.

The supervisory computer shall verify that the flow computer has received the current value. The value downloaded shall be shown together with, the value read back from the flow computer.

All values to be changed shall be stored to disk on the supervisory computer.

It shall be possible to request a configuration/parameter report at any time.

5.2.4.16 Automatic restart

The system must be capable of an orderly shutdown in the event of a total power failure or major transient. Restart after power failure shall be automatic and shall include restart for all features, devices and programs, including correct time from a radio clock, or a battery backed up calendar clock.

5.2.4.17 Background Compilation and Execute Capability

The system shall have the capability for program compilation and execution in a background mode without disturbing the continuous functions operating in the foreground. It must be possible to build, replace, and initiate foreground tasks without interrupting other system functions.

6 FUEL GAS MEASUREMENT

6.1 Functional requirements

6.1.1 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.

6.1.2 Products/Services

Reference is made to subclause 5.1.2.

6.1.3 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 or shared with the sales or allocation measurement system.

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

The measurement method shall be by ultrasonic meter, orifice meter or turbine meter.

6.1.4 Performance

6.1.4.1 Capacity

Reference is made to subclause 5.1.4.1.

6.1.4.2 Uncertainty

Class B system.

6.1.4.3 Lifetime

Reference is made to subclause 5.1.4.3.

6.1.4.4 Availability

The measurement system shall be designed for continuous measurement or calculation of all expected flow rates.

6.1.5 Process/ambient conditions

Reference is made to subclause 5.1.5.

6.1.6 Operational Requirements

6.1.6.1 General

The measurement system shall be operated from the computer part. The measurement system shall also be operable from SAS.

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.

Continuity in measurement of the gas flow shall be maintained during regular calibration of the field instruments and whenever a field instrument of any type fails.

For single meter run configuration, it shall be possible to route the gas stream through a by pass line for inspection and maintenance of the fuel meter run. When the system is in this bypass mode, flow calculations shall continue based on average flow rate in a user selectable time periods (that is from one minute to one hour) prior to opening to by pass (Manual override).

6.1.6.2 Measurement systems with multiple meter runs

Reference is made to subclause 5.1.6.2.

6.1.7 Maintenance Requirements

6.1.7.1 General

Reference is made to subclause 5.1.7.1.

6.1.7.2 Calibration

Reference is made to subclause 5.1.7.2.

6.1.7.3 Maintenance

Reference is made to subclause 5.1.7.3.

6.1.7.4 Isolation and sectioning

Reference is made to subclause 5.1.7.4.

6.1.7.5 Thermal Insulation

Reference is made to subclause 5.1.7.5.

6.1.8 Layout Requirements

Sufficient upstream and downstream length of pipe shall be installed.

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

6.1.9 Interface Requirements

Computer part interfaces:

- If dedicated computer: SAS.

- Sampling system and/or On-line gas chromatograph.
- Production database and allocation systems.

6.1.10 Testing and Commissioning Requirements

The testing and commissioning requirements in Annex B shall apply.

6.1.11 Special consideration for fuel gas system

Orifice meter should be preferred to gas turbine meter unless the cost of long upstream meter run lengths for the orifice meter outweighs the cost of annual flow calibrations at operating conditions of the gas turbine meter, and the cost of one spare gas turbine meter (in stores).

Also, a gas turbine meter should be preferred if the flow range of the fuel stream requires frequent changes of orifice plates during regular operation.

For every small fuel gas streams, in particular non-fuel streams withdrawn from the fuel distribution system downstream of the main fuel metering system, the following methods should be considered:

- For gas streams withdrawn manually at intervals: No meter, just estimation.
- For continuous streams smaller than specified by ISO 5167 and AGA 7, one of the following methods shall be used:
 - Small, full bore, gas turbine meters, designed to manufacturer's standard (minimum 6 mm).
 - Integral orifice meters (smaller than 12 mm).
 - Other suitable type of small flow meter with equivalent accuracy.

6.2 Technical requirements

6.2.1 General

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

6.2.2 Mechanical part

6.2.2.1 Sizing

Reference is made to subclause 5.2.2.1.

6.2.2.2 Meter run pressure setting/equalising

Reference is made to subclause 5.2.2.2.

6.2.2.3 Meter runs and header design for orifice

The mechanical design to be in accordance with ISO 5167-1.

6.2.2.4 Flow meter designs

Orifice meters:

Orifice plate carrier of junior type shall be applied.

Ultrasonic meters:

The ultrasonic meters shall have minimum 2 paths. The number of paths shall be determined by required uncertainty limit.

All geometric dimensions of the ultrasonic flow meter that affect the measurement result shall be measured and certified using traceable equipment, at known temperatures. The material constants shall be available for corrections.

In order for the ultrasonic meter to be accepted and considered to be of good enough quality the maximum deviation from the reference during flow calibration shall be less than $\pm 2,0$ %. The linearity shall be better than 1,5 % (band) and the repeatability shall be better than 1,0 % (band). These requirements are applicable after application of zero flow point calibration but before application of any correction factors, for flow velocities above 5 % of the maximum measuring range.

The meter shall be designed and installed so that any accumulation in the form of liquid or solid particles in the vicinity of the transducers is avoided.

The meter shall either by its own design or by necessary piping arrangements always be available for necessary maintenance.

For the meter tube, the minimum straight upstream/downstream length shall be in accordance with manufacturer's recommendations. Flow conditioner of a recognized standard shall be installed, unless it is verified that the ultrasonic meter is not influenced by the layout of the piping upstream or downstream, in such a way that the overall uncertainty requirements are exceeded.

Any diameter step between two sections shall be in accordance with ISO 5167. Gaskets between meter run and pipe section shall not protrude into the meter run.

Gas Turbine Meters:

Turbine meters shall have minimum straight upstream and downstream meter tube lengths according to AGA 7, ISO 9951 or manufacturer's requirements, whichever is the most stringent. Turbine flow meter shall be high quality meters of full profile, axial type, designed specifically for gas flow measurement. Design shall be according to AGA 7 Figure 1 (not figure 1A).

Other types of meters:

Project specific.

6.2.2.5 Block valves

The measure run inlet and outlet valves shall be of double block and bleed type. The valve balls shall be trunnion mounted, and independent up and downstream seals and firesafe. The valve shall be equipped with a body vent and the leakage control shall be by automatic or manual monitoring.

For single meter run the bypass valve shall be equipped with limit switches, which shall trigger the bypass calculation routine, a body vent and the leakage control shall be by automatic or manual monitoring.

Outlet On/Off valves at multiple meter runs shall have automatically operated actuators with failsafe "stay in position". Flow direction shall be clearly stated on valve bodies.

Electrical positioner shall be used for remote control, in addition to limit switches for on or off positions. Any flying leads shall be protected with a flexible conduit.

6.2.2.6 Vent systems

Reference is made to subclause 5.2.2.6.

6.2.2.7 Thermal Insulation

Reference is made to subclause 5.2.2.7.

6.2.3 Instrument Part**6.2.3.1 Location of sensors**

Reference is made to subclause 5.2.3.1.

6.2.3.2 Instrument panel and supplies

Reference is made to subclause 5.2.3.2.

6.2.3.3 Signal types

Reference is made to subclause 5.2.3.3.

6.2.3.4 Stability for smart transmitters

Reference is made to subclause 5.2.3.4.

6.2.3.5 Temperature loop

Reference is made to subclause 5.2.3.5.

6.2.3.6 Thermowells

Reference is made to subclause 5.2.3.6.

6.2.3.7 Density

Density shall be calculated by AGA 8 latest revision, detailed characterization method or ISO 12213-2, based on representative gas composition data. If the gas composition data is not available from an on-line system or the gas composition varies significantly the density should be measured.

6.2.3.8 Ultrasonic flow meter

Reference is made to subclause 5.2.3.9.

6.2.3.9 Differential pressure transmitter

Reference is made to subclause 5.2.3.10.

6.2.3.10 Local indicators

Reference is made to subclause 5.2.3.11.

6.2.3.11 Local pressure indication

Reference is made to subclause 5.2.3.12.

6.2.3.12 Instrument ball valves

Reference is made to subclause 5.2.3.13.

6.2.3.13 Instrument tubing

Reference is made to subclause 5.2.3.14.

6.2.3.14 Enclosures

Reference is made to subclause 5.2.3.15.

6.2.4 Computer Part**6.2.4.1 General**

Reference is made to subclause 5.2.4.1.

6.2.4.2 Computer design

Reference is made to subclause 5.2.4.2.

6.2.4.3 Process operator interface

Reference is made to subclause 5.2.4.3.

6.2.4.4 Computer system interface

Reference is made to subclause 5.2.4.4.

6.2.4.5 Calculations

The computer shall calculate flow rates and accumulated quantities for

- i) actual volume flow,
- ii) standard volume flow,
- iii) mass flow and
- iv) 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 seconds.

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

The mean 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.

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. The

figures shall be stored for the time period that is regarded as necessary. The files shall be secured in such a way that they can not be zeroed or altered unless a special security method is followed.

6.2.4.6 Check

Reference is made to subclause 5.2.4.6.

6.2.4.7 Error handling

Error detection and error correction functions in accordance to ISO 6551 section 3, level A shall be applied in the flow computer whenever a measurement system with gas turbine meters are selected.

6.2.4.8 Alarms

Reference is made to subclause 5.2.4.7.

6.2.4.9 Events

Reference is made to subclause 5.2.4.8.

6.2.4.10 Reporting of data

Reference is made to subclause 5.2.4.6.

6.2.4.11 Storing of data

Reference is made to subclause 5.2.4.7.

6.2.4.12 Availability

Reference is made to subclause 5.2.4.8.

6.2.4.13 Network Protection/Security

Reference is made to subclause 5.2.4.9.

6.2.4.14 Expandability

Reference is made to subclause 5.2.4.10.

6.2.4.15 Time Synchronisation

Reference is made to subclause 5.2.4.11.

6.2.4.16 Downloading of Constants and Ranges

Reference is made to subclause 5.2.4.12.

6.2.4.17 Automatic restart

Reference is made to subclause 5.2.4.13.

6.2.4.18 Background Compilation and Execute Capability

Reference is made to subclause 5.2.4.14.

7 FLARE GAS MEASUREMENT

7.1 Functional requirements

7.1.1 General

The system shall measure flow rate and accumulate quantities of flare gas, in Sm^3 , in accordance with governmental regulations. The calculation can either be done in a dedicated flow computer or in SAS.

7.1.2 Products / Services

Not applicable.

7.1.3 Equipment/Schematic

The measurement method should be by an ultrasonic transit time flow meter (USM).

The system may share supervisory computer with other measurement systems or use part of the SAS.

7.1.4 Performance

7.1.4.1 Capacity

Operating velocity range: 0.2 - 100 m/s.

7.1.4.2 Uncertainty

Class C system.

7.1.4.3 Lifetime

Reference is made to subclause 5.1.4.3.

7.1.4.4 Availability

The regularity for the flare measurement system shall be 98 %.

The measurement system shall be designed for continuous measurement of all expected flow rates. Calculation of expected flow rates shall not be a part of the flare gas measurement system.

7.1.5 Process/ambient conditions

Reference is made to subclause 5.1.5.

7.1.6 Operational Requirements

For flare measurement systems with dedicated computer, there shall as a minimum be regular transmission to SAS of:

- Standard volume flow rate and totals.
- Actual volume.
- Pressure and temperature.
- Mass (application specific).

For high/low alarm there shall be transmission of:

- Pressure and temperature.
- Actual volume flow rate.

The system shall provide access and space for maintenance and calibration.

The system shall in general not necessarily measure the gas during regular calibration of field instruments and when a field instrument of any type fails.

7.1.7 Maintenance Requirements

7.1.7.1 Meter verification

The stream computers shall have calibration mode.

7.1.7.2 Isolation and sectioning

Not applicable.

7.1.8 Layout Requirements

Minimum distances to upstream and downstream disturbance are 20 ID and 8 ID respectively.

7.1.9 Interface Requirements

Computer part interfaces:

- If dedicated computer: SAS.
- Production database and allocation systems.

7.1.10 Testing and Commissioning Requirements

Before being put into operation, the ultrasonic flare gas meter shall be checked to verify velocity of sound and zero flow point. Deviation limits for the various parameters shall be determined prior to or as soon as possible, after the meter is put into service.

7.2 Technical requirements

7.2.1 Mechanical part

All geometric dimensions of the ultrasonic flow meter which affect the measurement result shall be measured using traceable equipment, at known temperatures. The meter shall be designed and installed so that any accumulation of impurities in the vicinity of the transducers is avoided, or can be drained/flushed out without interrupting the operation.

The meter shall either by its own design or by necessary piping arrangement always be available for necessary maintenance.

7.2.2. Instrument Part

Critical parameters related to electronics and transducers shall be determined. A dedicated certificate stating critical parameters shall be attached.

The static pressure shall be measured by a bar absolute (bar a) sensor.

Reference is made to subclauses 5.2.3.3, 5.2.3.4, 5.2.3.5 and 5.2.3.9

7.2.3 Computer Part

The computer part shall consist of a computer performing the functions specified below, a VDU, a printer for reporting, and a communication system for transferring signals to other systems.

- Facilities shall be included to enable user verification of functions, parameters and accuracy for input, calculated and output values.
- During the operational phase, the parameters relevant to verify the condition of the meter shall be checked. If an alarm mode so indicates, the necessary verification and corrections shall be done.
- The computer shall raise and log alarms if any comparison checks exceed operator selected limits, if any measured value is outside predetermined limits, and in case of indications of instrument failure or computer failure.
- The computer shall report daily totals.
- 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, certified EEx ia, to safeguard warm start after minimum 1 year power off.

Algorithm and truncation/rounding errors for computations in the computer part shall be less than ± 0.01 %. This requirement shall be verifiable.

8 GAS SAMPLER SYSTEMS

8.1 Functional requirements

8.1.1 General

The system shall collect and store a representative gas sample at line conditions, allowing it to be transported to the laboratory for analysis. The system shall be mounted as close as possible to the pipeline to collect samples over a sample period, unattended. The system shall be in accordance with ISO 10715. The distance to the nearest upstream disturbance, shall be at least 20 ID.

The measurement system shall control an automatic gas sampler system, i.e.

- provide a flow proportional by mass pacing signal (and a fall back signal)
- monitor the sample volume collected and status of the sampling system.

In addition, there shall be a manual sample point, where the manual sampling probe shall be installed such that a representative sample of the gas can be collected. The distance to the nearest upstream disturbance, shall be at least 20 ID. However, if an auto-sampler or OGC sampling probe is included in the measurement system the manual sampling may be taken from the same probe.

8.1.2 Products/Services

Single phase natural gas.

8.1.3 Equipment/Schematic

The system consists of a probe, a by-pass loop, two separating devices (sample collection pumps), an instrumentation supply system, a timing system and two sample receivers (collection cylinders) for sample transportation.

The sample equipment shall be contained in a cabinet with exception for:

- the probe,
- tubing to/from the mainline and
- the back-pressure system.

The cabinet shall be located as close as possible to the sample point.

The cabinet shall be insulated, and if necessary, heated to keep the temperature well above the condensation temperature, minimum +10 °C. The heating shall be adjustable.

The manual sample point shall be equipped with flushing facilities and a cabinet/enclosure with required valves and quick connectors in addition to an arrangement where the sample cylinder can be placed during spot sampling.

8.1.4 Performance

8.1.4.1 General

ISO 10715 describes the performance requirements for a fiscal sampling system.

8.1.4.2 Availability

The availability for the system is satisfactory when subclause 8.1.3 is followed in addition to a manual sample point.

8.1.5 Process/Ambient Conditions

The sampling cabinet including the tubing shall be kept under sufficient controlled environment, i.e. providing necessary protection against cold, heat, rain, wind etc.

8.1.6 Operational Requirements

The control function shall be done from a dedicated controller, SAS or a measurement system. There shall be monitoring of maximum filling with adjustable alarm setting. In addition the measurement system shall provide a flow proportional pacing signal and monitor the sample volume collected and status of the sampling system.

8.1.7 Maintenance Requirements

There shall be easy access in cabinet(s) to all main components and valves.

8.1.8 Isolating and Sectioning

It shall be possible to isolate the system from the main process.

8.1.9 Layout Requirements

ISO 10715 describes the layout requirements for a fiscal sampling system.

8.1.10 Interface Requirements

The system shall be controlled and monitored from the measurement computer or SAS.

8.2 Technical requirements

8.2.1 Initial selection of automatic probe location

The sample point shall be chosen to provide a representative sample of the flowing gas in the pipe.

The sampling point shall be installed at least 20 diameters downstream of the nearest bend or restriction on a horizontal pipe. The probe shall be installed in a 10 - 2 o'clock position.

8.2.2 Design considerations for sampling systems

ISO 10715 describes the design considerations for a fiscal sampling system.

8.2.3 Probe design

The probe shall be a pitot tube type extending into the centre one-third of the pipeline diameter. In addition, the sampling probe should be designed so it is possible to be retracted under operating pressure by method accepted by the operator.

8.2.4 Sample collection pump

There shall be two parallel sample collection pumps, which shall be self-purging and be designed to operate under line conditions. The grab size volume shall be adjustable in the range 0,5 - 1,5 ml (by e.g. different cup sizes).

The sample collection pumps shall be located above and as close to the probe as is practically and possible. Filters, drip pots, screens, regulators and such conditioning equipment shall not be placed between the probe and the sampler.

8.2.5 Sampler Controller

The controller shall provide a flow proportional by weight sampling signal with a time proportional back-up possibility.

8.2.6 Sample receiver

- There shall be two parallel sample receivers.
- The filling of the two sample receivers shall have a maximum deviation of $\pm 5\%$.
- Heat tracing and insulation shall be provided to keep the temperature minimum $10\text{ }^{\circ}\text{C}$ above the condensation temperature.
- The receivers shall be of the floating piston type with back-pressure of an inert gas.
- The receivers shall be portable (max. weight 15 kg incl. transportation container, normal size 1000 ml).
- The receivers shall be equipped with a local piston position indicator and a limit switch for maximum filling.

8.2.7 Tubing and valves

- The tubing shall slope downwards from the sample pump to the sample receiver.
- The temperature in all parts of the sample lines/tubing and sample receivers shall be kept at a temperature minimum $10\text{ }^{\circ}\text{C}$ above the hydrocarbon dew point temperature.
- The valves for the sampling system shall be of type full-bore ball valves.
- The sample tubing from/to the main pipe should have a slope of at least 1:12 to avoid liquid traps.

8.2.8 Back-pressure system

There shall be a back-pressure system with inert gas (argon or helium). This shall include a booster facility. The back-pressure volume shall be at least five times larger than the receiver volume and of a size so that the pressure increase caused by 100% sample filling is less than 10 bar.

9 GAS CHROMATOGRAPH

9.1. Functional requirements

9.1.1. General

The purpose of an on-line gas chromatograph (OGC) is to give continuous quantitative composition analysis of natural gas from a process stream.

The analysis is normally limited to the following main components and concentrations:

<i>Components</i>	<i>Concentration range in mole %</i>		
Nitrogen	0	-	15
Carbon Dioxide	60	-	10
Methane	0	-	100
Ethane	0	-	15
Propane	0	-	5
Iso-Butane	0	-	1
Normal-Butane	0	-	1
Iso-Pentane	0	-	1
Normal-Pentane	0	-	1
Hexane's and heavier	0	-	1

The ranges shall be restricted to the operational needs for each project.

The OGC shall quantify the concentrations of the main components in the gas composition, for the purpose of gas accounting, calculation of calorific value and reference density in fiscal applications. The gas composition shall also be used for check of gas quality conformity with gas quality specifications defined by commercial gas agreements, and as a base for calculation of the operating density. The calculation of the operating density will normally be handled by the flow computers using live input values of the gas composition from the gas chromatograph.

Calculation of flow weighted average composition will normally be handled by the fiscal measurement computer system. The concentration given in mole % shall be converted to mass % for such calculations.

The analytical results shall be traceable regarding sample point, time and date, calibration gas cylinder, calibration table, and time of last calibration.

9.1.2. Products/Services

Not applicable

9.1.3. Equipment/Schematic

The system shall consist of the sampling system, the analytical unit, the computer unit, and the calibration equipment.

9.1.3.1 Sampling system

The sampling system shall ensure that the sample to the OGC is representative for the process stream and suitable for the OGC. Recommendations as specified in this document, by the analyser supplier and in the ISO 10715 "Natural gas - Sampling guidelines" shall be followed.

The shortest practical sampling route between sampling point and analyser should be taken. Calculation of the transport time from sample point to the gas chromatograph shall be presented. The effect that the sum of the transport time and the analysis cycle time could have on daily average analysis shall be evaluated.

9.1.3.2 Analytical unit

The analytical unit shall separate all components sufficiently from each other so all components present in the process gas are detected with sufficient accuracy. Special care shall be taken to check that the separation between nitrogen / carbon dioxide and methane and between hexane and n-pentane are handled by the gas chromatograph in such a way that the requirements given in subclause 9.1.4 are fulfilled.

The hexane's and heavier fraction (C6+) may include components from 2,2-dimethylbutane (neo-hexane) and upwards in an increasing order of boiling point. It shall be possible to enter the project specific relevant properties of the C6+ fraction in the computer part.

9.1.3.3 Computer unit

The computer unit shall control the chromatograph. Program software, interfaces and protocol should be robust with special consideration concerning automatic regeneration of all control and communicational functions after the event of a general power failure.

The software shall provide extended maintenance tools to enable statistical tracking of analyser performance.

Criteria for accepting the results from the calibration sequence shall be implemented.

The computer unit shall have the option of selecting an automatic calibration performed between a certain number of analysis, or executed at selected calendar dates or weekdays, or at a specified time during the day.

The computer system 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 according to ISO 6976
- Wobbe-index according to ISO 6976
- Relative density (real / ideal) according to ISO 6976
- Density at reference condition according to ISO 6976

Algorithm and truncation/rounding errors for computations in the computer unit shall be less than ± 0.001 %. This requirement shall be verifiable.

9.1.3.4 Calibration equipment

The calibration gas shall be permanently connected to the analytical unit. The system shall have a valve arrangement that provides the possibility of automatically selecting gas samples from the WGMs. Selection of WGMs shall be possible from the central control unit.

Each of the components in the calibration gases (WGM) used for either acceptance tests, commissioning or during operation shall have the following documented uncertainty limits (extended uncertainty with a coverage factor $k=2$):

Component range (mole %)	Uncertainty (%)
0,1 - 0,25	5,00
0,25 - 1	1,00
1 - 10	0,5
10 - 100	0,2

9.1.4. Performance**9.1.4.1 Uncertainty and repeatability**

The repeatability of the OGC shall be within the following limits:

Component range (mole %)			Standard deviation (mole %)
0	-	25	0,02
25	-	100	0,05

The linearity of each component, tested in accordance with Annex B 2.3.4, shall be so that the maximum deviation from values of any WGM when performing a MLC after adjustment of the OGC to correct reading after a SPC shall be so low that the resulting uncertainty in gross calorific value, U_{H_S} , is less than 0,15 % of the gross calorific value, H_S , when applying the following equation:

$$U_{H_S} = [\Sigma(H_S - H_{Si})^2 \cdot (U_{Xi})^2]^{1/2}$$

where H_{Si} is the gross calorific value for each component found in the ISO 6976.

9.1.4.2 Availability and reliability

The system shall be designed for continuous operation and for low downtime in case of maintenance, repair etc.

To increase the reliability of the results it should be possible to check the results from the OGC by other independent means. Such means may be another OGC installed in parallel, analytical equipment installed at other locations with which it is possible to compare the results, equipment measuring properties, which are dependent on the gas composition. Possible type of equipment for the latter check could be densitometers and ultrasonic flow meters reporting the velocity of sound. Evaluation of such check possibilities is project specific.

9.1.5 Process/Ambient conditions

The OGC should be kept under sufficient controlled environment, i.e. providing necessary protection against cold, heat, rain, wind etc.

Line pressure variations shall not affect the sample flow rate and pressure of the sample gas to the analyser.

9.1.6 Maintenance requirements

Care must be taken to allow for simple quick maintenance of filters and valves and for proper choice of filter media. If necessary, spare filters shall be installed. All fittings shall be accessible for maintenance and replacement.

9.2 Technical requirements**9.2.1 Sampling system**

The sampling system shall collect a representative gas sample.

The sampling probe shall be installed such that a representative sample of the gas can be collected. The distance to the nearest upstream disturbance, shall be at least 20 ID.

Conditioning equipment is required to reduce pressure to a level suitable for the analyser.

Adequate protective filtering and coalescer have to be installed after the pressure reduction system to remove dirt and liquid entrainments if such contamination will be present.

The temperature in all parts of the sample lines including sample conditioning equipment shall be kept at a temperature minimum 10 °C above the hydrocarbon dew point temperature. The dew point temperature shall be calculated by well recognised methods for every pressure level in the system. The temperature and pressure at critical points in the sampling system shall be indicated.

Slope of at least 1:12 should be maintained along the sample line from the probe to the pressure reduction system in order to avoid liquid traps.

The sampling probe should be designed so it is possible to be retracted under operating pressure by method accepted by the operator.

Spot sampling connection shall be provided.

All manually controlled shut off valves in the cabinets shall have a proper open/close indication.

Waste samples from the analyser shall be vented via a separated vent line. Waste bypass gas from the cabinets can be vented to a common vent/drain system. The vent system shall be design in order to avoid influence from ambient conditions.

9.2.2 Analytical unit

The time required for a full analysis cycle shall be less than 15 minutes.

The oven temperature shall be controlled with sufficient stability and accuracy to obtain required stability and accuracy of the analysis.

It should be possible to check the temperature at any time

The chromatograph shall use carrier gas in accordance with requirement given by the application. Pressure and flow rate of carrier gas shall be controlled with sufficient accuracy. Necessary equipment for safe operation in case of failure in carrier gas supply shall be installed if applicable.

The chromatograph shall use TCD.

9.2.3 Computer unit

Communications between the analytical unit and the computer unit should be according to the vendor's standard protocol.

The installation shall be according to NORSOK standard Z-010.

The following functions shall all be available for the operator and should also be available from the supervisory computer:

- Start and stop the analysis cycle
- Change the alarm limits.
- Acknowledge alarms.
- Define and / or read component table, retention time, RT tolerance, response factor and valve switching.
- Sequence, calibration frequency and WGM concentration.
- Password protected program modifications
- Define and / or read time, peak height, peak area, peak start time, peak end time (for each component) and total area.
- Select override analysis.

The computer unit shall have functions that give an alarm and inhibit the use of calibration tables containing response factors that are outside pre-set limits of acceptable values. The response factors for those components not present in the calibration gas shall either be automatically calculate by using a mathematical relation to other components, (that is calculate response factors for the hexane plus fraction from the response of pentanes or butanes) or be manually entered.

The chromatograms should be displayed in real time and also stored digitally with the possibility of later visual inspection. Start and stop of peak integration event marks and electronic baseline should be possible. Hard copies shall be available.

A main report for printouts and electronic transmission to the main network shall contain names of components, normalised mole % of each component rounded to the nearest 0,001%.

A quality control report for printouts and electronic transmission should contain information about retention time, peak height, peak width, peak area, response factor, and mole % before and after normalisation.

A control function in the software should give alarm if one or more components are missing from the report or that the sum of non-normalised values is outside pre-set limits. This alarm shall inhibit the transmission of potential erroneous results onto the main computer network.

The following requirements for displaying items should be considered:

- Alarm status
- Historical analysis data for a single component in chart form
- Historical analysis data in report format, average, max. and min. values for each component and calculated values
- The last measured concentration value for each component and calculated values
- Real time chromatogram and valve status.

Alarm generation shall be according to operational philosophies.

External interface shall be designed according to operational needs.

Communication with the main metering computer should be via serial data link.

9.2.4 Calibration equipment

The calibration gas bottles cabinet shall if necessary be electrically heated to prevent condensation.

It should be possible to enter, store and change the composition of the calibration gas.

The vendor of the WGM shall provide relevant documentation for the uncertainty calculations.

ANNEX A REQUIREMENTS FOR AUTOMATED CONDITION BASED MAINTENANCE (NORMATIVE)

A.1 General

The fiscal measurement systems shall be designed for fully automated condition based maintenance. This includes the ability to automatically verify the current condition of all measured field tags that are of importance to the integrity of the fiscal measurement system. These field tags are typically pressure, temperature, density, differential pressure, flow values (ultrasonic meter values), level in sampling container (compared to calculated level) etc.

This verification of current condition shall preferably be carried out using calibrated reference meters. The condition based monitoring may however also be carried out using duplicated equipment or by any other relevant method.

Where possible comparative monitoring of parallel meter runs shall be carried out, i.e. when two or more meter runs are operating concurrently.

A.2 Software requirements

The software shall be prepared for easy and reliable verification of the accuracy of each independent program routine and totalization. The computer under test must measure the duration of the accuracy tests, when the duration of the accuracy tests is influencing the estimated values.

The measured field tags and parameters indicating the condition of each field tag i.e. deviations from reference values, shall be stored and trended graphically. Additionally, a current condition report shall be generated at predefined times or on demand. The current condition report shall include comparisons against predefined limits of deviation for each parameter, and a written alarm shall be given in the report, if any limit is exceeded. Generally, a verification of current condition shall not include any manual interference with the measurement equipment or computers. The current condition report may be combined with the report of the daily status of the measurement system. The fiscal measurement reports shall not be combined with the current condition report.

ANNEX B TESTING AND COMMISSIONING (NORMATIVE)

B.1 Necessary tests

B.1.1 General

This annex outlines the minimum test requirements for fiscal measurement systems.

The Supplier shall not present any item for inspection and testing until he has completed his own inspection and testing. The purchaser reserves the right to perform any checking as deemed necessary.

A written record is to be made of all tests and results and copies made available to the purchaser if required.

The objective of the acceptance tests will be to assure that the systems meets the functional and technical requirements described in this document. Supplier shall prepare acceptance test procedures for factory and offshore acceptance tests, which shall demonstrate that all specifications of this document and subsequent functional design document are met. Purchaser will review and comment, as necessary, to arrive at a mutually agreeable acceptance test procedure prior to start of testing.

The equipment shall undergo a factory acceptance test prior to shipping. Personnel from purchaser will normally witness the test and decide if the equipment has performed satisfactorily. Any problems found shall be corrected by the Supplier, who shall demonstrate that any discrepancies have been corrected prior to shipment.

The supplier shall at each test, as a minimum demonstrate the following:

- The capability and proper operation of the hardware and software.
- The equipment's ability to meet all functional and technical requirements described in this document.
- That all the expandability requirements are included.
- That the communications software and hardware work properly.
- Satellite communication, if applicable.
- The operation of the graphics package.
- That all counters, registers, internal switches, etc. will be reset at the correct hour (project specific) each day, in such a way that no data is lost and there is no effect on the accuracy of calculations made following the turn-over.
- That no data will be lost/changed if switching over to a standby system (project specific).

- That all calculations are correct.
- Interface/total functional test to the SAS-system including displays, alarms, operator interactions etc.

B.1.2 Supplier internal system test

This test shall be performed as described above. There shall be an arrangement to simulate all field signals into the system and indicating or metering instruments to monitor the output signals of the system. This test must be documented as described in FAT procedure, and completed before the next test is performed.

B.1.3 Purchasers factory acceptance test

This test shall be performed as described above for all systems. The test shall be arranged as follows:

- The test will start with a review of suppliers documentation of the following:
 - All software is tested and is free of patches
 - All hardware modules have been tested in accordance with recognised industrial standards, with regard to susceptibility to environmental conditions, such as variations in signal and supply voltages.
 - Result of supplier's test as per above procedure.
- The purchaser will then perform the test on his own, assisted by supplier's personnel as required.
- During the test purchaser may also introduce some reasonable additional tests to check that the system operates accurately under normal or abnormal operating conditions.

This test must be completed before the next test is performed.

B.1.4 Site/yard acceptance test

Verification of system after power-up, full load test. Integrated test with SAS. Operating manuals must be available for this test.

B.1.5 Offshore/commissioning verification test

A simplified version of the FAT will be performed again after the equipment has been shipped offshore.

Field instruments i.e. secondary instruments shall prior to start up, be traceably re-calibrated by an accredited laboratory to international/national standards before the instruments are taken into service.

Ultrasonic meter for gas:

After being pressurised, before being put into operation, the ultrasonic flow meter shall be checked to verify velocity of sound and zero flow point for each individual sound path. The supplier shall determine deviation limits for the various parameters, before the meter is put into service.

The equipment will be accepted as operational after all required functions have been demonstrated and proven to be in actual operation.

B.2 Test of individual components

B.2.1 Test Equipment

All test equipment shall be of standard and precision which is appropriate to the tests to be performed, with calibration certificates from an accredited laboratory.

B.2.2 Inspection and testing of Field Instruments

Procedure for calibration shall be sent purchaser for review and acceptance. Purchaser will witness these calibrations (3 weeks notice required before verification).

For Class C and D systems, flow meters shall be tested as mutually agreed.

For class A and B systems, turbine and ultrasonic flow meters shall be individually calibrated at a laboratory, which is traceable to international/national standards at process conditions (velocity of flow, pressure and temperature), as similar to the operational conditions as possible. The effect of variations in temperature and pressure shall be determined. The calibration factor shall be determined. The meters shall be identified, and a certificate shall be issued. For the ultrasonic flow meter, the zero flow point correction shall be determined.

The turbine and ultrasonic flow meter shall be tested in the upper and lower part of the range, and at three points distributed between the maximum and minimum values. Five repeats shall be made for each point. When the zero flow point correction (ultrasonic flow meter) and the calibration factor correction are done, the deviation from the reference shall be less than $\pm 0.5\%$ for Class A and $\pm 1.5\%$ for Class B. The repeatability shall be 0.50 % (band) for Class A and 1.0 % (band) for Class B. These requirements apply to velocities above 5% of maximum range. The calibration factor, which derives from the calibration, shall always be used.

If it is impossible to calibrate the turbine or ultrasonic meter at process conditions the calibration shall aim to achieve the specified flow velocity range.

An inspection/test shall take place when the metering skids have been fully completed in all details and prior to purchaser's factory acceptance test. The inspection/test will as a minimum comprise:

- Check that all instruments are installed in such a way that they will give correct measurement and easy calibration.
- Review of calibration certificates for field instruments. Recent calibration certificates for all instruments within the skids shall be available. The purchaser may require some or all of the instruments to be check calibrated at this test.

This inspection/test will be witnessed/made by the purchaser.

B.2.3 Inspection and Testing of OGC

In addition to checks and verification of leakage testing, tagging, workmanship etc., the tests listed below should be performed to check the gas chromatograph system's functions.

B.2.3.1 Functional Acceptance Test Procedures

The following tests should be performed to check the gas chromatograph system's functions.

B.2.3.2 Ability to separate components

A gas sample containing all components present in the actual process gas shall be applied to the sample inlet of the gas chromatograph. The associated chromatograms for five consecutive runs shall be evaluated.

B.2.3.3 Stability test

Apply calibration gas with hydrocarbon components up to C5 and nitrogen and carbon dioxide to the sample inlet of the gas chromatograph and analyse continuously for 48 hours. Check on the printouts of normalised values that the precision is within the requirements given in section 9.1.4.1.

B.2.3.4 Linearity test

Three different certified calibration gases containing nitrogen, carbon dioxide, methane, ethane, propane, i-butane, n-butane and n-pentane should successively be applied for 10 consecutive cycles to the inlet of the gas chromatograph. One of the calibration gases shall be close to the normal sample gas composition. In the two other gases the components shall be so balanced that the extremes of expected compositions are covered.

The calibration gases shall have the accuracy defined in section 9.1.3.

The linearity test should be performed on normalised results.

The deviation between the reading of normalised value from the gas chromatograph and the certified value for any component for any calibration gas shall be so that criteria given in section 9.1.4.1 is fulfilled.

B.2.3.5 Calculation test

The calculation of the relevant gas properties performed by the computer part of the gas chromatography like gross calorific value, real standard density, Wobbe index etc. shall be checked for three different gas compositions. The compositions are entered into the computer. The calculations shall be checked against reference calculations to be within ± 0.001 % of specified value.

B.2.3.6 Auto-calibration function

The function automatic calibration shall be checked by connecting a gas sample to the process gas inlet and a calibration gas to the calibration gas inlet. Calibration interval and number of consecutive calibration runs (for example 3) shall be entered. With this configuration the chromatograph should run for minimum 24 hours allowing for at least four calibration runs. It should be checked that the calibration reports and the updating of the response factors are according to specifications. Included in the test shall also be a check of the criteria for accepting the response factor found during the calibration.

B.2.3.7 Output signals

The output signals, analogue, digital or serial links should be checked for correct information.

B.2.3.8 Alarm and event messages

Any alarm situation shall be simulated and it should be checked that the corresponding alarms are set and presented according to specifications. For example on flashing lights, on displays, on printers, on the serial communications etc.

B.2.3.9 System test

Apply reference gas to the inlet of the sampling system which shall include preconditioning and conditioning cabinets as close as possible to normal operating temperature and at a minimum, medium and maximum operating pressure for 10 analysing cycles at each pressure. The readings of normalised values shall not depend on the pressure and the reading of the normalised values shall be within the required repeatability.

B.3 Other instrument Equipment tests

Instrument panels which form part of the total measurement package shall undergo the functional tests as stated in the approved supplier test procedure.

The complete panels with all the equipment installed and connected, shall be tested for electric continuity, insulation and earth, and shall be heat soak tested as mutually agreed.

The supplier shall, before shipment, visually inspect, calibrate where necessary, and functionally test all instruments, which are included in the package instrumentation system. This shall apply whether instruments are mounted on the package, mounted but disconnected for shipment, or shipped loose for installation at the module construction yard or offshore.

Spool pieces shall be provided for all in line instruments that will have to be removed for flushing, pre-commissioning or commissioning tasks.

B.4 Preservation

The entire fiscal metering system shall be protected against corrosion and other damages during export shipment and storage. Supplier shall propose methods/procedures/conditions of warranty for period from FAT to start up operation.

ANNEX C SYSTEM SELECTION CRITERIA (INFORMATIVE)

C.1 Alternative cost/benefit analysis of metering concepts

The cost of using a concept with high accuracy (concept A) may be unreasonable in relation to the monetary value of the additional measurement uncertainty of a less accurate/less expensive concept (concept B). The selection of metering concept shall be based on one of the two alternative cost/benefit analyses given below.

C.1.1 For metering systems for main fields and sales metering

An analysis shall be performed to quantify:

- a) The measurement uncertainty of concept A and B
- b) The potential monetary loss from the additional measurement uncertainty, by using concept B instead of concept A, during the lifetime of the installation.
- c) The total cost savings, by using concept B instead of concept A, during the lifetime of the installation.
- d) The cost saving in c) minus the potential monetary loss in b).

The key parameter is this analysis for decision making, is the value in d).

All monetary values above shall be calculated as net present values of investment and operating cost.

C.1.2 For metering systems for satellite fields with tie-in and processing on existing field platforms

An analysis shall be performed to quantify:

- a) The monetary value of 1 % reduction in measurement uncertainty for oil and gas based on difference in ownership between satellite field owners and existing field owners, during the lifetime of the installation. (Assuming for example that owners are willing to use 0,25 NOK maximum to reduce measurement uncertainty by 1,0 NOK)
- b) The uncertainty of the well-test concept for oil and gas (No measurement).
- c) A matrix (table) showing the monetary value of reducing measurement uncertainty from the well-test concept towards 0 % measurement uncertainty for oil and gas.

The key parameter is this analysis for decision making, is the total cost of using a metering system with a specified measurement uncertainty, compared to the monetary value of the corresponding reduction in measurement uncertainty from the no measurement case for oil and gas, during the lifetime of the installation.

All monetary values above shall be calculated as net present values of investment and operating cost. A calculation to be performed for each field owner including all field owners shares.