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شرکت ملي گاز ايران

مديريت پژوهش و فنآوري

امورتدوين استانداردها

مشخصات فنی

سیستم های اندازه گیری جریان گاز طبیعی

Natural Gas Flow Measuring Systems

دفتر مدیرعامل

شرکت ملی گاز ایران

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ابلاغ مصوبه هیأت مدیره

مدیر محترم پژوهش و فناوری

باسلام،

به استحضار می‌رساند در جلسه ۱۷۹۶ مورخ ۱۳۹۷/۷/۸ هیات مدیره، نامه شماره گ۹/۸۳۰۵۷/۰۰۰ مورخ ۱۳۹۷/۷/۳ آن مدیریت درمورد تصویب نهایی استانداردها به شرح زیر:

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این مصوبه در حکم مصوبه مجمع عمومی شرکت‌های تابعه محسوب و برای کلیه شرکت‌های تابعه لازم الاجرا می‌باشد.

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FOREWORD:

This standard is intended to be mainly used by NIGC and contractors, and has been prepared based on interpretation of recognized standards, technical documents, knowledge, backgrounds and experiences in natural gas industry at national and international levels. Iranian Gas Standards (IGS) are prepared, reviewed and amended by technical standard committees within NIGC Standardization division and submitted to the NIGC's "STANDARDS COUNCIL" for approval. IGS Standards are subject to revision, amendment or withdrawal, if required. Thus the latest edition of IGS shall be checked/inquired by NIGC employees and contractors. This standard must not be modified or altered by NIGC employees or its contractors. Any deviation from normative references and / or well-known manufacturer's specifications must be reported to Standardization division. The technical standard committee welcomes comments and feedbacks about this standard, and may revise this document accordingly based on the received feedbacks.

GENERAL DEFNITIONS:

Throughout this standard the following definitions, where applicable, should be followed:

1- "STANDARDIZATION DIV." is organized to deal with all aspects of industry standards in NIGC. Therefore, all enquiries for clarification or amendments are requested to be directed to mentioned division.

2- "COMPANY": refers to National Iranian Gas Company (NIGC).

3- "SUPPLIER": refers to a firm who will supply the service, equipment or material to NIGC whether as the prime producer or manufacturer or a trading firm.

4- "SHALL ": is used where a provision is mandatory.

5- "SHOULD": is used where a provision is advised only.

6- "MAY": is used where a provision is completely discretionary.

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1. Scope

This Standard specifies functional requirements for the design, construction, testing, commissioning/ decommissioning, with suitable documented provisions for gas volume measuring systems used for custody transfer.
This Standard is applicable for Natural gas According to IGS – M – CH – 033 and not applicable for sour gases.
All parties involved shall exchange all appropriate information to ensure effective design, installation, commissioning ,testing and operation of the measuring system.

2.References

2.1.BS EN 1776:2015-Gas infrastructure — Gas measuring systems — Functional requirements
2.2.OIML R 140:2007- Measuring systems for gaseous fuel
2.3 EN 12186, Gas infrastructure — Gas pressure regulating stations for transmission and distribution —Functional requirements
2.4 .EN 12405-1, Gas meters — Conversion devices — Part 1: Volume conversion
2.5. IGS-M-IN-104(1)-Multipath Ultrasonic Transit-Time Gas Flow Meter
2.6. IGS-M-IN-106(0)-Gas Meters, Gas Volume Electronic Conversion Device(PTZ)
2.7. IGS-M-IN-102(2)-Turbine Meters
2.8. IPS-G-IN-230-General Standard For Analyzers
2.9. IPS-E-IN-230-Engineering Standard For Analytical Instruments
2.10.IPS-M-IN-110-Material And Equipment Standard For Pressure Instruments
2.11.IGS-C-IN-100(1)- Location of Installation of Devices for Measuring the Quantities of Natural Gas.

3.Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Accuracy of Measurement

Closeness of the agreement between the result of a measurement and a true value of the measured

3.2 Additional Components

elements or devices, required to ensure correct measurement or intended to facilitate the measuring operations, or which could in anyway affect the measurement

Additional components can be

a) filter;

b) flow conditioning device;

c) branch or by-pass line;

d) valves;

e) pressure reduction devices located upstream or downstream of the meter;

f) sampling systems;

g) piping.

3.3 Authorized Person
person who is appointed to fulfill a given task on gas measuring systems

3.4 Availability
probability, at any time, that the measuring system, or a measuring instrument forming a part of the measuring system, is functioning according to specifications

3.5 Base Conditions
specified conditions to which the measured quantities of gas are converted

Note 1 to entry: Operating and base conditions relate to the volume of gas to be measured or indicated only and should not be confused with “rated operating conditions” and “reference conditions” which refer to influence quantities.

3.6 Bias
systematic difference between the true value of measured and its determined value

3.7 Traceability
property of the result of a measurement or a value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties

3.8 Competent Person
person who is qualified, trained and experienced to perform activities to gas measuring systems

3.9 Compression Factor *Z*
ratio of the volume of an arbitrary mass of gas, at a specified pressure and temperature to the volume of the same mass of gas under the same conditions as calculated from the ideal-gas law

Note 1 to entry: The compression factor (Z) indicates the extent to which gas deviates from ideal gas behavior.

3.10 Conversion Device

3.10.1 Conversion Device
device that converts a quantity at metering conditions to a quantity to base conditions or energy

3.10.2 Energy Conversion Device
device which calculates, integrates and displays energy using quantity at base conditions and the calorific value and/or the gas composition

3.10.3 Volume Conversion Device
device that converts the quantity measured at measuring conditions into a quantity at base conditions

3.11 Custody Transfer
change in responsibility for the conveyance of gas, this may or may not involve a change of ownership of the gas

3.12 Documented Provisions
provisions established by the operator of a gas measuring system in order to give confidence that operations are performed according to metrological expectations

3.13 Drift
slow change of a metrological characteristic of a measuring instrument

3.14 Energy Determination
quantitative determination of the amount of energy of a quantity of gas based either on measurement or calculation using measured values or attributed values

3.15 Fail-Safe
characteristic of a device to go to a safe operating condition when a failure occurs

3.16 Gas Measuring Installation
complete set of measuring instruments and additional components assembled to carry out specified measurements

3.17 Gas Measuring Station
measuring station consists of one or more gas measuring installation(s) and includes its housing, compound, the inlet and outlet pipework as far as the isolating valves

Note 1 to entry: Measuring station does not normally apply for gas measuring installation for residential and commercial use, even if there is housing.

3.18 Gas Measuring System
consists of a gas measuring installation, documented provisions and where appropriate a gas measuring station

3.19 Gas Measuring System Operator
natural or legal person who is responsible for the operation and maintenance of the measuring system

Note 1 to entry: The gas measuring system operator is referred to be the operator.

3.20 Gas Meter
instrument designed to measure, memories and display the quantity of gas (volume or mass) that has passed it

3.21 Uncertainty
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

3.22 Hazardous Area
area in which an explosive or flammable gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment
[SOURCE: EN 60079-10-1:2009]

3.23 Housing
cabinet or meter compound external to the building

3.24 Installation Effect
difference in performance of the measuring instrument between the calibration conditions and actual conditions of use

Note 1 to entry:This difference can be caused by different flow conditions due to velocity profile, perturbations,
or by different working regimes (pulsation, intermittent flow, alternating flow, vibrations, etc.).

3.25 Maximum Permissible Error (MPE)
extreme absolute value of error permitted by specification

Note 1 to entry:Conformity with an MPE is based on calibration results for individual instruments and
on statistical methods for measuring systems.

3.26 Measuring Conditions
conditions of the gas at which the quantity is measured at the point of measurement (temperature and pressure of the measured gas)

3.27 Measuring Instrument
device intended to be used for measurements, alone or in conjunction with supplementary device(s)
EXAMPLE Gas meter, calorific value determination device.

3.28 Metering Temperature
absolute gas temperature to which the indicated quantity of gas is related

3.29 Pressure

3.29.1 Absolute Pressure
pressure of the gas measured with the reference to an absolute vacuum

3.29.2 Gauge Pressure
difference between the absolute pressure of the gas and the atmospheric pressure at the place and time of the measuring

3.29.3 Design Pressure DP
pressure on which design calculations are based

Note 1 to entry: A part of a measuring installation designed for a design pressure DP can comprise components designed for a different maximum allowable pressure PS.

3.29.4 Maximum Incidental Pressure MIP
maximum pressure which a system can experience for a short time, limited by the safety device(s)

3.29.5 Maximum Operating Pressure Mop
maximum pressure at which a system can be operated continuously under normal operating conditions

Note 1 to entry: Normal operating conditions are: no fault in any device or stream.

3.29.6 Metering Pressure (*P*m)
absolute pressure at which the volume of gas is measured

3.29.7 Temporary Operating Pressure TOP
pressure at which a system can be operated temporarily under control of the regulating device(s)

3.30 Representative Calorific Value
individual calorific value or a combination of calorific values that is considered to be, according to the constitution of the measuring system, the most appropriate calorific value to be associated with the metered quantity in order to calculate the energy.

3.31 Responsible Person
person who is responsible for design, construction, commissioning, operation and maintenance of the measuring installation and/or system

3.23 Sensor
instrument for measuring certain measured which are characteristic of the gas (temperature, pressure, calorific value, etc.)

3.33 Smart Meter
meter with additional functionalities one of which is data communication

3.34 Stability
ability of a measuring system, or a measuring instrument, to perform its functions for a specified period of time.

3.35 Stripped Gas
natural gas from which large amounts of easily liquefiable components have been removed.

4. Safety and environment

Metering systems shall be designed and supplied to operate in a safe manner and takes into account all aspects and rules related to safety, environment, space, location and operation constraints .Special care shall be paid for instance to sampling, venting, degassing, draining…

Safety is a management responsibility which requires that all personnel involved in design, installation, testing, commissioning, the gas measuring system shall be competent and have adequate safety training. The management shall ensure that all areas of responsibility are clearly defined.

Environmental and external conditions like sun, flare… which can generate failure, errors or generate difficulties in operation shall be considered. During normal operation, the gas measuring system shall meet locally established environmental noise levels. The owner / operator of the measuring system shall inform the consumer or the person responsible for the property of any risks associated with the system, e.g. instructions stating the precautions to be taken if the smell of gas persists.

All components of the measuring installation shall be resistant to or protected against external corrosion.

When designing a gas measuring system, safety provisions shall be integrated to ensure its safe access, egress, construction, operation, inspection and located such that risk and nuisance to the environment and its operation are kept within acceptable limits.

The designer of the gas measuring system shall ensure that proper care is taken to prevent noise generated hazards.

The gas pressure installation shall have at least one inlet valve to allow it to be safely isolated and undertake any maintenance. For higher accuracy installations an outlet valve should be fitted.

As part of the design of the system the electrical safety shall be considered. All electrical installations shall comply with the applicable NIGC specifications.

5. Hazardous Area Classification

The possible hazardous area in any housing, station and installation shall be assessed and classified according to API 505.

If a hazardous area is classified at the place of installation, any electrical equipment shall be suitable for the classified zone and be designed, selected and fitted in accordance with API RP 505 and manufacturer`s instructions.

Table1. Minimal design criteria for the constitution of measuring systems

Design Q_{max} at base conditions scm/h	Less than or equal to 160	Greater than 160 to 100,000[1]		More than 100,000
Accuracy Class	C	B	A	A
High pressure calibration certificate		*	*	*
Standby Meter Run		*	*	*
Z configuration design			*[2]	*[2]
Local checking system			*[2]	*[2]
Temperature conversion		*	*	*
Pressure conversion		*	*	*
duplicated pressure and temperature measurements			*[2]	*
Z conversion		*	*	*
Online gas composition device (GC)			*[2]	*[2]
gas composition determination (sampling or computation)		Two times in a Year		
on line analyzer device for dew point and Sulphur components			*[2]	*[2]
Archiving the metering data in Volume Corrector / flow computer (tables / trends)		*	*	*
Creating and saving the daily and monthly reports		*	*	*
Event & parameter Log in Volume Corrector / flow computer		*	*	*
Alarm system in Volume Corrector /flow computer		*	*	*
Connection to data gathering system (SCADA)		*[3]	*	*
Hardware & Software Security in Volume Corrector / flow computer		*	*	*

6. Basic Requirement for Measuring System

The output of the gas measuring system is Volume that is the product of gas volume at standard conditions.

NOTE Several different physical principles are used to determine gas volume flows. The most commonly used techniques are included in this Standard.

Involved parties shall ensure that the method of Volume determination is traceable, reliable and satisfies the measurement requirements such as accuracy, safety as well as economic criteria.

The chosen technique shall be sufficiently accurate to reduce random and systematic

[1] system accuracy class (A or B) shall be specified by N.I.G.C

[2] Optional only for city gate stations

3 not necessary for measuring system with Q_{max} lower than 10,000 scm/h

errors to such a level that contractual obligations are fulfilled and that can be justified on technical or economic considerations.Based on the accuracy requirements, the designer shall choose the most appropriate class according Table 1- Minimal design criteria for the constitution of measuring systems.

6.1 Components of a measuring system

A meter itself is not a measuring system or a metering module.

A measuring system may include elements of the following non exhaustive list:

- meter(s) or metering module;
- checking facilities;
- metrological seals;
- conversion devices; (* if applicable)
- Gas composition determining device; (* if applicable)
- memory or printing device and automatic chronological recorder; (* according to national regulation)
- switching equipment to select the appropriate number of meter lines corresponding to the real load of the station and used to ensure that any meter in service is measuring flows between its Qmin and Qmax; (*)
- gas sampling extraction and conditioning system; (* if applicable)
- provision for the calibration of the gas composition determining device including calibration standards; (* if applicable)
- isolating valves; (**)
- additional piping and fittings; (**)
- filter and separator; (**)
- gas pre-heating equipment; (**)
- equipment to reduce the noise level; (**)
- flow and pressure control equipment for the station or the metering line; (**)
- equipment to prevent the formation of hydrates and ice; (**)
- equipment to absorb vibrations and pulsations; (**)
- flow profile conditioning device; (**)
- other components; (**)
- Documented provisions and quality assurance systems. (***)

* is always part of the measuring system when present

** is part of the measuring system when there is a risk it influences the performance of the measuring system

*** is part of the measuring system when necessary to ensure the integrity and/or the correct operation of the measuring system.

If several meters and/or flow measuring devices are intended for a single measurement operation, these meters are considered to be included in the same metering module or measuring system.

If several meters and/or flow measuring devices intended for separate measuring

operations (different contracts) do have elements in common (calculator, filters, conversion device, etc.), each meter and/or flow measuring device is considered to make up, together with the common elements, one metering module or measuring system.

7. Accuracy classes

7.1 Type of Accuracy Classes

Measuring systems are classified into three accuracy classes: A, B, C.

7.2 Maximum permissible errors (mpes) for measuring systems

The maximum permissible relative errors, positive or negative, for measuring systems are specified in Table 1. These values are applicable for type approval and for initial verification.(see OIML 140 Part 6.2)

TABLE 2-mpes for measuring systems

Maximum permissible errors on determining:	Accuracy class A	Accuracy class B	Accuracy class C
Energy(if applicable)	± 1.0 %	± 2.0 %	± 3.0 %
Converted volume	± 0.9 %	± 1.5 %	± 2.0 %

The maximum permissible errors, positive or negative, for modules (parts or functions as stated in Table 3) are specified in Table 3. These values are applicable at type approval and at initial verification.

Table 3 - mpes for modules

Maximum permissible errors on:	Accuracy class A	Accuracy class B	Accuracy class C
Measuring volume at metering conditions	± 0.70 %	± 1.20 %	± 1.50 %
Representative calorific value determination	± 0.60 %	± 1.25 %	± 2.00 %

Moreover, when conformity to Table 2 cannot be verified directly, the conformity of the measuring system is assessed by calculation. By convention and where applicable, the global maximum permissible error of a measuring system is equal to the square root of the sum of the squares of the maximum permissible errors of the following modules (see Annex C OIML140 for an example):

- metering module (measuring the quantity at metering conditions);
- converting this quantity into volume at base conditions

Table 4 mpes for associated measuring instruments other than gas composition device

Maximum permissible errors on:	Accuracy class A	Accuracy class B	Accuracy class C
Temperature	± 0.5 °C	± 0.5 °C	± 1 °C
Pressure	± 0.2 %	± 0.5 %	± 1 %
Density	± 0.35 %	± 0.7 %	± 1 %
Compressibility factor	± 0.3 %	± 0.3 %	± 0.5 %

For Temperature, pressure, density and compressibility factor, the maximum permissible errors on the calculation of each characteristic quantity of the gas, positive or negative, are equal to one fifth of the relevant value specified in Table 4.

7.3 Other metrological performances of a gas composition device

Requirements from 7.3.1 through 7.3.6 and 7.3.9 apply to all types of gas composition devices. In addition, the provisions in 7.3.7 and 7.3.8 give additional requirements for specific types of gas composition devices.

7.3.1 General requirement

The complete gas composition device (not only the electronic part) shall fulfill the general requirements specified in part 13.

7.3.2 Repeatability

The repeatability error of gas composition device, as defined below, shall be smaller than or equal to one fifth of the magnitude of the mpe that would be applicable to the mean value of the measurement results.

Repeatability error :

For the purpose of this Recommendation: difference between the largest and the smallest results of successive measurements of a same quantity carried out under the same conditions.

7.3.3 Adjustment interval and drift

The drift at the end of the adjustment interval shall be smaller than or equal to half of the magnitude of the mpe. The adjustment interval and the adjustment procedure shall be specified by the manufacturer.

For gas composition device fitted with an automatic internal adjustment means, the means shall not be likely to drift and either the adjustment shall be performed automatically at the end of the adjustment interval or a warning calling for adjustment shall be generated automatically at the end of the adjustment interval.

7.3.4 Influence of the gas composition

The manufacturer shall specify the characteristics (limits of chemical composition) of the gas to be measured.

For gases of the same gas composition device, the influence of the composition shall be smaller than or equal to two-fifths (2/5) of the magnitude of the mpe.

Note: It is assumed that the uncertainties of the gas composition device of the calibration gases are consistent with the requirement.

7.3.5 Response time

The following provisions are applicable to the gas composition device itself and not to the gas composition device complemented with the sampling line.

Note: The delay due to the sampling line has to be considered as included in the uncertainty component U_T (shift in time).

7.3.6 Influence of gas supply

The manufacturer shall provide reference conditions and rated operating conditions for:

- Supply gas(es) pressure,
- Supply gas (es) flow rates.

7.3.7 Specific provisions applicable to Gas composition device

7.3.7.1 Influence of atmospheric pressure

The gas composition device shall be designed and manufactured so that it continues to operate as designed and so that its errors do not exceed the maximum permissible errors when it is subject to variations in atmospheric pressure.

The corresponding rated operating conditions shall be specified by the manufacturer.

7.3.7.2 Installation effects

The manufacturer shall provide any necessary information on the capability of the gas composition device to be subject to ambient air movements (draughts). The type approval certificate states any appropriate information.

7.3.8 Specific provisions applicable to gas chromatographs

A gas chromatograph shall be capable of measuring at least the following components:

- nitrogen;
- carbon dioxide;
- methane;
- ethane;
- propane;
- iso-butane;
- n-butane;
- n-pentane;

- iso-pentane;
- neo-pentane;
- Hexanes and superior.

If the manufacturer claims that a gas chromatograph is capable of measuring more components than those listed above, calibration gases shall be chosen accordingly. The measuring range shall be specified by the manufacturer. It shall not start at zero and shall not be nil.

7.3.9 Other influences for all technologies

The manufacturer shall declare other influences that have been identified. This declaration is checked at type approval taking into consideration the state of the art. To this end it is considered that an influence smaller than one-fifth (1/5) of the magnitude of the mpe is not significant.

Any significant influence (taking into consideration the state of the art) shall be specified in the type approval certificate, accompanied by relevant information.

Taking the above information into consideration, at type approval, initial verification or further verification, the Authority may:

- refuse the proposed gas composition device if it does not suit the real situation of the measuring system; or
- require significant influences to be taken into account in the uncertainty calculation; or
- Test other possible influences if it considers that the state of the art has not been respected (only at type approval).

8. Gas measuring system modules

Location type of Gas measuring system shall be in accord with IGS-M-IN-100(1).

When considering a measuring system individual modules shall be identified. All modules of the measuring system shall be under the same base conditions.

At the individual module level, the error displayed by a module can depend on the value of one or more input parameters.

EXAMPLE The error in volume at metering condition

Gas volume: measure the volume, this is one of the basic factors for determination of volume delivered. The volume measurement is at measuring conditions.

The absolute pressure within the meter has to be known for accurate conversion absolute) or attributed of the volume measured to the same base condition. This can be measured on site (gauge, absolute or attributed).

The absolute temperature within the meter has to be known for accurate conversion of the volume measured. This can be measured on site or attributed.

The compression factor is based on measurement and / or calculated.

8.1 Metering module

The meter(s) of a metering module shall comply with International standards, unless otherwise indicated in IGS meters standard(IGS-M-IN-104(1),IGS-M-IN-102(2), The maximum permissible errors laid down in this Recommendation are applicable to the metering module and not to the meter alone.

If a meter is likely to be overloaded given the supply conditions, a flow limiting device shall be provided. This device shall be installed downstream of the meter. It shall be possible to seal it(see 11). The flow limiting device may be mechanical or electronic.

If the system is fitted with heating devices upstream of the metering lines, a device shall keep the temperature within an acceptable operating temperature range, according to the conversion device used.

8.2 Parallel branches

Given the specified measuring range of the flow rate it may be necessary to consider several branches in parallel. Meters placed in parallel measuring branches shall not be able to influence the metrological characteristics of each other.

If there is a possibility to put parallel lines in series, the connections shall be arranged on the main pipes upstream and downstream of the straight lines required upstream and downstream of the meter. Generally, one isolation valve has to be placed upstream and another downstream (for instance, a stop valve with venting to the air) for each line.

8.3 Test possibility on site

The provision shall be made for using any recognized method such as master meter configuration proving system for checking and/or verifying the metering module on site in particular metering modules with Q_{max} equal to or greater than 50 000 m^3/h at base conditions .

8.4. Volume conversion as a function of density (density conversion)

In this case, the conversion device consists of a calculator and a density transducer. The volume at base conditions V_b is obtained by the relationship:

$$V_b = \frac{V \times \rho}{\rho_b}$$

V: volume at metering conditions
ρ: density at metering conditions
ρ_b: density at base conditions
ρ_b is provided in ISO 6976 .

8.5. Associated measuring instruments

In principle, the characteristic quantities of the measured gas used for the conversion shall be measured by means of associated measuring instruments.

However, depending on IGS standards, it is permitted that some of those quantities are

not measured at the measuring system location or that the associated measuring instruments are not subjected to a control when it can be demonstrated that the mpe requirements on the converted value are fulfilled. This demonstration is part of documented provisions

8.6. Installation

The conversion device shall be installed in a manner suitable for its application. The presence of the conversion device shall not affect the metrological integrity of the meter(s) and device(s) to which it is associated.

The conversion device and associated measuring instruments shall operate within their rated operating conditions.

The connections of the associated measuring instruments shall be in accordance with the manufacturer's requirements and type approval certificates.

9. Marking

Each measuring system, metering module, device or associated measuring instrument, which has been the subject of a type approval, shall bear, legibly and indelibly, either on the indicating device or on a special identification plate, the following indications, as far as relevant:

a) Type approval mark;
b) Manufacturer’s identification mark or trademark;
c) Name chosen by the manufacturer (not compulsory);
d) Serial number and manufacturing year; and, if applicable
e) Minimum flow rate, Q_{min};
f) Maximum flow rate, Q_{max};
g) Maximum gas pressure, P_{max};
h) Minimum gas pressure, P_{min};
i) Maximum gas temperature, T_{max};
j) Minimum gas temperature, T_{min};
k) Accuracy class;
l) Nature of the measured gas (es);
m) Minimum calorific value;
n) Maximum calorific value;
o) Climatic and mechanical class, I or O as defined in Annex A;
p) Appropriate information related to the determination of the compressibility factor.

If several meters are operating in one single system, using common elements, the indications prescribed for each part (element) of the system may be gathered on one single plate.

The indications, inscriptions or diagrams required by this Recommendation or by the type approval certificate, shall be written legibly either on the indicating device or close to it.

The measuring system designer shall ensure that markings identified on the indicating device of any meter which is part of the measuring system shall not contravene those on the identification plate of the measuring system (for example the range Q_{min} to Q_{max} indicated for the meter may not be greater than the corresponding range for the metering module).

10. Sealing

Sealing is preferably carried out by means of lead seals. However, other types of sealing are permitted on fragile instruments or when these seals provide sufficient integrity (electronic seals for instance).

Seals shall, in all cases, be easily accessible.

Sealing devices shall be provided on all parts of the measuring systems that cannot materially be protected otherwise against action likely to influence the measuring accuracy.

Sealing devices should prevent the parameters (among others, correction and conversion parameters) used for determining the measurement results from being altered when these parameters are not managed according to documented provisions or a quality assurance system providing traceability of modifications.

A stamping plate, the purpose of which is to receive the control marks, shall be sealed or shall be permanently fixed on the measuring system. This stamping plate may be combined with the identification plate of the measuring system.

10.1. Sealing devices

when access to parameters that participate in the determination of the results of measurement needs to be protected by mechanical seals, and the protection shall fulfill the following provisions:

a) Access shall only be allowed to authorized people, for example by means of a code (keyword) or special device (hard key, etc.); the code shall be changeable. However the National Authority may consider that a code is not sufficient;

b) It shall be possible to memorize all interventions between two verifications. The record shall include the date and a characteristic element identifying the authorized person making the intervention (see a) above). The traceability of interventions shall be assured for at least two years; if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

11. Design of gas measuring system

11.1. Structure

A gas measuring system shall comprise:

- a gas measuring installation,
- documented provisions; and
- Where appropriate, a gas metering station.

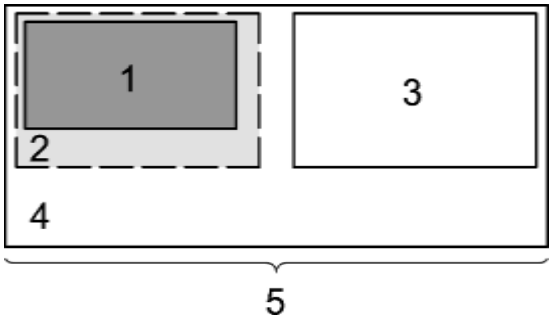


Figure 1 — Illustration of gas measuring system

Key

1 gas measuring installation
2 gas measuring station
3 documented provision
4 gas measuring system
5 output

The accuracy requirement for the system (i.e. the maximum permissible error) shall be determined applying.
When requested, the achieved accuracy of the system shall be available to involved parties to demonstrate compliance with the selected class.
The gas measuring installation should be located in a building, a compound, a cabinet or a shelter. Some higher capacity gas measuring installations can also be installed in open air, unless it unduly affects their integrity, operation, or accuracy. The advice of the manufacturer shall be sought to determine the appropriateness of installing the installation in such a location.

11.2. Housing

The design of a measuring station, including the layout, housing and materials for the housing, shall comply with the relevant requirements of NIGC Specifically and EN12186 and EN12279.
All meter housings shall be well ventilated and be adequate in size, layout and design to undertake all installation, commissioning and maintenance requirements.

11.3. Gas Measuring Station

A measuring station shall comprise:

- a measuring installation (see 12.5)
- additional components (see 12.14 and 12.18);
- Where appropriate housing (see 12.2).

11.4. External Influences

The performance of the gas measuring installation and housing when used in its specified operating conditions shall not be adversely affected by any expected external

influences, such as but not limited to:

- mechanical influences;
- electromagnetic influences;
- weather conditions,
- ambient temperature;
- Humidity.

11.5.Gas measuring installation and Construction

The design of the installation varies according to its required accuracy.

The measuring installation shall comprise a gas meter and one or more of the following components:

a) conversion device;

b) change-over equipment to select the appropriate number of meter runs to meet the actual load of the station;

c) Gas composition devices;

d) valves, pipes, gaskets and joints;

e) lagging for thermal insulation and noise reduction;

f) filters and separators;

g) electrical installation, lightning protection, earthing;

h) detection systems such as gas and / or fire detection

i) communication;

j) Others.

The design shall also take into account e.g. Vibrations, pulsation, noise. It shall ensure appropriate access/egress for inspection, removal or replacement of the gas meter.

In case of an emergency, it shall be possible to shut down the installation safely.

The capacity and the correct functioning of the installation shall be based on the minimum and maximum values for:

k) volume flow rate;

l) gas temperature;

m) velocity of gas in the meter run;

n) metering pressure;

o) acceptable pressure loss;

p) composition of the gas;

q) contaminants in the gas;

r) Internal diameter of the connection of the gas meter (to avoid steps in diameters and subsequent flow disturbances).

A gas measuring installation can be a stand-alone unit or connected with other gas installations (e.g. as part of a pressure regulating station).

Any additional connected installation or equipment shall not adversely affect the integrity of the gas measuring installation or its measurement.

Gas measuring installation shall be designed such that the correct functioning is ensured for all specified pressure and temperature ranges (i.e. MOP, TOP, MIP, minimal pressure at the inlet of the installation, T_{min}, T_{max}, ambient temperature) as well as where appropriate, impurities present in the gas.

Meters and the associated measuring instruments shall be handled with care because they are precision devices. They shall be stored in a clean and dry condition, taking due regard of the manufacturer's recommendations on storage and handling. The meter inlet and outlet connections shall be protected to prevent ingress of foreign material and moisture and shall remain until installation.

If required by regulation or contract, each measuring instrument shall be accompanied by a test and calibration certificate. It shall be confirmed that all components are suitable for the foreseen operational conditions to which they could be subjected.

All measuring instruments and additional components shall be installed in accordance with NIGC regulations and/or manufacturer's installation, operation and maintenance manual.

The installation of measuring instruments used in determination of Volume shall allow indexes and displays to be easily read. Relevant markings on additional components should also be easily read.

Prior to installation all relevant metrological seals shall be visually inspected to ensure they are present and not damaged.

Any tapping used for metrological input shall not be used for any other purposes. Any tapping and internal weld bead shall be such they shall not interfere with the flow profile upstream or downstream of the meter.

Alignment of pipe work and the correct placement of gaskets during construction are essential to avoid flow disturbances, especially in meter runs.

Gas pipe work shall be installed and supported in such a manner to avoid undue stress being placed upon any measuring instruments and additional components. Any temporary commissioning filters / strainer should be positioned upstream of mechanical gas meters in accordance with manufacturer's instructions. It shall be ensured that all swirl and debris have been removed from the pipe work

Low points in any sensing line or sampling line shall be avoided so that liquid or dirt cannot collect in them and cause false pressure readings.

All pressure containing components of the gas measuring installation shall withstand the strength test pressure. The strength test pressure is derived from the design pressure (DP) of the upstream system.

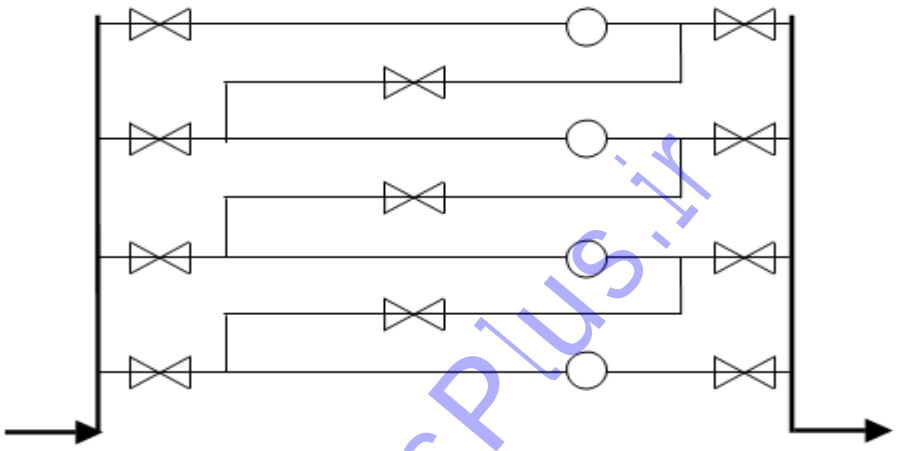
The technology selected for the gas measuring installation shall be sufficiently accurate to reduce random and systematic errors to such a level that contractual or legal obligations are fulfilled and that can be justified on technical and economic reasons.

The gas measuring installation shall be installed as close as possible to the point where the change of responsibility takes place.

For unidirectional gas measuring installation possible unwanted reverse flow during

operation should be avoided for example by installing a non-return valve.
Each meter run shall have its own upstream and downstream valves for isolation.
Where necessary, provisions shall be made to allow in-service verification of the measuring instrument(s), e.g:

- in case of multiple measuring lines of the same size and each with a single gas meter, it is recommended that parallel lines can be temporarily reconfigured in series – Z configuration;
- For metering systems with high financial stakes, it is recommended to make it possible to put two meter runs in series, in order to verify one meter against the other. The totality of the straight length will have to be included in the circuit.
- Following example for a 3-meter run unit, plus one stand by.



- Other metering schemes can be proposed to improve confidence in metering.
- spool for the installation of a temporary prover ;
- The use of meters with (self-) diagnostics capability.

EXAMPLE 2: Use mechanical indexes; no-break power for the whole installation, battery powered flow meters.
When continuity of supply is deemed to be essential the additional meter run (n+1 meter runs, where n is the number of meter runs needed for the design capacity), shall be considered;

11.6 Gas meters

The meter shall be selected so that it will operate correctly and safely under all operating conditions.
Any gas meter shall meet the NIGC specifications and safety requirements, related meter specifications are as following.
Gas meters installed under the scope of this Standard are generally of the following types:

- ultrasonic for custody transfer conforming to IGS-M-IN-104(1)
- turbine conforming to IGS-M-IN-102(2)
- Orifice plate conforming to AGA R NO.3

When selecting a meter consideration shall be given to the required:

- flow rate (expected minimum and maximum);
- accuracy class;
- pressure rating (P_{max});
- pressure loss across the meter at the installation's designed flow rate;
- suitability for the installation pipe work configuration;
- resistance to fluctuations of the flow rate;
- any pressure absorption limitations;
- Turndown ratio (Q_{min}/Q_{max}).

The effective turndown ratio (Q_{min}/Q_{max}).of the gas measuring installation could be affected by over-sizing which can influence the meter's accuracy.
Furthermore for some meter types, when calibration and operating conditions are different, correction should be considered in order to take into account the effect of gas pressure and temperature on the gas meter.

11.7 Gas meters with additional functionalities

The gas meter system can be designed with additional functionalities:

a) Functionality 1: Remote reading of metrological register(s) and provision to NIGC relevant organizations;
b) Functionality 2:Two-way communication between the metering system and NIGC relevant organization(s);
c) Functionality 3: To support advanced terrifying and payment systems;
d) Functionality 4: To allow remote disablement and enablement of supply and flow / power limitation;
e) Functionality 5: To provide secure communication enabling the meter to export metrological data for display and potential analysis to the end consumer or a third party designated by the end consumer;
f) Additional functionalities can be provided by attaching an additional functionality device to the meter or by directly incorporating these functionalities into the meter. Meters can be provided with devices such as; pulse transmitters, serial or wireless interface for transmission of measured quantity to other equipment such as totalizers, recorders or communication equipment.
Transmitter range and pulse significance shall be suitable for the application.

11.8 Sampling

Sampling and its system shall be in accordance with IPS-E-IN-230(2012), IPS-G-IN-230(2012).
The line shall be heat traced and insulated. The transit time between the sampling point and the analyzer shall be smaller than 1 minute. The analyzers shall be located in an air conditioned cubicle.

The status and performances of the analyzers shall be reported on a daily basis. The gas diverted for analysis shall be added to the quantities if it is not re-injected in the main line.

11.9 Gas pressure measurement

Pressure transducers and their installation shall comply with IPS-M-IN-110 In order to ensure accurate measuring; care shall be given to the design of the installation of pressure transducers to avoid mechanical vibrations and presence of liquid inside the sensing line. It shall be designed so that the pressure measurement can be verified using an additional appropriate pressure measurement means (tap or T connection) at the pressure measurement point.

Field maintenance, checking and recalibration require the possibility to isolate the sensor from the line with a valve without the need to shut down the whole installation and to apply a reference test pressure. Any valve in the sensing line should be capable of being sealed in the appropriate position to prevent unauthorized operation.

The pressure connections for differential pressure transducers should preferably be separated from all other pressure connections.

Mechanical stress shall not be applied to the sensor by the installation or by the sensing lines.

11.9.1 Gas pressure measurement Class A and Class B

Pressure can be measured with absolute pressure transmitters or gauge pressure transmitters.

For Class A an absolute pressure transmitter or a gauge pressure transmitter in combination with a barometric pressure transmitter shall be used.

For Class B, if gauge pressure transmitters are used it should be considered whether a barometric pressure transmitter or a fixed value for the atmospheric pressure is applied. When a fixed atmospheric pressure is applied the extra measuring uncertainty as a consequence should be taken into account.

Every pressure transmitter shall have its own continuous sensing line and shall not be combined with any other additional component.

The heights differences between the sensing point and the transmitter shall be as small as possible to avoid any significant effect of gravity on the pressure measurement.

11.9.2 Gas pressure determination Class C

Documented provision shall include how the absolute metering pressure is determined. Any pressure value used in these documented provisions could be derived from using a combined of the following:

a) set point of the upstream pressure regulator including Its accuracy and flow rate range;
b) average absolute / atmospheric pressure;
c) altitude of the location of gas measuring installation; or
d) a volume conversion device is used.

11.10 Gas temperature measurement

Temperature transducers and their installation shall comply with IPS-C-IN-120.

The gas temperature shall not adversely affect the performance of the gas meter and shall be kept within the operating range of the measuring instruments.

If thermo wells are used, they should protrude into the pipe work by about one third of the nominal bore. However, on diameter pipes larger than 300 mm and/or where resonant vibrations of the thermo well are known to be a possible problem, the design of the thermo well can restrict the depth of insertion.

Thermo wells shall not introduce any flow perturbations that influence the measurement accuracy. Therefore the thermo well shall be positioned downstream of the gas meter. To ensure a representative gas temperature measurement, any thermo well shall be protected against the ingress of water and be provided with the correct amount of heat conducting material at the sensor tip.

In order to ensure that the measured temperature at the thermo well is the same as that of the gas passing through the meter, it can be necessary to insulate the external part of the thermo well and the pipe work for a suitable distance downstream and upstream of the meter. The necessity to do so depends on the expected differences in gas and ambient temperature in a specific measuring station and on the desired accuracy.

Where attribute values are used for metering temperature (T), the documented provisions should be derived from a representative analysis of gas temperatures.

11.11 Conversion device

Conversion devices shall comply with IGS-M-IN- 106.

Conversion devices shall be directly connected to measuring instruments, when used for pressure and temperature, and where appropriate gas composition device(s). Any interfaces and connections fitted within the conversion device allowing connection of complementary devices shall not corrupt the metrological behavior of the device.

When different conversion devices are combined care shall be taken to ensure all calculations used are consistent.

In some cases it can be sufficient to use a fixed value within the conversion devices for temperature, pressure and gas composition for conversion (see Annex C OIML 140). These values shall be included within the documented provisions.

11.12 Volume conversion device

Volume conversion devices shall meet the requirements of IGS-M-IN-106 and be installed in accordance with manufacturer´s instructions.

For Class A the compression factor shall be calculated with live pressure, temperature and gas composition as the input.

For Class B depending on the metering pressure, the compression factor should be calculated with live pressure, temperature and a representative gas composition. When calculating the compression factor, for higher pressures and variations of the gas composition and properties it is important to obtain accurate determination of the gas composition.

For Class C the compression factor shall be calculated manually in defined temperature, pressure and a representative gas composition.
Depending on the gas composition ISO 12213-1 or ISO 12213-2 or ISO 12213-3 can be used; the operating range for ISO 12213-2 is more limited.

11.13 Pipe work requirements

In order to obtain acceptable velocity profile reference shall be made to the manufactures instructions and specific remarks given in Annex A EN 1776. In addition to Annex A EN 1776 the following should be considered:

a) The required upstream and downstream pipe section and the gas meter needs to have the same nominal diameter. Whether a flow conditioner is recommended or not, the manufacturer has to provide evidence of what minimum pipe lengths are required;

Flow conditioners can be also proposed and used to reduce size and / or improve metering accuracy provided the design is based on accepted practices and / or tests. For orifices the straight length for all type of meters shall be according to related standard. Deviations from standards should in that case be submitted to COMPANY specialist's approval based on clear references and / or on CFD studies.

The meter run shall be insulated from the flow profiler, along the straight length and the meter, down to 5D after the thermo wells.

• A strainer with 3 mm mesh, fitted with a differential pressure device able to trip an alarm in the operator interface,

a) any valve located just at the beginning of the required upstream straight pipe of the meter, section needs to be of a full bore type;

Necessary valves and elasticity shall be provided on the headers and on the meter runs to make it possible to dismount a run or add a new run, the unit being in operation.

b) if a pressure regulator is installed upstream of a meter, precautions need to be taken with respect to the sensitivity of the meter for noise and flow perturbation;

c) where appropriate, the use of pipe fittings or equipment should not produce significantly asymmetric velocity profiles and/or swirls;

d) If applicable, for Class A, the meter run should be thermally protected to minimize the influence of ambient temperature on velocity profile particularly at low flow rates.

In order to avoid noise, vibrations and/or erosion problems; the internal diameter of the pipe work of the gas measuring installation shall be calculated for gas velocities, which shall not exceed 20 m/s in the pipe work.

11.14 Valves

Any valve shall be suitable for its intended use. Where the meter or any additional component could be damaged through excessive flow rates (during commission and re-commissioning) a slow opening valve shall be used. All valves selected shall provide, when closed, internal gas tightness seal. Valves shall comply with IGS-M-PL-010-part 1:4.

Any piping that is likely to divert the gas around the meters or after it has been metered must be fitted with a "double block and bleed" system (combinations of valves and blind

flanges are acceptable depending on the practicality of the operations).

11.15 Parallel meter runs

Where a gas measuring installation incorporates more than one meter run, each run shall have its own upstream and downstream isolation valves.

Meter runs of different sizes within the same measuring installation shall not be used simultaneously if this will cause over speeding of any gas meters,

Appropriate to the application, the number of parallel meter runs should be such that the maximum flow rate can be measured with one meter out of service whilst the rest of the meters operate within their specifications.

If there is a meter run for series connection this shall tie into the main runs upstream and downstream of the required upstream and downstream straight length of the meter.

When a meter run is not in operation it shall be isolated such that the meter does not indicate any flow.

It shall be possible to measure the nominal flow rate with one line stopped, in standby mode, ready to be put into operation in case of a failure in another line or if the flow rate in another line exceeds the range where the specified accuracy is obtained.

Any measurement fault on a line (failure of the flow computer, of the measuring device, a pressure or temperature transmitter, etc.) shall cause the line to be automatically isolated and the backup line put into operation. In the cases where isolation could cause technical problems or damages, only an alarm shall be raised.

11.16 Consistency of measurement (Duplication of measuring instruments)

Depending on CLASS and accuracy requirements of the gas measuring installation and in order to increase the availability, the reliability and the confirmation of the results from measurement, measuring instruments should be duplicated and should operate independently.

EXAMPLE Double calculation for orifice meter, dual configuration ultrasonic meter or series connection for meters can be adopted.

The criteria to duplicate measuring instruments shall be agreed upon between the involved parties.

Several measurements that should read the same in normal operation shall be compared on a real time basis. In case of a discrepancy, an alarm shall be raised and a print out of all data required for a manual calculation shall be initiated.

- P & T:

For measuring system class A each temperature and pressure used to calculate the quantities shall be measured by two separate devices. One device shall supply the measurement required for the calculation and the other shall check the measurement. If this “Pay and Check” system is not economically justified, a validation of the measurements may be done by software comparison between the measurements of devices that should give the same readings (for instance the TT’s that are on the various meter runs).

- Flow rate:

The flow rate measured by each run shall be recorded over time. Any deviation

of the percentage flowing through each run for a given configuration shall raise an alarm

11.17 Pulsations and vibrations

Pulsations and/or vibrations shall not affect the gas measuring results beyond agreed tolerances. These phenomena shall be taken into account.

a) compressors, especially piston-type compressors;
b) piping layout generating resonances and/or
c) pressure regulators;
d) Volumetric/flow regulators.

When designing a measuring installation the effects of pulsation shall be checked. The following components can have an influence on the gas meter.

The influence of pulsations can be reduced by increasing the distance between the meter and the pulsation source or by using suitable pulsation dampers or by isolating the gas meter or by choosing less sensitive technologies.

EXAMPLE Tees, flow conditioners, change of diameters

The sensitivity characteristics of the installed gas meter shall be taken into account with view to pulsation frequency, noise and others.

Vibrations can arise when the mechanical natural frequency of the pipe system is equal or very close to the excitation frequency caused by components as mentioned, by the gas meters themselves or by flow induced pulsations.

To prevent or minimize vibration effects on the gas meter, appropriate calculations for the whole gas measuring system should be done, preferably at design stage.

Recommendations for specific flow meter types:

11.17.1 Turbine Meter

A turbine meter should not be used to measure flows which are rapidly pulsating, nor should they be used where total metered gas flow is on/off, unless the on-time is greater than 30 minutes. The positioning of any compressor is critical to ensure that the measuring installation is not adversely affected by pulsations.

11.17.2 Ultrasonic meter (Non-Domestic)

An ultrasonic meter shall not be where they are influenced by noise generated from pressure regulators, compressors or valves etc., without sufficient noise damping.

11.18 Filter

Dust, borne solids and/or fluids should not influence the results of measurement, therefore, where required, suitable filters and/or separators should be fitted upstream of the meter.

11.19 Gas conditioning, hydrate protection

According to ambient temperature and natural gas condition(gas temperature, dew point) , If pressure reduction or flow control cause hydrate or ice formation which affects

the operation of the measuring installation, a pre-heater shall be fitted or other suitable means shall be employed.
If any pre-heating is applied care shall be taken that the measurement results remain within their accuracy limits.

11.20 Ventilation

When the gas measuring installation is located in a housing, ventilation shall be adequate to ensure any minor escape of gas and does not built up to an explosive limit.

11.21 Odorants and/or additives

The addition of odorants and/or other additives used for gas treatment, e.g. for drying of the gas, shall not affect the performance and accuracy of the gas measuring installation. If odorants are injected at the same installation, the injection point should be located after the meter runs.

11.22 Electromagnetic compatibility (EMC)

The electrical and electronic sub-systems, the instruments and equipment used at the measuring installation shall comply with the requirements for electromagnetic emission and immunity stated in the applicable standards of the EN 61000 series.
It shall be ensured that electromagnetic effects do not adversely affect the metrological and operational performance of the measuring installation

12 Electronics And Electrical

12.1 Requirements

12.1.1 Electronic measuring systems and devices shall be designed and manufactured so that they continue to operate as designed and so that their errors do not exceed the relevant maximum permissible errors under rated operating conditions and which are defined in 7.2.
12.1.2 Electronic measuring systems and devices shall be designed and manufactured in such a way that no significant faults occur when they are exposed to the disturbances specified in Annex A of OIML R140.
12.1.3 The requirements 13.1 to 13.2 shall be met durably. For this purpose, electronic measuring systems shall be provided with the checking facilities specified in part 9.3 OIMLR 140 However, this requirement is not applicable to the internal securing (internal checking facilities, etc.) of gas meters designed in conformity with an OIML International Recommendation.
12.1.4 A type of a measuring system or device is presumed to comply with the requirements in 13.1.1 to 13.1.2 if it passes the tests specified in 17.6.
12.1.5 Measuring systems shall permit the retrieval of the information relating to the measured quantity contained within the instrument before a significant fault occurred and was detected by the checking facilities.
12.1.6 Electrical connections should be clearly identified. If they are intended for use

with separately approved peripheral equipment, they shall conform to the electrical interfacing standard used by the peripheral equipment to transmit their information. Compatibility will not only include the electrical levels and signal shape but also the communication protocol in use.

12.2 Power supply device

12.2.1 External power supply (AC or DC)

In case of failure of the external power supply and, if provided, before failure of the emergency power supply, the latest measured parameters and alarms shall be recorded.

12.2.2 Battery powered device

The manufacturer shall specify the minimal duration of functioning without replacing the battery under the following conditions:

- maximum allowable frequency input from the meter;
- minimum ambient temperature;

P_{max} and Tmin.

The instrument shall indicate that the battery or any form of electrical supply has to be recharged or replaced before 90 % of the life or of the estimated life of the battery has been exceeded.

The replacement of the battery shall be possible without breaking any metrological seals of the device. Separate seals may be provided for the battery enclosure.

During the battery exchange the following information has to be retained (when applicable):

- the energy;
- the volume at base conditions;
- the mass;
- the volume at metering conditions;
- the corrected volume;
- the calorific value;
- the alarms indications;
- the event logs;
- the entered data specified in 8.7.1.

The type of battery, capacity shall be specified by the manufacturer and approved by the end user.

13 Memory device

13.1 Storage unit

Measuring systems shall be fitted with a memory device to store measurement results at least 6 months for class B and 1 year for class A until their use or to keep a trace of commercial transactions, providing proof in case of dispute. Devices used to read stored information are considered as included in the memory devices.

13.2 Media reliability and capacity

The medium on which data are stored must have sufficient permanency to ensure that the data are not corrupted under normal storage conditions. There shall be sufficient memory storage for any particular application.

13.3 Exhausted storage capacity

When the storage is full, it is permitted to delete stored data when both the following conditions are met:

- data are deleted in the same order as the recording order and the rules established for the particular application are respected;
- Deletion is carried out after a special manual operation.

13.4 Data storage protection

Memorization shall be such that it is impossible to modify stored values without breaking the seals or similar actions.

14 Arrangement of the computing system

14.1 Flow computers

Each run line depends on the flow computer type (model 1 or 2) able to calculate the quantities, store the results and print out the measurement ticket and the parameter report on a daily basis. All these

Operations shall be possible even in case of a failure of the supervisory computer(s) or the data network.

The flow computer shall be designed to take into account the calibration curve of the measurement device.

A manual control of the valves from the flow computers shall be possible.

The spare meter run shall be equipped with a dedicated flow computer identical to other meter runs.

- Supervisory computer
- A supervisory computer for class A or B (if required) shall:
- Centralize the measurements taken by all the flow computers of the lines in service.
- Control the sampling units and analyzers.
- Print out automatic periodic reports (the daily and hourly reports, the event and alarm
- reports). A printer shall be dedicated to the reports requested by the commercial agreement and a second one to the other reports. In case nothing is specified, the daily report shall be printed on one printer, the hourly, alarm and event reports on the other printer.
- Print out intermediate reports (systematically and at the operator's request), the alarms and the configuration of the flow computers.
- Store all historic data, trends, reports…
- Allow for the control of the metering unit by an operator.

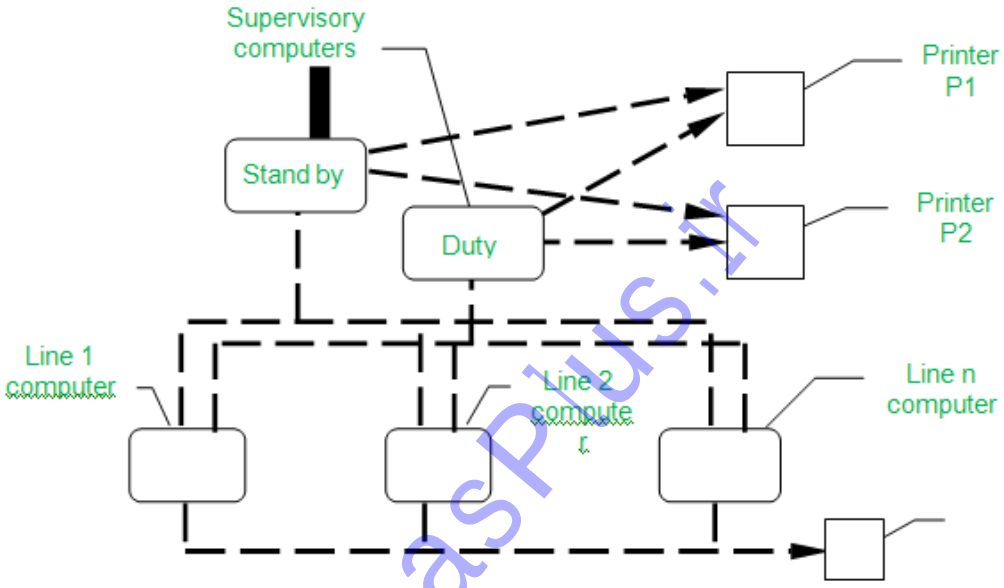
14.2 Enhanced availability for class A

Dual redundancy at the supervisory system level can be applied if extreme availability is requested.

"Hot redundancy" of supervisory computers shall be avoided because it is extremely difficult to make it reliable. Manual switching on of a spare computer standing next to the duty one shall be preferred.

The robustness of the supervisory system shall be evaluated through its sensitivity to spurious power shut downs and communication failures applied randomly at any device of the network. It is recommended to reject a system that could not cope with that.

Recommended bloc diagram for an enhanced availability computing system:



Dual redundancy shall be applied to the communication network too.

15 Documentation & Reporting

15.1 Reporting

The symbol or the name of the unit shall appear in the immediate vicinity of the indication.

The measuring system shall be provided with devices capable of indicating measurement results (indicating, printing or memory devices) the total quantity of volume, for each meter line where appropriate, the following information:

- the volume at base conditions ;
- the gas quantity at metering conditions;
- the corrected quantity, if applicable;
- the correction values, if applicable;
- the quantities measured by other associated measuring instruments (for example:

- pressure, temperature, and composition);
- the alarm indications;
- the conversion factor, if applicable;
- the ratio of the compressibility factors Z/Zb;
- any input data affecting the metrological results.

Moreover, when a printing or memory device is required or used to ensure this availability, there shall be provisions to allow for automatic printing or memorizing at predetermined time intervals. The printing and/or memory device(s) shall be capable of printing and/or memorizing thermodynamic
parameters, totals, starting and ending time of the various alarms as well as all relevant information to establish the chronology of the metering events for example printed sheet numbering, date, hour, etc.

15.2 Documented provisions

The documented provisions shall provide clear, transparent, objective and traceable calculations of the amount of volume delivered by the measuring system. The provisions shall include as necessary the following:

a) a clear description of which input parameters are required and how these values are used to calculate the volume delivered by the measuring system so that a competent person can reproduce the results . a clear description of the uncertainty calculations .

b) objective and traceable values for all input parameters not directly given by the measurement instrument readings and which attributed values are used and how these values are obtained;

c) a description of the general layout of the gas measuring installation and which readings/values are used for Volume calculation;

d) keep sufficient records, of all measuring data and relevant parameters for the specified/required period of time, to enable to reproduce the calculations;

e) a description of how to deal with missing or rejected instrument readings and include a procedure describing how Volume will be recalculated in case of error;

f) a procedure for the estimation of the gas quantities should the meter fail to measure the gas consumption.

15.3 Data handling

Within these provisions, data handling shall have the following functionalities:

a) acquisition of data;
b) storage;
c) monitoring;
d) reporting;
e) Verification and corrections.

Furthermore, the data handling shall provide procedures:

f) for approval of the measuring data from the gas measuring installation(s); and

g) For parameters for the determination of the accountable

Volume amounts. Data handling can have the other additional

parts and/or functionalities:

h) system and/or procedures for the determination of Volume with respect to gas measuring installations without local gas quality determination;

i) Recording of all actions and incidents relevant to the performance of the measuring system.

The data transmission shall not compromise the integrity and completeness of the measuring data. When measuring data, programs or commands are transmitted from the measuring installation to another location or vice versa, for further processing or storage, the transmission shall be done by secure and tamper-proof methods or channels.

The content of the data transmitted shall be transparent and only be shared with the contracted parties. Precautions shall be taken to ensure that any commands received shall not put the installation into an unsafe mode or cause unrecognized errors in the measuring system, even in the case of incomplete, interrupted or corrupted communication.

Any data or manipulation during or immediately before or after data transmission (e.g. upgrading completion) the methodology shall be transparent and traceable and shall be described in the documented provisions.

The unit shall be supplied with:

• A dossier containing all information needed for the approval of the authorities of the country where the unit is to be installed.

• The unit documentation, including the operating and maintenance manuals in English language .

• The certificates issued by the MANUFACTURER or his SUBCONTRACTORS stating that the equipment complies with the specified standards.

• The certified calculations of an independent, professionally recognized authority showing that the equipment and procedures used by the MANUFACTURER are capable of

Measuring to the degree of uncertainty specified in the section entitled "Uncertainty on quantities measured". (as per ISO 5168 or equivalent)

• The calculations of the acceptable variations in flow rates with regard to the choice of the measurement technique.

• The report of the initial calibration of the turbine or of the ultrasonic meter (if any), produced by an independent authority.

• The factory acceptance test report.

• Availability calculations.

• A first version of metering unit handbook.

16 Testing of the gas measuring installation/station

The test procedures shall be submitted to the supplier for comments at least 50 days before the planned date of the FAT.
The report of internal tests shall be sent together with the confirmation of the date of the tests. All tests shall be witnessed by supplier specialists.
The testing shall include the following:

16.1 Strength and tightness test

Strength and tightness tests of measuring installation station shall be carried out according to ASME / ANSI B31.8 or NIGC procedure

16.2 Factory acceptance tests of the unit

The FAT of the unit at the factory shall include the verification of the calculations and of the operator interface. It shall also include spurious power shut downs of each device of the system, to verify that the system can recover automatically as soon as the power is restored.

16.3 Site acceptance tests

The SAT shall include a check of the repeatability of the meters putting two lines in series, design of the unit permitting.

16.4 Test report

A test report including the strength and tightness test results of measuring station shall be compiled and retained, containing the following information as a minimum:

a) the identity of the authorized person responsible for the test;
b) the date of the test;
c) the owner and the names of fabricators of the gas measuring installation /station;
d) identification of the section to which the test relates;
e) the design pressure;
f) the strength and tightness test pressures reached during testing and the time for which
g) this pressure was maintained;
h) the test medium;
i) a reference to the testing procedure;
j) The test results.

The test report shall be retained until the gas measuring installation /station is taken out of service or has been re-tested and new test report has been filed.
A measuring system shall always be examined on the site of use. In any case the measuring system in use has to fulfill or has to be assumed to fulfill the applicable requirements.
This means that tests should be performed on site too. However, in particular in the case of a meter or a metering module, tests on site are in general difficult or impossible to

perform. For this reason, the National Authority may decide that tests are performed in the laboratory.

When a test is conducted, the expanded uncertainty, *U* (for k=2) for the determination of errors on indications of volume shall be less than one-third of the maximum permissible error applicable at type approval, at initial and at subsequent verifications. However, the uncertainty never needs to be less than 0.3 %.

In the case of an electronic measuring system, the application shall also include:

- when provided, a description of the electronic seals;
- a functional description of the various electronic devices;
- a flow chart of the software, explaining how the electronic devices work.

16.5 Type approval for an electronic device

In addition to the examinations or tests described in the preceding sub clauses, an electronic measuring system or an electronic constituent element of this system shall be subject to the following examinations and tests.

16.6 Performance tests

These tests aim at verifying that the measuring system or the device complies with the provisions in 9.1.1 and 9.1.2 in OIML R 140 with regard to influence quantities. These tests are specified in OIML-140 Annex A.

a) Performance under the effect of influence factors:

When submitted to the effect of influence factors as provided for in Annex A, the equipment shall continue to operate as designed and the errors shall not exceed the applicable maximum permissible error.

b) Performance under the effect of disturbances:

When submitted to external disturbances as provided for in Annex A, significant faults shall not occur.

Equipment under test (EUT)

The electronic devices shall be submitted separately for testing and shall comprise, as far as metering modules are concerned, at least the following devices:

- flow measuring device;
- calculator;
- indicating device;
- power supply; and
- Correction device, if any.

This equipment has to be included in a system enabling a representative simulation of the normal operation of the measuring system. For example, an appropriate device may simulate the gas movement.

16.7 Type approval for an ancillary device

16.7.1 When an ancillary device that repeats primary indications is intended to be

approved separately, its indications shall be compared with those provided by an indicating device that has already been approved and which has the same scale interval, or a smaller one. The results shall satisfy the provisions in 7.1.4.5 OIML R 140.
As far as necessary, conditions for compatibility with other devices of a measuring system are stated in the type approval certificate.
16.7.2 Electronic devices may be approved separately when they are used for the transmission of primary indications or other necessary information. For example: a device which receives information from two or more calculators and transmits it to a single printing device.When at least one of the signals of this information is analog, the device shall be tested in association with another device whose maximum permissible errors are specified in this Recommendation.
When all the signals of this information are digital, the above provision may be applied; however, when the inputs and outputs of the device are available, the device may be tested separately, in which case no error shall be introduced; only errors due to the testing method may be found out.
In both cases and as far as necessary, the required conditions for compatibility with other devices of a measuring system are stated in the type approval certificate.

16.8 Initial verification

The initial verification consists in verifying that the measuring system fulfils the full set of metrological requirements applicable to the measuring system on the site of use.
*Note:*This does not mean that each provision in this Recommendation is checked at initial verification and that each test or examination is performed on the site of use (see 10.1.1 of OIML R 140).

17 Pre-commissioning and commissioning of the gas measuring installation

Some gas measuring installations consist of complex mechanical and electronic equipment which shall be properly commissioned to ensure that it meets its design specification in operational service.

Verification of gas measuring installations shall be carried out in accordance with NIGC requirements and/or the manufacturer's installation, operation and maintenance manuals.

17.1 Pre-commissioning checks

Pre-commissioning checks shall be undertaken before the gas measuring installation is commissioned. Any specific pre-commissioning checks defined by the manufacturer shall be undertaken.
Pre-commissioning checks and verifications shall be carried out according to ANSI/ASME

It shall be confirmed that the installation has been successfully pressure tested, purged and sufficiently dried. The installation shall be inspected visually to ensure that it is complete,

undamaged (incl. seals), correctly Aligned and in accordance with the design. In particular the automatic and manual isolation and vent valves Shall be checked to ensure safe and reliable operation.Certificates for all measuring instruments (meter, conversion device, etc.) and for all electrical systems shall be available, as appropriate.
Cabling in hazardous areas shall be checked to ensure that they comply with the appropriate standards, manufacturer requirements and NIGC requirements.

17.2 Electrical or electronic system

The gas measuring installation shall be commissioned in accordance with EN 60079-17 "Explosive atmosphere Electrical installation, inspection and maintenance".

17.3 Commissioning and re-commissioning

When commissioning or re-commissioning the installation shall be pressurized and the performance of the complete measuring installation and its correct functioning in the system shall be verified. Care shall be taken when opening the valves to ensure that the meter is not subjected to excessive pressure differentials or subjected to over-speeding. This is particularly important when pressurizing large downstream pipe work volumes through turbine meters.
Before commencing any tests or verification on equipment located in temperature controlled areas, the tested equipment shall be left in an energized state for sufficient time for the temperature to stabilize.

17.4 Gas meters

A check shall be carried out to ensure that the instructions and requirements given in the manufacturer's operation, installation and maintenance manuals are applied correctly.
EXAMPLE 1 lubricating oil, pressure difference, etc.
Where applicable, all output signals from the meter shall be checked against the primary indicating devices.
Example 2 primary indicating devices can be a meter head index.
Visual inspection of the meter and its associated inlet and outlet pipework shall be carried out. Temporary commissioning filters/strainer should be positioned upstream of mechanical gas meters.
For Ultrasonic meters a check shall be made to ensure that there is a zero reading (no counting below low-flow cut off) on each chord when the meter is isolated from any flow; see IGS-M-IN- 104 (1) where requirements on field tests are described.
The ultrasonic meter can be connected to the volume conversion device (VCD) with a digital/analogue or pulse signal. When the signal used for the meter at the calibration facility is different from the signal used at the gas measuring installation, it should be checked that the flow rates given by both signals are the same.
NOTE 1 This can occur if the calibration facility uses the pulse output and on-site the serial port is used or vice
During commissioning and re-commissioning a check should be undertaken to monitor the

performance of the ultrasonic meter. If the ultrasonic meter has diagnostic tools it is recommended to bring those into service. There are two main parameters:

a) Speed of sound
b) Velocity profile.

The speed of sound of each chord shall be compared with the computation results based on the analysis of the gas composition and operational conditions. This check shall be used to verify the performance of the metering installation.

A comparison shall be undertaken between the velocity profile in the meter at the calibration facility with the profile given on site and ensure it is within the specifications.

The orifice plate shall be examined to ensure that it complies with AGA R NO.3 and no damage has occurred during its installation.

It shall be verified if formulae and discharge coefficients used for the computation of volumes based on pressure differential are correctly entered into the VCD according to the AGA R NO.3

17.5 Instrumentation

Any sensors and all additional components forming a measuring chain shall be verified as a single unit. Prior to the verification. a check shall be undertaken to ensure components are undamaged and correctly connected.

EXAMPLE These can include interfaces, signal convertors, power supply units, including cabling and other electronic equipment, the display, monitor, recorder or printer etc.

All verification results shall be recorded at the time of verification including all relevant prevailing operating Conditions.A check shall be undertaken to ensure that all instrumentation contributing to the end results of measurement ave been calibrated with traceability to a NIGC specification or international standard.

17.6 Conversion device

A check shall be carried out to ensure that the relevant constants and formulae have been properly configured into the conversion device in accordance with the agreed specifications/NIGC requirements and that it performs all calculations correctly.

17.7 Full functional test

Following the verification and calibration of the instrumentation, a full functional test shall be carried out on the gas measuring installation.

NOTE This test confirms the overall working of the installation including the sensors, the signal transmission, the analogue to digital conversion and the flow computation and checks if the results of the conversion are correct.

17.8 Initial comparison check

When measurement is duplicated the difference between all of used measurement

instruments and calculations to determine Volume shall be within the agreed limits.

17.9 Acceptance, documentation and hand-over

In line with the requirements of the contract, the responsible person for the system shall ensure that the owner of the system accepts the gas measuring system and is provided with sufficient written documentation concerning commissioning and re-commissioning in form of a technical file (for generic installations a master file may be acceptable). This has to be appropriate for the size and complexity of the system in order that the system may be used and maintained by the user in a safe condition.
Any technical file shall confirm at least the following:

a) successful commissioning of the installation has been undertaken;
b) all technical documentation, including drawings, all operational manuals, type approval, calibration and material certificates, etc., have been handed over;
Minimum documents are included: information on type of meter installed, index reading, meter serial number, etc.
c) all appropriate safety warning notices have been displayed;
d) exponential bonding of metal structure have been verified;
e) where appropriate, explosion protection documentation, including any classification of hazardous areas are available;

f) where appropriate, any changes to the point of custody transfer;

17.10 Commissioning checks

If commissioning checks are required as part of the commissioning procedure they shall be done by EN 1776 part10.1, 10.2, 10.3 and 10.5.

18 Checking facilities

18.1 Action of checking facilities

The detection by the checking facilities of significant faults shall result in the following actions, according to type:

Annex A
(Informative)
Guideline for meter station

Table A.1 provides an outline of characteristics of commonly used gas meters. It is not intended to be used as a rigid procedure to make a choice of a gas meter for a certain application, but to serve as a list of the points of attention when considering the layout of a gas measuring installation. It should not be treated as exhaustive.

Table A.1 — Guidelines for meter station

Applicable factors	Turbine meters	Ultrasonic meters	Orifice meter
Product	IGS-M-IN-102(2)	IGS-M-IN-104(1)	AGA 3
Gas density at operating conditions	Measuring range will increase with higher density	Low density can cause drop out	Flow range depends on density, as dp depends on mass
Gas borne solids	Blades may be damaged and freedom of rotation may be affected.	Deposits with impact on internal geometry / measurement	Deposits and abrasion possible.
Filter	Filter required	Filter recommend	Filter required
Electrically power requirement	yes	Yes	Yes
Pressure absorption (using air)	Medium	None	High **mbar**
	max 15 mbar	negligible	200 …500 Mbar
Rapid pressure and flow variations	max permitted rate 350 mbar/s	Depending on the frequency	Rapid pressure variations may cause damage.
	Rapid flow variations cause measure errors; particularly rapid flow reductions cause over reading		
Overload	Overload possible for a short time, according standard	Overload possible.	Overload possible.
Upstream DN	Relevant standard and manufactures instructions	Relevant standard and manufactures instructions	Relevant standard and manufactures instructions
Downstream DN	Relevant standard and manufactures instructions	Relevant standard and manufactures instructions	Relevant standard and manufactures instructions

Increase of the nominal capacity	Increase in maximum flow needs larger meters or additional streams or higher pressure.	Increase in maximum flow needs larger meters or additional streams or higher pressure.	Increase in maximum flow needs larger meters or additional streams or higher pressure.
Meter failure	No effect on the continuity in gas supplying	No effect on the continuity in gas supplying	No effect on the continuity in gas supplying
Pulsating flow	May cause measuring failure	Measurement unaffected (as long as the measuring rate is high enough)	May cause measuring failure
Environmental sensitivity	May be sensitive to high frequency pulsation (or their harmonics)	May be sensitive to fluid borne ultrasonic noise when its frequencies are close to the meter working frequencies	May be sensitive to high frequency pulsation (or their harmonics)
Typical turn- down ratios inside the permitted limit of error	20:1 to > 30:1 Turn down ratio will increase with higher density	>30:1	3:1 to 5-1
Maintenance requirements	Maintenance free or lubrication as per Manufacturer's instructions	Minimized when equipped with smart self-diagnostic means	Recommended particularly for orifice plate
Emitted noise	Can be noisy at high flow rates and/or high pressure	Not an issue	Can be noisy
Internal vibration	Not an issue	Not an issue	Not an issue

Space required for the meter and its upstream / downstream pipe work	Length of upstream / downstream straight pipe work as per the results of type test declared by the manufacturer. It is necessary to consider if high or low flow perturbation occurs	Length of upstream / downstream straight pipe work as per the results of type test declared by the manufacturer	Length of upstream / downstream straight pipe work as per the relevant standard and the manufacturer's instructions