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भारतीय मानक मसौदा

तापीय द्रव्यमान प्रवाह आधारित गैस मीटर — विशिष्टि

Draft Indian Standard

Thermal Mass Flow Based Gas Meters — Specification

ICS 17.120.10

Weights and Measures Sectional Committee, PGD 26	Last date for Comment: **10th July 2024**

NATIONAL FOREWORD

This Draft Indian Standard will be adopted by the Bureau of Indian Standards after the draft finalized by the Weights and Measures Sectional Committee had been approved by the Production and General Engineering Division Council.

During the development of this standard, tests related to effect of impurities on metrological performance and Test for gas fluctuation were kept in abeyance due to lack of data regarding occurrence of such issues in the Indian use cases. The panel on Thermal mass flow meter was in consensus that these tests are currently not required to be added but when research data in available on impurities in Indian gas supply and their effects on metrological performance of thermal mass flow-based meters then the committee will consider adding them to this standard.

In the preparation of this standard, considerable assistance has been derived from the following standards:

a)	ISO 14511 : 2019	Measurement of fluid flow in closed conduits — Thermal mass flowmeters
b)	EN 17526 : 2021	Thermal-mass flow-meter based gas meter
c)	OIML R 137 (Part 1 & 2) : 2012 including amendment 2014	Part 1: Metrological and technical requirements Part 2: Metrological controls and performance tests

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (second revision).' The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Contents

Draft Indian Standard

THERMAL MASS FLOW BASED GAS METERS — SPECIFICATION

1 SCOPE

This document specifies requirements and tests for the construction, performance, safety and production of battery powered class 1.5 capillary thermal-mass flow sensor gas meters (here in after referred to as meter(s)). This applies to meters having two pipe connections, which are used to measure volumes of 2nd and/or 3rd family of gases, as given in EN 437:2018.

In general, the term "thermal mass flow meters" applies to a flow-measuring device using heat transfer to measure and indicate gas flow rate.

NOTE — Although the word "mass" is present in the definition of the measurement principle, gas meters covered by this document provide measurement of gas at base conditions of temperature and pressure.

These meters have a maximum working pressure not exceeding 0.5 bar and a maximum flow rate not exceeding 40 m^3/h over a minimum ambient temperature range of -10°C to +55°C and a gas temperature range as specified by the manufacturer with a minimum range of 55°C.

This document applies to meters indicating volume at base conditions, which are installed in locations with vibration and shocks of low significance. It applies to meters in:

— Closed locations (indoor or outdoor with protection, as specified by the manufacturer) with condensing humidity or with non-condensing humidity;

or, if specified by the manufacturer:

— Open locations (outdoor without any covering) both with condensing humidity or with noncondensing humidity;

and in locations with electromagnetic disturbances likely to be found in residential, commercial and light industrial use.

For meters which indicate unconverted volume, reference can be made to Annex C.

Unless otherwise stated, all pressures given in this document are gauge pressures.

2 NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IS No./Other Publications	*Title*
IS/CISPR 32 : 2015	Electromagnetic compatibility of multimedia equipment — Emission Requirements

IS 101 (Part 5/Sec 3) : 2019/ISO 6272-1 : 2011	Methods of sampling and test for paints, varnishes and related products: Part 5 Mechanical tests: Section 3 Impact resistance — Falling-weight test, large-area indenter (*fifth revision*)
IS 554 : 1999/ ISO 7-1:1994	Pipe threads where pressure-tight joints are made on the threads — Dimensions, tolerances and designation (ISO 7-1:1994)
IS/ISO 834-1 : 1999	Fire-resistance tests — elements of building construction: Part 1 General requirements
IS 2643 : 2005/ ISO 228 -1:2003	Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation (ISO 228-1:2000)
IS 5572 : 2009/ IEC 60079-10 : 2002	Classification of hazardous areas (Other Than Mines) having flammable gases and vapours for electrical installation (Third Revision)
IS 9844 : 1981	Methods of testing corrosion resistance of electroplated and anodized aluminium coatings by neutral salt spray test
IS 14700 (Part 4/Sec 2) : 2018/IEC 61000-4-2:2008	Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques: Section 2 electrostatic discharge immunity test (*second revision*)
IS 14700 (Part 4/Sec 3) : 2018/IEC 61000-4-3:2006	Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques- Radiated, radio-frequency, electromagnetic field immunity test
IS 14700 (Part 4/Sec 8) : 2018/ IEC 61000-4-8 : 2009	Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques: Section 8 Power frequency magnetic field immunity test (*second revision*)
IS 14700 (Part 4/Sec 9) : 2019/IEC 61000-4-9 : 2016	Electromagnetic compatibility (EMC): Part 4 testing and measurement techniques: Sec 9 impulse magnetic field immunity test (Second Revision)
IS 14700 (Part 6/Sec 1) : 2019/IEC 61000-6-1 : 2016	Electromagnetic compatibility (EMC): Part 6 Generic standards: Section 1 Immunity standard for residential, commercial and light-industrial environments (*first revision*)
IS 14700 (Part 6/Sec 2) : 2019/IEC 61000-6-2 : 2016	Electromagnetic compatibility (EMC): Part 6 Generic standards Section 2 Immunity standard for industrial environments (*first revision*)
IS 15305 (Part 2) : 2019/ISO 12213-2 : 2006	Natural gas — calculation of compression factor: Part 2 Calculation using molar-composition analysis (*first revision*)
IS/IEC 60079-0 : 2017	Explosive atmospheres: Part 0 Equipment — General requirements (*third revision*)
IS/IEC 60079-11:2011	Explosive atmospheres: Part 11 Equipment protection by intrinsic safety “i” (*first revision*)
IS/IEC 60079-15:2017	Explosive atmospheres — Part 15: Equipment protection by type of protection "n"
IS/IEC 60529 : 2001	Degrees of protection provided by enclosures (IP Code)
IS/IEC 60695-11-5 : 2016	Fire hazard testing: Part 11 Test flames: Section 5 Needle — flame test method — apparatus, Confirmatory test arrangement and guidance (*first revision*)
IS/IEC 60695-11-10 : 2013	Fire hazard testing: Part 11 Test flames: Section 10 50 w horizontal and vertical flame test methods

IS/IEC 60730-1 : 1999	Automatic electrical controls for household and similar use : part 1 General Requirements
IS/IEC 62056-21 : 2002	Electricity metering — Data exchange for meter reading, tariff and load control: Part 21 Direct local data exchange
ISO 1518-1 : 2019	Paints and varnishes — Determination of scratch resistance — Part 1: Constant- loading method
ISO 2409 : 2020	Paints and varnishes — Cross-cut test
ISO 2812-1 : 2017	Paints and varnishes — Determination of resistance to liquids — Part 1: Immersion in liquids other than water
ISO 4628-2:2016	Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering
ISO 4628-3:2016	Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting
ISO 4892-3:2016	Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps
ISO 6270-1:2018	Paints and varnishes — Determination of resistance to humidity — Part 1: Condensation (single-sided exposure)
ASME B1. 20.1- 2013 (NPT)	Pipe Threads, General Purpose, Inch
BS 746 : 2014	Specification for gas meter unions and adaptors
EN 437 : 2018	Test gases — Test pressures — Appliance categories
EN 549 : 2019	Rubber materials for seals and diaphragms for gas appliances and gas equipment
EN 1092-1 : 2018	Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges
EN 16314 : 2013	Gas meters – Additional functionalities
EN 50561-1:2013	Power line communication apparatus used in low-voltage installations — Radio disturbance characteristics - Limits and methods of measurement — Part 1: Apparatus for in-home use

3 TERMS, DEFINITIONS AND SYMBOLS

3.1 Terms and Definitions

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

3.1.1 *Actual Flow Rate*

Flow rate at the gas pressure and gas temperature conditions prevailing in the gas distribution line in which the meter is fitted, at the meter inlet.

3.1.2 *Additional Functionality*

Functions over and above that within the meter, which can be integral to the meter, or included within a connected device.

3.1.3 *Additional Functionality Device*

Device that carries out additional functionalities

3.1.4 *Base Conditions*

Fixed conditions to which a volume of gas is converted (i.e. base gas temperature 15°C, base gas pressure 1013.25 mbar).

3.1.5 *Class* 1.5 *Meter*

Accuracy achieved by a meter, which has an error of indication between:

a) -3percent and +3 percent for flow rates Q, where $Q_{min} \leq Q < Q_t$
b) -1.5percent and +1.5percent for flow rates Q, where $Q_t \leq Q \leq Q_{max}$,

Where
$Q_{max} / Q_{min} > 150$
$Q_{max} / Q_t \geq 10$
$Q_r / Q_{max} = 1.2$

3.1.6 *Contaminants*

Gas borne dust, vapor and other substances that could affect the operation of the meter.

3.1.7 *Display*

Device which shows information from the meter (example, liquid crystal that displays registers, volume or flags)

3.1.8 *Distributed Gas*

Locally available gas

3.1.9 *Disturbance*

Influence quantity having a· value within the limits specified but outside the specified rated operating conditions of the measuring instrument.

NOTE — An influence quantity is a disturbance if the rated operating conditions for that influence quantity are not specified.

3.1.10 *Durability*

Ability of an instrument to maintain its performance characteristics over a specified period of use.

3.1.11 *Error of Indication*

Value which shows the relationship in percentage terms of the difference between the volume indicated by the meter and the volume which has actually flowed through the meter, to the latter value:

$$\varepsilon = \frac{100\ (V_i - V_c)}{V_c}$$

Where

ε = error of indication
Vi = indicated volume
Vc = volume which has actually flowed through the meter.

3.1.12 *Event*

Condition requiring action or to log an action.

3.1.13 *External Leak Tightness*

Leak tightness of the gas carrying components of the gas meter with respect to the atmosphere.

3.1.14 *Galvanic Connection/Interface*

Hard wired serial connection or pulse output from the meter.

3.1.15 *Gas Meter*

Instrument designed to measure, memorize and display the volume of fuel gas that has passed through it.

3.1.16 *Gauge Pressure*

Absolute pressure minus atmospheric pressure.

3.1.17 *Index*

Current reading of the total volume passed through the meter.

3.1.18 *Maximum Operating Pressure*

Maximum pressure at which a system can be operated continuously under normal conditions.

NOTE — Normal conditions are no fault in any device or stream.

3.1.19 *Maximum Error Shift*

Maximum mean error shift at any of the tested flow rates.

3.1.20 *Maximum Flow Rate*

Highest flow rate at which the gas meter provides indications that satisfy the requirements regarding maximum permissible error (*MPE*).

3.1.21 *Maximum Permissible Error* (*MPE*)

Extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications for a given measurement, measuring instrument, or measuring system.

3.1.22 *Maximum Working Pressure*

Upper limit of the working pressure for which the meter has been designed, as declared by the manufacturer and marked on the index or the data plate.

3.1.23 *Mean Error*

Arithmetic mean of consecutive errors of indication at a flow rate.

3.1.24 *Memory*

Element which stores digital information.

3.1.25 *Meter Case*

Pressure containing structure of the meter

3.1.26 *Meter Class*

Class to which a meter belongs, according to the metrological requirements of this document, that is, class 1.5.

3.1.27 *Meter Error Curve*

Plot of average error of indication against actual flow rate.

3.1.28 *Minimum Flow Rate*

Lowest flow rate at which the gas meter provides indications that satisfy the requirements regarding *MPE*.

3.1.29 *Normal Conditions of Use*

Conditions referring to the meter operating:

a) at a pressure up to the maximum working pressure (with or without a flow of gas);
b) within the range of flow rates;
c) within the ambient and gas temperature range; and
d) with the distributed gas

3.1.30 *Pressure Absorption*

Difference between the pressures measured at the inlet and outlet connections of the meter whilst the meter is operating.

3.1.31 *Pressure Measuring Point*

Permanent fitting on the meter outlet enabling a direct measurement of the outlet pressure to be obtained.

3.1.32 *Operating Mode*

Method (sample frequency and timing) of obtaining volume flow measurements.

3.1.33 *Optical Port*

Serial data port using an infra-red transmitter and receiver.

3.1.34 *Overload Flow Rate*

Highest flow rate at which the meter operates for a short period of time without deteriorating.

3.1.35 *Reference Conditions*

Condition of use prescribed for testing the performance of a measuring instrument or for inter- comparison of results of measurements.

3.1.36 *Register*

Electronic device comprising both memory and display, which stores and displays information.

3.1.37 *Sensor*

Element of a measuring instrument or measuring chain that is directly affected by the measured.

3.1.38 *Software Identifier*

Sequence of characters, that identifies the software; the identifier is logically considered a part of the software.

3.1.39 *Starting Flow Rate*

Lowest flow rate at which the meter is able to indicate a volume of gas passed.

3.1.40 *Storage Temperature Range*

Range of temperatures at which the meter can be stored without being adversely affected.

3.1.41 *Thermal Mass Flow-Meter TMF Meter*

Flow-measuring device which uses heat transfer to measure and indicate mass flow rate.

> NOTE — The term thermal mass flow meter also applies to the measuring portion of a thermal mass flow controller and not the control function. [SOURCE: ISO 14511:2019, 3.2.3]

Although the word 'mass' is present in the definition of the measurement principle, gas meters covered by this document provide measurement of gas at base conditions of temperature and pressure.

3.1.42 *Transitional Flow Rate*

Flow rate occurring between the maximum and minimum flow rates at which the flow rate range is divided into two zones, the upper zone and the lower zone, each zone having a characteristic *MPE*.

3.1.43 *Volume*

Volume without specifying whether it is a corrected volume at measurement conditions or an uncorrected volume at measurement conditions.

3.1.44 *Working Pressure*

Difference between the pressure of the gas at the inlet of the meter and the atmospheric pressure.

3.2 Symbols

D	-	Outside diameter of the pipe in millimetres (mm)
g	-	Acceleration due to gravity, in metres per square second ($m \cdot s^{-2}$)
H_i	-	Lower calorific value
H_s	-	Upper calorific value
MPE	-	Maximum permissible error, in percent (percent)
p_b	-	Base pressure to which the indicated volume is referred
p_{max}	-	Maximum working pressure
Q_{max}	-	Maximum flow rate
Q_{min}	-	Minimum flow rate
Q_r	-	Overload flow rate
Q_{start}	-	Starting flow rate
Q_t	-	Transitional flow rate
Q_x	-	Distributed air or gas flow, referred to the base conditions of the meter, with x = min, max, t, r; as described below
t_b	-	Base reference temperature to which the indicated volume is referred
t_g	-	Gas temperature
t_m	-	Ambient temperature
t_{max}	-	Maximum operating temperature
t_{min}	-	Minimum operating temperature
t_{sp}	-	Specified centre temperature for a temperature converted meter
V_b	-	Volume read by the meter, at base conditions
W_i	-	Lower Wobbe index
Ws	-	Upper Wobbe index
ε	-	Error of indication

4 NORMAL OPERATING CONDITIONS

4.1 General

If no specific requirements are given, the test equipment shall be traceable to a national reference standard error of and the uncertainty shall be equal or better than:

a) For type evaluation : 1/5 of the maximum permissible error (*MPE*);
b) For verification : 1/3 of the maximum permissible error (*MPE*).

4.2 Base Conditions

Base conditions of temperature (t_b) and pressure (p_b) shall be specified by the manufacturer and marked on the data plate of the meter.

To compute the error of indication, test volumes need to be converted to the base conditions of the meter under test:

$$V_{tb,pb} = V_a . \frac{(t_b + 273.15).p_a}{(t_a + 273.15).p_b}$$

Where $p_a = p_{amb} + p_{gauge}$

Where

p_a - absolute inlet pressure (in bar) of the meter under test, i.e. the sum of two pressure contributes defined as follows:

p_{amb} - barometric pressure during test;

p_{gauge} - inlet gauge pressure of meter under test;

P_b - Base pressure to which the indicated volume is referred (in bar);

t_a - steady temperature of the test volume (in °C);

t_b - base condition of the test volume (in °C);

V_a - volume at actual condition;

$V_{tb,pb}$ - Volume converted to the base temperature and pressure;

4.3 Flow Range

The flow rate range shall be one of those given in Table 1.

Table 1 Flow Rate Range
(*Clause* 4.3)

Gas Meter Designation G	Q_{max} (m^3/h)	Upper limit of Q_{min} (m^3/h)	Upper limit of Q_t (m^3/h)	Q_r (m^3/h)
1.6	2.5	0.016	0.25	3.0
2.5	4	0.025	0.4	4.8
4	6	0.04	0.6	7.2
6	10	0.06	1.0	12.0
10	16	0.1	1.6	19.2
16	25	0.16	2.5	30.0
25	40	0.25	4.0	48.0

A gas meter may have a lower value for the minimum flow rate, Q_{min}, than that shown in Table 1, but this lower value shall be equal to one of the values shown in the table or to a decimal submultiple of these values.

The values given in Table 1 ensure the minimum turndown ratio given in Table 2.

Table 2 Turndown Ratio
(*Clause* 4.3)

Q_{max} / Q_{min}	Q_{max} / Q_t	Q_r / Q_{max}
≥ 150	≥ 10	≥ 1.2

4.4 Maximum Working Pressure

The manufacturer shall declare the maximum working pressure of the meter which shall not exceed 0.5 bar.

4.5 Temperature Range

4.5.1 *General*

Unless otherwise stated, all temperatures given in this document shall be measured to within ± 1°C.

4.5.2 *Ambient Temperature Range*

All meters shall be designed for a minimum ambient temperature range of -10°C to +55°C. This shall be verified by conforming with the requirements given in **5** and **6**.

The manufacturer can declare a wider design temperature range but shall use the minimum and maximum temperature limits as specified in Table 3 and Table 4.

Table 3 Upper Temperature Limit
(*Clause* 4.5.2)

Upper temperature limit of t_{max}		
40°C	55°C	70°C

Table 4 Lower Temperature Limit
(*Clause* 4.5.2)

Lower temperature limit of t_{min}		
5°C	-10°C	-25°C

4.5.3 *Gas Temperature Range*

All meters shall be designed for a gas temperature range equal to, or within, the ambient temperature range, with a minimum span of 55°C. This shall be verified by conforming with the requirements of **5.3.1** and **5.8**.

4.5.4 *Storage Temperature Range*

All meters shall be designed for a storage temperature range of - 20°C to 70°C, and in any case shall have a range equal to or wider than the declared ambient temperature range. This shall be verified by conforming with the requirement of **6.9**.

4.6 Range of Gases

The manufacturer shall specify the range of gases for which the meter has been designed, in terms of gas families, for at least one group in accordance with EN 437:2018.

Additionally, the meter shall also be designed for working on air; therefore, fulfilling air-gas relationship requirements specified in **5.4**.

Conformity to gas families, or pertaining groups, for which the meters have been designed, shall be included in the technical design file of the instrument.

Therefore, the meter shall be tested with any one of the following:

a) Air;
b) Test gases representing the variability of distributed gases within the respective groups (*see* Annex B).

4.7 Installation Orientation

Where more than one installation orientation is specified in the manufacturer's instruction manual, meters shall be tested for permissible error as per **5.3** in all these orientations.

5 METROLOGICAL PERFORMANCES

5.1 General

Where the manufacturer declares that the meter can be used in two directions (forward and reverse flow) then all tests shall be performed in both directions.

The flow rate shall be determined using sampling times that are not readily predictable within discrete time intervals.

These time intervals (T) shall not exceed 2 s, unless the manufacturer can demonstrate that a proposed longer time interval will not cause the metrological characteristics of the meter to be affected by unsteady flow conditions.

Irrespective of whether the discrete time intervals are longer than 2 s, the requirements specified in **5.12.2** shall still be applied.

Provision shall be made for synchronizing the start and finish of test periods (with test equipment), according to manufacturer specification, example via a galvanic connection or optical port.

Any failure in synchronizing test equipment with the meter under test may introduce an error Contribution, calculated as follows:

$$\varepsilon\%^{MAX}(\tau, t) = 2\left(\frac{\tau}{t}\right).100$$

Where

τ = maximum sampling time of the meter under test, in seconds;
t = test time, in seconds.

Where $\boldsymbol{\tau}$ is not specified by manufacturer, $\boldsymbol{\tau}$ = 2 s shall be used in the calculation.
The meter shall have a mode, providing volume resolution of at least 0.1 dm^3.
The meter shall have a fast sampling mode with sampling time not exceeding 0.5 s.

NOTE — This mode can be accessible via the display even without any external tools, e.g. by means of a dedicated display menu. In operative conditions, the meter can be protected by password and not accessible to final user.

All modes other than the normal mode shall only be active for a maximum time of 24 h before reverting to normal operating mode.

5.2 Test Mode Comparison

5.2.1 *General*

When the meter has one or more fast sampling modes in addition to the normal operating mode, then provided the requirements in **5.2.2** are met, all subsequent tests requiring steady flow profiles in this document shall be carried out using the same test mode. If the requirements in **5.2.2** are not satisfied, then all subsequent tests shall be performed in normal operating mode.

Where specific modes of measurement for managing flow outside the controlled range are present in the normal operating mode, these can be disabled in test mode, unless otherwise specified in this document.

Provision shall be made to ensure that any test gas is properly detected by the meter under test. In particular, where the meter has a gas detection system that occurs at a fixed time interval, the gas detection procedure shall also be performed whenever the test mode is activated.

5.2.2 *Requirements*

The accuracy of the measurements shall not be influenced by different sampling modes.

The difference of the mean errors of the normal operating mode and the test mode shall not exceed the following limits:

a) 0.6 percent for any flow rate $Q_{min} \leq Q < Q_t$;
b) 0.3 percent for any flow rate between $Q_t \leq Q \leq Q_{max}$

In both modes, the mean error shall be within the maximum permissible errors as specified in Table 5.

5.2.3 *Test*

Test the meter in the normal operating mode and in the test mode in accordance with **5.3.2**, Table 6, Test (a) Calculate the difference in mean error at each flow rate, and ensure that requirements in **5.2.2** are met.

5.2.4 *Test Mode in Flow (Optional)*

5.2.4.1 *General*

Where the meter provides instantaneous flow rate readings, these can be used as an alternative to volume for calculating the error of measurement at steady flow profiles, unless otherwise specified in this document.

5.2.4.2 *Requirements*

Select the test mode, and carry out the test in accordance with **5.2.4.3** at a given steady test flow rate. The difference of the mean errors of the normal operating mode and the test mode shall not exceed the limits given below:

a) 0.6 percent for any flow rate between $Q_{min} \leq Q < Q_t$;
b) 0.3 percent for any flow rate between $Q_t \leq Q \leq Q_{max}$.

5.2.4.3 *Tests*

Test the meter in the normal operating mode and in the test mode in flow in accordance with **5.3.2**, Table 6, Test (a).
Calculate the difference in mean error at each flow rate, using the following equations, and ensure that error is within the limits specified in **5.2.4.2.**

$$E_x = \frac{V\text{b} - V\text{c}}{V\text{c}} . 100; \ \varepsilon_x = \frac{Q\text{b} - Q\text{c}}{Q\text{c}} . 100$$

Where

E_x - mean error in volume, expressed as a percentage;
ε_x - mean error in flow, expressed as a percentage;
V_b - volume read by the meter, at base conditions;
V_c - volume read by the reference instrument, converted to meter under test base conditions;
Q_b - flow rate read by the meter, at base conditions;
Q_c - flow rate read by the reference instrument, converted to meter under test base conditions. Q_c can be either measured directly or inferred by ratio $Q_c = V_c / t_x$ where t_x is the test duration at any given steady test flow rate.

5.3 Permissible Errors

5.3.1 *Requirements*

The meter shall be adjusted as per Weighted Mean Error (WME) between -0.6 percent and 0.6 percent.

When tested in accordance with **5.3.2**, the mean error E_x for both air and test gases shall be within the maximum permissible errors specified in Table 5. This also shall apply to measurements at maximum operating pressure and at minimum and maximum declared temperature including any additional test temperature comprised between t_{min} and t_{max}.

Table 5 Maximum Permissible Errors for Volume at Base Conditions
(*Clauses* 5.2.2, 5.3.1, 5.7.1, 5.10.1, 5.11.1, 5.11.2, 5.12.2, 6.3.7.1, 6.4.3.2.1, 6.5.1, 6.5.3, 6.9.1, 6.10.1, 6.11.1, 6.12.1, 7.5.1, 12.2.1.1, 12.2.2.1, 13.2.1, 13.3.1, 13.4.1, 13.5.1 *and* C-2.1.1)

Flow Rate	**Maximum permissible Error for Volume at base conditions**
$Q_{\text{min}} \leq Q < Q_{\text{t}}$	± 3.0 Percent
$Q_{\text{t}} \leq Q \leq Q_{\text{max}}$	± 1.5 Percent

Where the manufacturer declares the meter measures actual volume, Annex C can be applied.

5.3.2 *Test*

5.3.2.1 *General*

Thermally stabilize the meter to the temperature of the test laboratory. Pass a volume of air or gas, the actual volume of which is measured by a reference standard, through the meter and note the volume indicated by the meter. The minimum volume of air or gas to be passed through the meter is specified by the manufacturer and agreed with the test house.

Carry out the tests specified in **5.3.2.3** and **5.3.2.4** in any order, then record '*n'* errors at each of the flow rates, and calculate their mean value.

5.3.2.2 *Weighted mean error*

Calculate the WME using the mean values at different flow rates, in accordance with the following formula:

$$\text{WME} = \frac{\sum_{i=1}^{n} k_i E_i}{\sum_{i=1}^{n} k_i}$$

$$k_i = \frac{Q_i}{Q_{max}} \qquad \text{for } Q_i \leq 0.7\, Q_{\text{max}} \text{ and}$$

$$k_i = 1.4 - \frac{Q_i}{Q_{max}} \qquad \text{for } 0.7\, Q_{\text{max}} < Q_{\text{i}} \leq Q_{\text{max}}$$

Where

k_{i} - weighting factor at the flow rate Q_{i}
E_{i} - error at the flow rate Q_{i}

5.3.2.3 *Air and gas errors*

Test the meter using air and the test gases specified by the manufacturer in accordance with **5.3.2**, Table 6, Test (a).

5.3.2.4 *Temperature errors*

Test the meter on air at T_{min} and T_{max} (*see* **4.5**) in accordance with **5.3.2**, Table 6, Test (b).

Table 6 Error Test on Air and Gases
(*Clauses* 5.2.3, 5.2.4.3, 5.3.2.3, 5.3.2.4, 5.4.3, 5.7.2.2, 5.7.2.3.1, 5.10.2, 5.11.2, 6.3.7.2, 6.4.3.2.1, 6.5.3, 6.9.2, 6.10.2.1, 6.11.2, 6.12.2, 7.5.2, 11.2.2, 12.2.1.2, 12.2.2.2, 13.2.2, 13.3.2, 15.1, 15.2, 15.3, C-2.1.2 *and* C-3.1.2)

Test	**Test flow rates**	**Number of consecutive tests in air (n)**	**Minimum number of consecutive tests in gas(n)[a]**
a)	Q_{min}, $3Q_{min}$, $5Q_{min}$, $10Q_{min}$, $0.1Q_{max}$,$0.2Q_{max}$, $0.4Q_{max}$, $0.7Q_{max}$, Q_{max}	6	2
b)	Q_{min}, $0.1Q_{max}$, $0.4Q_{max}$, Q_{max}	3	2
c)	Q_{min}, $0.1Q_{max}$, Q_{max}	3	2
d)	$0.1Q_{max}$, Q_{max}	3	2
[a] Refer to **5.4.1.**			

5.4 Gas-Air relationship

5.4.1 *General*

Where meters fulfil the requirements in **5.4.2**, all of the subsequent tests shall be carried out on air only.

5.4.2 *Requirements*

The difference between the mean errors (i.e. the error of indication of the meter) on the test gases and on air, at each of the flow rates, shall be within the limits specified in Table 7.

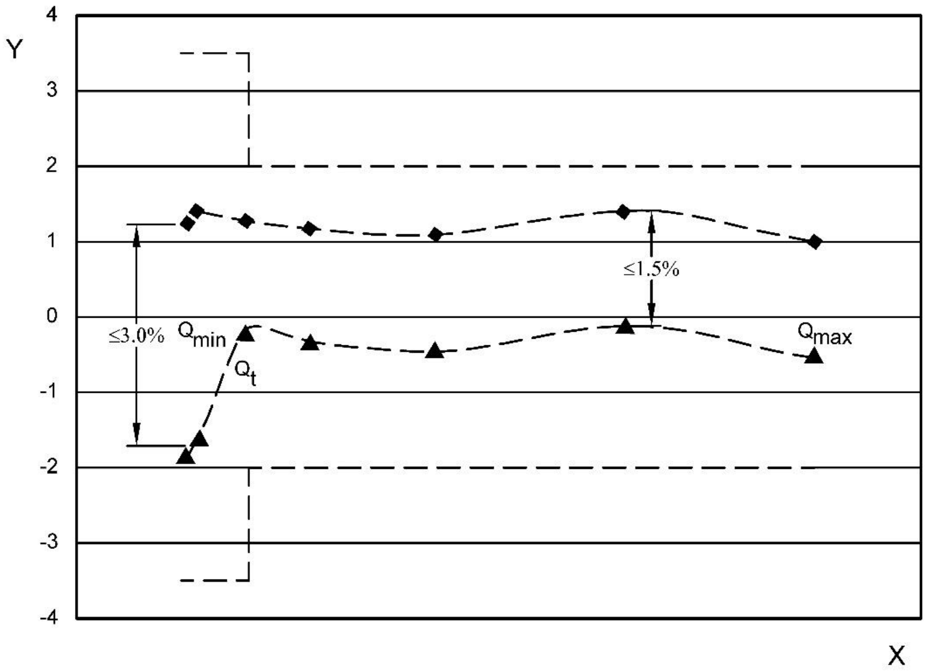
If the requirements given in Table 7 are not fulfilled, then all subsequent tests shall be carried out using both air and test gases. *See* Fig. 1.

Table 7 Mean Error Difference between Air and Gas at Given Flow Rate
(*Clause* 5.4.2)

Flow Rate	**Maximum mean error difference for class 1.5**
$Q_{min} \leq Q < Q_t$	3.0 percent
$Q_t \leq Q \leq Q_{max}$	1.5 percent

5.4.3 *Test*

Apply the requirements of **5.4.2** to the results from testing the meter in air and gas in accordance with **5.3.2**, Table 6, Test (a).



Key

X - flow rate
Y - error percent
----- - class 1.5
___ - maximum mean error difference
■ - error curve on air
▲ - error curve on gas

FIG. 1 MAXIMUM MEAN ERROR DIFFERENCE BETWEEN AIR AND GAS FOR CLASS 1.5

5.5 Pressure Absorption

5.5.1 *Requirements*

The pressure absorption of a meter with a flow of air with a density of 1.2 kg/m^3, at a flow rate equal to Q_{max} shall not exceed the values given in Table 8.

Table 8 Pressure Absorption
(*Clauses* 5.5.1, 6.3.7.1 and 7.5.1)

Q_{max}(m^3/h)	**Maximum permissible values for pressure absorption**	
	Initial (mbar)	**Endurance (mbar)**
$2.5 \leq Q_{max} \leq 16$	2.0	2.2
$25 \leq Q_{max} \leq 40$	3.0	3.3

5.5.2 *Test*

Supply the meter under test with a flow of air at a flow rate equal to Q_{max}, and measure the differential pressure across the meter using a suitable measuring instrument, accurate to 0.1 mbar.

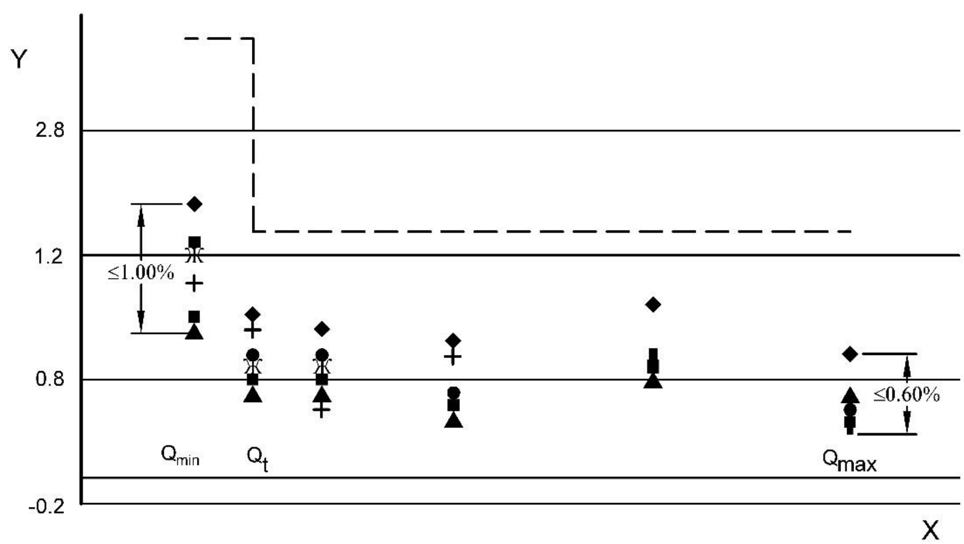
The distance between the pressure test points and the meter connections shall not exceed three times the nominal internal connection diameter of the meter connection points for two pipe meters.

5.6 Metrological Stability

Compare the results from **5.3.2.3** for each consecutive test and confirm that the difference between any two of the errors of indication at each flow rate does not exceed the value given in Table 9 (*see* Fig. 2).

Table 9 Difference of Error between any Two of the Errors of Indication
(*Clause* 5.6)

Flow range	**Difference of error**
$Q_{min} \leq Q < Q_t$	1.0 percent
$Q_t \leq Q \leq Q_{max}$	0.6 percent



Key

X - Flow Rate
Y - error percent
---- - Class 1.5
◆ - Test 1
■ - Test 2
▲ - Test 3
+ - Test 4
Ж - Test 5
● - Test 6

FIG. 2 MAXIMUM DIFFERENCE BETWEEN ERRORS OF INDICATION

5.7 Flow Disturbance

5.7.1 *Requirements*

When tested in accordance with **5.7.2**, the mean errors shall remain within the *MPE* and the mean error difference at each flow rate shall not exceed the values specified in Table 10. The meter shall recover from the flow disturbance to be within the initial *MPE* specified in Table 5.

Table 10 Maximum Permissible Error Shift During Installation Effect and Flow Disturbance Tests
(*Clauses* 5.7.1 and 5.7.2.2)

Flow range	Maximum permissible error shift
$Q_{min} \leq Q < Q_t$	1.0 Percent
$Q_t \leq Q \leq Q_{max}$	0.5 Percent

5.7.2 *Test*

5.7.2.1 *General*

Carry out the tests specified in **5.7.2.2**, **5.7.2.3** and **5.7.2.4**, using air or a representative test gas at atmospheric pressure conditions.

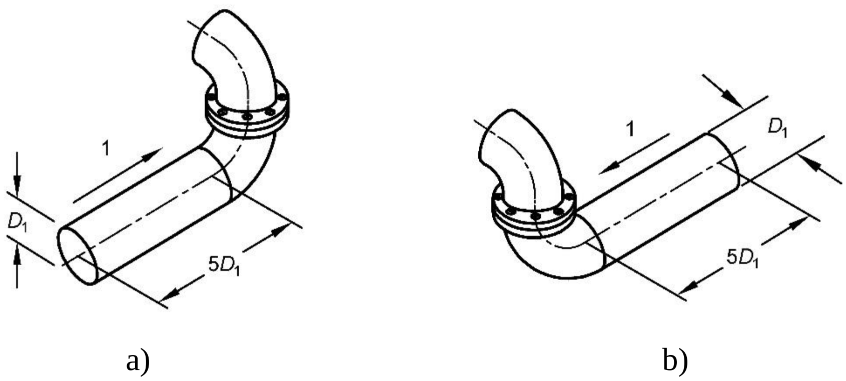
5.7.2.2 *Installation effects*

a) The piping configurations illustrated in Fig. 3 (a) and Fig. 3 (b) consist of a pipe with nominal diameter D_1 and length of 5 D_1, where D_1 is the diameter of the inlet and outlet connections of the meter, and two elbows with radius equal to 1.5 D_1 not in the same plane.

b) The Meter shall be tested in accordance with **5.3.2**, Table 6, Test (b), using the flow rates specified in **5.7.2** in the following configurations:

1) With a straight pipe of length not less than 10 D_1 connected to the meter inlet;
2) With the piping configurations illustrated in Fig. 3 a) installed 2 D_1 upstream of the meter inlet; and
3) With the piping configurations illustrated in Fig. 3 b) installed 2 D_1 upstream of the meter inlet.

c) The error difference between (1) and (2), and between (1) and (3) of **5.7.2.2 (b)** shall be checked. It shall be within the value specified in Table 10.



Key

1 - flow

FIG. 3 PIPING CONFIGURATIONS FOR INSTALLATION EFFECTS TEST

5.7.2.3 *Resistance to harmonic disturbances of the flow*

5.7.2.3.1 *General*

a) The meter is thermally stabilized to the temperature of the test laboratory. The meter is connected to the test equipment as shown in Fig. 4 with the outlet port opened.
b) A steady flow of air at Q_t is supplied and kept running for the entire duration of the test. The absolute pressure inside the meter during the test is ensured to be within (1013.25 ± 50) mbar.
c) The measurement error at Q_t of the meter in this configuration is determined, following the procedure specified in **5.3.2**, Table 6, Test (c).
d) A pure acoustic tone of given frequency and a peak-to-peak amplitude of (90.0 ± 0.3) dB (determined according to the method indicated in **5.7.2.4**) is generated and introduced into the flow. The measurement error at Q_t is detected according to **5.3.2**.
e) The tests are repeated at all frequencies below:
    1) From 200 Hz to 500 Hz, at 50 Hz intervals (i.e. 200 Hz, 250 Hz, 300 Hz, etc.);
    2) From 600 Hz to 2000 Hz, at 100 Hz intervals (i.e. 600 Hz, 700 Hz, 800 Hz, etc.).

5.7.2.3.2 *Test apparatus*

a) For this test, Steel or copper piping is preferred. Plastics such as PVC can also be used, provided that they have a grade of stiffness such to avoid dampening of acoustic vibrations (a minimum wall thickness of 4 mm is recommended).
b) The internal diameter *d* is function of the maximum flow rate, as indicated in Table 11.
c) Care shall be taken in protecting the reference instrument from disturbances, for example placing it in a suitable position along the apparatus.

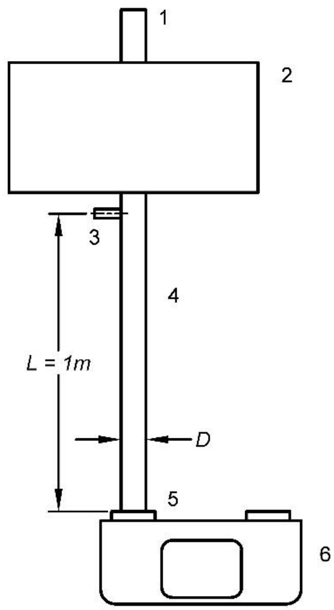
Table 11 Diameter size d as Function of Q_{max}
(*Clause* 5.7.2.3.2)

Q_{max} (m^3/h)	Internal diameter *d* (mm)
$2.5 \leq Q_{max} < 16$	25
$16 \leq Q_{max} < 40$	50

5.7.2.3.3 *Microphone*

The amplitude of the acoustic tone, corresponding to sound pressure level, shall be determined at Q_t. The microphone shall be positioned at a distance L of 1 m from the meter inlet, as shown in Fig. 4.

The microphone shall be inserted in a suitable pipe hole, ensuring a leak tight connection.



Key

1 - air supply (steady flow)
2 - box containing acoustic tone generator
3 - microphone
4 - straight pipe
5 - connection to inlet port of meter under test
6 - meter under test

FIG. 4 TEST APPARATUS FOR RESISTANCE TO HARMONIC DISTURBANCES

5.8 Zero Flow

5.8.1 *Requirements*

When tested in accordance with **5.8.2**, neither the meter display nor the internal register shall change in value (increment or decrement).

5.8.2 *Test*

a) Record the index reading and the internal register of the meter.
b) Carry out the test with air at minimum and maximum ambient temperatures declared by the

manufacturer.

c) Seal the inlet and outlet ports of the meter with gas tight fittings. Allow the meter to stabilize at each test temperature and then store for 12 h at each test temperature.
d) Record the index reading and the internal register of the meter after each 12 h period.

5.9 Reverse Flow

5.9.1 *Requirements*

If the meter is designed for use in one direction only, then when tested in accordance with **5.9.2**, the register shall neither increase nor decrease. If an additional reverse flow register is fitted, it shall indicate the passage of the test volume during the test described in **5.9.2**.

5.9.2 *Tests*

a) Initially record the index reading and the additional reverse flow register of the meter.
b) Pass a test flow rate at Q_{min} and Q_{max} through the meter for 0.2 h for each flow rate in the reverse direction.
c) Record the index reading and the additional reverse flow register of the meter and compare with the initial value.

5.10 Low Flow Registration (Starting Flow Rate)

5.10.1 *Requirements*

When tested in accordance with **5.10.2**, the error at Q_{start} shall be between – 50 percent absolute error and not exceeding 3 times the *MPE,* as given in Table 5 for $Q_{\mathrm{min}} \leq Q < Q_{\mathrm{t}}$.

The manufacturer shall declare the starting flow rate Q_{start} which shall not be greater than 0.25 Q_{min}.

5.10.2 *Tests*

a) Initially record the index reading of the meter.
b) Using the manufacturer's declared Q_{start} value, test the meter as specified in **5.3.2**, Table 6, Test (c), at a flow rate equal to 1.2 Q_{start}, and pass a minimum test volume equal to Q_{min} multiplied by 0.25 h (for example if Q_{min} = 0.04 m^3/h, V= (0.04 × 0.25) m^3 = 0.01 m^3).
c) Record the index reading of the meter for each test and compare with the initial value.

5.11 Overload Flow Rate

5.11.1 *Requirements*

When tested in accordance with **5.11.2** the error of indication shall remain within the maximum permissible error specified in Table 5.

The meter shall continue to register the passage of gas.

5.11.2 *Tests*

a) Test one meter as specified in **5.3.2**, Table 6, Test (c) with air and ensure the error is within the *MPE* given in Table 5.
b) Supply the same meter with air for 60 min at an overload flow rate of 1.2 Q_{max} and confirm that the meter continues to register the passage of gas.
c) Retest the same meter as specified in **5.3.2**, Table 6, Test (c) with air and determine the error curve remains within the *MPE* and a fault of less than or equal to one third of the maximum permissible error.
d) Record the result as a pass or fail.

5.12 Pulsed (Unsteady) Flow

5.12.1 *General*

When undertaking the following test, the time interval *T* shall be taken from **5.1**.

5.12.2 *Requirements*

a) Test the meter in accordance with **5.12.3**.
b) The difference between the cumulative volume at the ends of test runs 2 and 5 (*see* Table 12) and cumulative volume at runs 1 and 4 respectively shall not exceed two thirds of the total *MPE* range specified in Table 5.
c) The difference between the cumulative volume at the ends of test runs 3 and 6 (*see* Table 12) and cumulative volume at runs 1 and 4 respectively shall not exceed one third of the total *MPE* range specified in Table 5.

5.12.3 *Tests*

a) Test the meter in its normal operating mode.
b) Subject the meter to flow conditions specified in Table 12 with either continuous or square wave airflow at the on/off timings and flow rates, for a duration of 3600 *T* for runs 1 and 4, and 7200 *T* for runs 2, 5, 3 and 6, where *T* is the time interval specified in 5.1, calculating *MPE* errors recording the start and end index volumes of each test.

Table 12 Unsteady Flow Runs
(*Clauses* 5.12.2 and 5.12.3)

Run	Flow rate	Flow (wave form)
1	0.375 Q_{max}	Continuous
2	0.375 Q_{max}	1.05*T* on,1.05*T* off
3	0.375 Q_{max}	2.3*T* on, 2.3*T* off
4	0.07 Q_{max}	Continuous
5	0.07 Q_{max}	1.05*T* on,1.05*T* off
6	0.07 Q_{max}	2.3*T* on, 2.3*T* off

6 CONSTRUCTION AND MATERIALS

NOTE — The durability and legibility of marking requirements in **9.3**, can be addressed during the tests in **6.5**, **6.6.2.5**, **6.9**, and **6.12**.

6.1 Mechanical Interference

6.1.1 *Requirements*

a) The meter shall be constructed in such a way that any mechanical interference capable of affecting the measuring accuracy results in permanently visible damage to the gas meter or the verification or protection marks.
b) The meter connections shall be fitted with suitable non-sealing caps or covers to protect any threads and to prevent the entry of foreign matter during transit and storage.
c) The meter shall have a meter case that can be sealed in such a way that the internal parts of the meter are accessible only after breaking the metrological seal(s) or causing clear evidence of interference.

6.1.2 *Test*

Visually examine the meter to ensure that access cannot be gained without causing permanent visible damage or protection marks, and the meter connections are covered with non-sealing caps.

6.2 Electronic Sealing

When the access to parameters that contribute in the determination of results of measurements needs to be protected, the protection shall fulfil the following provisions:

a) Only authorized people are allowed to enter the configuration mode to modify following parameters using securing means such as a code (password) or special device (hard key, etc.):

   1) For access prior to changing the parameters, after which the instrument may be put into use "in sealed condition" again without any restriction, or
   2) For confirmation after the parameters have been changed, in order to bring the instrument back into service being the "in sealed condition" (similar to classical sealing).

b) The code (password) shall be alterable.
c) The device shall either clearly indicate when it is in the configuration mode (not under legal metrological control), or it shall not operate while in this mode. This status shall remain until the instrument has been put into use "in sealed condition" in accordance with **6.2 (a)**.
d) Identification data concerning the most recent intervention shall be recorded in an event logger. The record shall include at least:

   1) An identification of the authorized person that implemented the intervention, and
   2) An event counter or date and time of the intervention as generated by the internal clock.

In addition to the above-mentioned data the following data is also to be stored:

a) The old value of the changed parameter, and
b) The totals of the registers.

The traceability of the most recent intervention shall be assured. If it is possible to store the records of more than one intervention, and if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

6.3 Robustness of Meter Case

6.3.1 *Meter Case*

The external surface of the meter case, which is in direct contact with the ambient air, and the internal surface of the meter case, which is in direct contact with the gas, shall be deemed of sufficient thickness when the requirements given in **6.3**, **6.4**, **6.6**, **6.9**, **6.11**, and **6.12** are met.

6.3.2 *Protection Against Penetration of Dust and Water*

6.3.2.1 *Requirements*

The meter shall be designed in such a way that it gives protection against the ingress of dust and water so that it conforms, as a minimum, to the IP 67 degree of protection, in accordance with IS/IEC 60529 : 2001.

NOTE — Further information for ingress protection for climatic environments is given in EN 16314:2013.

6.3.2.2 *Tests*

Test the meter (including the battery compartment) in accordance with IS/IEC 60529 : 2001.

6.3.3 *External Leak Tightness*

6.3.3.1 *Requirements*

When tested in accordance with **6.3.3.1**, no leakage shall be observed.

6.3.3.2 *Test*

Either of the following leak tightness procedures shall be used:

a) Immerse the meter without its index, electronics and battery in water and observe it for leakage for 30 s after any external trapped air has been dispersed, and check that there is no leakage; or
b) Use any equivalent procedure utilizing calibrated and certificated test equipment with a declared resolution and full traceability.

The meter shall be tested in three stages:

Stage A - Pressurize the meter under test, at normal laboratory temperature, with air to 25 mbar and confirm leak tightness as above;

Stage B - Pressurize the meter under test, at normal laboratory temperature, with air to a minimum of 1.5 times the declared maximum working pressure and not less than 350 mbar and confirm leak tightness as above;

Stage C - Allow the pressure to reduce to atmospheric pressure, then re-pressurize the meter under test, at normal laboratory temperature, with air to 25 mbar and confirm leak tightness as above.

The results of all three stages (A, B & C) for type tests and stage B for routine tests shall be recorded and reported as pass or fail.

6.3.4 *Resistance to Internal Pressure*

6.3.4.1 *Requirements*

After testing in accordance with **6.3.4.2**, the meter shall remain leak tight (*see* **6.3.3**).

Any residual deformation of the unpressurized meter case shall not exceed 0.75 percent of the linear dimension over which it is measured.

6.3.4.2 *Test*

a) Pressurize the case of the meter under test progressively to 1.5 times the maximum working pressure or at least 350 mbar. Maintain the test pressure for 30 min and then release.
b) Ensure that the rate of pressurization or depressurization does not exceed 350 mbar/s.
c) Record the result as pass or fail.

6.3.5 *Heat Resistance*

6.3.5.1 *Requirements*

Following the test specified in **6.3.5.2**, the meter shall satisfy the requirements of **6.3.3.2**.

6.3.5.2 *Test*

a) For safety reasons, remove any battery fitted to the meter during the heating period.
b) Suspend the meter in an ambient temperature of (120 ± 2) °C for 15 min. Allow the meter to cool to ambient temperature.
c) Then carry out a leak tightness test in accordance with **6.3.3.2**. Record the results as pass or fail.

6.3.6 *Resistance to Impact*

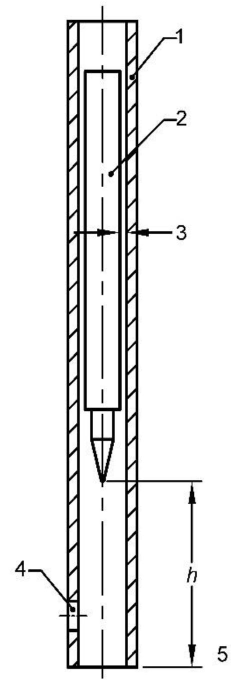
6.3.6.1 *Requirements*

When tested in accordance with **6.3.6.3** the meter shall remain leak tight.

6.3.6.2 *Apparatus*

a) The test apparatus consists of a hardened steel hemispherical tipped striker and a rigid smooth-bore tube in which the striker is capable of sliding freely (*see* Fig. 5).

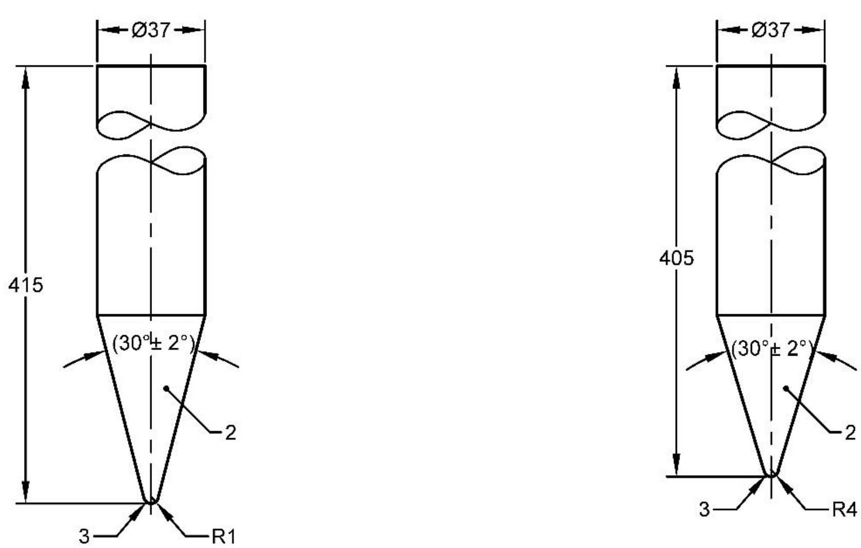
b) The total mass of the striker is 3 kg. There are two sizes of striker tip, one having a radius of 1 mm, the other having a radius of 4 mm (*see* Fig. 6).



Key

1 - Smooth bore rigid tube
2 - Hardened hemispherical tipped striker, mass 3 kg
3 - Radial clearance (0,50 ± 0,25) mm
4 - Vent hole
5 - Meter level

FIG. 5 IMPACT TEST APPARATUS



Key

1 - Striker, total mass 3 kg
2 - Steel tip, angle (30° ± 2°)
3 - Hardened steel ball; R1 = 1 mm radius, R4 = 4 mm radius

FIG. 6 TYPICAL HEMISPHERICAL TIPPED STRIKERS USED IN IMPACT TEST

6.3.6.3 *Test*

a) Using the apparatus described in **6.3.6.2** carry out the following test:

1) Use each size of striker tip during the test, but do not subject any test area on any one meter sample to more than one impact. If the same area is selected for testing with each size of striker tip, use a second meter sample.
2) For each strike, rigidly support the meter under test on a firm base with the intended area of impact. This can be any area of the meter case, providing the striker can hit the case perpendicular to the chosen plane. Place the end of the guide tube on the chosen impact area of the meter under test. Allow the striker to fall freely and vertically through the tube onto the test area, the striker tip falls from a height of h mm above the test area, where:

    1 For the 1 mm striker, h is 100 mm, producing an impact energy of 3 J; and
    2 For the 4 mm striker, h is 175 mm, producing an impact energy of 5 J.

b) Report the result as pass or fail.

6.3.7 *Resistance to Mishandling*

6.3.7.1 *Requirements*

When tested in accordance with **6.3.7.2**, the meter shall:

a) Remain leak tight in accordance with **6.3.3.2**;
b) Have the pressure absorption remaining within the allowed initial maximum permissible pressure absorption given in Table 8; and
c) Have the mean errors remaining within 2 *MPE* specified in Table 5.

6.3.7.2 *Test*

a) Test the meter in accordance with **5.3.2**, Table 6, Test (d) and confirm the errors of indication are within the allowed *MPE*.

b) Test the meter in accordance with **6.3.3.2** and confirm external leak tightness. Test the meter in accordance with **5.5.2** and confirm pressure absorption.

c) Hold the meter under test, with no packaging, in the upright position (in its horizontal plane), and drop vertically, from rest, on to a flat, hard, horizontal surface from a height as given in Table 13. The heights given refer to the distance from the bottom of the meter under test to the surface onto which it will fall.

Table 13 Drop Height
(*Clause* 6.3.7.2)

Q_{max} (m^3/h)	Dropping Height (m)
2.5 to 10	0.5
16 to 40	0.3

d) Retest the meter in accordance with **5.3.2**, Table 6, Test (d) and confirm the errors of indication remain within the allowed 2 *MPE*.

e) Retest the meter in accordance with **6.3.3.2** and reconfirm external leak tightness.

f) Report the result as pass or fail.

6.4 Connections

6.4.1 *Orientation*

6.4.1.1 *Requirements*

a) The connections of meters having top mounted two pipe connections shall have the centrelines of these connections within 2° of the vertical, with respect to the horizontal plane of the meter.

b) The distance between the centrelines of the connections, measured at the free end of the connections, shall be within ± 0.5 mm of the nominal distance between the centrelines, or within ± 0.25 percent of the nominal distance between centrelines, whichever is the greater, and the centrelines shall be within 2° of being parallel.

c) The free ends of the connections shall be level within 2 mm, or within 1 percent of the nominal distance between the centrelines of the connections, whichever is the greater, with respect to the horizontal plane of the meter.

6.4.1.2 *Test*

a) Measurements are taken using appropriate instruments capable of measuring to an accuracy better than that required in **6.4.1.1**.

b) The result shall be recorded as pass or fail.

6.4.2 *Threads and Flanges for Two Pipe Meters*

6.4.2.1 *Requirements*

The threads of threaded meter connections on two pipe meters shall be as specified in IS 554 : 1999, IS 2643 : 2005, BS 746:2014 or ASME B1. 20.1- 2013. Flanges of flanged meter connections shall have dimensions which are in accordance with one of the types of flange given in EN 1092-1:2018, Table 12 as declared by the meter manufacturer.

NOTE — The fact that the dimensions are taken from EN 1092-1:2018, Table 12 (the PN 10 table) does not denote that the meter has a pressure rating of 10 bar.

6.4.2.2 *Test*

a) Measurements are taken using appropriate instruments capable of measuring to an accuracy better than that required in **6.4.2.1**.

b) The result shall be recorded as pass or fail.

6.4.3 *Strength*

6.4.3.1 *Torque*

6.4.3.1.1 *Requirements*

a) The meter connection shall be subjected to the appropriate torque specified in Table 14 in accordance with **6.4.3.1.2**, and shall then conform to the following:

   1) External leak tightness (*see* **6.3.3**);
   2) Any residual rotational deformation of the meter connection shall not exceed 2°.

Table 14 Torque and Bending Moment
(*Clauses* 6.4.3.1.1 and 6.4.3.2.1)

Nominal connection diameter		**Torque value**	**Bending moment** ***M***
Inches	DN (mm)	Nm	Nm
1/2	15	50	10
3/4	20	80	20
1	25	110	40
1 1/4	32	110	40
1 1/2	40	140	60
2	50	170	60
2 1/2	65	170	60

6.4.3.1.2 *Test*

a) Firmly support the case of the meter under test and apply the appropriate torque value to each connection in turn using a suitable torque wrench.
b) Report the result as pass or fail.

6.4.3.2 *Bending moment*

6.4.3.2.1 *Requirements*

a) Each meter shall be subjected to the bending moment given in Table 14 in accordance with **6.4.3.2.2** and, during and after the test, the meter shall remain leak tight in accordance with **6.3.3**.

b) Before the bending moment test, the meter under test shall be tested in accordance with **5.3.2**,

Table 6, Test (d).

c) After the test, the residual deformation of the connections shall not exceed 5°.

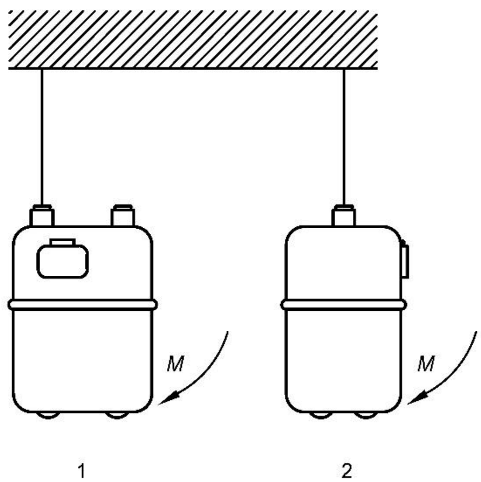
d) After the bending moment test, the meter under test shall be retested in accordance with the method given in **5.3.2**, Table 6, Test (d). The errors of indication shall be within the allowed maximum permissible error limit specified in Table 5.

6.4.3.2.2 *Test*

a) Rigidly support the meter under test by one of its connections as shown in Fig.7 and apply the appropriate bending moment for a period of 2 min. Use different meters for the lateral test(s) and the fore and aft test(s).

b) Repeat the lateral bending moment test on the other meter connection, but for the fore and aft test support the meter by both connections.

c) Report the result as pass or fail.



Key

1 - lateral
2 - fore and aft
M - bending moment

FIG. 7 ARRANGEMENT FOR BENDING MOMENT TEST

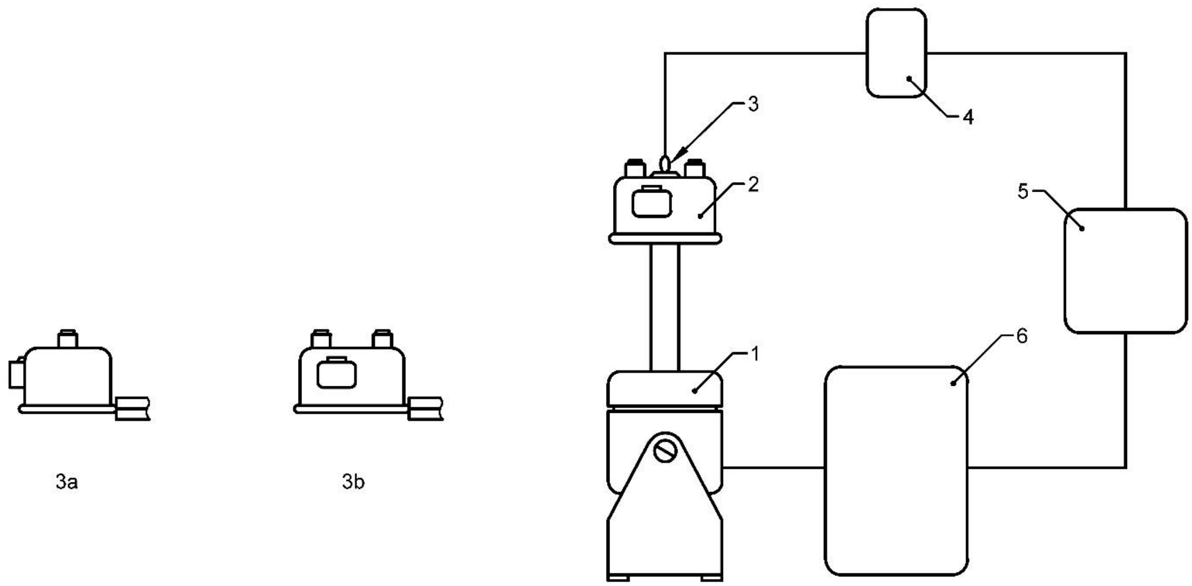
6.5 Resistance to Vibration

6.5.1 *Requirements*

The meter shall remain leak tight and its error of indication shall be within the initial permissible limits as given in Table 5, before and after being subjected to the vibration test described in **6.5.3**.

6.5.2 *Apparatus*

The apparatus described in Fig. 8 shall be used to undertake the test.



Key

1 - Electrodynamic shaker, driven by an amplified sine wave from a voltage generator

NOTE — The head of the shaker can be rotated through 90° for fore and aft and planes [*see* (3a) representing fore and (3b) representing aft plane of the meter mounted on shaker]

2 - Meter under test (vertical plane), mounted to spindle of electrodynamic shaker (1)
3 - Accelerometer (piezoelectric transducer)
4 - Automatic vibration exciter control, capable of being used in a sweeping mode in which the frequency is cycled between a pair of selected frequencies, alternately increasing and decreasing
5 - Charge amplifier, used to condition the output from the accelerometer (piezoelectric transducer) (3)
6 - Power amplifier, suitable for amplifying the power of the accelerometer

FIG. 8 LAYOUT OF THE VIBRATION TEST APPARATUS

6.5.3 *Test*

a) Carry out the error of indication test specified in **5.3.2**, Table 6, Test (c), to ensure that the accuracy of the meter under test is within the maximum permissible initial error limits given in Table 5 and confirm that the meter under test is leak tight, by carrying out the test described in **6.3.3.2**.

b) Secure the meter under test to the vibration test rig without causing damage or distortion to the meter case, as shown in Fig. 8, using a horizontal clamp across the top of the meter.

c) Subject the meter under test to a swept frequency between 10 Hz and 150 Hz (±5 percent) at a sweep rate of 1 octave per minute with a peak acceleration of 2 *g* (±5 percent), for 20 sweeps in the vertical plane, 20 sweeps in the fore-aft plane and 20 sweeps in the lateral plane. The displacement amplitude shall be limited to 0.35 mm.

d) Recheck the error of indication of the meter under test, by carrying out the test specified in **5.3.2**, Table 6, Test (c), and confirm the leak tightness by carrying out the test described in **6.3.3.2**.

NOTE — An octave is a band of frequency where the upper frequency limit of the band is exactly twice the lower limit, example 10 Hz to 20 Hz, 20 Hz to 40 Hz, 40 Hz to 80 Hz and 80 Hz to 160 Hz. Therefore, the time taken to sweep from 10 Hz to 100 Hz at a sweep rate of 1 octave per minute is 3 min 15s.

e) Report the result as pass or fail.

6.6 Corrosion Protection

6.6.1 *General*

a) Meters to which only decorative coatings (that is, coatings not intended to contribute to corrosion protection) are to be applied, shall be tested before application of the coating. Such decorative coatings shall not adversely affect the corrosion resistance of the meter.
b) All tests shall be performed on the gas-containing components themselves or on sample plaques.
c) Sample plaques shall only be used in place of a component if no forming operation has been carried out on the component after the protective finish is applied.
d) Sample plaques, if used, shall be 100 mm × 100 mm, their thickness being that of the component they are replacing.
e) The finishes on items supplied for test shall have been fully dried and cured.
f) Attack on the edges or up to 2mm from the edge of sample plaques shall be ignored if the component it replaces has no exposed edges when installed in the finished meter.

6.6.2 *External Corrosion*

6.6.2.1 *Scratch resistance of the protective coating*

6.6.2.1.1 *Requirements*

When tested in accordance with **6.6.2.1.2**, there shall not be evidence of penetration of the protective coating.

6.6.2.1.2 *Test*

a) Test in accordance with ISO 1518-1:2019 using a loading of 19.5 N, do not expose corrodible base material.
b) Where a metallic protective coating is applied directly onto a metal surface, the indicator lamp will light without any penetration of the surface. Visually inspect the surface for penetration of the coating.

6.6.2.2 *Adhesion of the protective coating*

6.6.2.2.1 *Requirements*

When tested in accordance with **6.6.2.2.2**, the result shall be less than classification 2 given in ISO 2409:2020.

6.6.2.2.2 *Test*

Test in accordance with ISO 2409:2020 and ensure the result is less than classification 2.

6.6.2.3 *Impact resistance of the protective coating*

6.6.2.3.1 *Requirements*

When tested in accordance with **6.6.2.3.2**, there shall be no cracking or loss of adhesion of the protective coating, any indentation shall not exceed 2.5 mm in depth.

6.6.2.3.2 *Test*

Place the surface of the test piece which would normally be the outside surface of the meter so that it faces upwards, then test in accordance with the method given in IS 101 (Part 5/Sec 3) : 2019 using a drop height of 0.5 m.

6.6.2.4 *Chemical resistance of the protective coating*

6.6.2.4.1 *Requirements*

When tested in accordance with **6.6.2.4.2**, the degree of blistering of the protective coating shall be less than that given as ratio density 2/size 2 given in ISO 4628-2:2016, and the degree of corrosion of the base material shall not be greater than that given as R_i 1 in Table 1 of ISO 4628-3:2016.

6.6.2.4.2 *Test*

Using the liquids specified in ISO 2812-1:2017, **A-2.2** and **A-3.1**, as well as 5 percent aqueous solution of sodium salts of sulphated broad cut primary alcohol, chain length C9 to C13 pH values **6.5** to **8.5**, test in accordance with ISO 2812-1:2017, **9.3**, Method A, using a test period of 168 h.

6.6.2.5 *Resistance to salt spray*

6.6.2.5.1 *Requirements*

When tested in accordance with **6.6.2.5.2**, the degree of corrosion shall not be greater than that given as R_i 1 in Table 1 of ISO 4628-3:2016.

6.6.2.5.2 *Test*

Use a complete meter for sizes of meter having a Q_{max} not exceeding 10 m^3/h, for meter above this size use a representative part of the meter, example deep-drawn parts, including at least one connection.

Test in accordance with IS 9844 : 1981, exposing the sample to the salt spray over 500 h.

6.6.2.6 *Resistance to humidity*

6.6.2.6.1 *Requirements*

When tested in accordance with **6.6.2.6.2**, the degree of blistering of the coating shall be less than that given as the ratio density 2/size 2 in ISO 4628-2:2016, and the degree of corrosion of the base material shall be not greater than that given as R_i 1 in Table 1 of ISO 4628-3:2016.

6.6.2.6.2 *Test*

Use a complete meter for sizes of meter having a Q_{max} not exceeding 10 m^3/h, for meter above this size use representative parts of the meter, example deep-drawn parts, including at least one connection.

Test in accordance with ISO 6270-1:2018 using a test duration of 500 h. Report the result as pass or fail.

6.7 Flame Retardance of External Surfaces

6.7.1 *Requirements*

All external surfaces of the meter (including the index window) and gas containing casework material shall not support combustion. The material shall have a flammability rating of V-0 in accordance with IS/IEC 60695-11-10 : 2013.

6.7.2 *Test*

Subject the external surfaces of the meter to the flame test as specified in IS/IEC 60695-11-5 : 2016. Apply the flame to the edges, corners and surfaces of the casing, each for a period of 30s.

6.8 Requirement for Rubber Components in the Gas Path

6.8.1 *Requirements*

All the rubber/elastomeric sealing components required for gas tightness shall be deemed acceptable if they conform to EN 549:2019.

6.8.2 *Test*

a) Confirm all the rubber/elastomeric sealing components required for gas tightness conform to EN 549:2019.
b) Report the result as pass or fail.

6.9 Resistance to Storage Temperature Range

6.9.1 *Requirements*

When tested in accordance with **6.9.2**, the mean errors shall remain within the *MPE* specified in Table 5.

6.9.2 *Test*

a) Test the meter in accordance with **5.3.2**, Table 6, Test (d).

b) Maintain the meter, with no gas flowing through it, under the following conditions:
   1) 3 h at a temperature of –20 °C, or lower if declared by the manufacturer;
   2) 3 h at a temperature of +70 °C, or higher if declared by the manufacturer.
c) At the end of each period, return the meter to normal laboratory ambient temperature and test in accordance with **5.3.2**, Table 6, Test (d).
d) Report the result as pass or fail.

6.10 Resistance to Toluene/ISO-Octane Vapour

6.10.1 *Requirements*

When tested in accordance with **6.10.2**, the mean errors after any stage of the test shall remain within the *MPE* specified in Table 5.

6.10.2 *Test*

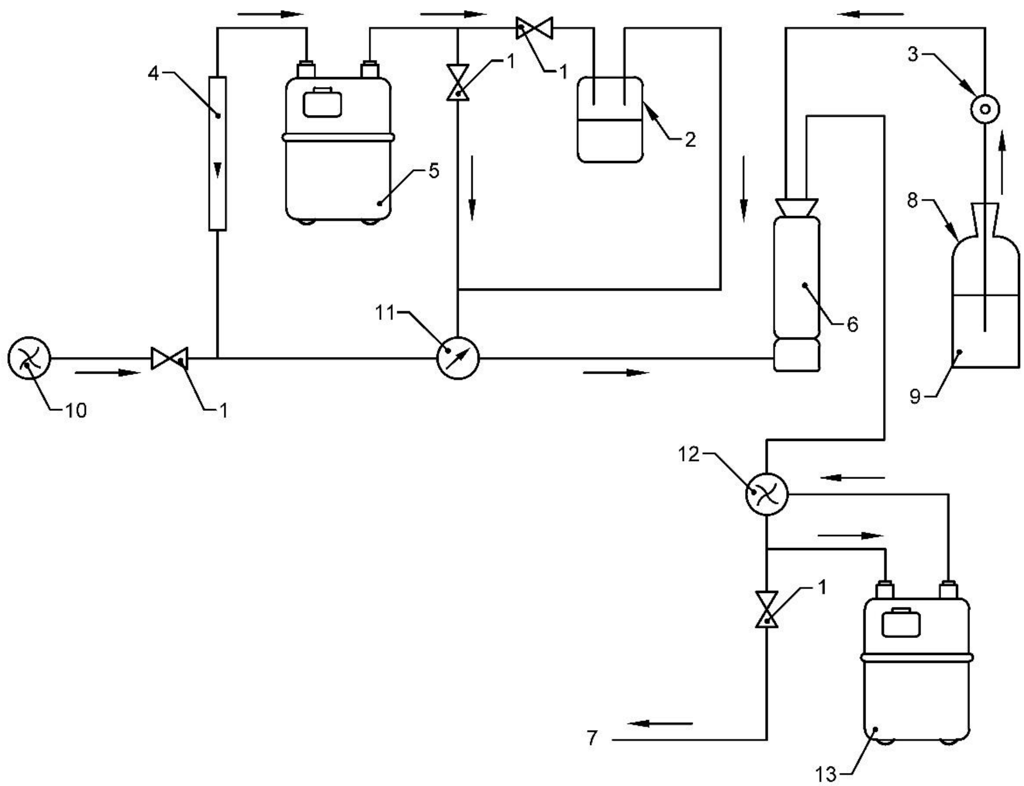
6.10.2.1 *General*

a) Test the meter in accordance with **5.3.2**, Table 6, Test (d).
b) Exercise the meter with nitrogen to which has been added a toluene/iso-octane mixture as specified in **6.10.2.3**, for a complete period of 42 days (1008 h) at (20 ± 2) °C, and a flow rate of not less than 0.25 Q_{max}. Then test the meter in accordance with **5.3.2**, Table 6, Test (d).
c) Exercise the meter with air for a further period of 7 days (168 h) at (20 ± 2) °C, (65 ± 10) percent relative humidity and a flow rate of not less than 0.25 Q_{max}.
d) Test the meter in accordance with **5.3.2**, Table 6, Test (d).

6.10.2.2 *Example of a typical apparatus*

An example of a typical apparatus is given in Fig. 9. The apparatus consists of the following components:

a) Meter exercise rig, open to atmosphere, fitted with a suitable circulating pump or blower;
b) Nitrogen supply with a flow rate measurement capability (flow meter, meter or both);
c) Relative humidity control, comprising a water reservoir and valves capable of giving a relative humidity of (65 ± 10) percent. The relative humidity is measured by a hair or paper hygrometer or by a moisture meter;
d) Solvent addition. The toluene/iso-octane mixture is added to the top of the vaporization tower by means of a micro-metering pump. The tower has a bottom diffuser plate and is filled with alternate layers of small glass beads and cotton fabric (or other material) to give a large surface area. The tower is surrounded with a heating blanket, which produces a temperature of 650°C at the blanket/tower interface to speed up vaporization.



Key

1 - Valve(s)
2 - Water reservoir for moisture adjustment
3 - Micro-metering pump
4 - Rotameter
5 - Meter for volume test
6 - Vaporization tower filled with alternate layers of glass beads and cotton fabric and surrounded by a blanket
7 - Exhaust
8 - Toluene/iso-octane reservoir
9 - Solvent addition
10 - Blower
11 - Hygrometer
12 - Circulating blower
13 - Meter under test

FIG. 9 TYPICAL APPARATUS FOR TOLUENE/ISO-OCTANE VAPOUR TEST

6.10.2.3 *Toluene / ISO-octane mixture with nitrogen*

Prepare a mixture 3 percent by volume of a 30 percent toluene/70 percent iso-octane mixture with nitrogen by carefully mixing 95.4 ml toluene with 346.5 ml iso-octane and adding 441.9 ml of this mixture to 2240 liter of nitrogen carrier gas. This is equivalent to 0.197 ml per liter of carrier gas.

Note that the actual amount of solvent to be added to the system is dependent on the carrier gas flow rate and the conditions inside the tower.

6.10.2.4 *Procedure*

Allow the toluene/iso-octane mixture (*see* **6.10.2.3**) to percolate down the tower and vaporize. Introduce nitrogen, at a controlled flow rate, through the diffuser at the bottom of the tower where it picks up the vaporized solvent. Pass the gaseous mixture into the exercise rig where it is circulated through the meter under test. A fresh supply of solvent is continuously added to give a consistent concentration.

6.11 Resistance to Water Vapour

6.11.1 *Requirements*

When tested in accordance with **6.11.2**, the mean errors after any stage of the test shall remain within the *MPE* specified in Table 5.

6.11.2 *Test*

a) Test the meter in accordance with **5.3.2**, Table 6, Test (d).

b) Connect the meter to the water vapour test rig (*see* Fig. 10).

c) Exercise the meter with air having a relative humidity of less than 20 percent for 7 days (168 h) at (20 ± 2) °C and a flow rate of not less than 0.25 Q_{max}, at the end of this period, test the meter in accordance with **5.3.2**, Table 6, Test (d).

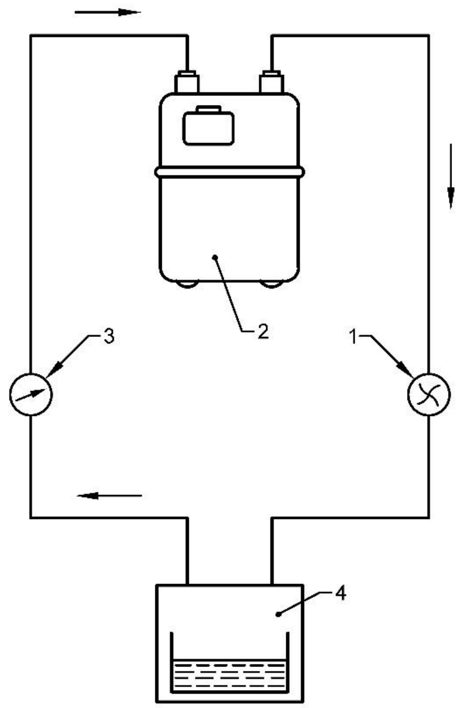
d) On completion of this low humidity performance test, exercise the meter with air having a relative humidity of (85 ± 5) percent for a complete period of 42 days (1008 h) at (20 ± 2) °C and a flow rate of not less than 0.25 Q_{max}.

e) Then exercise the meter with air having a relative humidity of less than 20 percent for at least 7 days (168 h) at (20 ± 2) °C and at a flow rate of not less than 0.25 Q_{max}. Then test the meter in accordance with **5.3.2** Table 6, Test (d).

6.11.3 *Example of a typical apparatus*

Fig. 10 shows a closed-circuit test rig which comprises the following:

a) a suitable circulating pump or blower;
b) meter under test;
c) a hygrometer with a range of 0 percent to 100 percent relative humidity; and
d) a chamber containing either a saturated solution of potassium acetate (CH_3COOK) to give a relative humidity of 20 percent at 20 °C, or a saturated solution of potassium hydrogen sulphate ($KHSO_4$) to give a relative humidity of 86 percent at 20 °C.



Key

1 - Circulating blower
2 - Meter under test
3 - Hygrometer
4 - Chamber containing the saturated solution for humidity control

FIG.10 EXAMPLE OF A WATER VAPOUR TEST APPARATUS

6.12 Ageing

6.12.1 *Requirements*

When tested in accordance with **6.12.2**, the following requirements shall be met:

a) The mean errors remain within the maximum permissible error limits specified in Table 5;
b) The index remains legible;
c) There is no damage or variation to the index reading;
d) There meter remains leak tight as specified in **6.3.3**;
e) There is no corrosion of the electronic circuits, such that the meter functionality is impaired.

6.12.2 *Tests*

a) Test the meter in accordance with **5.3.2**, Table 6, Test (d).
b) Carry out the test at the temperature declared by the manufacturer, using one of the values given in Table 15.
c) Use a complete meter having its ports sealed, to protect the internal parts.
d) Under zero flow conditions hold the meter at any one of the temperatures given in Table 15 and

with a relative humidity of (85 ± 5) percent for the time period given in Table 15.

Table 15 Temperature Times/Ageing Periods and Relative Humidity
(*Clause* 6.12.2)

Temperature (°C)	Time period (days)	Relative humidity (percent)
50	200	85 ± 5
60	100	
70	50	

e) At the end of this period, slowly return the meter to a temperature of (20°C ± 2) °C, at a rate of not more than 2 °C/h, and again test the meter in accordance with **5.3.2**, Table 6, Test (d).

7 OPTIONAL FEATURES

7.1 Pressure Measuring Point

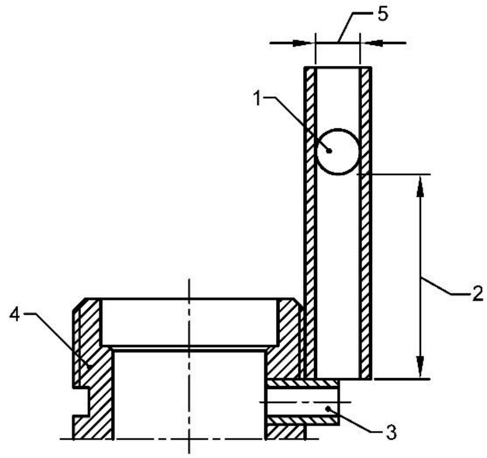
7.1.1 *Requirements*

If a pressure measuring point is provided on the meter, it shall:

a) Be either fixed by mechanical means (i.e. not only relying on solder, brazing or adhesive) or provided on electronic display if the meter has provision to measure;
b) For mechanical arrangements have a hole, through the pressure measuring point, the diameter of which shall be less than 1 mm; and
c) For electronic display, outlet side pressure of gas meter may be made available on electronic display of meter.
d) After carrying out tests specified in 7.1.2 the meter shall remain leak tight when tested in accordance with **6.3.3.2**; and

7.1.2 *Test*

a) Measure the diameter of the hole through the pressure measuring point. Test the meter for leak tightness in accordance with **6.3.3.2**.
b) Apply a torque of 8 Nm to the body of the pressure measuring point in a clockwise and anti-clockwise direction and then release. Drop a mass of 0.5 kg from a height of 250 mm, through a vertical tube of 40 mm maximum diameter onto the outer extremity of the body diameter of the pressure measuring point (*see* Fig. 11).
c) Recheck the meter under test for leak tightness in accordance with **6.3.3.2**. Report the result as pass or fail.



Key

1 - 0.5 kg steel ball
2 - Drop height (250 mm)
3 - Pressure measuring point
4 - Meter port
5 - Diameter of the vertical tube (max 40 mm)

FIG. 11 EXAMPLE OF A PRESSURE MEASURING POINT TEST APPARATUS

7.2 Electrical Insulating Feet (Optional)

7.2.1 *Requirements*

a) If insulating feet are provided on the meter, there shall be a minimum of 4 and they shall give a minimum clearance of 5 mm at the base of the meter.
b) After carrying out the test specified in **7.2.2**, the electrical resistance measured shall not be less than 100 kΩ.
c) When tested at 650 V AC as specified in **7.2.2**, there shall be no breakdown of the insulation.

7.2.2 *Test*

a) Place the meter under test on a flat metal plate and apply a potential of 500 V DC between the metal plate and each meter connection in turn for 60 s. Measure the electrical resistance between the metal plate and each connection successively.
b) Then apply a potential of 650 V AC between the metal plate and each meter connection, successively, for 60 s.
c) Report the result as pass or fail.

7.3 Resistance to High Ambient Temperatures

7.3.1 *Requirements*

a) Where the manufacturer declares that the meter is resistant to high temperatures, the following requirement shall apply.

b) Revise this and mandate it for safety concern
c) When tested in accordance with **7.3.2**., the leakage rate of the meter case shall not exceed 150 dm^3/h for meters of size up to and including those having a Q_{max} of 40 m^3/h.

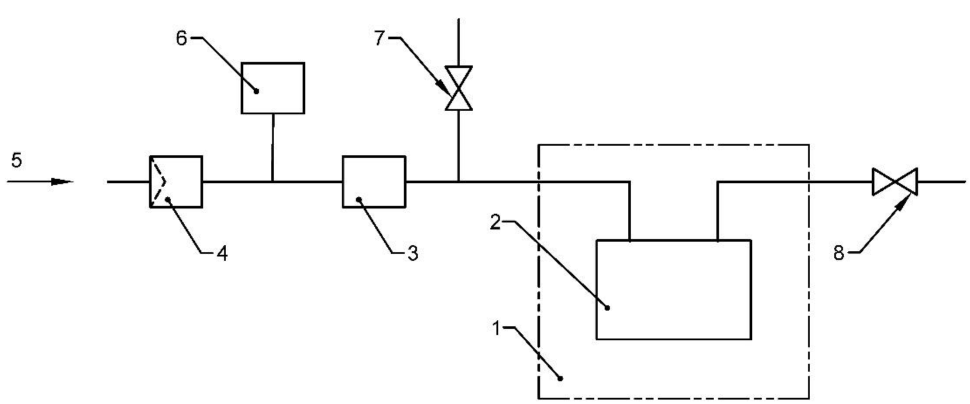
7.3.2 *Test*

a) Carry out the test on an empty meter case and without any battery(s).
b) Connect the meter case under test to the inlet and outlet connections and install the assembly in the centre of the furnace using supports if necessary (*see* Fig. 12).
c) If it is necessary to take into account the mass of the metering apparatus, place a metal weight equivalent to the mass of the metering apparatus on the meter case.
d) Perform the test at 100 mbar, irrespective of the p_{max} of the meter.
e) With the bleed valve closed, pressurize the meter under test to 100 mbar with nitrogen and verify its tightness.
f) With the meter under the nitrogen test pressure, increase the temperature of the furnace in accordance with the temperature rise curve of IS/ISO 834-1 : 1999.
g) When the temperature at the coldest point of the meter under test reaches 650°C, set the furnace to maintain this temperature for a period of 30 min.
h) During the complete test, maintain the pressure in the meter case at the test pressure by means of the bleed valve. Record the leakage rate as registered using metering periods not exceeding 5 min.
i) Calculate the leakage as the metered nitrogen volume divided by the measuring time. Report the result as pass or fail.

7.3.3 *Example of A Typical Resistance to High Temperature Test Apparatus*

Fig. 12 shows a closed-circuit test rig, which comprises the following:

a) furnace, capable of allowing an ambient temperature rise conforming to the curve defined in IS/ISO 834-1 : 1999. The internal dimensions of the furnace shall allow the installation of the meter under test and its connections to be in identical positions to those used in practice;
b) pressure regulator, capable of maintaining a constant pressure equal to 100 mbar during the complete test.



Key

1 - Furnace

2 - Meter at centre of furnace
3 - Check meter
4 - Pressure regulator
5 - Inlet
6 - Pressure gauge
7 - Bleed valve
8 - Air purge valve

FIG. 12 EXAMPLE OF A HIGH AMBIENT TEMPERATURE TEST APPARATUS

7.4 Gas Valve and System

7.4.1 *General*

The valve requirements are only intended for interruption of the gas supply and shall not replace any valve intended to isolate the gas supply, for example an Emergency Control Valve or similar. It shall not be regarded as a thermal or safety shut off valve. Where a valve is fitted in the meter, the valve shall meet the requirements of EN 16314 : 2013.

7.5 Additional Functionalities (if fitted)

7.5.1 *Requirements*

a) Any additional functionalities shall be approved for use by the meter manufacturer;
b) Any additional functionalities shall not obscure the markings specified in **9.1**;
c) When tested in accordance with **7.4.2**, the mean errors at all flow rates shall remain within the *MPE* and the mean error difference at each flow rate shall not exceed one third of the *MPE* specified in Table 5;
d) The pressure absorption shall remain within the initial values specified in Table 8.

7.5.2 *Test*

a) Confirm any additional functionalities have been approved by the meter manufacturer;
b) Confirm by visual inspection that markings are not obscured;
c) Test the meter without the additional functionalities in accordance with **5.3.2** at the flow rates specified in Table 6, Test (c). Repeat this test with the additional functionalities fitted, and calculate the *MPE* and the error difference;
d) With the additional functionalities fitted, test the meter in accordance with **5.5.2**.

7.6 Use in Hazardous Zones

7.6.1 *Requirements*

Where the manufacturer declares that the meter is suitable for use in hazardous zones as defined in IS 5572 : 2009, the design, construction and marking of the meter shall then comply with IS/IEC 60079-0 : 2017 and either IS/IEC 60079-11 : 2011, or IEC 60079-15:2017, as appropriate.

7.6.2 *Test*

Ensure that the design, construction and marking of the meter comply with IS/IEC 60079-0 : 2017 and either IS/IEC 60079-11 : 2011, or IEC 60079-15:2017, as appropriate.

8 INDEX

8.1 Recording and Storage

8.1.1 *Requirements*

The recorded cumulative volume shall be shown by the display and stored in a non-volatile storage device for a minimum of 60 months.

8.1.2 *Test*

Confirm by visual inspection. The memory retention time can be based on calculations from data for the relevant components, or from the results of manufacturer's own relevant tests.

8.2 Display

8.2.1 *Requirements*

a) In addition to a flag character, the display shall have a minimum number of numerical characters as specified in Table 16;
b) Any alphabetical flag character chosen shall not be able to be confused as a digit by the user;
c) An index shall have at least a sufficient number of numerals to ensure that the volume passed during 8000 h at a flow rate of Q_{max} does not return all of the numerals to their original positions;
d) The index shall be non-resettable, non-volatile and protected with a metrological seal.
e) The index shall be easily readable within an angle of 15° from normal to the window without the use of tools, within the ambient temperature range of −10°C to 55°C, or greater if declared by the manufacturer;
f) The numerals in the display before decimal shall have a minimum height of 4.8 mm;
g) The unit of measurement (m^3) and the symbol V_b shall be unambiguously and boldly displayed, within the index;
h) The numerals indicating the sub-multiples of the cubic meter shall be clearly distinguishable from the other numerals and they shall be separated from the other numerals by a clearly marked decimal sign;
j) If the index is constructed in such a way that the signal of the measuring part is produced in discrete steps, its internal resolution shall be equivalent or more accurate than the increment of the test element. The increment of the test element or pulse shall occur at least every 60 s at Q_{min}.

Table 16 Resolution of meter index
(*Clause* 8.2.1)

Q_{max} (m^3/h)	**Numbering** every dm^3	**Example of meter index** (m^3)	**Minimum number of digits**
2.5 ≤ Q_{max} ≤ 10	1	1 2 3 4 5 , 6 7 8	

$16 \leq Q_{max} \leq 40$	10	1 2 3 4 5 6 , 7 8	8

8.2.2 *Test*

a) Confirm the requirements of **8.2.1** by either visual inspection, measurement or design.
b) Where the indicated values, used in the accuracy tests, are obtained exclusively via the communications port, ensure that the inspection confirms that the reading from the communications port(s) is the same as the value registered in the display.

An example confirming how to meet the requirement **8.2.1**, (j).

Example:

A meter with a maximum flow rate Q_{max} of 6 m^3/h and a minimum flow rate Q_{min} of 0.04 m^3/h needs to have a test element of at least $(0.04\ m^3/3600\ s)\cdot 60\ s = 0.00067\ m^3$.

8.3 Display Functionality

8.3.1 *Requirements*

a) The test house shall confirm with the manufacturer what information has to be shown on the display. This information shall be displayed on the index in a complete, readable and legible form. The meter shall have a test routine that will display all information that is available to be seen. Meter having electronic display shall have option to ON and OFF of display segment/graphics for testing purpose.
b) The test routine shall either occur automatically, or activated on demand for a maximum duration of 5s. When the test routine is activated automatically, the occurrence shall not be less than 1 min.

8.3.2 *Test*

a) By visual inspection, confirm that the information shown on the display is complete, readable and legible.
b) Using a suitable timing device, confirm that requirements of **8.3.1** are met. If appropriate to the test, inject a test signal in accordance with the manufacturer's instructions.
c) Confirm the meter has a test routine and displays all information that is available to be seen.
d) Confirm the test routine activates the index for a maximum duration of 5s, automatically, or on demand. Confirm that, when the test routine is activated automatically, this occurrence is not less than 1 min.

8.4 Non-Volatile Memory

8.4.1 *Requirements*

a) The non-volatile memory shall be continuously updated at least every 6 h.
b) When tested in accordance with **8.4.2.1**, the non-volatile memory shall remain accessible and unchanged at the extremes of the declared temperature range.

c) When tested in accordance with **8.4.2.2**, the non-volatile memory shall be maintained without any power source at the extremes of the declared storage temperature range. There shall be no difference between the readings before and after the test.

8.4.2 *Test*

8.4.2.1 *Method (A)*

a) Access the information in the non-volatile memory as specified by the manufacturer;
b) prevent any registration;
c) record the index reading and the internal register of non-volatile memory;
d) subject the meter to the extremes of declared ambient temperature, for a minimum of 3 h at each temperature;
e) at each of the declared temperature extremes, at the end of the dwell time, record the index reading and the register in the non-volatile memory;
f) compare the readings obtained in (c) and (e) above;
g) report the result as pass or fail.

8.4.2.2 *Method (B)*

a) Access the information in the non-volatile memory as specified by the manufacturer;
b) immediately supply a flow rate equal to Q_{max} for 5 min;
c) confirm that the flow rate has been registered;
d) cap the meter to prevent further registration;
e) record the information which is in the non-volatile memory;
f) leave the meter at room temperature for a minimum of 6 h 5 min;
g) disconnect the non-volatile memory from the power supply and subject the meter to the declared minimum and maximum storage temperatures, for a minimum of 3 h at each temperature;
h) reconnect the power supply;
j) record information in the non-volatile memory;
k) compare the information as noted in (e) and (j);
m) report the result as pass or fail.

9 MARKING

9.1 All Meters

Each meter shall be marked with at least the following information, either on the index or on a separate data plate. All markings shall be in a clearly visible position and shall be durable under the normal conditions of the meter. Each meter shall be marked with at least:

a) The type approval mark and number (if applicable);
b) The identification mark or name of the manufacturer;
c) The serial number of the meter;
d) Year of manufacture, (YYYY);
e) The maximum flow rate, Q_{max} (m^3/h);
f) The minimum flow rate, Q_{min} (m^3/h);
g) The maximum working pressure, p_{max} (bar);

h) Group(s) of gases for which the meter is approved, e.g. Groups H, L, E;
j) Base temperature t_b and base pressure p_b;
k) Specified centre temperature value t_{sp} if different from t_b;
m) Ambient temperature range if greater than −10°C to 55°C, e.g. t_m = −25°C to 55°C (*see* 4.5);
n) Gas temperature range if different to the ambient temperature range, e.g. t_g = −10°C to 40°C;
p) Accuracy class of the meter, i.e. Class 1.5;

If the meter is resistant to high ambient temperatures (*see* **7.3**), it shall be marked additionally with T. If the meter is declared suitable for use in an open environment, it shall be marked additionally with H3.

The markings shall be in a clearly visible position and shall be durable under the normal conditions of the meter.

If all applicable information cannot be displayed on the meter, this shall be provided on the packaging or with the manual/literature supplied with the meter.

9.2 Two Pipe Meters

9.2.1 *Requirements*

Meters with two-pipe connections shall be clearly and permanently marked with the direction(s) of flow by means of an arrow(s).

9.2.2 *Test*

The test shall be confirmed by visual inspection.

9.3 Durability and Legibility of Marking and Labels

9.3.1 *Requirements*

When tested in accordance with **6.5**, **6.6.2.5**, **6.9**, **6.12**, **9.3.2**, and **9.4** all labels shall remain securely fixed, and their edges shall not lift from the backing surfaces. In addition, all markings on the meter, the index, index plate and any separate data plate, if fitted, shall remain legible.

Any adhesive metrology labels shall be tamper-evident. Manual removal shall result in damage, which prevents re-application. The peel adhesion, measured as the force required to remove the marking label, shall be greater than (0.40 ± 0.04) N/mm. The label shall also not become detached, crazed or blistered.

9.3.2 *Tests*

9.3.2.1 *Weathering test*

One meter shall be exposed for 66 days to artificial weathering and exposure to artificial radiation in accordance with ISO 4892-3:2016 and the parameters in Table 17. Prior to exposure, measurements shall be made to enable the test criteria to be assessed.

Table 17 Weathering Test Criteria
(*Clause* 9.3.2.1)

Test cycle	**Wavelength / lamp type**	**Irradiance**	**Black panel - temperature**
8 h, dry	UVA 340	0.76 W($m^{-2}\cdot nm^{-1}$) at 340 nm	(60 ± 3) °C
4 h, condensation		Light out	(50 ± 3) °C
Weathering test duration = 66 days			

Following shall be confirmed by visual examination:

a) That all labels are securely fixed, and their edges do not lift from the backing surfaces;
b) That the label and all markings on the meter, the index, index plate and any separate data plate, if fitted, are legible.
c) That electronic display, if fitted shall be legible in ambient light.

9.3.2.2 *Adhesion of metrology label test*

Test shall be conducted in the following sequence:

a) The meters which have adhesive labels shall conform to this test.
b) Following test shall be carried out at (20 ± 3) °C.
c) Apply a finished label to the finished meter surface or a sample of the same finished meter material by pressing half the label area to the surface, with the remaining half folded back through 180°.
d) Allow the adhesive to condition for a minimum of 48 h at (20 ± 3) °C.
e) Apply a traction of 300 mm/min separation rate to the unattached portion of the label, for example using a dynamometer.
f) Record the force (peel adhesion) at which the label loses adhesion or breaks and confirm the force required to remove the label is greater than (0.40 ± 0.04) N/mm. Provided that, if all the attached area of the label continues to adhere to the surface, it is permissible for the label to break during the test.

9.4 Indelibility of Marking

9.4.1 *Requirements*

When tested in accordance with **9.4.2**, all markings on the external surface of the meter, which can be touched when the meter is in normal use, shall conform to the requirements given in Annex A of IS/IEC 60730-1 : 1999.

9.4.2 *Tests*

The requirements given in Annex A of IS/IEC 60730-1 : 1999 shall be met.

9.5 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may also be marked with the standard mark.

10 SOFTWARE

10.1 Requirements

The metrological parts of the software of a gas meter and its constituents shall be clearly identified with the software version and a unique software identifier (for example, checksum). The identification may apply to more than one part, but at least one part shall be dedicated for metrological purpose. The manufacturer shall declare the means of software identification.

The metrological software identifier(s) shall be:

a) Permanently presented by the meter, or
b) Presented and displayed on command, without any external tools, or
c) Displayed during operation.

10.2 Tests

Test shall be confirmed by visual inspection and the relevant documentation submitted by the manufacturer shall be reviewed.

11 COMMUNICATION

11.1 General

11.1.1 *Requirements*

IS/IEC 62056-21 : 2002 or equivalent shall be referred, but with provisions for:

a) An alternative sign-off incorporating acknowledgement from the meter;
b) A test mode message structure, to enable common test procedures for meters.

The meter shall provide access to information stored in the memory of the meter via a serial data link. Data shall be provided through a suitable interface.

The information shall, as a minimum, provide for the transmission of the index reading (volatile and non-volatile memory), the meter serial number and the status flag and provision for error detection.

A facility shall be provided to clear the battery change flag once the battery has been changed. A procedure shall be defined by the manufacturer.

Inactivity time-out shall be min 10 s or as declared by manufacturer.

11.1.2 *Test*

a) Confirm the meter provides access to information stored in the memory of the meter via a serial data link, and that data have been provided by a suitable interface.
b) Confirm as a minimum that the index reading (volatile and non-volatile memory), the meter serial number and any status flag have been transmitted.
c) Induce an error and confirm the error has been detected and transmitted.
d) Change the battery in accordance to the manufacturer’s instructions and confirm the procedures demonstrates how to change battery and clear any related flags.
e) Confirm the inactivity time-out intervals as 10s, or declared by manufacturer.

11.2 Metrology Influence of Radio Communication Function

11.2.1 *Requirements*

Where a radio communication module is fitted to the meter, the metrological accuracy shall not be influenced by communication function.

When tested in accordance with **11.2.2** the difference of mean errors shall not exceed 0.3 percent.

11.2.2 *Test*

Test the meter in accordance with **5.3.2**, Table 6, Test (a) only at $0.1Q_{max}$ in the following two configurations:

a) With radio communication function disabled; and
b) With radio communication function in operation at each of the six measurement repetitions.

Check the error difference between a) and b) and ensure requirement in **11.2.1** is met.

11.3 Test Mode

11.3.1 *Requirements*

Where the meter has a test mode accessible via communication port, the following test mode command structure shall be used:

a) Request test mode measurement;
b) Enable test mode – standard measurement period;
c) Enable test mode – fast measurement period;
d) Disable test mode; and
e) Manufacturer specific test mode commands.

11.3.2 *Test*

Confirm a) to e) inclusive are accessible via the communication port.

11.4 Data Optical Port (Optional)

Any optical port and its associated reading head shall comply with **4.3** of IS/IEC 62056-21 : 2002, or equivalent, and shall be accessible with the meter mounted in its normal orientation.

11.5 Galvanic Port (Optional)

Any galvanic port shall conform to the requirements in **4.1** and **4.2** of IS/IEC 62056-21 : 2002. As a minimum, the connector shall conform to IP 54 in accordance with IS/lEC 60529 : 2001.

11.6 Diagnostics

11.6.1 *Requirements*

The meter shall be capable of indicating key features by the use of an unambiguous alphabetic flag on the display/index. The meter shall record details of any events relating to any displayed flag, including the first and last date when the flag was displayed, the meter-register value on those dates and the number of each type of operation error or other event.

In addition:

a) The configuration of the flag shall be agreed and documented with the utility, but in any case, the meter shall always record and retain the flag details on its internal memory even if the flag is no longer displayed on the meter-index display;
b) The meter manufacturer shall provide details on the type of operational errors and other events that can generate a flag on the display, including the number of errors or other operational-events required to generate a flag on the meter-display, and any time-delay between the initial event(s) and the display of the corresponding flag on the meter-index;
c) The meter manufacturer shall confirm what action (if any) is taken by the meter when a flag is displayed on the meter-index, and in particular whether or not the meter stops recording gas consumption while the flag is displayed (That is, whether or not the meter-index is "frozen" while the flag is displayed); and
d) The meter-manufacturer shall make a diagnostic-tool available to allow the purchaser to interrogate and extract these details from the meter in the event of a customer related meter-accuracy dispute.

11.6.2 *Test*

The requirements specified in **11.6.1** shall be met.

11.6.3 *Display Flags*

11.6.3.1 *Requirements*

a) The meter shall have display flags that identify errors that may occur. The manufacturer shall publish the types of incidents that can lead to the display flags.

b) The manufacturer shall provide guidance on the process used to categorize and map the operational errors or other events that could trigger display flags.

c) The manufacturer shall specify the parameters outside of which a flag will be generated. An example of flag types, the incident hierarchy and suitable actions is shown in Table 18.

Table 18 Example of Flag Types and Incident Descriptions
(*Clause* 11.6.3.1)

Flag	**Description**	**Examples**
Nothing	None	Meter operating normally, no action
A	Meter not working, replace immediately	Unable to perform prime metrological function.
		For example, EEPROM or microprocessor failure, or flow sensor or signal failure (i.e. failure to generate the required flow measurement signal due to incorrect functioning of the thermal mass flow sensor or associated circuitry etc.)
B	Investigate potential fraud	Power reset occurs without having received a battery change command.
		Meter has experienced a number of unsuccessful communications.

		Negative flow is detected.
C	Meter working but can have a problem	Flow readings are out of acceptable range.
	Read diagnostics – requires further investigation	Missed readings are experienced.
F	Replace battery	
O	Zero flow detected	

11.6.3.2 *Test*

The requirements specified in **11.6.3.1** shall be met.

12 BATTERY

12.1 General

The battery and its compartment shall conform to the requirements as given in **6** of EN 16314:2013.

12.2 Additional Requirements

12.2.1 *Voltage Interruptions*

12.2.1.1 *Requirements*

When tested in accordance with **12.2.1.2**, the difference of the mean errors shall not exceed one fifth of the *MPE* as specified in Table 5.

12.2.1.2 *Test*

Test the meter in accordance with **5.3.2**, Table 6, Test (d). Remove and replace the battery three times in succession, waiting 5 min before each replacement. Retest the meter in accordance with Table 6, Test (d).

12.2.2 *Minimum operating voltage*

12.2.2.1 *Requirements*

When tested in accordance with **12.2.2.2**, the errors of indication shall be within the *MPE* specified in Table 5.

12.2.2.2 *Test*

Test the meter in accordance with **5.3.2**, Table 6, Test (c), with the battery of the meter replaced by a voltage-controlled power supply set to the manufacturer's specified minimum operating voltage and ensure the requirement in **12.2.2.1** is met.

12.2.3 *Battery Life*

12.2.3.1 *Requirements*

The expected battery life, declared by the meter manufacturer, shall be at least 5 years.
After 90 percent of the useful life of the battery has expired, a warning flag shall be shown (*see* **11.6.3**).

12.2.3.2 *Test*

Simulate 90 percent of the usage of the battery, as declared by the manufacturer.

13 IMMUNITY TO ELECTROMAGNETIC DISTURBANCE

13.1 General

The meter and in particular its electronic hardware shall be designed and manufactured in such a way so as to minimize the effects of magnetic fields, electrostatic discharge and other electromagnetic disturbances. Meters meeting the requirements of **13.2.1**, **13.3.1**, **13.4.1** and **13.5.1** and **13.6.1** are deemed to have met this requirement.

The meter shall conform to the requirements of **4.12.2** of EN 16314:2013.

13.2 Electrostatic Discharge

13.2.1 *Requirements*

When tested in accordance with **13.2.2**, the difference in mean errors shall not exceed one third of the *MPE* specified in Table 5.

13.2.2 *Test*

a) Test the meter in accordance with **5.3.2**, Table 6, Test (c), and calculate the mean error at each flow rate.

b) With no flow through the meter, test the meter in accordance with IS 14700 (Part 4/Sec 2) : 2018 using 10 contact discharges to each of:

   1) The conductive surfaces;
   2) The horizontal surfaces; and
   3) A vertical coupling plane with a charge voltage of 6 kV according to IS 14700 (Part 6/Sec 1) : 2019 and IS 14700 (Part 6/Sec 2) : 2019 at intervals of a minimum of 1 s, with the battery fitted.

c) With no flow through the meter, test the meter in accordance with IS 14700 (Part 4/Sec 2) : 2018 using 10 air discharges (to insulating surfaces) with a charge voltage of 8 kV according to IS 14700 (Part 6/Sec 1) : 2019 and IS 14700 (Part 6/Sec 2) : 2019 at intervals of a minimum of 1 s, with the battery fitted.

d) During the test, connect the inlet boss of the meter under test to the ‘ground plane’.

e) Repeat the test in accordance with **5.3.2**, Table 6, Test (c), and calculate the difference in mean errors.

13.3 Radio Frequency Electromagnetic Field

13.3.1 *Requirements*

The meter shall satisfy the following requirements:

a) During the test specified in **13.3.2 (a)**, the meter index shall neither increment nor decrement; and
b) During the test specified in **13.3.2 (b)**, the flow rate calculated from the meter readings shall not vary by more than three times the *MPE* and after testing in accordance with **13.3.2 (b)**, the mean errors shall be within the *MPE* specified in Table 5.

13.3.2 *Test*

a) Arrange the test equipment so that it is possible to pass air through the test meter while it is being subjected to the electromagnetic field. The flow rate shall be held constant.

b) Set the flow rate to Q_{max}. Test the meter under the conditions given below. During the test, read the index and elapsed time at suitable intervals. From these readings calculate the corresponding flow rates.

   1) Set the flow rate to zero and subject the meter to the tests below;
   2) Test the meter in accordance with **5.3.2**, Table 6, Test (a), at Q_{max} only and subject the meter again to the tests below.

c) Using the values set out below, test the meter in accordance with IS 14700 (Part 4/Sec 3) : 2018:

   1) Frequency band : 26 MHz to 3 GHz;
   2) Test field strength : 10 V/m; and
   3) Amplitude modulation : 80 percent, 1 kHz sine wave.

d) Read the volume register and non-volatile memory and compare with the value before the high frequency test.

e) Test the meter in accordance with **5.3.2**, Table 6, Test (a), at Q_{max} only.

13.4 Electromagnetic Induction (Power Frequency)

13.4.1 *Requirements*

When tested in accordance with **13.4.2** (a), the meter index shall neither increment nor decrement.

During the test described in **13.4.2** (b), the flow rate calculated from the meter readings shall not vary by more than six times the *MPE* specified in Table 5, during any of the eight periods of the test without showing an error flag.

After the test in **13.4.2** (b), the mean errors shall be within the *MPE* specified in Table 5.

13.4.2 *Test*

a) Set the flow rate to zero and subject the meter to test level 3 of IS 14700 (Part 4/Sec 8) : 2018 for 15 min; and

b) With air passing through the meter at a flow rate of 10 Q_{min} test the meter to level 3 of IS 14700 (Part 4/Sec 8) : 2018 for 15 min.

13.5 Electromagnetic Induction (Pulsed field)

13.5.1 *Requirements*

The meter shall satisfy the following requirements:

a) During test 1 of **13.5.2 (a)**, the meter index shall neither decrement nor increment.

b) During the test specified in **13.5.2 (b)**, the flow rate calculated from the meter readings shall not vary by more than half of the *MPE* specified in Table 5, during any of the eight periods of the test without displaying an error flag.

c) After testing in accordance with **13.5.2 (b)**, the errors of indication shall be within the *MPE* specified in Table 5.

13.5.2 *Test*

a) Set the flow rate of the meter to zero and subject the meter to test level 3 of IS 14700 (Part 4/Sec 9) : 2019 for 15 min.
b) With air passing through the meter at a flow rate of 10 Q_{min}, subject it to test level 3 of IS 14700 (Part 4/Sec 9) : 2019 for 15 min.

13.6 Radio Interference Suppression

13.6.1 *Requirements*

The meter shall not generate radiated noise that can interfere with other equipment.

13.6.2 *Test*

Check that the meter satisfies class B radio interference limits in IS/CISPR 32 : 2015 and EN 50561-1:2013 at zero flow.

14 INSTRUCTIONS

Operating instructions shall be available in written form or as a database and shall identify the name and address of the manufacturer.

The manufacturer shall provide a list of the fault codes provided his meter.

When requested by the purchaser, each meter shall be delivered with installation, operation and maintenance manuals, in a language acceptable by the user and easily understandable, giving appropriate instructions.

15 METER SUPPLY FOR TESTING (TYPE, ACCEPTANCE AND ROUTINE)

The minimum number of meters to be supplied by the manufacturer for test purposes shall be no less than 15. The tests to be carried out on the supplied meters are given in Table 19.

By agreement with the manufacturer, more meters can be supplied, to enable speeding up of the test procedure.

Table 19 indicates the number of meters required for each of the tests in this standard. As a guide to planning the order in which tests are performed to evaluate a prototype, the table indicates where it is possible to re-use a meter for a subsequent test.

15.1 Type Testing

Table 19 Meters Required for Type Testing
(*Clause* 15)

	Clause	**Minimum number of meters**	**Testing meter to destruction**	**Metrological test**	**Test flow rates**
Metrological Performance					
Errors of indication - air	5.3.2	3	N	Y	5.3.2, Table 6, Test (a)
Errors of indication - gas	5.3.2	3	N	Y	5.3.2, Table 6, Test (a)
Gas-air relationship	5.4.3	3	N	Y	5.3.2, Table 6, Test (a)
Pressure absorption	5.5.2	3	N	Y	N/A
Metrological stability	5.6	3	N	Y	N/A
Zero flow	5.8.2	1	N	Y	0
Reverse flow	5.9.2	1	N	Y	N/A
Low flow registration (starting flow rate)	5.10.2	1	N	Y	Qstart
Overload flow rate	5.11.2	1	N	Y	5.3.2, Table 6, Test (c) and 1.2 Q_{max}
Pulsed (unsteady) flow	5.12.3	1	N	Y	N/A
Construction and Materials					
Mechanical interference	6.1.2	1	N	N	0.375 Q_{max} and 0.07 Q_{max}
Unauthorized interference	6.2.2	1	N	N	N/A
Protection against penetration of dust andwater	6.3.2	1[d]	Y	N	N/A
External leak tightness	6.3.3.1	1	N	N	N/A
Resistance to internal pressure	6.3.4.2	1[d]	Y	N	N/A
Heat resistance	6.3.5.2	1[d]	Y	N	N/A
Resistance to impact	6.3.6.3	1[d]	Y	N	N/A
Resistance to mishandling	6.3.7.2	1	Y	Y	5.3.2, Table 6, Test (d)
Connections - Orientation	6.4.1.2	1	N	N	N/A
Connections - Threads and flanges for two pipe meters	6.4.2.2	1	N	N	N/A
Connections - Torque	6.4.3.1.2	1[d]	Y	N	N/A
Connections - Bending moment	6.4.3.2.2	1	Y	Y	5.3.2, Table 6, Test (d)

Resistance to vibration	6.5.3	1	Y	Y	5.3.2, Table 6, Test (c)
External corrosion	6.6.2.1.2	see [c]	Y	N	N/A
Resistance to salt spray	6.6.2.5.2	1[d]	Y	N	N/A
Resistance to humidity	6.6.2.6.2	1	N	N	N/A
Flame retardance of external surfaces	6.7.2	see [c]	Y	N	N/A
Requirements for rubber components	6.8.2	see [c]	Y	N	N/A
Resistance to storage temperature	6.9.2	1	N	Y	5.3.2, Table 6, Test (d)
Resistance to toluene and iso-octane vapour	6.10.2	1[d]	Y	Y	5.3.2, Table 6, Test (d)
Resistance to water vapour	6.11.2	1	Y	Y	5.3.2, Table 6, Test (d)
Ageing	6.12.2	1	Y	Y	5.3.2, Table 6, Test (d)
Optional Features					
Pressure measuringpoint	7.1.2	1	N	N	N/A
Electrical insulting feet	7.2.2	1	Y	N	N/A
Resistance to high ambient temperature	7.3.2	1[d]	Y	N	N/A
Additional functionalities	7.4.2	1	N	Y	5.3.2, Table 6, Test (c)
Hazardous zones	7.5.2	1	N	N	N/A
Index					
Recording and storage	8.1.2	1	N	N	N/A
Display (general)	8.2.2	1	N	N	N/A
Display functionality	8.3.2	1	N	N	N/A
Non-volatile memory	8.4.2	1	N	Y	N/A
Marking					
Two-pipe meters	9.2.2	1	N	N	N/A
Durability and legibility of marking and labels – Weathering test	9.3.2.1	1	N	N	N/A
Durability and legibilityof marking and labels – Adhesion of metrology label test	9.3.2.2	see [c]	N	N	N/A
Indelibility of marking	9.4.2	see [c]	N	N	N/A
Software					
Test (general)	10.2	1	N	N	N/A
Communications					
Test (general)	11.1.2	1	N	N	N/A

Metrological influence of radio communication function	11.2.2	1	N	Y	5.3.2, Table 6, Test (a) And 0.1 Q_{max}
Test mode	11.3.2	1	N	N	N/A
Diagnostics - Test (general)	11.6.2	1	N	N	N/A
Diagnostics – Displayed flags	11.6.3.2	1	N	N	N/A
Battery					
Voltage interruptions	12.2.1.2	1	N	Y	5.3.2, Table 6, Test (d)
Minimum operating voltage	12.2.2.2	1	N	Y	5.3.2, Table 6, Test (c)
Immunity to Electromagnetic Disturbances					
Electrostatic discharge	13.2.2	1[b]	Y	Y	5.3.2, Table 6, Test (c)
Radio frequency electromagnetic field	13.3.2	1[b]	Y	Y	0 and Q_{max}
Electromagnetic induction (power frequency)	13.4.2	1[b]	Y	Y	0.05 Q_{max}
Electromagnetic induction (pulsed field)	13.5.2	1[b]	Y	Y	0.05 Q_{max}
Radio interference suppression	13.6.2	1[b]	Y	N	N/A

[a] The highly destructive nature of this test is such that, by agreement between the manufacturer and the test house, the test is performed on an empty meter case.

[b] The nature of these tests is such that, by agreement between the manufacturer and the test house, meters which have undertaken other tests in this group can be used for different tests in the same group.

[c] For the majority of tests in this group, representative component samples, rather than complete meters, are acceptable, unless specifically stated otherwise in the test.

[d] Can use meters from other, specific tests in the approval program.

15.2 Acceptance Testing

Table 20 Meters Required for Acceptance Testing
(*Clause* 15.2)

	Clause	Minimum number of meters	Testing meter to destruction	Metrological test	Test flow rates
Errors of indication —air	5.3.2	3	N	Y	5.3.2, Table 6, Test (c)
Pressure absorption	5.5.2	3	N	Y	N/A
Metrological stability	5.6	3	N	Y	5.3.2, Table 6, Test (c)
External leak tightness	6.3.3.1	1	N	N	N/A
Resistance to internal pressure	6.3.4.2	1[d]	Y	N	N/A
Connections — Torque	6.4.3.1.2	1[d]	Y	N	N/A
Connections — Bending moment	6.4.3.2.2	1	Y	Y	5.3.2, Table 6, Test (d)

Pressure measuring point	7.1.2	1	N	N	N/A
Display (general)	8.2.2	1	N	N	N/A
[d] Can use meters from other, specific tests in the approval program.					

15.3 Routine Testing

Table 21 Meters Required for Routine Testing
(*Clause* 15.3)

	Clause	**Minimum number of meters**	**Testing meter to destruction**	**Metrological test**	**Test flow rates**
Errors of indication —air	5.3.2	3	N	Y	5.3.2, Table 6, Test (c)
External leak tightness	6.3.3.1	1	N	N	N/A
Connections — Torque	6.4.3.1.2	1[d]	Y	N	N/A
Connections — Bending moment	6.4.3.2.2	1	Y	Y	5.3.2, Table 6, Test (d)
Zero flow	5.8.2	1	N	Y	0
[d] Can use meters from other, specific tests in the approval program					

ANNEX A

(*Informative*)

KEY PHYSICAL PROPERTY OF GASES FOR METER PERFORMANCE TESTING

A-1 GENERAL

This annex introduces the key physical property of test gases for thermal mass flow-meter based gas meters using the example of 2nd family gases specified in EN 437:2018.

The compositions of gases for meter performance testing are specified in Annex B.

A-2 BASIC THEORY

The sensing principle of a thermal mass flow-meter used in gas meters can be described by King's Law, in accordance to ISO 14511:2019:

$$\Delta T = A + B\sqrt{v.\rho.cp}$$

Whereas ΔT is the differential temperature in Kelvin [K] proportional to the flow of gas; A and B are design and calibration parameters; v = the flow velocity of gas in [m/s]; c_p = the heat capacity of gas in [J/(kg·K)]; ρ = density of gas in [kg/m^3]

As seen from King's law formula, the physical gas property $\rho \cdot c_p$ is the key gas dependent parameter for a thermal mass flow-meter, which needs to be taken into account when defining test gases for gas meters based on thermal mass flow-meters.

A-3 SELECTION CRITERIA FOR TEST GASES

A set of gases (*see* Annex B) has been identified for 2nd family gases in order to test a suitably wide range of the key physical gas property $\rho \cdot c_p$. Each gas group is addressed by two gases, one gas covering the lower borderline and one gas covering the upper borderline and therewith spanning the range of $\rho \cdot c_p$ for the respective group of natural gas.

The range of the physical gas property $\rho \cdot c_p$ has been determined by taking into account the gas density relative to air, the gas concentration levels of the major constituents of natural gas distributed in Europe and the Wobbe Index limits in accordance to EN 437:2018.

Fig. 13 illustrates the span of the gas property $\rho \cdot c_p$ of the respective group of 2nd family gases and the values of $\rho \cdot c_p$ of the gases for meter testing.

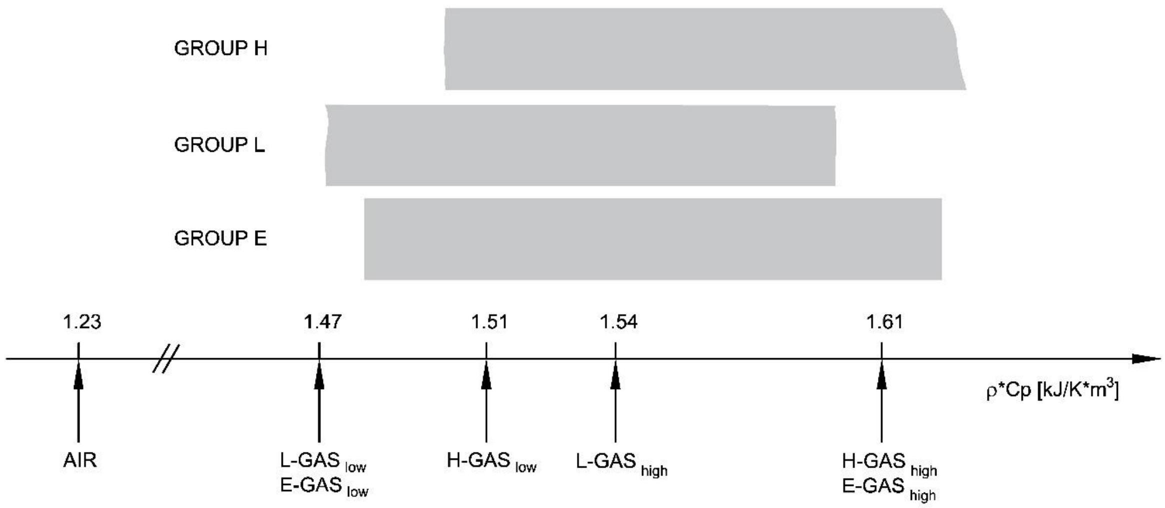


FIG. 13 SPAN OF THE GAS PROPERTY $\rho \cdot c_p$ OF 2ND FAMILY GASES AND VALUES OF $\rho \cdot c_p$ OF GASES FOR METER PERFORMANCE TESTING

ANNEX B

(*Clauses* 4.6, A-1 *and* A-3)

GASES FOR METER PERFORMANCE TESTING

B-1 GENERAL

B-1.1 This annex specifies gases to test gas meters based on thermal mass flow-meters designed for 2nd and/or 3rd family natural gas, which is defined in EN 437:2018.

B-1.2 The meter shall be tested using the applicable test gases specified in this annex using the range of gases for which the meter has been designed.

B-1.3 The key physical property $\rho \cdot c_p$ relevant for the selection of gases for meter performance testing is introduced in Annex A.

B-2 TEST GASES FOR 2ND FAMILY GASES

Table 22 Gases For Meter Testing For 2nd Family Gases

(*Clause* B-2)

Gas group	Gas designation	Composition by volume percent	$\rho \cdot c_p$ [kJ/K.m³] at 15°C and 1013.25 mbar	Comment	Reference
H	H-Gas$_{low}$	CH_4 = 100	1.51	Gas addressing the lower range of $\rho \cdot c_p$ for H-Gas	Gas G20 according to EN 437:2018
	H-Gas$_{high}$	CH_4 = 86 C_2H_6 = 8.5 C_3H_8 = 3 N_2 = 1 CO_2 = 1.5	1.61	Gas addressing the upper range of $\rho \cdot c_p$ for H-Gas	Gas mixture referring to Gas 3 according to IS 15305 (Part 2) : 2019
L	L-Gas$_{low}$	CH_4 = 86 N_2 = 14	1.47	Gas addressing the lower range of $\rho \cdot c_p$ for L-Gas	Gas G25 according to EN 437:2018
	L-Gas$_{high}$	CH_4 = 81.5 C_2H_6 = 4 C_3H_8 = 1 N_2 = 6 CO_2 = 7.5	1.54	Gas addressing the upper range of $\rho \cdot c_p$ for L-Gas	Gas mixture referring to Gas 5 according to IS 15305 (Part 2) : 2019
E	E-Gas$_{low}$	CH_4 = 86 N_2 = 14	1.47	Gas addressing the lower range of $\rho \cdot c_p$ for E-Gas	Gas G25 according to EN 437:2018

	E-Gas$_{high}$	CH_4 = 86 C_2H_6 = 8.5 C_3H_8 = 3 N_2 = 1 CO_2 = 1.5	1.61	Gas addressing the upper range of $\rho \cdot c_p$ for E-Gas	Gas mixture referring to Gas 3 according to IS 15305 (Part 2) : 2019

NOTES

1 To ease manufacturability of the gas mixtures, concentrations of gas constituents are rounded to 0.5 percent. Gas constituents with concentrations < 0.5 percent are not considered.

2 The values of $\rho \cdot c_p$ are calculated using the Thermodynamic Properties Suite (PPDS)

B-3 TEST GASES FOR 3RD FAMILY GASES

Table 23 Gases for Meter Testing For 3rd Family Gases
(*Clause* B-3)

Gas group	**Gas designation**	**Composition by volume percent**	**$\rho \cdot c_p$ [kJ/K.m^3]** at 15 °C and 1 013.25 mbar	**Comment**	**Reference**
B/P	G30	n-C_4H_{10} = 50 i-C_4H_{10} = 50	4.27	N.A.	Gas G30 according to EN 437:2018
P	G31	C_3H_8 = 100	3.14	N.A.	Gas G31 according to EN 437:2018

NOTE — Additional gases for meter testing for 3rd family gases might be agreed between the meter manufacturer and the test house.

ANNEX C
(*Informative*)
METERS WITHOUT TEMPERATURE OR PRESSURE CONVERSION

C-1 SCOPE

This annex specifies requirements and tests for meters which provide readings without temperature conversion or pressure conversion.

C-2 METERS WITHOUT TEMPERATURE CONVERSION

C-2.1 Error of Indication

C-2.1.1 *Requirements*

The following Table 24 replaces the Table 5 of **5.3.1**.

Table 24 Maximum Permissible Errors for Volume without Temperature Conversion
(*Clause* C-2.1.1)

Flow rate	**Maximum Permissible Error for volume without temperature conversion**
$Q_{min} \leq Q < Q_t$	±3.0 percent
$Q_t \leq Q \leq Q_{max}$	±1.5 percent

The maximum permissible error given in Table 24 should be fulfilled for the complete temperature range for which the meter is specified.

The manufacturer should specify the reading provided by gas meter on the meter plate.

C-2.1.2 *Test*

Perform the test as specified in **5.3.2**, Table 6, Test (a).

C-3 METERS WITHOUT PRESSURE CONVERSION

C-3.1 Error of Indication

C-3.1.1 *Requirements*

a) The requirements of **5.3.1** shall apply.
b) The manufacturer should specify the reading provided by gas meter on the meter plate.

C-3.1.2 *Test*

Perform the test as described in **5.3.2**, Table 6, Test (a).