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Indian Standard

**SPECIFICATION FOR
PRESSURE AND VACUUM GAUGES**

(Second Revision)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

SPECIFICATION FOR PRESSURE AND VACUUM GAUGES

(Second Revision)

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Indian Standard
SPECIFICATION FOR
PRESSURE AND VACUUM GAUGES
(Second Revision)

0. FOREWORD

0.1 This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards on 27 May 1987, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard was first published in 1966 which was revised in 1979 to make the standard more comprehensive by including the various pressure responsive elements used in pressure and vacuum gauges, other than bourdon tube.

0.3 The second revision includes various modifications and addition of new requirements on main parameters and metrological characteristics. The requirements of shock test have also been modified in this revised standard.

0.4 In preparing the revised standard, data has been received from Institute for Design of Electrical Measuring Instruments, Bombay.

0.5 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, shall be rounded off in accordance with IS : 2 - 1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the requirements of dial type indicating pressure gauges, vacuum gauges and compound gauges using elastic pressure responsive elements, such as bourdon tube, capsule, bellows or diaphragm. This standard also includes the requirements of test gauges.

*Rules for rounding off numerical values (*revised*).

2. NOMENCLATURE

2.1 The nomenclature for the various parts of a gauge shall be as given in Fig. 1 and 2.

2.2 The nomenclature for the various types of gauges with respect to method of mounting shall be as given in Fig. 3 to 5.

3. TERMINOLOGY

3.0 For the purpose of this standard, the following definitions shall apply.

3.1 Basic Gauge Definitions

3.1.1 *Pressure Gauge* — A gauge to measure and indicate pressure greater than ambient using ambient pressure as the datum point. Ambient pressure is the pressure surrounding the measuring element.

3.1.2 *Vacuum Gauge* — A gauge to measure and indicate pressure less than ambient using ambient pressure as the datum point.

3.1.3 *Compound Gauge* — A gauge to measure and indicate pressure both greater than and less than ambient using ambient pressure as the datum point.

3.1.4 *Absolute Pressure Gauge* — A gauge to measure and indicate pressure above zero absolute pressure using absolute zero pressure as the datum point.

3.1.5 *Differential Gauge* — A gauge having two connections and a means to measure and indicate the difference between two pressures.

3.2 Specific Gauge Service Classification

3.2.1 *Test Gauge* — A gauge designed to check the accuracy of other gauges or pressure actuated devices.

3.2.2 *Industrial Gauge* — A gauge of a specified order of accuracy intended for general industrial use.

3.2.3 *Receiver Gauge* — A gauge designed to measure and indicate the output signal from a pneumatic transmitter. It is calibrated in terms of the transmitter output. The dial may be graduated in units of pressure, temperature flow, level, etc, corresponding to the transmitter input.

3.2.4 *Refrigerant Gauge* — A gauge designed to measure and indicate the pressure of refrigerants other than ammonia. The dial markings include the service using REFRIGERANT or 'R' and the applicable refrigerant number. They also include the equivalent temperature scale marking.

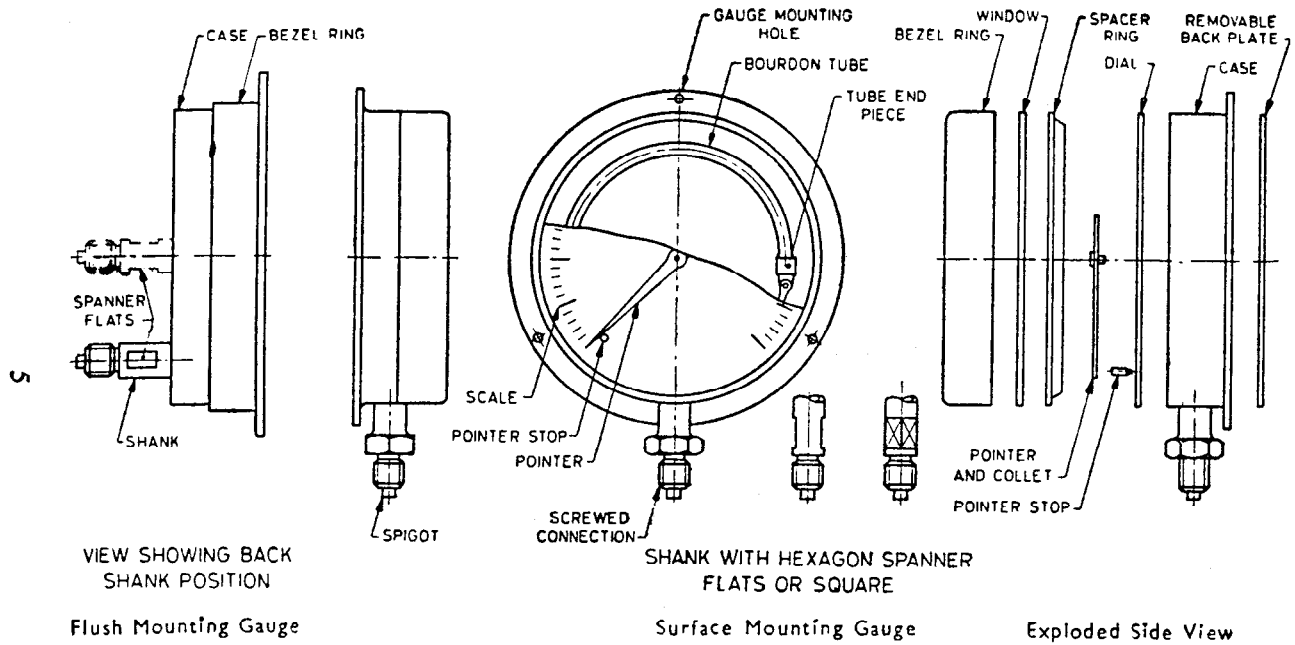


FIG. 1 NOMENCLATURE FOR COMPONENT PARTS OF PRESSURE GAUGE

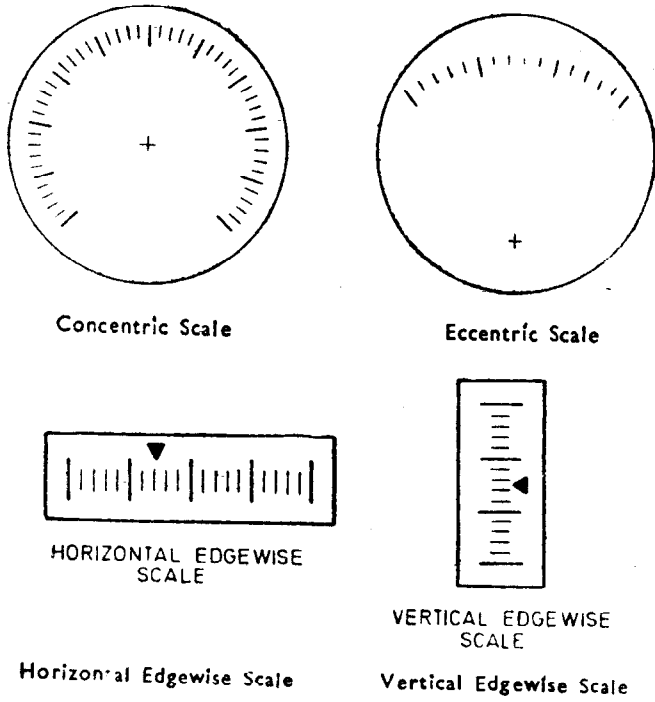


FIG. 2 CONFIGURATION OF SCALES FOR PRESSURE GAUGES

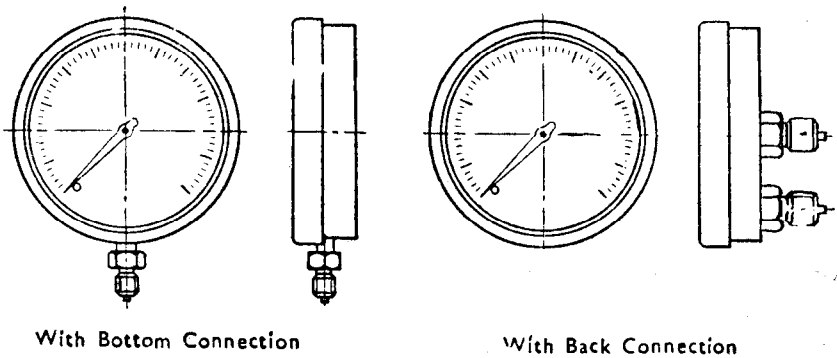
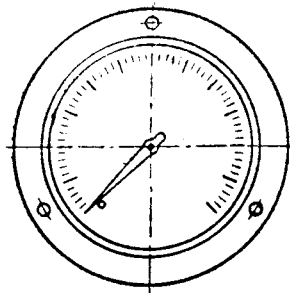
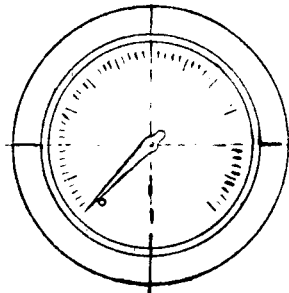
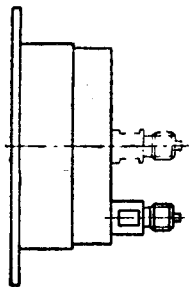


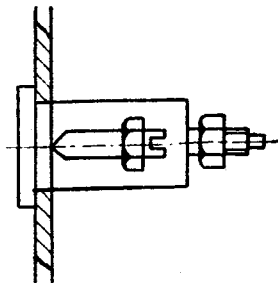
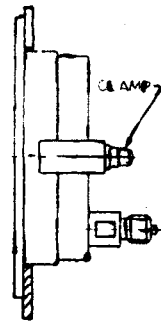
FIG. 3 DIRECT MOUNTING GAUGES



With Back Connection



With Clamp Fixing



Edgewise Scale Instrument

FIG. 4 FLUSH MOUNTING GAUGES

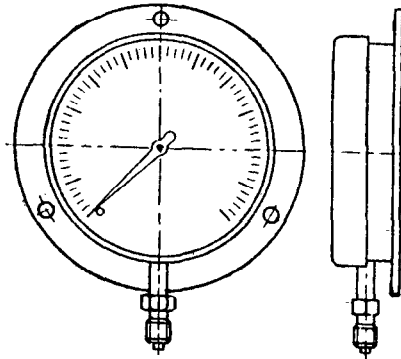


FIG. 5 SURFACE MOUNTING GAUGE WITH BOTTOM CONNECTION

3.2.5 Hydraulic Pressure Gauge — A gauge designed to measure and indicate the pressure developed by hydraulic presses. It is equipped with protective means to prevent damage to the gauge by a sudden pressure release. The dial generally has two concentric scales, one reading pressure and the other hydraulic ram force.

3.2.6 Liquid Level Gauges — A gauge designed to measure and indicate the hydrostatic head of a liquid. The dial is graduated in units of head height such as metres of water.

3.2.7 Oxygen Gauge — A gauge designed to measure and indicate oxygen pressure. It shall be equipped with features that will minimize damage to personnel and property in the event of failure. It shall be degreased and cleaned to an acceptable safe level. The dial shall be clearly marked 'OXYGEN' in black colour and 'USE NO OIL' in red (see Appendices B and C).

3.2.8 Acetylene Gauge — A gauge designed to measure and indicate acetylene pressure and shall be constructed using materials that are compatible with commercially available acetylene. The dial shall be clearly marked 'ACETYLENE' (see Appendices B and C).

3.2.9 Ammonia Gauge — A gauge designed to measure and indicate ammonia pressure and shall be constructed using materials to withstand the corrosive effects of ammonia. The dial shall be clearly marked 'AMMONIA' (see Appendix B).

3.2.10 Chemical Gauge — A gauge designed to measure and indicate the pressure of corrosive and/or high viscosity fluids. It is equipped with a diaphragm seal to isolate the pressure medium from the pressure responsive element.

3.3 Pressure Elements

3.3.1 Bourdon Tube — A pressure sensing element in the form of a curved tube which changes its curvature with changes in internal pressures.

3.3.2 Bellows — It is an axially elastic cylinder with deep folds or convolutions which expands or contracts axially with pressure applied internally or externally. The bellows may be used unopposed or it may be restrained by an opposing spring.

3.3.3 Capsule — It is an element formed by bonding two diaphragms at their periphery. The element may consist of one or more such capsules connected together to obtain large deflections for a particular pressure.

3.3.4 Diaphragm — A flat or corrugated circular metallic disc which deflects with pressure. This is, however, different from the slack diaphragm where the flexible non-metallic diaphragm is always opposed by a spring or other elastic member which determines its deflection versus pressure characteristics.

3.4 Method of Mounting

3.4.1 Direct Mounting Gauge — A gauge which is mounted and supported by its screwed connection. The screwed connection may be at the bottom of the periphery of the case (direct mounting gauges with bottom connection) or at the back of the case (direct mounting gauges with back connection) (see Fig. 3).

3.4.2 Flush Mounting Gauge — A gauge intended for mounting in a panel, the greater portion of the case being recessed in the panel, so that, the front of the gauge, after mounting, is virtually flush with the panel. The screwed connection is at the back of the gauge. The gauge may be mounted and supported by means of a flange at the front of the gauge or by means of a clamp attached to the back of the case and acting against the back of the panel (see Fig. 4).

3.4.3 Surface Mounting Gauge — A gauge intended for mounting on the surface of a panel, the gauge projecting forward therefrom, and which is mounted and supported by means of a flange at the rear of the case. The screwed connection is customarily at the bottom of the periphery of the case (see Fig. 5).

3.5 Components

3.5.1 Baffle Wall — A barrier between the pressure sensing element and the dial so disposed that, in the event of a leakage or burst in the pressure responsive element, the blast would be dissipated away from the front.

3.5.2 Bezel Ring — The ring fitted to and removable from the case, which holds or retains window to the case.

3.5.3 Blow-Out Device — A safety device incorporated in the case or back plate to permit the rapid and safe dissipation of internal pressure in the event of a leakage or burst in the pressure sensing element.

3.5.4 Case — The outer casing which contains the pressure responsive element and the movement, by custom of the trade, the term case does not include the bezel ring and spacer, nor the window, nor the back plate, if this is removable.

3.5.5 Connecting Link — That part of the movement which is connected to the free end of the pressure responsive element.

3.5.6 Connection — The terminal part of a guage which may be screwed or flanged.

3.5.7 Dial — The plate upon which the scale is marked.

3.5.8 Element Anchorage — That part to which the fixed end of the pressure responsive element is attached, and which may be integral with the shank or may be directly or indirectly connected with the shank by a pressure-conducting system.

3.5.9 Movement — The assembly by which the movement of the free end of the pressure responsive element is multiplied and communicated to the pointer spindle.

3.5.10 Pointer — The index, by the position of which, in relation to the scale, the value of the measured pressure or vacuum is indicated.

3.5.11 Pointer Stop — A screw, stud or other projection fitted to limit the travel of the pointer.

NOTE — It is not the function of a pointer stop to act as an overload stop.

3.5.12 Removable Back Plate — A plate at the back of the case, which is removable for the purpose of giving access to the interior.

NOTE — A removable back plate must not be confused with a blow-out device.

3.5.13 Scale — The graduations and related numerals on the dial. These may be concentric, eccentric or edgewise. Concentric scale forms a major part of a circle (an angle of approximately 270°), with the pointer spindle at the centre and the pointer radial to the scale. Eccentric scale forms a small part of a circle and in which the pointer is radial to the scale, but the centre of rotation of the pointer is not concentric with the scale. Edgewise scale is a graduation on a rectangular dial bent in the form of an arc with the pointer spindle as centre (see Fig. 2).

3.5.14 Shank — That part of the gauge which includes the screwed connection, the spanner flats, the spigot and the inlet orifice.

3.5.15 Window — The transparent front through which the dial is observed.

3.5.16 Zero Adjustment — A device which sets the pointer at the zero of the scale without removing the pointer, at ambient pressure.

3.6 Miscellaneous Definitions

3.6.1 Nominal Size — The nominal size of a gauge is the overall diameter or length of the dial.

3.6.2 Over-range Protection — A device provided to protect the measuring element in the event of overpressure and also to prevent disengagement of the movement gearing. This may be in the form of internal stops.

4. UNIT OF PRESSURE AND VACUUM

4.1 For the purpose of this standard, the unit of pressure shall be the pascal (Pa) or its multiples (kPa) or (MPa) or the bar.

NOTE — 1 pascal (Pa) = 1 N/m² = 10⁻⁵ bar
 1 kilopascal (kPa) = 10⁻³ bar
 100 kilopascal = 1 bar
 1 megapascal (MPa) = 10 bar
 1 kgf/cm² = 98.066 5 kPa

4.2 For ranges below 1 bar, the units in millimetre of water column (mmH₂O) or milli bar may also be used.

5. MAIN PARAMETERS

5.1 Limits of the Measurement Ranges

5.1.1 The upper limits of the measurement range must be chosen from the following two series:

1×10^n , 1.6×10^n , 2.5×10^n , 4×10^n , 6×10^n ,
 1×10^n , 2×10^n , 5×10^n ,

where n is a positive or negative whole number or equal to zero.

5.1.2 The normal limit of the measurement range is equal:

a) for gauge pressure

— to a fraction of the upper limit of the measurement range H , as indicated in the table below:

Upper Limit of the Measurement Range, H	Normal Limit of the Measurement Range	
	Steady Pressure	Variable Pressure
$H < 100$ MPa	$3/4 H$	$2/3 H$
$H \geq 100$ MPa	$2/3 H$	$1/2 H$

b) for vacuum pressure

— to the upper limit of the measurement range.

5.2 The accuracy class of the instrument must be chosen from one of the following two series:

- a) 0.25 0.4 0.6 1 1.6 2.5 4
- b) 0.2 0.5 1 2 5

5.3 The normal conditions of use (namely, ambient temperature, air humidity and dust content, vibration and shock levels, physical and chemical properties of the measured medium, etc) must be indicated in the technical manual or instruction provided by the manufacturer.

6. METROLOGICAL CHARACTERISTICS

6.1 Measurement and Hysteresis Error or Verification

6.1.1 The maximum permissible intrinsic error including hysteresis is equal to:

- a) $\pm 0.8 C$ for new or repaired instruments,
- b) $\pm C$, for instruments in service,
where C is numerically equal to the accuracy class index (see 5.2) and is expressed as 'a percentage of the sum of the upper limits of both measurement ranges for bilateral instruments'.

6.1.2 The hysteresis error must not exceed the maximum permissible error as specified in 6.1.3.

6.1.3 Error Limits

Vacuum and Pressure Gauges

Class Index (C)	Error	Hysteresis
0.3	0.25 C	0.3 C
0.6	0.5 C	0.6 C
1.0	0.8 C	1.0 C
1.6	1.3 C	1.6 C
2.5	2.0 C	2.5 C
4.0	3.0 C	4.0 C

6.1.4 The instruments must comply with requirements in 6.1.1 to 6.1.3 under the following reference conditions:

- a) The instruments must be installed in normal condition;
- b) The variation in pressure must be slow and continuous to suppress the effect of force of inertia;
- c) The temperature of the instruments and ambient must be equal to 25°C with a deviation which does not lead to a variation of indication greater than 1/5 of maximum permissible error;
- d) Relative humidity not exceeding 80 percent;
- e) Vibration and shocks absent or not reading a value causing the pointer to oscillate with an amplitude greater than 1/10 of the length of smallest scale division;
- f) The end of the coupling of the instrument being verified and that of the standard instrument must be the same horizontal plane;
- g) The medium (gas or liquid) used to transmit pressure must be :
 - 1) neutral gas for gauges with upper limit of measurement not exceeding 0.5 MPa,
 - 2) A non-corrosive liquid for gauges with upper limit of measurement not exceeding 0.5 MPa.

6.1.5 Validity of Calibration — The validity of calibration for pressure and vacuum gauges is as follows:

- a) two years for gauges with class indices 2.5 and 4.0, and
- b) one year for gauges with class indices 0.2 to 1.6.

7. NOMINAL DIAMETER OF GAUGES

7.1 The nominal diameter for gauges for industrial use shall be as given in Table 1.

7.2 The nominal diameter for test gauges shall be only 150 mm, 200 mm and 250 mm.

7.3 Unless otherwise specified, the size of bourdon tube shall not be less than 75 percent of the nominal diameter of the dial.

7.4 The nominal diameter for edgewise gauges (finish mounting type) shall be as given in Table 2.

TABLE 1 NOMINAL DIAMETER OF INDUSTRIAL GAGUES

(Clause 7.1)

All dimensions in millimetres.

GAUGES WITH CONCENTRIC SCALES	TOLERANCE	GAUGES WITH ECCENTRIC SCALES	TOLERANCE
(1)	(2)	(3)	(4)
50	± 1.0	50	± 1.0
63	± 1.0	63	± 1.0
100	± 1.5	100	± 1.0
150	± 1.5	150	± 1.5
200	± 2.0		
250	± 2.0		

TABLE 2 NOMINAL DIAMETER OF EDGEWISE GAUGES
(FLUSH MOUNTING TYPE ONLY)

(Clause 7.4)

All dimensions in millimetres.

BEZEL	CUT OUT
(1)	(2)
96 × 48	88 × 40
144 × 72	135 × 64
192 × 96	179 × 87
288 × 144	280 × 136

7.5 Nominal Diameters of Housing — The diameter of the housing for control gauges with accuracy 0.3 and 0.6 class index be minimum 160 mm (150 mm may be accepted for some time). The diameter of the housing for technical process manometers must be minimum 100 mm for class indices 1.0 to 2.5 and 80 mm for class 4.0.

8. RANGES FOR GAUGES

8.1 The ranges for gauges shall be as given in Tables 3A and 3B.

TABLE 3A RANGES FOR GAUGES

(Clause 8.1)

GAUGE	RANGE			MAXIMUM WORKING PRESSURE FOR WHICH THE GAUGE SUITABLE			
	KPa	MPa	Bar	Steady		Fluctuating	
				KPa	Bar	KPa	Bar
	Vaccum— 100 to 0	—	—	—	—	—	—
Compound	— 100 to + 60 — 100 to + 150 — 100 to + 300 — 100 to + 500 — 100 to + 900		— 1 to + 0.6 — 1 to + 1.5 — 1 to + 3 — 1 to + 5 — 1 to + 9	45 110 220 400 700	0.45 1.1 2.2 4 7	40 100 200 320 600	0.4 1 2 3.2 6
Pressure	0 to 100 0 to 160 0 to 250 0 to 400 0 to 600 0 to 1 000 0 to 1 600 0 to 2 500 0 to 4 000 0 to 6 000 0 to 10 000 0 to 16 000 0 to 25 000 0 to 40 000 0 to 60 000 0 to 100 000	0 to 0.1 0 to 0.16 0 to 0.25 0 to 0.4 0 to 0.6 0 to 1 0 to 1.6 0 to 2.5 0 to 4 0 to 6 0 to 10 0 to 16 0 to 25 0 to 40 0 to 60 0 to 100 0 to 16 0 to 25 0 to 40 0 to 60 0 to 100	0 to 1 0 to 1.6 0 to 2.5 0 to 4 0 to 6 0 to 10 0 to 16 0 to 25 0 to 40 0 to 60 0 to 100 0 to 160 0 to 250 0 to 400 0 to 600 0 to 1 000	80 120 180 300 450 750 1 200 1 800 3 000 4 500 7 500 12 000 18 000 30 000 45 000 75 000	0.8 1.2 1.8 3 4.5 7.5 12 18 30 45 75 120 180 300 450 750	60 100 160 260 400 650 1 000 1 600 2 600 4 000 6 500 10 000 16 000 26 000 40 000 65 000	0.6 1 1.6 2.6 4.0 6.5 10 16 26 40 65 100 160 260 400 650

NOTE — It should not be assumed that all the ranges in this table are available in all sizes of gauges given in Table 1.

9. MATERIALS AND CONSTRUCTION

9.1 The casing of the pressure gauge and its sealing arrangement for the protection of internal components shall be so designed and constructed that its performance under extra humid conditions is not effected. Appendix A gives recommendation for materials to be used for construction of pressure gauges.

TABLE 3B RANGES FOR GAUGES IN mm H₂O

(Clause 8.1)

VACUUM (mm H ₂ O)	PRESSURE (mm H ₂ O)	COMPOUND (mmH ₂ O)
— 25 to 0	0 to 25	— 10 to + 15 — 15 to + 10
— 40 to 0	0 to 40	— 15 to + 25 — 25 to + 15
— 60 to 0	0 to 60	— 20 to + 40 — 40 to + 20
— 100 to 0	0 to 100	— 60 to + 40 — 40 to + 60
— 160 to 0	0 to 160	— 60 to + 100 — 100 to + 60
— 250 to 0	0 to 250	— 150 to + 100 — 100 to + 150
— 400 to 0	00 to 400	— 150 to + 250 — 250 to + 150
— 600 to 0	0 to 600	— 200 to + 400 — 400 to + 200
— 1 000 to 0	0 to 1 000	— 400 to + 600 — 600 to + 400
— 1 600 to 0	0 to 1 600	— 600 to + 1 000 — 1 000 to + 600
— 2 500 to 0	0 to 2 500	— 1 000 to + 1 500 — 1 500 to + 1 000
— 4 000 to 0	0 to 4 000	— 1 500 to + 2 500 — 2 500 to + 1 500
— 6 000 to 0	0 to 6 000	— 2 000 to + 4 000 — 4 000 to + 2 000

NOTE — Maximum working pressure shall be limited to 75 percent of the maximum scale value.

9.1.1 The material of the elastic element must be designed so that the error limit will be guaranteed in case of temperature variation of $\pm 2^{\circ}\text{C}$ from the reference temperature of 27°C .

9.1.2 For industrial gauges, the case shall be weather proof to protect the inner components from humidity, liquid splash, dust and corrosion. The degree of protection shall be as per applicable IP Code related to specific environment of use.

9.1.3 Cases may be provided with baffle wall and blow out devices depending on the pressure and medium. Blow out devices shall be provided at gas pressures of 2 500 kPa above and liquid pressures of 6 000 kPa and above. For gauges below this range, the provision of blow out device is optional. The blow out aperture shall not be less than 25 mm diameter for gauges of 100 mm nominal size and above, which must be disposed in a concentric area with a diameter of 45 mm. For nominal sizes less than 100 mm, the blow disc shall be 20 mm diameter. This blow out device shall be capable of releasing any excess pressure over 30 kPa within the case and also prevent dust and water entering the case. The closure shall not be capable of being pressed in from outside while handling normally.

9.1.4 Gauges may have a solid back case or a removable back plate. In gauges with removable back plate, it shall be possible to adjust the gauge with back plate removed.

9.1.5 Appendix B specifies safety precautions relating to industrial pressure gauges and Appendix C specifies precautions relating to gauges for use with oxygen and acetylene, respectively.

9.2 Bezel — The bezel shall preferably be of the same material as the case. They may be either screwed type or fixed by screws.

NOTE — Attention is drawn to the fact that the nature of the liquid or gas for which the gauge is required may limit the use of certain materials (see Appendices A, B and C).

9.3 Shank and Element Anchorage — The shank and element anchorage shall be of materials not inferior to that of the element. When copper alloy is used, it shall conform to IS : 6912 - 1985*. Other materials may be used by agreement between the purchaser and the manufacturer.

9.3.1 The shank shall be in one piece with its hexagon (or square or flats) and shall also serve the purpose of element anchorage in the case of bourdon tube type gauges. For other types of elements, the element anchorage may be integral with the shank or connected with the shank by a flexible pressure conducting system. The material of the pressure conducting system shall not be inferior to the element. The shank and the pressure conducting system shall have a minimum bore of 3 mm to prevent clogging by dirt. Connection between shank and element anchorage by

*Specification for copper and copper alloy forging stock and forgings (*first revision*).

pressure conducting system shall not be used in the case of bourdon tube type gauges. The shank shall be fixed to the case by at least 2 screws. The use of check nuts for the above purpose shall be as below for the various types of gauges:

Direct mounting — Bottom or back

Flush mounting — Back

Surface mounting — Bottom or back

9.3.2 The screwed connection shall project for a sufficient length to enable the gauge to be fitted without fouling the case, and on surface mounting gauges, the spanner flats on the connection shall be placed sufficiently far from the rear flange to enable a standard spanner to be used.

9.3.3 The pressure connection at the shank shall have taper or parallel threads, the end of the shank shall have a flat seat with a spigot. The edge of the spigot shall be rounded off to prevent it from damaging the connection washer. The face of the seat may be chased with a concentric groove or grooves.

9.4 Pressure Sensing Element — The element shall be manufactured from a material suitable for use with the pressure medium at the pressures required, preferably one of the materials given in Appendix D. A general indication of mechanical properties, in the case of bourdon tubes, is given in Appendix E. The material of the element shall be stated on the dial of the gauge.

NOTE — In the case of gauges for use with fluids which would have a corrosive effect on copper alloy or steel, other materials may be used as agreed to between the purchaser and the manufacturer. The information given in Appendices D and E relate to elements as a material and not in its finished state as bourdon tube, bellows or diaphragm.

9.4.1 The assembly of the element with the anchorage should be carefully done so as to comply with the test requirements specified in 12.

9.4.2 The joint between the element and anchorage or the element and its end piece and any other joint in the pressure conducting system shall be made by soft soldering, silver brazing or welding according to the medium, pressure/temperature range and the particular application of the gauge. The recommended practice of joining, for various temperatures to which the element joints are subjected to, are given below:

Soft soldered	— 30 to 50°C
Silver brazed	— 30 to 120°C
Welded	— 30 to temperature above 120°C.

9.5 Movement — Material for the movement shall generally be of special grade brass conforming to IS : 319 - 1974* or stainless steel conforming to designation 04Cr18Ni10 of IS : 6603 - 1972†. Other materials, such as nylon and teflon for the pinion end bearings may be used to reduce the coefficient of friction and to resist abrasion. The movement shall be mounted on the element anchorage or any part of the gauge which is integral with the element anchorage or to which the element anchorage is attached, in such a manner that there can be no relative movement between the parts.

A typical pinion movement mechanism with its component parts is shown in Fig. 6.

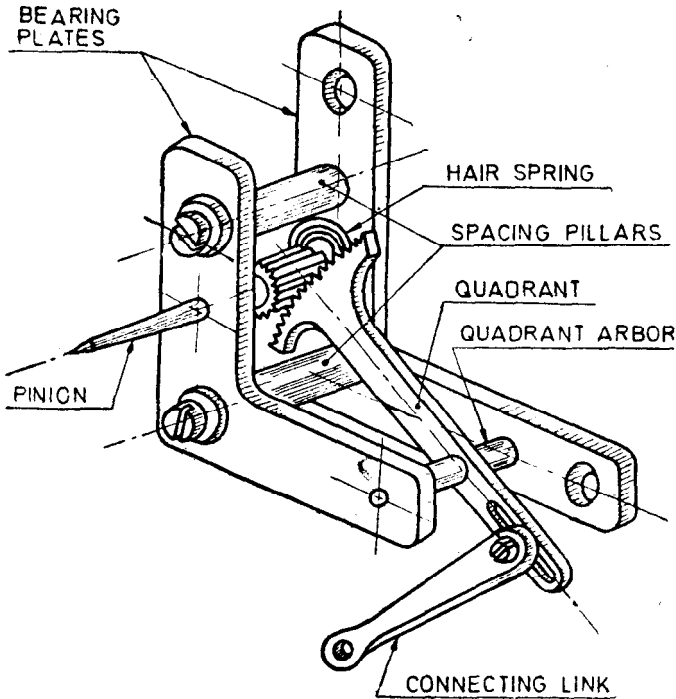


FIG. 6 NOMENCLATURE FOR COMPONENT PARTS OF A TYPICAL QUADRANT AND PINION MOVEMENT

*Specification for free cutting brass bars, rods and sections (*third revision*).

†Specification for stainless steel bars and flats.

9.6 Dial — The dial shall be made of a suitable metal or of such a plastic material that the finished dial shall be capable of withstanding a dry heat of 85°C for 10 hours, and immersion in water at 85°C for 1 hour without cracking, blistering, wrapping or discolouration of the dial or paint on the dial.

9.7 Pointer — The pointer shall be made of a suitable metal or plastic material and shall meet the requirements specified in 9.6. The pointer shall be so constructed that, when mounted on its spindle, it shall be balanced about its centre of rotation. The clearance of the pointer between the dial and the transport cover shall be adequate. It shall be securely fixed to its spindle.

9.7.1 The top of pointer must cover 1/10 to 9/10 of the length of the shortest lines of the graduation.

NOTE — This requirement does not apply to instruments whose scale and pointer are in the same place and where reading error does not exceed 1/5 of the maximum permissible error.

9.7.2 At the reading point, the type of the pointer must have:

- a) for instruments of accuracy classes 1 - 1.6 - 2.5 and 4, the form of isosceles triangle whose base does not exceed the thickness of the thickest line of the graduation and whose apex angle does not exceed 60°,
- b) for instruments of accuracy classes 0.25 - 0.4 and 0.6, the form of a knife perpendicular to the plane of the scale and thickness of tip not exceeding that of the thinnest line of graduation.

NOTE — Other shapes are allowed for the tip of the pointer, provided that the reading error does not exceed 1/5 of the maximum permissible error.

9.8 Pointer Stop — In general, a stop shall be provided either as a pin or thin projection on the dial or as an internal stop in the mechanism. This shall be provided at both the ends of the scale and shall not restrain the pointer motion at less than 105 percent above the maximum of the scale and than 5 percent below the minimum of the scale. They shall not permit pointer motion beyond a point midway between the last and first dial graduations.

9.9 Tail Pipes and Union Nuts — Tail pipes and union nuts, when specified, shall be of a material not inferior to that specified in IS : 6912-1985*. If the purchaser requires the tail pipes to be of a material suitable for brazing, he shall state this in his enquiry and order. In shut-off cock or vent of the control gauge joining the measuring gauge shall have a screw thread of $R\frac{1}{2}$ or $M20 \times 1.5$.

*Specification for copper and copper alloy forging stock and forgings (first revision).

NOTE — Brass conforming to IS : 319-1974* or stainless steel grade O4Cr17Ni12 - Mo2 as per IS : 6603 - 1972† is also recommended for the fabrication of wetted parts.

9.10 Window Cover — The transparent cover shall be made of a glass sheet having a thickness of 1.5 to 3 mm but in no case the thickness of glass sheet shall be less than 3 mm for gauges above 100 mm nominal size. It shall be uniform in thickness and free from defects which are likely to impair the readability of the gauge. Other transparent material including plastic may be used subject to an agreement between the supplier and the purchaser. But the material shall meet the requirements given in 9.6 (see Appendices B and C).

9.11 Over-range Protection — If it can be anticipated that during normal life of a pressure gauge the gauge will be subjected to overpressure, an internal stop or mechanism release shall be provided to protect the pressure element from damage and prevent disengagement of the mechanism gearing. Stops should be designed to restrain the pressure element or the mechanism rather than the pointer.

9.12 Zero Adjustment — Gauges of sizes 100 mm and above may be provided with a device for zero adjustment.

10. DIMENSIONS AND TURNING RADIUS

10.1 Mounting of Circular Surface Mounting Gauges — The flanges of surface mounting gauges shall have three fastening holes, equidistantly spaced on the pitch circle diameter given in Table 4. The holes shall be so disposed that one is at the top centre of the gauge.

TABLE 4 FIXING DIMENSIONS FOR CIRCULAR SURFACE MOUNTING GAUGES

All dimensions in millimetres.

NOMINAL SIZE OF GAUGE	PITCH CIRCLE DIAMETER	THREE CLEARANCE HOLES FOR SCREW SIZE
(1)	(2)	(3)
50	63	4.8
63	76	4.8
100	116	5.8
150	168	5.8
200	221	5.8
250	273	7.0

*Specification for free cutting brass bars, rods and sections (*third revision*).

†Specification for stainless steel bars and flats.

10.2 Mounting of Circular Flush Mounting Gauges — The dimensions for clamp fixing and for three-hole fixing shall conform to those given in Table 5. The flanges of circular flush mounting gauges for three-hole flange fixing shall have three holes for fastening equally spaced on the pitch circle diameters given in Table 5. The holes shall be so disposed that one is at the top centre of the gauge.

TABLE 5 FIXING DIMENSIONS FOR CIRCULAR FLUSH MOUNTING GAUGES

All dimensions in millimetres.

NOMINAL SIZE OF GAUGE	PANEL CUT - OUT DIAMETER	FLANGE DIAMETER, <i>Max</i>	PITCH CIRCLE DIAMETER	THREE CLEAR-ANCE HOLE FOR SCREW SIZE
(1)	(2)	(3)	(4)	(5)
50	57	76	65	4·8
63	70	90	78	4·8
100	112	134	121	5·8
150	165	188	175	5·8
200	215	240	225	5·8
250	270	305	285	7·0

10.3 Spanner Flats — All gauges shall have a hexagon or square or two flats on the shank, the thickness and the width across flats being as given in Table 6.

10.4 Shank — The screw threads on shanks for connection of gauges to pipe lines shall be parallel pipe threads or taper pipe threads as specified in IS : 554 - 1975*. The dimensions of shanks for screwed connections shall be as given in Table 6. Taper threads may be used for gauges to be mounted directly without tail pipes.

10.5 Tail Pipes — The dimensions of tail pipes for screwed connection shall be as given in Table 7.

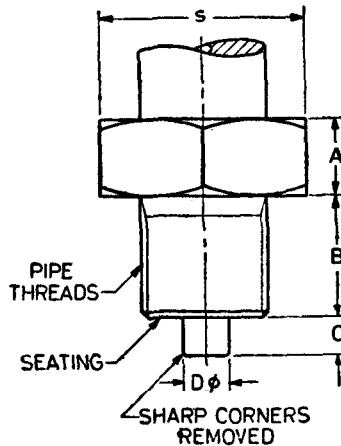
10.6 Union Nuts — The dimensions of union nuts for screwed connections shall be as given in Table 8.

10.7 The approximate dimensions of seating washers for screwed connections shall be as given in Table 9.

*Dimensions for pipe threads where pressure tight joints are required on the threads (*second revision*)

TABLE 6 DIMENSIONS FOR SHANK AND SCREWED CONNECTIONS

(Clauses 10.3 and 10.4)



All dimensions in millimetres.

*NOMINAL SIZE OF THREADS	PITCH	S	A <i>Min</i>	B <i>Min</i>	C <i>Max</i>	D [†]	SUITABLE FOR NOMINAL SIZE OF PRESSURE GAUGE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1/4	1.337	19	6.3	12	4	5	50, 63 and 100
3/8	1.337	22	10	16	5	6	100 and 150
1/2	1.814	27	13	20	5	6	150, 200 and 250

*See IS : 554 - 1975 Dimensions for pipe threads where pressure tight joints are required on the threads (*second revision*).

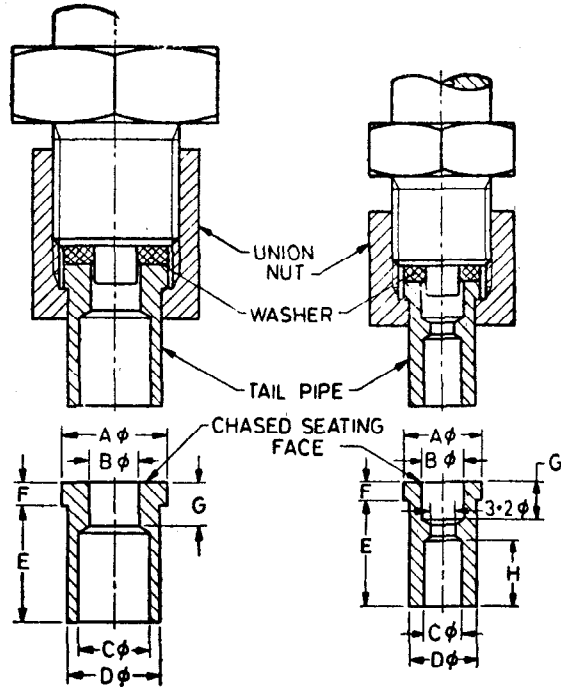
[†]Including undercut, if any.

10.8 Turning Radius of Direct Mounting Gauges — The dimensions of the case, flange and the location of screwed connection relative to the case, if direct mounting gauge with bottom connection shall be such that the gauge will rotate, with its screwed connection as centre, within a circumscribing circle of appropriate radius as given in Table 10.

TABLE 7 DIMENSIONS FOR TAIL PIPES

(Clause 10.5)

All dimensions in millimetres.



**Tail Pipe With Flat Seating
for FP $\frac{1}{4}$, FP $\frac{3}{8}$, and FP $\frac{1}{2}$**

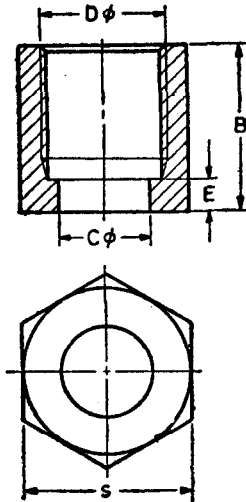
**Tail Pipe With Flat Seating
and Internal Shoulder for
FP $\frac{1}{4}$ Only**

NOMINAL SIZE OF THREADS	SUITABLE OUTSIDE DIAMETER OF CONNECTING PIPE																	
	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1/4	4.83	4.63	11.07	10.95	5.60	5.33	4.98	4.90	8.33	8.20	14.0	13.3	2.4	2.1	4.8	4.1	8.9	8.6
3/8	9.60	9.45	14.55	14.43	6.60	6.35	9.75	9.68	12.14	12.01	16.0	15.3	3.2	2.9	5.8	5.1	—	—
1/2	9.60	9.45	18.20	18.07	7.10	6.85	9.75	9.68	13.95	13.82	16.0	15.3	6.3	2.9	5.8	5.1	—	—

TABLE 8 DIMENSIONS FOR UNION NUTS

(Clause 10.6)

All dimensions in millimetres.



NOMINAL
SIZE OF
THREADS,
 D

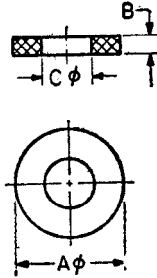
DIMENSIONS FOR UNION NUT

	DIMENSIONS FOR UNION NUT							
	Max	Min	Max	Min	Max	Min	Max	Min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1/4	15.5	15.0	8.58	8.46	3.4	3.1	19.00	18.57
3/8	22.0	21.5	12.39	12.27	4.3	4.0	22.00	21.16
1/2	27.0	26.5	14.20	14.07	5.8	5.5	27.00	26.16

TABLE 9 APPROXIMATE DIMENSIONS FOR SEATING WASHERS

(Clause 10.7)

All dimensions in millimetres.



NOMINAL SIZE OF THREADS	A	C	THICKNESS, B
(1)	(2)	(2)	(4)
1/4	11.1	5.5	Varies between 1.6 to 3.2 for all sizes depending on application
3/8	14.3	6.5	
1/2	18.3	6.5	

TABLE 10 TURNING RADIUS OF DIRECT MOUNTING GAUGES

(Clause 10.8)

All dimensions in millimetres.

NOMINAL SIZE OF GAUGE	DIRECT MOUNTING GAUGE MAXIMUM TURNING RADIUS
(1)	(2)
50	35
63	42
100	60
150	85
250	125

11. SCALES AND POINTER

11.1 In general, the design of scales, scale markings and pointer shall be in accordance with IS : 11222 - 1985*.

*Dimensions for pipe threads where pressure tight joints are required on the threads (*second revision*).

11.2 Test gauges shall be provided with knife edge pointer.

11.3 The length of the pointer from the centre line of the pointer shaft to the top of the point for circular dial gauges shall not be less than 40 percent of the nominal size of the gauge.

12. FINISH AND TREATMENT

12.1 The finish and treatment of bezel and case should be anti-corrosive or as agreed between the supplier and the purchaser.

12.2 **Protection Against Corrosion** — All ferrous parts shall be painted, or otherwise treated to resist corrosion by atmosphere.

12.3 The dial and pointer shall be so finished that they have non-reflective surface.

13. INFORMATION TO BE SUPPLIED WITH THE ENQUIRY

13.1 The first set of information will always be capable of definition and shall be provided, so that the most suitable gauges conforming to this standard are supplied and shall be as follows:

- a) Type according to this standard, that is, industrial or test;
- b) Any special requirements additional to this standard;
- c) Range, operating pressure and temperature;
- d) Accuracy;
- e) Nominal size of gauge;
- f) Type of pressure element, that is, bourdon, bellows or diaphragm;
- g) Material of case;
- h) Connection type, location and size;
- j) Type of mounting — direct, surface or flush;
- k) Capillary length; and
- m) Accessories like tail pipe, syphon, snubbers, dampers, etc.

13.2 The second set of information may not always be equally capable of ready definition, but when those details are given, they will enable the pressure gauges to be selected as may be best suited for the required

operating conditions. This set consists of the following:

- a) Type of equipment to which the gauge will be fitted:
 - 1) Stationary,
 - 2) Mobile, or
 - 3) Portable.
- b) Any adverse conditions, such as exposure of the gauge to weather, corrosive atmosphere, extreme heat or cold, and high humidity;
- c) Maximum pressure likely to be applied;
- d) Whether pressures will be steady or fluctuating;
- e) Whether subject to :
 - 1) Sudden increase of pressure (shock loading); and
 - 2) Sudden decrease of pressure (shock unloading).
- f) Whether subject to :
 - 1) Mechanical vibration; and
 - 2) Mechanical shock.
- g) Static head;
- h) Name and state of fluid; and
- j) Any other information which may assist in the selection of suitable gauges.

14. TESTS

14.1 Accuracy

14.1.1 Test Gauges — Each gauge shall be subjected to a pressure equal to the maximum scale value, and shall be maintained at that pressure for not less than 1 hour. After the pressure is released and without recalibration or adjustment, the gauge shall be tested over its entire scale, with readings taken both up and down the scale.

The error in pressure indication, with either increasing or decreasing pressure, at any point on the scale, shall not exceed ± 0.25 percent of the maximum scale value at 27°C.

14.1.2 Industrial Concentric/Edgewise Scale Gauge Class 1A — Each gauge shall be tested over its entire scale with readings taken both up and

down the scale. The error in pressure indication with either increasing or decreasing pressure, at any point, shall not exceed one - half of 1 percent of the maximum scale value, and for the rest of the scale, 1 percent of the maximum scale value.

14.1.3 Industrial Concentric/Edgewise Scale Gauge Class 1B — Each gauge shall be tested over its entire scale, with readings taken both up and down the scale. The error in pressure indication with either increasing or decreasing pressure, at any point, shall not exceed one percent of the maximum scale value, and, for the rest of the scale, $1\frac{1}{2}$ percent of the maximum scale value.

14.1.4 Industrial Concentric/Edgewise Scale Gauges Class II — Each gauge shall be tested over its entire scale, with readings taken both up and down the scale. The error in pressure indication with either increasing or decreasing pressure, at any point on the scale, shall not exceed three percent of the maximum scale value.

14.1.5 Industrial Eccentric Scale Gauges — Each gauge shall be tested over its entire scale, with readings taken both up and down the scale. The error in pressure indication with either increasing or decreasing pressure, at any point above 10 percent and below 90 percent of the maximum scale value, shall not exceed two percent of the maximum scale value, and for the rest of the scale, 3 percent of the maximum scale value.

14.1.6 Industrial gauges with bellows, diaphragms or capsules as pressure sensing elements shall be tested over its entire scale with readings taken both up and down the scale. The error in pressure indication with either increasing or decreasing pressure, at any point in the scale, shall not exceed $1\frac{1}{2}$ percent of the maximum scale value.

NOTE 1 — The specified permissible errors for eccentric scale gauge are larger than those for concentric scale gauges of equal nominal size, since the scale base length is substantially shorter and the error of observation is likely to be greater.

NOTE 2 — Recommendations as to suitable calibration standards for the testing of pressure gauges are given in Appendix F.

NOTE 3 — The gauge may be lightly tapped during testing.

NOTE 4 — The above tests shall be conducted on the gauge at a temperature of $27 \pm 5^\circ\text{C}$.

14.2 Test for Influence of Temperature (Type Test) — This test is applicable for pressure and vacuum gauges of Industrial applications. The instruments shall be tested for variation of error with temperature. The variation of error shall not exceed ± 0.3 percent of the error of the instrument determined under test in 14.1 for a change of $\pm 10^\circ\text{C}$ in temperature.

14.3 Overload Test

14.3.1 The overload test is not applicable to test gauges.

14.3.2 For industrial gauges, the pressure shall be raised steadily to a value representing the overload on the maximum scale value as given in the table below.

<i>Maximum Scale Value</i> MPa	<i>Overload on Maximum Scale Value</i> Percent
Up to and including 15	25
Above 15 up to and including 60	15
Above 60	10

14.3.3 The pressure shall then be released steadily to zero and when the gauge is again tested for accuracy by the procedure laid down in 13.2 or 13.3, it shall not show errors exceeding the specified limits.

14.3.3.1 In the case of eccentric scale gauges, the complete overload test should be applied, if practicable. If impracticable, the pressure shall be increased to the point where the pointer touches the spacer. The procedure specified in 12.3 shall then be carried out.

14.4 Shock Test

14.4.1 The gauges shall be subjected to a shock test, shaking with an acceleration of 30 m/s^2 and a frequency of 80 to 120 shocks per minute for a period of not less than 2 hours. After this test, the error shall not change by more than ± 2 percent of maximum scale value.

14.5 Endurance Test

14.5.1 The gauge shall be subjected to cyclic pressure fluctuations on satisfactory completion of overload and shock tests:

- a) Low pressure gauges with a steady working pressure up to and including 6 MPa shall be subjected to pressure fluctuation of approximately 50 percent of maximum pressure range. It shall be adjusted to lie between 25 to 75 percent of maximum scale reading having a frequency of 60 cycles per minute for a period of 300 hours.
- b) High pressure gauges with a steady working pressure above 6 MPa shall be subjected to pressure fluctuation of approximately 30 percent of maximum pressure range. It shall be adjusted to

lie between 35 to 65 percent of maximum scale reading having a frequency of 30 cycles per minute for a period of 100 hours.

- c) The gauges must be capable of withstanding a pressure varying in a continuous manner, with a frequency not exceeding 1 Hz between the limits and for a total number of cycles indicated below:

<i>Upper Limit of the Measurement Range</i> MPa	<i>Limits of Pressure Variation as Percent of the Upper Limit of the Measurement Range</i>	<i>No. of Cycles</i>
From 0.05 to 10 included	30 - 70	15 000
From 10 to 60 included	40 - 60	10 000
From 60 to 160 included	40 - 60	5 000
From 160 to 1 000 included	40 - 60	1 000

14.5.2 The gauge shall be considered to have failed in the above test if pressure element is fatigued and the required 2 percent of maximum scale value.

14.5.2.1 The difference at any point in the range between gauge errors before and after endurance test shall not exceed 2 percent of maximum scale value.

15. MARKING

15.1 Scale Marking

15.1.1 The pressure gauges for the whole range, vacuum gauges and in combined pressure and vacuum gauges, the pressure and vacuum scale markings shall normally be black on a white background and should be a non-reflective surface. However, the vacuum scale markings may also be provided in red, if so desired by the user. When a particular maximum marking pressure or vacuum is to be indicated, this indication shall take the form of a bold and long red line on the scale.

15.1.2 In pressure gauges and in combined pressure and vacuum gauges, the pointers shall move clockwise for increase of pressure.

15.1.3 The scale markings and layout shall be in accordance with IS : 8525 - 1977*.

*Recommendations for design of linear scales and indexes for indicating instruments to be read to 0.33-1.25 percent resolution.

15.2 Each gauge shall be legibly and permanently marked with the manufacturer's name or trade-mark and, in addition, the following particulars:

- a) Designation of pressure units;
- b) The material of the pressure element;
- c) The words 'Test Gauge' if applicable; and
- d) Any other marking shall be kept to a minimum, preferably outside the area swept by the pointer.

15.2.1 The purpose or the function of the gauge should not be marked on the dial, unless it is to identify the pressure medium, that is, oxygen and acetylene (*see* Appendix C).

15.2.2 The gauges may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the rules and regulations made there-under. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers, may be obtained from the Bureau of Indian Standards.

16. PACKING

16.1 The inlet and screwed connection shall be protected by a suitable cap. Each gauge shall be wrapped individually in a bubbled polythene sheet and packed in a thermocole box. Such boxes shall be packed in a carton or box, with adequate cushioning material to minimize movement of the gauge and to ensure that the gauge is capable of withstanding normal transit risks without damage.

16.2 The gauges shall be transported in packing, which ensures that their metrological characteristics are maintained.

Where it becomes necessary to check the effect of the transport conditions, the instruments are subjected to:

- a) an ambient air temperature of $- 20^{\circ}\text{C}$ and $+ 50^{\circ}\text{C}$ for 6 hours at each of these temperatures, and
- b) Subject it to shock test specified in 14.3.

A P P E N D I X A

(Clause 9.1)

RECOMMENDATIONS FOR MATERIAL AND USE OF PRESSURE GAUGES

A-1. GENERAL CONSIDERATIONS

A-1.1 Although gauges may be expected to give a long period of reliable service, if correctly selected, installed and used, the selection of the type of gauge unsuited to the particular application or careless installation may result in inaccurate indication and even early failure of the gauge. Particular care is essential in selecting and installing a gauge which is to operate under adverse working conditions, such as rapidly fluctuating pressure, vibration, excessive heat or cold, or with corrosive or explosive fluids.

A-2. WORKING PRESSURE LIMITS

A-2.1 The maximum working pressure limits are given in Table 2. If these pressures are exceeded repeatedly, the pressure element may take a permanent set, thus causing error in the pressure indication. In no case, after installation, should a gauge be exposed to a pressure beyond the maximum scale value. It follows that plain vacuum gauges should not be subjected to pressure.

A-3. SEATING WASHERS

A-3.1 Seating washers used in connections should be of a material which will not easily fray or extrude and shall also be compatible with the pressure medium. The use of rubber should be avoided.

For working pressures of 6 MPa and under, the following materials are suitable for seating washers:

- a) Compressed asbestos fibre;
- b) Rubber-bonded compressed asbestos;
- c) Copper asbestos;
- d) Teflon; and
- e) Neoprene.

For working pressure above 6 MPa, it is recommended that one of the following metal washers is used to avoid the possibility of blow-out:

- a) Annealed copper,
- b) Annealed aluminium, or
- c) Metal-bonded seals.

A-3.2 For examples of correct and incorrect methods of making the connections and mounting the pressure gauges, see Fig. 7 to 9.

A-3.3 Information regarding washers for connecting gauges with oxygen or acetylene lines is given at C-1 and C-2.

A-4. PRESSURE CONNECTION

A-4.1 Direct Mounting Gauges — When direct mounting gauges are being connected to the pressure connecting point, the joint on the seating water should be tightened by means of the spanner flats provided and should not be tightened by grasping the case, as this may injure the gauge.

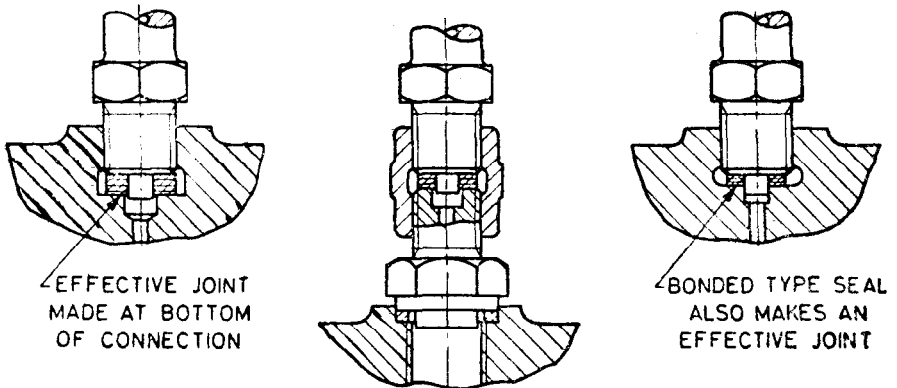
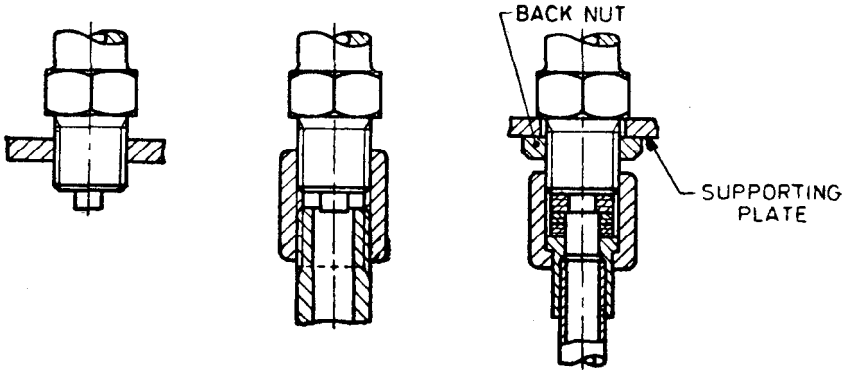


FIG. 7 CORRECT METHODS OF CONNECTING DIRECT MOUNTING GAUGES

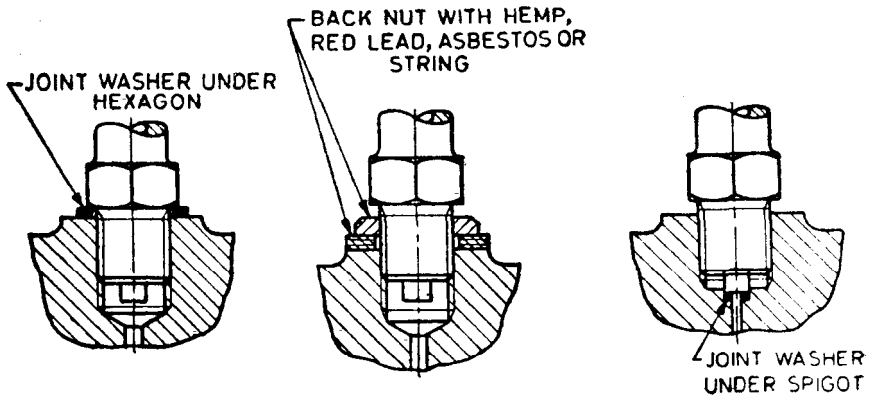
A-4.1.1 When gauges are connected to pressure piping through screwed connections, the sealing should be made on the seating face with a washer. Correct methods of connecting a gauge of direct mounting type are shown in Fig. 6. Where orientation of the gauge is difficult, a right and left hand connecting nut and adaptor is often advantageous.

A-4.1.2 Gauges with parallel threads shall have their sealing only at the flat seat using suitable washers. It is incorrect to attempt sealing at the

threads of the screwed connection by means of thread sealing compounds, red lead, hemp, asbestos string, etc, or the sealing washer in wrong position. The use of such joints or jointing by insufficient length of thread engagement are potential sources of danger. In case of high pressures, it may result in stripping of threads and consequent blow out of the gauge. Examples of incorrect connection of gauges of direct mounting type are shown in Fig. 8.



8A Joint Attempted on Thread in Wall of Pipe or Tank
 8B Joint Attempted on Thread in Pipe Socket
 8C Insufficient Thread Engagement



8D Joint Attempted under Hexagon
 8E Insufficient Thread Engagement
 8F Joint Attempted under Spigot

FIG. 8 INCORRECT METHODS OF CONNECTING DIRECT MOUNTING GAUGES

run of piping to the gauge. For syphon tubes, a quality equivalent to that specified in IS : 1545 - 1982* or that specified in IS : 1239 (Part 2) - 1969†, is recommended.

A-6. TEMPERATURE PROTECTION

A-6.1 Gauges shall not be exposed to excessive heat or cold, since this causes them to indicate the pressures incorrectly. They should be protected from exposure to high temperatures, and not be mounted on hot boiler casings or hot machine parts, and should be placed at some distance from boilers or other sources of heat. When exposed to frost, bourdon tubes which contain water, are liable to burst.

A-6.2 Gauges for Hot Liquids and Gases — Gauges should be connected to the tapping point by means of a piping which is sufficiently long to keep the gauge and pressure element cold. If a gauge cannot be grasped by hand without discomfort, it is working at too high a temperature.

A-7. POSITION OF GAUGE

A-7.1 Normally, gauges should be installed with the face of the dial in a vertical position and oriented so that the scale shall be symmetrically displaced about the vertical centre line of the gauge. In other positions, the weight of the working parts may influence the reading. It is, therefore, necessary to advise the manufacturer, if it is intended to use the gauge in any position other than vertical so that the gauge may be suitably calibrated.

A-7.2 Gages with a blow-out back should be mounted not less than 20 mm away from a wall, panel or other obstruction.

A-8. EFFECT OF LIQUID COLUMNS

A-8.1 If static head of liquid is acting on the gauge, allowance should be made for this at the time of calibration of the gauge and the dial of the gauge should be marked to show the allowance. In these cases the manufacturer should be advised by the purchaser.

*Specification for solid drawn copper alloy tubes for condensers and heat exchangers (*second revision*).

†Specification for mild steel tubes, tubulars and other wrought steel fittings: Part 2 Mild steel tubulars and other wrought steel pipe fittings (*third revision*).

A-9. RAPIDLY FLUCTUATING PRESSURE, SHOCK PRESSURES AND VIBRATION

A-9.1 Gauges cannot be expected to have a normal life if they are used without protection in any of the following conditions:

- a) Pressure changing in value very quickly or fluctuating rapidly, for example, more than one cycle per second;
- b) Pressure applied or released very quickly so as to produce shock or heating (often occurring on hydraulic presses and hydraulic tests);
- c) Pressure oscillating with high frequency, producing a destructive pressure ripple (often originating in hydraulic pumps and chattering relief valves); and
- d) Mechanical vibration transmitted to the gauge through either the piping or the mounting.

A-9.2 It is possible to provide protection for gauges which have to work in the conditions indicated in **A-10.1**, but there is no single device or procedure which is effective in every case. In such cases, protective devices, such as throttle screws, pulsation dampeners or gauge savers could be provided to protect and extend the life of the gauge.

A-10. PROTECTION AGAINST MECHANICAL VIBRATION

A-10.1 It is impossible to prescribe protection against mechanical vibration for all conditions. If a machine on which the gauge would normally be mounted vibrates noticeably, it is preferable to mount the gauge with adequately flexible piping on a wall or stanchion nearby.

A-11. SEALING

A-11.1 Type of seals are designed for use with bourdon type pressure instruments on process applications where:

- a) the process fluid would normally clog the bourdon tube,
- b) materials capable of withstanding corrosive effects of certain fluids are not available as bourdon tube materials, and
- c) the process fluid in the bourdon tube might freeze due to changes in ambient temperatures.

A-11.2 The diaphragm materials may be stainless steel, monel, tantalum, hastelloy or any other material to suit the pressure medium.

APPENDIX B

(Clause 9.1.5)

SAFETY PRECAUTIONS RELATING TO INDUSTRIAL PRESSURE GAUGES

B-1. FOR USE WITH HIGH PRESSURE GAS

B.1.1 Although there is not necessarily any great risk in the use of gauges for gases at pressure less than 6 MPa, the purchaser should consider the nature of the gas and the installation conditions, and if necessary, order a gauge of the safety pattern. Gauges used for gases and graduated to any maximum scale value exceeding 6 MPa should be of the safety pattern described at B-1.2.

B-1.2 For safety pattern gauges, the case should be of metal and a solid baffle should be interposed between the bourdon tube and the dial, and a suitable blow-out release should be so fitted to the gauge that in the event of an explosion or fracture of the pressure element of the gauge, the blast will be away from the front. The hole, enabling the pointer spindle to pass through the solid baffle, should be kept as small as practicable. Where the case is of the surface mounting type, that is, with a rear flange case, it is essential that the gauge is mounted at least 20 mm away from the wall or panel to allow for the dissipation of the blast between the rear of the case and the surface on which mounted. It is recommended that the gauge manufacturer supplies the gauge fitted with study on the flange or loose distance pieces for this purpose. The window should be of non-splintering glass or a clear plastic material.

B-1.2.1 The lack of a solid front gauge shall have an opening or openings whose total area is at least 75 percent of the cross-sectional area of the inside of the case surrounding the elastic element. The opening (s) shall be closed by a device that will relieve case pressure build up.

B-2. SAFETY CONSIDERATIONS

B-2.1 The pressure sensing element in most gauges is subjected to high internal stresses, and applications exist where the possibility of catastrophic failure is present. Pressure regulators, chemical scale, pulsations dampers or snubbers, siphons, etc, are available for use in these potentially hazardous systems.

B-2.2 Pressures in excess of full scale pressure (or vacuum) should not be applied, unless recommended by the manufacturer.

B-2.3 The window material will not provide adequate protection against internal case pressure build-up and can, in fact, be the most hazardous component.

B-2.4 The following systems are considered potentially hazardous and must be carefully evaluated:

- a) Compressed gas systems,
- b) Oxygen systems,
- c) Systems containing hydrogen or free hydrogen atoms,
- d) Corrosive fluid systems (gas and liquid),
- e) Pressure systems containing any explosive or flammable mixture or medium,
- f) Steam systems,
- h) Systems where high overpressure could be accidentally applied,
- j) Systems where interchangeability of gauges could result in hazardous internal contamination or where lower pressure gauges could be installed in higher pressure systems,
- k) Systems containing radioactive or toxic fluids, and
- m) Systems installed in a hazardous environment.

B-2.5 When gauges are to be used in contact with media having known or uncertain corrosive effects or known to be radioactive, random or unique destructive phenomena can occur. In such cases the user should always furnish the supplier or manufacturer with information relative to the application and solicit his advice prior to installation of the gauge.

B-2.6 Fires and explosions within a pressure system can cause pressure element failure with very violent effects, even to the point of completely disintegrating or melting the pressure gauge. Violent effects are also produced when failure occurs due to : (a) hydrogen embrittlement, (b) contamination of a compressed gas, (c) formation of acetylides, (d) melting of soft solder joints by steam or other heat sources, (e) corrosion, (f) fatigue, (g) the presence of shock, and (h) excessive vibration. Nearly any failure in a compressed gas system produces violent effects.

B-2.7 The maximum pressure at which a pressure gauge is continuously operated shall not exceed 75 percent of full scale pressure. The gauge selected should have a full scale pressure of approximately twice the intended operating pressure. This does not apply to retarded or suppressed scale gauges. Contact supplier for recommendations.

B-2.8 The elastic element is generally a thin walled member, that of necessity operates under high stress conditions and must, therefore, be carefully selected for compatibility with the pressure medium being measured. None of the common element materials is impervious to every type of chemical attack. The potential for corrosive attack is established by many factors including the concentration, temperature and contamination of the medium. The user should inform the gauge supplier of the installation conditions so that the appropriate element materials can be selected.

B-2.9 Some special applications require the pressure element assembly to have a high degree of leakage integrity. Special arrangements should be made between the manufacturer and the user to assure that the allowable leakage rate is not exceeded.

B-2.10 An effective contamination control programme starts with determining the sensitivity of product to contamination. Because absolute values or limits are difficult to establish, it is common practice to select a level of cleanliness based on judgement and economic considerations.

Cleanliness is determined by the size and quantity of maximum permissible solid contaminants on significant surfaces and/or by the quantity (ppm) discernible in the fluid used to clean such surfaces.

B-2.11 Gauges having high and low electric alarm contacts should be built with intrinsic safe casing when used in hazardous areas. Any spark occurring on the contacts should be of a low strength to avoid explosion in such areas.

APPENDIX C

(Clause 9.1.5)

PRECAUTIONS RELATING TO GAUGES FOR USE WITH OXYGEN AND ACETYLENE

C-1. GAUGES FOR USE WITH OXYGEN

C-1.1 Oxygen under pressure forms an explosive mixture with oil or grease, and a serious explosion may result, if the two are brought together. Thin films and slight deposits of oil or grease are particularly susceptible to ignition. It is imperative that extreme care be exercised in the manufacture and testing of oxygen gauges, and in the subsequent cleaning and

handling of oxygen gauges and their connections, so that they are kept absolutely free from oil and grease.

C-1.2 When oxygen gauges are tested, oil shall not be allowed to touch or enter the gauge. They should be tested with only dry and clean air on testing equipment used for that purpose alone, and no other gauges should be tested on this equipment to avoid the risk of oil contamination. It should be remembered that factory air supplies are rarely, if ever, free from oil contamination. After any test, the equipment should be thoroughly degreased.

C-1.3 It is essential that all gauges for use with oxygen should be of the safety pattern and that they should incorporate all of the feature prescribed in Appendix B for gauges for use with high-pressure gas.

C-1.4 Seating washers for oxygen gauges may be of the same materials as those described in A-4, except leather, provided they are free from oil or grease of any description.

C-1.5 It is essential that all gauges for use with oxygen shall have plainly inscribed on the dial in black letters the word 'Oxygen' and in red letters the warning 'Use no oil'.

C-1.6 For oxygen gauges, the connection should be immediately plugged after testing is over to avoid entrance of grease or oil parties.

C-1.7 After the testing is over, the gauge should be thoroughly degreased reagents such as trichloroethylene or carbon tetrachloride.

C-2 GAUGES FOR USE WITH ACETYLENES

C-2.1 Acetylene in conjunction with copper or silver may form an explosive compound and the use of high copper or silver content alloy for any part of the gauge that may come in contact with the gas should be avoided. Where possible, the bourdon tube and all other parts with which the gas may make contact should be constructed of steel. Where the use of steel is impracticable, a low copper content alloy should be used.

C-2.2 Seating washers for acetylene gauges may be of the same material as those described in A-4 except annealed copper and copper asbestos.

C-2.3 It is essential that all gauges for use with acetylene should be of the safety pattern and incorporate all of the features prescribed in Appendix B for gauges for use with high pressure gas.

C-2.4 It is essential that all gauges for use with acetylene shall have plainly inscribed on the dial in red letters the word 'Acetylene'.

A P P E N D I X D

(Clause 9.4)

**FERROUS AND NON-FERROUS MATERIALS FOR
BOURDON TUBING**

D-1. NON-FERROUS MATERIALS

D-1.1 Beryllium Copper Tubing — The chemical composition shall be as under:

Beryllium	Not less than 1.70 percent Not more than 1.90 percent
Cobalt or nickel or cobalt plus nickel	Not less than 0.05 percent Not more than 0.40 percent
Total impurities	Not more than 0.50 percent
Copper	The remainder

D-1.2 Brass Tubing — The chemical composition shall be as under:

Copper	Not less than 64.0 percent Not more than 67.0 percent
Iron	Not more than 0.10 percent
Lead	Not more than 0.10 percent
Total other impurities, ex- cluding iron and lead	Not more than 0.40 percent
Zinc	The remainder

D-1.3 Nickel - Copper - Aluminium Alloy Tubing — The chemical composition shall be as under:

Aluminium	Not less than 2.00 percent Not more than 4.00 percent
Titanium	Not less than 0.25 percent Not more than 1.00 percent
Copper	Not less than 27.0 percent Not more than 33.0 percent
Carbon	Not more than 0.25 percent
Silicon	Not more than 1.00 percent

Manganese	Not more than 1.50 percent
Sulphur	Not more than 0.01 percent
Iron	Not more than 2.00 percent
Total impurities	Not more than 0.2 percent
Nickel (including cobalt)	Not remainder but not less than 63.00 percent

D-1.4 Phosphor Bronze Tubing — The chemical composition shall be as under:

Tin	Not less than 4.5 percent
	Not more than 5.5 percent
Phosphorus	Not less than 0.01 percent
	Not more than 0.20 percent
Lead	Not more than 0.02 percent
Total impurities (including lead)	Not more than 0.20 percent
Copper	The remainder

D-2. FERROUS MATERIAL

D-2.1 Chromium - Molybdenum Alloy Steel Tubing — The chemical composition shall be as under:

Carbon	Not less than 0.27 percent
	Not more than 0.33 percent
Silicon	Not less than 0.10 percent
	Not more than 0.35 percent
Manganese	Not less than 0.40 percent
	Not more than 0.90 percent
Chromium	Not less than 0.80 percent
	Not more than 1.10 percent
Molybdenum	Not less than 0.15 percent
	Not more than 0.25 percent
Nickel	Not more than 0.4 percent
Vanadium	Not more than 0.05 percent
Sulphur	Not more than 0.04 percent
Phosphorus	Not more than 0.04 percent

D-2.2 Stainless Steel Tubing — The chemical composition shall be as under:

Carbon	Not more than 0.08 percent
Silicon	Not more than 1.0 percent
Manganese	Not more than 2.0 percent
Chromium	Not less than 16.0 percent Not more than 18.0 percent
Molybdenum	Not less than 2.0 percent Not more than 3.0 percent
Nickel	Not less than 10.0 percent Not more than 14.0 percent
Phosphorus	Not more than 0.04 percent
Sulphur	Not more than 0.03 percent

D-2.3 Carbon Steel Tubing — The chemical composition shall be as under:

Carbon	Not less than 0.32 percent Not more than 0.38 percent
Silicon	Not more than 0.40 percent
Manganese	Not more than 1.20 percent
Phosphorus	Not more than 0.05 percent
Sulphur	Not more than 0.05 percent
Total residual impurities	Not more than 0.75 percent
Iron	The remainder

D-2.4 Iron Base, Nickel, Chromium, Titanium (Precipitation Hardening) Alloy Tubing — The chemical composition shall be as under:

Carbon	Not more than 0.06 percent
Silicon	Not more than 1.00 percent
Manganese	Not more than 0.80 percent
Chromium	Not less than 4.90 percent Not more than 5.50 percent
Nickel (including cobalt)	Not less than 41.00 percent Not more than 43.00 percent
Phosphorus	Not more than 0.04 percent
Sulphur	Not more than 0.04 percent

Aluminium	Not less than 0.30 percent Not more than 0.80 percent
Titanium	Not less than 2.10 percent Not more than 2.60 percent
Total impurities	Not more than 0.2 percent
Iron	The remainder.

APPENDIX E

(Clause 9.4)

MECHANICAL PROPERTIES OF COLD DRAWN BOURDON TUBING

The mechanical properties given below provide a general indication of the properties of the tubing used for the fabrication of bourdon tubes. Apart from the hardness values, they do not constitute a mandatory part of the Standard:

<i>Material</i>	<i>Condition</i>	<i>Tensile Strength MPa</i>	<i>Elongation Percent in 50 mm</i>	<i>Hardness HV</i>	<i>Modulus of Elasticity GPa</i>
*Beryllium copper	W	463 - 540	35 - 45	85 - 120	124 - 131
*Beryllium copper	W (1/4 H)	618 - 772	10 - 25	120 - 185	124 - 131
Brass	(1/4 H)	340 - 432	5 - 20	100 - 140	103
*Nickel-copper-aluminium alloy	W	618 - 757	25 - 40	190 <i>Max</i>	158 - 179
*Nickel-copper-aluminium alloy	W (1/4 H)	695 - 834	15 - 30	250 <i>Max</i>	158 - 179
Phosphor bronze	(1/4 H)	340 - 432	15 - 35	110 - 140	110
Chromium-molybdenum steel	Annealed	463 - 556	30 - 40	165 <i>Max</i>	196

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Stainless steel	Lightly cold - worked condition	649 - 772	20 - 40	200 - 250	176 - 186
Carbon steel	Lightly cold - worked condition	540 - 695	20 - 30	150 - 190	193 - 200
*Iron base, nickel-chromium, titanium alloy	Annealed (solution treated)	525 - 618	35 - 45	120 - 180	165 - 190
*Iron base, nickel-chromium-titanium alloy	Solution treated and lightly cold-worked condition	649 - 772	15 - 30	170 - 230	165 - 190

NOTE — Attention is drawn to the fact that the fabrication of the tubing into a bourdon tube will in all instances affect these initial properties to a greater or lesser degree, as also may such processes as soldering, brazing and welding. Those materials marked with an asterisk will not attain the properties requisite in a bourdon tube without heat treatment. The instrument manufacturer should consult the tubing manufacturer as to the appropriate heat treatment and the mechanical properties to be expected in the material after such heat treatment.

The following letters have been used in the above table to indicate the condition of heat treatment for the non-ferrous materials:

W — Material which has been solution heat-treated and will respond effectively to precipitation treatment.

W (1/4 H) — Material which has been solution heat-treated and subsequently lightly cold - worked.

(1/4 H) — Material in the lightly cold-worked condition.

APPENDIX F

(Clause 14.1.6)

RECOMMENDED METHOD AND APPARATUS FOR TESTING GAUGES

F-1. SUITABLE APPARATUS FOR TESTING GAUGES

F-1.1 Test Gauges — The recommended apparatus for testing test gauges is as follows:

- | | |
|----------------------------------------------------------|-----------------------------------------------------------|
| a) With range — 100 to 0 kPa (vacuum) and 0 to 150 kPa | Mercury manometer or dead-weight tester with air pressure |
|----------------------------------------------------------|-----------------------------------------------------------|

- b) Maximum scale value above 150 kPa Dead - weight tester

F-1.2 Industrial Gauges — The recommended apparatus for testing industrial gauges is as follows:

- a) With range — 100 to 0 kPa (vacuum) Mercury manometer with air pressure test gauge as specified in F-4 (Dead-weight tester or mercury column may be used by agreement between the purchaser and the manufacturer)
- b) Maximum scale value 100 to 600 kPa
- c) Maximum scale value above 600 kPa Test gauge as specified in F-4 or dead-weight tester.

F-2. DEAD-WEIGHT TESTERS

F-2.1 The accuracy of a dead-weight tester depends principally upon the correctness of the piston area, the accuracy of the weights, and the character of the fit between the piston and the cylinder. With a properly constructed instrument, the pressure computed from the piston area and the weights may be assumed to be correct to within one-tenth of 1 percent. When greater accuracy is desired, it is recommended to compare the tester directly with mercury manometer.

F-3. MERCURY MANOMETERS

F-3.1 The calibration of the mercury manometer consists essentially of:

- a) checking the accuracy of the manometer scale against a standard of length, making allowance for the fall of mercury in the reservoir;
- b) determining, if the manometer scale correctly indicates the difference in height between the two mercury columns over the entire range of the manometer; and
- c) applying the necessary temperature corrections to the value used for the density of the mercury. It is recommended that the glass tubing used be of an internal diameter of not less than 9.5 mm. In using the manometer, precautions should be taken to avoid errors in reading arising from parallax.

F-4. TEST GAUGES USED AS TEST STANDARDS

F-4.1 Test gauges used as test standards should meet the accuracy requirements specified in 13.1. Test gauges should be calibrated by comparison

with the same test standards as specified in F-1.1. In addition, each test gauge should meet the following special requirements.

F-4.1.1 The maximum scale of the test gauge should be such that it is neither less than that of the gauge to be tested by comparison with it, nor more than twice the maximum scale value of the gauge to be tested.

F-4.2 The test gauge shall be equipped with a device or devices to minimize parallax reading errors.

F-4.3 The nominal size of the test gauge shall not be smaller than 150 mm.

F-4.4 The range of the test gauge shall not be less than that of the gauge being calibrated nor more than twice that of the gauge being calibrated.

F-4.5 The test gauge shall not have a stop pin unless it is located below the true zero pressure point of the graduated scale.

F-4.6 The test gauge shall be tested before and after a period of use. The frequency of recalibration will depend on the ability of the gauge to retain its accuracy during use. The indicating error for each cardinal point and the date of last calibration shall be noted prominently on the front of the gauge.

F-5. TEST PROCEDURES

F-5.1 The following procedures are suggested when testing a pressure gauge for the operating parameters such as range, span, hysteresis, linearity, calibration, etc, and determining its compliance with the accuracy grades mentioned in 12.

F-5.1.1 Reference Temperature — A temperature of $27 \pm 5^{\circ}\text{C}$ shall be the reference standard for testing all gauges. All gauges other than temperature compensated gauges shall be tested at the reference temperature. Temperature compensated gauges shall be tested at several ambient temperatures within the range specified by the manufacturer.

NOTE — Gauges represented as being compensated for service at various temperatures include those having components of special materials to compensate for the effects of temperatures on Young's modulus and thermal expansion. The magnitude of the greatest error when tested over the entire temperature range specified for the gauge shall determine the accuracy classification of the gauge.

F-5.2 Liquid Head — In calibrating a gauge using a deadweight tester filled with a liquid, the elevation at the bottom of the piston shall correspond exactly with a reference level on the gauge. This level shall be at a point where its neutral neutralises the effect of head and weight of the liquid in the system.

When used in connection with an air deadweight tester, there shall be no liquid in the gauge or in the lines between the gauge and the deadweight tester.

F-5.3 Accuracy

F-5.3.1 Test Gauges and Class IA Gauges — Each gauge shall be subjected to pressure equal to the maximum scale pressure (or vacuum). This pressure shall be maintained for a period of not less than 5 minutes. Within 10 minutes after the pressure is released and without recalibration or adjustment, the gauge shall be read on increasing pressure (or vacuum) from one end to the other of the scale, reading the number of test points shown below; then decreasing pressure (or vacuum) back to the starting and reading the same test points. The gauge lightly tapped before each reading.

Test Gauge — Minimum 8 equal test points

Class IA — Minimum 5 equal test points.

The difference (error) noted at each test point (whether upscale or downscale) is the accuracy. When taken as percent of span, it shall not exceed values shown in 12. (14)

F-5.3.2 Classes IB and II Gauges — The gauge shall be tested as described in F-5.3.1. The minimum number of test points shall be five for Class IB and three for Class II gauges. The error shall be within the values shown in 12. (14)

F-5.3.3 Eccentric Scale Gauges and Gauges with Bellows, Diaphragms, Capsules as Measuring Element — The gauges shall be tested as described in F-5.3.1. The minimum number of test points shall be three. The error shall be within the values shown in 12. (14)

F-5.3.4 Hysteresis Error — This can be determined from data obtained in the accuracy test. It is the difference between an upscale and downscale reading for the same pressure input. The gauge being tested shall be lightly tapped before each reading.

Hysteresis is a function of the pressure input excursion (the maximum amount of pressure applied) and maximum hysteresis usually accrue at or near the middle of that excursion. When taken as a percent of span, it shall not exceed the limit shown in 12. For the applicable accuracy grade, it is included as part of the accuracy. (14)

F-5.3.5 Repeatability — This can be determined at any given point as follows:

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Raise or lower the pressure to the desired value as noted on the test standard. Lightly tap the gauge under test and read the pointer. Return the pressure to the original value and repeat the procedure.

The difference between the two pointer readings taken as a percent of span is the repeatability. This does not include hysteresis or friction error.