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(दूसरा पुनरीक्षण)

Indian Standard

CURRENT TRANSFORMERS — SPECIFICATION

PART 1 GENERAL REQUIREMENTS

(Second Revision)

(Incorporating Amendment Nos. 1 & 2)

UDC 621.314.224

BUREAU OF INDIAN STANDARDS
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Instrument Transformers Sectional Committee, ETD 34

FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Instrument Transformers Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was first published in 1964 and revised in 1981. This revision has been undertaken to bring it in line with the latest developments at the international level.

Indian Standards on current transformers have been published in four parts:

Part 1 General requirements,

Part 2 Measuring current transformers,

Part 3 Protective current transformers, and

Part 4 Protective current transformers for special purpose applications.

On the basis of available meterological data concerning the temperature and other conditions prevailing in several parts of the country during different seasons, a reference ambient temperature of 40°C has been specified in this standard.

It is recognized that for current transformers for use in special cases (for example, defence), special provisions like environmental testing may be necessary. In such cases additional requirements should be separately specified.

In the preparation of this standard, assistance has been taken from the following:

IEC 185 (1987) 'Current transformers', published by International Electrotechnical Commission.

BS 3938 : 1973 'Specification for current transformers' with latest amendments; published by the British Standards Institution.

Guidance regarding application of Current Transformers covered by this standard may be obtained from IS 4201 : 1967 (*under revision*).

This edition 3.2 incorporates Amendment No. 1 (October 1996) and Amendment No. 2 (April 2002). Side bar indicates modification of the text as the result of incorporation of the amendments.

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 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CURRENT TRANSFORMERS — SPECIFICATION

PART 1 GENERAL REQUIREMENTS

(Second Revision)

1 SCOPE

This Indian Standard (Part 1), specifies the general requirements applicable to current transformers for use with electrical measuring instruments and electrical protective devices at frequencies from 15 to 100 Hz. This standard basically applies to current transformers with separate windings, but where appropriate, it will also apply to auto-transformer type current transformers.

2 REFERENCES

Indian Standards given in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

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

3.1 Instrument Transformer

A transformer intended to supply measuring instruments, meters, relays and other similar apparatus.

3.2 Current Transformer

An instrument transformer in which the secondary current, in normal conditions of use, is substantially proportional to the primary current and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections.

3.2.1 *Current Transformer* (*Wound Type*)

A current transformer having a primary winding of more than one full turn wound on the core (s).

3.2.2 *Current Transformer* (*Bar Type*)

A current transformer in which the primary winding consists of a bar of suitable size and material forming an integral part of the current transformer.

3.2.3 *Current Transformer* (*Dry Type*)

A current transformer which does not require the use of any liquid or semi-liquid material.

3.2.4 *Current Transformer* (*Liquid Immersed*)

A current transformer which requires the use of oil or other suitable liquid of suitable characteristics as insulating and/or cooling medium.

3.2.5 *Hermetically Sealed Current Transformer*

A liquid immersed current transformer which is sealed and does not communicate with atmospheric air.

3.2.6 *Current Transformer* (*Ring Type*)

A current transformer which has an opening in the center to accommodate a primary conductor through it.

3.2.7 *Multi-Core Current Transformers*

A current transformer having more than one secondary core and winding with a common primary winding.

3.2.8 *Multi-Ratio Current Transformer*

A current transformer in which more than one ratio is obtainable by reconnection, or tappings, in primary or secondary windings.

3.3 Measuring Current Transformer

A current transformer intended to supply indicating instruments, integrating meters and similar apparatus.

3.4 Protective Current Transformer

A current transformer intended to supply protective relays and similar apparatus.

3.5 Dual Purpose Current Transformer

A current transformer intended to serve the dual purposes of measuring and protection.

3.6 Primary Winding

The winding through which flows the current to be transformed.

3.7 Secondary Winding

The winding which supplies the current circuits of measuring instruments, meters, relays or similar apparatus.

3.8 Secondary Circuit

The external circuit supplied by the secondary winding of a current transformer.

3.9 Rated Primary Current

The value of the primary current which appears in the designation of the transformer and on which the performance of the current transformer is based.

3.10 Rated Secondary Current

The value of the secondary current which appears in the designation of the transformer and on which the performance of the transformer is based.

3.11 Actual Transformation Ratio

The ratio of the actual primary current to the actual secondary current.

3.12 Rated Transformation Ratio

The ratio of the rated primary current to the rated secondary current.

3.13 Current Error (Ratio Error)

The error with a transformer introduces into the measurement of a current and which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio.

The current error expressed in percent is given by the formula:

$$\text{Current error, percent} = \frac{(K_a \,.\, I_s - I_p) \times 100}{I_p}$$

where

K_a = rated transformation ratio,

I_p = actual primary current, and

I_s = actual secondary current when I_p is flowing under the conditions of measurement.

3.14 Phase Displacement

The difference in phase between the primary and secondary current vectors, the direction of the vectors being so chosen that the angle is zero for a perfect transformer. The phase displacement is said to be positive when the secondary current vector leads the primary current vector. It is usually expressed in minutes.

NOTE — This definition is strictly correct for sinusoidal currents only.

3.15 Accuracy Class

A designation assigned to a current transformer the errors of which remain within specified limits under prescribed conditions of use.

3.16 Burden

The impedance of the secondary circuit in ohms and power factor.

NOTE — The burden is usually expressed as the apparent power in volt-amperes absorbed at a specified power-factor and at the rated secondary current.

3.17 Rated Burden

The value of the burden on which the accuracy requirements of this specification are based.

3.18 Rated output

The value of the apparent power (in volt-amperes at a specified power factor) which the current transformer is intended to supply to the secondary circuit at the rated secondary current and with rated burden connected to it.

3.19 Highest System Voltage

The highest rms line-to-line voltage which can be sustained under normal operating conditions at any time and at any point on the system. It excludes temporary voltage variations due to fault conditions and the sudden disconnection of large loads.

3.19.1 *Nominal System Voltage*

The rms line-to-line voltage by which the system is designated.

NOTE — The rated voltage of apparatus is not necessarily the same as the nominal system voltage.

3.19.2 *Rated Voltage*

The rms value of the voltage used to designate the current transformer for a particular highest system voltage.

3.20 Rated Insulation Level

That combination of voltage values (power frequency and lightning impulse, or where applicable, lightning and switching impulse) which characterizes the insulation of a transformer with regard to its capability to withstand dielectric stresses.

3.21 Isolated Neutral System

A system which has no intentional connection to earth except through indicating, measuring or protective devices of very high impedance.

3.22 Resonant Earthed System (A System Earthed Through an Arc-Suppression Coil)

A system earthed through a reactor, the reactance being of such value that during a single phase-to-earth fault, the power-frequency inductive current passed by this reactor substantially neutralizes the power frequency capacitive component of the earth-fault current.

NOTE — With resonant earthing of a system, the current in the fault is limited to such an extent that an arcing fault in air is self-extinguishing.

3.23 Earth-Fault Factor

At a selected location of a three-phase system (generally the point of installation of an equipment) for a given system layout, the ratio of the highest rms phase-to-earth power-frequency voltage on a sound phase during a fault to earth (affecting one or more phases at any point) to the rms phase-to-phase power-frequency voltage which would be obtained at the selected location with the fault removed.

NOTES

1 This factor is a pure numerical ratio (higher than one)

and characterizes in general terms the earthing conditions of a system as viewed from the selected location, independently of the actual operating value of the voltage at that location. The earth-fault factor is the product of $\sqrt{3}$ and the factor of earthing which has been in general use up to now.

2 The earth-fault factors are calculated from the phase-sequence impedance components of the system, as viewed from the selected location, using, for any machines the subtransient reactances.

3 The earth-fault factor does not exceed 1.4, if, for all system configurations, the zero-sequence reactance and resistance are less then, respectively, three and one time(s) the positive-sequence reactance.

3.24 Earthed Neutral System

A system in which the neutral is connected to earth, either solidly or through a resistance or reactance of low enough value to reduce transient oscillations and to give a current sufficient for selective earth fault protection.

3.24.1 *Effectively Earthed Neutral System*

A three-phase system with effectively earthed neutral at a given location in a system characterized by an earth fault factor at this point which does not exceed 1.4 under all conditions of operation.

3.24.2 *Non-Effectively Earthed Neutral System*

A three-phase system with non-effectively earthed neutral, at a given location, characterized by an earth-fault factor at this point that may exceed 1.4.

NOTE — This includes resistance earthed systems and resonant earthed systems where earth faults are not allowed to persist for longer than 8 hours in any 24 hours or a total of 125 hours per annum. For other cases where there is no intentional connection to earth except through indicating, measuring or protective devices of very high impedance or where the duration of earth fault exceeds the period referred above, the manufacturer shall be consulted.

3.25 Electrically Exposed Installation

An installation in which the apparatus is subject to overvoltages of atmospheric origin.

NOTE — Such installations are usually connected to overhead transmission lines, either directly, or through a short length of cable.

3.26 Electrically Non-Exposed Installation

An installation in which the apparatus is not subject to overvoltages of atmospheric origin.

NOTE — Such installations are usually connected to cable networks.

3.27 Rated Frequency

The value of the frequency on which the requirements of this standard are based.

3.28 Rated Short-Time Thermal Current (I_{th})

The rms value of the primary current which the current transformer will withstand for a rated time, with their secondary winding short circuited, without suffering harmful effects.

3.28.1 *Rated Time*

The time in seconds for which the current transformer shall withstand the rated short-time thermal current in accordance with the specification.

3.28.2 *Rated Short Time Factor* (*STF*)

That factor which when multiplied by the rated primary current gives the rated short-time thermal current.

3.29 Rated Dynamic Current (I_{dyn})

The peak value of the primary current which a current transformer will withstand, without being damaged electrically or mechanically by the resulting electromagnetic forces, the secondary winding being short circuited.

3.30 Rated Continuous Thermal Current

The value of the current which can be permitted to flow continuously in the primary winding, the secondary windings being connected to the rated burdens, without the temperature rise exceeding the specified values.

3.31 Type Tests

Tests carried out to prove the general qualities and design of a given type of current transformer in accordance with the requirements of this standard. Tests may be carried out on a prototype which may incorporate special arrangements for the measurements required by this standard.

3.32 Routine Tests

Tests carried out on each current transformer to check requirements likely to vary during production.

3.33 Optional Tests

Tests, which may be in the nature of type tests or routine tests, and are carried out only by agreement between manufacturer and purchaser.

4 SERVICE CONDITIONS

4.1 Unless otherwise specified, current transformers shall be suitable for the following service conditions. The manufacturer shall be informed if the conditions, including the conditions under which Transformers are to be transported, differ from those specified.

4.2 Standard Ambient Conditions

a) Maximum ambient air temperature	Not exceeding 45°C
b) Maximum daily average ambient air temperature	Not exceeding 35°C
c) Maximum yearly average ambient air temperature	Not exceeding 30°C
d) Minimum ambient air temperature	– 5°C

4.2.1 The standard reference ambient temperature shall be 40°C.

4.2.2 Where the ambient temperature conditions given by the user are substantially different from the standard conditions given in **4.2** and if the user has not specified any reference ambient temperature, the reference ambient temperature may be determined in accordance with IS 9676 : 1980.

4.3 Altitude

Up to 1 000 m above mean sea level.

4.4 Atmospheric Conditions

Atmospheres which are not heavily polluted, and atmospheres not conducive to the growth of fungi and condensation of moisture.

4.5 System Earthing

One of the following to be specified:

a) Isolated neutral system (*see* **3.21**),

b) Resonant earthed system (*see* **3.22**),

c) Earthed neutral system (*see* **3.24**),

i) Effectively earthed neutral system (*see* **3.24.1**), and

ii) Non-effectively earthed system (*see* **3.24.2**).

5 CONSTRUCTION

5.1 The constructional features for liquid immersed current transformers are given in Annex B.

5.2 Earthing

5.2.1 The assembly comprising of the chassis, framework and the fixed parts of the metal casing of the current transformer, where used, shall be provided with two separate earthing terminals. However, for the indoor type current transformers only one earthing terminal may be provided. These terminals shall be provided over and above all other means provided for securing metallic enclosures (armour or other metallic coverings) of current carrying cables.

5.2.2 The earthing terminals shall be readily accessible and so placed that the earth connection of the current transformer is maintained when the cover or any other movable part is removed.

5.2.3 The earthing terminals shall be of adequate size, protected against corrosion and metallically clean. Under no circumstances shall a movable metal part of the enclosure be insulated from the part carrying the earthing terminal when the movable part is in place.

5.2.4 The earthing terminal shall be identified by means of the sign '⏚' marked in a legible and indelible manner on or adjacent to the terminals.

6 RATINGS

6.1 Rated Frequency

Unless otherwise specified, the rated frequency shall be 50 Hz.

NOTE — Current transformers for use on systems of frequency other than 50 Hz shall be considered to comply with this standard if they conform in all other respects with the requirements of this standard at the frequency for which they are intended.

6.2 Standard Values of Rated Primary Current

6.2.1 *Single Ratio Transformers*

The standard values in amperes of rated primary current are 10, 12.5, 15, 20, 25, 30, 40, 50, 60, 75, and their decimal multiples or fractions. The preferred values are those underlined.

6.2.2 *Multi-Ratio Transformers*

The standard values given in **6.2.1** refer to the lowest values of rated current.

6.3 Standard Values of Rated Secondary Current

The value of the rated secondary current shall be 1A and 5A.

NOTE — For transformers intended for delta connected groups these ratings divided by $\sqrt{3}$ are also standard values.

6.4 Rated Continuous Thermal Current

Unless otherwise specified, the rated continuous thermal current shall be the rated primary current.

6.5 Rated Outputs

The standard value of rated output up to 30VA are: 2.5, 5.0, 7.5, 10, 15 and 30VA. Values above 30VA may be selected to suit the application.

NOTE — For a given transformer, provided one of the values of rated output is standard and associated with a standard accuracy class, the declaration of other rated outputs, which may be non-standard values, but associated with other standard accuracy classes, is not precluded.

6.6 Short-Time Current Ratings

Current transformers supplied with a fixed primary winding or conductor shall comply with the requirements of **6.6.1** and **6.6.2**.

6.6.1 *Thermal Rating*

A rated short-time thermal current (Ith) or a rated short-time factor (STF), for a rated time of one second (unless a different rated time is specified), shall be assigned to the current transformer.

NOTE — An assigned Ith for a rated time of one second is related to other values of Ith for different rated times.

6.6.2 *Dynamic Rating*

The peak value of the rated dynamic current (I_{dyn}) shall normally be 2.5 times the rated short-time thermal current (Ith), unless otherwise specified.

6.7 Rated Insulation Levels

6.7.1 The rated insulation levels of current

transformers having highest system voltages up to and including 72.5 kV, defined by the power frequency and the lightning impulse withstand voltage, shall be one of the sets of values given in Table 1A.

Table 1A Rated Insulation Levels for Highest System Voltages Up to and Including 72.5 kV

(*Clauses* 6.7.1, 9.3.1, 9.8.1 *and* 9.9)

Nominal System Voltage	Highest System Voltage	Power Frequency Withstand Voltage	Lightning Impulse Withstand Voltage	
(1)	(2)	(3)	(4)	
kV (rms)	kV (rms)	kV (rms)	kV (peak)	
			List 1	List 2
Up to 0.60	0.66	3	—	—
3.3	3.6	10	20	40
6.6	7.2	20	40	60
11	12.0	28	60	75
15	17.5	38	75	95
22	24.0	50	95	125
33	36.0	70	145	170
45	52.0	95	250	250
66	72.5	140	325	325

NOTES

1 Underlined values are preferred.

2 The choice between Lists 1 and 2 should be made by considering the degree of exposure to lightning and switching overvoltages, the type of system neutral earthing and the kind of the overvoltage protection. Some guidance is given in IS 2165 (Part 1) : 1977.

6.7.2 The rated insulation levels of current transformers having highest system voltages of 123 kV and above, up to and including 245 kV, defined by the power frequency and lightning impulse withstand voltages, shall be one of the values given in Table 1B.

Table 1B Rated Insulation Levels for Highest System Voltages of 123 kV and Above, Up to and Including 245 kV

(*Clauses* 6.7.2, 9.3.1, 9.8.1 *and* 9.9)

Nominal System Voltage	Highest System Voltage	Power Frequency Withstand Voltage	Lightning Impulse Withstand Voltage
(1)	(2)	(3)	(4)
kV (rms)	kV (rms)	kV (rms)	kV (peak)
110	123	185	450
		230	550
132	145	230	550
		275	650
220	245	360	850
		395	950
		460	1 050

NOTE — Underlined values are preferred.

6.7.3 The rated insulation levels of current transformers having highest system voltage of 420 kV and above, defined by the rated switching and lightning impulse withstand voltages, shall be one of the sets of value given in Table 1C.

Table 1C Rated Insulation Level for Highest System Voltage of 420 kV and Above

(*Clauses* 6.7.3, 9.3.1, 9.8.1, 9.9 *and* 9.11.1)

Nominal System Voltage	Highest System Voltage	Lightning Impulse Withstand Voltage	Switching Impulse Withstand Voltage
(1)	(2)	(3)	(4)
kV (rms)	kV (rms)	kV (peak)	kV (peak)
400	420	1 175	950
		1 300	1 050
		1 425	1 050
525	525	1 425	1 050
		1 550	1 175
765	765	1 800	1 300
		2 100	1 425
		2 400	1 550

6.7.4 The choice of rated insulation level of a current transformer shall be made in accordance with IS 2165 (Part 1):1977 and IS 3716:1978. If thereby, the rated insulation level is less than any of the sets of values in this standard, the lowest values therein specified shall apply.

7 REQUIREMENTS

7.1 All current transformers shall comply with the relevant requirements of Parts 2, 3 and 4 of this standard. Current transformers for dual purpose applications shall comply with the requirements of current transformers for both applications.

7.2 Limits of Temperature-Rise

7.2.1 The temperature-rise of a current transformer winding when carrying a primary current equal to the rated continuous thermal current, at a rated frequency and with a unity power factor burden corresponding to rated output connected to the secondary windings, shall not exceed the appropriate values given in Table 2. The temperature-rise of the windings is limited by the lowest class of insulation either of the winding itself or of the surrounding medium in which it is embedded.

Table 2 Limits of Temperature-Rise of Windings

(*Clauses* 7.2.1, 7.2.1.1, 7.2.1.2 *and* 7.2.4)

Class of Insulation	Maximum Temperature-Rise
(1)	(2)
	(k)
All classes immersed in oil	55
All classes immersed in oil and hermetically sealed	60
All classes immersed in bituminous compound	45
Classes not immersed in oil or bituminous compound	
Y	40
A	55
E	70
B	80
F	105
H	130

NOTE — For some materials (such as epoxy resin) the manufacturer should specify the relevant insulation class.

7.2.1.1 The values given in Table 2 are based on the standard reference ambient temperature conditions given in **4.2.1**. For higher reference ambient temperature in accordance with **4.2.2**, the permissible temperature rise in Table 2 shall be reduced by an amount equal to the difference between such reference ambient temperature and 40°C.

7.2.1.2 If a transformer is specified for service at an altitude in excess of 1 000 m and tested at an altitude below 1 000 m, the limits of temperature-rise given in Table 2 shall be reduced by the following amounts for each 100 m, the altitude at the operating site exceeds 1 000 m.

a) Oil-immersed transformers — 0.4 percent, and

b) Dry-type transformers — 0.5 percent.

7.2.2 When the transformer is fitted with conservator tank or has any gas above the oil, or is hermetically sealed, temperature-rise of the oil at the top of the tank or housing shall not exceed 50 K.

7.2.3 When the transformer is not fitted or arranged as in **7.2.2**, the temperature-rise of the oil at the top of the tank or housing shall not exceed 45 K.

7.2.4 The temperature-rise measured on the external surface of the core and other metallic parts in contact with, or adjacent to, insulation (if accessible) shall not exceed the appropriate value in Table 2.

7.3 Dielectric Tests

7.3.1 The current transformer shall withstand the specified dielectric tests corresponding to the rated insulation level specified.

8 MARKING

8.1 Rating Plate

All current transformers shall carry at least the following markings:

a) The manufacturer's name and country of origin;

b) Year of manufacture;

c) A serial number and a type designation;

d) The rated primary and secondary currents (for example, 200-100/1-1A);

e) Rated frequency; and

f) Rated output and the corresponding accuracy class (for example, 10 VA, class 1 or 10 VA/1);

NOTE — When more than one separate secondary windings are provided, the marking should indicate the output of each secondary winding in VA, the corresponding accuracy class and the rated current of each winding.

g) Highest system voltage (for example, 72.5 kV);

h) Rated insulation level (for example, 140/325 kV);

NOTE — The items (g) and (h) may be combined into one marking (for example, 72.5/140/325 kV).

j) Rated short-time thermal current or short-time factor with rated time (if different from 1 second) (for example 13.1kA/0.5 or STF 100/0.5);

k) Rated dynamic current if different than 2.5 times the rated short-time thermal current; and

m) Reference to this standard.

8.1.1 All information shall be marked in an indelible manner on the current transformer itself or on a rating plate securely attached to the transformer.

8.1.2 The following shall be marked if required by agreement between the purchaser and the manufacturer:

a) Class of insulation, and

b) The use of secondary winding(s) and the corresponding terminals.

NOTE — If several classes of insulating material are used, the one which limits the temperature-rise of the windings shall be indicated.

8.2 Terminal Markings

The terminal markings shall be in accordance with Annex C.

8.3 The current transformers may also be marked with BIS Standard Mark.

9 TESTS

9.1 Classification of Tests

9.1.1 *Type Tests*

The following shall constitute the type tests:

a) Short-time current tests (*see* **9.6**).

b) Temperature-rise test (*see* **9.7**).

c) Lightning impulse test for current transformers for service in electrically exposed installation (*see* **9.8**).

d) Switching impulse voltage tests for current transformers of 420 kV and above (*see* **9.11**).

e) High voltage power-frequency wet withstand voltage tests on outdoor current transformers up to and including 245 kV (*see* **9.9**).

NOTE — If the porcelain weather casing/bushing has been subjected to this test separately, the requirements of this test shall be deemed to have been complied with.

f) Determination of errors or other characteristics according to the requirements of the appropriate designation or accuracy class (*see* individual parts of this standard).

NOTES

1 The dielectric type tests in (c), (d) and (e) shall all be carried out on the same transformer unless otherwise agreed.

2 After the current transformers have been subjected to the dielectric type tests (c), (d) and (e) they shall be subjected to all the routine tests.

3 Type tests may be omitted when the manufacturer holds a certificate of type tests made on a similar transformer which is acceptable to the purchaser.

9.1.2 *Routine Tests*

The following shall constitute the routine tests:

a) Verification of terminal marking and polarity (*see* **9.2**).

b) Power frequency dry withstand tests on primary windings (*see* **9.3**).

c) Power frequency dry withstand tests on secondary windings (*see* **9.4**).

d) Over-voltage inter-turn test (*see* **9.5**),

e) Partial discharge tests in accordance with IS 11322 : 1985.

NOTE — This test is applicable only for current transformers with solid insulation for highest system voltages 7.2 kV and above and current transformers with liquid immersed insulation for highest system voltages of 72.5 kV and above.

f) Determination of errors or other characteristics according to the requirements of the appropriate designation or accuracy class (*see* individual parts of this standard).

NOTES

1 The determination of errors or other characteristics in (e) shall be carried out after the tests (b), (c) and (d). The order or possible combination of other tests is not standardized.

2 Repeated power frequency tests on the primary windings shall be performed at 80 percent of the specified test voltage, except when the method of **9.3.2.2** is used.

9.1.3 *Optional Tests*

The following tests where applicable, shall be carried out by mutual agreement between the purchaser and the manufacturer:

a) Chopped lightning impulse test as a type test (*see* **9.10**).

b) Measurement of dielectric dissipation factor for oil immersed current transformers of 72.5 kV and above (*see* **9.12**).

c) Commissioning tests on new current transformers up to and including 36 kV (*see* **9.13**).

9.2 Verification of Terminal Markings and Polarity

Terminal markings and polarity shall be verified for their compliance with **8.2**.

9.3 High Voltage power Frequency Test on Primary Windings

9.3.1 *Current Transformers Having Highest System Voltage up to and Including 245 kV*

The test shall be conducted in accordance with IS 2071 (Part 1):1974 and IS 2071 (Part 2):1974. The value of the test voltage shall be the appropriate power frequency test voltage specified in Tables 1A or 1B. The test voltage shall be applied between the terminals of the primary windings (connected together) and earth. The frame, case (if any), core (if accessible and if intended to be earthed) and all the terminals of the secondary windings shall be connected together and earthed. The test voltage shall be applied for one minute. There shall be no disruptive discharge.

9.3.2 *Current Transformers Having Highest System Voltage of 420 kV and Above*

The test shall be carried out by either of two methods given in **9.3.2.1** and **9.3.2.2**, at the discretion of the manufacturer, unless otherwise agreed.

9.3.2.1 *Method 1*

The test shall be carried out in accordance with the procedure set out in **9.3.1** except that the value of the test voltage shall be the appropriate value given in Table 3A.

Table 3A Power-Frequency Withstand Voltages for Transformer Windings with Highest System Voltage of 420 kV and Above

Rated Lightning-Impulse Withstand Voltage	Power-Frequency Short-Duration Withstand Voltage
kV (peak)	kV (rms)
1 175	510
1 300	570
1 425	630
1 550	680
1 800	790
2 100	880
2 400	975

9.3.2.2 *Method 2*

The current transformer shall be subjected to the appropriate specified power-frequency prestress voltage given in Table 3B for 10 seconds. The voltage shall then be reduced to the corresponding specified partial discharge test voltage given in Table 3B without interruption and this voltage shall be maintained for 15 minutes. The maximum permissible partial discharge magnitude measured during the last minute at the specified partial discharge test voltage shall be 10 pC.

NOTE — The method in **9.3.2.2** may be preceded by a lightning impulse test in order to complete the dielectric routine tests of the primary windings.

Table 3B Power-Frequency Test Voltages for Transformer Windings having Highest System Voltage of 420 kV and Above

Highest System Voltage	Power-Frequency Prestress Voltage	Partial Discharge Test Voltage
kV (rms)	kV (rms)	kV (rms)
420	510	315
525	630	395
765	790/880*	575

* To be determined by the rated lightning impulse withstand voltage.

9.3.3 For all current transformers, where the primary winding is divided into two or more sections, each section shall withstand for one minute a test voltage of 3 kV (rms) applied between the section and earth. All other sections, windings, frame, and case (if any) shall have been connected together and earthed.

9.3.4 If for any reason, it is considered necessary to repeat the test, the test voltage shall be reduced to 80 percent of the prescribed test voltage.

9.4 High Voltage Power Frequency Test on Secondary Windings

The test shall be conducted in accordance with IS 2071 (Part 1) : 1974. The test voltage of 3 kV (rms) shall be applied for one minute between the terminals of the secondary windings (connected together) and earth. The frame, case (if any), core (if accessible and if intended to be earthed) and all terminals of the primary winding shall have been connected together and earthed. There shall be no disruptive discharge.

9.4.1 When there are more than one secondary windings or sections, each winding or section shall withstand, without disruptive discharge, a test voltage of 3 kV (rms) applied between that winding or section and all other windings or sections connected together and earthed.

9.5 Over-Voltage Inter-Turn Test

At the discretion of the manufacturer, the test may be carried out by any of the methods given in **9.5.1** and **9.5.2**.

9.5.1 With the secondary winding open-circuited, a voltage at power frequency shall be applied to the primary winding. The value of the voltage shall be such as to produce a primary current of rms value equal to the rated primary current (in the case of a current transformer with an extended range, a current equal to the extended range primary current) or a value which corresponds to a secondary voltage of 4.5 kV peak, whichever is lower. The applied voltage shall be withstood satisfactorily for one minute.

9.5.2 With the primary winding open-circuited a voltage at a frequency not greater than five times the rated frequency shall be applied to the secondary winding. The value of the voltage shall be such as to produce a secondary current of rms value equal to the rated secondary current (in the case of a current transformer with an extended range, a current equal to the extended range secondary current) or a value of 4.5 kV peak, whichever is lower. The applied voltage shall be withstood satisfactorily for one minute.

NOTE — The overvoltage inter-turn test is not intended to reproduce service condition with the secondary windings open-circuited, but only to indicate that the inter-turn insulation is sound. Open-circuiting of secondary winding/circuit under service conditions (particularly, if the secondary winding has a large number of turns) may produce excessive heating and permanent magnetization in the core and dangerous dielectric stress on the insulation, which may permanently damage the Current Transformer. This condition is, therefore, to be avoided.

9.6 Short Time Current Tests

9.6.1 *Short Time Thermal Current Test*

The transformer shall initially be at a temperature between 17°C and 40°C. The test shall be carried out with the secondary winding short-circuited and at a current 'I' for a time 't' such that $I^2\ t >= I^2_{th}\ .\ t_r$ where 't_r' is the rated time; provided 't' has a value between 0.5 and 5 seconds.

NOTE — Experience has shown that this requirement is complied with in the case of current transformers with Class A insulation provided that the current density in the windings, corresponding to the rated short-time current, does not exceed 180 A/mm^2 for a rated time of one second, where the winding is of copper of conductivity not less than 97 percent of the value given in IS 613:1984. For other rated times, the corresponding current density is obtainable from the formula $I^2_d,\ t_r = 32\ 400$, where 'I_d' is the corresponding current density at rated time 't_r'. Consequently, compliance with this requirement may take the place of tests.

9.6.2 *Dynamic Current Test*

The test shall be carried out with the secondary winding(s) short-circuited and with a primary current, the peak value of which is not less than the rated dynamic current (I_{dyn}) for at least one peak.

The dynamic current test may, at the discretion of the manufacturer, be combined with the thermal current test, provided the first major peak of the test current is not less than the rated dynamic current (I_{dyn}).

NOTES

1 For dynamic current test, this requirement shall have been complied with if a current transformer having a product of primary turns and rated dynamic current same or less than that of a current transformers of similar construction has passed this test. The primary current rating, number of cores, its burdens and accuracy class shall not be considered significant for this test.

2 If agreed between the manufacturer and the purchaser, the short-time thermal current test and dynamic current tests may be carried out with a specified value of connected burden.

9.6.3 The current transformer shall have passed the short-time current tests if, after cooling to ambient temperature, it satisfies the following conditions:

a) It is not visibly damaged;

b) In the case of measuring and protective current transformers or measuring and protective cores of multi-core current transformers, the errors at rated burden at the connections at which the short-time current tests were carried out do not differ from those recorded before the tests by more than half the limits of its accuracy class;

In the case of current transformer or cores of multi-core current transformers conforming to Part 4 of this standard, the exciting current at the rated minimum knee-point voltage and the turns ratio error at the connections at which the short-time current tests were carried out do not differ from those recorded before the tests by more than half the permissible limits.

NOTE — All measurements after the short-time current tests shall be necessarily carried out only after the cores have been demagnetized.

c) It withstands the dielectric tests specified in **9.3**, **9.4** and **9.5** with the test voltages or current reduced to 90 percent of those given;

d) Subject to the Note below, on examination, the insulation next to the surface of the conductor does not show significant deterioration (for example carbonization).

NOTE — Examination (d) is not necessary provided the current density in winding, corresponding to the rated short-time thermal current for one second, does not exceed 160 A/mm^2 where the winding is of copper of conductivity not less than 97 percent of IACS or 105 A/mm^2 where the winding is of aluminium of conductivity not less than 55 percent of IACS. The corresponding current densities for other rated times may be obtained by the formulae:

'$I^2{}_d$, t_r' is 25 600 for copper windings and 11 025 for aluminium windings, where 'I_d' is the required current density at rated time 't_r'.

9.7 Temperature-Rise Test

The current transformer shall be tested for compliance with **7.2**. The transformer shall be mounted in the manner representative of the mounting in service. It shall be deemed to have attained a steady temperature when the rate of rise of temperature does not exceed 1 K per hour. The ambient temperature shall not exceed 40°C.

The temperature-rise of the windings shall, where practicable be measured by the increase in resistance method, but for windings of very low resistance, thermometer or thermocouples may be employed. The temperature-rise of parts other than windings, shall be measured by thermometers or thermocouples. For methods of temperature measurements (*see* Annex D).

9.8 Lightning Impulse Voltage Test for Current Transformers for Service in Electrically Exposed Installations

9.8.1 Current transformers for service in electrically exposed installations shall withstand the appropriate full wave lightning impulse voltage specified in Tables 1A, 1B and 1C according to the highest system voltage and the specified insulation level.

9.8.2 The test shall be conducted in accordance with IS 2071 (Part 1) : 1974 and IS 2071 (Part 2) : 1974. The test voltage shall be applied between the terminals of the primary winding (connected together) and earth. The frame, case (if any), core (if intended to be earthed) and all the terminals of the secondary winding shall be connected together and earthed. The test voltage shall have the appropriate values specified in Tables 1A, 1B or 1C according to the highest system voltage and the rated insulation level. The reference impulse voltage shall be between 50 percent and 75 percent of the rated impulse withstand voltage. The peak value and the waveshape of the impulse voltages shall be recorded.

9.8.2.1 *For indoor current transformers up to and including 36 kV,* five consecutive full wave impulses of each polarity with correction for atmospheric conditions shall be applied.

For Current Transformers up to and including 245 kV, fifteen consecutive full wave lightning impulses of each polarity without correction for atmospheric conditions shall be applied. If other tests to check the external insulation (for example, separate lightning impulse test on the porcelain weather casing/bushing of oil immersed current transformers) have been carried out, the number of lightning impulses should be reduced to three of each polarity without correction for atmospheric conditions.

9.8.2.2 The current transformer shall have passed the test if:

a) no disruptive discharges occur in the non-self-restoring insulation;

b) no flashovers occur along the non-self-restoring external insulation;

c) no more than two flashovers occur across the self-restoring external insulation (only where 15 impulses of each polarity are applied); and

d) no other evidence of failure is detected.

9.8.3 *For Current Transformers of 420 kV*, three consecutive impulses of each polarity without correction for atmospheric conditions shall be applied.

9.8.3.1 The current transformer shall have passed the test if the conditions of **9.8.2.2** have been satisfied.

9.9 High Voltage Power Frequency Wet Withstand Voltage Tests on Outdoor Current Transformers

The external insulation of outdoor current transformers shall be subjected for one minute to a power frequency voltage having a peak value equal to $\sqrt{2}$ times the value specified in Tables 1A, or 1B corrected for atmospheric conditions appropriate to the highest system voltage and the rated insulation level. The test shall be conducted in accordance with IS 2071 (Part 1):1974 and IS 2071 (Part 2):1974. This test is applicable only for outdoor current transformers up to and including 245 kV highest system voltage.

9.10 Chopped Lightning Impulse Test on Primary Winding

9.10.1 The chopped lightning impulse test shall be carried out with the negative polarity only and shall be combined with the negative polarity full wave lightning impulse test in the following manner:

a) For highest system voltages up to and including 245 kV where it is considered necessary to test for external insulation:

— one 100 percent full impulse,

— two 100 percent chopped impulses, and

— fourteen 100 percent full impulses.

b) For highest system voltages up to 245 kV where external insulation need not be

checked by 15 full wave impulses and for highest system voltage of 420 kV and above:

— one 100 percent full impulse,

— two 100 percent chopped impulses, and

— two 100 percent full impulses.

9.10.2 The standard lightning impulse shall be chopped after 2 to 5 micro seconds and the chopping circuits shall be so arranged that the amount of overswing to the positive polarity is limited to 30 percent of the chopped impulse.

9.10.3 Significant changes in wave shape of full wave application before and after the application of the chopped impulses are indicative of internal fault.

9.10.4 Flashovers during chopped impulses along self-restoring external insulation should be disregarded during this test.

9.11 Switching Impulse Test on Current Transformers Having Highest System Voltage of 420 kV and Above

9.11.1 The test shall be carried out in accordance with IS 2071 (Part 2):1974. The test voltage shall have the appropriate value in Table 1C according to the specified rated insulation level.

9.11.2 The switching impulse test voltage shall be applied between the terminals of the primary winding (connected together) and earth. The frame, case (if any), core (if intended to be earthed) and all terminals of the secondary windings shall be connected together and earthed.

9.11.3 Fifteen consecutive impulses of both positive and negative polarity, corrected for atmospheric conditions, shall be applied. Outdoor type transformers shall be subjected only to wet tests. Dry test is not required.

9.11.4 The transformer shall have passed the test if the conditions given in **9.8.2.2** have been satisfied.

9.12 Measurement of Dielectric Dissipation Factor for Liquid Immersed Current Transformers of 72.5 kV and Above

The measurement of dielectric dissipation factor (tan δ) shall be made after the power frequency test on the primary windings. The ambient temperature and the temperature of the equipment under test shall be between 10°C and 40°C. The measurement of tan shall be made by means of a Schering Bridge or other equivalent method.

The test voltage, which shall be agreed between the manufacturer and the purchaser but in no case exceeding the highest system voltage divided by $\sqrt{3}$, shall be applied to the primary terminals connected together. The secondary terminals, any screen and isolated metal casing shall be connected to the measuring bridge. If the transformer has a special device (terminal) suitable for the measurement, the other terminals shall be short-circuited and connected to the earthed or the screened metal casing. The value measured shall not exceed the value agreed between the manufacturer and the purchaser.

NOTE — The dielectric dissipation factor is dependent on both voltage and temperature. Measurements of the dielectric dissipation factor at low voltage (for example 2.5 kV or 10 kV) may be used as a reference in monitoring the condition of insulation in service.

9.13 Commissioning Tests on New Transformers

9.13.1 *Power-Frequency Test on Primary Windings*

By agreement between the manufacturer and the purchaser, separate source power frequency tests on the primary winding insulation may be made after erection on site provided that the transformer is in a satisfactory conditions for testing and has not been in service. The transformers shall be temporarily disconnected from any other apparatus to which it may be connected. The one minute test voltage shall 80 percent of specified power frequency test voltage.

9.13.1.1 If for any special reasons the duration of the test exceeds one minute, the relationship between duration of the test and the percentage of the one-minute test voltage shall be as given in Table 4.

NOTE — Commissioning test on current transformes for highest system voltage over 36 kV are deprecated.

Table 4 Applied Power-Frequency High Voltage Tests for Duration Exceeding One Minute (After Erection on Site)

Duration of Test	Percentage of One-Minute Test Voltage
(1)	(2)
minutes	
2	83.5
3	75.0
4	70.0
5	66.6
10	60.0
15	57.7

10 INFORMATION TO BE GIVEN WITH ENQUIRY AND ORDER

10.1 The particulars given in Annex E shall be furnished by the purchaser with each enquiry and order.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
335 : 1983	New insulating oils
613 : 1984	Copper rods and bars for electrical purposes
2053 : 1974	Thermocouple pyrometers
2071 (Part 1) : 1974	Methods of high voltage testing: Part 1 General definitions and test requirements
2071 (Part 2) : 1974	Methods of high voltage testing: Part 2 Test procedures
2099 : 1986	Bushings for alternating voltages above 1 000 V
2147 : 1962	Degree of protection provided by enclosures for low voltage switchgear and controlgear
2165 (Part 1) : 1977	Insulation coordination: Part 1 Phase to earth insulation coordination
3716 : 1978	Application guide for insulation coordination
4201 : 1983	Application guide for current transformers
5621 : 1980	Hollow insulators for use in electrical equipment
9676 : 1980	Reference ambient temperature for electrical equipment
10601 : 1983	Dimensions of terminals for high voltage switchgear and controlgear
11322 : 1985	Method for partial discharge measurement in instrument transformers
12360 : 1988	Voltage bands for electrical installations including preferred voltages and frequency

ANNEX B

(*Clause* 5.1)

CONSTRUCTIONAL FEATURES OF LIQUID IMMERSED CURRENT TRANSFORMERS

B-1 PORCELAIN INSULATORS

B-1.1 The hollow porcelain insulator or housing where provided, shall conform to IS 5621:1980.

B-1.2 Where demountable bushings are provided, these shall conform to IS 2099:1986.

B-1.3 For outdoor current transformers for use in polluted atmospheres, the minimum creepage distance measured on the insulation surface and the maximum creepage factor shall be as given below:

Pollution Level	*Minimum Nominal Specific Creepage Distance Between Phase and Earth (mm/kV of Highest System Voltage)*	*Maximum Creepage Factor*
Light	16	3.5
Normal	20	3.5
Heavy	25	4.0
Very Heavy	31	4.0

NOTES

1 Unless otherwise agreed between the manufacturer and the purchaser the Pollution Level shall be deemed to be normal.

2 The creepage factor equals l/S where l is the total creepage distance of the insulator, and S is the arcing distance, which is the shortest distance in air outside the insulator, not considering arcing horns, between the metallic parts to which the voltage is normally applied.

3 If an insulator has a profile with a creepage factor higher than the limits indicated, the insulator profile may be used if experience in operation, or laboratory test reproducing operation conditions, permits the assumption of good performance. An insulator or bushing, the dimensions of which have been standardized by any Indian Standard shall also be considered to meet this criteria.

4 Protected creepage distance shall not be specified as a parameter characterizing a shed profile.

B-2 OIL

B-2.1 Unless otherwise agreed, the oil used in liquid immersed current transformers shall conform to IS 335:1983.

B-2.2 The current transformer shall be so constructed as to ensure that the oil does not flow out or leak out even when the current transformer is used continuously at the maximum allowable temperature.

B-3 PRIMARY TERMINALS

B-3.1 It is suggested (without being mandatory) that the primary terminals of current transformers to which the line connections are to be made shall have the dimensions given in IS 10601:1983.

B-4 SECONDARY TERMINALS

B-4.1 The secondary terminals of outdoor current transformers shall be brought out in a suitable compartment which shall have a removable cover. The terminal box, with the cover closed and tightened and the cable/conduit in position when supplied shall have a degree of protection conforming to IP 54 of IS 2147 : 1962, unless otherwise agreed.

B-5 Unless otherwise agreed, the external surfaces of the steel tanks or casing of current transformers shall be painted with one coat of primer and two coats of synthetic enamel paint. The internal surfaces of the steel tanks or casing shall be painted with two coats of a suitable oil-insoluble paint.

ANNEX C

(*Clause* 8.2)

TERMINAL MARKING

C-1 GENERAL

C-1.1 The terminal marking shall identify:

a) the primary and secondary windings;

b) the winding sections, if any;

c) the relative polarities of windings and winding sections; and

d) the intermediate tappings, if any.

C-2 METHOD OF MARKING

C-2.1 The terminals shall be marked clearly and indelibly either on their surface or in their immediate vicinity.

C-2.2 The marking shall consist of letters followed, or preceded, where necessary, by numbers. The letters shall be in block capitals.

C-2.3 The marking of current transformers shall be as indicated in Fig. 1 to 4.

C-2.4 All the terminals marked P1, S1 and C1 shall have the same polarity at any instant.

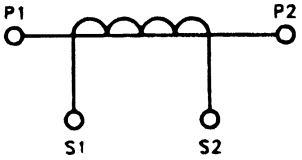

FIG. 1 SINGLE RATIO TRANSFORMER

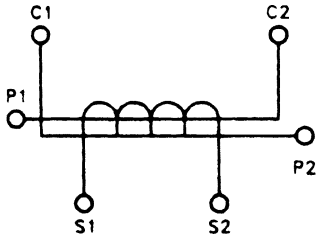

FIG. 3 TRANSFORMER WITH PRIMARY WINDING IN TWO SECTIONS INTENDED FOR CONNECTION EITHER IN SERIES OR PARALLEL

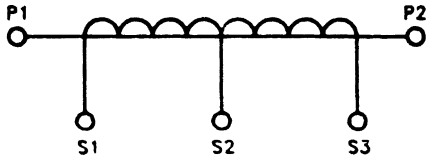

FIG. 2 TRANSFORMER WITH AN INTERMEDIATE TAPPING ON SECONDARY WINDING

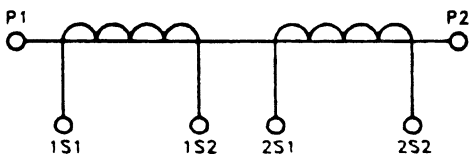

FIG. 4 TRANSFORMER WITH TWO SECONDARY WINDINGS

ANNEX D

(*Clause* 9.7)

METHODS OF TEMPERATURE MEASUREMENT

D-1 SELF RESISTANCE METHOD

D-1.1 In the self-resistance method, the temperature-rise of winding is determined by the increase in the resistance of the conductor itself.

D-1.1.1 The temperature of the winding and the oil or other medium surrounding the winding measured before beginning the test should not differ. The initial resistance and the initial temperature of the winding should be measured under steady temperature conditions, at the same time.

D-1.1.2 Since the resistance of copper over a range of temperature varies in direct proportion to the temperature as measured from minus 234.5°C, the ratio of the hot temperature (T_2) to the cold temperature (T_1) may be calculated from the ratio of the hot resistance (R_2) to the cold resistance (R_1) as follows:

$$\frac{R_2}{R_1} = \frac{T_2 + 234.5}{T_1 + 234.5}$$

$$\text{or } T_2 = \frac{R_2}{R_1}(T_1 + 234.5) - 234.5$$

D-1.1.3 The temperature-rise is the difference between the calculated temperature T_2 and that of the surrounding air at the conclusion of the test.

D-1.2 The method of testing by increase in resistance is applicable at the ambient temperature of the test room to all windings having a resistance of not less than 0.01 ohm. For windings having a resistance of less than 0.01 ohm, the surface temperature should be taken by thermometer or thermocouple.

D-2 THERMOMETER METHOD

D-2.1 Three types of thermometers may be employed, namely bulb thermometers containing mercury or alcohol and resistance thermometers.

D-2.2 When bulb thermometers are used in places where there is any varying or moving magnetic field, those containing alcohol should be used in preference to those containing mercury in which eddy currents may produce sufficient heat to yield misleading results.

D-2.3 When a thermometer is used to measure the temperature of a surface such as that of a winding, the bulb shall be surrounded by a single wrapping of tin foil having a thickness of not less than 0.025 mm. The tin foil shall form a complete covering for the bulb, which shall then be secured in contact with the surface under test. The exposed part of the wrapped bulb shall be completely covered with a pad of heat-insulating material, without unduly shielding the test surface from normal cooling.

D-3 THERMOCOUPLE METHOD

D-3.1 The two conductors between which the thermo-electric effect is produced shall be welded at both the hot and cold junction (*see* IS 2053 : 1974).

D-3.2 When applied to the surface the temperature of which is to be measured, the hot junction shall be covered with insulation and wrapped with tin foil as described for bulb thermometers. The thermocouple circuits shall be earthed to minimize the possibility of capacitance currents.

D-3.3 The protecting pad of heat insulating material specified in **D-3.2** shall be employed whether the junction is insulated or not.

D-3.4 The cold junction shall be maintained at a steady temperature. When an oil bath is used, the oil should preferably be contained in a vacuum flask or be thermostatically controlled, and the oil temperature shall be measured by means of a thermometer.

D-4 MEASUREMENT OF AMBIENT TEMPERATURE

D-4.1 The temperature of the surrounding air shall be measured by means of at least two thermometers, so placed as to take account of the maximum and minimum temperatures, and the mean reading shall be adopted.

ANNEX E

(*Clause* 10.1)

INFORMATION TO BE GIVEN WITH ENQUIRY AND ORDER

At the time of enquiry and order, the following information may be given:

a) Type of current transformer, type of supply and earthing conditions

(for example indoor/outdoor, ring type/cast resin/oil immersed, etc)

b) Highest system voltage, type of supply and earthing conditions

(for example 7.2 kV, 3-phase, effectively earthed)

c) Rated insulation level

(for example 230/550 kV)

d) Rated short-time thermal current (and its duration if different from 1 second)
(*e.g*. 13.1 kA/0.5 s)

e) Frequency, if other than 50 Hz.

f) Rated transformation ratio

(for example 200/1 for a single ratio current transformer or 200-100/1-1 for a multi-ratio, multi-core current transformer)

g) Rated output and corresponding accuracy class for measuring or protective current transformers
(for example 15 VA/0.5 for a measuring current transformer or 15 VA/5P10 for a protective current transformer.

h) Rated knee-point voltage and limitations of exciting current for Class PS current transformers
(for example Vk not less than 40(RCT + 19) and exciting current at 0.25 Vk not more than 30 mA)

j) Service conditions including, for example, whether the current transformers are for use indoors or outdoors, whether for use at unusually low temperature, altitudes (if over 1 000 metres), humidity, and any special conditions likely to exist or arise, such as exposure to steam or vapour, fumes, explosive gases, vibrations, excessive dust, etc.

k) Special features, such as limiting dimensions.

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

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Amendments Issued Since Publication

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