IS 14415 (1997): Volt-Amphere hour meters for restricted power factor range [superseding IS:722 (Part 5):1980 [ETD 13: Equipment for Electrical Energy Measurement and Load Control]

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भारतीय मानक

सीमित पॉवर-फेक्टर रेंज के लिए वोल्ट-एम्पीयर घंटा मीटर — विशिष्टि

Indian Standard

VOLT-AMPERE HOUR METERS FOR RESTRICTED POWER FACTOR RANGE — SPECIFICATION

ICS 17.220.20

BUREAU OF INDIAN STANDARDS
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Price Group 8

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Equipment for Electrical Energy Measurements and Load Control Sectional Committee had been approved by the Electrotechnical Division Council.

Tariffs based on apparent power, that is on maximum demand KVA, have an ever increasing importance specially in India where loads due to motors, mercury vapour, sodium vapour and fluorescent lighting take a much higher share of the total power capacity. This apparent power can be measured by instruments and methods having a strictly restricted range of application. The need was felt to standardize apparent energy meters that is volt-ampere hour meters for restricted power factor range. This requirement was orginally covered in IS 722 (Part 5) AC electricity meters: Part 5 volt-ampere hour meters for restricted power factor range, class 3.5 published in 1985. The standard was then revised in 1980.

This standard covers volt-ampere-hour meters for restricted power factor range with higher precision. This standard also covers the sustained accuracy test and recommended sampling plan for the acceptance of the lot.

Attention is drawn to the fact that the limits of errors specified in this standard are higher than those stipulated in the IE Act 57 (1956). This is in view of the fact that the meters covered in this standard are not ordinary volt-ampere-hour meters since calibration tolerance has also been allowed in addition to theoretical error for meeting the accuracy requirements covered in the standard.

The volt-ampere-hour meters covered in this standard belong to a particular category of the more generalized Q-hour meters and indeed these are induction type watt-hour meters with modifications indicated below:

a) Voltage applied to the metering elements are phase displaced generally by 30 degree with phase shifters or phase-shifting auto transformer or by cross-phasing of three phase voltage.

b) Volatge and/or current fluxes are further lagged, as required for the necessary phase shift of the voltage fluxes relative to the current fluxes.

These meters have the general deficiency of incorrect registration of the negative sequence component of the volt- ampere hour in case of unbalance in voltages and/or current. When the voltages are balanced, this error is totally eliminated or greatly minimized irrespective of any unbalance in currents.

This standard shall be read in conjuction with IS 722 (Part 1) : 1986 AC electricity meters : Part 1 General requirements and test (*third revision*). In the preparation of this standard, assistances has been derived from IEC publication 211 : 1966 Maximum demand indicators, Class 1.0 (first edition).

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 '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 values in this standard.

Indian Standard

VOLT-AMPERE HOUR METERS FOR RESTRICTED POWER FACTOR RANGE — SPECIFICATION

1 SCOPE

1.1 This standard specifies the requirements and tests for 3 phase whole current and transformer operated volt-ampere hour meters for restricted power factor range with maximum demand indicator and other tariff devices or accessories for unbalanced load for use in 3-phase 3-wire and 3-phase 4-wire supplies.

1.1.1 For maximum demand indicators, the requirements covered in IS 8530 : 1977 shall apply.

1.2 It does not apply to:

a) Volt-ampere hour meters for unrestricted full power factor range, and
b) volt-ampere hour meters in which the principle of measurement requires balanced conditions of load only.

NOTE — The application and operation of volt-ampere-hour meters are given in Annex A.

2 REFERENCES

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

3 TERMINOLOGY

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

3.1 Volt-Ampere Hour Meter (Apparent Energy Meter)

An integrating instrument which measures apparent energy in volt- ampere hours or in suitable multiples thereof.

3.2 Induction Meter

A meter in which currents carried by fixed coils react with the currents inducted in a conducting moving element, generally a disc(s), which causes their movement.

3.3 Multi-rate Meter

A meter provided with a register consisting of more than one set of drums or dials, each set becoming operative at times corresponding to different tariff rates.

3.4 Meter Rotor

The moving element of the meter upon which the magnetic fluxes of fixed winding and of braking elements act and which operates the register.

3.5 Meter Driving Element

A working part of the meter which produces a torque by the action of its magnetic fluxes upon the currents induced in the moving element. It generally comprises electromagnets with their control devices.

3.6 Meter Braking Element

The part of the meter which produces a braking torque by the action of its magnetic flux upon the currents induced in the moving element. It comprises one or more magnets and their adjusting devices.

3.7 Register of a Meter (Counting Mechanism of a Meter)

The part of the meter which registers the energy, or more generally the value of the quantity measured by the meter.

3.8 Meter Base

The back of the meter by which it is generally fixed and to which are attached the frame, the terminals or the terminal block and the cover. For a flush-mounted, it may include the sides of the case.

3.9 Meter Socket

An enclosure with jaws to accommodate terminals of a detachable meter and which has connector from the termination of the circuit conductors. It may be a single-position socket for one meter or a multi-position socket for two or more meters.

3.10 Meter Cover

The enclosure in front of the meter made either wholly of transport material or opaque material provided with window(s)/through which the movement of the rotor can be seen and the register can be read.

3.11 Meter Case

This comprises the base and the cover.

3.12 Meter Frame

The part to which are affixed the driving elements and usually the rotor bearings, the register, the braking element and the adjusting devices.

3.13 Accessible Conducting Part

A conducting part which can be touched by the standard test finger when the meter is installed ready for use.

NOTE — To determine whether a part is accessible, either visual inspection shall be used; or the flexible test finger given in Fig. 1 of IS 1401 : 1970, or the rigid test finger given in Fig. 2 of IS 1401 : 1970 shall be applied. In case of doubt, the latter shall be applied with a maximun force of 30 N.

3.14 Protective Earth Terminal

The terminal connected to accessible conducting parts of a meter for connection to the earth.

3.15 Terminal Block

A support made of insulating material on which all or some of the terminals of the meter are grouped together.

3.16 Terminal Cover

A cover which encloses the meter terminals and, if required, the ends of the external wires or cables connected to the terminals.

3.17 Current Circuit

The winding of the driving element and the internal connections of the meter through which flows the current of the circuit, to which the meter is connected.

NOTE — When the meter incorporates a current transformer the current circuit also includes the transformer windings.

3.18 Voltage Circuit

The winding of the driving element and internal connections of the meter, supplied with the voltage of the circuit to which the meter is connected.

3.19 Auxiliary Circuit

The elements (windings, lamps, contracts, etc) and connections of an auxiliary device within the meter case intended to be connected to an external device, for example, clock relay and impulse counter.

3.20 Basic Current (I_b)

The value of current in accordance with which the relevant performance of the meter is fixed.

3.21 Rated Maximum Current (I_{max})

The highest value of current at which the meter purports to meet the accuracy requirements of this standard. It is indicated in rms value, unless otherwise specified.

3.22 Reference Voltage

The value of voltage in accordance with which the relevant performance of the meter is fixed. It is indicated in rms value, unless otherwise specified.

3.23 Reference Frequency

The value of frequency in accordance with which the relevant performance of the meter is fixed.

3.24 Basic Speed

The nominal speed of rotation of the rotor expressed in revolutions per minute when the meter is under reference conditions and carries basic current at cos Φ (or sin Φ) = 1, as applicable.

3.25 Basic Torque

The nominal vlaue of torque on the rotor at rest when the meter is under reference conditions and carried basic current at cos Φ (or sin Φ) = 1, as applicable.

3.26 Meter Constant

Constant expressing the relation between energy registered by the meter and corresponding number of revolutions of the rotor, expressed in revolutions per kilo watt-hour (rev/kWh).

3.27 Reference Temperature

The ambient temperature specified for reference conditions.

3.28 Clearance

The shortest distance measured in air between conductive parts.

3.29 Creepage Distance

The shortest distance measured over surface of insulation between the conductive parts.

3.30 Percentage Error

The percentage error as determined from meter registration is given by the following formula:

$$\text{Percentage error} = \frac{R - A}{A} \times 100$$

where

R = energy registered by the meter, and
A = true energy.

The percentage error is determined from rotor speed as following:

$$\text{Percentage error} = \frac{T - t}{t} \times 100$$

where

T = true time or the time a correct meter would require for the same number of revolutions of the rotor, and
t = actual time (or time as observed) taken for a given number of revolutions.

3.31 Variation of Error Due to an Influence Quantity

The difference between percentage errors of meter when only one influence quantity assumes successively two specified values.

3.32 Influence Quantity or Factor

Any quantity or any factor other than the measured quantity whose effects may modify the measured results.

3.33 Distortion Factor

The ratio of rms value of the harmonic content (obtained by subtracting from a non-sinusoidal alternating quantity, its fundamental component) to the rms value of the non-sinusoidal quantity. The distortion factor is usually expressed as a percentage.

3.34 Mean Temperature Coefficient

The ratio of variation of percentage error to the change of temperature which produced this variation.

3.35 Vertical Working Position

The position of the meter in which the shaft of the rotor is vertical.

3.36 Class Index

A number which gives the limits of permissible percentages error, for all values of current between 10 percent of 1, and 1........, for cos Φ (sin Φ) = 1, as applicable (and in the case of polyphase meters with balanced loads) when the meter is tested under reference conditions (including permitted tolerance on the reference values) as defined in this standard.

3.37 Classification Angle (Degree of Phase Displacement)

The nominal phase displacement between voltage and current magnetic fluxes of a single driving element (*see* Note) in the principal air gaps when the voltage and current applied to this single element are in phase.

NOTE — Driving element includes any necessary accessories, resistors, inductors and shunts.

3.38 Type Tests

Test carried out to prove conformity with the requirements of this standard. These are intended to prove the general qualities and design of a given type of meter.

3.39 Type

Designation used for defining a particular design of meter manufactured by one manufacturer, having :

a) similar metrological properties,
b) the same uniform construction of part determining these properties,
c) the same number of ampere-turns for the current winding at basic current and the same number of the turns per volt for the voltage winding at reference voltage, and
d) the same ratio of the rated maximum current to the basic voltage.

They may have several values of basic current and several values of reference voltage.

These meters are designated by the manufacturer by one or more groups of letters or number, or of a combination of letters and numbers. Each type has one designation only.

NOTES

1 The type is represented by the sample meter(s) intended for type tests and whose characteristics (basic current and reference voltage) are chosen from the values of ratios proposed by the manufacturer.

2 Where the number of ampere-turns would lead to a number of turns other than a whose number, the product of the number of turns of the windings by the value of the basic current may differ from that of the sample meter(s) representative of the type. It is advisable to choose the next number immediately above or below in order to have whole number of turns. Only for this reason, may the number of turns per volt of the voltage windings differ, but by not more than 20 percent from that of the sample meters representative of the type.

3 The ratio of the highest to the lowest basic speed of the rotors of each of the meters of the same type shall not exceed 1.5.

3.40 Routine Tests

Tests carried out on each meter to check conformity with the requirements of this standard in aspects which are likely to vary during production.

3.41 Acceptance Tests

Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

3.42 Mean Power Factor

The power factor corresponding to the mean current vector angle of the outer limits of the power factor range specified.

NOTE — The following letter symbols have been used in this standard to denote various power factors in the restricted power factor range and the corresponding current vector angles:

u = upper limit of the power factor range at which the theoretical error is the maximum negative corresponding to the accuracy class.

l = lower limit of the power factor range at which the theoretical error is the maximum negative corresponding to the accuracy class.

m = mean power factor at which the theroetical error is the maximum positive corresponding to the accuracy class.

u_o = upper power factor at which the theoretical error is zero.

l_o = upper power factor at which the theoretical error is zero.

where Φ_u, Φ_i, Φ_m, Φ_u and Φ_l = Current vector angles corresponding to the power factors u, i, m, u_b and l respectively.

4 CLASSIFICATION AND POWER FACTOR RANGE

4.1 The volt-ampere hour meters shall be classified as class 1 - 1, class 1 - 2 and class 2.5 - 2, and shall have power factor ranges as specified in Table 1. In accuracy classification, the first numeral denotes the theoretical error limit of a restricted power factor range kVAh meter and the second numeral denotes the accuracy class of the basic watt-hour meter used.

Table 1 Restricted Power Factor Ranges and Accuracy Class
(*Clause* 4.1)

kVA Tariff power factor range[1)]	0.5 - 1.0			0.67 - 0.98		
Recommended use of meter power factor ranges[1)]	0.50 - 0.80 and 0.75 - 0.95 and 0.92 - 1.0		0.5 - 0.9 and 0.8 - 1.0		0.66 - 0.90 and 0.82 - 0.98	0.67 - 0.98
kVAh theoretical error limit	± 1.0%		± 2.5%		± 1.0%	± 2.5%
Recommended watt-hour accuracy class	1.0	2.0	2.0	1.0	2.0	2.0
kVAh accuracy class designation	1-1	1-2	2.5 -2	1-1	1-2	2.5 - 2

[1)]Generally these are lagging power factors.

5 RATINGS

5.1 Standard Basic Currents (I_b)

The standard basic current shall be 5, 10, 20, 30, 50 and 100 A for whole current meters and 1 and 5 A for CT operated meters.

5.2 Rated Maximum Current (I_{max})

The rated maximum current shall be generally 120 percent of the basic current. Other values like 200 percent of the basic current are also permissible.

5.3 Standard References Voltage

5.3.1 *Direct Connected Meters*

The reference voltage shall be one of the standard system voltages given in IS 12360 : 1988.

5.3.2 *Voltage Transformer Operated Meters*

The reference voltages for the meters connected through voltages transformers shall be 110 and 63.5 V [*see* IS 3156 (Part 1) : 1992].

6 GENERAL AND CONSTRUCTIONAL REQUIREMENTS

6.1 General

Meter shall be designed and constructed in such a way as to avoid introducing any danger in normal use and under normal conditions, so as to ensure safety against:

a) electric snock,
b) effects of excessive temperature, and
c) spread of fire.

All parts which are subjects to corrosion under normal working conditions shall be effectively protected against corrosion due to atmospheric causes. Any protective coating shall not be liable to damage by ordinary handling nor seriously affected by exposure to air, under normal working conditions.

The meter shall have adequate mechanical strength and shall withstand the fluctuations of temperature which are likely to occur in normal working conditions. The components shall be reliably fastened and secured against loosening.

The electrical connections shall be such as to prevent any opening of the circuit under normal conditions of use, including any overload conditions specified in this standard.

The construction of the meter shall be such as to minimize the risks of short-circuiting of the insulation between live parts and accessible conducting parts due to accidental loosening or unscrewing of the wiring screws, etc.

The meter shall not produce appreciable noise in use.

6.2 Case

The meter shall have a reasonably dust-proof case, which may be sealed in such a way that the internal parts of the meter are accessible only after breaking the seals. The cover shall not be removable without the use of a tool, coin or any similar device. The holding on and sealing screws shall be held captive in the meter cover.

The case shall be so constructed and arranged that any nonpermanent deformation cannot prevent the satisfactory operation of the meter.

The case of a Class 0.5 meter shall be constructed so that, if mounted according to the manufacturer's instructions, the meter shall not deviate by more than 0.5° in all directions from its normal position (*see* Note 2 in Table 7).

The meters, having a case wholly or partially made of metal, shall be provided with a protective earth terminal.

6.3 Windows

If the meter cover is not transparent, one or more windows shall be provided for reading the register and observation of the rotor. These windows shall be covered by plates of transparent material which cannot be removed without breaking the seals.

6.4 Terminals

6.4.1 *Terminal Block(s) and Protective Earth Terminals*

Terminals may be grouped in a terminal block(s) having adequate insulating properties and mechanical strength, they shall permit the connection of both solid and stranded conductors.

The holes in the insulating material which form a prolongation of the terminal holes shall be of sufficient size to accommodate the insulation of the conductors also.

It shall be possible to disconnect easily the relevant voltage terminal(s).

NOTE — Whether the disconnecting device for the meter voltage circuit will be in the terminal compartment or inside the meter cover, shall be a matter of agreement between the manufacturer and the purchaser.

6.4.2 *Fixing of Conductors*

The manner of fixing the conductors to the terminals shall ensure adequate and durable contact such that there is no risk of loosening or undue heating (*see also* **6.1**). Screw connections transmitting contact force and screw fixings which may be loosended and tightened several times during the life of the meter shall screw into a metal nut, electrical connections shall be so designed that contact pressure is not transmitted through insulating material.

Two screws shall be provided in each current terminal for effectively clamping the external leads or thimbles. Alternatively, if an elastic pressure plate or similar effective device is provided to keep the entire length of the conductor within the terminal well pressed, one screw may be used. Each clamping screw shall engage a minimum of three threads in the terminal. The ends of screws shall be such as not to pierce and cut the conductors used.

Meters with rated maximum current 100 A and above shall be connected through soldering/crimped sockets. Meters with rated maximum current of 60 A may be connected through soldering/crimped sockets.

6.4.3 *Connection of Current Circuit Conductors to Meter Current Terminals*

The conductors of current circuit of a meter shall be connected to its current terminals inside the meter terminal block adopting any of the recommended methods given in Annex C so as to ensure satisfactory, durable and adequate contact surfaces between the conductors and the terminals.

6.4.4 *Dimensions of Terminal Holes*

The internal diameter of teminal holes shall be as specified in Table 2.

Table 2 Terminal Holes
(*Clause* 6.4.4)

Rated Maximum Current A (1)	Internal Diameter *Min*, mm (2)
Up to and including 40	5.5
60	8.5
120	9.5

6.4.5 *Clearances and Creepage Distances*

The clearances and creepage distances of terminal block and those between the terminals and the sourroundings parts of the metal enslousure shall be not less than the values specified in Table 3 for voltages operated under references conditions.

Table 3 Clearances and Creepage Distances
(*Clause* 6.4.5)

Voltage V (1)	Clearance mm (2)	Creepage Distance mm (3)
Up to and including 25	1	1
26 to 60	2	2
61 " 250	3	3
251 " 450	3	4
451 " 600	4	6

For current circuits, the voltage shall be considered to be the same as for the related voltage circuit. Clearance of minimum 3 mm shall be provided between incoming and outgoing terminals of the same phase.

For phantom loading during test, the pressure terminals are required to be connected separately from the current terminals of the same phase. A clearance of minimum 1.2 mm shall be provided between pressure terminal and current terminals of the same phase.

Terminals with different potentials which are grouped close together shall be protected against accidental short-circuiting. Protection may be obtained by insulating barrics. Terminals of one current circuit are considered to be at the same potential.

The terminals, the conductor fixing screws, or the external or internal conductors shall not be liable to come into contact with metal terminal covers, and meter terminal base. For this purpose, terminal blocks shall be rigidly fixed to the meter base.

The clearance between the terminal cover, if made of metal, and the upper surface of the screws when screwed down to the maximum applicable conductor fitted shall be not less than the relevant values specified in Table 3. If the terminal cover, is made of insulating material, the clearance shall be not less than 1 mm.

6.4.6 *Protective Earth Terminal*

The protective earth terminal, if any, shall:

a) be electricity bonded to accessible metal parts ;
b) form part of the meter base, if possible ;
c) preferably be located adjacent to its terminal block ;
d) accomodate a conductor having a cross-section at least equipment to the main current conductors but with a lower limit of 6 mm^2 and an upper limit of 16 mm^2 ; and
e) be clearly identified by the earth symbol.

All parts of every terminal shall be such that the risk of corrosion resulting from contact with any other metal part is minimized.

After installation, it shall not be possible to loosen the protective earth terminal without the use of a tool, coin or any similar device.

6.5 Terminal Cover(s)

Every terminal block shall be provided with a terminal cover conforming to **6.5.1** or **6.5.2**.

6.5.1 *Short Terminal Cover*

The terminals, their fixing screws and the insulated compartment, housing them shall be enclosed by a cover with a provision for sealing. The cover may be of the same size as that of the terminal block. The wiring with this type of cover may be carried out from the front of the meter board.

6.5.2 *Extended Terminal Cover*

The terminals, their fixing screws, a suitable length of external insulated conductor and its insulation shall be enclosed by a cover with a provision for sealing. The wiring with this type of cover shall be carried out from the rear of the meter board.

6.5.3 The fixing screws used on the terminal cover for fixing and sealing in **6.5.1** and **6.5.2** shall be held capative in the terminal cover.

6.5.4 The requirements of **6.5.1** and **6.5.2** shall not apply to portable meters provided with back connections.

6.5.5 When the meter is mounted on the meter board, no access to the terminals shall be possible without breaking the seal(s) of the terminal.

6.6 Non-flammability

The terminal block, the terminal cover (if not of metal) and the case (if not of metal) shall be of a material which complies with the requirements of methods specified in IS 11731 (Part 1) : 1986.

NOTE — If the materials of the terminal block, terminal cover and the case meet this requirement, the finished meter need not be tested.

6.7 Register (Counting Mechanism)

6.7.1 *General*

The register shall be of pointer of drum type.

The principal units in which the register records shall be Kilovolt-amperehour (kVAh) or the megavolt-ampere-hour (MVAh).

In drum-type registers, the principal unit in which the register records shall be marked adjacent to the set of drums. In this type of register, only the last drum, that is, the drum on the extreme right may be movable continuously.

In pointer-type registers, the unit in which the register records shall be marked adjacent to the units dial in the form, for example ; 1 kVAh/div, and adjacent to the other dials shall be marked the decimal multiples. For example, in meter registering in terms of kVAh, the units dial shall be marked: 1 kVAh/div and adjacent to the other dials to the left of the units dial shall be marked: 10, 100, 1 000, etc.

Decimal dials or drums shall be coloured, or encircled in colour, the fastest moving being graduated and numbered. The smallest division of the fastest moving drum or dial shall represent not more than 30 revolutions of the rotor.

The register shall be able to record, starting from zero, for a minimum of 15 hours, the energy corresponding to rated maximum current at reference volatge and cos Φ (or sin Φ) = 1, as applicable.

Register marking shall be indelible and easily readable.

The meter shall be of self-aligning type, so that the register will align itself correctly with respect to the rotor when pushed into the full extent.

6.7.2 Dimensions

6.7.2.1 *Pointer-register*

The pointers shall indicate on circular dials each divided into ten equal divisions. The radius of the circles shall be not less than 7.0 mm and the radial length of the pointer shall be less than the radius of the circles but by not more than 0.5 mm. The highest of the figures round the circles shall be not less than 2.5 mm nor than one kilovolt ampere hour per division may be smaller than 7.0 mm.

6.7.2.2 *Drum register*

The diameter of the drums shall be at least 14 mm. The highest of the numerals on the drums shall be at least 4 mm and their width at least 2 mm.

6.8 Direction of Rotation and Marking of the Rotor

The edge of the rotor nearest to an observer viewing a meter from the front shall move from left to right for positive registration. The direction of rotation shall be marked by a clearly visible indelible arrow. The edge and upper surface of the disc shall carry an easily visible mark to facilitate revolution counting. The circumference of the disc shall also be graduated on the upper surface into 100 divisions or multiples thereof.

7 SPEED OF ROTATION

7.1 The speed of the meter rotor shall not exceed 50 rev/min at reference voltage and basic current. It is recommended that the speed of rotation of the meters shall not exceed 25 rev/min at reference voltage and basic current. These provisions shall be applicable over the specified power factor range.

8 MARKINGS OF METERS

8.1 Markings and Nameplates

Every meter shall be marked with the following information and the marking shall be indelible, distinct, and readable from outside the meter:

a) Manufacturer's name or trade-mark;
b) Designation of type;
c) Nature of current (for example, ac or dc), and the serial number of phases and number of wires for which the meter is suitable (for example, 1 phase 3-wire, 3-phase 3-wire, 3-phase 4-wire);
d) Serial number and year of manufacture. If the serial number is marked on a plate fixed to the cover, this number is also to be marked on the base or frame;
e) Principal unit in which the meter records (for example, kVAh or Kvarh);
f) Reference voltage in one of the forms given in Table 4;
g) Currents in the form given as example in Table 5;
h) Reference frequency in Hertz;
j) Meter constant, for example, in the form rev/kVAh;
k) Class index, for example, Class 0.5, Class 1, Class 2;
m) Restrictive points factor range;
n) Classification angle (for varhour meters), that is 0°, 60° or 90°, if required ;
p) Reference temperature, if different from 27° C;
q) Rated power factor range (for volt-ampere hour meters); and
r) Tansformation ratio(s), if the meter registers energy through instrument transformer(s) of which account is taken in the meter constant.

NOTES

1 The information under (a), (b) and (c) marked on an external plate permanently attached to the meter cover.

The information under (d) to (r) shall be marked on a nameplate preferably placed within the meter and which may, for example, be attached to the meter register. The information may be marked on the meter dial.

2 If the meter is of special type (for example, provided with a reversal preventing device or is intended for a capacitive load), this shall be indicated on the nameplates or on a separate plate.

3 Standard graphical symbols for production and conversion of electrical energy may also be used [*see* IS 12032 (Part 6) : 1987].

Table 4 Voltage Markings
(*Clause* 8.1)

Type of Meter (1)	Method of Marking (2)	Example (3)
1-phase, 2-wire, direct connected	Voltage between line and neutral	240 V
2-phase, 2-wire, transformer	Meter circuit voltage	-/110 V 6 600/110 V
3-phase, 3-wire	3× voltage between lines	(3 × 415 V (3 × 6 600/110 V
3-phase, 4-wire	3× voltage between line and neutral	3 × 240 V

Table 5 Current Markings
(*Clause* 8.1)

Type of Meter (1)	Method of Marking (2)	Example (3)
1-phase, whole current I_b 10 A, I max 20 A	Basic current and rated maximum current	10-20 A
1-phase, transformer oprated I_b 1A, I_{max} 60A	Basic current	-/1 A
3-phase, whole current I_b 50 A, I_{max} 60 A	Basic current	50 A
3-phase, transformer operated I_b 5 A I_{max} 6 A	Basic current	-/5 A

8.1.1 *BIS Certification Marking*

The meter may also be marked with the Standard Mark.

8.1.1.1 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 thereunder. The details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producters may be obtained from the Bureau of Indian Standards.

9 PACKING

9.1 Meters shall be suitably packed in order to avoid any damage or disturbance during transit or handling. General recommendations for packing of meters are given in Annex D.

10 CONDITIONS FOR TESTS

10.1 Unless otherwise specified, tests shall be carried out under the following conditions.

10.1.1 The meter cover shall be in position.

10.1.2 For drum type registers, only the most rapidly moving drum shall be turning.

10.1.3 Before any tests are made, the voltage circuits shall have been energized for at least one hour.

The measuring currents shall be set progressively to increasing or decreasing values and the current circuits shall be energized at each value for a sufficient time to obtain thermal stability with corresponding constant speed of rotation.

10.1.4 In addition, for polyphase meters:

a) the plans sequence shall be marked on the diagram of connections, and
b) the voltages and currents shall be substantially balanced (*see* Table 6).

10.1.5 The reference conditions for various influence quantities shall be as specified in Table 7.

Table 6 Voltage and Current Balance
(*Clause* 10.1.4)

Polyphase Meters	Class of Meter		
	0.5	1	2 and worse
(1)	(2)	(3)	(4)
Each of the voltage between line and neutral or between any two lines shall not differ from the average corresponding voltage by more than	±0.5%	±1%	±1%
Each of the currents in the conductors shall not differ from the average current by more than	±1%	±2%	±2%
The phase displacements of each of these currents from the corresponding line-to-neutral voltage, irrespective of the power factor shall not differ from each other by more than	2°	2°	2°

Table 7 Reference Conditions for Influence Quantities
(*Clause* 10.1.5)

Influence Quantity	Reference Value	Permissible Tolerances For Meters of Class		
		0.5	1	2 and worse
(1)	(2)	(3)	(4)	(5)
Ambient temperature	Reference temperature or in its absence 27°C (*see* Note 1)	±1°C	±2°C	±2°C
Working position	Vertical working position (*see* Note 2)	±0.5°	±0.5°	±0.5°
Voltage (*see* Note 3)	Reference Voltage	±0.5%	±1%	±1%
Frequency	Reference frequency or in its absence 50 Hz	±0.2%	±0.3%	±0.5%
Magnetic induction of external origin at the reference frequency (*see* Note 4)	Magnetic induction equal to zero	Induction value which caused a variation of error not greater than		

NOTES

1 If the tests are made at a temperature other than the reference temperature, including permissible tolerances, the results shall be corrected by applying appropriate temperature coefficient of the meter.

2 Determination of Vertical Working Position (*see* 6.2) The construction and assembly of the meter should be such that the correct vertical position is ensured (in both the front-to-back and left-to-right vertical planes) when:

a) the base of the meter is supported against a vertical wall, and

b) a reference edge (such as the lower edge of the terminal block) or a reference line marked on the meter case is horizontal.

3 When testing polyphase varhour meters, errors may arise if the testing method used and the meter under test are differently affected by voltage unbalance. In such cases, the reference voltage shall be carefully adjusted to a high degree of symmetry.

4 The test consists of:

a) *For a single-phase meter* — Determining the errors, at first with the meter normally connected to the mains and then after inverting the connections to the current circuits as well as to the voltage circuits. Half of the difference between the two errors is the value of the variation of error. Because of the unknown phase of the external field, the test has to be made at 0.1 I at 0.5 power factor.

b) *For a three-phase meter* — Making three measurements, at 0.1 I at cos Φ (or sin Φ) = 1, as applicable after each of which the connections to the current circuits and to the voltage circuits are changed over 120°, while the phase sequence is not altered. The greatest difference between each of the errors so determined and their average vlaue is the value of variation of error.

10.2 For special provisions reference should be made to E-3 and E-4 of Annex E.

11 TESTS

11.1 Classification of Tests

11.1.1 *Type Tests*

Test schedule and sequence shall be as given in Table 8.

11.1.1.1 *Number of samples and criteria for conformity*

Type tests shall be applied to three test specimens; in event of one specimen failing to comply in any respect, further three specimens shall be taken all of which shall comply with requirements of this standard.

Table 8 Schedule of Type Tests
(*Clause* 11.1.1)

Sl No. (1)	Test (2)	Clause No. (3)
i)	Insulation resistance	11.2
ii)	Running with no load	11.3
iii)	Starting	11.4
iv)	Limits of errors	11.5
v)	Interpretation of test results and adjustment (if required)	11.6
vi)	Test of meter constant	11.7
vii)	Power loss	11.8
viii)	Heating	11.9
ix)	Dielectric strength	11.10
x)	Effect of influence quantities	11.11
xi)	Effect of short-circuit	11.12
xii)	Effect of self-heating	11.13
xiii)	Range of adjustment	11.14
xiv)	Independence of adjustment	11.15
xv)	Sustained accuracy test	11.16

11.1.2 *Acceptance Tests*

Test schedule shall be as given in Table 9.

Table 9 Schedule of Acceptance Tests

Sl No. (1)	Test (2)	Clause Ref (3)
i)	Insulation resistance	11.2
ii)	Running with no load	11.3
iii)	Starting	11.4
iv)	Limits of errors	11.5
v)	Interpretation of test results and adjustment (if required)	11.6
vi)	Power loss (voltage circuits)	11.8.1
vii)	Range of adjustment	11.14

11.1.2.1 *Recommended sampling plan and criteria for acceptance*

A recommended sampling plan and the criteria for acceptance of the lot are given in Annex F.

11.1.3 *Routine Tests*

Test schedule and sequence shall be as given in Table 10.

Table 10 Schedule of Routine Tests

Sl No. (1)	Test (2)	Clause Ref (3)
i)	Insulation resistance	11.2
ii)	Running with no load	11.3
iii)	Starting	11.4
iv)	Limits of errors	11.5
v)	Interpretation of test results and adjustment (of required)	11.6
vi)	Dielectric strength	11.10

11.2 Insulation Resistance

The insulation resistance test shall be carried out in accordance with Table 11. The voltage shall be applied for a minimum of one minute or a sufficient time for the pointer of the insulation tester to have come practically to rest.

Table 11 Insulation Resistance Test

Test Voltage (1)	Points of Application of Test Voltage (2)	Insulation Resistance (3)
500±50 V dc	a) Between frame and current circuit, voltage circuit, and voltage circuits, if any all connected together	5 megohms
	b) Between each current circuit (or voltage circuits) and, each and every other circuit	50 megohms

NOTE — Where two or more voltage circuits are permanently jointed together, the combination may be treated as one circuit for this test.

11.3 Running with No Load

Unless specified otherwise, the conditions and the values of the influence quantities shall be as given in **10.1.5.**

With no current in the current circuits(s), the rotor of the meter shall not make a complete revolution at any voltage between 80 and 110 percent of the reference voltage.

For drum type registers, these conditions shall apply with only one drum moving.

11.4 Starting

The starting current shall be 0.4 percent basic at mean power factor for accuracy class 1 - 1 or, 0.5 percent basic current at mean power factor for accuracy class 1-2 or 2.5-2. If the meter is provided with reverse running stop and/or contacting device and/or maximum demand indicator, there shall be an allowable increase of starting current to the extent of 100 percent the value specified.

11.5 Limits of Errors

The percentage errors shall not exceed the limits given in Tables 12 and 13.

Table 12 Limits of Error

(THREE PHASE METERS CARRYING A 1 - PHASE LOAD BUT WITH BALANCED THREE PHASE VOLTAGE APPLIED TO VOLTAGE CIRCUITS)

Accuracy Class	Power Factor (CosΦ)	Value of Current	Limits of Percentage Error
1 – 1	I_o	20% I_b to I_b	± 2.0
	u_o	20% I_b to I_b	± 2.0
1 – 2	I_o	20% I_b to I_b	± 3.0
	u_o	20% I_b to I_b	± 3.0
2.5 – 2	I_o	20% I_b to I_b	± 3.0
	u_o	20% I_b to I_b	± 3.0

NOTES

1 When testing for compliance the test current shall be applied to each element in sequence.

2 *See* Annex E for various values of I_o and u_o.

Table 13 Overall Limits of Percentage Error
(3-Phase Meters with Balanced Loads)
(*Clause* 11.5)

Value of Current	At Mean Power Factor (m)*			At End Power Factors (l, u)		
	Class 1 - 1	Class 1 - 2	Class 2.5 - 2	Class 1 - 1	Class 1 - 2	Class 2.5 - 2
Between 10 percent I_b and I_{max}	+2.0 and 0	+3.0 and – 1.0	+4.5 and + 0.5	0 and – 2.0	+ 1.0 and – 3.0	_0.5 and – 4.5
5 percent I_b	+ 2.5 and – 0.5	+ 3.5 and – 1.5	+ 5.0 and 0	+ 0.5 and – 2.5	+ 1.5 and – 3.5	0 and – 5.0

*NOTE — *See* Annex E for various values of l, m and u.

11.5.1 The difference between the percentage error when the meter is carrying a 1-phase load at basic current and the percentage error when the meter is carrying a balanced 3-phase load at basic current shall not exceed the values specified below. These test conditions shall apply at both the power factor u_o and l_o

Accuracy Class	*Maximum Difference*
1 - 1	1.5 percent
1 - 2 and 2.5 - 2	2.5 percent

11.5.2 For routine test, the error shall be determined at the points specified below:

Current (Percent of I_b)	*Power Factor* *Cos* Φ
5	u_o and l_o
10	u_o and l_o
100	u_o and l_o
I_{max} (If I_{max} is more than 120 percent I_b)	u_o and l_o

Type test shall, however prove conclusively that the meter as tested above shall satisfy limits of errors given in Tables 12 and 13.

11.5.3 When the meter is properly calibrated in accordance with **11.5**, Table 12, the overall kVAh meter errors are within limits as shown in Table 13.

11.5.4 If the meter is provided with a reverse running stop and/or contacting device and/or maximum demand indicator, the limit of negative percentage error at 5 percent basic current and at u_o, l_o shall be subject to an allowable increase of 0.5 for class 1 - 1 and 1.0 and 1.0 for class 1 - 2 or 2.5-2.

11.6 Interpretation of Test Results

The permissible displacement of the zero line shall be not more than 0.5 percent for accuracy class 1-1 and 1 percent for accuracy class 1-2 or 2.5-2.

11.7 Test of Meter Constant

It shall be verified that the ratio between the revolutions of the meter rotor and indication of the register is correct.

11.8 Power Loss

11.8.1 *Voltage Circuit*

The power loss shall not exceed 1.5 W and 7.5 VA in each voltage circuit.

11.8.2 *Current Circuit*

The apparent power taken by each current circuit of a current transformer operated meter at basic current, reference frequency and reference temperature shall not exceed 2.5 VA.

11.9 Heating

Under normal conditions of use, windings and insulation shall not reach a temperature which might adversely affect the operation of the meter.

With each current circuit of the meter carrying rated maximum current and with each voltage circuit (and with those auxiliary voltage circuit which are energized for periods of longer duration than their thermal time constants) carrying 1.2 times the reference voltage, the temperature-rise of the respective parts shall not exceed the values given in Table 14 with an ambient temperature not exceeding 40°C.

Table 14 Heating

Part of Meter (1)	Temperature Rise, °C (2)
Windings	60
External surfaces of the case	25

During the test, the duration of which shall not be more than 2 hours, the meter shall not be exposed to draught or direct solar radiation.

After the test, the meter shall show no damage and shall comply with the dielectric tests of **11.10.2**.

Except for the requirements relating to the temperature-rise of the windings specified in Table 14, the insulation materials shall comply with the appropriate requirements of IS 1271 : 1985.

The temperature rise of windings shall be determined by variation of resistance method. The measurement shall be carried out at the point of connection between the current windings and the respective terminals.

For measurement of circuit resistance, the cable to be used for energizing the meter shall have a length of about 1 m and a cross-section such that the current density is less than $4A/mm^2$.

In the case of varhour meters having shunts associated with their current circuits, the temperature-rise shall be measured (all circuits of the meter being energized as required above) by a direct method (theromocouple). The temperature-rise stated above shall apply to the current windings only, and not to the shunts.

11.10 Dielectric Strength

The meter and its incorporated auxiliary devices, if any, shall be such that they retain adequate dielectric qualities under normal conditions of use, taking account of the atmospheric influence and different voltages to which they are subjected under normal conditions of use.

Consequently, the meter shall withstand the dielectric proving tests detailed in **11.10.2**.

The tests shall be carried out on a complete meter, with its cover (expect when indicated hereafter) and terminal cover, the screws being screwed down to the maximum applicable conductor fitted in the terminals.

These tests shall be carried at once only on a meter.

During type tests, the dielectric property tests are considered to be valid only for terminal arrangement to the meter which has undergone the tests. When the terminal arrangements differ, all the dielectric property tests shall be carried out a new.

For the purpose of these tests, the term 'earth' has the following meaning:

a) When the meter case is made of metal, the earth is the case itself placed on a flat conducting surface.
b) When the meter case or only a part of it is made of insulating material, the earth is a conductive foil wrapped around the meter and connected to the flat conducting surface on which the meter base is placed. Where the terminal cover makes it possible, the conductive foil shall approach the terminals and the holes for the conductors within a distance of not more than 2 cm.

During the ac voltage tests, the circuits which are not under test, are connected either to the frame or to the earth as indicated hereafter.

During these tests, no flashover, discharge or puncture shall occur.

After these tests, there shall be no change in percentage error of the meter greater than the uncertainly of the measurement.

In this clause, the expression 'all the terminals' mean the whole set of the terminals of the current circuits, voltage circuits and, if any, auxiliary circuits having a reference voltage over 40 V.

11.10.1 *General Conditions of Dielectric Strength Tests*

These tests shall be made in normal conditions of use. During the tests, the quality of insulation shall not be impaired by dust or abnormal humi dity. Unless otherwise specified, the normal conditions for insulation- tests are:

Ambient temperature	15 to 45 °C
Relative humidity	45 to 95 percent
Atmospheric pressure	86 to 106 kPa

11.10.2 *AC Voltage Test*

The ac voltage test shall be carried out in accordance with Table 15.

The test voltage shall be substantially sinusoidal, having frequency between 40 and 60 Hz and applied for one minute. The power source shall be capable of supply at least 500 VA.

During the tests relative to the frame [(a) in Table 15], the circuits which are not under tests shall be connected to the frame.

During the tests relative to each [(c) in Table 15], the auxiliary circuits with reference voltage equal to or below 40 V shall be connected to earth.

11.11 Effect of Influence Quantities

The percentage variations in errors due to the influence quantities shall not exceed the limits specified in Table 16.

11.12 Short Circuits

The variation of error shall not exceed the values specified in Table 17.

Table 15 High Voltage Test
(*Clause* 11.10.2)

Test Voltage r.m.s.		Points of Application of the Test Voltage
(1)		(2)
	a)	Test which may be carried out with cover and terminal cover removed — between on the one hand, frame and — on the other hand
2 kV	1)	Each current circuit which, in normal service is separated and suitably insulated from the other circuits (*see* Note 1).
2 kV	2)	Each voltage circuit, or set of voltage circuits having a common point which, in normal service, is separated and suitably insulated from the other circuits (*see* Note 1).
2 kV	3)	Each auxiliary circuit or set of auxiliary circuits having a common point and whose reference voltage is over 40 V.
2 kV	4)	Each assembly of current-voltage windings of one and the same driving element which, in normal service, are connected together but separated and suitably insulated from the other cricuits (*see* Note 2)
500 kV	5)	Each auxiliary circuit whose reference voltage is equal to or below 40 V.
	b)	Tests which may be carried out with terminal cover removed but with cover in place when it is made of metal.
2 kV		Between the current circuit and the voltage circuit of each driving element, normally connected together, this connection being temporarily broken for the purpose of the test (*see* Note 3).
	c)	Test to be carried out with cover and terminal cover in place
2 kV		Between, on the one hand, all the current and voltage circuits as well as auxiliary circuits whose reference voltage is over 40 V, connected together, and, on the other hand, the earth.

NOTES

1 The simple breaking of connection which is normally included between current and voltage windings, is not generally sufficient to ensure suitable insulation which can withstand a test voltage of 2 kV.

Tests (1) and (2) generally apply to meters operated from instrument transformers and also to certain special meters having separate current and voltage windings.

2 Circuits which have been subjected to tests (1) and (2) are not subjected to test (4). When the voltage circuits of a polyphase meter have a common point in normal service, this common point shall be maintained for the test and, in this case, all the circuit of the driving elements are subjected to a single test.

3 It is not, strictly, speaking a dielectric strength test but a means of verifying that the insulation distances are sufficient when the connecting device is open.

Table 16 Limits of Variations in Errors
(*Clause* 11.11)

Choice in the Values of The Influence Quantities With Respect to Reference Conditions	Value of Current	Power Factor Cos Φ	Limits of Variation in Percentage Error for Meters of Class	
			1-1	1-2 2.5-2
(1)	(2)	(3)	(4)	(5)
Ambient temperature(mean temperature coefficient) ±10°C	10 percent I_b to I_{max}	m	0.0.5 percent	0.1/°C
Oblique suspension 3°	5 percent I_b,	m	2.0	3.0
	I_b and I_{max}	m	0.4	0.5
Voltage ±10 percent	1 percent I_{max}	m	1.0	1.5
	50 percent I_{max}	m	0.7	1.0
Frequency ±5 percent	10 percent I_b	m	1.0	1.5
	50 percent I_{max}	m	0.8	1.3
Magnetic induction of external origin 0.5 mT	I_b	m	2.0	3.0
Magnetic field of an accessory 5 percent	5 percent I_b	m	0.5	1.0
Mechanical load of 5 percent	5 percent I_b	m	1.5	2.0

NOTE — Where the value of current specified in col 2 results in a figure not available on the test bench, testing at the nearest available higher value shall be permissible.

Table 17 Variations Due to Short Circuits
(*Clause* 11.12)

Meters For	Value of Current	Power Factor Cos Φ	Limits of Variation in Percentage Error For Meters of Class	
			1-1	1-2, 2.5.2
(1)	(2)	(3)	(4)	(5)
Direct connection	100	m	1.0	1.5
Connection through current transformer	100	m	0.5	1.0

11.13 Influence of Self Heating

The variation of error shall not exceed the values specified in Table 18.

Table 18 Variations Due to Self-heating

Value of Current	Power Factor Cos Φ	Limits Of Variations In Percentage Error For Meters of Class	
		1-1	1-2 2.5-2
(1)	(2)	(3)	(4)
Rated *I*max	m	0.7	1.0

11.14 Range of Adjustment

The minimum range of adjustment shall be as specified in Table 19.

Table 19 Minimum Range of Adjustment

Adjustment	Value of Current	Power Factor Cos Φ	Minimum Range of Adjustment Rotation Speed of the Rotor In Percentage
(1)	(2)	(3)	(4)
Braking element	50 percent rated *I*max	m	±4
Low load	50 percent *I*b	m	±4

NOTE — For polyphase meters, the verification of the range of adjustment for inductive load should be made on each driving element and should be determined when the current circuit of each element is carrying basic current lagging 60° behind the voltage at the terminals of that element, all the voltage, whose rms value is equal to the reference voltage in the phase sequence as indicated on the concerned diagram.

11.15 Independence of Adjustment

The mutual effects of different adjustments shall not affect the rotor speed by more than the values specified in Table 20.

Table 20 Independence of Adjustment

Magnitude of Adjustment	Value of Current	Power Factor Cos Φ	Maximum Variation of Rotation Speed of the Rotor Percentage
(1)	(2)	(3)	(4)
4 percent low load	50 percent rated I_{max}	m	0.2

11.16 Sustained Accuracy

11.16.1 An initial test of accuracy shall be carried out at the rated voltage and frequency at the following loads and percentage error noted:

a) Rated maximum current, unity power factor;
b) 100 percent basic current, unity power factor; and
c) 10 percent basic current, unity power factor.

11.16.2 After initial test, the meter shall be run preferably continuously at approximately rated maximum current, rated voltage and unity power factor, up to a registration in kWh numerically equivalent and unity power factor. On completion of this run the meter shall be retested as in **11.6.1** and the percentage error shall not differ by more than one percent from the error of the meter under initial test condition **11.6.1** (a) and **11.6.1** (b) and two percent for test condition **11.6.1** (c).

11.16.3 After this test, the condition of bottom bearing (except magnetic suspension bearing) shall not show any undue wear when examined under microscope.

ANNEX A

(*Clause* 1.2, Note)

APPLICATION AND OPERATION OF kVAh METERS

A-1 BASIC APPLICATION FOR kVAh METERS

A-1.1 Kilovolt-ampere hour meters are mainly used in industrial insulations for general billing purposes. The tariffs are usually based on the consumption in kWh and the maximum demand in kVA and are two-part tariffs similar to those based on kilowatt-hour meters with kW maximum demand indicator (*see* IS 8530 : 1977).

A-2 TYPES

A-2.1 Kilovolt-ampere meters are of the following two basic types:

a) kVAh meters for the entire power factor range (*see* **A-2.2**), and
b) kVAh meters for restricted power factor range (*see* **A-2.3**).

A-2.2 Kilovolt-Ampere Hour Meters for the Entire Power Factor Range

These meters are real kVAh meters which may be used normally over a power factor range extending from zero lag to unity. Over the entire range, the rate of registration is :

$$R = KUI \left(1 + \frac{E}{100}\right)$$

where

R = rate of registration in kVAh or speed of kVAh register or driving element,
K = constant taking into account the number of phases of the system and the meaning given to R,
U = voltage,
I = current, and
E = percentage error of meter, that is:

$$100 \times \frac{\text{Registered kVAh} - \text{Actual kVAh}}{\text{Registered kVAh}}$$

A-2.3 Kilovolt Ampere Hour Meters for the Restricted Power Factor Range

It may be said with approximation that a kWh meter registers power in kVAh over a certain limited range of power factor. The rate of registration of kWh meter is:

$$R = KUI \left(1 + \frac{E}{100}\right) \cos \Phi$$

where

$\cos \Phi$ = the power factor, and
E = percentage error of kWh meter.

If this meter is used for the registration of kVAh, the terms $\cos \Phi$ becomes a source of additional error which considerably restricts the range of power factor for which the kWh meter can be considered as being a kVAh the error E inherent to the kWh meter and a theoretical error due to the position of the current vector, that is:

$$F = 100 \times \frac{KUI\,(1 + E\ 100)\,.\,\cos \Phi - KUI}{KUI} \text{ percent}$$

$$= (100 + E) \cos \Phi - 100 \text{ percent}$$

A-2.3.1 A suitably adjusted kWh meter could be used as a kVAh meter with:

a) limits of error with ± 1 percent over a power factor range of 0.98 lagging (θ_1 = 11°28′42″ lagging) to 0.98 leading (θ_u = 11°28′42″ lagging) to 0.98 leading (θ_u = 11°28′42″ leading), or
b) limits of error within ±2.5 percent over a power factor range of 0.95 leading (θ_u = 18°11′41.5″ lagging to 0.95 leading (θ_u = 18°11′41.5″ leading).

When a kWh is executed with phase displacement of voltage flux of each element by a lagging angle α, it will register kVAh within ±1 percent accuracy limits over a power factor range of α ±1 percent accuracy limits over a power factor range of α ±11°28′42″ or within ±2.5 percent accuracy limits over a power factor range of α ±18°11′41.5″

The rate of registration of such a meter is:

$$R = KUI \left(1 + \frac{E}{100}\right) \cos (\Phi - \alpha)$$

and the percentage error F becomes

$$F = (100 + E) \text{ Cos } (\Phi - \alpha) - 100.$$

This is a general formula for error in percent.

A-2.3.2 Since the term $100 \times \text{Cos } (\Phi - \alpha) - 100$ can only assume nonpositive values, the error E is given a suitable positive value to control the error F of the kVAh meter within the desired limits of ±1 percent or ±2.5 percent depending on the accuracy class. This error at the mean power factor '*m*' (corresponding to $\theta_m = \alpha$) is the error of the basic kWh meter at unity power factor at a particular load.

A-2.3.3 As is evident from **A - 2.3.2**, a kVAh meter of the type described can be used over a limited range of power factor with desired accuracy limits. Beyond this range the error becomes very rapidly negative.

As indicated in **3.1**, Table 1, the coverage of the tariff power factor range of kVA maximum demand, may be given by using more than one restricted power factor range kVAh meters.

a) with a power factor relay for change of voltage connection from one such meter to another when the power factor varies from one range to another, alternatively.

b) by keeping all the meters in circuit and considering the highest value of maximum demand reading of such meters as the kVA maximum demand, alternatively.

c) by activating only one register from the metering element having the highest torque, through mechanical/electrical means.

ANNEX B

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
722 (Part 1) : 1986	ac electricity meters: Part 1 General requirements and tests (*third revision*)
1271 : 1985	Thermal evaluation and classification of electrical insulation (*first revision*)
1401 : 1970	Accessability test probes (*first revision*)
3156 (Part 1) : 1992	Voltage transformers : Part 1 General requirements (*second revision*)
4905 : 1968	Methods for random sampling
6842 : 1977	Limits for electromagnetic interference
8530 : 1977	Maximum demand indicators (Class 1)
11731 (Part 1) : 1986	Methods of test for determination of flammability of solid electrical insulating materials when exposed to an igniting source: Part 1 Horizontal specimen method
12032 (Part 6) : 1987	Graphical symbols for diagrams in the field of electrotechnology: Part 6 Production and conversion of electrical energy
12360 : 1988	Voltage bands for electrical installations including preferred voltages and frequency

ANNEX C

(*Clause* 6.4.3)

RECOMMENDED METHODS OF CONNECTIONS OF CURRENT CIRCUIT CONDUCTORS TO METER TERMINALS

C-0 The current circuit conductors of a meter shall be connected to its current terminals inside the meter base adopting any of the following recommended methods so as to ensure satisfactory, durable and adequate contact surfaces between the conductors and the terminals.

C-1 The ends of current coils wound from round section wire or flat strip shall be formed into loops. Each complete loop shall be accommodated between a flat section of the top end of a current terminal and a flat rectangular or circular washer plate having central hole, the three being pressed together by a screw having sufficiently large head to cover the loops, the current terminals shall have thread for fixing of the screw. The washer plate shall be of good conducting materials and shall have spring action.

C-2 Current coils having rectangular section conductors of sufficient width shall have flattened ends. Each end shall be accommodated betweeen a flat section of the top end of a current terminal and a flat rectangular or circular washer plate, the three being pressed together by a screw having sufficiently large head to cover the flattened end of the current coil. The washer plate shall have holes for clear passage of the screw. The plate shall be of good conducting material and shall have spring action. In order to ensure proper gripping of the screw head, the central hole of the washer plate and the corresponding part of the screw head may be counter sunk.

C-3 In case where methods **C-1** or **C-2** cannot be satisfactorily adopted, especially where a number of rectangular section conductors or strips or wires have been used, the ends of current coils shall be terminated into elongated soldering-cum-crimping sockets having machined flat bottom ends which shall then be connected to meter current terminals by adopting method **C-2**. The soldering socket shall be of the same material as that of the current terminal.

ANNEX D

(*Clause* 9.1)

RECOMMENDATIONS FOR PACKING OF METERS

D-1 SINGLE-PHASE METERS (WITHOUT MAXIMUM DEMAND INDICATOR)

D-1.1 Adequate provisions may be made to suitably immobilize the rotor to avoid any damage or disturbance to the movement during transit.

D-1.2 Each meter may be suitably packed in the first instance to prevent ingress of moisture and dust, and then placed in a cushioned carton of a suitable material to prevent damage due to shocks during transit. The lid of the carton may be suitably sealed.

D-1.3 A suitable number of sealed cartons may be packed in a case of adequate strength with extra cushioning if considered necessary. The cases may then be properly sealed against accidental opening in transit.

D-1.4 The packing cases should be marked to indicate the fragile nature of the contents.

D-2 POLYPHASE METERS (WITH MAXIMUM DEMAND INDICATOR)

D-2.1 The packing method described in **D-1** is employed in addition to the protection specified in **D-2.1.1**.

D-2.1.1 Extra protection may be povided for the front glass and the maximum demand indicator resetting knobs.

ANNEX E

(*Clause* 10.2)

POWER FACTORS/POWER FACTOR ANGLES AND RELATIONSHIP WITH THEORETICAL ERROR

E-1 The variation of the theoretical error (*F*) of a kVAh meter for restricted power factor range with power factor angle (*s*) is illustrated graphically for five different power factor ranges within ± 1 percent error band in Fig. 1 and three different power factor ranges within ± 2.5 percent error band in Fig. 2.

E-2 Various values of relevant power factors and power factor angles are tabulated in Table 22 corresponding to different error curves as illustrated in Fig. 1 and 2. These values are useful for accurate setting of the current vector angles of each phase during testing/callibration of such kVAh meters vide **11.5**, Tables 12 and 13, and also for references to Tables 14 to 19.

E-3 During calibration of kVAh meters, the setting of power factor angles are to be carried out with precision of ± 0.5° for class 1 - 1 and 1 - 2 meters, and ±1° for class 2.5 - 2 meters, in each phase.

E-4 For calibration of kVAh meters as described in this standard, a high degree symmetry of voltage vectors is generally necessary. This is accomplished by:

a) setting each line to neutral voltage within ±0.5 percent divergence from the average value,
b) setting each voltage vector within 120 ±1° from each other, and
c) confirming each line to line voltage within ±1 percent divergence from the average value.

ANNEX F

(*Clause* 11.1.2.1)

RECOMMENDED SAMPLING PLAN

F-1 LOT

F-1.1 In any consignment, all the meters of the same type and rating manufactured by the same factory during the same period shall be grouped together to constitute a lot.

F-1.2 Sample shall be tested from each lot for ascertaining the conformity of these to the requirements of specified acceptance test.

F-2 SCALE OF SAMPLING

F-2.1 The number of meters to be selected from the lot depends upon the size of the lot and shall be in accordance with Table 21.

Table 21 Sampling Plan
(*Clauses* F-2.1 *and* F-3.1)

Lot Size	N_1[1)]	N_2[2)]	(N_1+N_1)	C_1	C_2
(1)	(2)	(3)	(4)	(5)	(6)
Up to 300	2	8	10	0	0
301 to 500	13	13	20	0	2
501 to 1 000	20	20	40	0	3
1 001 and above	32	32	64	1	4

1) Size of first sample.
2) Size of second sample.

F-2.2 The meters shall be taken at random from the lot. The procedure given in IS 4905 : 1968 may be adopted.

F-3 NUMBER OF TESTS AND CRITRIA FOR ACCEPTANCE

F-3.1 Tests for Running with No Load and Starting

A sample of N_1 meters selected according to col 2 of Table 21 shall be tested for the above tests. Any meter failing in any one of these shall be considered defective. If the number of defectives found in the sample is less than or equal to C_1 the lot shall be considered to be conforming to these tests. If the number of defective is greater than or equal C_2 the lot shall be considered as not conforming of these tests. If the number of defectives is between C_1 and C_2 a further sample of N_2 meters shall be taken according to col 2, 3 and Table 21 and subjected to these tests. If the number of defectives in two samples combined is less than C_2 the lot shall be considered as conforming to these tests, otherwise rejected.

F-3.2 Tests for Insulation Resistance, Limits of Error and Interpretation of Tests Results and Adjustment (if Required)

From the samples of meters which have been drawn according to **F-3.1** and those that have passed all tests of **F-3.1**, a sample of 8 meters shall be tested, all of which shall pass for conformity to these tests. If any one of the meters fails in any of these tests, the whole lot shall be declared not conforming to the requirements of these tests.

F-3.3 The lot shall be considered as conforming to this standard, if provisions of both **F-3.1** and **F-3.2** are statisfied.

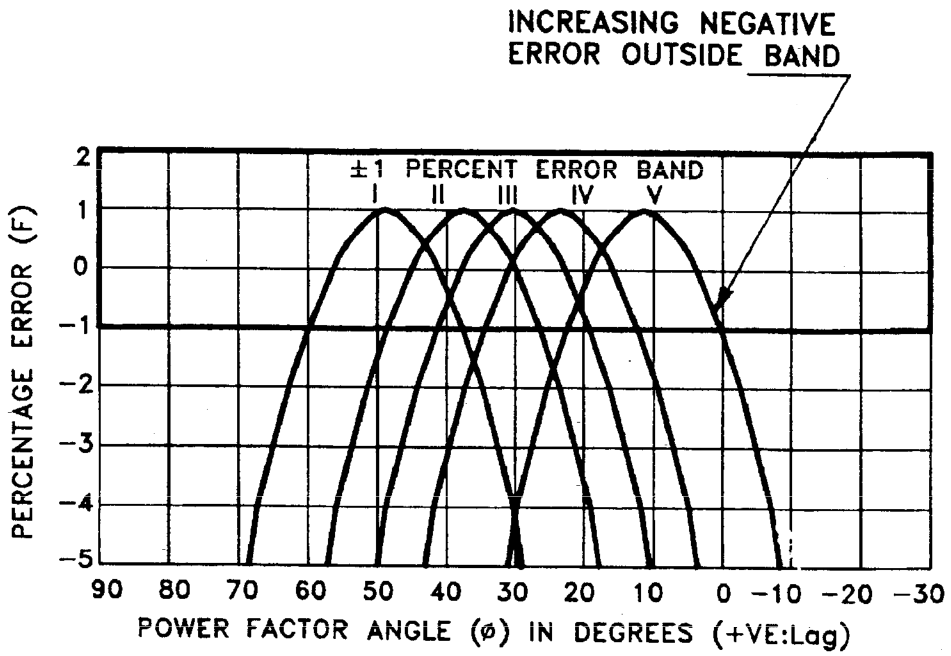

FIG. 1 THEORETICAL ERROR *VS* POWER FACTOR ANGLE-ERROR BAND ±1 PERCENT

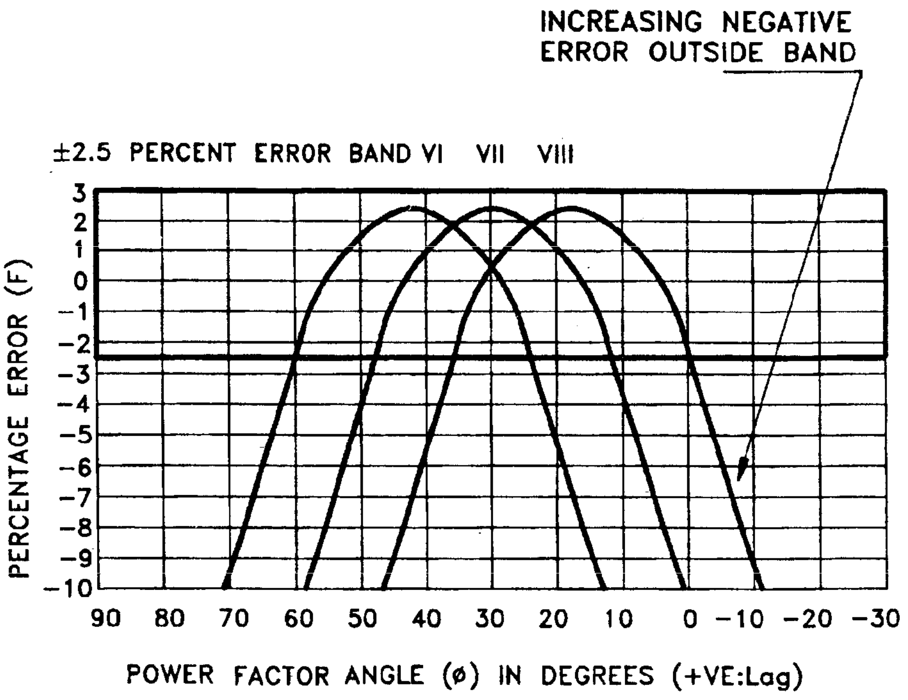

FIG. 2 THEORETICAL ERROR *VS* POWER FACTOR ANGLE-ERROR BAND ± 2.5 PERCENT

Table 22 Values of Power Factor and Power Factor Angles for Different Error Curves

(*Clause* E-2)

Accuracy Class	Curve No.	Restricted P.F. Range	Power Factor Values					Power Factor Angles				
			l	*l*0	*m*	*u*0	*u*	Φl	Φ *l*0	Φ m	Φ u0	Φ u
1 -1 and 1 - 2 (Fig. 1)	I	0.5 to 0.8	0.500 0	0.550 0	0.662 3	0.761 4	0.798 2	60°0′0″	56°37′54″ (56.632°)	48°31′18″ (48.522°)	40°24′44.5″ (40.412°)	37°2′36″ (37.043°)
	II	0.66 to 0.9	0.662 3	0.705 2	0.798 2	0.875 2	0.902 1	48°31′18″ (48.522°)	45°9′9.5″ (45.153°)	37°2′36″ (37.043°)	28°56′0″ (28.933°)	25°33′54″ (25.565°)
	III	0.75 to 0.95	0.749 2	0.786 8	0.866 7	0.927 9	0.948 2	41°28′42″ (41.478°)	38°6′34.5″ (38.110°)	30°0′0″	21°53′25.5″ (21.890°)	18°31′18″ (18.522°)
	IV	0.82 to 0.98	0.824 8	0.856 6	0.920 8	0.966 6	0.980 0	34°26′6″ (34.435°)	31°3′60″ (31.067°)	22°57′24″ (22.957°)	14°50′50.5″ (14.847°)	11°28′42″ (11.478°)
	V	0.92 to 1.0	0.920 8	0.942 1	0.980 0	0.998 3	1.00 0	22°57′24″ (22.957°)	19°35′15.5″ (19.588°)	11°28′42″ (11.478°)	3°22′6″ (3.368°)	0°0′0″
2.5 - 2 (Fig. 2)	VI	0.5 to 0.9	0.500 0	0.578 7	0.745 4	0.874 9	0.916 3	60°0′0″	54°38′37″ (54.644°)	41°48′18.5″ (41.805°)	28°57′59″ (28.966°)	23°36′37″ (23.610°)
	VII	0.67 to 0.98	0.666 6	0.733 3	0.866 7	0.955 5	0.978 8	48°11′41.5″ (48.195°)	42°50′19″ (42.839°)	30°0′0″	17°9′41″ (17.161°)	11°48′18.5″ (11.805°)
	VIII	0.8 to 1.0	0.805 0	0.856 9	0.950 0	0.995 6	1.000 0	36°23′23″ (36.390°)	31°2′1″ (31.034°)	18°11′41.5″ (18.195°)	5°21′23″ (5.356°)	0°0′0″

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