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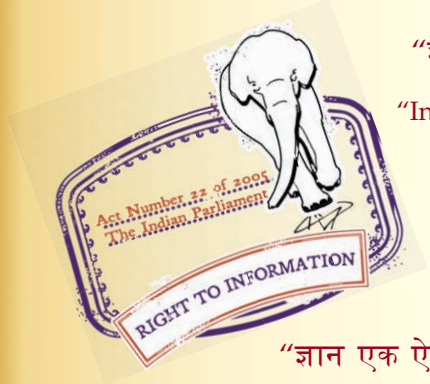
IS 5142 (1969): Continuously variable voltage auto transformers [ETD 16: Transformers]



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IS : 5142 - 1969

Indian Standard

SPECIFICATION FOR CONTINUOUSLY VARIABLE VOLTAGE AUTO-TRANSFORMERS

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

Gr 4 *October* 1969

Indian Standard

SPECIFICATION FOR CONTINUOUSLY VARIABLE VOLTAGE AUTO-TRANSFORMERS

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SPECIFICATION FOR CONTINUOUSLY VARIABLE VOLTAGE AUTO-TRANSFORMERS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 16 June 1969, after the draft finalized by the Instrument Transformers Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 Variable voltage auto-transformers are generally used to control current, power, etc, by controlling the voltage. Such transformers are commonly used in laboratories. They are also used to control heat, light, etc, which are sensitive to voltage change.

0.3 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*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard covers natural dry type and oil immersed manually operated, torroidally wound continuously variable voltage auto-transformers. Motor operated variable voltage auto-transformers and variable voltage auto-transformers having a partial variation of output voltage are not covered in this standard.

2. TERMINOLOGY

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

2.1 Auto-Transformer — A transformer in which the electrical circuit is single wound and common partly or wholly between the primary and secondary circuits.

2.2 Continuously Variable Voltage Auto-Transformer — An auto-transformer wherein the input voltage being fixed, the output to input

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

voltage ratio can be varied continuously by a brush in contact with the conductor of the transformer winding.

2.3 Oil Immersed Transformer — A transformer having the core and the winding, immersed in a mineral oil or a synthetic insulating liquid.

2.4 Dry Type Transformer — A transformer whose core and winding are surrounded by air and are not immersed in any insulating oil.

2.5 Terminal — The part of a transformer intended to receive external connections.

2.6 Tapping — A connection brought out of a winding at some point between its extremities.

2.7 Brush — A brush is a conductor, serving to maintain an electrical connection between stationary and moving parts of a machine or apparatus.

2.8 Rating — A statement of operating limitations assigned to the transformer by the manufacturer under the specified conditions.

2.9 Rated Frequency — The value of the frequency on which the performance of the transformer is based.

2.10 Rated Output Current — The current which the transformer can deliver to the output circuit at the maximum output voltage under steady loading conditions without exceeding the specified temperature rise.

2.11 Service Conditions — External factors (atmospheric conditions, air temperature, voltage changes, etc) which may influence the performance of the transformer.

2.12 Type Test — Test carried out to prove conformity with the requirements of this specification. These are intended to prove the general quality and design of a given type of a transformer.

2.13 Routine Test — Test carried out on each transformer to check requirements likely to vary during production.

3. RATING

3.1 Rated Voltage — The rated voltage of the continuously variable voltage auto-transformers shall be as follows:

No. of Phases	*Input Voltage* Volts	*Output Voltage* Volts
Single Phase	240	0 to 240 *or* 0 to 270
3-Phase	415	0 to 415 *or* 0 to 470

3.2 Rated Frequency — The rated frequency shall be the standard frequency of 50 Hz.

3.3 Rated Output Current The rated output current of the transformer shall be one of the following values:

1, 2, 2·5, 4, 6·3, 8, 10, 16 amperes and their decimal multiples.

NOTE — The underlined values are the preferred rated currents.

4. INSULATING MATERIALS

4.1 Solids — For transformers immersed in oil or synthetic liquid, Class A insulating material specified in IS 1271-1958* is recognized.

4.2 Liquids

4.2.1 *Mineral Oil* — It shall comply with IS 335-1963†.

4.2.2 *Synthetic Liquids* — In the absence of a standard on synthetic insulating liquids, the provision of such liquids is a matter of agreement between the manufacturer and the purchaser.

NOTE — Oil and synthetic liquids should not be interchanged or mixed.

5. CONSTRUCTION

5.1 Indicator Disc — An indicator disc shall be provided with graduated markings showing the full range of output voltage at no load as percentage of rated maximum output voltage. Alternatively, the graduations may be marked to indicate the output voltage in volts.

5.1.1 The smallest graduation shall be 2 percent or 5 volts as the case may be.

5.1.2 In the case of regulating variable voltage auto-transformers where many rotations of the operating handle have to be made, the output voltage may be indicated by providing a voltmeter instead of an indicator disc. In such a case a pointer as required in **5.2** shall not be necessary.

5.2 Operating Handle (Knob) — An operating handle shall be provided for continuously varying the output voltage in its entire range. The handle shall also include a pointer to read the output voltage on the indicator disc. The movement of the operating handle shall be such that the output voltage increases when it is moved in clockwise direction.

5.3 Terminals — The terminals shall be adequately designed to carry the rated output current continuously.

*Classification of insulating materials of electrical machinery and apparatus in relation to their thermal stability in service.

†Specification for insulating oil for transformers and switchgear (*revised*)(Since revised).

5.4 Brushes — The brushes which make contact with and carry current from the uninsulated portion of the winding should be made of high grade carbon or any other suitable material. It should be capable of withstanding a minimum of 10 000 operations under the specified test conditions (*see* **10.2**).

6. INSULATION LEVELS

6.1 Test Voltage – The transformer shall be capable of withstanding a voltage of 2·5 kV (rms) at the rated frequency, for one minute, when applied between the winding terminals and the body of the transformer which shall be earthed.

7. LIMITS OF TEMPERATURE-RISE

7.1 The temperature-rise of any transformer above the cooling air temperature when tested in accordance with **10.7** shall not exceed the following limits:

a) *Windings* — Average temperature-rise as measured by increase in resistance of the winding (*see* **10.7**), and	55°C
b) In case of oil cooled transformers, temperature-rise as measured by thermometer in top oil.	45°C

NOTE — The reference ambient temperature for the purpose of temperature-rise measurement shall be 40°C.

7.2 The correction of temperature-rise with respect to the altitude shall be done in accordance with Appendix A.

8. TERMINAL MARKINGS

8.0 The transformers shall have a minimum of three and a maximum of five terminations for each winding. There shall be one winding for each phase.

8.1 Table Mounting Transformers

8.1.1 In case of table mounting or wall mounting or front of panel mounting type transformers, the extreme end terminal of the winding, which is common to both the input and output circuits shall be designated as *C* as shown in Fig. 1A. The other extreme terminal being designated as *A*.

8.1.2 The terminal *C* in case of table mounting transformer, shall be so chosen that the output voltage increases with the rotation of the operating handle or knob in clockwise direction.

8.1.3 In case of transformers having their maximum output voltage more than the input voltage (*see* Fig. 1B), the tapping on the winding at which the input is given shall be designated as *B*.

8.2 Flush Mounting Transformers

8.2.1 In case of flush mounting type or back of panel mounting type of transformers the extreme end terminal of the winding which is common to both the input and output circuits, shall be designated as *A* as shown in Fig. 1C. The other extreme terminal being designated as *C*.

8.2.2 The terminal *A*, in case of flush mounting transformers, shall be so chosen that the output voltage increases with the rotation of the operating handle or knob in clockwise direction

8.2.3 In case of transformers, having their maximum output voltage more than the input voltage (*see* Fig. 1D), the tapping on the winding at which the input is given shall be designated as *D*.

8.3 The terminal to which the brush is connected shall be designated as *E*.

9. MARKING

9.1 Terminal Marking Plate — A plate shall be provided with a diagram inscribed on it showing the terminal markings as given in **8** with the relative electrical positions.

9.2 Rating Plate — All transformers shall have the following information marked on it or on a label permanently attached to it:

a) A reference of this standard, that is, 'Ref IS : 5142-1969,

b) Manufacturer's name and country of manufacture,

c) Manufacturer's serial number,

d) Rated output current,

e) Rated input voltage,

f) Rated output voltage range,

g) Rated frequency,

h) Number of phases, and

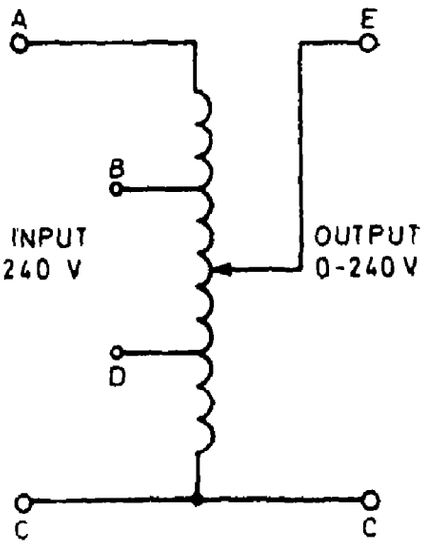
i) Type of cooling *ON*, *SN*, *AN*.

NOTE — The designation *ON*, *SN* and *AN* shall indicate the following type of cooling:

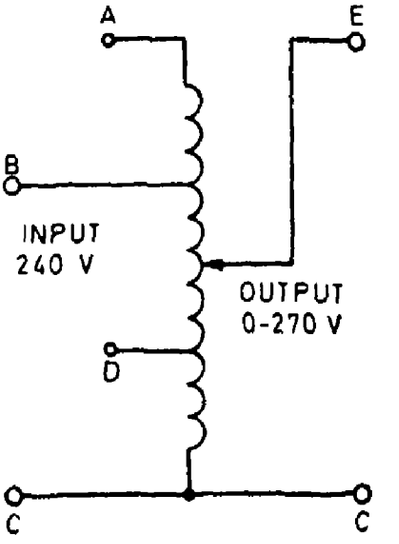
ON — Natural oil cooled,

SN — Natural synthetic liquid cooled, and

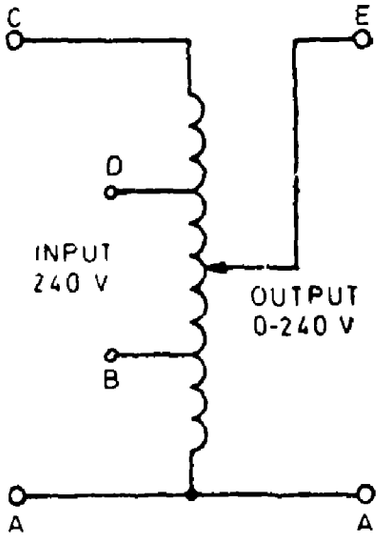
AN — Natural air cooled.



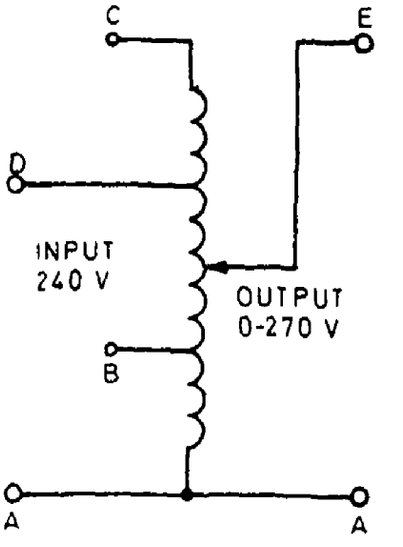
1A Table Mounting, Normal Range



1B Table Mounting, Higher Range



1C Flush Mounting, Normal Range



1D Flush Mounting, Higher Range

FIG. 1 TERMINAL MARKINGS FOR SINGLE PHASE VARIABLE VOLTAGE AUTO-TRANSFORMERS

10. TESTS

10.0 Conditions for Tests

10.0.1 Tests shall be made at the manufacturer's works at room temperature and with all those external fittings in place which are likely to affect the performance.

10.0.2 The test basis for all characteristics except insulation is rated condition, unless specifically stated otherwise.

10.1 Classification of Tests

10.1.1 The following shall comprise the type tests:

a) Endurance test (**10.2**),
b) No-load current test (**10.3**),
c) Variation of output voltage test (**10.4**),
d) Load losses test (**10.5**),
e) Insulation resistance test (**10.6**),
f) Temperature-rise test (**10.7**),
g) High voltage test (**10.8**), and
h) Induced voltage test (**10.9**).

10.1.2 The following shall comprise the routine tests and shall be carried out on all transformers:

a) No-load current test (**10.3**),
b) Variation of output voltage test (**10.4**),
c) Load losses test (**10.5**),
d) Insulation resistance test (**10.6**),
e) High voltage test (**10.8**), and
f) Induced voltage test (**10.9**).

10.2 Endurance Test — The brushes should be operated over the entire range of the transformer 10 000 times starting from minimum voltage to full output voltage and back to the starting position. The value of the connected load shall be such that full rated output current flows at maximum rated output voltage, the power factor of the test load being unity. The frequency of operation shall be limited to thousand operations per hour. When the brushes are being moved, sparking, if any, should be negligible. After this test the transformer shall pass all the remaining type and routine tests.

10.3 No-Load Current Test — The no-load current shall be measured at rated frequency with the rated voltage applied to the input terminals, the output terminals being kept open circuited. The no-load current shall not be in excess of 5 percent of rated output current.

10.4 Variation of Output Voltage Test — For this test a voltmeter of accuracy class not higher than 0·5 shall be connected across the output terminals with the rated voltage applied to the input terminals. The output voltage shall be varied from zero to the maximum rated output

voltage in four steps of 25 percent. The reading of voltmeter at each setting shall not differ by more than two percent the reading on the indicator disc or the reading on the integral voltmeter as the case may be.

10.5 Load Losses Test — The output voltage on the indicator disc shall be set at half of the input voltage value. The output terminals shall be short-circuited through an ammeter. The load losses shall be measured by wattmeter method by applying to the input terminals a voltage required to produce the rated current at rated frequency in the short-circuited output terminals. The measured load losses when corrected to 75°C shall not differ by more than ten percent from the guaranteed load losses at 75°C.

10.6 Insulation Resistance Test — The insulation resistance between the terminals and the body of the transformer shall be measured and recorded. It shall not be less than 5MΩ when measured at 500 V dc at room temperature not exceeding 40°C.

10.7 TEMPERATURE-RISE TEST

10.7.1 The test may be made at any room temperature not exceeding 40°C. For the purpose of this test, the transformer shall be loaded to full rated current in accordance with **10.7.1.1** and **10.7.1.2** under both the conditions mentioned therein and the higher of the two values obtained should be taken for the purpose of temperature-rise test.

10.7.1.1 *Table mounting transformers*

a) Input between terminals *B* and *C* and output between terminals *A* and *C* (*see* Fig. 1).

b) Input between terminals *B* and *C* and output between terminals *A* and the middle point of *A* and *C*.

10.7.1.2 *Flush mounting transformers*

a) Input between terminals *A* and *D* and output between terminals *A* and *C*.

b) Input between terminals *A* and *D* and output between terminals *C* and the middle point of *A* and *C*.

10.7.2 Temperature-rise of transformers shall be measured by resistance method and in case of oil cooled transformers may be measured by thermometer in oil or resistance method.

10.7.3 To measure the temperature-rise by resistance method, the resistance should be measured between terminals *A* and *B* for table

AMENDMENT NO. 2 MAY 1978

TO

IS : 5142-1969 SPECIFICATION FOR CONTINUOUSLY VARIABLE VOLTAGE AUTO-TRANSFORMERS

Alteration

(*Page* 11, *clause* **10.9**) — Substitute the following for the existing clause:

'**10.9 Induced Voltage Test** — To test the inter-turn insulation of the winding an ac voltage shall be applied to the terminals of winding for a single phase transformer and to the terminals of one winding at a time for a three phase transformer. The magnitude of the test voltage between any two terminals shall be twice the voltage appearing between those terminals when rated input voltage is applied to the input terminals. The test voltage shall be applied for 60 seconds for any frequency up to and including twice the rated frequency. When the test frequency exceeds twice the rated frequency the duration of the test shall be:

$$\frac{120 \times (\text{rated frequency})}{\text{test frequency}} \text{ seconds}$$

but not less than 15 seconds. The voltage shall be satisfactorily withstood .'

Addendum

(*Page* 7, *clause* **9.2**) — Add the following new clause after **9.2**:

'**9.2.1** The transformers may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.'

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mounting transformers and between terminals *C* and *D* for flush mounting transformers, which carries major portion of the current.

NOTE — The resistance of the winding between terminals *A* and *B* for table mounting transformers and *C* and *D* for flush mounting transformers being very small, special precautions should be taken to measure it accurately, otherwise the errors in the measurements will be magnified in the results and may lead to wrong conclusions

10.7.4 Transformers, having their maximum output voltage equal to input voltage, should be loaded in accordance with **10.7.1.1**(b) and **10.7.1.2**(b) and the temperature-rise should be measured by resistance method. The resistance of the whole winding, that is, between terminals *A* and *C* should be measured

10.7.5 Methods of temperature measurement are given in Appendix B.

10.8 High Voltage Test — The test voltage as specified in **6.1** shall be applied at rated frequency for one minute between the winding and the body of the transformer which shall be earthed. This test shall be carried out immediately after the temperature-rise test There shall be no disruptive discharge.

10.9 Induced Voltage Test — To test the inter turn insulation of the winding, an ac voltage shall be applied to the terminals of winding for a single phase transformer and to the terminals of one winding at a time for a three phase transformer. The magnitude of the test voltage between any two terminals shall be twice the voltage appearing between those terminals when rated input voltage is applied to the input terminals The voltage shall be satisfactorily withstood.

APPENDIX A

(Clause 7.2)

CORRECTION FOR TEMPERATURE-RISE

A-1. TEMPERATURE CORRECTION FOR ALTITUDE

A-1.1 When the transformers, intended for service at high altitudes are tested near sea level the limits of the temperature-rise of the windings and oil given under **7.1** shall be reduced by $H/500$°C in case of natural air cooled transformers, where H is the excess over 1 000 metres of the altitude of the site above sea level. If, however, the ambient temperature at site is lower than the reference ambient temperatures, advantage shall be taken of the difference to off-set any reduction in temperature-rise on account of altitude.

A-1.2 No correction shall be made for altitudes below 1 000 metres nor shall any correction be made for greater altitudes if the prevailing ambient temperatures at site are so much lower than the standard reference ambient temperatures as to fully off-set or more than off-set the reductions based on altitudes.

APPENDIX B

(*Clause* 10.7.5)

METHODS OF TEMPERATURE MEASUREMENT

B-1. SELF-RESISTANCE METHOD

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

B-1.1.1 The temperature of the winding as measured by thermometer before beginning the test should not differ from that of the surrounding medium. The initial resistance and the initial temperature of the winding should be measured, under steady temperature conditions, at the same time.

B-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 deg 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:

$$\frac{R_2}{R_1} = \frac{T_2 + 234{\cdot}5}{T_1 + 234{\cdot}5}$$

or

$$T_2 = \frac{R_2}{R_1}(T_1 + 234{\cdot}5) - 234\,5$$

B-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.

B-1.2 Limitation of the Self-Resistance Method — The method of testing by increase of 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.

B-2. THERMOMETER METHOD

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

B-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 current may produce sufficient heat to yield misleading results.

B-2.3 When thermometer is used to measure the temperature of 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.

B-3. THERMOCOUPLE METHOD

B-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 : 2053-1962*).

B-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 circuit shall be earthed to minimize the possibility of capacitance currents.

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

B-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.

B-4. MEASUREMENT OF AMBIENT TEMPERATURE

B-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 ambient temperatures, and the mean reading shall be adopted.

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*Specification for thermocouple pyrometers, (Since revised).

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