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**6 kV Encapsulated-winding
distribution transformers**

ICS 29.180

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS C 4306 : 1991** is replaced with this Standard.

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6 kV Encapsulated-winding distribution transformers

1 Scope This Japanese Industrial Standard specifies transformers with a rated power not exceeding 500 kVA and a rated frequency of 50 Hz or 60 Hz in the category of 6 kV single-phase or three-phase indoor self-cooled encapsulated-winding transformers used for the purpose of general power distribution (hereafter referred to as “transformers”).

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS C 1502 *Sound level meters*

JIS C 1505 *Precision sound level meters*

JIS K 6911 *Testing methods for thermosetting plastics*

3 Definitions For the purpose of this Standard, the following principal definitions apply:

a) **General**

- 1) **transformer** A static induction device with an iron core and two windings which, by electromagnetic induction, transforms a system of alternating voltage and current into another system of different voltage and current and at the same frequency for the purpose of transmitting electrical power.
- 2) **single-phase transformer and three-phase transformer** A single-phase transformer means a transformer which carries out transfer of single-phase power individually, and a three-phase transformer means a transformer which carries out transfer of three-phase power individually.
- 3) **encapsulated-winding transformer** A transformer in which all the surfaces of primary winding and of secondary winding are covered with a resin(s) or an insulating base material including a resin(s).
- 4) **thermal class** Classification in accordance with heat resistant characteristic of insulating material which constitutes a transformer.

b) **Meteorological data with respect to cooling**

- 1) **daily average temperature** $\frac{1}{2}$ of the sum of the highest temperature and the lowest temperature in a day.
- 2) **monthly average temperature** $\frac{1}{2}$ of the sum of the average value of daily highest temperature and the average value of daily lowest temperature during a particular month over many years.
- 3) **yearly average temperature** $\frac{1}{12}$ of the sum of monthly average temperatures.

c) **Winding**

- 1) **winding** The assembly of turns forming an electrical circuit associated with one of the voltages assigned to the transformer.
- 2) **phase winding** The assembly of turns forming one phase of a three-phase winding.
- 3) **primary winding** The winding which receives the power from power supply side circuit under operation. The side of 6 kV is called primary.
- 4) **secondary winding** The winding which sends the power to load side circuit under operation. The side of 210 V is called secondary.

d) **Ratings**

- 1) **rating** Those numerical values assigned to the quantities which define the operation of the transformer in the conditions specified in this clause of this Standard and on which the manufacturer's guarantees and the tests are based.
- 2) **rated frequency** The frequency at which the transformer is designed to operate.
- 3) **rated voltage** The voltage assigned to be applied, or developed at no-load, between the terminals of a primary winding and secondary winding connected to the principal tapping. It is expressed by the r.m.s. value.

Remarks : When the rated voltage is applied to a winding, the other winding induces its rated voltage under no-load.

- 4) **rated power** The apparent power entered on the rating plate which is available between the secondary terminals without exceeding the limit of temperature rise specified in this Standard, at the rated secondary voltage, rated frequency and rated power factor. It is expressed by kilo volt ampere (kVA).
- 5) **rated power factor** The power factor at which a transformer is designed for service.
- 6) **rated current** The line current which is obtained by dividing the rated power with the rated voltage and the appropriate phase factor. It is expressed by the r.m.s. value.

Phase factor

Number of phases	Phase factor
1	1
3	$\sqrt{3}$

e) **Tapping**

- 1) **principal tapping** The tapping to which the rated quantities are related.
- 2) **tapping voltage** The assigned voltage to be applied across line terminals of the winding at an optional tapping under no-load.

- 3) **voltage between tappings** The difference between two adjacent tapping voltages.
- 4) **tapping range** The difference between the highest tapping voltage and the rated voltage and the difference between the lowest tapping voltage and the rated voltage.
- 5) **full-power tapping voltage** A tapping voltage at which a transformer is capable of being used at the rated power without exceeding the specified limit of temperature rise.
- 6) **reduced-power tapping voltage** A tapping voltage at which the rated power must be reduced to use a transformer without exceeding its specified limit of temperature rise.
- 7) **tapping current** The line current which is obtained by dividing the power of a winding with its tapping voltage and the appropriate phase factor. It is expressed by the r.m.s. value.

f) **Characteristics**

- 1) **no-load current** The r.m.s. value of the line current flowing through a winding when rated voltage is applied at rated frequency, the other winding(s) being open-circuited. It is expressed by the percentage (%) of the rated current of the winding.
Remarks : For a three-phase transformer, the average value of all the currents is taken, if the no-load currents are different from each other.
- 2) **no-load loss** The active power absorbed when rated voltage at rated frequency is applied to one of the windings, the other winding(s) being open-circuited.
Remarks : The no-load loss includes iron loss, resistance loss due to no-load current, dielectric loss in insulation, etc.
- 3) **transformation ratio** The voltage ratio of two windings under no-load, with secondary winding being the reference.
- 4) **specified transformation ratio** The voltage ratio entered on the rating plate. It is expressed with the secondary voltage being the reference.
- 5) **reference winding temperature** The reference temperature for calculation of such characteristic values as load loss and short-circuit impedance. It is expressed by °C.
- 6) **load loss** The absorbed active power when rated current is passed through one winding by applying a voltage at rated frequency while terminals of the other winding are short-circuited. The load loss shall be expressed by the value corrected to the specified reference winding temperature.
- 7) **efficiency** The ratio of active output to (active output + no-load loss + load loss) at rated secondary voltage and rated frequency. It is expressed by percentage (%).
- 8) **short-circuit impedance** The impedance converted to that of equivalent star connection measured at rated frequency and referring to a particular

tapping, across the terminals of one winding of a pair, when the terminals of the other winding are short-circuited. Unless otherwise specified, the value at the principal tapping is expressed by the percentage (%) of the reference impedance of the winding measured. The short-circuit impedance is expressed by the value converted to that at reference winding temperature. The reference impedance is expressed by the following formula using tapping voltage and rated power of each winding:

$$\text{Reference impedance} = \frac{(\text{Tapping voltage})^2}{\text{Rated power}}$$

A short-circuit impedance expressed by percentage is equal to the ratio of the applied voltage which passes the tapping current while the other winding is short-circuited to the tapping voltage in percentage.

- 9) **balance of single-phase 3-wire system** The degree of electromagnetic balance of each group of windings when unbalanced loads are applied on two groups of windings of a single-phase transformer.
- 10) **voltage regulation** The ratio obtained by dividing the arithmetical difference between the voltage produced across terminals of one winding when the voltage stated below is applied to the other winding at the specified load and power factor, and the no-load voltage, with the voltage stated below. It is expressed by percentage (%).
- 10.1) Rated voltage when the transformer is connected to the principal tapping.
- 10.2) The tapping voltage when the transformer is connected to another tapping.
- g) **Temperature**
 - 1) **temperature rise** The difference between the temperature measured on each part of a transformer and the reference ambient temperature.
 - 2) **reference ambient temperature** The ambient temperature to be taken as the reference when temperature rise of a transformer is determined.
- h) **tolerance** The allowable range of difference between the specified value or guaranteed value and the test result.
- i) **terminals and neutral point**
 - 1) **line terminal** A terminal intended for connection to a line conductor of an external network.
 - 2) **neutral terminal** There are two kinds of neutral point given below.
 - 2.1) The terminal connected to common point of a star-connected winding, for three-phase transformers.
 - 2.2) The terminal intended for connection to a neutral point of a network, for single-phase transformers.
 - 3) **neutral point** Neutral point has the following two meanings:

- 3.1) The point in a three-phase balanced circuit which is normally at zero potential.
- 3.2) The common connected point in a star-connected three-phase circuit.

j) **Connections**

- 1) **star connection** The winding connection so arranged such that each of the phase windings of a three-phase transformer is connected to the neutral point i.e. common point and the other end to its appropriate line terminal.
- 2) **delta connection** The winding connection so arranged such that the phase windings of a three-phase transformer are connected in series to form a closed circuit.
- 3) **phase displacement** The angular difference between the phasors representing the voltages between the neutral point and the corresponding terminals of two windings.
- 4) **exclusive connection for single-phase 3-wire system** Such a connection system that secondary windings of a single-phase transformer are connected exclusively for single-phase 3-wire distribution system.

k) **Noise level**

- 1) **noise level (A characterized sound pressure level)** Ten times the ratio, in common logarithm, of the square of the r.m.s. value of the sound pressure weighted by the characteristics A specified in **JIS C 1502** or **JIS C 1505** (P_A) to the square of reference sound pressure P_0 ($20 \mu P_a$). This is expressed by unit symbol dB.
- 2) **reference radiant plane** The plane from which the sound is radiated, which is assumed on the circumference of the transformer.
- 3) **measuring plane** A plane distant from the reference radiant plane by the specified spacing on which the measurement is made.
- 4) **background noise** The ambient noise condition at the time of the noise measurement, i.e. the noise level at the transformer measurement plane when the transformer is stopped.

l) **Classification of tests**

- 1) **routine tests** The test carried out generally on individual transformers.
- 2) **type tests** The tests carried out on a representative transformer, for the items not included in the routine tests, to verify that the transformer is complying with the specified requirements.

Remarks : A transformer is considered to be representative if it is identical in its specifications and construction. The type tests which have been carried out on a transformer slightly different in specifications or other characteristics are considered effective subject to agreement between the purchaser and the manufacturer.

- 3) **special tests** The tests other than routine tests and type tests, which are carried out if especially specified.

4 Normal service conditions Normal service conditions mean such a state that all the service conditions stated below are satisfied; and unless otherwise specified transformers shall be used under the following conditions:

- a) **Altitude** Transformers shall be used in a height above sea-level not exceeding 1 000 m.
- b) **Ambient temperature** The ambient temperature shall be -5°C to $+40^{\circ}\text{C}$.
The daily average temperature shall not exceed 35°C , and the yearly average temperature shall not exceed 20°C .
- c) **Waveshape of supply voltage** The voltage waveshape of a circuit to which transformers are connected shall be approximately sinusoidal.
- d) **Symmetry of three-phase supply voltage** The voltages of three-phase circuit to which three-phase transformers are connected shall be approximately symmetrical.

5 Unusual service conditions When a transformer(s) is (are) used under the environment stated below, the purchaser shall show the environment of installation and the like.

- a) When the transformer(s) is (are) used under the conditions other than the normal service conditions specified in clause 4.
- b) When the load is intermittent.
- c) When the site is severely dirty due to sea breeze, dust, etc.
- d) When the site is in water vapour or in humid and moist conditions.
- e) When explosive, flammable, corrosive or other poisonous gas exists in the site.
- f) When the site is subjected to abnormal vibration or shock.

6 Classification by thermal class The classification by thermal class shall be as given in Table 1.

Table 1 Classification by thermal class

Unit: $^{\circ}\text{C}$

Thermal class	Permissible highest temperature
B	130
F	155
H	180

7 Ratings

7.1 Classification by rated power The classification by rated power shall be as stated in Table 2.

Table 2 Rated power

Unit: kVA

Classification	Rated power									
Single-phase	10	20	30	50	75	100	150	200	300	500
Three-phase	20	30	50	75	100	150	200	300	500	

7.2 Rated voltages The rated voltages shall be as given in Table 3.

Table 3 Rated voltages

Unit: V

Rated primary voltage	Rated secondary voltage	
	Single-phase	Three-phase
6 600	210-105	210

7.3 Tapping voltages The tapping voltages on primary winding shall be as given in Table 4.

Table 4 Tapping voltages

Rated power kVA	Tapping voltage V			
Not more than 50	6 300	6 000		
Not less than 75	6 750	6 450	6 300	6 150

Remarks 1 6 750 V, 6 450 V and 6 300 V are full power tapping voltages; and 6 150 V and 6 000 V are reduced power tapping voltages.

2 The tapping voltages of a single-phase transformer not exceeding 50 kVA may be 6 750 V, 6 450 V, 6 300 V and 6 150 V when especially specified.

7.4 Rated power factor The rated power factor shall be 100 % ($\cos\phi = 1$).

8 Performances

8.1 No-load current When the test is carried out in accordance with 10.3, the no-load current should preferably have the value specified in Table 5 for single-phase transformers and the value specified in Table 6 for three-phase transformers.