



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS C 4304 : 1999

6 kV Oil-immersed distribution transformers

ICS 29.180

Descriptors : transformers, oil-immersed transformers, single-phase transformers,
three-phase transformers, alternating-current transformers, electric power
distribution, outdoor electric equipment, distribution transformers

Reference number : JIS C 4304 : 1999 (E)

PROTECTED BY COPYRIGHT

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 4304 : 1977** is replaced with this Standard.

Date of Establishment: 1955-07-22

Date of Revision: 1999-11-20

Date of Public Notice in Official Gazette: 1999-11-22

Investigated by: Japanese Industrial Standards Committee
Divisional Council on Electricity

JIS C 4304 : 1999, First English edition published in 2004-01

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2004

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

Contents

	Page
1 Scope	1
2 Normative references	1
3 Definitions	1
4 Normal service conditions	6
5 Unusual service conditions	6
6 Classification by anti-pollution characteristic	6
7 Ratings	7
7.1 Classification by rated power	7
7.2 Rated voltages	7
7.3 Tapping voltages	7
7.4 Rated power factor	8
8 Performances	8
8.1 No-load current	8
8.2 No-load loss	9
8.3 Transformation ratio	9
8.4 Short-circuit impedance	9
8.5 Balance of single-phase 3-wire system	9
8.6 Voltage regulation	10
8.7 Efficiency	10
8.8 Limit of temperature rise	10
8.9 Dielectric strength	11
8.9.1 Applied potential withstand voltage	11
8.9.2 Induced withstand voltage	11
8.9.3 Lightning impulse withstand voltage	11
8.10 Noise	11
8.11 Ability to withstand short circuit	12
8.11.1 Thermal ability	12

8.11.2	Mechanical ability.....	12
8.12	Pollution performance of bushing.....	12
8.13	Variation in voltage and frequency.....	13
8.14	Tolerance	13
9	Construction	13
9.1	Construction in general.....	13
9.2	Bushing.....	14
9.3	Lead wire	14
9.4	Tap change-over terminals	14
9.5	Earth terminal	15
9.6	Connection of transformer	15
9.6.1	Single-phase transformer	15
9.6.2	Three-phase transformer	15
9.7	Terminal mark, polarity and phase displacement.....	15
9.7.1	For single-phase transformer	15
9.7.2	For three-phase transformer	16
9.8	Accessories	17
10	Tests.....	17
10.1	General matters relating to routine tests, type tests and special tests.....	17
10.1.1	Routine tests	17
10.1.2	Type tests	18
10.1.3	Special tests	18
10.2	Measurement of winding resistance.....	18
10.3	No-load current and no-load loss tests	18
10.4	Transformation ratio test, polarity test and phase displacement test ..	19
10.5	Load loss and short-circuit impedance tests	19
10.6	Test for balance of single-phase 3-wire system	21
10.7	Voltage regulation	22
10.8	Efficiency.....	23
10.9	Temperature rise test	23

10.9.1	Loading methods	23
10.9.2	Thermally equilibrium state	23
10.9.3	Methods for measurement and calculation of transformer temperature	23
10.9.4	Determination of reference ambient temperature	24
10.9.5	Temperature rise	24
10.10	Dielectric withstand voltage tests	25
10.10.1	Applied potential withstand voltage test	25
10.10.2	Induced withstand voltage test	25
10.10.3	Lightning impulse withstand voltage test.....	25
10.10.4	Repetitive withstand voltage tests	27
10.11	Noise test	27
10.11.1	Test method	27
10.11.2	Background noise	27
10.11.3	Measuring method of transformer noise level	28
10.11.4	Calculation method of transformer noise level	28
10.11.5	Correction for background noise	28
10.12	Test for ability to withstand short circuit	29
10.12.1	General.....	29
10.12.2	Thermal ability.....	29
10.12.3	Mechanical ability.....	30
10.13	Test for pollution performance of bushing	31
10.13.1	Test on finished product	32
10.13.2	Test of porcelain tube with lead wire	33
10.14	Construction test	33
11	Designation of product	33
12	Marking	34

6 kV Oil-immersed distribution transformers

1 Scope This Japanese Industrial Standard specifies 6 kV single phase or three-phase outdoor self-cooled oil-immersed transformers with a rated capacity not exceeding 500 kVA and a rated frequency of 50 Hz or 60 Hz 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 C 3609 *High-voltage drop wires for pole transformer*

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

a) General

- 1) **power 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 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) **oil-immersed transformer** A transformer of such construction that the iron core and windings are immersed in oil and the iron core, windings and insulating oil are cooled by natural convection of ambient air.
- 4) **thermal class** Classification in accordance with heat resistant characteristic of insulating material which constitutes a transformer.
- 5) **thermal class A** A thermal class with maximum allowable temperature of 105 °C.

b) Meteorological data with respect to cooling

- 1) **daily average temperature** $\frac{1}{2}$ of the sum of highest temperature and 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 power from the 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 under 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 its 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 tapplings** 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 by 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 each other.

- 2) **no-load loss** The active power absorbed when rated voltage at rated frequency is applied to one of the windings, while the other winding(s) being open-circuited.

Remarks : The no-load loss includes, iron loss, resistance loss of windings 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. This shall be 75 °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, by 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 terminal given below.
 - 2.1) The terminal intended for connection 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 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 that each of 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 can be used exclusively for single-phase 3-wire distribution system.
- 5) **common connection for single-phase 2-wire/single-phase 3-wire system** Such a connection system that secondary windings of a single-phase transformer can be used for single-phase 2-wire system or single-phase 3-wire system.

k) **Noise level**

- 1) **noise level (A characterized sound pressure level)** Ten times common logarithm of ratio between the square of the r.m.s. value of the sound pressure P_A weighted by the characteristics A specified in **JIS C 1502** or **JIS C 1505** and 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) **back ground 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 transformer.
- 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 represent other transformers if they are identical in their specifications and construction. The type tests which have been carried out on a transformer slightly

different in the 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) **Attitude** Transformers shall be used in a height above sea-level not exceeding 1 000 m.
- b) **Ambient temperature** The ambient temperature shall be -20°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 equilibrium.

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 exceedingly dirty due to sea breeze, dust, etc.
- d) When the site is in steam or in air with much moisture and water content.
- e) When explosive, flammable, corrosive or other poisonous gases exist in the site.
- f) When much ice and/or snow exist(s) in the site.
- g) When the site is subjected to abnormal vibration or shock.

6 Classification by anti-pollution characteristic The classification by anti-pollution characteristic of transformer bushings is as stated in Table 1.

Table 1 Classification by anti-pollution characteristic

Unit: mg/cm²

Classification	Degree of pollution (equivalent saline adherence)
General service	—
Heavy pollution service	Over 0.06 up to and incl. 0.12
Extra-heavy pollution service	Over 0.12 up to and incl. 0.35

Remarks : General service means the service in such an area that there is almost no saline effect, the equipment is contaminated mainly by dust, and special means to cope with saline pollution are not necessary, where the equivalent saline adherence is 0.01 mg/cm² as the target.

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	5	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.