इंटरनेट मानक

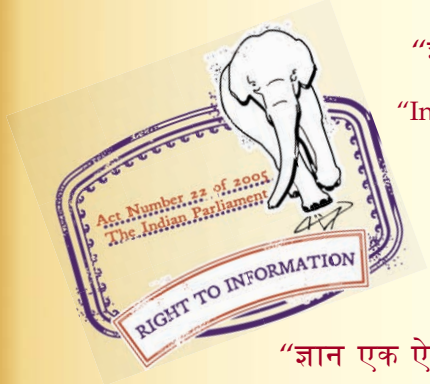
Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 12977 (1990): Arc Furnace Transformers [ETD 16: Transformers]



"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

IS 12977 : 1990
(Reaffirmed 2004)

भारतीय मानक

आर्क भट्टी ट्रांसफार्मर — विशिष्टि

Indian Standard

ARC FURNACE TRANSFORMERS — SPECIFICATION

UDC 621·314·212 : 621·365·2

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

February 1991

Price Group 3

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 20 March 1990, after the draft finalized by the Transformers Sectional Committee had been approved by the Electrotechnical Division Council.

This standard covers the service conditions and requirements of 3-phase or 1-phase, 50 Hz, mineral-oil-immersed indoor transformers for feeding electric power, from high voltage network, to direct arc steel-melting furnaces at a range of low voltages suitable for arc furnace operation.

The general design features of electric direct arc melting furnaces are covered in IS 12188 : 1987 Electric direct-arc melting furnace. This standard may therefore be read in conjunction with the above standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

ARC FURNACE TRANSFORMERS— SPECIFICATION

1 SCOPE

1.1 This standard lays down the requirements for 3-phase or 1-phase, 50 Hz, mineral-oil-immersed indoor transformers together with supplementary series reactor, if any, rated 250 kVA and above, primary voltage up to 33 kV, used for supplying electric power to direct arc melting furnaces.

1.1.1 The specification of series reactors, if built in the same main unit, are also included.

2 REFERENCES

2.1 A list of standards which have been referred in this specification is given in Annex A.

3 TERMINOLOGY

3.1 All characteristics and definitions, except as specifically covered in this standard shall be in accordance with IS 1885 (Part 38) : 1977.

4 SERVICE CONDITIONS

4.1 Reference Ambient Temperatures

The reference ambient temperatures assumed for the purpose of this specification are as follows:

a) Maximum ambient air temperature	50°C
b) Maximum daily average ambient air temperature	40°C
c) Maximum yearly weighted average ambient temperature	32°C
d) Minimum ambient air temperature	— 5°C
e) *Water* — When the cooling-medium is water, it is assumed that a temperature of 35°C will not be exceeded	
f) Temperature rise limits based on cooling water at 35°C at inlet	
g) Oil temperature rise	50°C
h) Winding temperature rise by resistance method	55°C
i) Cooling water temperature rise	10°C at rated load

4.1.1 Transformers complying with this specification are suitable for operation continuously, at their ratings provided the temperature of the cooling air or water does not exceed any of the reference ambient temperatures specified under **4.1.**

It is also recognized that operation of a transformer at its rated kVA provides normal life expectancy, if the hot spot temperature based on maximum yearly weighted average ambient temperature is 98°C.

4.1.2 For service conditions differing from the normal conditions mentioned above, it is recommended that above parameters be agreed upon after mutual agreement between the manufacturer and the purchaser.

4.2 Quantity of Cooling Water

The cooling water used for the arc furnace shall be as follows:

a) Total dissolved solids	150 ppm
b) Total hardness, *Max* (in terms of equivalent $CaCo_3$)	100 ppm
c) Carborate hardness, *Max*	50 ppm
d) *p*H value	7-8
e) Suspended particle	less than 100 ppm
f) Particle size, *Max*	0·1 mm

5 RATINGS

5.0 General

The manufacturer shall assign ratings to the transformer, which shall be marked on the rating plate. These ratings shall be such that the tranformer can deliver its rated current under steady loading conditions without exceeding the limits of temperature-rise specified in IS 2026 (Part 2) : 1977 assuming that the applied voltage is equal to the rated voltage and that the supply is at rated frequency.

5.1 Rated kVA

The rated kVA assigned shall take into account service conditions corresponding to those specified in **3** and shall be related to the product of rated voltage, rated current and the appropriate phase factor given in Table 1.

Table 1 Phase Factors

(*Clause* 5.1)

Number of Phases	Phase Factor
(1)	(2)
1	1
3	1·73

NOTES

1 The rated kVA assigned, corresponds to continuous duty; nevertheless oil-immersed transformers complying with this standard may be overloaded

and guidance on overloads is given in IS 6600 : 1972. Within the conditions defined in IS 6600 : 1972, occasional overloads up to 1·5 times the rated value may be allowed on transformers with rated powers up to 100 MVA. Under these conditions no limitations by bushings, tap-changers, or other auxiliary equipment shall apply. Regular daily overloads or emergency overloads in excess of this may be restricted by consideration of auxiliary equipment and in these cases reference shall be made to the manufacturer.

2 With rated voltage applied to one of the windings, the apparent power (kVA) that can really be delivered by (one of) the other winding(s) loaded with its rated current will deviate from its rated kVA by an amount depending on the corresponding voltage drop (or rise). This apparent power is equal to the product of the actual voltage on load of the latter winding, the rated current related to that winding and the appropriate phase factor (*see* Table 1).

5.2 Load Cycle

Unless otherwise agreed between the manufacturer and the user, the furnace transformer should be suitable for the following duty cycle:

120 percent of the continuous apparent power for 2 hours

60 percent of the continuous apparent power for 1 hour

No power for ½ hour

Total period of the load cycle is 3½ hours

5.3 RMS Value of the Loading Cycle

The maximum admissible continuous rated power is derived from the RMS value of the loading cycle, usually rounding up to a value slightly higher than the RMS value as preferred by the user.

6 TRANSFORMER TAPPINGS

6.1 A range of low voltages shall be provided to regulate power input to the furnace for optimizing furnace operation.

6.2 The various low voltages are obtained from a furnace transformer by changing taps provided on the high voltage windings. An additional range of low voltages may be obtained by changing connection of the tapped high voltage windings from delta to star in the case of 3-phase transformer or bank of 3-single phase transformers. The change-over in the connection must take place under de-energized condition.

6.3 The range of low voltages may be obtained by employing an auto-regulating transformer to give variable supply voltages to the primary side of a fixed ratio furnace tranformer, or by employing a series booster furnace transformer.

6.4 Unless otherwise asked for, it is assumed that no tappings are provided on a furnace transformer to compensate for variation in supply voltage. For applied high voltage of between 100 and 105 percent of the rating, the transformer shall be capable of delivering, for each connection, a maximum kVA equal to the rated kVA output of that connection at 100 percent applied high voltage without any injury. For applied high voltage of between 95 and 100 percent of the rating, the transformer shall be capable of delivering, for each connection, a maximum current equal to the rated current output of that connection at 100 percent applied high voltage.

6.5 The tappings shall be controlled by a tap-changer, preferably motor operated from a remote point. The tapchanger may be suitable for either de-energized or on-load operation depending upon the drive mechanism of the tapchanger must incorporate multi-position auxiliary radial switches necessary for electrode control or any other purchase, in addition to the one required for remote indication of the tap-changer. The number, the rating and sequence of operation of the switches shall be stipulated by the client.

6.6 In case of on-load tap-changer (OLTC), all the diverter switches of OLTC shall be immersed in oil in a separate compartment so that it will not be possible for oil from this chamber to mix with the oil in the main transformer tank. Also, the compartment shall permit easy removal of the diverter switch for maintenance.

7 SPECIFICATION OF TAPPING QUANTITIES

7.1 General

The tapping quantities are the numerical values which define the tapping duty. The tapping quantities include for each winding and each tapping:

a) a tapping voltage,

b) a tapping power; and

c) a tapping current.

7.2 Rated Tapping Quantities

The purchaser is to determine, from the expected on-load operating conditions of the furnace transformer, the tapping quantities to be specified at no-load.

7.3 Principal Tapping

The tapping at which the maximum rated voltage (or top voltage) is obtained on the secondary side of a furnace transformer corresponding to the rated voltage applied on the primary side, and whose tapping power is equal to the rated kVA of the transformer. The principal tapping is, therefore, also the maximum voltage tapping and corresponds to the maximum working induction in the core of a furnace transformer. Unless otherwise desired by the purchaser, the tap selector or voltage position for the principal tap shall be denoted by 1 in the voltage chart of the diagram of connections.

Unless otherwise stated, the losses and impedance shall be guaranteed at the principal tapping.

7.4 Full-Power Tapping — Reduced-Power Tapping

Depending upon the maximum line current required to flow through the electrode of a furnace, the current on the secondary side of a furnace transformer shall be kept constant at tap voltages lower than the rated voltage at which the maximum secondary current occurs. The tapping whose tapping power is equal to the rated kVA of the transformer is 'full-power tapping'. The tapping whose tapping power is lower than the rated kVA is 'reduced power' (or 'constant current') tapping.

7.5 Maximum Current Tapping

The maximum current tapping shall correspond to a voltage on the secondary side of a furnace tranformer at which the maximum current is derived and delivered to the furnace, and whose tapping power is equal to the rated kVA of the furnace transformer. For this tapping, the tapping current of both primary and secondary winding is simultaneously a maximum. Therefore, the maximum current tapping is also the maximum temperature rise tapping. While the losses and impedance may be guaranteed at the principal tapping (vide **5.5.3**), the temperature rise guarantee shall apply at the maximum current tapping.

7.6 Minimum Voltage Tapping

The minimum voltage tapping shall correspond to the minimum (or bottom) voltage in the range of secondary voltages of a furnace transformer. Unless otherwise desired by the purchaser, the tap selector or voltage position for this tapping shall be denoted by the highest tap position number in the voltage chart of the diagram of connections.

7.7 Tolerance

A tolerance of one percent or $\pm$ 1 volt whichever is smaller shall apply on the tapping quantities.

7.8 Calculation Procedure for the Tapping Quantities

The values of the six parameters as a function of the secondary voltages showing typical ratings and tapping voltages is shown in Table 2.

8 IMPEDANCE VOLTAGE

8.1 Transformer Impedance

The guaranteed transformer impedance shall be tested under the following conditions:

a) The rated kVA;

Table 2 Typical Ratings and Tapping Voltage

(*Clause* 7.8)

Switch Position	Voltage Ratio, n	H. V. Side			L. V. Side			Rated Power kVA or MVA	Tapping Designation
		Conn.	Volts (Line)	Current (Phase)	Conn.	Volts (Line)	Current (Phase)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Highest No.	n_{max}	Delta or Star	U_{HV} (rated)	I_{HV}* (reduced)	Delta	U_{LV} (min)	I_{LV} (max or constant)	** $S_{reduced}$	Reduced power constant current tapping
						*			Full power tapping
						*			Full power tapping
						*			Full power tapping
	n_1			I_{HV} (rated)		U_{LV} (full power)	I_{LV} (max)	S_{max} (or rated)	Full power max current tapping
				*		*		**	Reduced power
				I_{HV} (reduced)		U_{LV} (reduced power)	I_{LV} (max or constant)	$S_{reduced}$	constant current tapping
						*		**	
						*		**	
						U_{LV} (reduced power)			
1	n_{min} (or n_u)	Delta or Star	U_{HV} (rated)	I_{HV} (rated)	Delta	U_{LV} (max)	I_{LV} (rated)	S_{max} (or rated)	Principal tapping

*Values of voltages and currents to be calculated.

**Tapping power to be calculated.

b) The transformer connected at the principal tapping giving maximum secondary voltage;

c) The supplementary series reactor not in circuit;

d) The measurement made at the transformer terminals; and

e) The secondary delta closed and short circuited outside when secondary delta is not enclosed inside.

8.2 Reactor Impedance

The ratings of reactors and tappings shall be specified by the furnace designer purchaser.

8.2.1 Where transformer and reactor is a combined unit mounted inside a common tank and connected electrically inside, the impedance shall be guaranteed and measured for the combined unit with transformer connected to principal tap and reactor connected at a known tap position.

9 TERMINAL MARKING

9.1 The terminal markings, tappings and connectors shall conform to IS 2026 (Part 4) : 1977.

10 TEMPERATURE RISE

10.1 The transformer shall pass the temperature rise test specified in IS 2026 (Part 2) : 1977.

11 INSULATION LEVEL

11.1 The insulation levels shall be in accordance with IS 2026 (Part 3) : 1977.

12 SHORT CIRCUIT CHARACTERISTICS

12.1 Short-Circuit Capability

The furnace transformer including its tap changing equipment and supplementary series reactor shall be designed and constructed to withstand without damage the thermal and dynamic effects of external short-circuits in accordance with **8** and **9** of IS 2026 (Part 1) : 1977.

12.2 Short-Time Current Surges

The furnace transformer including its tap changing equipment and supplementary series reactor shall be capable of withstanding without injury an indefinite number of current surges as typically encountered in direct arc steel-melting furnace operation. It shall be assumed that the peak current in such surges will never exceed 3·0 times the crest value of the rated current. The thermal effects of surge currents shall be such as not to overload the transformer.

13 ACCESSORIES

13.1 The following items are to be included in addition of the standard accessories specified in IS 2026 (Part 1) : 1977:

a) On-load tap changer wherever provided shall have a separate oil surge relay or overpressure protective device.

b) For OFWF type transformers, following need to be provided:

i) Stand, by pump and heat exchangers;

ii) Oil-flow indicator with alarm contacts;

iii) For each heat exchanger pressure indication for pressure and flow indication for water; and

iv) Temperature and flow indication with alarm for the composite external cooling system.

14 TRANSFORMER CONNECTIONS

14.1 Connection of HV Phase Winding

The connections of HV phase winding shall be in star or delta or alternatively in star delta with a change over switch. The connection of low voltage phase winding shall be open suitable for closing outside in delta formation. The low voltage connection may be brought-out by 1 kV/ 3 150 amps bushings single or 2 in parallel for currents up to 5 000 amps and thereafter by air cooled bars on tap or side of the transformer, for closing delta outside by air or water cooled bus system.

15 INSULATION LIQUID

15.1 Mineral oil, if used, shall comply with IS 335 : 1983.

16 TESTS

16.1 All the tests specified in IS 2026 (Part 1) : 1977, shall apply.

NOTE — The short-circuit test specified in **16.11** of IS 2026 (Part 1) : 1977 is not applicable in the case of furnace transformers.

17 MARKING

17.1 Each Arc Furnace Transformer shall be provided with a rating plate of weather-proof material, fitted in a visible position, showing the appropriate items given below. The entries on the rating plate shall be indelibly marked (for example, by etching, engraving or stamping):

a) Number of this standard, Ref IS : 12977;

b) Manufacturer's name;

c) Manufacturer's serial number;

d) Year of manufacture;

e) Number of phases;

f) Rated kVA;

g) Rated frequency;

h) Rated voltages;

j) Rated currents;

k) Connection symbol;

m) Percent impedance voltage at rated current (measured value corrected to 75°C) and if necessary, the reference power;

n) Type of cooling;

p) Total mass; and

q) Mass and volume of insulating oil.

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*	*IS No.*	*Title*
335 : 1983	New insulating oils (*third revision*)	(Part 3) : 1981	Insulation levels and dielectric tests (*second revision*)
1885 (Part 38) : 1977	Electrotechnical vocabulary : Part 38 Transformers (*first revision*)	(Part 4) : 1977	Terminal markings, tappings and connections (*first revision*)
2026 (in Parts)	Power transformers:	6600 : 1972	Guide for loading of oil-immersed transformers
(Part 1) : 1977	General (*first revision*)	12188 : 1987	Electric direct arc melting furnaces
(Part 2) : 1977	Temperature-rise (*first revision*)		

Standard Mark

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 Standard 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 BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Revision of Indian Standards

Indian Standards are reviewed periodically and revised, when necessary and amendments, if any, are issued from time to time. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition. Comments on this Indian Standard may be sent to BIS giving the following reference :

Doc : No. ETD 16 (2736)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	{ 331 01 31 331 13 75
Eastern : 1/14 C.I.T. Scheme VII M, V.I.P. Road, Maniktola CALCUTTA 700054	37 86 62
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	2 18 43
Southern : C.I.T. Campus, IV Cross Road, MADRAS 600113	41 29 16
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) BOMBAY 400093	6 32 92 95

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. PATNA. THIRUVANANTHAPURAM.

Printed at Swatantra Bharat Press, Delhi, India