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Indian Standard

SPECIFICATION FOR RESISTANCE WELDING EQUIPMENT

PART I SINGLE-PHASE TRANSFORMERS

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

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Indian Standard

SPECIFICATION FOR RESISTANCE WELDING EQUIPMENT

PART I SINGLE-PHASE TRANSFORMERS

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PART I SINGLE-PHASE TRANSFORMERS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 4 November 1968, after the draft finalized by the Electric Welding Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This specification covers transformers incorporated in single-phase ac resistance welding equipment, dealing with such general aspects as design, construction and electrical performance. This part shall be read in conjunction with the relevant parts, which are in the course of preparation, for making complete specifications for resistance welding machines, such as rocker-arm type spot welding machines, projection welders, combination spot welders, seam welders, etc.

0.3 In this standard, the rating of welding machines has been based on the maximum conventional power at 50 percent duty cycle as agreed to at the international level. It is, however, recognized that this basis of rating has its own shortcomings and therefore the committee felt that the marking 'maximum short circuit secondary current' which is directly related to performance and provides a realistic means of assessment of capacity and quality for both the buyer and the seller, should also be given in the name plate.

0.4 In preparing this standard, reference has been made to the following publications:

Draft ISO Recommendation No. 974 Rating of resistance welding equipment. International Organization for Standardization.

B.S. 3065-1959 The rating of resistance welding equipment. British Standards Institution.

Bull. No. 16. 1966. Electrical standards for resistance welding equipment. Resistance Welder Manufacturers' Association, USA.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final values, observed or calculated, expressing the results 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 values should be the same as that of the specified values in this standard.

1. SCOPE

1.1 This standard lays down the requirements, methods of test and service conditions for transformers incorporated in the following single-phase transformer type ac resistance welding equipment:

a) Spot welders,
b) Projection welders,
c) Combination spot welders,
d) Fixture type resistance welders,
e) Portable gun welders,
f) Resistance heating machines,
g) Resistance heating and upsetting machines,
h) Seam welders,
j) Upset butt welders, and
k) Flash butt welders.

1.2 It does not apply to the methods of operation or control of resistance welding equipment.

1.3 This standard does not apply to:

a) Special purpose resistance welding or resistance heating transformers and machines or equipment,
b) Capacitor discharge or stored energy resistance welding equipment,
c) Percussion welding equipment,
d) 3-phase and frequency conversion or rectifier type resistance welding equipment.

2. TERMINOLOGY

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

2.1 Resistance Welding — A group of welding processes where in coalescence is produced by the heat obtained from resistance of the work to

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

the flow of electric current in a circuit of which the work is a part and by the application of pressure.

2.2 Duty Cycle — The ratio of time during which the output side of the transformer is loaded, to the integrating period.

2.3 Integrating Period — The sum of the load and no-load periods during which the equipment is operated for a particular application.

2.4 Rated Primary Current — is that current calculated by dividing maximum conventional power rating at 50 percent duty cycle by the rated voltage.

2.5 Maximum Primary Current — The primary current passed when rated supply voltage and frequency are supplied and the secondary of the equipment is short-circuited under specified conditions.

2.6 Maximum Short-Circuit Power, *Pm* — The maximum apparent power at the terminals of the machine, expressed in kilovolt-amperes, absorbed at the highest regulator setting, the electrodes being short-circuited according to conditions laid down in the methods of test (*see* **7.8**) and the machine arranged in such a manner as to have the minimum secondary impedance compatible with this method of short-circuit.

2.7 Maximum Short-Circuit Secondary Current — The maximum current flowing in the secondary circuit of the transformer, expressed in kilo amperes, the regulator being at its highest setting, the electrodes being short-circuited according to specified conditions and the machine arranged in such a manner as to have the minimum secondary impedance compatible with this method of short circuit.

2.8 Maximum Welding Current — That maximum current passing through the parts to be welded at the fused area and is approximately equal to 0·8 times the value of the maximum short-circuit secondary current.

2.9 Maximum Conventional Power at 50 Percent Duty Cycle, Pc — The maximum apparent power, expressed in kilovolt-amperes, corresponding to an actual or assumed continuous service at a duty cycle of 50 percent with the regulator at its highest setting without exceeding the temperature rises specified in **6** when tested in accordance with this standard.

2.10 Open Circuit Voltage — The voltage between electrodes when no welding current is flowing.

2.11 Secondary Circuit — Those parts of a welding machine, and its transformer that convey the secondary current to and from the work-piece or a dummy load.

2.12 Throat Depth — The unobstructed work clearance in a welding machine, from the centre line of the electrodes or platens to the nearest point of obstruction of flat work or sheets.

2.13 Throat Clearance — The unobstructed work clearance in a welding machine between arms throughout the throat depth.

2.14 Type Tests — Tests carried out to prove conformity with the specification. These are intended to prove the general qualities and design of an equipment.

2.15 Routine Tests — Tests carried out on each equipment to check requirements which are likely to vary during production.

3. MATERIAL, CONSTRUCTION AND WORKMANSHIP

3.1 General

3.1.1 The materials employed in the manufacture shall generally conform to relevant Indian Standards where applicable.

3.1.2 *Insulating Material* — The insulating materials used in the construction of the transformer shall be substantially non-hygroscopic.

3.2 Construction

3.2.1 The transformer shall be of the double-wound type, the primary being electrically isolated from the secondary.

3.2.2 Live parts shall be so insulated or supported that they cannot come into electrical contact with one another, thereby causing a short circuit, or with any earthing conductor or metal parts exposed to personal contact.

3.2.3 Live parts shall be so enclosed that no person can inadvertently come into contact with any live part which may normally attain a potential in excess of 32 volts above earth potential. Covers for the guarding of live parts shall be effectively secured in position, such that the use of a tool is required for their removal.

3.2.4 *Provisions of Primary Taps* — Where taps are provided in the windings the following requirements shall apply:

a) The transformer shall be capable of supplying the current corresponding to every tap without exceeding the maximum temperature-rise.

NOTE — On taps other than those producing the maximum secondary voltage, maximum output current and the thermal rating may be reduced in direct proportion to the secondary voltage.

b) The taps shall be numbered progressively with the highest open-circuit secondary voltage being associated with the highest numbered tap.

3.3 Cooling Water Flow — Water-cooling systems where provided for the transformer shall be designed to operate effectively with inlet water at a temperature not exceeding 30°C and maximum rates of flow at a pressure not exceeding 2·1 kgf/cm² of equipment:

up to 100 kVA	4·5 l/min
above 100 kVA but not exceeding 400 kVA	9 l/min
above 400 kVA	13·5 l/min

3.4 Workmanship — All parts shall be manufactured to a high standard of workmanship and finish.

4. SERVICE CONDITIONS

4.1 Normal Conditions

4.1.1 The following shall constitute the normal service conditions:

a) Maximum ambient air temperature not exceeding 40°C,
b) An altitude not exceeding 1 000 metres,
c) The ingoing cooling water temperature not exceeding 30°C and water pressure neither less than 2·1 kgf/cm² nor more than 8·4 kgf/cm² for water cooled equipment, and
d) Location or atmospheric conditions as to dust, moisture or fumes, which will not seriously interfere with the operation of the equipment.

4.2 Unfavourable Conditions

4.2.1 Unfavourable conditions which are not normal to resistance welding processes may exist in some cases and it is recommended that they may be brought to the manufacturer's attention. Among such conditions are:

a) exposure to unusual corrosive fumes,
b) exposure to steam or excessive humidity,
c) exposure to excessive oil vapour,
d) exposure to explosive gases,
e) exposure to abnormal vibration or shock,
f) exposure to excessive dust,
g) exposure to weather,
h) exposure to usual sea coast or shipboard conditions,
j) ambient temperature above 40°C,

k) inlet water temperature above 30°C,
m) ingoing water pressure less than 2·1 kgf/cm² or more than 8·4 kgf/cm², and
n) altitudes greater than 1 000 metres.

4.3 Rating — The standard rating of the resistance welding equipment shall be the maximum conventional power at 50 percent duty cycle in an integrating period of 60 seconds.

4.3.1 *Permissible Equivalent kVA Rating for Duty Cycles Other than 50 Percent* — Shall be arrived at by the formula:

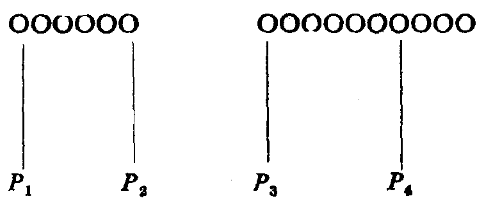
$$Pc = Px\sqrt{\frac{x}{50}}$$

where

Pc = Rating at 50 percent duty cycle,
Px = kVA rating at other duty cycle, and
x = Other duty cycle in percent.

5. TERMINAL MARKING

5.1 The appropriate designating letter and subscript members assigned to the winding and tapping shall be legibly and indelibly marked on, or adjacent to, the terminals with which they are associated. The primary taps shall be numbered progressively with the highest open circuit secondary voltage being associated with the highest numbered tap. In a resistance welding transformer having a series/parallel primary winding, the terminals identification shall be P_1, P_2, P_3 and P_4 arranged as follows:



Parallel connection P_1 to P_3, P_2 to P_4
Series connection P_2 to P_3

6. TEMPERATURE-RISE

6.1 The temperature-rise of the transformer when tested under rated conditions and in accordance with the requirements of this specification shall not exceed the limits given in Table 1.

TABLE 1 LIMITS OF TEMPERATURE-RISES

[*Clauses* 6.1, 7.6.1 (b) *and* 7.6.1.1]

Mode of Cooling	Method of Determination	Classes of Insulation				
		A °C	E °C	B °C	F °C	H °C
Air	Thermometer	50	65	70	95	115
	Resistance (or E.T.D.)	60	75	80	100	125
Water	Thermometer	60	75	80	95	115
	Resistance (or E.T.D)	70	85	90	110	135

NOTE 1 — The numerical values quoted for classes F and H should be considered as tentative only and may be revised when more practical experience is available. If class C insulation is used, the temperature-rise shall be a matter of agreement between the purchaser and the supplier.

NOTE 2 — These maximum temperature-rises apply only where there is intimate contact between the windings and parts directly cooled by water.

7. TESTS

7.1 Classification of Tests

7.1.1 *Type Tests* — The following shall constitute type tests:

a) Transformer cooling water flow (where applicable),
b) Water pressure (where applicable),
c) High voltage,
d) Insulation resistance,
e) Temperature rise,
f) Determination of the maximum short circuit secondary current,
g) Maximum short circuit power, and
h) Mechanical stress.

7.1.2 *Routine Test* — The following tests shall be carried out as routine tests:

a) Transformer cooling water flow (where applicable),
b) Water pressure (where applicable),
c) High voltage, and
d) Insulation resistance.

7.1.3 *Test Certificate* — The type tests may be made by mutual agreement between the purchaser and the supplier and if the record of type tests on any resistance welding equipment which in essential details is representative of the one being purchased, are furnished, the purchaser may accept these as evidance of type test instead of actual test.

7.1.4 *Conditions of Tests* — The following general conditions of tests shall apply.

7.1.4.1 *Ambient temperature*

a) *Air cooled equipment* — To be made at any ambient temperature between 10°C and 40°C, but whatever the value of this cooling air temperature the permissible temperature limits during test shall not exceed those specified in **6.1**.

b) *Water cooled equipment* — The ambient temperature shall be taken as the temperature of ingoing water which shall be neither less than 10°C nor more than 30°C. The temperature of the surrounding air shall be between 10°C and 40°C.

7.1.4.2 *Measurement of ambient temperature*

a) *Air cooled equipment* — Thermometer shall be placed around the equipment at a distance of approximately 1 m and level with the centre line of the transformer or transformers. They shall be protected from all heat radiation and draughts; the bulbs shall be placed in small cups of oil to even out temperature variations.

b) *Water cooled equipment* — The thermometers shall be placed in the water supply at the inlet to the equipment.

c) *Mean temperature* — The value to be adopted for the ambient temperature during a test is the mean of the readings of the thermometers, placed as specified above, taken at equal intervals of time during the last quarter of the duration of the test.

7.1.4.3 *Measurement of input*

a) *Method* — Input measurements under operating conditions shall be made by means of suitable indicating instruments in the usual way, provided the duration of a welding operation is sufficient (about 2 seconds with ordinary well damped instruments) for the instrument pointers to assume a steady position. When the duration of a welding operation is so short that the instrument pointers cannot assume steady position, a more appropriate instrument shall be used.

b) *Voltage adjusting devices* — If the nature of the welding operation requires that the voltage be reduced by a reactor or auto-transformer, the loss in such a device shall be included in determining the input.

7.2 Test for Cooling Water (Where Applicable) — The flow of the cooling water shall be brought to and maintained at a flow-rate within 5 percent, but not exceeding, the relevant maximum rate specified in **3.3**. The water pressure shall then be measured and shall not exceed 2·1 kgf/cm^2.

7.3 Test for Water Pressure (Where Applicable) — The cooling water system shall be arranged as a closed system and connected to a suitable hydrostatic unit maintaining a water pressure of 8·4 kgf/cm^2 for not less then 30 minutes. There shall be no leakage of water during the period of this test.

This test shall be immediately followed by the high voltage test described in **7.4**.

7.4 High Voltage Test

7.4.1 *General* — The high voltage test shall be made with single-phase alternating voltage as nearly as possible of sine-wave form and at rated supply frequency.

7.4.2 *Condition of Equipment* — The high voltage test shall be applied to completely assembled transformer which has previously not been subjected to the tests described above and which is in the *as new state,* free from dirt and like contamination, which could cause failure.

7.4.3 *Test Voltages for Primary Circuits* — For equipment having a primary voltage of 650 volts or less, a voltage of 4 kV rms, obtained from a separate source, shall be applied for one minute between each winding in turn and the remaining windings, and between the primary windings only and secondary windings, core frame tank or casing of the transformer, all connected together to earth.

For equipment having a primary voltage above 650 volts, up to and including 1·1 kV, a voltage of 12 kV rms, obtained from a separate source, shall be applied for one minute between each winding in turn and the remaining windings, and between the primary windings only and secondary windings, core, frame, tank or casing of the transformer, all connected together to earth.

The equipment shall be rejected if failure, partial failure, or arcing-over occurs during this test.

7.4.4 *Test Voltage for Secondary Circuits* — A voltage of 1 kV rms, obtained from a separate source, shall be applied for one minute between the secondary windings, and core, frame, tank or casing of the transformer, all connected together to earth. This test does not apply in cases where the secondary circuit is designed to be bonded to the frame of the equipment.

The equipment shall be rejected if failure, partial failure, or arcing-over occurs during this test.

7.5 Insulation Resistance Test — The insulation resistance shall be measured at a voltage of 500 volts dc between primary and secondary circuits, and between *either or both* circuits and the core of the resistance welding equipment, except in cases where the secondary circuit is designed to be bonded to the frame of the equipment. The voltage shall be applied for a sufficient time for the reading of the testing indicator to become practically steady.

The insulation resistance so measured shall be not less than 2 megohms.

7.6 Temperature-Rise Test

7.6.1 The transformer shall be tested at 50 percent duty cycle based on a sixty second integrating period with the transformer connected so as to give the highest secondary voltage and at rated primary current or under conditions to produce equivalent results.

Where power is not available to the required extent it shall be permissible to test the transformer at an equivalent kVA rating of 100 percent duty cycle on an uninterrupted basis. The equivalent kVA shall be obtained from the following formula:

$$Pc = Pm\sqrt{\frac{x}{50}}$$

where

Pc = Maximum conventional power @ 50 percent duty cycle (kVA)

Pm = Primary power (kVA)

x = Duty cycle

A reduced voltage shall then be impressed upon the primary until the necessary current is obtained, the transformer being connected at the tap that gives the highest secondary voltage.

The temperature test shall be continued until either:

a) the temperature-rises that can be observed during the test have attained the steady final value; or

b) the rate of increase of temperature-rise does not exceed 2°C per hour and the asymptotic values of maximum temperature-rise do not exceed the values given in Table 1.

7.6.1.1 The temperature-rises so determined (*see* Appendix A) shall not exceed the appropriate values given in Table 1.

7.7 Determination of the Maximum Short-Circuit Secondary Current

7.7.1 *Conditions of Loading*

7.7.1.1 For purposes of standardization the conditions of short circuit are defined in the appropriate parts of these standards for the various types of resistance welding equipment.

7.7.2 *Method of Measurement*

7.7.2.1 The transformer shall be connected at the tap to produce the highest open circuit secondary voltage. A voltage of the value required to cause approximate rated primary current to flow shall then be impressed upon the transformer primary when the secondary is shorted as specified in **7.7.1.1**.

7.7.2.2 The maximum short circuit secondary current shall be computed from the formula:

$$\frac{(\textit{Rated Primary Voltage})^2 \times \textit{Measured Primary Current at Test Voltage}}{\text{Test Voltage} \times \text{Maximum (no load) Secondary Voltage}}$$

7.7.2.3 The maximum short circuit secondary current thus calculated shall not be less than the values marked in the appropriate parts of these standards for resistance welding equipment.

7.8 Maximum Short Circuit Power

7.8.1 The maximum short circuit power shall be computed from the results of the test described under **7.7** as follows:

$$\frac{(\textit{Rated Primary Voltage})^2 \times \textit{Measured Primary Current at Test Voltage}}{\text{Test Voltage}}$$

7.9 Test for Mechanical Stress — The transformer shall be connected at the tap that produces the highest open circuit secondary voltage and the transformer secondary circuit shall be short-circuited in the appropriate manner described under the relevant parts of the machine standards.

Where adequate power is available, the transformer primary shall be energised at such voltage as to produce twice the maximum short circuit secondary current. The transformer shall be subjected to current impulses of 4 consecutive cycles each, from a power supply at rated frequency, and these impulses should be regularly applied 10 times a minute for a period of 10 minutes. The transformer shall withstand this test without mechanical damage and there shall be no observable movement in the windings.

Where it is impractical to carry out this test, due to inadequacy of power, visual examination of the transformer windings shall be deemed sufficient for the purpose of this specification.

APPENDIX A

(*Clause* 7.6.1.1)

TEMPERATURE MEASUREMENTS

A-1. METHODS

A-1.1 Three methods of measuring temperature are recognized by this standard:

a) Resistance method,
b) Thermometer method, and
c) Thermocouple or embedded detector.

NOTE — The resistance method should be preferred.

A-1.2 Resistance Method — In this method, the temperature-rise of the winding shall be determined by the increase in the resistance of the windings. However if desired, a check may be made by thermometers applied to the accessible surfaces of the windings and the temperature-rise thus determined shall not exceed the permissible limit specified for the resistance method.

A-1.2.1 The temperature of the windings as measured by thermometer before commencing the test shall not differ from that of the cooling medium. The initial resistance and initial temperature of the windings shall be measured at the same time.

A-1.2.2 Since the resistance over the range of temperature referred to in this standard varies in direct proportion to the temperature above minus 234·5°C for copper and minus 229·8°C for aluminium, the hot temperature is obtained from the following equation:

$$t_2 = (R_2/R_1) (t_1 + X) - X$$

where

t_2 = temperature of windings hot in °C,
R_2 = resistance of windings hot,
R_1 = resistance of windings cold,
t_1 = temperature of windings cold in °C, and
X = 234·5 for copper and 229·8 for aluminium.

A-1.3 Thermometer Method — When using this method, the temperature shall be measured by thermometers applied to the hottest accessible surfaces during the test period.

NOTE — The term 'accessible surfaces' is intended to convey that the established limits of temperature-rise of windings measured by thermometer are based on the use of thermometers placed on the external surfaces of the windings or iron cores with which the windings may be in contact. The measurements are not intended to cover readings which might be obtained by inserting thermometers into narrow interstices between coils, or between insulating flanges and coils. In such locations the temperatures may be higher and allowance is made foı this in fixing the permissible temperature-rises measured at the surface.

The fact that the typr of construction renders a winding difficult of access is not to be taken as permission to operate such windings at higher temperatures than are allowed on those windings or portions of windings on which the thermometers can be more easily placed, and the standard limits of temperature-rise should not be exceeded on any winding surface. If a reasonable proportion of the winding is readily accessible to a thermometer, temperature-rise should be determined by a thermometer placed on these portions of the windings.

A-1.3.1 The term 'thermometer' means mercury or alcohol bulb thermometer. In measuring temperature, thermocouples or resistance thermometer may be substituted for thermometers provided such instruments were inserted in narrow interstices which would be accessible to the bulb of normal thermometer not less than 5 mm.

A-1.3.2 The bulb of the thermometer, except at the point of contact, shall be covered with a pad of felt, cotton wool or other non-conducting material 3 mm thick extending at least 20 mm in every direction from the bulb and pressed into contact with the surfaces to which this is applied, to prevent loss of heat by radiation and convection from the bulb.

A-2. PRECAUTIONS TO BE OBSERVED IN MAKING RESISTANCE MEASUREMENTS

A-2.1 Special care sbould be taken when measuring the temperature of windings by this method to ensure that apparatus and methods of adequate accuracy are used.

A-2.2 To determine temperatures of the windings when hot, an accurate measurement of resistance and associated temperature should be taken when the windings are cold.

A-3. MEASUREMENT OF TEMPERATURE OF COOLING MEDIUM

A-3.1 In general, the temperature of the cooling medium shall be measured by means of several thermometers placed at different points around and half-way up the equipment and at a distance of 1 to 2 m away from it. These thermometers shall be so placed as to indicate the temperature of the current of air flowing towards the welding equipment and shall be protected from heat radiation and stray draughts.

A-3.2 Where temperature tests are carried out under such conditions that parts of the welding equipment are in a position in which ventilation may be impeded, for example, in a pit, the temperature in such a restricted area shall be deemed to be the cooling temperature.

A-3.3 If the air is admitted into the equipment through a definite inlet opening or openings, the temperature of the cooling medium shall be measured by means of thermometers placed in the current of incoming air near the place it enters the equipment.

A-3.4 The value to be adopted for the temperature of the cooling medium during the temperature test shall be the average of the readings of the thermometers mentioned above, taken at the beginning and the end of the last half hour of the test.

A-3.5 To avoid errors due to the time lag between the temperatures of a large welding transformer and the variation in the temperature of the cooling medium all reasonable precautions shall be taken to reduce those variations and the errors arising from them.

A-4. MEASUREMENT BY THERMOCOUPLE OR EMBEDED DETECTOR

A-4.1 Temperature measurements may be made by means of thermocouples (*see* IS : 2053-1962*).

A-4.2 Thermocouple for measuring the temperature are attached to the surface in such a way that good thermal contact is obtained with the minimum of disturbance of the thermal conditions.

Adequate thermal contact can be obtained by the following methods whichever is most appropriate:

a) By mechanical clamping under existing screw.

b) By soldering using the smallest possible amount of solder.

c) By suitable adhesive using only the minimum quantity needed to fix the thermocouple and taking care that the junction is not separated by the adhesive from the surface to be measured, or lagged by an excess of adhesive covering it. Applying the adhesive to the sides of the wires is a suitable technique. For transparent materials, a colourless cement is used to avoid absorbing radiations. With thermoplastic materials, the cement

*Specification for the thermocouple pyrometers.

is preferably one based on the material itself. When measuring the surface temperature of materials of low thermal conductivity, a length of about 2 cm of the thermocouple wires leading to the junction is also cemented to the surface to minimize conduction losses.

d) By means of thermocouple in holder, a little oil or grease being applied to the surface where the junction touches to ensure good thermal contact.

A-4.3 The emf developed by the thermocouple is preferably measured by a potentiometer circuit. The cold junction is kept in a small deep dewar vessel containing a suitable liquid, for example, glycerine, to prevent rapid changes in temperature. Its temperature is measured by an accurate mercury-in-glass thermometer.

A-5. TIME AT WHICH TEMPERATURES ARE TO BE TAKEN

A-5.1 The temperature of the equipment shall, whenever possible, be taken during working as well as after stopping the equipment, the highest temperature thus obtained shall be adopted. When successive measurements show increasing temperature after shut-down, the highest value shall be taken.

A-5.2 If the interval between the instant of cutting off the power and the welding transformer is considerable, corrections, by extra-polation from a cooling curve, shall be applied so as to obtain as nearly as practicable, the temperature at the instant of shut-down.

A-6. TEMPERATURE-RISE

A-6.1 The temperature-rise shall be the difference between the highest temperature measured under **A-4**, and the mean temperature measured under **A-3**.

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5-8-56C L. N. Gupta Marg, (Nampally Station Road), HYDERABAD 500001	22 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71 6 98 32
117/418B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
Hantex Bldg (2nd Floor), Rly Station Road, TRIVANDRUM 695001	52 27

Inspection Office (With Sale Point):

Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 410005	5 24 35

*Sales Office in Bombay is at Novelty Chambers, Grant Road, Bombay 400007 — 89 65 28

†Sales Office in Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, Calcutta 700072 — 27 68 00

Reprography Unit, BIS, New Delhi, India