

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION R 700

RATING OF MANUAL ARC WELDING EQUIPMENT

1st EDITION
March 1968

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Printed in Switzerland

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 700, *Rating of manual arc welding equipment*, was drawn up by Technical Committee ISO/TC 44, *Welding*, the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question by the Technical Committee began in 1957 and led, in 1965, to the adoption of a Draft ISO Recommendation.

In May 1966, this Draft ISO Recommendation (No. 973) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Ireland	Sweden
Belgium	Israel	Switzerland
Brazil	Japan	Turkey
Chile	Korea, Rep. of	U.A.R.
Czechoslovakia	Norway	United Kingdom
Denmark	Poland	U.S.S.R.
France	Romania	Yugoslavia
Germany	South Africa,	
Hungary	Rep. of	
India	Spain	

Five Member Bodies opposed the approval of the Draft :

Canada
Finland
Netherlands
Portugal
U.S.A.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in March 1968, to accept it as an ISO RECOMMENDATION.

RATING OF MANUAL ARC WELDING EQUIPMENT *

PART I

GENERAL

1. SCOPE

This ISO Recommendation applies to the following most commonly used types of welding equipment for manual arc welding :

- (a) single operator arc welding generators with drooping characteristics and with associated driving equipment (except internal combustion engines);
- (b) single operator arc welding transformer equipment, with drooping characteristics.

It specifies the *minimum* requirements for establishing a common basis for the rating of such equipment.

NOTE. — Welding apparatus with a drooping characteristic is defined as apparatus having an external static characteristic (see clause 2.8) which, in its normal operating region, is such that the voltage decreases as the current increases.

This ISO Recommendation applies to equipment for use under the following conditions :

- (a) *Altitude*. In the absence of any information in regard to height above sea level at which the equipment is intended to work in ordinary service, the altitude is assumed not to exceed 1000 m (3300 ft).
- (b) *Temperature of the cooling medium*. In the absence of any information to the contrary, it is assumed that, in the case of air cooled equipment, none of the following temperature limits is exceeded :
 - maximum ambient air temperature 40 °C
 - daily average ambient air temperature 30 °C
 - yearly average ambient air temperature 20 °C

2. DEFINITIONS**

- 2.1 *Operating conditions*. All quantities defining the performance of a machine, an appliance or network.
- 2.2 *Rated*. Qualifying term applied to a quantity which is used in the specification of the welding equipment.

* For the purposes of this ISO Recommendation, "manual arc welding" implies a reference maximum duty cycle of 60 %.

** All electrical quantities specified in the definitions are those obtained under steady conditions.

- 2.3 *Duty.* A schedule of the loads on a machine or apparatus taking account of their respective duration and sequence.
- 2.4 *Periodic duty.* A duty which is repeated periodically.
- 2.5 *Duty cycle.* The ratio of the duration of operation under load to the duration of the complete cycle. This ratio, lying between 0 and 1, may be expressed as a percentage.

NOTES

1. The duty considered in this ISO Recommendation is periodic duty comprising a certain period of operation on constant load followed by a certain period of no-load operation; this represents the usual conditions obtained during welding.
 2. In English, the term "duty factor", as used in the ISO and IEC definitions, and the term "duty cycle" are synonymous.
- 2.6 *Conventional welding current.* Current delivered by a welding machine on a practically non-inductive resistance load.
- 2.7 *Load voltage.* The voltage between the output terminals of a welding machine, i.e. those to which the electrode and return leads are connected, when a specified current is flowing through a non-inductive resistance load.
- 2.8 *Conventional load voltage.* The voltage, at the output terminals of a welding machine, bearing a linear relationship to the conventional welding current such that it is
- 20 volts at 0 ampere
44 volts at 600 amperes
- i.e. such that the voltage is $(20 \pm 0.04 I)$ volts
where I is the numerical value of conventional welding current in amperes.
- For currents above 600 amperes, the voltage should remain constant at 44 volts.
- 2.9 *Conventional operating welding conditions.* Operating conditions defined by a conventional welding current and the corresponding conventional load voltage.
- 2.10 *Conventional welding duty.* A periodic duty with a duty cycle of 0.6 comprising cycles of 5 minutes duration, a complete cycle consisting of a period of 3 minutes under the conventional operating welding conditions followed by a period of 2 minutes of no-load operation.
- 2.11 *Rated welding current.* The maximum value of the conventional welding current at the conventional load voltage at which the machine meets the requirements of this ISO Recommendation when operated at the conventional welding duty.
- 2.12 *Rated short-circuit current.* The current obtained at the maximum setting of the welding apparatus when operating with a length of cable having a resistance as specified in Table 1 below, the cross-sectional area of the cable being that used in welding practice for the rated current.

TABLE 1 – Resistance corresponding to rated welding current

Rated welding current in amperes		Resistance in ohms
over	up to and including	
–	125	0.013
125	160	0.0070
160	200	0.0050
200	250	0.0040
250	315	0.0030
315	400	0.0020
400	500	0.0015
500	630	0.0012

NOTE. – A tolerance of $\pm 10\%$ should be allowed on the values of resistance.

2.13 *Rated maximum current.* The maximum value of the current which can be obtained at the conventional load voltage for the maximum setting.

2.14 *Duty at rated maximum current.* The periodic duty related to the rated maximum current which corresponds to a duty cycle within the permitted heating limitations, and a cycle duration which is the same as that for the conventional welding duty.

2.15 *No-load voltage.* The voltage between the output terminals of a welding machine when the external circuit is open.

NOTE. – This definition applies generally where the welding machine is not fitted with a device for providing a lower open-circuit voltage. If the machine does have such a device, the no-load voltage defined above appears at the output terminals immediately before the action of the time relays whose action is to effect a reduction in the voltage when the welding circuit is open.

3. PRINCIPLE OF HEATING TESTS

The load should be a non-inductive resistance, and at a voltage equal to the appropriate conventional load voltage. A tolerance of $\pm 10\%$ should be allowed on the value of the conventional load voltage.

Two tests should be made as follows :

- (a) with rated welding current as defined in clause 2.11 and at the duty cycle of 0.6;
- (b) with the rated maximum current as defined in clause 2.13 and at a duty cycle as defined in clause 2.14.

Test (b) may follow test (a) without the equipment returning to ambient temperature.

In the case of welding equipment with circuits which carry heavier current under no-load conditions, an additional heating test should be carried out under no-load conditions and should immediately follow test (a) or (b) without the equipment returning to ambient temperature.

4. CONDITIONS UNDER WHICH TEMPERATURE MEASUREMENTS ARE TO BE TAKEN

The temperature should be determined at the end of the first half of the last period of on-load operation (see Fig. 1, point A).

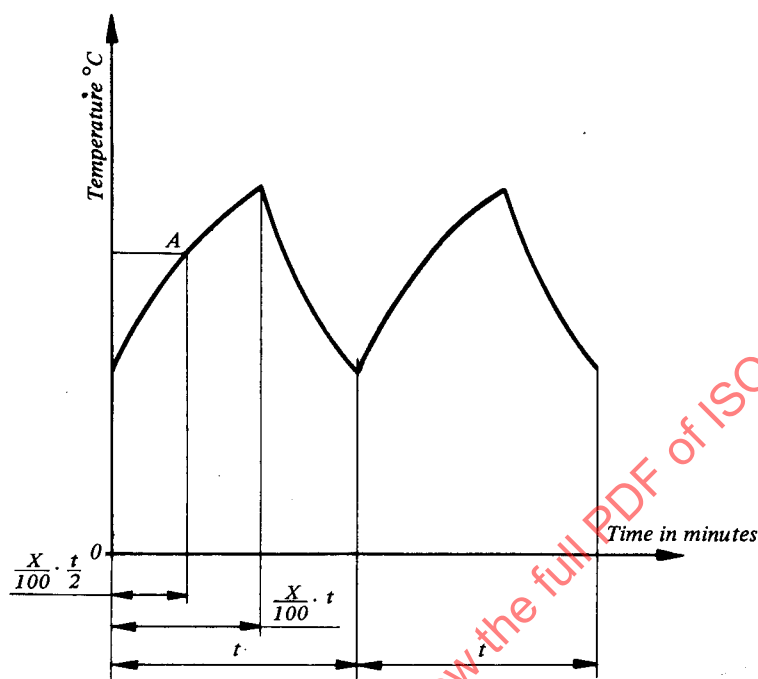


FIG. 1 - Time-temperature curve.
This diagram is drawn for 60 % duty cycle ($X = 60$)

5. LIMITS OF TEMPERATURE RISE

The limits of temperature rise for single operator natural, or forced air cooled or oil immersed arc welding transformers, and for single operator arc welding generators measured under the conditions specified in Part II, section 1, should be in accordance with the following :

5.1 Natural and forced air cooled arc welding transformers (see Table 2 below)

TABLE 2 - Limits of temperature rise*

Class of insulation	Limits of temperature rise	
	measured by thermometer °C	measured by resistance °C
A	65	60
E	80	75
B	90	80
F **	115	100
H **	140	125

* The values given in Table 2 comply with IEC Recommendations and may be modified should those Recommendations be changed.

** The numerical values quoted for these classes of insulation should be considered as tentative only and may be revised when more practical experience is available.

5.2 Oil immersed single operator arc welding transformers

The temperature rise of all windings should be measured by change of resistance and should not exceed 65 °C, and the temperature rise of the oil near the free surface should not exceed 55 °C.

5.3 Arc welding generators and associated electrical driving motors (see Table 3 below)

TABLE 3 – Limits of temperature rise*

Class of insulation	A		E		B		F**		H**	
	T	R	T	R	T	R	T	R	T	R
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
1.										
(a) a.c. windings										
(b) Field-windings of a.c. and d.c. machines having d.c. excitation other than those in item 2	55	60	65	75	70	80	85	100	105	125
(c) Windings of armatures having commutators										
2.										
Low resistance field-windings of one or more layers and compensating windings	60	60	70	70	80	80	100	100	125	125
3.										
Iron core and other parts in contact with windings	60		75		80		95		110	
4.										
Commutators and slip rings open or enclosed	60		70		80		80		80	
T = Temperature measurement by thermometer										
R = Temperature measurement by resistance										

* The values given in Table 3 comply with IEC Recommendations and may be modified should those Recommendations be changed.

** The numerical values quoted for these classes of insulation should be considered as tentative only and may be revised when more practical experience is available.

PART II

METHODS OF TESTS

1. DETERMINATION OF TEMPERATURE RISE
AND MEASUREMENT OF TEMPERATURE

The temperature rise of a part of a machine is the difference between the temperature of that part of the machine and that of the cooling air, temperature being determined by one of the following methods.

1.1 Thermometer method

In this method the temperature is measured by thermometers applied to accessible surfaces of windings or other parts in accordance with the conditions stipulated below.

In measuring temperatures, thermocouples or resistance thermometers may be substituted for thermometers provided that such instruments are inserted only in interstices accessible to the bulb of a normal thermometer not less than 5 mm diameter.

1.2 Resistance method

In this method the temperature rise of windings is determined by increase in resistance. For copper windings, the rise in temperature is obtained from the formula

$$\frac{t_2 + 235}{t_1 + 235} = \frac{R_2}{R_1}$$

For practical purposes the following alternative formula may be found convenient in calculating rise in temperature :

$$t_2 - t_a = \frac{R_2 - R_1}{R_1} (235 + t_1) + (t_1 - t_a)$$

where

- t_2 is the temperature of the winding, in degrees Celsius, at the end of the test;
- t_1 is the temperature of the winding (cold) or at the moment of the initial resistance measurement, in degrees Celsius;
- t_a is the ambient air temperature, in degrees Celsius, at the end of the test;
- R_1 is the initial resistance of the winding (cold);
- R_2 is the resistance of the winding at the end of the test.

The temperature rise should be measured as follows :

- *for windings*, by means of the resistance method or, if this is not practicable, by means of a thermometer placed at the hottest accessible spot on the surface of the winding;
- *for other parts*, by means of a thermometer;
- *for oil immersed equipment*, by means of thermometers placed as near as possible to the top level of the oil in the tank.

It is not intended that measurement by both thermometer and resistance should be used and one method only should be chosen to determine the temperature rise of any particular winding.

Generally, welding equipment has hot spots, the size and spread of which depend essentially on the design of the circuits.

In addition, the electric circuits of welding machines often have low resistance on the output side and may contain a large number of joints, which, in general, renders temperature measurement by resistance inadvisable as it can only give an average value for the temperature and may not be accurate.

In the case of welding transformers with forced air cooling, the temperature rise is preferably measured by the change of resistance.

NOTE. — In places where there is a varying magnetic field, mercury thermometers should not be used, as the results could be erratic.

2. GENERAL CONDITIONS TO BE OBSERVED DURING HEATING TESTS

At the start of the heating test, the following conditions should be observed :

2.1 Temperature of cooling air

Welding equipment may be tested at any convenient cooling air temperature between 10 and 40 °C, but whatever this temperature is during the test the permissible rises of temperature should not exceed those recommended in section 5 of Part I.

2.2 Measurement of initial resistance

The initial resistance of the winding should be determined when the temperature of the winding is within ± 3 °C of the ambient air temperature, the temperature of the winding being determined by thermometer.

2.3 Placing of thermometers

Thermometers should be placed on accessible spots where the maximum temperature is likely to occur.

Efficient heat transmission between the point of measurement and the thermometer should be ensured and protection should be provided for the thermometer against the effect of air currents and radiation. Neither the instruments nor the protection should be allowed to interfere substantially with the circulation of cooling air.

2.4 Setting of equipment

For welding equipment in which the rated current can be obtained from two or more settings, the test should be carried out under conditions which give maximum heating. The current regulating device should be set at the position corresponding to the value of the conventional welding current at which the test is to be carried out and the loading resistance should be regulated to maintain the required current for the duration of the test. The load voltage should be within ± 10 % of the appropriate conventional load voltage throughout the test.

NOTE. — In the case of motor generator equipment, if the tolerance of ± 10 % on the conventional load voltage is found to be excessive and does not permit a proper temperature test to be made on the motor, the test should be made at the rated current and at a lower tolerance to be fixed by the interested parties.

2.5 State of equipment and operating of measuring devices

The welding equipment should be new, dry and completely assembled. When placing the measuring devices, the only access permitted should be through openings with cover plates, and inspection doors provided by the manufacturer.

The measuring devices used should not interfere with the normal ventilation of the equipment, or cause transfer of heat to the equipment.

The welding equipment under test should include all ancillary equipment, and the ventilation should be identical with that prevailing under normal service conditions.

3. CONDITIONS GOVERNING TEMPERATURE MEASUREMENT DURING HEATING TEST

3.1 Measurement of the temperature of the cooling medium

The temperature of the cooling medium should be obtained by thermometers placed as follows :

- (a) in the case of natural air cooled equipment, the thermometers should be placed around, and at mid-height of the equipment under test, and one to two metres away from all heat radiation and draughts;
- (b) in the case of forced air cooled equipment, the thermometers should be placed where the air enters the cooling system.

In the above two cases, if the air temperature is constant, or varies only slightly, the mean of the thermometer readings taken at equal intervals of time during the last quarter of the duration of the test can be adopted as the standard temperature.

If the temperature of the cooling medium fluctuates comparatively rapidly during the test, all necessary precautions should be taken to avoid error consequent upon the slowness with which the equipment under test follows the variations of temperature of the cooling medium.

3.2 Measurement of temperatures of parts of the equipment

Where possible temperatures should be recorded while the equipment is in operation and after it is shut down. On those parts where the recording of temperatures is not possible while the equipment is in operation, temperatures should be taken after shut-down, as described in section 4, below.

4. DURATION OF HEATING TEST

Heating tests should be carried out until the rate of temperature rise does not exceed 2 deg C per hour on any component part of the equipment.

In order to ensure thermal equilibrium, temperature measurements may be made at the end of the on-load period.

5. CORRECTION OF TEMPERATURE MEASUREMENTS TAKEN AFTER SHUT-DOWN OF EQUIPMENT

As soon as the heating tests are finished it is necessary to obtain an accurate record of the temperature variations as quickly as possible, together with the precise times after shut-down at which the temperatures are measured. As many readings as possible should be taken in the first two minutes after shut-down.

If, on plotting the temperature on a base of time after shut-down, there is a decrease in successive readings, the extrapolation of the curve back to time of shut-down will provide the maximum temperature.

If temperatures increase after shut-down, the maximum should be taken.

6. COMMUTATION

Arc welding generators should have good commutation for all the operating conditions under which the machine may have to work and more especially for maximum current.

The following tests will enable the quality of the commutation to be ascertained.

Before commutation tests commence, the commutator and brushes should be in perfect condition.

The commutation of the machine should be observed at the following times :

- (a) during the heating tests carried out as specified in paragraphs (a) and (b) of section 3, Part I;
- (b) during a special 2 minutes short-circuit test at maximum current setting, to be carried out immediately after the heating tests specified in paragraphs (a) and (b) of section 3, Part I.

For this short-circuit test the generator should be operated with a resistance, the value of which is given in section 2 of Part I.

There should be no injurious sparking, nor damage to commutator or brushes resulting from these tests.

7. INSULATION RESISTANCE AND INSULATION DIELECTRIC STRENGTH

A note will be added when the recommendations of IEC Committee 26 are available. This committee has been asked to study questions related to safety in electric welding.

MARKING OF NAME PLATES

The name plate should indicate the following information (see Fig. 2) :

~~Symbols~~

- | | | |
|-----|---|----------|
| 1.1 | Identity of maker | |
| 1.2 | Maker's type reference of equipment | |
| 1.3 | Serial number of equipment | |
| 1.4 | Standard according to which equipment is rated | |
| 1.5 | Welding current : a.c. (state frequency if different from supply) | ∞ |
| | d.c. | = |
| 1.6 | No-load voltage : maximum | U_0 |
| | minimum | |

The maximum load voltage (U_m) should also be shown if it is higher than the no-load voltage.

- | | | |
|------|--|-------------|
| 1.7 | Current range at conventional load voltage | |
| | maximum | |
| | minimum | I, U |
| 1.8 | Corresponding currents and duty cycles for rated welding currents, and maximum current | $I_{\max.}$ |
| 1.9 | Rated short-circuit current | I_c |
| 1.10 | Duty cycle | X |

In addition to the information specified in clauses 1.1 to 1.10 above, name plates for welding generators should indicate the following information :

- | | | |
|-----|---|-------------|
| 2.1 | Speed of rotation* in revolutions per minute | n |
| 2.2 | Maximum driving power required at maximum setting, in kilowatts | $P_{\max.}$ |

If the equipment is intended for use at 100 % duty cycle, the maximum continuous current should be stated.

* The direction of rotation should be clearly indicated on the body of the equipment.