BRITISH STANDARD

BS 2618:1975

Specification for

Electric traction equipment

UDC 629.423:621.337:621.316

Co-operating organizations

The Electrical Industry Standards Committee under whose supervision this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organizations:

Associated Offices Technical Committee
Association of Consulting Engineers*
Association of Manufacturers of Domestic Electrical Appliances
Association of Mining Electrical and Mechanical Engineers
Association of Supervisory and Executive Engineers
British Electrical and Allied Manufacturers' Association
British Electrotechnical Approvals Board for Household Equipment
British Radio Equipment Manufacturers' Association
British Railways Board*
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Lighting Industry Federation Limited
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National Inspection Council for Electrical Installation Contracting
Oil Companies Materials Association
Post Office
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The industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

London Transport Executive
Railway Industry Association of Great Britain

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Contents

Foreword

This British Standard has been prepared under the authority of the Electrical Industry Standards Committee. It is based upon IEC Publication 77 *"Rules for electric traction equipment"* and is technically identical to it.

This revision of BS 2618 has been extended to cover not only d.c. control equipment for electric traction, but also all the components in the various vehicle circuits with the exception of rotating machines, main transformers, reactors and static convertors for which there are other separate British Standards.

The various circuits each have a specific function. They are so arranged that the motive power unit exhibits the characteristics and qualities required for its operation, having regard to the kind of current used and the characteristics of the supply network in the case of electric vehicles, or the characteristics of the power source in the case of vehicles without external supply.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This specification applies to equipment installed on motive power units in the following categories:

vehicles supplied with so-called high-voltage d.c., i.e. with a voltage between 600 V and 3 000 V;

vehicles supplied with high-voltage a.c. at industrial frequency or at special frequency;

multi-system vehicles capable of being supplied from a number of the systems described above;

vehicles with independent power source (i.e. accumulators, or heat engines with electrical or other transmission) but excluding road vehicles.

It also applies to equipment installed on control trailers, or distributed among trailer coaches of multiple unit trains.

NOTE 1 Parts of this specification, after agreement between user and manufacturer, are suitable for use for electrical equipment installed on other vehicles such as d.c. electric rolling stock supplied at voltages below 600 V, mine locomotives, trolley-buses and so on.

NOTE 2 The title of the British Standard referred to in this standard is given on the inside back cover.

2 Limitations of the specification

Equipment meeting the requirement of this specification may be used in:

the main circuits: apparatus for circuit isolation, protection, current breaking, control, regulating and vehicle interconnection;

high and low-voltage auxiliary circuits (circuits for motors driving vehicle auxiliaries, lighting circuits and circuits for heating or air conditioning of the vehicle or train); apparatus for isolating, protection, interruption, control, regulating and adjustment;

control and indication circuits apparatus for control, checking, indication and vehicle interconnection.

Control of the various components forming the equipment may be of the mechanical, pneumatic, electrical, hydraulic, electro-magnetic or electro-pneumatic type, or consist of a combination of several types. These equipments may include individual or group controls.

This specification does not apply to the following components or equipment:

cables (these shall form the subject of special agreement including the methods of installation),

resistors for use in main circuits,

lightning arresters,

current collector gear (which depends mainly on the general design of the contact system and the speed of the rolling stock),

fuses for voltages below 600 V,

fuses for high-voltage a.c.,

lamps for lighting,

heating couplers,

roof bushing insulators,

measuring instruments,

equipment for repeating track signals on the rolling stock,

electronic or automatic control equipment,

control couplers,

and, generally, all equipment covered by other British Standards.

However, provided that there has been previous agreement between user and manufacturer, the specification may be applied to certain equipments, such as:

heating, air-conditioning and lighting equipment,

apparatus for the remote control of doors,

electro-pneumatic or electro-magnetic braking equipment.

3 Service conditions

3.1 The specification applies to equipment used in the following conditions:

3.1.1 *Altitude.* In the absence of information on the height above sea level at which the equipment is normally to function, it is to be assumed that this height shall not exceed 1 200 m.

3.1.2 *Temperature.* In the absence of information on the ambient temperatures in which the equipment is normally to function, it is to be assumed that these lie between – 25 °C and + 40 °C, with an annual average temperature not exceeding + 25 °C.

3.1.3 *Shocks and mechanical vibration.* In the absence of information concerning the degree of vibration and shock to which the equipment is likely to be subjected in service, it is to be assumed:

that the vibration is of sine-wave form, that the frequency f of vibration is between 1 Hz and 50 Hz, and that the amplitude a, expressed in millimetres, is given as a function of f, by the equations:

$a = \frac{25}{f}$ for values of f from 1 Hz up to 10 Hz

$a = \frac{250}{f^2}$ for values of f exceeding 10 Hz and up to 50 Hz

that the stresses due to sudden variations in vehicle speed correspond to maximum accelerations of ± 3 *g* (*g* being the value of acceleration due to gravity).

Where shock absorbers are fitted for a piece of apparatus or for a complete equipment, they shall be considered as part of the assembly.

3.1.4 *Installation.* With due regard to its location and method of installation on the vehicle, the equipment shall be capable of operating correctly in spite of dust, dirt, mist, rain and snow (especially powdered snow) to which rolling stock is normally exposed in service.

3.1.5 *Surface creepage and electrical clearance.* For equipment operating at the nominal line voltage between live parts and ground, or between positive and negative poles in systems where both conductors are insulated, surface creepage and clearance values shall be those given in Table 1.

The following meanings have been assigned to the terms used in the headings of Table 1:

1) *Clean conditions.* Applies to equipment mounted in vehicle compartments, switch-group (control-group) cases cupboards and all enclosed apparatus.

2) *Dirty conditions.* Applies in particular to resistors mounted in a resistor compartment, beneath the underframe or on the roof of the vehicle.

3) *Roof mounted.* Applies in particular to ceramic insulators for pantographs and for bare conductors. It does not apply to rubber piping for pantograph air supply or to roof cabling, to which larger values shall be applied.

4) *Inside mounted.* Applies to equipment mounted either in an enclosure which is dust-proof or in a chamber where clean conditions apply.

5) *Outside mounted.* Applies to equipment which does not fulfil the conditions for inside mounting.

6) *Electrical clearance.* The values given in the table do not apply to situations influenced by electrical arcs.

Equipment for trolleybuses on systems having nominal voltages up to 600 volts shall conform to the 600 volt values given in Table 1, except that for roof or chassis mounted resistors that are not totally enclosed the minimum surface creepage to the chassis shall be 45 min.

NOTE 1 Equipment which is operating on any of the nominal line voltages shown in the table, but which is at a potential less than the nominal line voltage, may have proportionally less creepage and electrical clearance values with a minimum of the 600 volt values given in the table.

NOTE 2 Special conditions may demand that the creepage clearances in Table 1 be increased.

NOTE 3 Creepage and clearance values at voltages below 250 V are excluded from Table 1. Other criteria assume greater importance at low voltages and it is not possible to give specific figures without taking this into account. Each application needs to be judged on its own merits and, where appropriate, figures agreed between the user and the manufacturer.

3.2 Special arrangements shall be agreed between user and manufacturer to cover the case of service conditions of greater severity than those mentioned in **3.1**, e.g.

altitude above 1 200 m;

ambient temperature exceeding 40 °C;

minimum temperature below – 25 °C, in this case it shall be for the user to change the quality of the lubricant;

high average temperature combined with high relative air humidity;

equipment mounted directly on non-suspended components (e.g. bogies, axles and on prime movers);

heavy rain, sandstorms, etc.

Checks on the effectiveness of such arrangements may form the subject of investigation tests (see Clause **8**).

Table 1 — Surface creepage and electrical clearance values for equipment in circuits operating at voltages exceeding 250 volts and not exceeding 3 000 volts

Nominal line voltage	Minimum surface creepage values			Minimum electrical clearance values	
	Clean conditions	Dirty conditions	Roof mounted	Inside mounted	Outside mounted
volts	mm	mm	mm	mm	mm
250 to 600	12	30	60	12	25
750	20	50	65	12	35
1 200	30	60	80	15	45
1 500	40	70	90	20	50
2 400	60	90	115	25	65
3 000	75	100	140	30	75

Section 2. Definitions and terminology

For the purposes of this British Standard, the definitions given below shall apply.

4 Equipment voltages

4.1 Supply from the contact system. The supply voltage for an equipment fed from the contact system is the declared voltage of the traction system.

4.2 Supply from a transformer. The rated voltage for an equipment supplied from an auxiliary winding of the main transformer is equal to the no-load r.m.s. voltage at the terminals of the winding when the transformer primary is supplied at the declared system voltage.

If an auxiliary transformer is interposed between the above-mentioned secondary and the equipment, the rated voltage is equal to the above-mentioned voltage multiplied by the transformer ratio of the auxiliary transformer.

4.3 Supply from a single-phase/d.c. static convertor. The rated voltage for an equipment supplied by such a convertor is the average value specified for the convertor output voltage. In the absence of a specified value, it shall be taken to be 90 % of the r.m.s. no-load voltage of the main or auxiliary transformer winding supplying the rectifier then the line voltage is at its declared value.

4.4 Supply from a variable voltage generator. The concept of rated voltage has no precise meaning in this case.

However, for the application of this specification, the rated voltage of equipment supplied from such a generator may be considered to be the maximum voltage of that generator.

4.5 Supply from an auxiliary generator. The rated supply voltage for an equipment supplied by an auxiliary generator is the voltage specified for that generator.

4.6 Supply from a battery. The rated supply voltage for an equipment supplied by an accumulator battery is the voltage specified for that battery.

This voltage shall be selected from among the following values:

24 V, 48 V, 72 V and 110 V.

5 Rated air pressure

5.1 The rated supply pressure to pneumatic or electro-pneumatic equipment is a specified value. It shall be specified, or accepted, by the user.

5.2 The air pressure referred to in this specification is relative and not absolute pressure.

6 Equivalent continuous rating

6.1 Traction service is generally characterized by values of current, voltage, compressed air pressure, etc. which vary with time.

It is sometimes possible to determine the continuous rating which in practice corresponds from the point of view of electrical, mechanical or thermal stresses to the intermittent service under consideration. This is known as the continuous rating equivalent to actual service (abbreviated to “equivalent continuous rating”).

If it is not possible to determine the equivalent continuous rating, the various parts of the equipment may be defined by a complete statement of the conditions to be fulfilled.

6.2 Equivalent continuous rated current. The equivalent continuous rated current is the current corresponding to the equivalent continuous rating as defined in **6.1**.

6.3 Equivalent continuous rated voltage. The equivalent continuous rated voltage is the voltage corresponding to the equivalent continuous rating as defined in **6.1**.

7 Current breaking equipment

7.1 Classification. Current-breaking equipment may be divided into two categories.

7.1.1 Protective equipment comprising the whole of the apparatus providing general protection for the equipment such as: circuit-breakers, contactor groups (breaking circuit either directly or in several steps) and apparatus providing individual protection for a particular circuit.

NOTE Fuses may be included in this category. However, this specification only applies to high-voltage fuses used for the protection of d.c. power circuits.

7.1.2 Current-breaking equipment comprising the whole of the apparatus or groups of apparatus for interrupting the various circuits in normal service.

7.2 Prospective current of a circuit. The current which would flow if the apparatus were replaced by a connection of negligible impedance without any other change in the circuit or in its supply conditions.

7.3 Short-circuit current. The steady current which would flow in a circuit having zero impedance beyond the apparatus (short-circuit), if the apparatus were replaced by a connection of negligible impedance without any change in the supply conditions of the circuit.

7.4 Cut-off current. Instantaneous maximum value reached during the breaking operation when the breaking speed of the apparatus is such that the prospective current in the circuit is not attained.

7.5 Critical current. Minimum value of current that the apparatus is capable of breaking without risk of failure to extinguish the arc between the contacts.

7.6 Breaking capacity. Breaking capacity expresses the current which the apparatus is capable of interrupting at given values of recovery voltage, power-factor or time constant of the circuit and in specified operating conditions.

A distinction should be made between:

7.6.1 *Rated breaking capacity*. The highest value of current that the apparatus is capable of breaking repeatedly at the declared or rated voltage (as appropriate) without electrical or mechanical damage which would affect its subsequent satisfactory operation.

7.6.2 *Maximum breaking capacity*. The highest value of current that the apparatus is capable of breaking at maximum voltage.

7.7 Making capacity. The making capacity of a switching device is expressed by the current on which the apparatus is capable of closing repeatedly at a given voltage and in specified operating conditions without electrical or mechanical failure.

8 Categories of tests

There are three categories of tests:

type tests,

routine tests,

investigation tests.

Type tests are carried out on a single piece of equipment of given design.

Routine tests are carried out on all pieces of equipment for the same order. After agreement between the manufacturer and the user, the routine tests for certain equipment may be carried out only on a selected proportion of items from an order.

Investigation tests are special tests of an optional character carried out on a single piece of equipment in order to obtain additional information on its performance; they are only to be carried out if they are particularly specified in the contract between the parties.

The results of investigation tests are not to be taken as influencing the acceptance of the material.

The differences between these three categories of tests are brought out in the text.

Standard production equipment shall be deemed to have passed the type tests and shall be exempted from them if the manufacturer produces a duly signed record of type tests already carried out on identical equipment constructed on a previous occasion.

Section 3. Conditions which electrical equipment has to satisfy

9 Limits of variation of supply voltage

NOTE In the following text, U represents the rated value of supply voltage as defined in Clause **4**.

9.1 With the exception of the special cases forming the subject of **9.2** to **9.6**, electrical, electromagnetic or electro-pneumatic equipment shall operate satisfactorily at any value of supply voltage between 0.7 U and 1.25 U after attaining a steady temperature when energized continuously at 1.0 U.

9.2 When the supply voltage is directly dependent on that of an a.c. contact system, the upper limit mentioned in **9.1** is to be altered to 1.1 U.

9.3 In the case of equipment supplied either by an auxiliary generator provided with a voltage regulator or by a generator, the voltage of which is completely independent of the contact system, the limits given in **9.1** are to be altered to 0.8 U and 1.1 U respectively.

9.4 When the supply voltage is provided by an accumulator battery having special arrangements for the correction of voltage variation (e.g. different cell groupings on charge and on discharge), a relaxation of the limits specified in **9.1** may be allowed by agreement between the parties.

9.5 For equipment supplied from a stabilized source, the limits of supply voltage variation shall be decided by agreement between user and manufacturer.

9.6 In special cases involving large voltage drops, e.g. where the vehicle comprises equipment or devices taking high currents, such as electro-magnetic brakes, the lower limits given above may be reduced to a value fixed by agreement between user and manufacturer.

10 Limits of variation of supply air pressure

10.1 When the equipment is pneumatically or electro-pneumatically operated, it shall function satisfactorily at an air pressure which may vary between the limits specified for the equipment in question, the value of these limits depending on the duty required of the equipment concerned. In general the ratio between maximum and minimum pressures shall not exceed 1.8.

10.2 However, for equipment supplied through a separate pressure reducing valve, the difference between the limits may be reduced by agreement between the parties.

11 Temperature-rise limits

11.1 The temperature rises of the various items of equipment measured during the tests carried out in accordance with Clause **19** shall not exceed the limits given in Table 2 and Table 3 hereafter.

11.2 However, in cases where the maximum ambient temperature is always well below 40 °C, an increase in these limiting values may be accepted by agreement between the parties.

NOTE The different classes of insulation employed at the present time in the construction of the apparatus forming the subject of this specification are defined with special regard to their composition in BS 2757.

Table 2 — Temperature-rise limits for insulated windings

Class of insulation	Temperature-rise limit measured by variation of resistance[a]
	°C
Class A insulation	80
Class E insulation	95
Class B insulation	105
Class F insulation	130
Class H insulation	155

[a] Where measurement by variation of resistance is not possible, an electrical thermometer shall be used.

Table 3 — Temperature-rise limits for various components

Component	Temperature-rise limit (measured by thermometer
	°C
Bare wire coils	105[a]
Contacts in air:	
Pure copper in the form of a spring	35
Brass or bronze in the form of a spring	65
Pure copper or copper alloy not forming a spring	75
Solid silver or silver plated	100
Flexible connections in air	90

[a] Provided that this value has no adverse effect on the satisfactory operation of adjacent parts.

11.3 During tests on equipment, no correction shall be made to the temperature rises observed if the cooling-air temperature is between 10 °C and 40 °C. Outside these limits, the correction to be applied to the temperature rises observed shall be decided by agreement between user and manufacturer, with due regard to any special characteristics of the materials under test.

12 Special provisions applicable to protective apparatus

12.1 The maximum breaking capacity of the apparatus or apparatus groups, which provide protection either to the equipment generally or to main circuits fed directly or indirectly from the supply network, shall correspond to the short-circuit current of the protected circuit.

The short-circuit current on the line side shall be specified by the user.

12.2 The maximum breaking capacity of the apparatus protecting circuits supplied from an internal source must be at least equal to the short-circuit current of the protected circuit at maximum voltage.

Section 4. Tests

13 List of tests

The principal tests to be carried out on electric traction equipment are set out in Table 4 below, together with the clause numbers to which reference should be made.

14 Checking of mechanical operation

This comprises type tests and routine tests.

14.1 Type tests

14.1.1 Type tests shall be carried out, before mounting on the vehicles, at both the lowest ambient temperature to which the equipment can be subjected in service (or at which its correct operation is guaranteed) and at the highest temperature it can attain.

These tests consist in checking twenty times in succession, for each combination, that the equipment will operate correctly within the limits of supply voltage and air pressure specified in Clauses **9** and **10**.

14.1.2 A check shall also be made that the operation of the equipment is still satisfactory when carried out under the most unfavourable combination of voltage, air pressure and temperature obtainable within the limits specified in Clauses **9**, **10** and **11**.

Table 4 — List of tests

Nature of test	Clauses	
	Type test	Routine test
1. Mechanical tests		
Checking of mechanical operation	**14.1**	**14.2**
Tests of mechanical endurance	**15**	
Tests for withstanding vibration and shock	**16**	
Air tightness tests for pneumatic equipment	**17.1**	**17.2**
Leakage tests for hydraulic equipment	**18.1**	**18.2**
2. Electrical tests		
Measurement of resistance and impedance		**19**
Temperature-rise tests	**20**	
Breaking and making capacity tests	**21**	
Determination of time/current characteristics of high-voltage d.c. fuses	**22**	
Check on setting and operation of protective equipment and relays		**23**
Voltage withstand tests		**24**

In the case of electro-magnetic or electro-pneumatic apparatus, hot operation at minimum voltage shall be considered to be satisfactory if the apparatus when cold operates normally when it is supplied with a current equal to that which would flow through the apparatus at minimum voltage after 1 h of operation at the rated voltage.

This method is not, however, applicable to apparatus used for preparing the vehicle for service (electro-pneumatic valve for pantographs, machine starting contactors, etc.) since this apparatus has in general to meet special requirements.

14.2 Routine tests. Routine tests consist of carrying out the tests described in **14.1.1** at ambient shop temperature only.

15 Tests for mechanical endurance

These are type tests. They are made first on apparatus selected individually, then on the mounted equipment.

15.1 Individual tests on apparatus. The tests for mechanical endurance of the apparatus shall be made at the rated supply voltage of the control circuit and at the rated air pressure for apparatus with electro-pneumatic control, the apparatus operating at no-load. They are to be carried out on apparatus which has already been subjected to the temperature rise and dielectric tests.

These tests are as follows:

1 000 000 operations for a single contactor or for each of a group of contactors on a camshaft

200 000 operations for apparatus used at each starting or braking operation

100 000 operations for reversers not included in the above

20 000 operations for all other apparatus.

Mechanical endurance tests shall be carried out at a rate, and with a method of lubrication depending on the nature of the apparatus, to be agreed between the user and the manufacturer.

Apparatus shall be considered as having successfully passed the mechanical strength tests if, after the tests, they are capable of operating normally without special attention other than cleaning and greasing.

15.2 Tests on assembled equipment. The assembled equipment is to be submitted to an endurance test on the vehicle at rated supply voltage and rated air pressure. The test is applied by operating the controller so as to produce 200 complete starts and switchings off with the equipment operating on no-load. The rate of execution of successive operations shall correspond to the most severe conditions to which the equipment concerned is to be subjected in service.

During the first thirty and last thirty operations the supply shall be at the lowest voltage which can be obtained on the vehicle.

NOTE If the user so requests, tests on the assembled equipment may be carried out in the manufacturer's workshops.

16 Test for withstanding vibration and shock

These tests are type tests.

The apparatus is secured in a suitable position to a machine producing vibrations of sinusoidal form with adjustable amplitude and frequency and is then subjected to the tests given below.

The apparatus under test shall be able to withstand successfully the electrical tests and, in particular, the voltage withstand tests applicable to the equipment concerned.

The test is carried out successively in each of the three directions vertical, longitudinal and transverse.

16.1 The determination of resonant frequencies. In order to determine the possible existence of critical frequencies producing resonance, the frequency shall be varied progressively over the whole range mentioned in **3.1.3** within a time of not less than 4 min, the amplitude of the oscillations being that indicated as a function of the frequency.

If resonance is produced, the corresponding frequency shall be maintained for a few minutes in each case with the apparatus alive. A check shall be made that no ill effects result on the operation of the apparatus (abnormal tripping of a relay, sparking at contacts, temperature rise at contacts, etc).

16.2 Tests with sustained vibration. The apparatus, at no-load, is next subjected to a test with sustained vibration for a period of 2 h:

1) either at the critical frequency, if any such well defined frequency has been detected in the course of the test given in **16.1**;

2) otherwise, at a frequency of 10 Hz.

In both cases, the amplitude of the vibrating table is adjusted to the value corresponding to the frequency concerned (see **3.1.3**).

In the case of relays, circuit-breaking equipment, etc. the test is carried out during the first hour in the de-energized or "open" position, and in the second hour in the energized or "closed" position.

The test is considered to be satisfactory if there is no resulting damage or abnormality in operation.

Subject to agreement between user and manufacturer, as an investigation test, the apparatus on full load may be subjected to sustained vibration for a longer period (25 h to 50 h).

16.3 Tests to simulate the effect of shunting shocks. In the direction corresponding to the longitudinal movement of the vehicle on which it is to be mounted, the apparatus is subjected for 2 min to 50 Hz vibrations of such a nature that the maximum acceleration is equal to 3 g (amplitude a = 0.3 mm).

In the case of apparatus for vehicles with rigid drawgear without buffers, the above vibration test shall be replaced by a series of three successive shocks each corresponding to a maximum acceleration of 3 g.

If the apparatus is designed for mounting on shock absorbing devices, these shall be in place during the test.

17 Air-tightness tests for pneumatic equipment

These tests apply mainly to magnet valves and to those air cylinders in which the air pressure shall be permanently maintained. They include type tests, and routine tests.

17.1 Type tests. Type tests are made on apparatus selected individually. Recommended methods of test are indicated below, but any equivalent simplified test may be used.

17.1.1 *Magnet valves.* In order to check the two valves normally present in a magnet valve, the latter shall be subjected to the following test, firstly when its cold winding is supplied with a current equal to that obtained with the winding hot (after 1 h), and secondly with the valve de-energized.

The magnet valve is connected to a 1 litre vessel charged at the maximum pressure. Air tightness shall be satisfactory if the pressure in the vessel does not decrease by more than 10 % of the maximum pressure after 10 min on test.

17.1.2 *Air cylinders.* Cylinders used for operating apparatus shall be subjected to the following test in order to check that piston and packing are airtight and the materials non-porous.

The cylinder equipped with its piston or diaphragm is connected to a reservoir having a volume in litres not greater numerically than 0.02 times the diameter of the cylinder in millimetres with a minimum of 1 litre charged to the maximum pressure; air tightness shall be satisfactory if the pressure in the reservoir does not decrease by more than 5 % of the maximum pressure after 10 min on test.

17.2 Routine tests. The routine tests shall be carried out by a simplified method which is to be the subject of an agreement between the user and the manufacturer. The purpose of the tests shall be the verification that the air leakage is not greater than that specified for the type tests. Use may be made of the following methods which are quoted as examples.

17.2.1 *Magnet valves.* A current equal to that which would be obtained with the winding hot (after 1 h) at minimum voltage is passed through the winding of each magnet valve when cold; the valve chambers of ten magnet valves are next connected to a 1 litre vessel charged at the maximum pressure.

The results obtained shall be of the same order of magnitude as those obtained in the type tests, with the proviso that in any case the drop in pressure shall not exceed 10 % of the maximum pressure after 1 min on test.

17.2.2 *Air cylinders.* Each cylinder, equipped with its piston or diaphragm and connected to a 1 litre capacity vessel charged to the maximum pressure, shall not show a loss of pressure greater than 5 % of the maximum pressure after 10 min on test.

For equipment having several cylinders which cannot be tested separately (pneumatic servo-motors for example), it is sufficient to check that the total leakage is not greater than the sum of the leakages allowable for each component. This test shall be carried out by connecting the various cylinders and, if required, the corresponding magnet valves to a vessel of 1 litre capacity charged to the maximum pressure; the pressure in this vessel shall not show a loss of pressure greater than 10 % of the maximum after a test time T, given in minutes, by the expression

$$T = \frac{10}{m + 0.5\ n}$$

where m and n denote respectively the number of magnet valves and the number of air cylinders connected to the 1 litre vessel.

17.2.3 *Installed equipment.* Finally, the following test shall be carried out after the installation of the equipment on each vehicle.

The supply reservoir of the control equipment shall be charged to the maximum pressure. The reservoir shall then be cut off from the compressor and, if appropriate, from braking and automatic door circuits. After a period of 20 min or 40 min, according to agreement between the user and the manufacturer, it shall be confirmed that the pressure is sufficient for all the equipment to operate correctly by making the complete series of control operations. Apparatus which is constructed with certain deliberate leakage shall be excluded from this test.

18 Leakage tests for hydraulic equipment

18.1 Type tests. An endurance test of three months' duration shall be made on a complete hydraulic equipment operating on a load cycle agreed between the user and the manufacturer to verify that no leaks exist which would either jeopardize the functioning of the equipment or necessitate replenishing the hydraulic fluid. There shall be no loss of fluid from the system as a whole.

The duration of the test may be established for a period other than three months after agreement between the user and the manufacturer.

18.2 Routine tests

18.2.1 *Cylinders.* With the pistons fitted with packing, rings or gaskets there shall be no significant leakage from the cylinder with the maximum load applied externally to the piston rod.

18.2.2 *Hydraulic spool and directional valves.* Hydraulic spool and directional valves shall be tested at maximum rated flow and maximum rated pressure. The leakage under these conditions shall not exceed 0.35 % per minute of the maximum rated flow per 100 bars[1)].

19 Measurement of resistance and impedance

These are routine tests.

Measurements of resistance shall be made on all electro-pneumatic or electro-magnetic control devices when cold, such as: magnet valves, servo-motors, voltage relays and electro-magnetic contactors, which include windings, the resistance of which may affect the operation of these devices.

The measurements obtained for any given winding, when corrected to a temperature of 20 °C, shall not vary by more than ± 8 % from the specified value or, alternatively, from the mean of the values measured on the first ten units tested.

The measurements of resistance are also made when cold on the various resistances inserted in the control, indication and auxiliary circuits. The allowable tolerances which vary according to the application shall be agreed between the parties concerned.

For apparatus in a.c. circuits or in d.c. circuits where correct operation depends on the impedance, measurements of resistance shall, if necessary, be accompanied by measurements of impedance carried out with a.c. at the specified frequency.

20 Temperature-rise tests

20.1 General. These are type tests. They are applied to constituent parts of equipment; windings, blow-out coils, main contacts, flexible connections, and regulating and protective resistances.

The apparatus to be tested shall be mounted so as to reproduce approximately the normal service conditions on the vehicles, particularly as regards ventilation. For apparatus to be mounted outside a vehicle, artificial ventilation reproducing conditions similar to those encountered in service shall be applied by agreement between the parties.

[1)] 1 bar = 10^5 N/m^2 = 100 kPa.

Each test shall be carried out for a period of time sufficient to enable the temperature rise to reach a steady value. In practice, this condition is fulfilled when the temperature variation does not exceed 1 °C per hour.

The ambient temperature shall be measured during the last quarter of the test period by means of at least two thermometers arranged symmetrically around the apparatus at the same height and at a distance of about 1 m. The thermometers shall be protected against draughts and heat radiation. In order to avoid errors arising from rapid variations of temperature, they may be placed in small containers of oil having an oil capacity of about half a litre.

20.2 Insulated windings. Temperature tests on windings: circuit-breaker holding coils, magnet valve coils, electro-magnetic contactor operating coils, relay coils, etc., shall be made at a voltage equal to the equivalent continuous rated voltage defined in Clause **6**.

If this equivalent continuous rated voltage cannot be determined, tests shall be made at a voltage equal to the upper limit of voltage in the circuit in which the windings under consideration are to be connected.

For windings fed through additional resistances, the voltage to be applied to the terminals of the windings shall be equal to the actual voltage at the terminals when the voltage applied to the winding-resistance assembly is equal to the continuous rated voltage or, if this cannot be determined, to the maximum voltage specified above.

The temperature rise measured by variation of resistance shall not exceed the limiting values given in Table 2.

The above temperature-rise tests shall not be required for special items operating very infrequently, i.e. with operation sufficiently infrequent to enable the items in question to cool down between two successive operations. In such case, the temperature-rise tests shall form the subject of agreement between the user and the manufacturer.

20.3 Bare windings, main contacts and flexible connections. Temperature-rise tests on blow-out coils, on the windings of relays constructed of a single layer of heavy section turns, on contact tips and on their flexible connections are to be carried out with equivalent continuous rated current. If this cannot be determined, they are to be carried out at the rated current of the apparatus.

Temperature rises measured by thermometers applied to locations assumed to be the hottest shall not exceed the limiting values given in Table 3.

In the case of multi-layer windings, the temperature rise is measured by variation of resistance and shall not exceed the values given in Table 2.

20.4 Regulating and protective resistors. Temperature-rise limits for resistors shall be fixed in accordance with the kind of material employed, the general design of the apparatus and the temperatures which the enclosures and adjoining equipment (terminals, cables, etc.) are able to withstand.

21 Breaking and making capacity tests

21.1 General. These are type tests applicable to all current-breaking equipment.

The apparatus to be tested is to be located in surroundings representing as closely as possible the conditions of installation on the vehicle (clearance from earth, volume of air, method of fixing, etc.).

During the tests, the cases containing the apparatus or the supporting structures normally connected to earth, and the screens representing the steel work or panelling of the vehicle, are to be connected to the terminal which is of the same polarity as the return circuit. The same is also to apply to the low-voltage control circuits.

In the test circuit of appropriate resistance, an inductance of suitable value is to be inserted so as to obtain the power-factor or time constant specified. The polarity of the circuit and the position of the apparatus in the circuit are to be chosen in accordance with the conditions of use, the test impedance being substituted for that of the circuit to be supplied.

The tests to be carried out on the various categories of equipment and the methods to be employed are given below.

21.2 Breaking capacity test on protective equipment

21.2.1 *A.C. protective equipment.* The apparatus under test is to be connected in a circuit so adjusted as to obtain a power-factor of approximately 0.15 and a short-circuit current equal to the maximum breaking capacity of the apparatus. The apparatus shall perform three successive interruptions at 2 min intervals by means of its own (external or internal) overload relays. After this test, some small maintenance work may be needed, such as cleaning or filing the contacts.

21.2.2 *D.C. protective equipment.* The apparatus under test shall be connected in a circuit so adjusted as to obtain a short-circuit current equal to the maximum breaking capacity of the apparatus and a time constant of specified value. In the absence of specification, the value of the time constant shall be as given by Table 5. The apparatus shall perform three successive interruptions at 2 min intervals by means of its own overload relays without causing any overvoltage higher than given in Table 6. After this test, some small maintenance work may be needed such as cleaning or filing the contacts, etc.

Table 5 — Time constants

Breaking capacity	Time constant
kA	ms
Below 5	30
Between 5 and 25	20
Above 25	10

Table 6 — Overvoltages

Rated voltage	Peak value of the voltage during the transient period
kV	kV
Up to and including 0.75	3
1.5	6
3	12

21.2.3 *Check on the critical current.* Finally, a check shall be made that the apparatus is capable of satisfactorily breaking at maximum voltage a current equal to the lower of the two values: 0.1 times the minimum static setting, or 50 A.

The last test shall be carried out three times at 2 min intervals, firstly without inductance in the circuit, and afterwards with the inductance called for in **21.2.1** or **21.2.2** in the circuit.

21.3 Making capacity tests on protective equipment. The apparatus under test shall be connected to a circuit so adjusted as to obtain a current corresponding to the rated making capacity of the apparatus at rated voltage. The apparatus shall successfully perform 180 operations at 2 min intervals.

21.4 Breaking capacity tests on current-breaking apparatus

21.4.1 *A.C. current-breaking apparatus.* The apparatus under test is to be connected in a circuit so adjusted as to obtain a power-factor of 0.8, and a current equal to rated breaking capacity of the apparatus. The apparatus shall perform successfully, under its normal control, 180 interruptions at 2 min intervals.

21.4.2 *D.C. current-breaking apparatus.* The apparatus under test is to be connected in a circuit so adjusted as to obtain a current equal to the rated breaking capacity of the apparatus and a time constant of the order of 10 ms to 15 ms. The apparatus shall perform successfully, under its own control, 180 interruptions at 2 min intervals.

21.5 Breaking capacity test on apparatus designed for both protection and current-breaking. Apparatus designed for both protection and current-breaking shall be subjected to the tests in **21.2.1** (or **21.2.2**), **21.2.3**, **21.3** and **21.4.1** (or **21.4.2**).

21.6 Breaking capacity test on high-voltage d.c. fuses. High-voltage d.c. main fuses shall be subjected to the tests in **21.6.1** to **21.6.3** below.

21.6.1 The current in the test circuit is adjusted to a value between 100 % and 115 % of the breaking capacity of the fuse.

If the cut-off current exceeds 60 % of the prospective current, two further tests shall be carried out.

If, and only if, the cut-off current is less than 60 % of the prospective current, the test in **21.6.2** shall be carried out.

21.6.2 With the time constant maintained at a steady value, the circuit prospective current is reduced during the test so as to bring the cut-off current to a value between 60 % and 80 % of the new prospective current.

The test shall be carried out twice.

21.6.3 The circuit prospective current is finally adjusted to a value between 100 % and 140 % of the minimum fusing current, as defined by the asymptote drawn parallel to the time axis of the time/current characteristic (see Clause **22**).

The test shall be carried out twice.

21.6.4 During the tests, overvoltages are to be recorded by a cathode-ray oscillograph connected to the terminals of the fuse.

Unless otherwise specified, these overvoltages shall not exceed the values given in Table 6.

In the course of operation, there shall be no flashover to earth nor any external effect involving danger to the surroundings.

After the melting of the fuse element, the components of the fuse assembly, apart from those intended to be replaced after each operation, shall be in the same state as before. However, slight damage is allowable to the components required for holding the fuse element of replaceable fuses provided that this is not such as to prevent the replacement of the fuse element, or decrease its breaking capacity, or modify its breaking characteristics or increase its temperature rise in normal service.

22 Determination of the time/current characteristic of high-voltage d.c. fuses

This is a type test.

The determination of the time/current characteristic may be made at any ambient air temperature between 15 °C and 30 °C. The cooling and ventilation conditions shall be in accordance with those obtained in normal service.

The curve representing the melting time against prospective current shall be drawn with logarithmic scales for both co-ordinates. For this purpose, the oscillograph records obtained during the tests for checking breaking capacity shall be used completed, if necessary by a few tests at intermediate current values. Unless the manufacturer objects, these latter tests may be carried out with low-voltage a.c.

The results obtained shall not deviate from the declared curve supplied by the manufacturer by more than ± 20 % of the current values.

23 Check on the setting and operation of protective apparatus and relays

These checks are routine tests to be carried out both on apparatus (relays), the operation of which is determined by the value of the line voltage, or by that of the voltage of the source supplying the control or auxiliary circuits, and on all apparatus (circuit-breakers, current relays), the operation of which is determined by the value of the current passing through them.

Generally speaking, all such apparatus shall operate with a tolerance of ± 5 % of their setting.

This tolerance shall, however, be raised to ± 7.5 % for mechanically latched relays.

For apparatus having a time delay feature, the tolerance on the operating time shall be fixed by agreement between user and manufacturer. In the absence of such agreement, for apparatus having a specified value of time delay, a tolerance of 10 % of this value shall be accepted.

Any calibration markings on protective apparatus and relays shall be correct to approximately ± 5 %, this tolerance being added to the setting tolerance previously mentioned.

24 Voltage withstand tests

24.1 General. Voltage withstand tests are routine tests.

They are carried out with alternating current on every single piece of apparatus, then on the equipments when mounted on the vehicle. In certain cases, to be agreed between the user and the manufacturer, they may also be carried out on assemblies of apparatus connected in groups.

The tests shall be carried out at the normal temperature of the test site.

The test voltage at a frequency of 50 Hz shall be of approximately sinusoidal form.

The methods of test and the r.m.s. values of the test voltage, the time of application of which is fixed at 1 min in all cases, are defined below.

NOTE In all the formulae giving test voltages, U represents the rated supply voltage (see Clause 4) of the circuit in which is connected in service the apparatus subject to the test. However, where the circuit contains a mid-point permanently connected to earth, U shall be taken to be one-half of this supply voltage.

24.2 Tests on single pieces of apparatus

24.2.1 *Main circuit-breakers of vehicles supplied with a.c.* Parts of the main circuit-breaker electrically connected to the contact system shall be tested by the application between contacts and earth when in the closed position, and between contacts in the open position, of a voltage of an r.m.s. value of:

$2.2\ U + 20\ 000$ V

24.2.2 *Apparatus connected in circuits with a rated voltage equal to or exceeding 300 V d.c. and 100 V a.c.*

1) For each piece of apparatus or group of apparatus, intended to break a circuit, the test shall consist of the application between the input and output sides of the apparatus or group — with contacts open and are chutes in position — of a voltage of an r.m.s. value equal to:

$2\ U + 1\ 500$ V

For all breaking apparatus connected in parallel with a resistor, the test voltage shall be limited to 0.75 times the value mentioned above.

2) For all apparatus taken singly and for each component, a dielectric test at a voltage equal to:

$2.5\ U + 2\ 000$ V

shall be applied between main circuits and earth, and between main circuits and control circuits when the apparatus includes windings connected in these circuits and mounted on magnetic circuits which are not permanently earthed[2)].

3) Where certain items have double insulation, the dielectric test shall be carried out:

between circuit and frame insulated from earth, at a voltage of 2 U + 1 000 V;

between insulated frame and earth, at a voltage of 2.5 U + 2 000 V.

NOTE Where the main insulation is provided between circuit and frame insulated from earth, the above test voltages shall be reversed.

4) Control apparatus included in the high-voltage circuit, but not in a part subjected to a voltage greater than 500 V to earth, shall be tested at 2 500 V unless otherwise specified.

24.2.3 *Apparatus in circuits with rated voltages below 300 V d.c. or 100 V a.c.* Dielectric tests of apparatus and component parts shall be made to earth at a voltage of 1 500 V r.m.s.

However, for apparatus in circuits of rated voltage less than 30 V, the test shall be carried out at 750 V.

24.3 Tests on apparatus groups. When it is necessary to carry out a dielectric test on a group of apparatus, this test shall be made with a voltage equal to 0.85 times the test voltage of the apparatus taken singly.

24.4 Tests on an equipment mounted on the vehicle. Before delivery of the stock, each mounted equipment shall be subjected to a dielectric test to earth. Rotating machines and, unless otherwise specified, control apparatus inserted at points in the power circuit or an auxiliary circuit normally subjected in service to a voltage of less than 500 V to earth, shall be disconnected from the circuits to which they belong.

The test shall be carried out at an r.m.s, voltage equal to 0.85 times the test voltage defined in 24.2, for the apparatus in the circuit concerned.

Control apparatus in circuits of rated voltages above 300 V, which, in accordance with the arrangements mentioned above, had previously been disconnected as belonging to a part of these circuits not subjected to a voltage above 500 V, shall be tested individually at a voltage of 2 500 V.

[2)] However, in certain special cases, after specific agreement between user and manufacturer, a test voltage higher than that given by the formula 2.5 U + 2 000 may be used.

Publication referred to

This standard makes reference to the following British Standard:

BS 2757, *Classification of insulating materials for electrical machinery and apparatus on the basis of thermal stability in service.*

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