

Specification for

Capacitors for connection to power-frequency systems

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The scientific and 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:

British Fractional Horsepower Electric Motor Manufacturers Association

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Foreword

This standard makes reference to the following British Standard:

BS 923, *Guide on high-voltage testing techniques*.

This revision of BS 1650, issued under the authority of the Electrical Industry Standards Committee, follows closely the technical content of Publication 70, 2nd Edition 1967, of the International Electrotechnical Commission.

In this revision, capacitors for the starting and running of single-phase motors are no longer included. A separate standard is to be issued on this subject.

Some additional information is given in appendices and attention is directed to these.

This standard is amended following the endorsement by CENELEC of IEC 871-1 as HD 525-1 S1 to remove references to capacitors intended for a.c. power systems having rated voltages above 660 V which are addressed by the reference document.

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 18 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.

1 General

1.1 Scope

This British Standard applies to capacitors intended to be used for power factor correction on a.c. power systems having rated voltages up to 660 V operating at frequencies up to and including 100 Hz.

It applies to capacitors intended for use within ambient temperature limits of $-40\text{ }^{\circ}\text{C}$ and $+50\text{ }^{\circ}\text{C}$ and at altitudes not exceeding 1 000 m. The specification does not apply to the following types of capacitor, which may form the subject of separate British Standards:

Self-healing capacitors.

Series capacitors.

Capacitors for use in tubular fluorescent, mercury and sodium discharge lamp circuits.

Starting and running capacitors for single-phase motors.

1.2 Definitions

For the purposes of this British Standard the following definitions apply:

1.2.1

capacitor element (or element)

an indivisible part of a capacitor consisting of electrodes separated by a dielectric

1.2.2

capacitor unit (or unit)

an assembly of one or more capacitor elements in a single container with terminals brought out

1.2.3

capacitor bank (or bank)

a group of units, connected electrically to each other, e.g. a three-phase bank may be composed of three single-phase units

1.2.4

capacitor equipment

an assemblage of a capacitor unit or units together with protective and/or control gear suitable for connection to a circuit

1.2.5

capacitor

used where it is not necessary to lay particular stress upon the different meanings of the terms such as “capacitor unit”, “capacitor bank”, or “capacitor equipment”

1.2.6

discharge device

a device connected across the terminals or busbars, or built into the capacitor unit, capable of reducing the residual voltage to a safe value after the capacitor has been disconnected from the supply

1.2.7

rated voltage, U_n

the r.m.s. value of the voltage at rated frequency between terminals, which the capacitor is intended to withstand continuously

for capacitors consisting of one or more separate circuits (e.g. single-phase units intended for use in polyphase connection, or polyphase units with separate circuits), U_n refers to the rated voltage of each separate capacitor circuit

for polyphase capacitors with internal electrical connections between phases, U_n refers to the line-to-line voltage

1.2.8

insulation level

the insulation level of a capacitor unit is the combination of test voltage values (both power-frequency and impulse) which the insulation between the line terminals and the container is required to withstand

the insulation level of a capacitor bank is that combination of test voltage values (both power-frequency and impulse) which the insulation between the line terminals (or terminal) of the bank and any metal which is intended to be earthed, is required to withstand

1.2.9

rated output

the reactive output (kVAr) at rated voltage and rated frequency for which the capacitor is designed. (The effect of harmonics on capacitor loading is dealt with in Appendix E.)

1.2.10

rated current

the r.m.s. current through one line terminal at rated voltage and rated frequency

1.2.11

capacitor losses

the active power consumed by a capacitor

NOTE Unless otherwise stated, the capacitor losses will be understood to include losses in fuses and discharge devices forming an integral part of the capacitor.

1.2.12

tangent of the loss angle ($\tan \delta$)

the capacitor losses divided by the reactive output of the capacitor

1.2.13

highest system voltage, U_m

the highest r.m.s. line-to-line voltage which can be sustained under normal operating conditions at any time and at any point of the system. It excludes temporary variations due to fault conditions or the sudden disconnection of large loads

1.2.14

ambient air temperature

the temperature of the air at the proposed location of the capacitor

1.2.15

cooling air temperature

the temperature of the cooling air measured at the hottest position in the bank midway between two units. If only one unit is involved it is the temperature measured at a point approximately 0.3 m away from the capacitor container and at two thirds of the height from its base

1.2.16

container temperature rise

the difference between the temperature of the hottest point of the container and the ambient air temperature

1.3 Classification

This specification applies to capacitors intended for use within ambient air temperature limits of $-40\text{ }^{\circ}\text{C}$ and $+50\text{ }^{\circ}\text{C}$ and at altitudes not exceeding 1 000 m.

For this purpose capacitors are classified in temperature categories, each being characterized by both the lowest ambient air temperature at which the capacitor may be energized, chosen from three values, $-40\text{ }^{\circ}\text{C}$, $-25\text{ }^{\circ}\text{C}$ and $-10\text{ }^{\circ}\text{C}$, and the upper limit of ambient air temperature at which the capacitor may be operated, as defined in Table 1.

Table 1 — Maximum ambient temperatures

Upper limit of category ambient air temperature	Maximum ambient air temperature		
	Mean over 1 h	Mean over 24 h	Mean over 1 year
$^{\circ}\text{C}$	$^{\circ}\text{C}$	$^{\circ}\text{C}$	$^{\circ}\text{C}$
40 (temperate)	40	30	20
45 (tropical)	45	40	30
50 (super-tropical)	50	45	35

Typical temperature categories are:

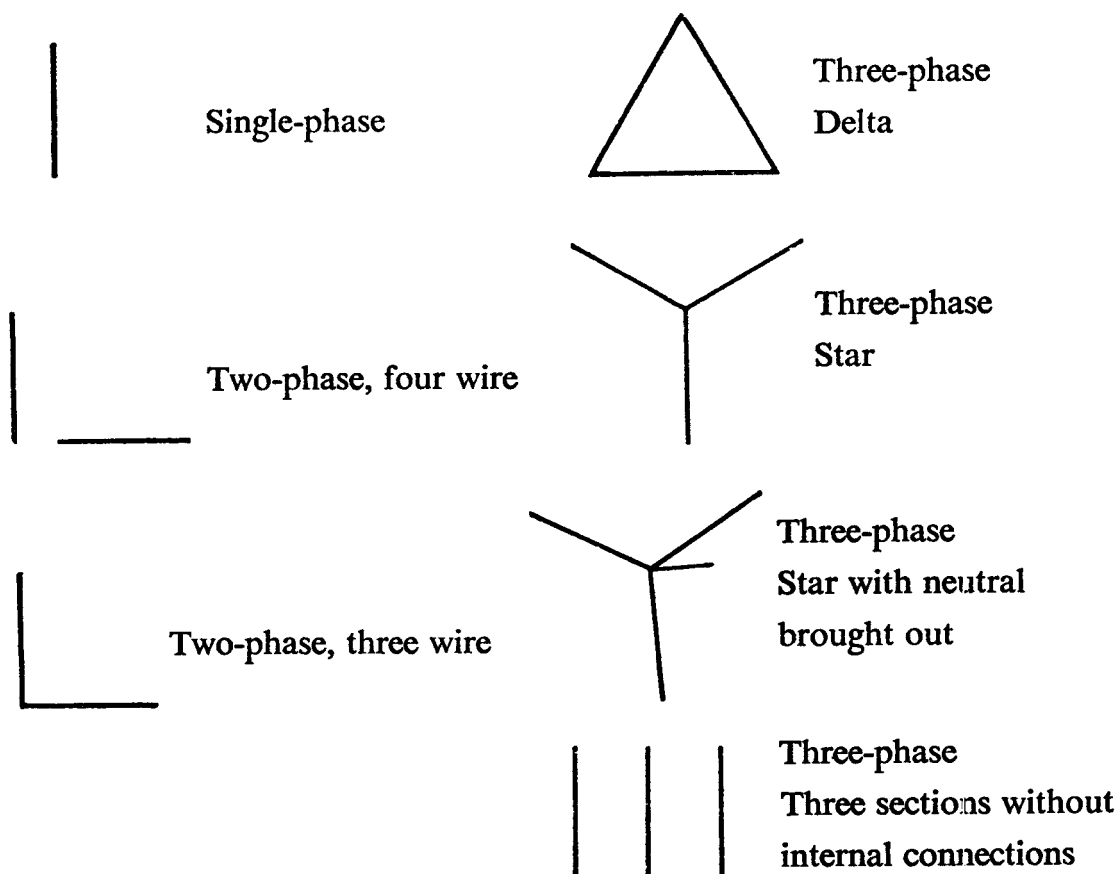
– 40/+ 40 °C, – 25/+ 40 °C, – 10/+ 40 °C, – 10/+ 45 °C.

1.4 Rating plate

1.4.1 The following information shall be given on the rating plate or container of each capacitor. However, for small units where it is impracticable to indicate all the items on the rating plate, items 8) and 9) may be stated in an instruction sheet.

- 1) Manufacturer's name or trade mark.
- 2) The number of this British Standard, i.e. BS 1650.
- 3) Serial number.
- 4) Rated output in kVAr.
- 5) Rated voltage U_n in volts or kilovolts.
- 6) Rated frequency in Hertz.
- 7) Temperature category (see 1.3).
- 8) Connection symbol (see 1.4.2).
- 9) Discharge device(s), fitted or not fitted.

1.4.2 The type of connection shall be indicated by the following symbols:



2 Safety requirements

NOTE The purchaser should specify, at the time of ordering, any special requirements with regard to safety which are not covered by the following clauses.

2.1 Discharge device

2.1.1 Capacitor equipments shall be provided with a directly connected discharge device, unless they are to be connected directly to other electrical equipment providing a discharge path without having a disconnecting switch, fuse cut-out or series capacitor interposed.

NOTE The purchaser should inform the supplier if the latter condition applies.

2.1.2 The discharge device (or the other electrical equipment mentioned in **2.1.1**) shall reduce the residual voltage from the crest value of the rated voltage U_n to 50 V or less within 1 min after the capacitor is disconnected from the source of supply (but see Note 3).

NOTE 1 Where capacitor units are connected in series, discharge devices fitted to each unit may not be adequate to ensure compliance with the requirements of this clause, owing to the cumulative effect of the residual voltages. If the supply voltage is so high that this occurs, then an additional external discharge device will be necessary and should be directly connected across the capacitor equipment or bank.

NOTE 2 A discharge device is not a substitute for short-circuiting the capacitor terminals together and to earth before handling. A residual charge may sometimes be left on the interconnections of series-connected capacitor units, due to blown fuses, interrupted internal connections or non-linear behaviour of the dielectric resulting from over-stressing. These interconnections, therefore, should be short-circuited to earth before handling.

NOTE 3 Special discharge arrangements may be necessary when capacitors are switched off and on at very short intervals (see **A.5**).

2.2 Container connection

Provision shall be made on the metal container of the capacitor for a connection of adequate size to be made to permit reliable and permanent connection of the container to earth or other point of fixed potential.

3 Quality requirements and tests

3.1 Standard temperatures for testing

All the tests specified, except where otherwise stated or agreed, shall be carried out within the ambient temperature range of 15 °C to 35 °C inclusive. If corrections have to be made, the reference temperature shall be 20 °C.

3.2 Routine tests

All capacitors shall withstand the following routine tests, in the order specified below:

- 1) output test (see **3.2.1**);
- 2) voltage test between terminals (a.c. or d.c.) (see **3.2.2**);
- 3) a.c. voltage test between terminals and container (dry test) (see **3.2.3**);
- 4) discharge device test, if required (see **3.2.4**);
- 5) final output test (see **3.2.5**).

The following test may be carried out at any convenient point in the testing sequence:

- 6) sealing test (see **3.2.6**).

3.2.1 Output test. The output shall be measured using a method which excludes errors due to harmonics and to accessories. This measurement shall demonstrate that at the rated voltage and frequency the output of a capacitor, a capacitor bank or an equipment is not less than the rated output and not more than 110 % of the rated output. The rated output of a capacitor unit forming part of a bank shall be not less than 95 % and not greater than 110 % of the nominal rated output of the unit. Two methods of making these measurements are described in Appendix C.

In polyphase capacitors the balance between phases shall be such that, with a symmetrical supply voltage, the ratio between the maximum and minimum r.m.s. values of the line current does not exceed 1.08.