

Low-voltage controlgear —

Part 2: Specification for semiconductor contactors (solid state contactors) —

(Implementation of CENELEC HD 419.2 S1)

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Foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Committee and is related to IEC 158-2:1982 published by the International Electrotechnical Commission (IEC). This standard is in agreement with Harmonization Document HD 419.2 S1 published by the European Committee for Electrotechnical Standardization (CENELEC), which has introduced modifications to 8.2.3.3, 8.2.9.2b) and 8.2.9.3b).

BS 5424 consists of the following Parts:

- Part 1:1977: *Contactors*;
- Part 2:1987: *Specification for semiconductor contactors (solid state contactors)*;
- Part 3:1987: *Additional requirements for contactors subject to certification*.

Terminology and conventions. For ease of reproduction, most of the text and format of IEC 158-2 has been used as the basis of this British Standard. Some terminology and conventions are not identical with those in British Standards.

Cross-references

International Standard	Corresponding British Standard
IEC 60-2:1973	BS 923 <i>Guide on high-voltage testing techniques</i> Part 2:1980 <i>Test procedures</i> (Identical)
IEC 144:1963	BS 5420:1977 <i>Specification for degrees of protection of enclosures of switchgear and controlgear for voltages up to and including 1 000 V a.c. and 1 200 V d.c.</i> (Identical)
IEC 158-1:1970	BS 5424 <i>Specification for controlgear for voltages up to and including 1 000 V a.c. and 1 200 V d.c.</i> Part 1:1977 <i>Contactors</i> (Identical)
IEC 664:1980	PD 6499:1981 <i>Guide to insulation co-ordination within low-voltage systems including clearances and creepage distances for equipment</i> (Identical)

The Technical Committee has reviewed the provisions of IEC 65 and IEC 147-0, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. A related British Standard to IEC 65:1987 is BS 415:1979.

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 to iv, pages 1 to 26, 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.

1 General

1.1 Scope

This standard applies to semiconductor contactors intended for performing electrical operations by changing the state of electric circuits between on state and off state.

This standard is additional to IEC Publication 158-1: Low-voltage Controlgear, Part 1: Contactors (including Supplements A and B) which is applicable, provided it is not amended by this standard.

It applies only to semiconductor contactors, the main circuit of which is intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V a.c. or 1 500 V d.c.

NOTE 1 Semiconductor contactors dealt with in this standard are not intended to provide short-circuit protection of the main circuit, but may contain short-circuit protective devices for semiconductor parts.

NOTE 2 Semiconductor motor-starters will be dealt with in a later publication.

This standard applies also to hybrid-semiconductor contactors, which are also covered by the scope of IEC Publication 158-1 as concerns their electromagnetic part.

1.2 Object

See IEC Publication 158-1¹⁾.

2 Definitions

For the purpose of this standard, the following definitions shall apply:

2.1 Definitions concerning contactors and semiconductor contactors

2.1.1

semiconductor switching device

a switching device designed to make the current in an electric circuit by means of the controlled conductivity of a semiconductor

NOTE In a circuit where the current passes through zero (alternately or otherwise), the effect of “not making” the current following such a zero value is equivalent to breaking the current.

2.1.2

mechanical switching device

see IEC Publication 158-1

2.1.3

controlgear

see IEC Publication 158-1

2.1.4

contactor (mechanical)

see IEC Publication 158-1

2.1.5

semiconductor (Sub-clause 0-1.1 of IEC Publication 147-0²⁾)

a material with resistivity usually in the range between metals and insulators, in which the electrical charge carrier concentration increases with increasing temperature over a certain temperature range

2.1.6

semiconductor contactor

a device which performs the function of a contactor by utilizing a semiconductor switching device

NOTE A semiconductor contactor may also contain mechanical switching devices.

2.1.7

hybrid semiconductor contactor

a device which performs the function of a contactor by utilizing a combination of semiconductor and mechanical devices with the switching duty performed by a semiconductor device while the current-carrying duty is taken care of by a mechanical device

2.1.8 (Vacant)

2.1.9 (Vacant)

2.1.10

main circuit (of a semiconductor contactor)

all the conductive parts of a semiconductor contactor included in the circuit it is designed to control

2.1.11

pole of a contactor

see IEC Publication 158-1

2.1.12 (Vacant)

2.1.13

breaking current (of a semiconductor contactor)

a general term used to designate the value of current in a pole of a semiconductor contactor:

- for a.c., the r.m.s. value of the current immediately before the change from the “on-state” to the “off-state”;
- for d.c., the value of the current just before the turn-off is initiated.

¹⁾ Whenever reference is made to IEC Publication 158-1, the clause with the same clause number applies, in some instances modified by the text which follows, it being understood that the word “contactor” shall be replaced by “semiconductor contactor”.

²⁾ Essential Ratings and Characteristics of Semiconductor Devices and General Principles of Measuring Methods, Part 0: General and Terminology.

2.1.14**breaking capacity (of a semiconductor contactor)**

for a.c., the r.m.s. value of the maximum breaking current of a semiconductor contactor which will cease to flow when the control initiating the “on-state” is removed and for d.c., the maximum current that can be turned off when the “turn off” signal is applied and the “turn on” signal is removed, at a stated value of voltage under prescribed conditions of use and behaviour

2.1.15**making capacity**

see IEC Publication 158-1

2.1.16 Recovery voltage

See IEC Publication 158-1.

2.1.16.1**transient recovery voltage**

see IEC Publication 158-1

2.1.16.2**power-frequency recovery voltage**

see IEC Publication 158-1

2.1.17**short-time withstand current**

the current that a semiconductor contactor can carry in the on-state during a specified short-time under prescribed conditions of use and behaviour

2.1.18**over-current**

see IEC Publication 158-1

2.1.19**overload**

see IEC Publication 158-1

2.1.20**conductive part**

see IEC Publication 158-1

2.1.21 Clearance

See IEC Publication 158-1.

2.1.21.1**clearance between poles**

see IEC Publication 158-1

2.1.21.2**clearance to earth**

see IEC Publication 158-1

2.1.21.3 (Vacant)**2.1.22****creepage distance**

see IEC Publication 158-1

2.1.23**exposed conductive part**

a conductive part which can be touched readily and which normally is not live, but which may become live under fault conditions

NOTE Typical exposed conductive parts are walls of enclosures, operating handles, etc.

2.1.24**ambient air temperature**

see IEC Publication 158-1

2.1.25**maximum on-state current for one-half a cycle**

the peak value of the current which a semiconductor contactor can carry in the on-state for half a cycle of the supply voltage without losing its ability to perform as intended

2.1.26**off-state leakage current I_L**

the maximum current which flows through the main circuit of a semiconductor contactor in the off-state

2.1.27**minimum load current**

the minimum operational current in the main circuit which is necessary for correct action of a semiconductor contactor in the on-state

NOTE The minimum load current should be given as r.m.s. value.

2.2 Definitions concerning states, control and auxiliary circuits of a semiconductor contactor**2.2.1****inactive state**

the condition of a semiconductor contactor without any control signal

2.2.2**control circuit (of a semiconductor contactor)**

all the conductive parts (conductors, resistors, capacitors, coils, diodes, etc.) of a semiconductor contactor intended to be included in a circuit (other than the main circuit) used to initiate the making and breaking operation of the semiconductor contactor

2.2.3 (Vacant)**2.2.4****auxiliary circuit**

all the conductive parts (conductors, resistors, capacitors, contacts, diodes, etc.) of a semiconductor contactor intended to be included in a circuit other than the main circuit and the control circuits of the semiconductor contactor

NOTE Some auxiliary circuits serve supplementary requirements such as signalling, interlocking, cooling, etc. and, as such, they may be part of the control circuit of another switching device.

2.2.5

auxiliary contact

a contact included in an auxiliary circuit of a semiconductor contactor and operated by the contactor

2.2.6 (Vacant)

2.2.7 (Vacant)

2.2.8

ON-state

the condition of a semiconductor contactor when the conduction current can flow through its main circuit

2.2.9

OFF-state

the condition of a semiconductor contactor when no control signal is applied and no current exceeding the OFF-state leakage current I_L flows through the main circuit

NOTE Semiconductor contactors may not provide in the OFF-state a contact gap in the main circuit. Therefore, the main circuit on the load side shall be considered to be live.

2.2.10

operation (of a semiconductor contactor)

the transition from the ON-state to the OFF-state or the reverse

2.2.11

operating cycle (of a semiconductor contactor)

a succession of operations from one state to the other and back to the first state

NOTE A succession of operations not forming an operating cycle is referred to as an operating series.

2.2.12

making operation

an operation by which the semiconductor contactor is brought from the OFF-state to the ON-state

2.2.13

breaking operation

an operation by which the semiconductor contactor is brought from the ON-state to the OFF-state

3 Classification

3.1 (Vacant)

3.2 According to the cooling system, semiconductor contactors can be divided into different groups, for example natural cooling, forced air cooling, liquid cooling. The cooling system is considered as a part of the device.

3.3 According to the degree of protection provided by the enclosure. Full details are given in IEC Publication 144: Degrees of Protection of Enclosures for Low-voltage Switchgear and Controlgear.

4 Characteristics of semiconductor contactors

4.1 Summary of characteristics

See IEC Publication 158-1.

4.2 Type of semiconductor contactor

The following shall be stated:

4.2.1 Number of poles

4.2.2 Kind of current

See IEC Publication 158-1.

4.2.3 (Vacant)

4.2.4 (Vacant)

4.3 Rated values

The rated values established for a semiconductor contactor shall be stated in accordance with Sub-clauses 4.3.1 to 4.3.8, but it is not necessary to establish all rated values listed.

4.3.1 Rated voltages

A semiconductor contactor is defined by the following rated voltages:

4.3.1.1 Rated operational voltages

See IEC Publication 158-1.

4.3.1.2 Rated insulation voltage

See IEC Publication 158-1.

4.3.2 Rated currents

A semiconductor contactor is defined by the following rated currents:

4.3.2.1 Rated conventional thermal current

See IEC Publication 158-1B.

4.3.2.2 Rated enclosed thermal current

See IEC Publication 158-1B.

4.3.2.3 Rated operational currents or rated operational powers

See IEC Publication 158-1B.

4.3.3 Rated frequency

See IEC Publication 158-1.

4.3.4 Rated duty

The rated duties considered as normal are as follows:

4.3.4.1 *Eight-hour duty*

Duty in which the semiconductor contactor remains in the on-state while carrying a steady current long enough to reach thermal equilibrium but for not more than 8 h without interruption.

NOTE This is the basic duty on which the rated thermal current of the apparatus is determined.

4.3.4.2 *Uninterrupted duty*

Duty in which the semiconductor contactor remains in the on-state while carrying a steady current without interruption for periods of more than 8 h (weeks, months or even years).

NOTE For semiconductor contactors, the difference between uninterrupted duty and 8 h duty may be negligible. Uninterrupted duty can be taken account of either by a derating factor, or by special design considerations.

4.3.4.3 *Intermittent periodic duty or intermittent duty*

Duty in which the semiconductor contactor remains in the on-state for periods bearing a definite relation to the no-load periods, both periods being too short to allow the semiconductor contactor to reach a thermal equilibrium.

Intermittent duty is characterized by the actual values of current during the on-load time period, the duration of the current flow and the on-load factor, which is the ratio of the inservice period to the entire period, often expressed as a percentage.

Example: An intermittent duty comprising a current flow of 100 A for 4 min every 10 min may be stated as: “intermittent duty 100 A, 4 min/10 min” or “intermittent duty 100 A, six operating cycles per hour, 40 %”.

Standard values of on-load factor are 15 %, 25 %, 40 % and 60 %.

NOTE If this duty is applied with a variable on-load factor in order to vary the effective value of a quantity controlled by the semiconductor contactor (e.g. the temperature of an oven), it is also called “multicycle control” (see IEC standards for thyristor a.c. power controllers) (under consideration), and is not covered by this standard.

Classes of intermittent duty

According to the number of operating cycles (see Sub-clause 2.2.11) which they shall be capable of carrying out per hour, semiconductor contactors are divided into the following classes:

- Class 0.03: up to 3 operating cycles per hour;
- Class 0.1: up to 12 operating cycles per hour;
- Class 0.3: up to 30 operating cycles per hour;
- Class 1: up to 120 operating cycles per hour;
- Class 3: up to 300 operating cycles per hour;
- Class 10: up to 1 200 operating cycles per hour;
- Class 30: up to 3 000 operating cycles per hour;

- Class 100: up to 12 000 operating cycles per hour;
- Class 300: up to 30 000 operating cycles per hour;
- Class 1 000: up to 120 000 operating cycles per hour;
- Class 3 000: up to 300 000 operating cycles per hour.

For intermittent duty with a large number of operating cycles per hour, the manufacturer shall indicate the values of the rated operational currents, either in terms of the true cycle if this is known, or in terms of conventional cycles designated by him, or in the form of a load diagram.

NOTE Appendix E shows the preferred method of presenting a load diagram.

4.3.4.4 *Temporary duty*

Duty in which the semiconductor contactor remains in the on-state for periods of time insufficient to allow the semiconductor contactor to reach thermal equilibrium, the current-carrying periods being separated by no-load periods of sufficient duration to restore equality of temperature with the cooling medium.

Standard values of temporary duty are 10 min, 30 min, 60 min and 90 min.

4.3.5 *Making and breaking capacities*

A semiconductor contactor is defined by its making capacities and breaking capacities, in accordance with utilization categories as specified in Table II (see Sub-clause 4.3.6).

4.3.5.1 *Rated making capacity*

The rated making capacity of a semiconductor contactor is a value of current determined under steady-state conditions which the semiconductor contactor can make without undue change of its relevant characteristics, under specified making conditions.

The making conditions which shall be specified are:

- the voltage between poles before the making operation;
- the characteristics of the test circuit.

The rated making capacity is stated by reference to the rated operational voltage and rated operational current and to the utilization category, according to Table II.

For a.c., the rated making capacity is expressed by the r.m.s. value of the symmetrical component of the current.

NOTE 1 For a.c., the peak value of the current during the first half-cycles following closing of the semiconductor contactor may be appreciably greater than the peak value of the current under steady-state conditions used in the definition of making capacity, depending on the power-factor of the circuit and the instant on the voltage wave when closing occurs.

A semiconductor contactor shall be capable of making on a current corresponding to the symmetrical value of the current which defines its making capacity, whatever the value of the asymmetrical component may be, within the limits which result from power-factors indicated in Table II.

NOTE 2 In performing the test, the value of di/dt specified by the manufacturer should not be exceeded.

The rated making capacity is only valid when the semiconductor contactor is operated in accordance with the requirements of Sub-clause 7.5.

4.3.5.2 Rated breaking capacity

The rated breaking capacity of a semiconductor contactor is a value of current which the semiconductor contactor can break without undue change of its characteristics, under specified breaking conditions at the rated operational voltage.

The breaking conditions which shall be specified are:

- the characteristics of the test circuit;
- the recovery voltage.

The rated breaking capacity is stated by reference to the rated operational voltage and rated operational current and to the utilization category, according to Table II.

A semiconductor contactor shall be capable of breaking any value of the load current up to its highest rated breaking capacity according to Sub-clause 4.3.6.

For a.c., the rated breaking capacity is expressed by the r.m.s. value of the symmetrical component of the current.

This rating applies when the starting temperature of the semiconductor contactor is at the thermal equilibrium temperature corresponding to the rated operational current, at the maximum ambient temperature specified in Sub-clause 6.1.1.

4.3.5.3 Ability to withstand overload currents

See IEC Publication 158-1B.

4.3.6 Utilization category

See IEC Publication 158-1.

4.3.7 (Vacant)

4.3.8 Endurance

A semiconductor contactor is characterized by the number of on-load operating cycles, corresponding to the service conditions given in Table III, at a stated frequency of operation and on-load factor, which can be made without repair or replacement and also without failure or change in its relevant operating characteristics.

Table I — Utilization category

Category		Typical applications
A.C.	AC-1	Non-inductive or slightly inductive loads, resistance furnaces.
	AC-2	Slip-ring motors: Starting, plugging ^a .
	AC-3	Squirrel-cage motors: Starting, switching off motors during running.
	AC-4	Squirrel-cage motors: Starting, plugging ^a , inching ^b .
D.C.	DC-1	Non-inductive or slightly inductive loads, resistance furnaces.
	DC-2	Shunt-motors: Starting, switching off motors during running.
	DC-3	Shunt-motors: Starting, plugging ^a , inching ^b .
	DC-4	Series-motors: Starting, switching off motors during running.
	DC-5	Series-motors: Starting, plugging ^a , inching ^b .
NOTE The application of semiconductor contactors to the switching of capacitors, tungsten filament lamps, or d.c. circuits, with very low inductance should be subject to special agreement between manufacturer and user.		
^a By plugging, is understood stopping or reversing the motor rapidly by reversing motor primary connections while the motor is running.		
^b By inching (jogging), is understood energizing a motor once or repeatedly for short periods to obtain small movements of the driven mechanism.		