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# Aircraft — Smart contactor — General requirements

*Aéronefs — Contacteurs intelligents — Exigences générales*



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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 1, *Aerospace electrical requirements*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

A list of all parts in the ISO 20949 series can be found on the ISO website.

# Introduction

This document provides general requirements of the smart contactor for aircraft.

Smart Contactor based power distribution systems are emerging among advanced aircraft applications, especially among More Electric Aircraft and All Electric Aircraft. Standardization is increasingly needed for Smart Contactors in aircraft power systems based on intelligent high current switching and protecting technology. Those systems have the potential for higher reliability and longer operating life, with higher capability for status sensing, over-current protection, lower maintenance costs, higher flexibility of designing power switching as well as protecting performance compared with conventional contactor switched systems.

The purpose of this document, the definitions of smart contactor and the contents of the document are as follows:

a) The purpose of this document:

  1) To standardize the requirements for smart contactors that are physically and environmentally diversified.

  2) To provide the applicable document for various smart contactors.

b) The definitions of smart contactor:

  1) Consists of an intelligent circuit and a power switch.

  2) Turns on/off the power output by receiving the control signal.

  3) Detects the over current in the load which results in shutting down for this current.

  4) Indicates the on/off status of the power output.

  5) Reports the status of smart contactor.

c) The contents of this document:

  1) Definitions of the technical terms.

  2) Electrical requirements.

  3) Test methods.

In order to satisfy the purpose of this document, requirements such as physical, environmental and individual items are specified in accordance with the detail requirements that are issued individually.

# Aircraft — Smart contactor — General requirements

## 1 Scope

This document specifies the definitions, titles of design and general requirements and test methods to determine the performance of smart contactors for use in aircraft electrical power systems. The smart contactor consists of a switching driving circuit and a power switch for protection, action on control signals, and providing status information.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1540, *Aerospace — Characteristics of aircraft electrical systems*

ISO 2678:1985,*Environmental tests for aircraft equipment — Insulation resistance and high voltage tests for electrical equipment*

ISO 7137:1995,*Aircraft — Environmental conditions and test procedures for airborne equipment*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

**3.1**
**bounce time**
for a contact which is closing (opening) its circuit, the time interval between the instant when the contact circuit first closes (opens) and the instant when the circuit is finally closed (opened)

**3.2**
**contact bounce**
intermittent opening of contacts after initial closure due to contact impact

**3.3**
**control signals**
signals including control or status which is specified for operation of the smart contactor, i.e. voltage supply, control signals including turn on/off, switch status, and/or communication signals, or other

**3.4**
**load voltage**
voltage between the power output terminal of the smart contactor and the power ground

**3.5**
**off state**
condition which, with the turn-off signal applied, the device prevents power from being passed to the load

**3.6**
**on state**
condition which, with the turn-on signal applied, the device allows power to be passed to the load

**3.7**
**peak let-through current**
peak value of the current at maximum system voltage that the smart contactor will conduct for a specified time interval without damage

**3.8**
**power dissipation**
power dissipation which includes all power dissipated in the power switching circuit, power losses due to internal leakage currents, and power supplies

Note 1 to entry: When the smart contactor is OFF, the power dissipation includes only dissipation due to leakage currents and internal power supplies.

**3.9**
**reset**
restoration of the tripped smart contactor to a state from which it can be turned ON

**3.10**
**rupture current**
maximum current the power circuit is capable of interrupting at maximum system voltage without damage

**3.11**
**short circuit**
circuit with the impedance of less than 1 mΩ applied between the output terminal and ground

**3.12**
**short-circuit current**
maximum current that the power circuit will pass without damage for a specified maximum time under the most adverse combination of electrical and environmental conditions

**3.13**
**smart contactor**
device consisting of an intelligent circuit and a power switch

Note 1 to entry: The contactor provides a power switch for high current from its power supply to its load terminal when in the ON state and a high impedance in the OFF state. The intelligent circuit consists of a driving circuit to drive the contactor, a detecting circuit sensing the current in the load and intelligent core circuit with but not limited to programmable signal processing, programmable protection characteristics, commutating capability that can trip, report device status, provide command to driving circuit in accordance with the control signal and the on/off status.

Note 2 to entry: The state of the power switch normally conforms to that represented by the last command signal applied to the smart contactor.

— The smart contactor reverts to the OFF state on detection of an electrical overload or other specified condition. A resetting operation is required to terminate the trip state. Trip-free action prevents the ON state being held in the presence of an overload trip condition.

— The state of the power switch is represented by an indication signal supplied by the smart contactor.

**3.14**
**supply voltage**
voltage applied between the power input terminal of the smart contactor and the power ground

**3.15**
**switch status**
indication showing the actual state of the smart contactor (ON state or OFF state)



 

**3.16**
**trip**
automatic reversion to the OFF state of the smart contactor output caused by an overload condition

**3.17**
**trip curve**
curve which sets the minimum and maximum trip points of the smart contactor and is plotted as current versus time

**3.18**
**trip free**
feature which will prevent subsequent re-closing unless preceded by a reset signal, when the smart contactor has tripped due to an over current condition

**3.19**
**trip time**
time interval between the application of an over current condition and the 10 % value of rated output current

Note 1 to entry: In general, the higher is the over current condition the shorter is the trip time.

**3.20**
**turn-off signal**
control signal level at which the smart contactor is turned OFF

**3.21**
**turn-off time**
time interval between initiation of turn-off signal and the time when the output reach 10 % of its steady-state ON value

**3.22**
**turn-on signal**
control signal level at which the smart contactor is turned ON

**3.23**
**turn-on time**
time interval between initiation of turn-on signal and the time when the output reach 90 % of its steady-state ON value

**3.24**
**unwanted trip**
tripping function in response to a condition that is not an over-current protection but a condition that occurs as part of the normal or anticipated operation of circuit components

Note 1 to entry: Nuisance trip is synonymous with unwanted trip.

**3.25**
**voltage drop**
voltage across input and output terminals of the smart contactor in the ON state at the specified load

# 4 General requirements

## 4.1 Detail specification sheets

The device manufacturer shall prepare an individual specification sheet for each type of device produced. The individual specification sheet shall define the value for parameters.

## 4.2 Materials

Materials shall be used which will enable the smart contactors to meet the performance requirements of this document.

Materials used shall not support combustion, give off noxious gases in harmful quantities, give off gases in quantities sufficient to cause explosion of sealed enclosures, cause functional contamination of any part of the smart contactor, or form unintended current-carrying tracks when subjected to any of the tests specified herein.

## 4.3 Construction

Smart contactors shall be of design, construction, minimum mass and physical dimensions compatible with requirements. Smart contactors shall be designed so as to ensure proper operation when mounted in any attitude.

The construction of the smart contactors shall preclude mechanical damage, flaking of finish, loosing of terminals, or deterioration of marking when subjected to the test methods of this document.

## 4.4 Terminals

### 4.4.1 Main terminals

#### 4.4.1.1 General

There are two acceptable types of terminal as follows.

#### 4.4.1.2 Stud terminals (threaded)

These terminals shall accept connections using aircraft-approved crimped-type lugs. A flat washer having a diameter at least equal to that of the base of the terminal, and a standard nut with suitable locking washer shall be used on each terminal. Suitable insulation barriers shall be placed between the terminals in order to prevent an accidental short circuit. The height and extent of these barriers shall be sufficient to prevent the short-circuiting of any adjacent terminals through the presence over these partitions of a flat conducting part.

No rotation or other loosening of a terminal, or any fixed portion of a terminal, shall be caused by material flow or shrinkage, or any mechanical force (specified in Tables 1 and 2) involved in connection or disconnection, throughout the life of the smart contactor.

The equivalent metric threads given in Table 2 may be used.

Each terminal shall have a terminal seat that shall provide the normal current-conduction path. The diameter of the seat shall not be less than the area necessary to assure that the current density does not exceed l,55 A/mm$^2$. The seat does not include the cross-sectional area of the stud.

Stud terminals shall be capable of accommodating two crimped-type lugs, with hardware as specified. A minimum of one and a half threads shall remain above the nut, with all parts tightened in place.

#### 4.4.1.3 Plug-in terminals

Plug-in terminals, where applicable, shall conform to the dimensions and requirements necessary for proper mating with the associated sockets.

Units shall have the electrical and environmental tests performed with the associated socket or connector assembled to the unit.



 

**Table 1 — Strength of threaded terminals (Static value of pull and torque)**

| Thread designation | Force | | Installation torque | | Design torque | |
|---|---|---|---|---|---|---|
| | N | lbf | N·m | lbf-in | N·m | lbf-in |
| No. 4-40 UNC | 22,2 | 5 | 0,3 | 2,4 | 0,5 | 4,4 |
| No. 6-32 UNC | 133,4 | 30 | 0,5 | 4,5 | 1,1 | 10 |
| No. 8-32 UNC | 155,7 | 35 | 1 | 9 | 2,3 | 20 |
| No. 10-32 UNF | 177,9 | 40 | 1,7 | 14,5 | 3,7 | 32 |
| No. 10-24 UNC | 177,9 | 40 | 1,8 | 16 | 4 | 35 |
| 1/4-28 UNF | 222,4 | 50 | 3,9 | 34 | 8,6 | 75 |
| 5/16-24 UNF | 311,4 | 70 | 5,2 | 45 | 11,5 | 100 |
| 3/8-24 UNF | 444,8 | 100 | 7,8 | 68 | 17,3 | 150 |
| 7/16-20 UNF | 444,8 | 100 | 7,8 | 68 | 17,3 | 150 |
| 1/2-20 UNF | 444,8 | 100 | 7,8 | 68 | 17,3 | 150 |
| 1) See Reference [4]. | | | | | | |

**Table 2 — Strength of threaded terminals — Metric units (Static value of pull and torque)**

| Thread designation | Force | | Installation torque | | Design torque | |
|---|---|---|---|---|---|---|
| | N | lbf | N·m | lbf-in | N·m | lbf-in |
| M2,5 | 22,2 | 5 | 0,3 | 2,4 | 0,5 | 4,4 |
| M3 | 133,4 | 30 | 0,5 | 4,5 | 1,1 | 10 |
| M4 | 155,7 | 35 | 1 | 9 | 2,3 | 20 |
| M5 | 177,9 | 40 | 1,8 | 16 | 4 | 35 |
| M8 | 311,4 | 70 | 5,2 | 45 | 11,5 | 100 |
| M10 | 444,8 | 100 | 7,8 | 68 | 17,3 | 150 |
| M12×1,25 | 444,8 | 100 | 7,8 | 68 | 17,3 | 150 |
| M14×1,25 | 444,8 | 100 | 7,8 | 68 | 17,3 | 150 |
| NOTE There is no direct metric equivalent to the thread size l/4-28 UNF. M7 would correspond but is not used. | | | | | | |

### 4.4.2 Auxiliary terminals

The auxiliary circuits and control/status connections may be connected by stud, plug-in or connector terminals to the appropriate specification.

## 4.5 Enclosures

### 4.5.1 General

The enclosure design is identified by a single digit, in accordance with Table 3.

**Table 3 — Enclosure design**

| Type | Enclosure |
|---|---|
| 1 | Open |
| 2 | Enclosed (ventilated, explosion-proof) |
| 3 | Sealed (other than hermetically) |
| 4 | Hermetically sealed |

#### 4.5.2 Open enclosures

Type 1 smart contactors shall be uniformly coated on all surfaces with the exception of the mounting and terminals.

#### 4.5.3 Enclosed enclosures (ventilated explosion-proof)

Unsealed units shall be totally enclosed for mechanical and dust protection and shall be explosion-proof.

#### 4.5.4 Sealed (other than hermetically) enclosures

Environmentally sealed enclosures shall be constructed by any means other than that defined under hermetically sealed enclosures to achieve the degree of seal specified. Environmentally sealed units shall be purged and filled with a suitable gas of such characteristics that the leakage rate may be determined by conventional means. The units shall be designed to ensure that the essential electrical performance is not jeopardized in the event of a failure of the environmental seal in service.



#### 4.5.5 Hermetically sealed enclosures

Hermetically sealed enclosures shall be constructed as gas-tight enclosures which have been completely sealed by fusion of glass or ceramic to metal, or by welding, brazing or soldering of metal to metal. Hermetically sealed units shall be purged and filled with a suitable inert gas of such characteristics that the leakage rate may be determined by conventional means.

#### 4.5.6 Grounding of enclosures

The enclosures for type 2, 3 and 4 smart contactors shall be electrically isolated and provide means for grounding where appropriate.

The mountings shall provide an effective electrical contact to ground when the unit is mounted as specified. Alternatively, the enclosures shall be provided with a grounding connection such as a terminal or lug.

The covers shall be rugged in design, constructed of high-impact materials and securely mounted to the unit. Metal covers shall be provided with a means of grounding.

### 4.6 Installation clearances

Adequate clearance shall be provided for the installation of terminals mounting hardware. Clearance for socket wrenches shall be provided, where appropriate. Special installation tools shall not be required.

### 4.7 Terminal marking

Stud terminal identification shall be durable and legibly marked.

### 4.8 Terminal covers and barriers

The unit shall be provided with adequate covering or separation of terminal parts to provide protection against inadvertent shorting, grounding, or contact by personnel. Barriers may be removable or may be integral with removable covers.

Terminal covers and barriers shall be designed to meet performance requirements applicable to the unit. The enclosure(s) shall be so designed that when the cover is removed, the smart contactor shall be capable or operating without adjustment.

The cover design shall be such that pressure differentials cannot exist between the inside and outside.

### 4.9 Mounting

No rotation or other loosening of a stud, or any fixed portion of a stud, shall be caused by material flow or shrinkage, or by any mechanical forces (as specified in Table 4) involved in mounting or demounting, throughout the life of the smart contactors.

**Table 4 — Strength of threaded mounting studs (Static value pull and torque)**

| Thread size designation | Force | | Torque | |
|---|---|---|---|---|
| | N | Ibf | N·m | Ibf·in |
| No. 4-40 UNC | 31,1 | 7 | 1,1 | 10 |
| No. 6-32 UNC | 111,2 | 25 | 2 | 18 |
| Mo. 8-32 UNC | 155,7 | 35 | 4,2 | 37 |
| No. 10-32 UNF | 222,4 | 50 | 6,8 | 60 |
| 1/4-28 UNF | 266,9 | 60 | 11,3 | 100 |
| 5/16-24 UNF | 355,9 | 80 | 18,1 | 160 |
| 3/8-24 UNF | 511,5 | 115 | 31,1 | 275 |
| 7/16-20 UNF | 622,8 | 140 | 53,7 | 475 |

## 5 Design characteristics

### 5.1 General

**5.1.1** Smart contactors provide both control and protection functions (as well as status feedback information).

**5.1.2** The smart contactor shall incorporate a current-sensing means to measure output current flow and to detect specified over-currents. The smart contactor should incorporate specified trip-time characteristics.

**5.1.3** Up to a specified fault-current level, the device shall follow a defined trip characteristic. Above this level, the device shall current-limit or provide a near instantaneous trip.

**5.1.4** After the smart contactor has tripped on overcurrent, it shall exhibit a trip-free characteristic remaining in the OFF state (and providing trip status information) until reset.

**5.1.5** Reset is accomplished by cycling the control input from ON to OFF and then back to ON, or employing a dedicated RESET (auxiliary) input.

**5.1.6** In the event of repeated attempts to switch into a fault, the smart contactor shall not be damaged. In order to prevent damage to associated wiring, as well as the overheating of the smart contactor, a working pattern for switching into various overload conditions shall be specified.

**5.1.7** The smart contactor shall meet the specified stabilization times after power-up, after a momentary power outage and during a supply voltage drop due to a fault, until the smart contactor opens, clearing the fault and allowing supply voltage recovery.

**5.1.8** The smart contactor shall incorporate BIT means to determine the important part including intelligent circuit, power switch and transducer normal or abnormal.

### 5.2 Control signal

Each smart contactor shall be designed to operate from one of the following types of input signal.

a) Nominal voltage 28 V d.c.

b) Grounded smart contactor input to switch smart contactor ON; in the ON state the impedance seen by the input control shall not exceed 600 Ω.

c) Logic level signal for interfacing to a control bus (TTL or CMOS).

d) 10 mA source at 1 V to 12 V to switch smart contactor ON. This allows compatibility with existing circuit breakers.

### 5.3 Status signals for smart contactors

As a minimum, one status signal shall be provided. The preferred status signals are switch status and/or current-flow status.

### 5.4 Fail-safe characteristics

When a fail-safe feature is incorporated, its characteristics shall be specified. When tested, the fail-safe element shall open the circuit at specified currents and times.

## 6 Operating characteristics

### 6.1 General operating characteristics

When tested as specified in Clause 8, the smart contactor shall operate with supply voltage variations in accordance with ISO 1540 or the detail requirements, and the smart contactor shall be capable of controlling all type of loads as required by the detail requirements.

All smart contactors shall function satisfactorily over the full specified range of applied electrical and mechanical steady-state and transient conditions.

### 6.2 Timing sequence

The timing sequence shall be as specified in Figure 1.

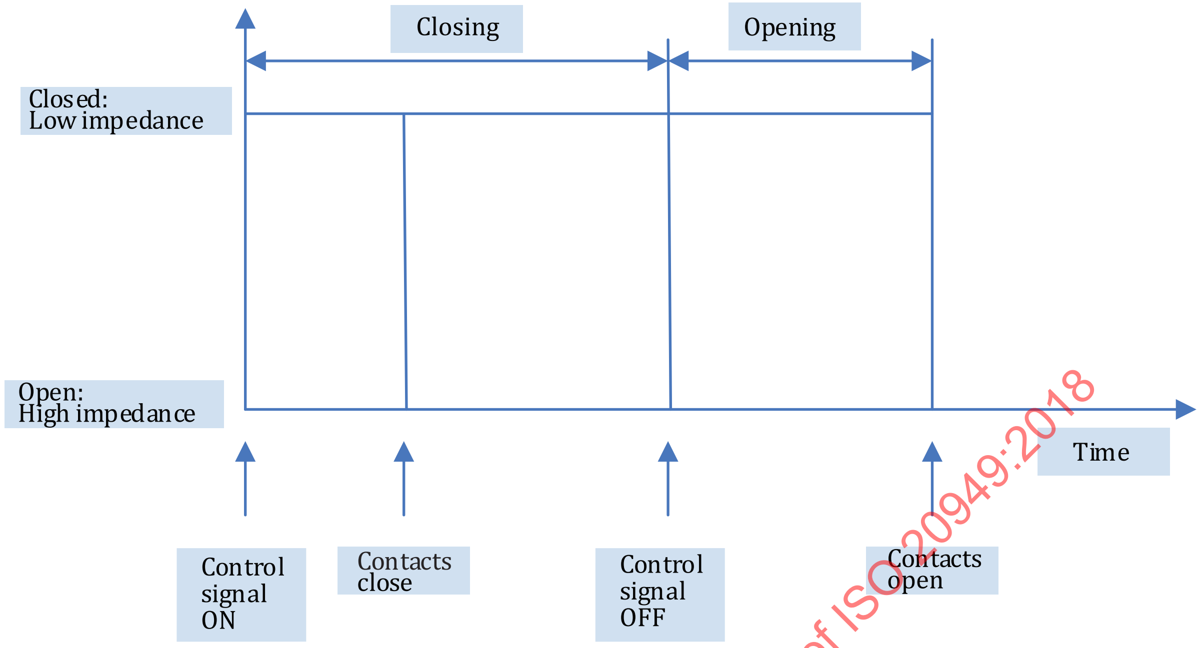


**Figure 1 — Timing sequence diagram**



## 6.3 Operating voltage

### 6.3.1 General

The operating voltage of Smart Contactor shall guarantee Smart Contactor turn on or turn off reliably in specified working range.

### 6.3.2 Pickup voltage

When smart contactors are tested in accordance with 8.4.2, each set of contacts shall make positive contact or open, as applicable, in the energized position when a potential voltage not in excess of the specified pickup voltage is applied to the contactor coil. All normally open switching circuits shall close with positive contact and all normally closed circuits, if applicable, shall open. Once the device has picked up, the contacts shall not change state (break and remake) when the coil voltage is increased from the point of pickup to the maximum coil voltage, excluding normal contact bounce. For qualification inspection, the pickup voltage shall fall within the maximum specified when the contactor is mounted in each of three mutually perpendicular planes.

### 6.3.3 Dropout voltage

When smart contactors are tested in accordance with 8.4.3, each set of normally open contacts shall open, and each set of normally closed contacts shall close as applicable, when the applied coil voltage is in the specified dropout voltage range. Excluding normal contact bounce, once the device has dropped out, the contacts shall not change state when the voltage is reduced from the point of dropout to 0 V. For qualification inspection, the dropout voltage shall be measured with the device in each of three mutually perpendicular planes.

## 6.4 Electrical characteristics

### 6.4.1 General

Smart contactors shall be capable of making, carrying and breaking all values of load current up to the rated short-circuit fault level.

Smart contactors shall be self-protecting with respect to fault-current level and incorporate suppression for operating coil voltage spikes. Semiconductor devices shall be adequately protected from smart contactors-generated and external transients.

Smart contactors shall, as a minimum requirement, protect their associated connecting cables from damage.

### 6.4.2 Contact voltage drop

When smart contactors are tested in accordance with 8.5.2, the voltage drop values measured at the appropriate terminal with rated resistive current shall not exceed the values given in Table 5.

**Table 5 — Contact voltage drop**

| Terminals | Rated current strength | Voltage drop, mV | |
|---|---|---|---|
| | | Initial | After endurance tests |
| Main contacts | Same rating as contactor | 150 | 175 |
| Auxiliary Contacts | 5A (or as rated) | 100 | 180 |

When a connector is used for connecting the auxiliary circuits, the voltage drop value shall be increased by amount permitted for the connector.

### 6.4.3 Quiescent power dissipation

The smart contactor power dissipation in the OFF-state for a normally open device, or in the ON-state for a normally closed device, shall be a minimum.

### 6.4.4 Control signals

#### 6.4.4.1 General

The control signals of smart contactor shall be in accordance with ISO 1540 and with specified detail specification.

#### 6.4.4.2 Control power supply current

When tested as specified in 8.5.4.1, the control power supply current shall be as specified in the detail requirements.

#### 6.4.4.3 Transient voltage

When tested as specified in 8.5.4.2, the transient voltage shall be as specified in the detail requirements.

#### 6.4.4.4 Status turn-off time

When tested as specified in 8.5.4.3, the status turn-off time shall be as specified in the detail requirements.

#### 6.4.4.5 Status turn-on time

When tested as specified in 8.5.4.4, the status turn-on time shall be as specified in the detail requirements.

#### 6.4.4.6 Turn-off voltage

When tested as specified in 8.5.4.5, the turn-off voltage shall be as specified in the detail requirements.

#### 6.4.4.7 Turn-on voltage

When tested as specified in 8.5.4.6, the turn-on voltage shall be as specified in the detail requirements.

#### 6.4.4.8 Control current

When tested as specified in 8.5.4.7, the control current shall be as specified in the detail requirements.

### 6.5 Contact bounce, operating and release time

Photographic records of contact operating and release times, and contact bounce at nominal coil voltage shall be taken for qualification test approval.

When smart contactors are tested in accordance with 8.6, the contact bounce operating and release times shall be within limits specified in the detail specification (see 4.1). The operating and release times shall not include the contact bounce time. The operating time and release time of each pole of a multiple relay shall be within 1 ms of each other pole of that relay for relays with contact ratings of 15 A or less, and within 2 ms for smart contactors with contact ratings greater than 15 A. Synchronized switching control parameters for auxiliary contacts relative to main and each other shall be specified in the detail specification. Unless make-before-break action is specified in the detail specification. Double-throw smart contactors shall show no evidence of any normally open contacts closing before all normally closed contacts open; any normally closed contacts shall not make before all normally open contacts break. Contact break bounce on release of normally open contacts when specified in the detail specification shall be less than 100 µs.

### 6.6 Dielectric strength

Unless otherwise specified, tests shall be carried out in accordance with ISO 2678:1985, 4.1. The insulation of the devices shall be capable of withstanding without damage. The test voltage shall be in accordance with ISO 2678:1985, 4.1.

All restrictions arising from the semiconductors shall be declared.

**Table 6 — Minimum values for high voltage tests**

| Rated voltage | Test voltage | Duration |
|---|---|---|
| 28 V a.c. | 500 V, 50 Hz to 60 Hz | 1 min |
| 115/200 V a.c. | 1 000 V, 50 Hz to 60 Hz | 1 min |
| 28 V a.c | 600 V, 50 Hz to 60 Hz | 5 s to 10 s |
| 115/200 V a.c | 1 500 V, 50 Hz to 60 Hz | 5 s to 10 s |

### 6.7 Insulation resistance

The requirements for an adequate insulation resistance shall be detailed in the relevant equipment specification. They shall be deemed to be met when the minimum values of Table 7 are obtained in accordance with ISO 2678.

**Table 7 — Minimum values for insulation resistance**

| Category | Equipment | Insulation resistance (minimum values) between live parts, and between live parts and case (earth) MΩ | |
|---|---|---|---|
| | | In conjunction with climatic tests[1)] | In conjunction with non-climatic tests |
| A | Wiring components(terminal blocks, connectors, selectors, limit switches, circuit-breakers, relay contacts or contactors) | 50 | 100 |
| B | Equipment incorporating electronics components | 2 | 10[2)] |

1) The climatic tests referred to are listed in ISO 7137.

2) When measuring the insulation resistances of individual assemblies, the minimum value shall be increased to 50 MΩ.

## 6.8 Overload characteristics

### 6.8.1 General

Monitoring of terminal temperature rise where appropriate is required only during qualification testing.

### 6.8.2 Trip characteristics with the overload condition

When tested, the smart contactor shall not reset until commanded, the trip time shall be within the trip curve specified in the detail requirements without any damage.

### 6.8.3 Circuit breaker compatibility

This test is applicable only if specified in the detail specification.

When smart contactors are tested in accordance with 8.9.2, there shall be no evidence of contact welding or sticking and the contact voltage drop shall conform to 5.1.8 after the test. The terminal temperature rise shall not exceed 75 °C. Blowing of the fuse connected between case and load system ground or neutral shall constitute a failure.

## 6.9 Ground Fault Interrupt characteristics

The smart contactors (when specified), in the case of three-phase a.c. devices, detect a phase imbalance greater than a specified value and trip all load switching devices to OFF.

## 6.10 Trip-free characteristics

When tested the smart contactor shall reset, trip-out and stay tripped out for the duration of the test.

## 6.11 Life

Smart contactors shall be tested in accordance with 8.12, smart contactors having two or more sets of contacts and which are tested for multiphase (115/200 V a.c. three phase) shall be capable of handling multiphase power on adjacent contacts. Phase-to-phase arcing shall constitute a failure. Test conditions shall conform to product requirements. There shall be no mechanical or electrical failure. Welding or sticking of contacts, failure to make, carry or break the load, or blowing of the fuse connected between case and load system ground or neutral shall constitute a failure. The terminal temperature rise shall not exceed 75 °C.



 

Endurance tests for smart contactors shall be carried out at ground level and laboratory temperature, or as specified in product requirements.

# 7 Environmental conditions and test procedures

These shall be in accordance with ISO 7137 and in accordance with the categories given in Table 8.

**Table 8 — Environmental conditions and test procedures**

| No. | Test | Procedure given in ISO 7137 | Category | Comment |
|---|---|---|---|---|
| 7.1 | Temperature and altitude | 1.1 | E1 | Unpressurized, uncontrolled temperature up to 21 300 m (70 000 ft) |
| 7.2 | Temperature variation | 1.2 | B | Internal, temperature not controlled |
| 7.3 | Humidity | 1.3 | A | Standard humidity environment |
| 7.4 | Shock | 2.1 | As specified | No malfunction |
| 7.5 | Vibration | 2.2 | As specified | |
| 7.6 | Explosion | 4.1 | According to sealing category | Flammable mixtures can be expected to occur as a result of fault or spillage |
| 7.7 | Waterproofness | 1.5 | W | Subject to falling water, i.e. condensation |
| 7.8 | Fluids contamination | 1.6 | F | |
| 7.9 | Sand and dust | 1.7 | D | |
| 7.10 | Fungus resistance | 1.8 | F | Subjected to severe fungus contamination |
| 7.11 | Salt spray | 1.9 | S | |
| 7.12 | Magnetic effect | 3.1 | A | |
| 7.13 | Power input | 3.2 | Z | |
| 7.14 | Voltage spike | 3.3 | A | Installation where a high degree of protection against damage by voltage spikes |
| 7.15 | Audio frequency susceptibility | 3.4 | Z | For all types of electrical system |
| 7.16 | Induced signal susceptibility | 3.5 | B | Installations where mutual interference is held to a tolerable level |
| 7.17 | Radio frequency susceptibility(radiated and conducted) | 3.6 | S | The internal EMI environment from aircraft equipment |
| 7.18 | Emission of radio frequency energy | 3.7 | B | Installations where mutual interference is held to a tolerable level |
| 7.19 | Lightning-induced transient susceptibility | 3.8 | K | Installations in a moderate environment |

# 8 Qualification Tests

## 8.1 General

The object of tests is to ensure that the design is capable of meeting the specifications of this document. Production units shall be used for the tests according to the specifications of Table 9.

**Table 9 — Tests**

| No. | Test | | | Requirements | Test procedure |
|---|---|---|---|---|---|
| 1 | Timing sequence | Turn-off time | | 6.2 | 8.3.1 |
| 2 | | Turn-on time | | | 8.3.2 |
| 3 | Operating voltage | Pickup voltage | | 6.3.2 | 8.4.2 |
| 4 | | Dropout voltage | | 6.3.3 | 8.4.3 |
| 5 | Electrical characteristics | Contact voltage drop | | 6.4.2 | 8.5.2 |
| 6 | | Quiescent power dissipation | | 6.4.3 | 8.5.3 |
| 7 | | Control signals | Control power supply current | 6.4.4.2 | 8.5.4.1 |
| 8 | | | Transient voltage | 6.4.4.3 | 8.5.4.2 |
| 9 | | | Status turn-off time | 6.4.4.4 | 8.5.4.3 |
| 10 | | | Status turn-on time | 6.4.4.5 | 8.5.4.4 |
| 11 | | | Turn-off voltage | 6.4.4.6 | 8.5.4.5 |
| 12 | | | Turn-on voltage | 6.4.4.7 | 8.5.4.6 |
| 13 | | | Control current | 6.4.4.8 | 8.5.4.7 |
| 14 | Contact bounce, operating and release times | | | 6.5 | 8.6 |
| 15 | Dielectric withstanding voltage | | | 6.6 | 8.7 |
| 16 | Insulation resistance | | | 6.7 | 8.8 |
| 17 | Overloads | Trip characteristics with the overload condition | | 6.8.2 | 8.9.1 |
| 18 | | Circuit breaker compatibility | | 6.8.3 | 8.9.2 |
| 19 | Ground Fault Interrupt characteristics | | | 6.9 | 8.10 |
| 20 | Trip-free characteristics | | | 6.10 | 8.11 |
| 21 | Life | | | 6.11 | 8.12 |
| 22 | Terminal strength | | | 4.4 | 8.13 |
| 23 | Seal | | | 4.5 | 8.14 |

Subsequent production acceptance tests have the objective of ensuring that the performance standard is maintained based on short-duration tests.

Additional quality assurance tests based on random sampling are designed to verify that performance is sustained in the areas requiring longer-term tests.

Detailed specifications for qualification approval testing, production testing and additional quality assurance shall be based on the detailed performance specification, and this International Standard can only identify the basic requirements.

Physical attributes, such as size, mass or appearance, shall be derived from the detailed performance specification and are 100 % tests.

## 8.2 Visual and mechanical examination

Smart contactors shall be examined to verify that the materials, external design and construction, physical dimensions, mass, marking and workmanship are in accordance with the applicable requirements given in Clause 4.

## 8.3 Timing sequence

### 8.3.1 Turn-off time

Smart contactors shall be tested for turn-off time using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated output load, voltage and frequency (if applicable).

c) Apply the specified control power supply voltage (if applicable), status voltages (when specified) and the control voltage to turn the device ON. Adjust the control voltage to the value specified to turn the device OFF.

d) Verify on oscilloscope (or equivalent instrument) that the device shuts OFF in the specified time.

See 6.2.

### 8.3.2 Turn-on time

Smart contactors shall be tested for turn-on time using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated output load, voltage and frequency (if applicable).

c) Apply the specified control power supply voltage (if applicable), status voltages (when specified) and the specified control voltage to turn the device ON.

d) Verify on oscilloscope (or equivalent instrument) that the device turns ON in the specified time.

See 6.2.

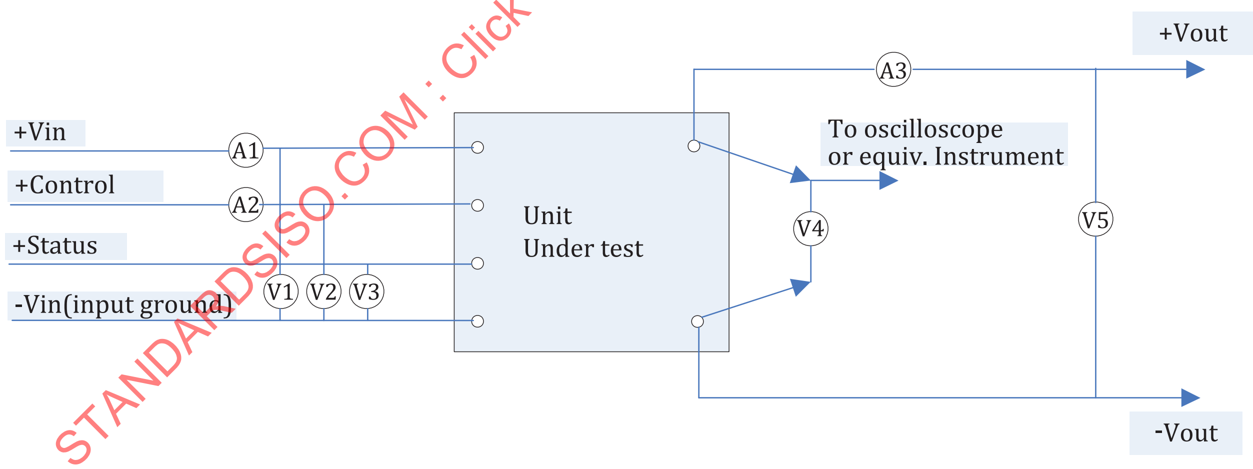


**Figure 2 — General test set-up**

## 8.4 Operating voltage

### 8.4.1 General

Test smart contactors in accordance with 8.4.2 and 8.4.3. The pickup and dropout voltages shall be as specified in the detail specification, when checked within the temperature limits for the relay class and mounted in the most unfavourable attitude. Perform the following additional tests during qualification.

a) With the smart contactor de-energized for 30 min prior to test, check the contacts do not change state (break and remake) when the coil voltage is increased from the point of pickup to the maximum coil voltage.

b) With the device energized for 30 min at maximum coil voltage prior to test (for continuous duty coils only), check that the contacts do not change state (break and remake) when the coil voltage is reduced from the point of dropout to 0 V.

### 8.4.2 Pickup voltage

#### 8.4.2.1 General

Test smart contactors to determine that the energized function is completed when a potential not in excess of the specified pickup voltage is applied to the coil.

#### 8.4.2.2 Pickup voltage at room temperature

Apply the pickup voltage as a step function. Use an indicating device to determine that the contacts operate satisfactorily.

#### 8.4.2.3 Pickup voltage at high temperature

Subject the smart contactor to an operating test at the maximum ambient temperature specified in the detail specification. Apply the maximum specified voltage to the coils for 1 h. During this test, continuously energize the continuous duty coils. Cycle the intermittent duty coils at the rate specified for resistive load. Do not lead the contacts during this test. Within 30 s following this period, and with the device maintained at the test temperature, determine the pickup voltage in accordance With 8.4.2.2 Check that the pickup voltage is within the limits specified in the detail specification.

### 8.4.3 Dropout voltage

Apply the maximum operating voltage to the coil terminals and then reduce the voltage. Check that the device releases to the de-energized position with the specified limits of dropout voltage. Use an indicating device to determine that the contacts operate satisfactorily.



## 8.5 Electrical characteristics

### 8.5.1 General

Unless otherwise specified, devices shall be tested in accordance with ISO 7137:1995, Table 1, test procedure 4.1.

Unless otherwise specified, all tests shall be made within the following ambient condition.

a) Relative Humidity: Not greater than 85 %.

b) Ambient Pressure: 84 kPa to 107 kPa, which correspond to the altitude between +1 525 m and −460 m (+5 000 ft and −1 500 ft).

NOTE The condition is in coordination with DO-160 published by RTCA, incorporated.

These conditions are intended to apply as a laboratory tests environment for the purpose of performance assurance for the smart contactor. Appropriate environmental conditions and test procedures should be selected from ISO 7137 for the purpose of quality assurance for the smart contactor s installed in the airborne equipment.

#### 8.5.2 Contact voltage drop

Smart contactors shall be tested for contact voltage drop using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated load, voltage and frequency (if applicable).

c) Apply the specified control power supply voltage (if applicable), status voltages (when specified) and the specified control voltage to turn the device ON.

d) Verify with voltmeter V4 that the voltage drop is within the specified limits.

For an a.c. smart contactors, a true RMS voltmeter shall be used.



#### 8.5.3 Quiescent power dissipation

Smart contactors shall be tested for power dissipation using the following procedure.

a) ON state

 1) See Figure 2 for test set-up.

 2) Apply the rated load, voltage and frequency, if applicable.

 3) Apply the maximum specified control power supply voltage (if applicable), status voltages (when specified) and the specified maximum control voltage to turn the device ON.

 4) Read the instruments and calculate the power dissipation by adding the products of the control voltage × control current, contact voltage drop × output current, for each output switch, in addition to any power dissipated by internal power supplies (and the status voltage × status current for each status).

 5) Take measurements after the device has reached thermal equilibrium.

b) OFF state

 1) See Figure 2 for test set-up.

 2) Apply the rated load, voltage and frequency, if applicable.

 3) Apply the specified control power supply voltage (if applicable), status voltages (when specified) and the specified maximum turn-off control signal.

 4) Read the instruments and calculate the power dissipation by adding the products of the control voltage × control current, contact voltage drop × output current, for each output switch, in addition to any power dissipated by internal power supplies (and the status voltage × status current for each status).

#### 8.5.4 Control signals

##### 8.5.4.1 Control power supply current

Smart contactors shall be tested for control power supply current (when specified) using the following procedure.

a) See Figure 2 for test set-up.

 

b) Apply the specified control power supply voltage (if applicable), status voltages (when specified).

c) Apply the specified control voltage.

d) Verify with ammeter Al that the input current is within specification.

#### 8.5.4.2 Transient voltage

Smart contactors shall be tested for transient voltage of auxiliary power in accordance with test procedure ISO 7137:1995, Table 1, test procedure 3.2. The category of the device and all relevant restrictions shall be declared.

#### 8.5.4.3 Status turn-off time

Smart contactors shall be tested for status turn-off time (when specified) using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated load, voltage and frequency (if applicable). Apply the specified control power supply voltage (if applicable), and the specified control voltage.

c) Apply the specified voltage (if applicable) to the status terminal.

d) With the oscilloscope (or other equivalent measuring instrument) triggering on the specified trigger signal, apply the necessary conditions to activate the status output.

e) Verify that the time required for the status signal to reach 10 % of the final value is within specification. Measure the status signal at voltmeter V3.

#### 8.5.4.4 Status turn-on time

Smart contactors shall be tested for status turn-on time (when specified) using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated load, voltage and frequency (if applicable). Apply the specified control power supply voltage (if applicable), and the specified control voltage.

c) Apply the specified voltage (if applicable) to the status terminal.

d) With the oscilloscope (or other equivalent measuring instrument) triggering on the specified trigger signal, apply the necessary conditions to de-activate the status output.

e) Verify that the time required for the status signal to reach 10 % of the final value is within specification. Measure the status signal at voltmeter V3.

#### 8.5.4.5 Turn-off voltage

Smart contactors shall be tested for turn-off voltage using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated resistive load, voltage and frequency (if applicable).

c) Apply the specified control power supply voltage (if applicable), status voltages (when specified) and the specified control voltage to turn the device ON. Adjust the control voltage to the value specified to turn the device OFF.

d) Verify that the device is OFF with the aid of ammeter A3, or oscilloscope (or equivalent instrument), or voltmeter V5 across the output.

#### 8.5.4.6 Turn-on voltage

Smart contactors shall be tested for turn-on voltage using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated output load, voltage and frequency (if applicable).

c) Apply the specified control power supply voltage (if applicable), status voltages (when specified) and the specified control voltage to turn the device ON.

d) Verify that the device is ON.

#### 8.5.4.7 Control current

Smart contactors shall be tested for control current using the following procedure.

a) See Figure 2 for test set-up.

b) Apply the rated load, voltage and frequency (if applicable).

c) Apply the specified control power supply voltage (if applicable), status voltages (when specified) and the specified control voltage.

d) Verify with ammeter A2 that the control current is within specification.

## 8.6 Contact bounce, operating and release times

### 8.6.1 General

See Figure 3 for suggested circuit.