International Standard 6859/1

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Aircraft — Proximity switches — Part 1 : General requirements

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

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It has been approved by the member bodies of the following countries :

Austria	Germany, F. R.	South Africa, Rep. of
Belgium	Italy	Spain
Brazil	Japan	Sweden
Canada	Netherlands	United Kingdom
Czechoslovakia	Romania	USA

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France

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Aircraft — Proximity switches — Part 1 : General requirements

0 Introduction

This International Standard has been prepared to provide requirements for class 1 proximity switches, for use in unprotected positions on aircraft, and for class 2 proximity switches, intended for use in less arduous environments.

This Part of ISO 6859 deals with general requirements for all proximity switches. Requirements for magnetic proximity switches, for inductive proximity switches, and for Hall effect proximity switches, will form the subjects of Parts 2, 3 and 4 of this International Standard respectively. Further Parts may be added in due course, covering other basic methods of operation.

1 Scope and field of application

This Part of ISO 6859 specifies general requirements for proximity switches for aircraft, suitable for use in nominal 28 V d.c. systems, or 115/200 V, 400 Hz a.c. systems, having the characteristics specified in ISO 1540.

Two classes of switch are specified :

— class 1 : switches for use in unprotected positions on aircraft;

— class 2 : switches intended for less arduous environments.

Specific requirements for proximity switches using a particular method of operation will be given in the relevant Part of this International Standard (see the introduction) and shall be read in conjunction with this Part.

NOTE — This Part of ISO 6859 has been prepared primarily for class 1 switches. The applicability of the requirements for class 1 and different requirements for class 2 switches are summarized in annex C.

2 References

ISO/R 224, *Standard form of declaration of performance of aircraft electrical equipment.*

ISO 1467, *General purpose push-pull single-pole circuit-breakers for aircraft — Performance requirements.*

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

ISO 2653, *Environmental tests for aircraft equipment — Part 2.3 : Ice formation.*

ISO 2669, *Environmental tests for aircraft equipment — Part 3.2 : Steady state acceleration.*

ISO 2678, *Environmental tests for aircraft equipment — Part 4.3 : Insulation resistance and high voltage tests for eiectrical equipment.*

ISO 2683, *Environmental tests for aircraft equipment — Part 5.1 : Explosion proofness.* [1)]

ISO 2859, *Sampling procedures and tables for inspection by attributes.*

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

3 Definitions

For the purpose of this International Standard, the following definitions apply.

3.1 proximity switch system : A switch system which provides one or more circuit switching functions when the target is brought within the declared operating region of the sensor. The system may include a separate relay or electronic module in addition to the target and sensor.

1) At present at the stage of draft.

3.1.1 magnetic proximity switch : A switch system in which the operation is performed by the magnetic effect between target and sensor.

3.1.2 inductive proximity switch : A switch system in which the operation is performed by the inductive effect between target and sensor.

3.1.3 Hall effect proximity switch : A switch system in which the operation is performed by Hall effect between target and sensor.

3.2 target : A specific material which is moved into proximity with the sensor in order to operate the switch.

3.3 sensor : A device designed to detect the proximity of a target.

3.4 electronic module : An arrangement of solid-state electronic components which operates as a switch when actuated by an electrical signal from the sensor.

3.5 overtravel : The distance between the operating position and the total travel position.

3.6 operating position : The position, relative to the sensor, to which the target has to be advanced in the intended direction of operation to cause subsequent operation of the switch. This may be reached by a head-on or a side-on approach of the target.

3.7 release position : The position of the target relative to the sensor to which the target has to be withdrawn to de-operate the switch.

3.8 differential travel : The distance between the operating position and the release position.

3.9 operating time : The time interval between establishment of the required input signal and the operation of the last output circuit.

3.10 simultaneity : The time interval between the first and last similar output circuit operation of the switch.

3.11 ice shear force : The force required to disrupt ice formation on either target and/or sensor that would prevent correct operation.

3.12 response : The interval between a target entering or leaving the operating region and the completion of the electrical switching functions.

3.13 normal temperature, pressure and humidity :

temperature : 15 to 35 °C

pressure : 86 to 106 kPa (860 to 1 060 mbar)

humidity : 45 to 75 %

3.14 vane operation : A form of engagement of target and sensor in which one enters as a vane in a channel of the other.

3.15 magnetic shunt : An alternative magnetic circuit provided to reduce the effective field of the sensing element.

3.16 circuit malfunction : The opening or closing of an output circuit which is not demanded by the sensing mechanism.

3.17 head-on approach : The approach of target to sensor such that the movement is perpendicular to the plane of the sensing face.

3.18 side-on approach : The approach of the target sensor such that the movement is parallel to the plane of the sensing face.

3.19 full engagement : The position where the target is located at the minimum designed clearance from the sensor.

3.20 quality assurance : The maintenance of type test standard by periodic special testing during production.

4 Proximity switch systems

4.1 Description and design parameters

4.1.1 Two classes of proximity switch systems are specified :

a) class 1, intended for unprotected positions in aircraft; these shall comply with the general requirements specified in this Part of ISO 6859 and also with the requirements appropriate to their method of operation (see clause 1);

b) class 2, suitable for less arduous environments; the applicability of the requirements for class 1 switches and differing requirements, are summarized in annex C.

4.1.2 All switch systems shall operate by a target moving into the influence-field of a sensor to initiate a switching function. Particular methods of sensing and switching shall comply with the relevant Part(s) of this International Standard.

4.1.3 The sealing of the switch shall comply with the relevant Part(s) of this International Standard.

4.1.4 Overtravel of the target after the switching action has occurred shall be provided; the actual value will be stated in the relevant Part(s) of this International Standard.

4.1.5 All exposed metal parts shall be insulated from all current carrying parts, and should be connected to earth via the mounting.

4.1.6 Connections shall be as specified in 6.3.1 for the sensor and in 7.3 for a separate module or relay.

4.1.7 Each lead or terminal shall be identified by a number in accordance with the diagram on the switch system and/or appropriate drawings.

4.1.8 The switch system shall be suitable for mounting in any attitude. The recommended tolerances on installational position shall take into account any long term drift of operating characteristics.

4.1.9 The switch system shall be designed to meet the environmental conditions specified in 4.4 and shall operate satisfactorily with the power supplies defined in ISO 1540.

4.1.10 Target and sensor shall be provided with means for ensuring accurately reproducible alignment as defined in the relevant installation drawing.

4.1.11 The switch system shall be designed to operate with target speeds up to 250 mm/s. The response time shall be kept to a minimum and shall be declared by the manufacturer.

For target speeds in excess of 250 mm/s, see 10.12.

4.1.12 In addition to the declarations required by ISO/R 224, the manufacturer shall declare the following :

a) the limits of target position, along each intended direction of operation, with respect to :

1) overtravel,

2) differential travel,

3) operating position;

b) maximum overload current (see 10.11);

c) any limitation with respect to adjacent materials or switch system interference.

4.2 Marking

In addition to the output connection diagram and flying lead identification, the following shall be clearly and indelibly marked on each part :

a) the number of this International Standard and the classification;

b) the manufacturer's name or identification;

c) the manufacturer's type number;

d) the manufacturer's date code.

4.3 Electrical and mechanical rating and life

The electrical and mechanical ratings of the switch system shall be in accordance with the relevant Part(s) of this International Standard.

4.4 Environmental conditions

NOTE — Electronic modules for installation in protected zones remote from the sensor may comply with the less stringent environmental conditions defined for class 2 (see 4.1.1 and annex C).

4.4.1 Temperature, pressure and humidity

The switch system shall comply with the requirements specified in 10.16.

4.4.2 Tropical exposure

The switch system shall comply with the requirements specified in 10.16.

4.4.3 Resistance to mould growth

The switch system shall comply with the requirements specified in 10.18.

4.4.4 Vibration

Unless specified in the relevant Part(s) of this International Standard, the switch system shall comply with the requirements specified in 10.14.

4.4.5 Acceleration

The switch system shall comply with the requirements specified in 10.15 for the following acceleration grades :

a) equipment security grade 3;

b) structural integrity category A.

4.4.6 Ice formation

Unless otherwise stated, the switch system shall be capable of undergoing and passing the ice-formation tests specified in 10.8.

4.4.7 Fluid contamination

The switch system shall comply with the requirements specified in 10.19.

4.4.8 Salt mist

The switch system shall comply with the requirements specified in 10.20.

4.5 Sealing

The switch system shall comply with the requirements specified in 10.23.

4.6 Explosion proofness

The switch system shall comply with the requirements specified in 10.21.

4.7 Magnetic influence

The switch system shall comply with the requirements specified in 10.22. Its operation shall not be adversely affected by such interference. Because of mutual interference, it may not be possible to place targets or sensors close together. The supplier shall state any limitations in this respect and shall declare the same in any limitations of use.

4.8 Electromagnetic interference

The switch systems shall not radiate, nor conduct, nor be susceptible to radio interference, and shall comply with the requirements specified in 10.25. The performance of the switch system shall not be adversely affected by inadvertent pickups from leads which are running in close proximity to the switch leads.

4.9 Supply voltage variation

The switch system shall comply with the requirements specified in 10.24.

4.10 Dimensions and mounting methods

The dimensions and mounting methods shall be as specified in the relevant Part(s) of this International Standard.

4.11 Overall response time

The response time for operation and de-operation shall not exceed 20 ms, unless otherwise specified in the relevant Part(s) of this International Standard.

4.12 Switching arrangements

4.12.1 A minimum of two complementary outputs should be provided. Methods of series and parallel operation shall be stated by the manufacturer. Isolation of the outputs with respect to the input supplies shall also be stated.

4.12.2 Outputs shall be suitable for control of the loads specified in the relevant Part(s) of this International Standard.

4.12.3 Voltage drops shall comply with the requirements specified in 10.6.

4.13 Positive line switching

The switch system should be commutable between a position in the positive line (load or earth) or in the negative line (switch to earth). If this is impracticable, then positive line switching is preferred.

4.14 Circuit protection

4.14.1 Accidental reversal of the polarity of the supply shall not damage the switch system.

4.14.2 The switch system should include short circuit protection to operate whether the circuit is made at the time of occurrence or whether the switch is closed on to the overload. The method of overload function shall be as stated in the relevant Part(s) of this International Standard. Alternatively, the switch system shall comply with the requirements for the short circuit test specified in 10.9.

4.15 Magnetic debris

The switch system performance shall not be adversely affected by small particles of metal filings adhering to the target or sensor due to operating or residual magnetism or due to a thin film of grease on these parts. It shall comply with the requirements specified in 10.26.

4.16 Non-magnetic materials

The switch system performance, when in its operational mode, shall not be adversely affected by adjacent non-magnetic materials, such as aircraft aluminium alloys and titanium, or any debris from such materials. It shall comply with the requirements specified in 10.26.

4.17 Cable length

The switch system performance shall not be adversely affected by up to 80 m of up to size 20 cable between the sensor and any associated electronic module.

4.18 Interchangeability

There shall be no externally accessible adjustment on any part of the switch system in respect to its electrical performance. Like units or assemblies shall be fully interchangeable, dimensionally, electrically, and functionally, without recourse to further adjustment.

4.19 Reliability

The following requirements shall be satisfied in connection with life operation and mean time between failures.

4.19.1 Life operation

The switch system shall achieve not less than 10^6 operations at the maximum rated resistive load.

4.19.2 Mean time between failure

The mean time between failures (MTBF) shall not be less than 10^5 operations at maximum rated resistive load for a declared duty cycle.

5 Target

5.1 General

5.1.1 Form

The form of target shall be a rigid, robust piece of material, stiffened, if necessary, so that it can be mounted to project clear of any supporting structure.

5.1.2 Marking

The target shall be marked with the intended direction of motion, and with an indication of the mounting face, if applicable. The following additional information shall also be marked :

a) the manufacturer's type or part number;

b) the number of this International Standard.

5.2 Mechanical properties

5.2.1 Lateral strength

The strength of the target in any axis at right angles to the intended direction of motion shall be adequate to withstand a force of at least 900 N, applied at the edge furthest from the mounting, without damage or permanent distortion.

5.2.2 Longitudinal strength

The strength of the target along the intended axis of motion, and the strength of the mounting arrangement, shall be adequate to withstand a distributed force of 900 N without damage or permanent distortion.

5.3 Earth bonding

Provision shall be made for bonding the target to the airframe such that all exposed metal parts have a resistance to that point of less than 0,025 Ω.

6 Sensor

6.1 General

6.1.1 Form

The form of the sensor shall comply with the relevant Part(s) of this International Standard.

6.1.2 Marking

The sensor shall be marked to indicate the operative face. Additionally, the information specified in 4.2 a), b), c) and d) shall also be marked.

6.1.3 Stacking

It should be possible to mount sensors side by side. However, because of the possibility of mutual interference, the supplier shall declare any limitations.

6.2 Mechanical properties

6.2.1 Strength

The strength of the sensor in any axis, and the mounting arrangements, shall be adequate to withstand a distributed compressive force of 900 N, applied in any direction, without damage or loss of performance.

6.2.2 Flying lead anchorage

Wire leads shall be mechanically anchored to withstand a pull of 45 N on any one or combination of leads, without damage to the wire, insulation or sensor.

6.3 Electrical properties

6.3.1 Connections

Connections shall be by either wire leads or connectors. Wire leads shall be potted-in and shall have a minimum length of 1,8 m. When necessary, wire leads should be etched to ensure proper bonding between the wire and the potting, and shall be protected from damage due to flexing at the point of emergence from the potting.

6.3.2 Earth bonding

Provision shall be made for bonding the sensor to the airframe such that all exposed metal parts have a resistance to that point of less than 0,025 Ω.

7 Associated relays and electronic modules

7.1 Relay

Where a relay is supplied as part of the complete switch system, in order to ensure complete compatibility with sensors, it shall be the responsibility of the supplier to ensure that it will meet all requirements, including compatibility, interchangeability and reliability.

7.1.1 Marking

Relays shall be marked in accordance with 4.2.

7.2 Electronic module

Where an electronic module is required as a separate item, it shall be fully interchangeable without adjustment to the switch system.

7.3 Electrical connections

Connections to the relay or module may be by any approved method.

8 Tests

8.1 Nature and order of tests

Tests shall be carried out to confirm compliance with the relevant requirements of this International Standard. It is not intended or recommended that all tests be carried out on every proximity switch.

Four kinds of test, are, therefore, specified, as follows.

8.1.1 Production tests (9.1 to 9.10)

Production tests shall be performed on every switch in the order stated.

8.1.2 Type tests (10.1 to 10.27)

Type tests shall be carried out on switches which have passed the production tests. Each basic type of switch shall be subjected to type tests in accordance with the schedule in table 1 and in the order stated. It is not intended that variants of a basic type of switch be subjected to all of the tests. The extent of type tests on such switches shall be agreed between the manufacturers and the approving authority.

8.1.3 Quality assurance tests (11.1 to 11.4)

Quality assurance tests shall be performed on samples selected in accordance with the schedule in table 6.

8.1.4 Serviceability tests

The tests recommended to verify the serviceability of switches after storage or use are indicated in annex B.

8.2 General test requirements

8.2.1 The switches shall be numbered for the purposes of recording and allocation of tests. The actual batch serial numbers and issue numbers of the switches used in the tests shall also be recorded.

8.2.2 If apparatus for any these tests is not available at the contractor's works, they may be carried out by an approved testing establishment.

8.2.3 All tests shall be carried out with the switch mounted on a metal plate earthed via a 100 mA fuse.

8.2.4 Unless otherwise specified, tests shall be carried out at normal temperature and pressure, as defined in 3.12.

8.2.5 All test results shall be recorded.

8.2.6 If a switch fails any of the tests, two further switches shall be submitted to the same series of tests up to completion of the test in which the first switch failed, and then one of the three shall continue the schedule to completion. If either of the second switches also fails, then the batch shall be deemed to have failed to meet the requirements of this International Standard. The approving authority for type tests shall be notified accordingly, and the cause of failure investigated and subsequent action decided.

8.2.7 A record of all test equipment and circuits, as applicable, shall be kept and the list shall form a part of the type test record.

8.2.8 The proximity switch action during relative movement of target and sensor shall be controlled using a micrometer screw thread device, for measurement of calibration, and a calibrated cam for rapid operation.

8.2.9 During any check to ensure correct operation, an indicating device shall be connected to each output circuit of the proximity switch.

8.2.10 100 mH air cored coils shall be used for d.c. inductive endurance load tests.

8.2.11 Targets shall be included in the full type test.

9 Production tests

9.1 Workmanship and finish

Each switch system shall be inspected to ensure that it conforms to the relevant drawings. To ensure that the type test standard has been maintained, workmanship, finish and general assembly shall be to the satisfaction of the approving authority.

9.2 Marking

Each switch system shall be marked in accordance with 4.2.

9.3 Pre-test conditioning

After all manufacturing processes and finishes have been completed and inspected, each switch system shall be operated for 200 cycles. Where semiconductors are used, the switch shall be energized for a period of 10 h, unless the semiconductors have already been aged, in which case the period shall be 2 h, during which time the 200 cycles shall be performed. Tests shall be conducted at extreme positive and negative temperatures.

9.4 Mechanical calibration

Travel in the operate position and in the release position, shall be measured at extreme positive and negative temperatures for each switch system, and shall be recorded in the head-on approach and in the side-on approach from two directions at right angles, where the design permits. The requirements of 8.2.8 and 8.2.9 shall apply.

9.5 Sealing

Each sensor and target shall pass the sealing tests specified in 10.23, unless otherwise specified in the relevant Part of this International Standard.

9.6 Insulation resistance

Each switch system shall pass the insulation resistance test specified in 10.5, unless otherwise specified in the relevant Part of this International Standard.

9.7 Voltage drop

The switch system shall be tested as specified in 10.6.

9.8 Supply voltage variation

Each switch system shall be tested at declared minimum and maximum voltages for correct functioning as specified in 10.24 for category B switches.

9.9 Consequences of failure

Any switch system failing to meet the requirements in 10.1 to 10.8 shall be deemed not to comply with the requirements of this International Standard. Such switch systems may, however, be resubmitted to these tests after rectification.

10 Type tests

NOTE — See also the relevant Part(s) of this International Standard.

10.1 Allocation of switches for type tests

The manufacturer shall submit at least eight switches for the type test schedule in table 1, together with the additional switches required for the appropriate endurance tests specified in table 4. The additional number of switches shall be at least seven in order to take into account the fluid contamination tests (see table 1).

10.2 Mass

The switch, including all mounting hardware, shall be weighed.

10.3 Mechanical calibration

10.3.1 Travel characteristics

The travels required of the target towards the sensor to actuate the switch shall be measured in the head-on approach and in the side-on approach from two directions at right angles, where the design permits. The requirements of 8.2.8 and 8.2.9 shall apply. Record the following :

a) the operate position of each output;

b) the de-operate position of each output;

c) the differential travel of each output;

d) simultaneity.

Table 1 — Type test schedule

Sub-clause	Test	Switch number							Remarks
		1	2	3	4	5	6	7 to 15	
10.2	Mass	*	*	*	*	*	*	*	
10.3	Mechanical calibration	*	*	*	*	*	*	*	
10.4	Strength of terminations and mountings	*	*						
10.5	Insulation resistance	*	*	*	*	*	*	*	
10.6	Voltage drop	*	*	*	*	*	*	*	
10.8	Icing			*	*				
10.16	Temperature, pressure and humidity					*	*		
10.12	Endurance (fast operation)								See table 4
	Endurance (slow operation)								See table 4
10.3	Mechanical calibration		*	*	*	*	*	*	
10.5	Insulation resistance			*	*	*	*	*	
10.6	Voltage drop			*	*	*	*	*	
10.9.1	Short circuit (closed circuit)			*	*				
10.9.2	Short circuit (making circuit)					*	*		
10.10	Short circuit (protected circuit)			*	*				As applicable in lieu of 10.9.1 and 10.9.2
10.13	Switch response time	*	*						
10.11	Overload	*	*						
10.3	Mechanical calibration	*	*	*	*	*	*		
10.5	Insulation resistance	*	*	*	*	*	*		
10.6	Voltage drop	*	*	*	*	*	*		
10.14	Vibration	*	*						
10.27	Impact (shock)	*	*						
10.15	Constant acceleration			*	*				
10.17	Tropical exposure					*	*		
10.3	Mechanical calibration	*	*	*	*	*	*		
10.5	Insulation resistance	*	*	*	*	*	*		
10.6	Voltage drop	*	*	*	*	*	*		
10.7	Continuous current and non-derangement			*	*				
10.18	Mould growth			*	*				
10.19	Fluid contamination							*	Total of seven required
10.20	Salt mist	*							
10.3	Mechanical calibration	*		*	*			*	
10.5	Insulation resistance	*		*	*			*	
10.6	Voltage drop	*		*	*			*	
10.22	Magnetic influence	*							
10.26	Magnetic debris							*	Two switches only
10.21	Explosion proofness								As required
10.3	Mechanical calibration	*	*						
10.24	Supply voltage variation	*	*						
10.3	Mechanical calibration	*	*						
10.5	Insulation resistance	*	*						
10.6	Voltage drop	*	*						
10.23	Sealing	*	*	*	*	*	*	*	Two switches only, from 7 to 15
10.28	Examination	*	*	*	*	*	*	*	

NOTE — A revised schedule using fewer switches may be used with the prior agreement of the approving authority.

10.4 Mechanical strength of terminations and mountings

10.4.1 The sensor and target, when mounted normally, shall be subjected to a force of 900 N applied separately in each of three mutually perpendicular directions. No damage shall be incurred.

10.4.2 Screwed terminals of a module, when the module is mounted normally, shall withstand the pull tests (see table 2) for 1 min. The pull shall be applied both along the axis and at right angles to the axis of the terminal screw, or along the lead wire slot, as appropriate. No damage shall be incurred.

Table 2 — Strength of terminations

Size of thread	Tightening torque N·m	Pull force N
M3	1,0	45
M4	2,0	45

10.4.3 A module having potted-in flying leads, and the sensor, when mounted normally, shall have each lead in turn subjected to a pull of 45 N for 1 min in a direction along the line of exit of the lead. No damage shall be incurred.

This test shall also apply to leads connected by integrated terminal junctions.

10.4.4 The sensor mounting bushing torque shall be measured, where applicable.

A bushing mounted sensor shall be mounted on a metal panel using normal mounting means and the specified hardware. A torque (see table 3) shall be applied to the mounting nut. If the unit has provision for a non-turn device, the mounted sensor housing shall be additionally subjected to a torque of 0,5 N·m with the non-turn device mounted on the sensor in the normal manner. No damage shall be incurred.

Table 3 — Mounting bushing torque

Overall diameter of bushing thread	Torque
mm	N·m
0 to 12	3,5
12 to 20	7,0
20	14,0

10.4.5 On completion of these tests, the switch shall continue to function normally and shall be checked for compliance with the requirements specified in 10.3, 10.5 and 10.6.

10.5 Insulation resistance

Unless otherwise specified in the relevant Part of this International Standard, the switch shall be subjected to the insulation resistance test for category A equipment specified in ISO 2678, and shall comply with the requirements specified therein.

10.6 Voltage drop

The voltage drop measured across each pair of output terminals or potted-in leads at each test interval shall be measured for five consecutive operations of the switch and shall not exceed the values specified in the relevant Part(s) of this International Standard. The voltage drop in the leads shall be deducted from the measured values.

10.7 Continuous current and non-derangement

For the purpose of these tests, at least 2 m of size 20 cable shall be attached to each termination and no more than 1 m of this length shall be housed inside the heating chamber.

10.7.1 All normally open, and all normally closed circuits in turn, shall carry, for not less than 2 h and without deterioration of the switch, the electrical loads at the maximum declared ambient temperature.

10.7.2 On completion of this test, and whilst at maximum temperature, the insulation resistance shall be measured as specified in 10.5. The insulation resistance shall be not less than 100 M Ω.

10.7.3 Where non-derangement temperatures are declared, the switch shall be maintained at these temperatures for the specified period and no damage or derangement shall occur.

10.7.4 After a recovery period of up to 24 h and at normal ambient temperature, the switch shall comply with the requirements specified in 10.3, 10.5 and 10.6.

10.7.5 Where a separate module or relay is used, the sensor and module or relay shall each be maintained at their respective maximum temperature.

10.8 Icing

The target and sensor shall be subjected to ice-formation test C, specified in ISO 2653. The object of the test is to ensure that the presence of ice cannot prevent intended approach of target to sensor.

10.8.1 Ice shall be allowed to build up to a thickness of 6 mm on both target and sensor, a temperature of −40 °C being maintained during the test.

10.8.2 The following forces shall be measured :

a) the force required to shear the ice when the target approaches the sensor at the declared design clearance, or in the case of passing clearance, at a distance of 6 mm, whichever is the smaller;

b) similarly, the breakaway force when the target and sensor are disengaging.

10.8.3 In both cases, the force shall be less than 200 N.

10.9 Short circuit : devices without built-in short circuit protection

Switches shall be subjected to the following short circuit tests, whilst wired into a test circuit equivalent to that shown in figure 1. The test circuit shall be protected by a device rated at the normal full load capacity of the switch output.

10.9.1 Closed circuit

10.9.1.1 One normally closed circuit of the switch under test shall be wired into the test circuit which shall be calibrated as defined in the relevant Part(s) of this International Standard. Calibration shall be carried out without the circuit-breaker, test switch and test leads in the circuit. With the switch under test in a closed position, the circuit shall be closed by a third switch. A minimum of 2 min shall elapse between successive operations of the third switch, and the test shall be conducted five times. There shall be no malfunction of the switch output circuits, mechanical failure or damage to the switch after each short circuit.

10.9.1.2 The test shall be repeated on a normally open circuit with the target and sensor in full engagement.

10.9.1.3 On completion of the above tests, checks shall be carried out to ensure compliance with the requirements specified in 10.3, 10.5 and 10.6.

10.9.2 Making circuit

One normally open circuit of the switch under test shall be wired into the test circuit which shall be calibrated to supply the same current as required in 10.9.1.

Calibration shall be carried out without the circuit-breaker, test switch and test leads in circuit. With the switch circuit under test in the open position, the supply shall be switched on and then the switch circuit under test shall be closed on to the short circuit and shall remain closed for not less than 20 s.

10.9.2.1 The test shall be repeated on a normally closed circuit.

10.9.2.2 On completion of the above tests, checks shall be carried out to ensure compliance with the requirements specified in 10.3, 10.5 and 10.6.

10.10 Short circuit : devices with built-in short circuit protection

For a device with built-in short circuit protection, the output current shall not exceed 150 % of the maximum rated current for any load impedance.

A resistance giving a load current equal to this maximum rated current shall be connected to the output and progressively decreased in value towards zero resistance.

The current in the load resistance shall be measured at all times during this process. The value of this current shall not exceed 150 % of the maximum rated current.

10.11 Overload

The switch shall be subjected to an overload test on a resistive load at 28,5 V d.c. on one pair of normally open contacts on one switch and on one pair of normally closed contacts on another switch in turn. Fifty operations shall be completed on each switch at a speed of five to six operations per minute and the duty cycle shall be approximately 50 % on and 50 % off.

The overload current for this test shall be the maximum current which can flow before the built-in protection is operative. In the case of a switch without built-in protection, the maximum current shall be 150 % of the maximum resistive current.

At the conclusion of the overload tests, correct operation of the switch shall be checked by means of the tests specified in 10.3, 10.5 and 10.6.

10.12 Endurance test conditions

The endurance test shall be carried out so that the number of operations, electrical loading and environmental conditions comply with the requirements of table 4.

For operating rates of 2 per second, the target speed shall be 250 mm/s, and for operating rates of 2 per minute, it shall be 10 mm/s. Where a switch has been designed for target speeds in excess of 250 mm/s, a higher value may be used in the endurance tests.

10.12.1 Endurance test checks

For each of the endurance tests, the voltage drop tests shall be carried out as specified in 10.6 and the switch response time shall be measured in accordance with 10.13, at the start of the test and after the intervals stated in table 5. Throughout the tests, the outputs shall be monitored for correct functioning. At the conclusion of each endurance test at a particular load and in a particular environment, insulation resistance tests shall be carried out as specified in 10.5.

10.12.2 Standard of acceptance

On completion of all the endurance tests, the tests specified in 10.3, 10.5, 10.6 and 10.23 shall be conducted where applicable, and their requirements met.

Table 4 — Endurance test conditions

Total number of operations per switch	Test conditions		Electrical loading				Switch number
	Temperature °C (± 3 °C)	Altitude	Voltage	Current	Operating speed	Nature of load	
50 000	Maximum declared temperature	Sea level	28 d.c.	Maximum declared	2 per second	Resistive	7 and 8
50 000	−55	21 000 m					
50 000	Maximum declared temperature	Sea level	28 d.c.	Maximum declared on DDP	2 per second	Inductive	9 and 10
10 000	20	Sea level	28 d.c.	Maximum declared on DDP	2 per minute	Lamp load	11
50 000	20	Sea level	As declared on DDP	As declared on DDP	2 per second	Low level resistance	12 and 13
50 000	−55	Sea level					
100 000	20	Sea level	115/200 a.c.	Maximum declared on DDP	2 per second	Resistive	14[1]
50 000	20	Sea level	115/200 a.c.	Maximum declared on DDP	2 per second	Inductive	15[1]
50 000	20	21 100 m					

1) Where no a.c. rating is declared in the DDP, switches 14 and 15 are not required.

Table 5 — Test intervals for voltage drop and insulation resistance tests

Number of operations	Test interval
Start	Start
100 000 and above	Every 5 000 operations up to 20 000 operations, and thereafter every 20 000 operations until completion of the test
50 000	Every 2 500 operations up to 10 000 operations and thereafter every 10 000 operations until completion of the test
25 000	At 2 500 operations, at 5 000 operations and thereafter every 5 000 operations until completion of the test
10 000	At every 2 000 operations until completion of the test

10.13 Switch response time

The switch system shall be operated 10 times at a target speed of 10 mm/s and 250 mm/s as appropriate to the test sequence. Switch operations shall be satisfactory and the switch response time shall be measured for both directions of movement of the target.

Where a higher speed than 250 mm/s has been used in the endurance tests, the response time shall be measured at the higher value.

10.14 Vibration (resonance and endurance)

Sinusoidal vibration with frequency sweep tests shall be carried out as specified in ISO 2668, severity level R. Fifty percent of each endurance run shall be carried out in each of the operate and de-operate conditions. Tests shall be carried out at each frequency and amplitude to ensure correct operation, using an oscilloscope or a suitable indicating device to ensure that no inadvertent operation occurs. No inadvertent closure of circuit is permissible, but open circuits lasting less than the time specified in the relevant Part(s) of this International Standard are acceptable.

On completion of either of the above tests, the tests specified in 10.3, 10.5 and 10.6 shall be carried out and their requirements met.

10.15 Constant acceleration

10.15.1 The switch system shall be subjected to acceleration tests as specified in ISO 2669 for severity grade 3 and structural integrity category A.

10.15.2 For the functional test, the switch shall be mounted in six attitudes using the normal mounting face as the reference base. During this test, with the switch in the operate and de-operate positions, there shall be no inadvertent operation of, or damage to, the switch.

10.15.3 For the structural integrity test, the switch system shall be mounted as specified in 10.15.2.

10.15.4 At the conclusion of the acceleration tests, the switch system shall satisfy the requirements specified in 10.3, 10.5 and 10.6.

10.16 Temperature, pressure and humidity

The switch system shall be subjected to the climatic tests specified in ISO 2651 for category E1 equipment with the following modifications.

10.16.1 During the tests, the switch system shall have at least 2 m of size 20 cable attached to each terminal, approximately half of which shall be contained within the test chamber. Allowance shall be made for the length of these leads when the voltage drop checks are conducted.

10.16.2 A separate electronic module may be tested in accordance with ISO 2651, for category D1 equipment, in cases where it is unable to comply with the requirements of 10.16.1. In this case, the test on the module shall be conducted simultaneously with testing of the sensor in accordance with ISO 2651, for category E1 equipment.

10.16.3 The following procedure shall be observed in testing.

10.16.3.1 When testing to category E1, the temperatures for the test procedures specified in sub-clauses 7.5, 7.6 and 7.9 of ISO 2651 shall be + 85 °C, + 70 °C and + 150 °C respectively, except that, for a separate electronic module a temperature of + 80 °C for the test procedure specified in sub-clause 7.9 of ISO 2651 is required.

10.16.3.2 When testing a separate electronic module to category D1, the temperature for the test procedure specified in sub-clause 7.9 of ISO 2651 shall be + 55 °C.

10.17 Humidity (24 h cycle)

The switch system shall be subjected to the tests specified in ISO 2652 for grade A equipment and shall be in the idle state.

At the conclusion of the test, the switch system shall satisfy the requirements specified in 10.3, 10.5 and 10.6, and there shall be no signs of undue deterioration likely to affect the performance of the switch system.

10.18 Mould growth

The switch shall be subjected to the 28 day test specified in ISO 2658. Upon conclusion, it shall be inspected visually. There shall be no signs of mould growth and it shall comply with the requirements specified in 10.5.

10.19 Fluid contamination

10.19.1 The sensor and target shall be subjected to the fluid contamination tests described in annex A. A separate sensor and target shall be used for each fluid listed.

10.19.2 At the conclusion of each test, and after reaching normal temperature, the switch shall be operated and any signs of deterioration shall be declared. Where a switch contains a sealed cavity, which is essential for the full performance of the switch, the sealing test specified in 10.23 shall be performed.

10.19.3 A separate module, designed for installation in clean environments, shall be tested in accordance with annex A, using fluid group numbers 10 and 12 of table 7; otherwise it shall be tested using all the fluids listed in table 7.

10.20 Salt mist

The sensor and target shall be subjected to the salt mist test described in ISO 2659.

At the conclusion of the test, the switch shall be subjected to the tests specified in 10.3, 10.5 and 10.6.

10.21 Explosion proofness

The switch system shall be tested as specified in ISO 2683, for environment IIa, to a category appropriate to the switch enclosure.

10.22 Magnetic influence

The switch system shall be tested as specified in ISO 2676.

10.23 Sealing

The sensor and targets shall be subjected to sealing tests appropriate to the equipment grade and enclosure. These will form the subject of ISO 2663.

10.24 Supply voltage variation

The switch system shall be tested, at the declared minimum and maximum voltages for correct functioning, by the method specified in ISO 1540.

10.25 Electromagnetic interference

The switch system shall be tested to a declared level of conducted and radiated susceptibility in accordance with national standards, if available.

10.26 Magnetic and non-magnetic debris

The switch system shall be lightly greased and magnetic particles, between 0 and 400 µm in size, shall be dusted on to the surfaces to achieve a distribution of 200 mg/cm^2. The switch system shall be tested as specified in 10.3 and the specified requirements shall be met.

The test shall be repeated using light alloy (aluminium) particles.

10.27 Impact (shock)

The switch system shall be subjected to impact shock tests. These will form the subject of a future International Standard.

10.28 Examination

On completion of the type tests, the switch system shall be examined for signs of damage and undue wear of working parts. A report on its condition shall be submitted to the approving authority.

11 Quality assurance test

11.1 General

The purpose of these tests is to verify that the quality of switch systems is being maintained during production. The tests are to be carried out on switch systems which have previously been subjected to and passed the production tests specified in 9.1 to 9.8.

11.2 Method of test

11.2.1 Test conditions

The conditions for testing shall be in accordance with the requirements of 8.2.

11.2.2 Provision of production samples for test

Unless otherwise agreed, the manufacturer shall select the samples in accordance with the requirements of 11.3.

11.2.3 Identification of switch systems for test

Each switch system shall be suitably identified and subjected to the tests in the order listed in table 6. Where measurements are required, they shall be recorded.

11.3 Selection of samples

The procedure for selecting samples from batch production shall be agreed between the manufacturer and the purchaser or approving authority, as appropriate, and declared. The procedure and sampling plan so agreed should preferably be chosen from ISO 2859.

After completion of the type tests, a further two switch systems shall be selected at random at intervals of six months, or from each batch if the interval between batches is greater than six months, and subjected to one group of tests as detailed in table 6. The groups of tests shall be taken in rotation for each series of tests, as shown in figure 2.

When it is known that the switches have passed all the tests satisfactorily, the batches represented by the switch systems may be released until the next group of tests are required.

Sampling shall be continued at the above rate, and in the above order (see also figure 2) throughout the whole period of production of the units concerned.

11.4 Action in event of failures

If any selected switch system fails to pass any of the quality assurance tests detailed in table 6, this shall be declared, and a second switch system shall immediately be selected at random, preferably from the same batch if still available, and submitted to the particular test or tests which the previous switch system originally failed. Should this second switch system also fail any such test, the particular switch system type concerned shall be deemed not to comply with the requirements of this International Standard, and the manufacturer shall immediately suspend delivery of the type of switch system concerned against all contracts and sub-orders governed by this International Standard, including batches already packed for despatch. The manufacturer shall then investigate the cause of failure, and, when this has been established, he shall then submit a report in duplicate to the inspection and approving authorities, stating what changes in design and/or manufacture are considered necessary to remedy the defects, and recommending what action should be taken in respect of switch systems already delivered.

The supply of the type of switch system concerned shall not recommence until the inspection and approving authorities are satisfied that the cause of all failure has been rectified.

Additional tests to ensure that the fault has been rectified and that the switch systems meet the requirements of this International Standard may be necessary; these additional tests shall be agreed between the manufacturer and the inspection and approving authorities.

Table 6 — Quality assurance test schedule

Sub-clause	Test	Group 1 tests		Group 2 tests		Group 3 tests	
		Switch number					
		1	2	1	2	1	2
10.2	Mass	*	*	*	*	*	*
10.3	Mechanical calibration	*	*	*	*	*	*
10.5	Insulation resistance	*	*	*	*	*	*
10.6	Voltage drop	*	*	*	*	*	*
10.4	Strength of terminations and mountings		*				
10.12	Fast operations, 50 % of endurance run (see table 4, switches 7 and 8)			*			
10.12	Slow operations, 50 % of endurance run (see table 4, switch 11)				*		
10.7	Continuous current and non-derangement	*					
10.3	Mechanical calibration	*	*				
10.5	Insulation resistance	*	*				
10.6	Voltage drop	*	*				
10.9.1	Short circuit, closed circuit		*				
10.9.2	Short circuit, making circuit	*					
10.10	Short circuit, protected circuit (as applicable in lieu of 10.9.1 and 10.9.2)	*	*				
10.13	Switch response time	*	*	*	*		
10.3	Mechanical calibration	*	*	*	*		
10.5	Insulation resistance	*	*	*	*		
10.6	Voltage drop	*	*	*	*		
10.11	Overload					*	
10.3	Mechanical calibration					*	*
10.5	Insulation resistance					*	*
10.6	Voltage drop					*	*
10.12	Vibration			*	*		
10.3	Mechanical calibration			*	*		
10.5	Insulation resistance			*	*		
10.6	Voltage drop			*	*		
10.15	Constant acceleration			*	*		
10.3	Mechanical calibration			*	*		
10.5	Insulation resistance			*	*		
10.6	Voltage drop	*	*				
10.8	Icing	*	*				
10.3	Mechanical calibration	*	*				
10.5	Insulation resistance	*	*				
10.26	Magnetic debris					*	*
10.24	Supply voltage variation			*	*		
10.3	Mechanical calibration			*	*		
10.5	Insulation resistance			*	*		
10.6	Voltage drop			*	*		
10.25	Electromagnetic interference					*	*

Table 6 (*concluded*)

Sub-clause	Test	Group 1 tests		Group 2 tests		Group 3 tests	
		Switch number					
		1	2	1	2	1	2
10.16	Temperature and humidity					*	*
10.3	Mechanical calibration					*	*
10.5	Insulation resistance					*	*
10.17	Tropical exposure					*	*
10.3	Mechanical calibration					*	*
10.5	Insulation resistance					*	*
10.23	Sealing	*	*	*	*	*	*
10.27	Examination	*	*	*	*	*	*

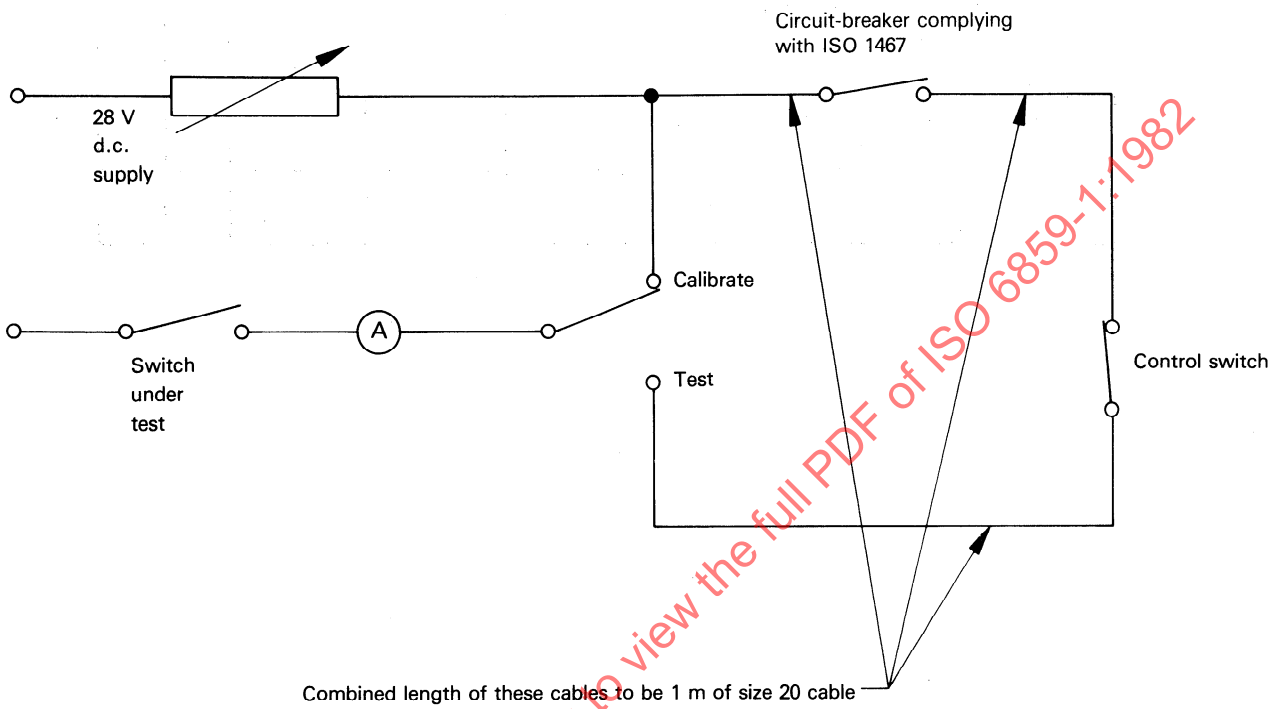

Figure 1 — Typical test circuit for short circuit test

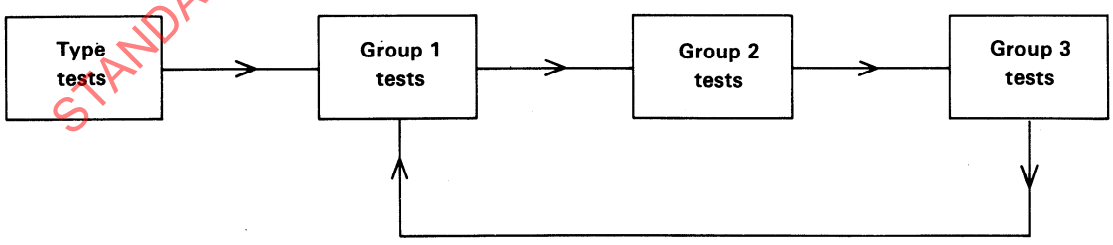

Figure 2 — Sequence of groups of tests for quality assurance

Annex A

Fluid contamination tests

A.1 Test fluids

The fluids to be used for these tests are given in table 7.

A.2 Apparatus

The following apparatus is required :

a) a chamber in which the temperature can be maintained within the limits specified in table 7;

b) suitable means of spraying the test fluids.

A.3 Procedure

A.3.1 Spray the unit with one of the test fluids so that it is thoroughly wetted, and freely suspend it in the chamber.

A.3.2 Adjust the temperature in the chamber to the temperature specified in table 7, and maintain it at that temperature for 7 days.

A.3.3 Test fluids of groups 2 and 10 shall be resprayed each day during the test period.

A.3.4 Remove the unit from the chamber and allow it to regain room temperature.

Table 7 — Test fluids

Fluid	Test fluid group number in accordance with ISO 2684	Temperature of test °C
Petroleum fuel	2	50 ± 3
Aviation turbine fuel	1	50 ± 3
Hydraulic fluid	5	50 ± 3
	4	50 ± 3
	7	50 ± 3
Lubricating oil	9	50 ± 3
Cleaning fluid	10	50 ± 3
Fire extinguishing agents	12	50 ± 3

Annex B

Serviceability tests

B.0 Introduction

The minimum requirements recommended to verify the serviceability of switches manufactured in compliance with the requirements of this International Standard are as follows.

B.1 Marking

Each switch shall be marked in accordance with 4.2.

B.2 Mechanical conditions

Each switch shall be free from signs of mechanical damage, and shall comply with the requirements specified in 9.1.

B.3 Mechanical calibration

Each switch shall be checked for operating and release position as specified in 9.4.

B.4 Voltage drop

Each switch shall be tested for voltage drop and for correct operation of all outputs as specified in 9.8.

B.5 Insulation resistance

Each switch shall be tested for insulation resistance as specified in 9.6.