BS 2G 239 : 1992

Specification for

Primary active lithium batteries for use in aircraft

Foreword

This edition of this British Standard, which has been prepared under the direction of the Aerospace Standards Policy Committee, introduces technical changes but it does not reflect a full review or revision of the standard, which will be undertaken in due course. It introduces revised and additional tests for primary lithium batteries to assist manufacturers to overcome difficulties experienced when implementing the previous standard. It supersedes BS G 239 : 1987 which is withdrawn.

This British Standard specifies requirements and tests for type approval and quality assurance for primary lithium batteries designed for use in aircraft and specifies general design requirements applicable to such batteries. Examples of an individual specification sheet and form of Declaration of Design and Performance are given in annexes A and B. Methods of determining electrical performance, including service output, are included. It is not the purpose of this standard to specify particular sizes but a range of chemical systems based on lithium is covered.

The type approval tests contained in this British Standard include an evaluation of intrinsic safety. Additionally, guidance for users of batteries is included in annex C.

This British Standard calls for the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

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

Contents

Specification

1 Scope

This British Standard specifies design, type approval and quality assurance requirements for all primary active lithium batteries for use in aircraft.

NOTE 1. Typical examples of the chemical systems employed in the cells from which the batteries are constructed are given in table 1.

NOTE 2. The manufacturer is encouraged to refer the purchaser to the information contained in annex C.

Table 1. Typical chemical systems used in primary active lithium batteries

Chemical system	Nominal voltage V
Li-$SOCl_2$ (lithium-thionyl chloride)	3.5
Li-MnO_2 (lithium-manganese dioxide)	3.0
Li-$(CF_x)_n$ (lithium-polycarbon monofluoride)	3.0
Li-SO_2 (lithium-sulfur dioxide)	3.0
Li-$Cu_4O(PO_4)_2$ (lithium-copper oxyphosphate)	2.5
Li-CuO (lithium-copper oxide)	1.5
Li-FeS_2 (lithium-iron disulfide)	1.5

2 References

2.1 Normative references

This British Standard incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back page. Subsequent amendments to, or revisions of, any of these publications apply to this standard only when incorporated in it by updating or revision.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back page, but reference should be made to the latest editions.

3 Definitions

For the purposes of this British Standard, the following definitions apply.

3.1 nominal voltage

The value of voltage assigned to a battery type for the purpose of identification or classification.

3.2 end-point voltage (V_E)

The on-load voltage at which the discharge is considered complete, as defined in the individual specification sheet.

3.3 operational temperature limits (T_H, T_L)

The maximum temperature T_H and minimum temperature T_L between which the battery is designed to be used and to comply with this standard as defined in the individual specification sheet.

3.4 duty discharge requirements

The electrical load demands of the application for which the battery is intended, expressed in terms either of resistance, current or power versus time.

3.5 duty discharge duration (N_L, N, N_H)

The duration for which the battery, at a temperature of T_L, 20 °C or T_H respectively, is required to perform its duty discharge in accordance with **3.4**, down to the end-point voltage V_E, and as defined in the individual specification sheet.

3.6 rated capacity (C_r)

The product of the constant current equivalent to the mean of the duty cycle current and the discharge time at 20 °C down to the end-point voltage V_E, as defined in the individual specification sheet.

3.7 voltage delay time (D)

The maximum time interval between the application of the duty discharge load and the terminal voltage reaching and sustaining a value not less than V_E, as defined in the individual specification sheet.

3.8 cell

An individual electrochemical unit.

3.9 battery

An assembly consisting of one or more cells.

3.10 centre of cell

a) for a cylindrical cell, the mid-point of the length of the cell;

b) for a coin cell, the centre of one face of the cell;

c) for rectangular and irregular shaped cells, the centre of the side with the largest surface area.

4 Individual specification sheet

The manufacturer shall prepare an individual specification sheet for each type of battery produced. The individual specification sheet shall define the values for parameters given in annex A.

5 Identification and marking

5.1 At least the following information shall be clearly and indelibly marked on the battery casing, except for those batteries referred to in **5.2**:

a) 'LITHIUM BATTERY' (in block capitals);

b) chemical system employed (words or chemical symbols);

c) manufacturer's name or identification;

d) manufacturer's type or part number;

e) nominal battery voltage;

f) 'CAUTION: *NEVER* CHARGE, SHORT CIRCUIT, PUNCTURE, DEFORM OR INCINERATE. REMOVE WHEN DISCHARGED.' (in block capitals);

g) 'Positive terminal polarity'.

5.2 Where lithium batteries are too small to incorporate all the information required by **5.1**, such batteries shall, at a minimum, be identified by the items detailed in **5.1**d and **5.1**g, and the full information required by **5.1** shall accompany the battery on a separate leaflet.

6 Design

6.1 General construction

NOTE. It is essential that the battery be constructed such that the risk of failure due to rough handling is minimized.

No cell interconnections shall be exposed such that they can be accidentally damaged or present a risk of electrical short circuit.

6.2 Battery case

The casing of the battery shall be of a material and form which satisfy the environmental tests given in clause **9**.

Additionally the material used shall be of low flammability such that it satisfies *Joint Airworthiness Requirements*, Part 25, paragraph 25.853(b)[1].

The manufacturer shall define on the individual specification sheet the method of in-service mounting employed for the type tests. Any restrictions on the method of mounting shall be declared on the Declaration of Design and Performance (**6.10**) under 'Limitations'.

6.3 Venting

All cells shall incorporate a pressure relief mechanism or shall be so constructed that they will relieve excessive internal pressure at a value and rate which will preclude explosion or self-ignition. If encapsulation is necessary to support the cells within the outer case, the type of encapsulant and the method of encapsulation shall not cause the battery to overheat under normal operation nor inhibit the operation of the pressure relief mechanism.

The battery case material and/or its final assembly shall be so designed that, in the event of one or more cells venting, the battery case does not present a hazard in its own right.

6.4 Protective devices

6.4.1 *General*

Batteries shall be so designed that they do not present a safety hazard under all normal and electrically abusive conditions of use.

NOTE. To meet this requirement it may be necessary to provide the devices specified in **6.4.2** to **6.4.4**.

When the devices specified in **6.4.2** to **6.4.4** are provided, they shall:

a) form an integral part of the battery;

b) not be susceptible to short-circuiting or any failure which will allow them to be bypassed;

c) not be replaceable by the user;

d) be rated such that the reliable operation of the battery over the full range of operating and environmental conditions is not inhibited.

6.4.2 *Overload protection*

The battery shall comply with the short circuit requirement (see **11.7**).

NOTE. This may be achieved by the incorporation of a suitable device.

6.4.3 *Charge protection*

Where the possibility of external charging exists, the battery shall be provided with a series diode or other protective device. Parallel-connected series strings of cells in a battery shall be protected from internal charge by the inclusion of a series diode or other device in each string.

6.4.4 *Reverse polarity*

The battery shall comply with the forced discharge requirement (see **11.4**) by the inclusion of a shunt diode or other device across each cell, if necessary.

6.5 Electrical outputs

Single voltage output batteries shall be employed wherever possible. Batteries shall not derive multi-voltage outputs by means of series chain tappings.

6.6 Electrical terminals

Output terminations shall be mechanically polarized. If flying leads are employed, these shall be made from an approved aircraft cable and be suitably terminated to prevent accidental discharge.

NOTE. It is essential that the output terminations be shrouded so as to minimize the risk of an electrical short circuit.

6.7 Attitude

Batteries shall be suitable for operation in any attitude.

6.8 Fixing

Batteries shall be provided with means of attachment to the structure unless they are designed to be closely fitted within an equipment.

6.9 Environmental conditions

6.9.1 *Temperature*

The battery shall be suitable for operation over at least the temperature range T_L to T_H and shall not be deranged by exposure (non-operation) to the temperature range −40 °C to 75 °C or the temperature range specified in the individual specification sheet.

6.9.2 *Altitude*

The battery shall be suitable for operation over the altitude/pressure range −457 m (−1500 ft), 106.94 kPa to +16 764 m (+55 000 ft), 9.12 kPa on the pressure range specified in the individual specification sheet.

6.10 Declaration

A Declaration of Design and Performance shall be prepared for each battery type.

NOTE. The format in annex B is strongly recommended and should be used unless otherwise required by the Design Authority.

7 Type approval

7.1 General

7.1.1 Type approval of a battery shall be based upon the tests given in clauses **8**, **9** and **10** as determined in the individual specification sheet and in clause **11**. The manufacturer shall demonstrate to the satisfaction of the Approving Authority[1)] that the batteries comply with the requirements of this standard.

NOTE 1. The Approving Authority will signify type approval of the battery by the issue of the appropriate certification.

NOTE 2. The Approving Authority may, on a discretionary basis, grant an approval before the completion of the storage tests (clause **10**) on the basis of an appropriate technical submission.

7.1.2 Except for those batteries detailed in **11.1**, batteries subjected to type approval testing shall be to a defined build standard and be made using production tooling and assembly techniques and at the production plant at which production is intended. The manufacturer shall ensure that the plant is approved by the appropriate Quality Assurance Authority for the manufacture of the appropriate battery type. The type approval batteries shall in every way be representative of normal production and shall have successfully passed at least the following production acceptance tests prior to submission for type approval.

a) *Dimensions and mass.* The dimensions and mass of the batteries shall be measured and shall comply with the controlled outline and interface drawings.

b) *Identification.* The information displayed on each battery shall comply with that required by the individual specification sheet and by clause **5**.

7.1.3 Type approval of a battery to this standard shall relate solely to its use in the application(s) stated in the individual specification sheet; it shall not be taken as an approval for general application.

7.2 Type approval tests

7.2.1 The appropriate numbers of batteries shall be subjected to type approval tests in accordance with figure 1. No cell in any of the type approval test batch of batteries shall leak, vent or explode or in any other way discharge its contents except where subjected to the test in **11.1**.

NOTE. Because of the long storage capability of the batteries covered by this specification, interim approval may be granted by the Approving Authority after the successful completion of all tests, excluding the long-term storage testing of batteries in excess of 1 year.

7.2.2 Unless otherwise specified in a given test, all tests shall be carried out at the prevailing temperature, pressure and humidity. Where these parameters are specified in a given test, the values given shall be subject to the following tolerances:

a) temperature	± 2 °C;
b) pressure	± 1 kPa;
c) relative humidity	± 10 %.

7.2.3 The test equipment used for the type approval tests shall, unless otherwise specified in this standard, have at least the following degree of accuracy and have a range appropriate to the quantity being measured.

a) Voltmeters shall conform to BS 89 : Part 2 : 1990, class index 0.3.

b) Ammeters shall conform to BS 89 : Part 2 : 1990, class index 0.3.

c) Thermometers shall have an accuracy of 1 °C.

d) Chronometers shall have an accuracy not exceeding 2 % for periods less than 10 s, 0.5 % for periods between 10 s and 24 h, and 0.1 % for periods greater than 24 h.

e) Resistors shall have an accuracy of 0.5 % up to 100 W dissipation and 1.0 % above 100 W dissipation.

[1)]The Approving Authorities for batteries for British civil aircraft and military aircraft are, respectively, the Airworthiness Division of the Civil Aviation Authority (or a Design Authority approved by them) or the Ministry of Defence.

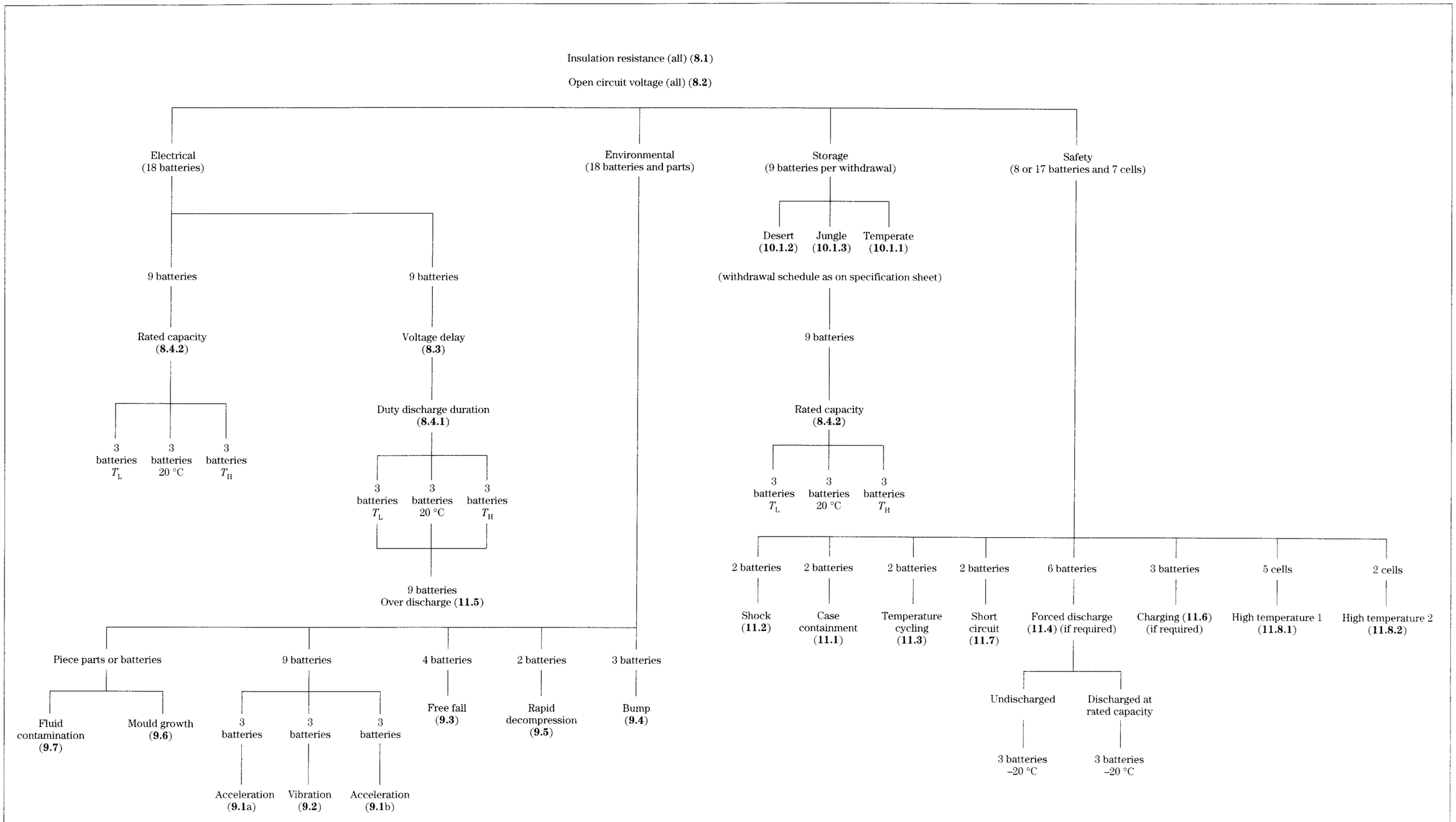

Figure 1. Type approval test programme

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7.3 Maintenance of approval

On approval, the design of the batteries shall be frozen and the drawings sealed. No change shall be made to the design without prior advice to the Approving Authority.

NOTE. Any such design changes may invalidate the approval and necessitate full or partial repetition of the type approval tests to reinstate the approval.

7.4 Preparation for test

Batteries selected for test shall have been manufactured not less than 4 weeks and not more than 12 weeks prior to the commencement of test, and shall have been stored at a temperature of 20 °C ± 5 °C during the intervening period. Unless otherwise specified in a given test, batteries shall be held at the specified test temperature for not less than 16 h and not more than 24 h prior to commencement of any test, and the specified ambient temperature (see **7.2.2**) shall be maintained throughout the test period.

7.5 Applicability of safety tests

7.5.1 *Case containment test*

This test (see **11.1**) shall be applied to all batteries.

NOTE. Where there is evidence that a cell cannot be forced to vent if it is subjected to electrical abuse (other than charging) or to an internal/manufacturing defect, then this test may be waived with the agreement of the Approving Authority.

7.5.2 *Forced discharge test*

This test (see **11.4**) shall only be undertaken if an external power source can be connected in series with the battery when it is in its specified equipment, or if a single circuit fault in the equipment could cause such a connection.

7.5.3 *Charging test*

This test (see **11.6**) shall only be undertaken if it is called up in the individual specification sheet and then only if an alternative secondary battery is available for use in the equipment, or if a single fault in the equipment could connect a power source in parallel with the battery.

8 Electrical tests

8.1 Insulation resistance

The insulation resistance between externally exposed metal surfaces of the battery, excluding electrical contact surfaces and the positive terminal, shall be not less than 10 MΩ at 500 V d.c.

8.2 Open circuit voltage

The open circuit voltage of each battery, when measured using a voltmeter having an internal resistance of not less than 20 000 Ω/V, shall be recorded and shall be within the limiting values given in the individual specification sheet.

8.3 Voltage delay

Conduct the test at each temperature T_L, 20 °C and T_H, as given in the specification sheet, using batteries that have not previously been subjected to any discharge. Connect the battery to a duty discharge load, as defined in the individual specification sheet.

The terminal voltage at time D shall be greater than V_E as given in the individual specification sheet. For approval tests this voltage shall be recorded.

NOTE. This test may be incorporated as part of the duty discharge duration test (**8.4.1**).

8.4 Capacity

8.4.1 *Duty discharge duration*

Determine the duty discharge duration, i.e. the time from D until the voltage falls to V_E at each of the specified temperatures T_L, T_H and 20 °C, when the battery is being discharged to the specified duty discharge.

The duration of discharge in hours (N, N_L and N_H) at each temperature shall be not less than that declared in the individual specification sheet.

8.4.2 *Rated capacity*

Discharge the batteries at a constant current equivalent to the mean of the duty discharge current or through an equivalent fixed resistive load at a temperature of T_L, T_H and 20 °C to a terminal voltage V_E. If this current results in a duration in excess of 1000 h, carry out the test at the 1000 h rate.

The value of the duration of the discharge (in hours) multiplied by the discharge current (in amperes) shall be not less than the value of C_r given in the individual specification sheet.

9 Environmental tests

9.1 Acceleration

Mount the battery on the test table in a manner similar to the intended in-service mounting. Subject the battery to the acceleration tests defined in BS 3G 100 : Part 2 : Section 3 : Subsection 3.6 : 1972 as follows:

a) normal: class 1A(ii) grade C;

b) crash: class 11 grade E.

During the acceleration tests, subject the battery to the 20 °C rated capacity test in **8.4.2**.

The battery terminal voltage shall be monitored throughout the test period and shall not fall below V_E. The rated capacity test shall be continued after completion of the normal acceleration test to the voltage end-point (V_E) and the battery shall conform to the requirements of **8.4.2**. The battery subjected to the crash acceleration test shall be physically examined for signs of damage or leakage and shall be free of any such damage or leakage.

9.2 Vibration

Mount the battery on the vibration table in a manner similar to the intended in-service mounting. Test the battery in accordance with **4.3**, **4.4.1**, **4.4.2** and **4.5** of BS 3G 100 : Part 2 : Section 3 : Subsection 3.1 : 1969 with vibration levels in accordance with figure 3, category 3 of that standard (10 Hz to 1000 Hz). Throughout the endurance part of the vibration test, discharge the battery through its rated capacity load or at the 100 h rate, whichever is longer.

Throughout the test the voltage level shall not fall below V_E for periods longer than that defined in the individual specification sheet. No visible physical damage shall result from this test.

9.3 Free fall

Drop each battery once from a height of 1 m onto a hard surface of concrete faced with a steel plate of effective mass at least 20 times that of the battery. Drop four batteries, two at a temperature of T_H and two at a temperature of T_L. Drop one battery at each temperature on the face containing the connector and one at each temperature on a face perpendicular to the connector face.

The batteries shall exhibit no physical damage likely to detract from their subsequent use and each battery shall conform to the discharge requirements of the rated capacity test (see **8.4.2**).

9.4 Bump

Test the batteries in accordance with BS 2011 : Part 2.1Eb : 1987. Mount the batteries securely on the bump machine test table and subject to a total of 4200 bumps, 1400 along each of three mutually perpendicular axes. The severity shall be 98 m/s^2 with a pulse width of 16 ms.

At the conclusion of the test the batteries shall exhibit no signs of physical damage and shall conform to the requirements of the rated capacity test (see **8.4.2**).

9.5 Rapid decompression

9.5.1 This test shall be applied to batteries that are used or carried in the pressurized container of an aircraft.

NOTE. This test is based on the requirement of BS 3G 100 : Part 2 : Section 3 : Subsection 3.4 : 1972 for equipment grade A and aircraft class IV.

9.5.2 Carry out the following test at 20 °C ± 5 °C.

a) Throughout the following sequence, discharge the battery through the rated capacity load.

b) 30 min from the start of discharge, reduce the ambient pressure to 80.5 kPa within not more than 10 min and maintain this pressure for 1 h.

c) Reduce the ambient pressure to 4.5 kPa within 1 min ± 20 s and maintain this pressure for 1 h.

d) Return the pressure to the laboratory ambient pressure within 10 min and continue the discharge to the end voltage specified in the individual specification sheet.

e) Inspect the battery for leakage or distortion.

9.5.3 Repeat **9.5.2**a to e, at a temperature of 45 °C or as required by the individual specification sheet.

9.5.4 Subsequent to the test, the batteries shall exhibit no signs of physical damage or leakage.

9.6 Mould growth

Subject samples of those materials used for the outer, exposed surfaces of the battery (or subject a complete battery if more convenient) to the 28-day short exposure test described in BS 3G 100 : Part 2 : Section 3 : Subsection 3.3 : 1972.

At the end of the test period there shall be no signs of mould growth when the battery is examined without visual aids.

9.7 Fluid contamination

Subject samples of those materials used for the outer, exposed surfaces of the battery (or subject a complete battery if more convenient) to the tests defined in BS 3G 100 : Part 2 : Section 3 : Subsection 3.12 : 1991 for class A exposure. The test fluids shall be as defined in the individual specification sheet, each sample being subjected to one fluid only. The test temperature shall be 20 °C ± 5 °C.

At the conclusion of the 7-day test period the batteries or material samples shall exhibit no sign of distress, e.g. shrinkage, softening, swelling.

10 Storage tests

10.1 Storage conditions

10.1.1 *Temperate*

Batteries shall be stored at an ambient temperature of 20 °C ± 5 °C.

10.1.2 *Desert*

Batteries shall be stored at an ambient temperature of 20 °C ± 5 °C with one excursion to 50 °C ambient for 6 h on each of 4 days in every 7 days. The transition time between the two ambient temperatures shall be complete within 1 h.

10.1.3 *Jungle*

Batteries shall be stored at an ambient temperature of 20 °C ± 5 °C with one excursion to 35 °C ambient for 6 h on each of 5 days in every 7 days. The transition time between the two ambient temperatures shall be complete within 1 h. The relative humidity throughout shall be not less than 95 %.

10.2 Storage programme

Unpackaged batteries shall be stored under each of the conditions and periods defined in the individual specification sheet. Any necessary protection of the terminations shall also be defined in the individual specification sheet.

10.3 Examination and tests during storage

Throughout the storage period batteries shall be examined and tested at intervals not exceeding 8 weeks, except that in the case of batteries stored for periods of 2 years or more this period may be extended to 13 weeks. Batteries shall not show signs of distortion, leakage or any other defect which would prevent their satisfactory use. At each examination, the open circuit voltage of each battery shall be measured and shall be recorded for trend analysis.

10.4 Post-storage tests

At the conclusion of each storage period the batteries withdrawn shall be subjected to the rated capacity test (**8.4.2**). Prior to this test the batteries shall be subjected to the voltage delay test (**8.3**). Batteries shall conform to the requirements of these clauses.

11 Safety tests

NOTE. The tests in this clause are intended to demonstrate that batteries do not present a safety hazard, either to the equipment in which they may be used or to personnel, when they are subjected to abuse or fault conditions. See **7.5** for the applicability of **11.1**, **11.4** and **11.6**.

11.1 Case containment

NOTE. This test is to demonstrate that if a cell in an encased battery should vent, then the venting will not be a major physical hazard to adjacent personnel or equipment.

Remove all external protective devices and force a cell in the battery to vent, or to discharge its contents, by either:

a) applying an external short circuit of 50 mΩ ± 10 mΩ for 24 h to the cell; or

b) forced discharge of the complete battery to the electrical requirements of **11.4**; or

c) undertaking any other test agreed by the Approving Authority.

The case of the battery shall remain essentially intact and there shall be no fragmentation or break-up. Distortion and/or splitting of the case shall be permitted, as shall the attack of plastics and other case materials by battery fluids. The escape of fluids or gases shall also be permitted.

11.2 Shock

Subject the batteries in both the undischarged and fully discharged conditions to the shock test requirements of BS 2011 : Part 2.1Ea : 1988 with the exception that the peak acceleration shall be $100g_n$ ± 10 % with a pulse duration of 23 ms ± 2 ms. Apply a single shock in each direction along each of three mutually perpendicular axes making a total of six shocks. Ensure that one axis coincides with the major axis of the majority of the cells. Mount the batteries solidly on the shock machine table such that the shock transmitted to the case of the battery is unattenuated.

The batteries shall exhibit no sign of physical damage after the test. The three undischarged batteries shall be subjected and conform to the rated capacity test in **8.4.2**.

11.3 Temperature cycling

NOTE. Table 2 gives a range of test levels. The individual battery specification should state which level is to be used for this test.

Carry out the following procedure.

a) Place the batteries in a test chamber and raise the temperature of the chamber to the required upper level within not more than 30 min.

b) Maintain the chamber at the upper temperature for 4 h.

c) Reduce the temperature of the chamber to 20 °C ± 5 °C within not more than 30 min and maintain at this temperature for 2 h.

d) Reduce the temperature of the chamber to the required lower level within not more than 30 min and maintain at this temperature for the length of time required to complete a 24 h cycle.

e) Repeat the sequence for a further three cycles.

f) After the fourth cycle, return the battery to a temperature of 20 °C ± 5 °C and store for 7 days to 10 days.

g) At the end of this period examine the battery for signs of physical distress.

Any minor leakage or evidence of physical degradation which is not hazardous shall be acceptable and shall be fully declared. In such cases the manufacturer shall establish the lowest temperature to which it is possible to cycle the battery without causing any leakage or physical degradation. The batteries shall then be subjected to the rated capacity test in accordance with **8.4.2** and the results of the performance shall be declared.

Table 2. Test levels

Test level	Upper temperature[1)] °C	Lower temperature[1)] °C
A	70	−65
B	70	−40
C	55	−40
D	55	−32
E	45	−20

[1)]or as specified in the individual specification sheet.

11.4 Forced discharge

Carry out the test at an ambient temperature of −20 °C on both undischarged batteries and batteries which have previously been discharged to the end-point voltage V_E at the N_H discharge rate. Discharge the battery in series, with an external constant current power supply derived from a 28 V d.c. source at the maximum value of continuous current at which the protection device will not operate or, where such protection is not fitted, at a value of current to be declared by the manufacturer. Where the operating current of the overload protection device is temperature dependent, take the highest value within the temperature range of the battery. Continue the test for a period equal to the normal rated capacity of the battery C_r in A·h divided by the discharge current in amperes. Then let the batteries remain on open circuit for 24 h.

The condition of the batteries shall be monitored throughout the test and there shall be no signs of physical distress or leakage.

NOTE. This test may require the overload protection device to be bypassed.

11.5 Over discharge

Following the duty discharge duration tests of **8.4.1**, continue the discharges by using for the electrical load fixed resistors of adequate wattage that have a value of V_E divided by the maximum current used during the duty discharge. Leave the resistors connected at the test temperatures for 48 h after the battery voltages have fallen below V_E.

The condition of the batteries shall be monitored throughout the test and there shall be no signs of physical distress or leakage.

11.6 Charging

Using a nominal 28 V constant potential supply, attempt to pass a charging current through both undischarged and fully discharged batteries, where this current is controlled to a value in amperes numerically equal to one of the following:

a) the normal A·h hour rating of the battery C_r for a period of 1 h; or

b) the rate of the overload protection device applicable to the battery for a period which will equate to the nominal capacity of the battery or until any other protection device operates; or

c) a rate detailed in the specification sheet and determined by the equipment manufacturer as the maximum possible for a period equivalent to the nominal capacity of the battery or until a protection device operates.

Leave the battery on open circuit for a further 24 h.

The batteries shall be monitored throughout the test period and shall exhibit no signs of physical distress or leakage.

11.7 Short circuit

Connect the battery into a load of 50 mΩ ± 10 mΩ for 24 h after stabilization in an ambient air temperature of T_H.

The battery shall not leak, vent or explode.

11.8 High temperature

NOTE. These tests are undertaken on individual cells, whether used singly or as components in multi-cell batteries.

11.8.1 *High temperature (1)*

11.8.1.1 *Procedure*

Carry out the following procedure.

a) Place five cells in an ambient temperature of 70 °C for 2 h.

b) Examine every cell. Any evidence of leaking, venting or explosion shall be classified as a failure.

c) Place the cells in an ambient temperature of 160 °C for 2 h, or as defined in the individual specification sheet.

d) Examine the tested cells.

11.8.1.2 *Hermetically sealed cells*

For hermetically sealed cells, every cell shall have vented through the designated vent area. Failure to vent, venting other than through the designated areas or tearing of the cell case in the vicinity of the vent by more than 5 mm shall be classed as a failure.

11.8.1.3 *Non-hermetically sealed cells*

For non-hermetically sealed cells, it is not a pass/fail criterion that all cells shall have vented. However, any venting shall have occurred through or around the seal. No tearing of metallic parts shall be permitted, but distortion of the cell shall be acceptable. All cells shall remain substantially intact, with no solid component being ejected.

11.8.2 *High temperature (2)*

11.8.2.1 *Procedure*

Carry out the following procedure.

a) At a temperature of 20 °C, discharge two cells at the rated capacity load to 75 % of their nominal capacity.

b) Support the test cell vertically.

NOTE. For cylindrical and rectangular cells, the suggested means is to support the cell in a wire cage constructed of 0.5 mm diameter nichrome wire. This is done by making two loops around the circumference of the cell towards the top and bottom, avoiding the vent area and making a third loop, linking the two circumferential loops, around the length of the cell, to retain it without forming a short circuit. The cage is then supported by wire from the top and bottom to prevent it moving out of the flame in the event of cell venting (see figure 2). Means of support for cells of other shapes (e.g. button or coin cells) should be agreed with the Approving Authority.

c) Using a suitable gas torch, heat the centre of each cell with a flame of such intensity that it will cause the cell to vent, within 3 min, without burning through or melting the case. The gas torch shall be capable of heating an aluminium block of equivalent dimensions to the test cell to at least 200 °C.

d) Keep the flame applied for 10 min or until all activity ceases. If the cell has not remained within the flame throughout the test and if venting has not occurred, repeat the test.

e) Examine the tested cells.

11.8.2.2 *All cells*

The cases of the cells shall remain in one piece. All cells shall remain substantially intact with no solid component being ejected.

11.8.2.3 *Hermetically sealed cells*

For hermetically sealed cells, every cell shall have vented through the designated vent area. Failure to vent, venting other than through the designated areas or tearing of the cell case in the vicinity of the vent by more than 5 mm, shall be classed as a failure.

11.8.2.4 *Non-hermetically sealed cells*

For non-hermetically sealed cells, it is not a pass/fail criterion that all cells shall have vented. However, any venting shall have occurred through or around the seal. No tearing of metallic parts shall be permitted, but distortion of the cell shall be acceptable.

NOTE. If during the course of this test it is found that solid particles or gases are released, a declaration should be made to the Approving Authority.

12 Quality assurance

12.1 Quality plan

The manufacturer shall prepare a quality plan defining the procedures for the inspection of materials, components, cells and batteries, during the course of manufacture, to be applied to the total process of producing a specified type of battery.

NOTE. For batteries released under the authority of the Civil Aviation Authority (Airworthiness Division) the quality plan and the quality control procedures, used by the manufacturer, may be agreed by the purchaser through, his approved Design or Inspection (Quality Assurance) Authority, as appropriate.

For batteries procured under Ministry of Defence contracts, the manufacturer should submit the quality plan and the quality control procedures for approval to the Quality Assurance Authority nominated in the contract.

12.2 Quality control

Batteries shall be subjected to tests under three categories as follows.

Category A. This category consists of non-destructive tests to be applied to every completed battery.

Category B. This category consists of functional tests to be applied to sample batteries taken from batches, for release purposes.

Category C. This category consists of a more comprehensive series of tests selected from the type approval test schedule, to be applied to sample batteries taken at prescribed intervals.

12.3 Records

The manufacturer shall maintain records that demonstrate the effective operations of his quality control system. Inspection records shall include explicit identification of materials, components, cells and batteries, test results, deficiencies found, quantities approved or rejected and the nature of any corrective action taken. Records shall be retained and the manufacturer shall be prepared to make them available to the relevant authority.

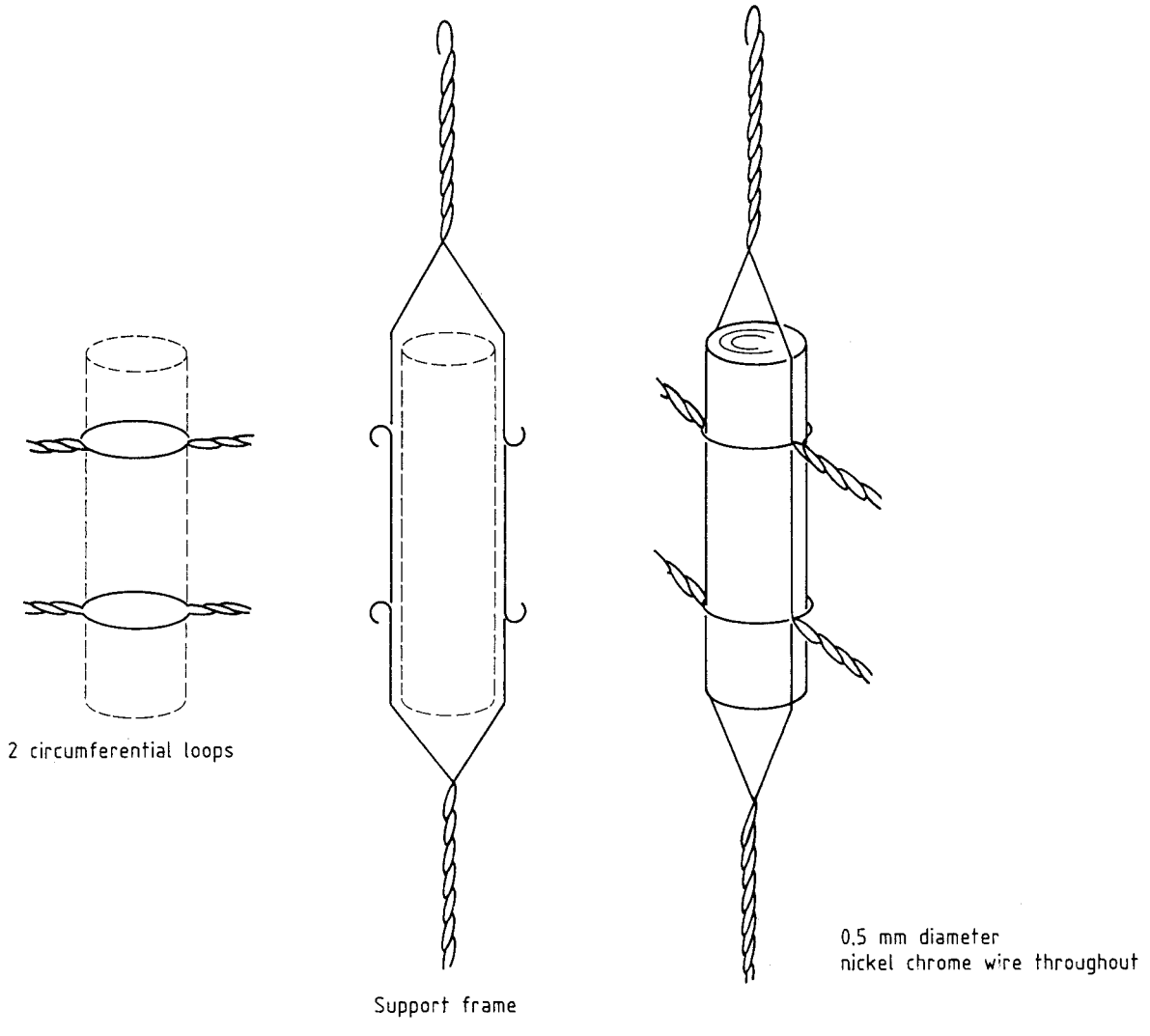

Figure 2. Suggested support method for cylindrical and rectangular cells

Annexes

Annex A (normative)
Example of an individual specification sheet

Manufacturer ..... End-point voltage (V_E).....

Battery system (e.g. Li-SO_2) Type or part no. .....

Nominal on-load voltage..... Open circuit voltage .....

Max. ambient temperature (T_H)..... Min. ambient temperature (T_L).....

Duty discharge duration (N) ..... (N_L)..... (N_H) ..... (hours)

Rated capacity C_r ..... (in A·h) at the rate of .....

Duty discharge[1)]

Voltage delay (D).....max. Mass.....

Storage capability .....years (temperate) .....years (desert) .....years (jungle)

Environmental requirements

Acceleration..... Rapid decompression .....

Vibration..... Mould growth .....

Free fall..... Fluid contamination .....

Bump.....

Outline and interface dimensions

Side elevation	End elevation	
Plan view		Interface details

Terminations.....

Drawing (if necessary)

Markings

Drawing of label

[1)]See **3.4**.

Annex B (informative)
Example of form of Declaration of Design and Performance

NOTE. Before specifying equipment, check with (Company's name) that this declaration is the latest issue.

D.D.P. Number .....

Issue Number .....

(Name and address of Company)

.....

.....

.....

DECLARATION OF DESIGN AND PERFORMANCE

of ..... (name of equipment)

Basic number: .....

Description

DESIGN

Mass:

Overall dimensions and position of the centre of gravity (or reference to drawing, if attached):

Design specification reference:

Drawing schedule reference:

Quality control procedure reference:

Development contract no. (if applicable):

Approving Authority

Modification standard reference:
(if affecting this declaration)

System or wiring diagram (if appropriate):

Installation drawing no.:

Maintenance, repair and overhaul manual reference and issue nos.:

Test report reference:

Fault analysis reports:
(if appropriate)

Particulars of approvals held for the equipment and a brief summary of experience of equipment (e.g. aircraft types to which fitted):

Airworthiness requirements with which the equipment complies, where applicable (e.g. British Civil Airworthiness Requirements):

PERFORMANCE

To be declared under subheadings relevant to the particular equipment (i.e. electrical and mechanical characteristics peculiar to the equipment, time rating and duty cycle, etc.)

DECLARATIONS

Characteristic	Information (values, range, etc.)	Test report reference	Relevant clause in this British Standard	
			BS 2G 239	Compliance
Electrical characteristics Open circuit voltage			**8.2**	
Voltage delay *D*			**8.3**	
Capacity duty cycle *N*			**8.4.1**	
N_L				
N_H				
Rated capacity			**8.4.2**	
Temperature			**6.9.1**	
Altitude			**6.9.2**	
Flammability (where applicable)			**6.2**	
Storage			**10.4**	
Case containment			**11.1**	
Shock			**11.2**	
Capacity (post-temperature cycling)			**11.3**	
Forced discharge			**11.4**	
Charging abuse			**11.6**	
Vibration category			**9.2**	
Acceleration			**9.1**	
Normal Class	1A(ii)			
Grade	C			
Crash Class	11			
Grade	E			
Free fall			**9.3**	
Bump			**9.4**	
Rapid decompression, grade A, aircraft class IV			**9.5**	
Mould growth			**9.6**	
Fluid contamination			**9.7**	

Limitations

(NOTE. The designer should state any known limitations not specifically covered by the above declarations which may limit the application in aircraft. These should include, for example:

a) any restrictions in mounting attitude or methods;

b) whether the equipment needs particular protection from fluids normally used in aircraft;

c) any limitations in installation arising from the production of toxic or noxious materials.)

Departures from specification

(NOTE. The equipment designer should list any departures from this British Standard.)

I hereby certify that the information contained in this Declaration of Design and Performance is accurate and is made under the authority of (Company's design approval reference number). (Company's name) cannot accept responsibility for satisfactory operation of equipment used outside the declared conditions set out above, without their agreement.

Signed ..... (Approved signatory)
on behalf of

.....(Company's name)

Date .....

Annex C (informative)
Guidance for battery users

C.1 General

Lithium, non-aqueous electrolyte active primary batteries are available as individual cells, multi-cell batteries or permanently built into equipments. They all have a long shelf life and give good or excellent low temperature performances. Some versions can give high power outputs.

The guidance in this annex is intended to promote their safe storage, use and disposal.

C.2 Chemistry of lithium batteries

Lithium primary batteries are lighter and smaller than conventional primary or secondary batteries of equivalent electrical characteristics. Most cell systems are of the 3.0 V type, so they are not interchangeable with similar sizes of conventional primary and secondary cells.

Lithium, the negative electrode in the cell, is a lightweight, flammable metal that reacts vigorously with water. All electrolytes contain inorganic salts, some of which are strong oxidizing agents dissolved in most cases in organic liquids. Some cells contain corrosive liquids that are also irritants to the eyes and the respiratory tract.

All lithium cells are made under very dry conditions and are fully sealed to prevent the ingress of moisture and release of their contents. Crushing or piercing of a cell may lead to spontaneous ignition of the contents.

C.3 Design and use

Batteries complying with this standard may contain electrical fuse links, protective diodes or thermal switches to stop them venting their contents under abusive or fault conditions.

No lithium battery should be used for other than its intended application.

Lithium batteries should not be installed near a source of heat. Generally, operating temperatures above 70 °C should be avoided, even though some types are designed to function at higher temperatures.

C.4 Storage

The storage area should be dry and well-ventilated. Lithium batteries should normally be kept in the same area as flammable or liquid stores. Humidity or temperature control is not necessary in most instances but, for maximum shelf life, the temperature should be between −10 °C and 35 °C. Generally, exposure to temperatures above 50 °C should be kept to a few days in any 1 year. Storage temperatures above 70 °C are to be avoided.

C.5 Carriage

The carriage of lithium batteries by air, as opposed to the fitment of batteries within aircraft, is subject to the latest edition of the International Civil Aviation Organization (ICAO) document *Technical instructions for the safe transport of dangerous goods by air* 9284 - AN/905 [2].

Carriage by surface transport may be subject to other regulations and any such regulations should be checked before transportation.

C.6 Damage in stores or workshops

Should any lithium battery be severely damaged (by conditions well beyond those specified for aircraft use), then the following procedures should be adopted.

a) Clear the area. Apply maximum ventilation.

b) Wear face mask, goggles and gloves. Disconnect the battery if it is attached to equipment, avoiding contact with any liquid or internal component.

c) Place the battery in an isolated, well-ventilated area until all the odour has disappeared.

d) Use copious amounts of clean water to wash away any split liquid. This is particularly important in equipment where the battery involved is a sulfur dioxide or thionyl chloride type, because of the corrosive nature of their electrolyte.

Dispose of the debris as suggested in **C.7**.

C.7 Disposal

Under no circumstances should lithium batteries be crushed prior to disposal or incinerated in other than a specially designed furnace.

At any one time, up to five of the smaller sizes of battery (as defined in the ICAO document detailed in **C.5**) can be disposed of with domestic rubbish. Discharged or unwanted batteries of other sizes or quantities which show no signs of physical damage should have any exposed electrical connections insulated and should then be packed securely for transport to the manufacturer or other agency qualified and prepared to undertake disposal.

Damaged batteries or battery debris which needs to be transported for investigation should have any exposed electrical connections insulated and be double wrapped, sealed into plastics bags or sheets, packaged securely and labelled with the appropriate hazard warnings.

C.8 Fire-fighting in storage areas

If lithium batteries are involved in a fire, their behaviour will depend largely upon the chemistry and mechanical design of the individual cells.

In a fire all types that are likely to be found in aircraft equipment relieve the internal build-up of pressure either by rupturing a weakened area of the steel case (thionyl chloride or sulfur dioxide types) or by the melting of a thermoplastics sealing grommet (manganese dioxide, polycarbon monofluoride or copper oxide types).

Venting may be accompanied by electrolyte and lithium fires. These may last for several minutes during which burning material may be ejected.

If sulfur dioxide or thionyl chloride cells are involved, respiratory protection will be required during fire-fighting.

A lithium fire is difficult to extinguish as the metal burns in most gases and reacts with water, evolving hydrogen.

WARNING. When fighting a lithium battery fire, it is imperative that personnel proceed as follows.

a) Use graphite powder extinguishers, specifically formulated for lithium fires. This is an efficient technique but the residue has to be washed with plenty of water to destroy any remaining lithium.

b) Alternatively, drench the fire with copious amounts of water, applied continuously in a fine spray from a diffuser-type nozzle. The fire will not be extinguished immediately and burning fragments may be ejected from the centre of the fire. Wear protective clothing.

c) DO NOT use damp solids or small amounts of water.

d) DO NOT use carbon dioxide extinguishers or dry powder types that are not based on graphite. They are ineffective.

e) DO NOT use halon extinguishers, as recommended for electrical fires. They are ineffective and toxic gases may be generated.

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 89 :	*Direct acting indicating analogue electrical measuring instruments and their accessories*
BS 89 : Part 2 : 1990	*Specification for special requirements for ammeters and voltmeters*
BS 3G 100 :	*Specification for general requirements for equipment for use in aircraft*
BS 3G 100 : Part 2 :	*All equipment*
BS 3G 100 : Part 2 : Section 3 :	*Environmental conditions*
BS 3G 100 : Part 2 : Section 3 : Subsection 3.1 : 1969	*Vibration*
BS 3G 100 : Part 2 : Section 3 : Subsection 3.3 : 1972	*Mould growth*
BS 3G 100 : Part 2 : Section 3 : Subsection 3.6 : 1972	*Acceleration requirements*
BS 3G 100 : Part 2 : Section 3 : Subsection 3.12 : 1991	*Fluid contamination*
BS 2011 :	*Environmental testing*
BS 2011 : Part 2.1 :	*Tests*
BS 2011 : Part 2.1Ea : 1988	*Test Ea. Shock*
BS 2011 : Part 2.1Eb : 1987	*Test Eb. Bump*

Other references

[1] *Joint Airworthiness Requirements*, Part 25, obtainable from the Civil Aviation Authority, Printing and Publications Services, Greville House, 37 Gratton Road, Cheltenham, Gloucestershire GL50 2BN.

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 3G 100 :	*Specification for special requirements for ammeters and voltmeters*
BS 3G 100 : Part 2 :	*All equipment*
BS 3G 100 : Part 2 : Section 3 :	*Environmental conditions*
BS 3G 100 : Part 2 : Section 3: Subsection 3.4 : 1972	*Differential pressure requirements*

Other references

[2] *Technical instructions for the safe transport of goods by air*, Civil Aviation Organization document 9284 - AN/905, obtainable from IAL Merchandizing Service Aeradio House, Hayes Road, Southall, Middlesex UB2 5NJ.

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Aerospace Standards Policy Committee (ACE/-) to Technical Committee ACE/6, upon which the following bodies were represented:

British Airways
British Cable Makers' Confederation
British Rubber Manufacturers' Association
Civil Aviation Authority (Airworthiness Division)
Electronic Components Industries Federation
Ministry of Defence
Society of British Aerospace Companies Ltd.

This British Standard, having been prepared under the direction of the Aerospace Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 October 1992

First published January 1987
Second edition October 1992

The following BSI references relate to the work on this standard:
Committee reference ACE/6
Draft for comment 91/76255 DC

ISBN 0 580 21110 X

Amendments issued since publication

Amd. No.	Date	Text affected

BSI, 2 Park Street, London W1A 2BS **BSI, Linford Wood, Milton Keynes MK14 6LE**