IECEx TEST REPORT COVER

ExTR Reference Number...............:	NO/PRE/ExTR15.0012/00
ExTR Free Reference Number......:	D0001494-00
Compiled by + signature (ExTL)....:	Hien Van Le Thanh Hien Van Lethanh
Reviewed by + signature (ExTL)....:	Arne Hortman Arne Hortman
Approved by + signature (ExCB)...:	Asle Kaastad Asle Kaastad
Date of issue ....:	2015-04-21
Ex Testing Laboratory (ExTL)........:	Presafe AS
Address ....:	Gaustadalléen 30, NO - 0373 Oslo, Norway
Ex Certification Body (ExCB).........:	Presafe AS
Address ....:	Gaustadalléen 30, NO - 0373 Oslo, Norway
Applicant's name...........................:	Riken Keiki Co., Ltd
Address ....:	2-7-6 Azusawa, Itabashi, Tokyo 174-8744, Japan
Standards associated with this ExTR package ....:	IEC 60079-0: 2011 6th Edition IEC 60079-11: 2011 6th Edition IEC 60079-26: 2006 2nd Edition
Clauses considered ....:	All clauses
Test procedure ....:	IECEx System
Test Report Form Number.............:	ExTR Cover_5 (released 2014-01)
Test item description......................:	Portable Gas Monitor
Model/type reference ....:	GX-6000
Code (e.g. Ex __ II__ T__)............:	Ex II 1 G Ex ia IIC T4 Ga -20°C ≤ Ta ≤ +50°C
Rating..:	Battery operated. Battery units BUL-6000 & BUD-6000. Charger module BC-6000 (or SDM-6000): U_m= 250V
All testing fully performed by ExTL staff at ExTL address above:	No. See General product information and below for additional details.

Instructions for Intended Use of ExTR Cover:
An ExTR Cover is the sole top-level document to associate together all other parts of an IECEx Test Report (ExTR) package. An ExTR package is comprised of an ExTR Cover and one or more associated ExTR documents (which may include Ex Test Reports, ExTR Addendums and ExTR of National Differences). All ExTR package documents are compiled and reviewed by the ExTL. The Issuing ExCB indicates final approval of the overall ExTR package on this ExTR Cover.

Manufacturer's name ....:	Riken Keiki Co., Ltd
Address ....:	2-7-6 Azusawa, Itabashi, Tokyo 174-8744, Japan
Trademark.....................................:	RIKEN KEIKI

Particulars: Test item vs. Test requirements

Classification of installation and use .... :	portable / hand-held
Ingress protection ....:	Min. IP 20
Rated ambient temperature range (°C) ....:	-20°C ≤ Ta ≤ +50°C
Rated service temperature range (°C) for Ex Components.....:	Not applicable

General remarks:

The test results presented in this ExTR package relate only to the item or product tested.

- "(see Attachment #)" refers to additional information appended to the ExTR package.
- "(see appended table)" refers to a table appended to the ExTR package.
- Throughout this ExTR package, a point is used as the decimal separator.
- *Where the term "N/A" appears in any part of an ExTR package, it indicates that the associated issue was considered "Not applicable" to the involved evaluation.*
- *In accordance with IECEx 02, a Receiving ExCB may request a sample of the Ex equipment and copies of the documentation referred to in an ExTR Cover.*
- The majority of test results presented in this ExTR package are extracted from the respective certification which are listed in appended tables for reference.

The technical content of this ExTR package shall not be reproduced except in full without the written approval of the Issuing ExCB and ExTL.

The standard IEC 60079-26: 2006 2nd Edition make reference to IEC 60079-0: 2004 4th edition. However since IEC 60079-0: 2004 4th edition is withdrawn, IEC 60079-0: 2011 6th edition is considered for this investigation.

This investigation is valid for both IECEx and ATEX certification which is handled by Presafe AS. The Ex codes for both ATEX and IECEx certification may appear in associated test reports.

Copy of Marking Plate:

MODEL BUL-6000
INST.NO.
RIKEN KEIKI Co.,Ltd./2-7-6Azusawa.
Itabasi-ku,Tokyo 174-8744,Japan
WARNING
Do not charge battery in haz.loc.

MODEL BUD-6000
INST.NO.
RIKEN KEIKI Co.,Ltd./2-7-6Azusawa.
Itabasi-ku,Tokyo 174-8744,Japan
WARNING
Use only battery types:LR6 TOSHIBA

MODEL GX-6000
INST.No.
RIKEN KEIKI CO.,LTD
2-7-6 Azusawa,Itabashi-ku,Tokyo174-8744,Japan

CE 1180
II 1 G Ex ia IIC T4 Ga
Presafe15ATEX6171
IECEx PRE 15.0011
-20℃≦Ta≦+50℃
WARNING
Read manual for safety info.
Do not open in haz.loc.

Charger’s markings

警告 WARNING
・本来の使用目的以外の使用はしないでください.
·Do not use for any purpose other than original intended use.
・落下や水は故障の原因となります.
·Protect from impact and moisture.
・充電は非危険場所にて行なってください.
·Not for use in hazardous area.
・指定のACアダプタを使用してください.
·Use only with exclusive AC adaptor.

注意 CAUTION
・ご使用の前に取扱説明書を必ずお読みください.
·Read and understand operation manual before use.

MODEL
INST. No.
DATE
CE
DC INPUT : 12V ⎓ 0.8A
DC OUTPUT : 6V ⎓ 1.6A
RIKEN KEIKI Co.,Ltd. JAPAN

WARNING
·Not for use in hazardous area.
·Use only with exclusive AC adaptor.
Um=250V

General product information:

Equipment under test hereby referred to as EUT is a portable gas monitor model GX-6000 manufactured by Riken Keiki Co., Ltd . EUT is used for measuring flammable gas concentration in hazardous location. EUT is build up in major by approximately same parts of similar models (e.g. models GX-2012GT, GX-2009 or GX-8000 which all are manufactured by Riken Keiki) and has same Ex protection concept (intrinsic safe). These similar models are separately Ex certified devices. This investigation is therefore based on former evaluation of the used parts. Test results and safety info are extracted from respective test reports of similar models and are documented in this report package. Additional evaluation are performed for relevant requirements which may not be covered by these certifications.

EUT is an battery-operated handheld portable device and is built up by plastic enclosure with minor metal parts such as assembly screws. The display is located in front/top of EUT. At the bottom/rear side is the battery unit. Two alternative battery units may be used with EUT. BUD-6000 is the alkaline dry battery unit and BUL-6000 is the Li-ion battery unit. Replacement or charging of battery unit can be performed by end-users and is only allowed in non-hazardous areas. More technical details of design is explained in Appendix A.1 of the associated IEC60079-11 test report. See also Photos below.

Several safety instructions are found in attached manual. Specific safe instructions are also marked on labels. See Copy of marking plate in addition.

・Warning: ”Do not charge in hazardous location”

・Warning: ”Do not charge it except by genuine charger

. Warning: “Do not replace battery unit in hazardous location”

・Warning: ”Do not replace dry batteries in hazardous location

・Warning: “Do Not attempt to disassemble or alter the instrument”

・Use only battery unit type BUD-6000 with three series connected Alkaline Manganese AA batteries, type LR6 manufactured by Toshiba, or use chargeable battery unit type BUL-6000.

EUT is consisting of a main part and a battery unit (BUL-6000 or BUD-6000). No tools is needed to remove battery units from the main part. The BUL-6000 battery unit is an encapsulated device. The enclosure used anti-electrostatic material with minor smaller parts of other regular plastic material. Small accessible metal parts are built-in to the anti-electrostatic material and therefore are not considered to be isolated. Inside the main part is electronics including small internal pump RP-12, DC vibration motor and piezoelectric device BZ-9K. These devices are used in similar models which have been separately certified with regards to Ex requirements. The majority of this investigation is based on test reports and associated appendix with inter alia Test report no. NL/KEM/ExTR11.0038 & NL/DEK/ExTR13.0075/00. However report reference to extracted test results will be detailed in associated test reports of this certification.
The charger modules BC-6000 & SDM-6000 are assessed and included in this investigation but not the AC/DC power adapter. Electronic design concept of charger modules are identically. The difference between the two charger modules made no impact to the type of protection. Assessment of module BC-6000 is representative for module SDM-6000 as well.
Included in this certification are following parts which comprise EUT:

- GX-6000: Portable Gas Monitor
- BUL-6000: Rechargeable Li-ion battery unit
- BUD-6000: Alkaline battery unit. Only type Toshiba LR6 AA size is allowed.
- BC-6000: Charge module
- SDM-6000: Charge module
- NC-6264A: Combustible gas sensor
- Toxic gas sensor
- Oxygen sensor
- Smart sensor type DES
- Smart sensor type ESS
- Smart sensor type PIS
- Smart sensor type OSS

Photos. GX-6000 main unit & Battery units

Details of change (applicable only when revising an existing ExTR package): Origin report
In accordance with OD 024, testing not fully performed by ExTL staff at the above ExTL address: The majority of test results presented in this ExTR package are extracted from the test reports which are associated to separate IECEx certification.
National differences considered as part of this evaluation, if any: No national differences included.
“Specific Conditions of Use” for Ex Equipment or “Schedule of Limitations” for Ex Components, if any: No ‘Specific condition of use’ are claimed.
Routine tests, if any: No routine tests are required by the applicable requirements

Manufacturer’s Documents

Title:	Drawing No.:	Rev. Level:	Date:
Index GX-6000	E3-6991-5470-70-01K	2	2015-03-27

	IECEx TEST REPORT **IEC 60079-0** **Explosive atmospheres – Part 0:** **Equipment – General requirements**

ExTR Reference Number...............:	NO/PRE/ExTR15.0012/00
ExTR Free Reference Number ......:	D0001494-00
Compiled by + signature (ExTL) ....:	Hien Van Le Thanh
Reviewed by + signature (ExTL)....:	Arne Hortman
Date of issue ....:	2015-04-21
Ex Testing Laboratory (ExTL) ....:	Presafe AS
Address ....:	Gaustadalléen 30, NO - 0373 Oslo, Norway
Applicant's name...........................:	Riken Keiki Co., Ltd
Address ....:	2-7-6 Azusawa, Itabashi, Tokyo 174-8744, Japan
Standard..:	IEC 60079-0:2011, 6th Edition
Test procedure ....:	IECEx System
Test Report Form Number ....:	ExTR60079-0_6B (released 2014-08)

Instructions for Intended Use of Ex Test Report:
An Ex Test Report provides a clause-by-clause documentation of the initial evaluation and testing that verified compliance of an item or product with an IEC Ex standard. This Ex Test Report is part of an ExTR package that may include other Ex Test Report, Addendum, National Differences and Partial Testing documents, along with a single ExTR Cover. An Ex Test Report is to be compiled and reviewed by the ExTL. The Issuing ExCB indicates final approval of the Ex Test Report as part of the overall ExTR package on the associated ExTR Cover.

Possible test case verdicts:

- test case does not apply to the test item ....:	**N/A**	Not applicable
- test item does meet the requirement ....:	**P**	Pass

General remarks:
The test results presented in this Ex Test Report relate only to the item or product tested.

- "See Attachment #" refers to additional information appended to this document.
- "See appended table" refers to a table appended to this document.
- "See General product information" refers to item 'General product information' in ExTR Cover report.
- "See Copy of marking plate" refers to item 'Copy of marking plate' in ExTR Cover report.
- Throughout this document, a point "." is used as the decimal separator.

The technical content of this Ex Test Report shall not be reproduced except in full without the written approval of the Issuing ExCB and ExTL.

This investigation is valid for both IECEx and ATEX certification which is handled by Presafe AS. The Ex codes for both ATEX and IECEx certification may appear in associated test reports.

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
1	Scope		
2	Normative references		
3	Terms and definitions		
4	Equipment grouping		**P**
4.1	Group I		**N/A**
4.2	Group II	Equipment under test hereby referred to as EUT is portable gas monitor GX-6000 including charger modules BC-6000/SDM-6000. See General product information. Ex ia IIC T4 Ga -20°C ≤ Ta ≤ +50°C	**P**
4.3	Group III		**N/A**
4.4	Equipment for a particular explosive atmosphere	No particular explosive atmosphere specified.	**N/A**
5	Temperatures		
5.1	Environmental influences		
5.1.1	Ambient temperature	Ex ia IIC T4 Ga -20°C ≤ Ta ≤ +50°C	**P**
5.1.2	External source of heating or cooling		**N/A**
5.2	Service temperature	Not required due to exclusion of cl. 7.2 by Table 1 of IEC60079-11: 2011.	**N/A**
5.3	Maximum surface temperature		
5.3.1	Determination of maximum surface temperature	Maximum surface temperature is considered taken into account requirements of thermal ignition compliance of cl.5.6 of IEC 60079-11. Evaluation documented in Appendix A.3 & B.3 of associated IEC60079-11 test report.	**P**
5.3.2	Limitation of maximum surface temperature		
5.3.2.1	Group I electrical equipment		**N/A**
5.3.2.2	Group II electrical equipment	See 5.3.1. T4 temperature class assigned and recognized. See Copy of marking plate.	**P**
5.3.2.3	Group III electrical equipment		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
5.3.2.3.1	Maximum surface temperature determined without a dust layer	Not Group III electrical equipment.	**N/A**
5.3.2.3.2	Maximum surface temperature with respect to dust layers		**N/A**
5.3.3	Small component temperature for Group I or Group II electrical equipment	Considered taken into account requirements of thermal ignition compliance cl. 5.6 of IEC 60079-11. Evaluation documented in Appendix A.3 & B.3 of associated IEC60079-11 test report.	**P**

6	Requirements for all electrical equipment

6.1	General	Requirements of IEC60079-11: 2011 considered. Code Ex ia IIC T4 Ga.	**P**

6.2	Mechanical strength of equipment	Excluded by Table 1 of IEC60079-11: 2011 except for the drop test which is documented in appended Table 26.4.3. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable.	**P**

6.3	Opening times	Excluded by Table 1 of IEC60079-11: 2011	**N/A**

6.4	Circulating currents in enclosures (e.g. of large electrical machines)	Excluded by Table 1 of IEC60079-11: 2011	**N/A**

6.5	Gasket retention	Excluded by Table 1 of IEC60079-11: 2011	**N/A**

6.6	Electromagnetic and ultrasonic energy radiating equipment	EUT is not electromagnetic or ultrasonic energy radiating equipment	**N/A**
6.6.1	Radio frequency sources	No radio frequency sources.	**N/A**
6.6.2	Lasers or other continuous wave sources	The lamp OL-8270BPA is separately Ex certified, test report TxTR12.0033 is documented. See Appendix D in associated IEC60079-11 test report.	**P**
6.6.3	Ultrasonic sources	No ultrasonic sources	**N/A**

7	Non-metallic enclosures and non-metallic parts of enclosures

7.1	General		
7.1.1	Applicability	Excluded by Table 1 of IEC60079-11: 2011. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable	**N/A**
7.1.2	Specification of materials		
7.1.2.1	General	See above and clauses 7.4 & 24.	**P**
7.1.2.2	Plastic materials	See above.	**P**
7.1.2.3	Elastomers	O-ring used but not for Ex safety purpose.	**N/A**

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
7.2	Thermal endurance		
7.2.1	Tests for thermal endurance		**N/A**
7.2.2	Material selection	Excluded by Table 1 of IEC60079-11: 2011. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable	**N/A**
7.2.3	Alternative qualification of elastomeric sealing O-rings	See above.	**N/A**
7.3	Resistance to light	Excluded by Table 1 of IEC60079-11: 2011. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable	**N/A**
7.4	Electrostatic charges on external non-metallic materials		
7.4.1	Applicability	Applied.	**P**
7.4.2	Avoidance of a build-up of electrostatic charge on Group I or Group II electrical equipment	Material ESC9448N & LCD panel sheet PET 300R. All material have surface resistance of less than 1GΩ. See appended table 26.13. All smaller parts of regular plastic material have surface area less than 400mm². Refer to drawing M2-4777-01-01K.	**P**
7.4.3	Avoidance of a build-up of electrostatic charge on equipment for Group III	Not Group III equipment.	**N/A**
7.5	Accessible metal parts	Small accessible metal parts exist but enclosure’s conductive plastic materials are used so the mentioned parts are not isolated. However small metallic parts are considered to represent not more than 3pF. Refer to Note 2 of cl. 7.5 of this standard. See appended Table 26.13	**P**
8	Metallic enclosures and metallic parts of enclosures		
8.1	Material composition	See 8.3 & 24.	**P**
8.2	Group I	Not Group I equipment.	**N/A**
8.3	Group II	Small parts of stainless steel material used such as air inlets. Less than 10 % in total of Al, Mg, Ti & Zr and less than 7.5% in total of Mg, Ti & Zr. See also 7.5	**P**
8.4	Group III	Not Group III equipment.	**N/A**
9	Fasteners		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
9.1	General	Excluded by Table 1 of IEC60079-11: 2011. See 7.5 and 8.3.	**N/A**
9.2	Special fasteners	No such parts. See 9.1	**N/A**
9.3	Holes for special fasteners		
9.3.1	Thread engagement		**N/A**
9.3.2	Tolerance and clearance		**N/A**
9.3.3	Hexagon socket set screws		**N/A**
10	Interlocking devices	No such parts.	**N/A**
11	Bushings	No such parts.	**N/A**
12	Materials used for cementing	No such parts.	**N/A**
13	Ex Components		
13.1	General	EUT is not investigated as Ex component.	**N/A**
13.2	Mounting		**N/A**
13.3	Internal mounting		**N/A**
13.4	External mounting		**N/A**
13.5	Ex Component certificate		**N/A**
14	Connection facilities and termination compartments		
14.1	General	Requirements of this clause is excluded by Table 1 of IEC60079-11. Gas monitor GX-6000 and charger module BC-6000 are treated as the entire EUT. Connection between them is intrinsic safe and is assessed according to requirements of IEC60079-11. Charging in safe area only. Refer to associated IEC60079-11 test report.	**N/A**
14.2	Termination compartment		**N/A**
14.3	Type of protection		**N/A**

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
14.4	Creepage and clearance		**N/A**
15	Connection facilities for earthing or bonding conductors		
15.1	Equipment requiring earthing		
15.1.1	Internal	Handheld portable equipment which does not require earthing.	**N/A**
15.1.2	External	Handheld portable equipment	**N/A**
15.2	Equipment not requiring earthing	Excluded by Table 1 of IEC60079-11: 2011.	**N/A**
15.3	Size of conductor connection	Excluded by Table 1 of IEC60079-11: 2011.	**N/A**
15.4	Protection against corrosion	Excluded by Table 1 of IEC60079-11: 2011.	**N/A**
15.5	Secureness of electrical connections	Excluded by Table 1 of IEC60079-11: 2011.	**N/A**
16	Entries into enclosures		
16.1	General	Excluded by Table 1 of IEC60079-11: 2011. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable	**N/A**
16.2	Identification of entries		**N/A**
16.3	Cable glands		**N/A**
16.4	Blanking elements		**N/A**
16.5	Thread adapters		**N/A**
16.6	Temperature at branching point and entry point		**N/A**
16.7	Electrostatic charges of cable sheaths		**N/A**
17	Supplementary requirements for rotating machines		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
17.1	Ventilation		
17.1.1	Ventilation openings	Excluded by Table 1 of IEC60079-11: 2011. However EUT's built-in micro pump type RP-12 is assessed for intrinsic safe requirements. Refer to associated IEC60079-11 test report.	**N/A**
17.1.2	Materials for external fans		**N/A**
17.1.3	Cooling fans of rotating machines		
17.1.3.1	Fans and fan hoods		**N/A**
17.1.3.2	Construction and mounting of the ventilating systems		**N/A**
17.1.3.3	Clearances for the ventilating system		**N/A**
17.1.4	Auxiliary motor cooling fans		**N/A**
17.1.5	Ventilating fans		
17.1.5.1	Applicability		**N/A**
17.1.5.2	General		**N/A**
17.1.5.3	Fan and fan hoods		**N/A**
17.1.5.4	Construction and mounting		**N/A**
17.1.5.5	Clearances for rotating parts		**N/A**
17.2	Bearings		**N/A**
18	Supplementary requirements for switchgear		
18.1	Flammable dielectric	No such parts.	**N/A**
18.2	Disconnectors		**N/A**
18.3	Group I – Provisions for locking		**N/A**
18.4	Doors and covers		**N/A**
19	Supplementary requirements for fuses	Excluded by Table 1 of IEC60079-11: 2011.	**N/A**
20	Supplementary requirements for plugs, sockets outlets and connectors		
20.1	General	Excluded by Table 1 of IEC60079-11: 2011.	**N/A**

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
20.2	Explosive gas atmospheres		**N/A**
20.3	Explosive dust atmospheres		**N/A**
20.4	Energized plugs	No batteries are allowed to be replaced in hazardous zone. Warnings are provided. See 29.12	**N/A**
21	Supplementary requirements for luminaires		
21.1	General	No such parts.	**N/A**
21.2	Covers for luminaires of EPL Mb, EPL Gb, or EPL Db		**N/A**
21.3	Covers for luminaires of EPL Gc or EPL Dc		**N/A**
21.4	Sodium lamps		**N/A**
22	Supplementary requirements for caplights and handlights		
22.1	Group I caplights	No such parts.	**N/A**
22.2	Group II and Group III caplights and handlights		**N/A**
23	Apparatus incorporating cells and batteries		
23.1	General	Refer to associated IEC60079-11 test report for detailed assessments and testing of battery units.	**P**
23.2	Batteries	BUD-6000 & BUL-6000 units & SR616 button cell assessed. See 23.1	**P**
23.3	Cell types	Refer to associated IEC60079-11 test report	**P**
23.4	Cells in a battery	Refer to associated IEC60079-11 test report	**P**
23.5	Ratings of batteries	Refer to associated IEC60079-11 test report	**P**

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
23.6	Interchangeability	Warnings provided. See General product information and Copy of marking plates. For alkaline batteries only Toshiba LR6 (AA size) is allowed to be used. See also 29.12. No other batteries are interchangeable.	**P**
23.7	Charging of primary batteries	No charging circuits for dry battery unit BUD-6000	**P**
23.8	Leakage	Refer to associated IEC60079-11 test report	**P**
23.9	Connections	Refer to associated IEC60079-11 test report	**P**
23.10	Orientation	Refer to associated IEC60079-11 test report	**P**
23.11	Replacement of cells or batteries	Warnings provided. See 29.12 and Copy of marking plates and associated IEC60079-11 test report.	**P**
23.12	Replaceable battery pack	See 23.11	**P**
24	Documentation	Documentation concerning explosion safety aspects of EUT is prepared by the manufacturer and is reviewed as part of this investigation. Documentation is kept in file at DNV Nemko Presafe AS.	**P**
25	Compliance of prototype or sample with documents	EUT is checked for compliance with documentation required by clause 24.	**P**
26	Type tests		
26.1	General	Type tests performed accordingly. Refer to Measurement section of this report and Appendix section of the associated IEC 60079-11: 2011 test report.	**P**
26.2	Test configuration	Least favorable test condition considered for each test.	**P**
26.3	Tests in explosive test mixtures	Refer to associated IEC60079-11 test report.	**P**
26.4	Tests of enclosures		
26.4.1	Order of tests		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
26.4.1.1	Metallic enclosures, metallic parts of enclosures and glass parts of enclosures	Considered taking into account requirements of IEC60079-11: 2011.	**P**
26.4.1.2	Non-metallic enclosures or non-metallic parts of enclosures	Considered taking into account requirements of IEC60079-11: 2011.	**P**
26.4.1.2.1	Group I electrical equipment		**N/A**
26.4.1.2.2	Group II and Group III electrical equipment	See below and associated IEC60079-11 test report.	**P**
26.4.2	Resistance to impact	Impact test is exempted for enclosure but is performed according to the testing of the built-in piezoelectric device, buzzer type BZ-9K. Refer to associated IEC60079-11 test report.	**P**
26.4.3	Drop test	See appended table 26.4.3.	**P**
26.4.4	Acceptance criteria	Considered.	**P**
26.4.5	Degree of protection (IP) by enclosures		
26.4.5.1	Test procedure	Requirements of IP20 is checked and recognized for compliance. Higher IP rating is not covered by this investigation.	**P**
26.4.5.2	Acceptance criteria	See above.	**P**

26.5	Thermal tests		
26.5.1	Temperature measurement		
26.5.1.1	General	Refer to associated IEC60079-11 test report.	**P**
26.5.1.2	Service temperature	See 5.2.	**N/A**
26.5.1.3	Maximum surface temperature	Modified requirements considered. See 5.3.1 to 5.3.3.	**P**
26.5.2	Thermal shock test	Excluded by Table 1 of IEC60079-11: 2011. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable.	**N/A**
26.5.3	Small component ignition test (Group I and Group II)		
26.5.3.1	General	See 5.3.1 to 5.3.3 and associated IEC60079-11 test report	**P**
26.5.3.2	Procedure	See above.	**P**
26.5.3.3	Acceptance criteria	See above.	**P**

26.6	Torque test for bushings		
26.6.1	Test procedure	No such parts.	**N/A**
26.6.2	Acceptance criteria		**N/A**

26.7	Non-metallic enclosures or non-metallic parts of enclosures		
26.7.1	General	Excluded by Table 1 of IEC60079-11: 2011. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable. See General product information.	**N/A**
26.7.2	Test temperatures	See above.	**N/A**

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
26.8	Thermal endurance to heat	See 26.7.1	**N/A**
26.9	Thermal endurance to cold	See 26.7.1	**N/A**
26.10	Resistance to light		
26.10.1	Test procedure	See 7.3	**N/A**
26.10.2	Acceptance criteria		**N/A**
26.11	Resistance to chemical agents for Group I electrical equipment	Not Group I equipment. Also excluded by Table 1 of IEC60079-11: 2011.	**N/A**
26.12	Earth continuity	Handheld portable equipment.	**N/A**
26.13	Surface resistance test of parts of parts of enclosures of non-metallic materials	See appended table 26.13.	**P**
26.14	Measurement of capacitance		
26.14.1	General	See 7.5	**N/A**
26.14.2	Test procedure	Considered.	**N/A**
26.15	Verification of ratings of ventilating fans	Excluded by Table 1 of IEC60079-11: 2011.	**N/A**
26.16	Alternative qualification of elastomeric sealing O-rings	Excluded by Table 1 of IEC60079-11: 2011. Requirement of cl. 6.1.2.3 a) of IEC60079-11: 2011 is not applicable.	**N/A**
27	Routine tests	No routine verification and tests are required for any used components by clause 11 of IEC60079-11: 2011	**N/A**
28	Manufacturer's responsibility		
28.1	Conformity with the documentation	The manufacturer is held responsible to carry out necessary tests and verifications to ensure that each produced items is in compliance with the documentation which is provided for this investigation. Such verifications should be part of the procedures incorporated in the QA system of manufacturer.	**P**
28.2	Certificate	Certificate is issued in due course of this investigation.	**P**

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
28.3	Responsibility for marking	Compliance with applicable requirements of relevant standards is documented.	**P**

29	Marking		
29.1	Applicability	Marking applied.	**P**
29.2	Location	Marking labels are visible on external enclosure.	**P**
29.3	General	See below.	**P**
29.4	Ex marking for explosive gas atmospheres	Ex ia IIC T4 Ga -20°C ≤ Ta ≤ +50°C See Copy of marking plate.	**P**
29.5	Ex marking for explosive dust atmospheres		**N/A**
29.6	Combined types (or levels) of protection	See 29.4. One type/level of protection employed.	**N/A**
29.7	Multiple types of protection		**N/A**
29.8	Ga equipment using two independent Gb types (or levels) of protection	No such application.	**N/A**
29.9	Ex Components	Ex equipment considered.	**N/A**
29.10	Small equipment and small Ex Components		**N/A**
29.11	Extremely small equipment and extremely small Ex Components		**N/A**
29.12	Warning markings	Warnings provided with regards to specific instructions of type of battery, replacement & charging, and safety instructions in User manual. See Copy of marking plate and General product information.	**P**
29.13	Alternate marking of equipment protection levels (EPLs)	No alternative marking used.	**N/A**

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
29.13.1	Alternate marking of type of protection for explosive gas atmospheres		**N/A**
29.13.2	Alternate marking of type of protection for explosive dust atmospheres		**N/A**
29.14	Cells and batteries	Properly marked internally.	**P**
29.15	Converter-fed electrical machines	No such parts.	**N/A**
29.16	Examples of marking	See Copy of marking plate.	**P**
30	Instructions		
30.1	General	Documentation required by clause 24 of IEC60079-0 & clause 13 of IEC60079-11 is reviewed and recognized for compliance.	**P**
30.2	Cells and batteries	Specific safety instructions are provided with regards to brand & type of battery.	**P**
30.3	Electrical machines	No such parts.	**N/A**
30.4	Ventilating fans	No such parts.	**N/A**
Annex A (Normative)	Supplementary requirements for cable glands		
A.1	General	No cable glands.	**N/A**
A.2	Constructional requirements		
A.2.1	Cable sealing		**N/A**
A.2.2	Filling compounds		**N/A**
A.2.3	Clamping		
A.2.3.1	General		**N/A**
A.2.3.2	Group II or III cable glands		**N/A**
A.2.4	Lead-in of cable		
A.2.4.1	Sharp edges		**N/A**
A.2.4.2	Point of entry		**N/A**
A.2.5	Released by a tool		**N/A**
A.2.6	Fixing		**N/A**
A.2.7	Degree of protection		**N/A**
A.3	Type tests		
A.3.1	Tests of clamping of non-armoured and braided cables		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
A.3.1.1	Cable glands with clamping by the sealing ring		**N/A**
A.3.1.2	Cable glands with clamping by filling compound		**N/A**
A.3.1.3	Cable glands with clamping by means of a clamping device		**N/A**
A.3.1.4	Tensile test		**N/A**
A.3.1.5	Mechanical strength		**N/A**
A.3.2	Tests of clamping of armoured cables		**N/A**
A.3.2.1	Tests of clamping where the armourings are clamped by a device within the gland		**N/A**
A.3.2.1.1	Tensile test		**N/A**
A.3.2.1.2	Mechanical strength		**N/A**
A.3.2.2	Tests of clamping where the armourings are not clamped by a device within the gland		**N/A**
A.3.3	Type test for resistance to impact		**N/A**
A.3.4	Test for degree of protection (IP) of cable glands		**N/A**
A.4	Marking		
A.4.1	Marking of cable glands		**N/A**
A.4.2	Marking of cable-sealing rings		**N/A**

Annex B (Normative)	Requirements for Ex components.		
Table B.1	Clauses with which Ex Components shall comply	Ex equipment considered.	**N/A**

Annex C (Informative)	Example of rig for resistance to impact test

Annex D (Informative)	Motors supplied by converters

Annex E (Informative)	Temperature rise testing of electric machines

Annex F (Informative)	Guideline flowchart for tests of non-metallic enclosures or non-metallic parts of enclosures (26.4)

Measurement Section, including Additional Narrative Remarks (as deemed applicable)

Clause 26.4.2 Impact test is exempted for enclosure but is performed according to the testing of the built-in piezoelectric device, buzzer type BZ-9K. Refer to associated IEC60079-11 test report.

§ 26.4.3	Drop test		**P *)**
Part under test	Test condition	Remarks	
GX-6000 w/ BUD-6000	*)	No visible damages or scratch	
GX-6000 w/ BUL-6000	*)	No visible damages or scratch	

Supplementary information.

***)** Samples were pre-conditioned in cold chamber with temperature of 30°C. Conditioning time: from 2015-01-12 time 09.00 to 2015-01-14 time 08.00. The samples were dropped on horizontal concrete surface in the cold chamber. Drop performed four times for each sample in different positions. The samples were functioning normal after test.

§ 26.13	Surface resistance test		**P**
Part under test	Test condition *)	Remarks	
ESC 9448N (black). Middle case	*)	155Ω (<1GΩ)	
PET 300R. Panel sheet	*)	1.3MΩ (<1GΩ)	

Supplementary information.

*) 24h pre-conditioning: 23.1°C & 47.8% rth. 500V insulation test in 60s duration. 10s rise/fall time. All other smaller parts of regular plastic material are checked for surface area less than 400mm². Test performed on 2014-10-27
¤) 24h pre-conditioning: 22.4°C & 26.4% rth. 500V insulation test in 60s duration. 10s rise/fall time. Test performed 2015-02-05

IECEx TEST REPORT
IEC 60079-11
Explosive atmospheres – Part 11:
Equipment protection by intrinsic safety "i"

ExTR Reference Number...............:	NO/PRE/ExTR15.0012/00
ExTR Free Reference Number.......:	D0001494-00
Compiled by + signature (ExTL).....:	Hien Van Le Thanh Hien Van Le Thanh
Reviewed by + signature (ExTL)....:	Arne Hortman Arne Hortman
Date of issue.................................:	2015-04-21
Ex Testing Laboratory (ExTL) ....:	Presafe AS
Address ....:	Gaustadalléen 30, NO - 0373 Oslo, Norway
Applicant's name ....:	Riken Keiki Co., Ltd
Address ....:	2-7-6 Azusawa, Itabashi, Tokyo 174-8744, Japan
Standard...:	IEC 60079-11:2011, 6th Edition
Test procedure ....:	IECEx System
Test Report Form Number ....:	ExTR60079-11_6A (released 2011-08)

Instructions for Intended Use of Ex Test Report:
An Ex Test Report provides a clause-by-clause documentation of the initial evaluation and testing that verified compliance of an item or product with an IEC Ex standard. This Ex Test Report is part of an ExTR package that may include other Ex Test Report, Addendum and National Differences documents, along with a single ExTR Cover. An Ex Test Report is to be compiled and reviewed by the ExTL. The Issuing ExCB indicates final approval of the Ex Test Report as part of the overall ExTR package on the associated ExTR Cover.

Possible test case verdicts:

- test case does not apply to the test item .... :	**N/A**	Not applicable
- test item does meet the requirement.......................... :	**P**	Pass

General remarks:
The test results presented in this Ex Test Report relate only to the item or product tested.

- "See Attachment #" refers to additional information appended to this document.
- "See appended table" refers to a table appended to this document.
- "See General product information" refers to item 'General product information' in ExTR Cover report.
- "See Copy of marking plate" refers to item 'Copy of marking plate' in ExTR Cover report.
- Throughout this document, a point "." is used as the decimal separator.

The technical content of this Ex Test Report shall not be reproduced except in full without the written approval of the Issuing ExCB and ExTL.

This investigation is valid for both IECEx and ATEX certification which is handled by Presafe AS. The Ex codes for both ATEX and IECEx certification may appear in associated test reports.

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
1	Scope		
2	Normative references		
3	Terms and definitions		
4	Grouping and classification of intrinsically safe apparatus and associated apparatus	Equipment under test (EUT) is portable gas monitor GX-6000 and charger module BC-6000. See General product information. Ex ia IIC T4 Ga -20°C ≤ Ta ≤ +50°C	**P**
5	Levels of protection and ignition compliance requirements of electrical apparatus		
5.1	General		**P**
5.2	Level of protection "ia"	Refer to Appendix A.1 for details.	**P**
5.3	Level of protection "ib"	Suitable for application of ‘ib’ type of protection.	**N/A**
5.4	Level of protection "ic"	Suitable for application of ‘ic’ type of protection.	**N/A**
5.5	Spark ignition compliance	Refer to Appendix A.2 & B.2 for details.	**P**
5.6	Thermal ignition compliance		
5.6.1	General	Refer to Appendix A.3 & B.3 for details.	**P**
5.6.2	Temperature for small components for Group I and Group II	Refer to Appendix A.3.1 & B.3 for details.	**P**
5.6.3	Wiring within intrinsically safe apparatus for Group I and Group II	Refer to Appendix A.3.2 for details.	**P**
5.6.4	Tracks on printed circuit boards for Group I and Group II	Refer to Appendix A.3.3 for details.	**P**
5.6.5	Intrinsically safe apparatus and component temperature for Group III	Not Group III equipment.	**N/A**
5.7	Simple apparatus	Not simple apparatus.	**N/A**
6	Apparatus construction		

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
6.1	Enclosures		
6.1.1	General	Considered.	**P**
6.1.2	Enclosures for Group I or Group II apparatus		
6.1.2.1	General	See below.	**P**
6.1.2.2	Apparatus complying with Table 5	Enclosure complying with minimum IP20 provided. Compliance with table 5 considered.	**P**
6.1.2.3	Apparatus complying with Annex F	See above.	**N/A**
6.1.3	Enclosures for Group III apparatus	Not group III apparatus.	**N/A**

6.2	Facilities for connection of external circuits		
6.2.1	Terminals	No external connections other than charging facilities. Charging protection circuit and connection is provided and is evaluated in 7.4.	**N/A**
6.2.2	Plugs and sockets		**N/A**
6.2.3	Determination of maximum external inductance to resistance ratio (*Lo/Ro*) for resistance limited power source	AC/DC power adapter is not covered by this investigation. See also above.	**N/A**
6.2.4	Permanently connected cable	No such parts.	**N/A**
6.2.5	Requirements for connections and accessories for IS apparatus when located in the non-hazardous area	Charging is only allowed in non-hazardous area. Charging is evaluated and is documented throughout sub-clauses of 7.4 of this report.	**N/A**

6.3	Separation distances		
6.3.1	General	Considered. See Appendix A.1 & B.4 for details	**P**
6.3.2	Separation of conductive parts	Current limiting resistors is used in major part of internal electronics. Fuses are used in different parts and are documented in measurement section	**P**
6.3.2.1	Distances according to Table 5	Distances according to Table 5 are considered.	**P**
6.3.2.2	Distances according to Annex F	Not used.	**N/A**
6.3.3	Voltage between conductive parts	Voltage of battery units considered. See Appendix A.1 to A.4 for details	**P**
6.3.4	Clearance	Considered.	**P**
6.3.5	Separation distances through casting compound	Considered for the moulded BUL-6000 (Li-ion battery pack). See also 7.3	**P**
6.3.6	Separation distances through solid insulation	Suitable internal wiring considered. See also above and 6.3.12	**P**
6.3.7	Composite separations	No composite separations	**N/A**
6.3.8	Creepage distance	See Appendix A.1 & B.4 for details	**P**
6.3.9	Distance under coating	No coating used.	**N/A**

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
6.3.10	Requirements for assembled printed circuit boards	Complied with requirements of 6.3.2. See Appendix A.1 & B.4 for details.	**P**
6.3.11	Separation by earthed screens	No earthed screens.	**N/A**
6.3.12	Internal wiring	See Appendix A.3.2 & B.4 to B.5	**P**
6.3.13	Dielectric strength requirement	Suitable insulated wiring is used. Dielectric strength test is considered to be unnecessary.	**N/A**
6.3.14	Relays	No relays.	**N/A**
6.4	Protection against polarity reversal	Provided for BUL-6000 & button cell Sony SR616. Appropriate internal markings provided for BUD-6000. See Appendix A.1 to A.4.	**P**
6.5	Earth conductors, connections and terminals	Portable handheld equipment. No earthing required.	**N/A**
6.6	Encapsulation		
6.6.1	General	See Appendix A.5	**P**
6.6.2	Encapsulation used for the exclusion of explosive atmospheres	BUL-6000 Li-ion battery pack is encapsulated and therefore is exempted from requirements of spark ignition assessment. See Appendix A to C	**P**
7	Components on which intrinsic safety depends		
7.1	Rating of components	Refer to Appendix A.4 for details.	**P**
7.2	Connectors for internal connections, plug-in cards and components	Incorrect connection of battery units is not possible due to the design. Removal or replacement of battery is not allowed in hazardous area. Warnings and adequate markings are provided.	**P**
7.3	Fuses	A fuse is provided at the input of charger circuit. The charging is only allowed in safe area. This fuse is therefore not required to be encapsulated. See 7.5.2-7.5.3 & 10.6.2 & Appendix A.6	**P**
7.4	Primary and secondary cells and batteries		
7.4.1	General	EUT is powered by batteries. Batteries have therefore several aspects of safety concern. See Appendix B.6 & C.	**P**
7.4.2	Battery construction	Adequate protection concept investigated and recognized. See throughout Appendix A to C	**P**
7.4.3	Electrolyte leakage and ventilation	See Appendix B.6 & C.	**P**

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
7.4.4	Cell voltages	See throughout Appendix A to C. Alkaline/BUD-6000 $V_{peak\ open\text{-}circuit}$=1.65V, V_n=1.5V Li-ion/BUL-6000: $V_{peak\ open\text{-}circuit}$=4.2V, V_n=3.8V Button cell (silver oxide) Sony SR616: $V_{peak\ open\text{-}circuit}$=1.63V, V_n= 1.55V	**P**
7.4.5	Internal resistance of cell or battery	Test according to cl. 10.5.3 is documented. See Appendix C.	**P**
7.4.6	Batteries in equipment protected by other types of protection	Intrinsic safe protection concept.	**N/A**
7.4.7	Batteries used and replaced in explosive atmospheres	Batteries are used but replacement is not allowed in explosive atmospheres.	**N/A**
7.4.8	Batteries used but not replaced in explosive atmospheres	Proper protection concept provided for charging & discharging. Charger input is based on U_m=250V and is evaluated accordingly.	**P**
7.4.9	External contacts for charging batteries	Complied with option a) of this requirement. Safe circuit using current limiting resistors and blocking diodes provided.	**P**

7.5	Semiconductors		
7.5.1	Transient effects	Adequate means of limiting transients provided. See below & Appendix A.6.	**P**
7.5.2	Shunt voltage limiters	By use of fuse F1 and triplicate controllable semiconductors (Field Effect Transistor), the shunt voltage limiters (Q1, Q2, Q3, ZD1, ZD2, ZD3, R1, R2, R3 in charger circuit) are composed and the voltage supplied to the charger circuit is limited. See Appendix A.6	**P**
7.5.3	Series current limiters	D1-D3 are used in line with the components which are described above. See Appendix A.1	**P**

7.6	Failure of components, connections and separations	Considered. See Measurement section of this report.	**P**

7.7	Piezoelectric devices	The buzzer is considered. See Appendix A.2.6.	**P**

7.8	Electrochemical cells for the detection of gases	See Appendix B.6 and Appendix D to F for documented testing of different sensors	**P**

8	Infallible components, infallible assemblies of components and infallible connections on which intrinsic safety depends

8.1	Level of Protection “ic”	‘ia’ protection concept. See Appendix A to C	**P**

8.2	Mains transformers		
8.2.1	General	No transformers. See 8.4	**N/A**
8.2.2	Protective measures		**N/A**

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
8.2.3	Transformer construction		**N/A**
8.2.4	Transformer type tests		**N/A**
8.2.5	Routine test of mains transformers		**N/A**
8.3	Transformers other than mains transformers	No transformers. See 8.4	**N/A**
8.4	Infallible windings		
8.4.1	Damping windings	See below.	**N/A**
8.4.2	Inductors made by insulated conductors	Wingdings of pump is not considered as infallible. Refer to assessments of pump circuits.	**N/A**
8.5	Current-limiting resistors	See Appendix A.1 & A.4	**P**
8.6	Capacitors		
8.6.1	Blocking capacitors	No such components.	**N/A**
8.6.2	Filter capacitors		**N/A**
8.7	Shunt safety assemblies		
8.7.1	General	Minimum two parallel paths of zener diodes used.	**P**
8.7.2	Safety shunts	See 7.5.2 and Appendix A.1 & A.4	**P**
8.7.3	Shunt voltage limiters	See 7.5.2 and Appendix A.1 & A.4	**P**
8.8	Wiring, printed circuit board tracks, and connections	See Appendix A.1 & A.3 & A.4 & B.4 with regards to wiring and PCB	**P**
8.9	Galvanically separating components		
8.9.1	General	No galvanically separating components.	**N/A**
8.9.2	Isolating components between intrinsically safe and non-intrinsically safe circuits		**N/A**
8.9.3	Isolating components between separate intrinsically safe circuits		**N/A**
9	Supplementary requirements for specific apparatus		
9.1	Diode safety barriers		
9.1.1	General	No diode safety barriers. See 7.5.2	**N/A**
9.1.2	Construction		

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
9.1.2.1	Mounting		**N/A**
9.1.2.2	Facilities for connection to earth		**N/A**
9.1.2.3	Protection of components		**N/A**
9.2	FISCO apparatus	No such parts.	**N/A**
9.3	Handlights and caplights		**N/A**
10	Type verifications and type tests		
10.1	Spark ignition test		
10.1.1	General	Higher safety factor achieved. Spark ignition test is found un-necessary.	**N/A**
10.1.2	Spark test apparatus		**N/A**
10.1.3	Test gas mixtures and spark test apparatus calibration current		
10.1.3.1	Explosive test mixtures suitable for tests with a safety factor of 1.0 and calibration current of the spark test apparatus		**N/A**
10.1.3.2	Explosive test mixtures suitable for tests with a safety factor of 1.5 and calibration current of the spark test apparatus		**N/A**
10.1.4	Tests with the spark test apparatus		
10.1.4.1	Circuit test		**N/A**
10.1.4.2	Safety factors		**N/A**
10.1.5	Testing considerations		
10.1.5.1	General		**N/A**
10.1.5.2	Circuits with both inductance and capacitance	See through Appendix A.2 for details.	
10.1.5.3	Circuits using shunt short-circuit (crowbar) protection	No crowbar protection. However the charger circuit is functioned similarly.	**N/A**
10.1.5.4	Results of spark test		**N/A**
10.2	Temperature tests	See Appendix A.3 & B.3 & B.6 & C to F	**P**
10.3	Dielectric strength tests	Not needed for this investigation.	**N/A**
10.4	Determination of parameters of loosely specified components	Max voltage of Li-ion batteries during charging has been determined by measuring the voltage of the batteries in BUL-6000 on 10 samples.	**P**

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
10.5	Tests for cells and batteries		
10.5.1	General	See Appendix B.6 & C.	**P**
10.5.2	Electrolyte leakage test for cells and batteries		**P**
10.5.3	Spark ignition and surface temperature of cells and batteries		**P**
10.5.4	Battery container pressure tests		**P**

10.6	Mechanical tests		
10.6.1	Casting compound	Internal encapsulation. No exposed surface.	**N/A**
10.6.2	Determination of the acceptability of fuses requiring encapsulation	F1 in battery charger circuit is used in safe area and is protected for reversed current by D1-D3 in BUL-6000	**P**
10.6.3	Partitions		**N/A**

10.7	Tests for intrinsically safe apparatus containing piezoelectric devices	Buzzer BZ-9K considered. See Appendix A.2.6.	**P**

10.8	Type tests for diode safety barriers and safety shunts	Adequate transient protection provided. See Appendix A.6	**N/A**

10.9	Cable pull test	No external cable.	**N/A**

10.10	Transformer tests	No transformers	**N/A**

10.11	Optical isolators tests		
10.11.1	General	No such parts.	**N/A**
10.11.2	Thermal conditioning, dielectric and carbonisation test		**N/A**
10.11.2.1	Overload test at the receiver side		**N/A**
10.11.2.2	Overload test at the transmitter side		**N/A**
10.11.2.3	Thermal conditioning and dielectric strength test		**N/A**
10.11.2.4	Carbonisation test		
10.11.2.4.1	Receiver side		**N/A**
10.11.2.4.2	Transmitter side		**N/A**
10.11.3	Dielectric and short-circuit test		**N/A**
10.11.3.1	General		**N/A**
10.11.3.2	Pre-test dielectric		**N/A**
10.11.3.3	Short-circuit current test		**N/A**

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
10.11.3.4	Current limited short-circuit current test		**N/A**
10.11.3.5	Dielectric strength test		

10.12	Current carrying capacity of infallible printed circuit board connections	Suitable PCB are used and are well documented.	**N/A**

11	Routine verifications and tests

11.1	Routine tests for diode safety barriers		
11.1.1	Completed barriers	No barriers.	**N/A**
11.1.2	Diodes for 2-diode “ia” barriers		**N/A**

11.2	Routine tests for infallible transformers	No transformers.	**N/A**

12	Marking

12.1	General	See Copy of marking plate.	**P**
12.2	Marking of connection facilities	Appropriate internal markings provided for BUD-8000. See Appendix A.1 to A.4.	**P**
12.3	Warning markings	Warnings provided with regards to specific instructions of type of battery, replacement & charging, and safety instructions in User manual. See Copy of marking plate and General product information.	**P**
12.4	Examples of marking	See Copy of marking plate.	**P**

13	Documentation	Documentation concerning explosion safety aspects of EUT is prepared by the manufacturer and is reviewed as part of this investigation. Documentation is kept in file at DNV Nemko Presafe AS. See also Copy of marking plate	**P**

Annex A (Normative)	Assessment of intrinsically safe circuits		
A.1	Basic criteria	See Appendix A.1 to A.2	**P**
A.2	Assessment using reference curves and tables	See above.	**P**
A.3	Examples of simple circuits		**P**
A.4	Permitted reduction of effective capacitance when protected by a series resistance	Considered.	**N/A**

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict

Annex B (Normative)	Spark test apparatus for intrinsically safe circuits		
B.1	Test methods for spark ignition		
B.1.1	Principle	See Appendix D to F for thermal ignition test of lamp part and sensors. Separate documented testing was reviewed and recognized.	**N/A**
B.1.2	Apparatus	See above.	**N/A**
B.1.3	Calibration of spark test apparatus		**N/A**
B.1.4	Preparation and cleaning of tungsten wires		**N/A**
B.1.5	Conditioning a new cadmium disc		**N/A**
B.1.6	Limitations of the apparatus		**N/A**
B.1.7	Modifications of test apparatus for use at higher currents		**N/A**

Annex C (Informative)	Measurement of creepage distances, clearances and separation distances through casting compound and through solid insulation

Annex D (Normative)	Encapsulation		
D.1	Adherence	See Appendix A.5	**P**
D.2	Temperature	See above	**P**

Annex E (Informative)	Transient energy test

Annex F (Normative)	Alternative separation distances for assembled printed circuit boards and separation of components		
F.1	General	Not used.	**N/A**
F.2	Control of pollution access		**N/A**
F.3	Distances for printed circuit boards and separation of components		
F.3.1	Level of protection “ia” and “ib”		**N/A**
F.3.2	Level of protection “ic”		**N/A**

Annex G (Normative)	Fieldbus intrinsically safe concept (FISCO) – Apparatus requirements		
G.1	Overview	No FISCO apparatus.	**N/A**
G.2	Apparatus requirements		
G.2.1	General		**N/A**

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
G.2.2	FISCO power supplies		
G.2.2.1	General		**N/A**
G.2.2.2	Additional requirements of ‘ia’ and ‘ib’ FISCO power supplies		**N/A**
G.2.2.3	Additional requirements of ‘ic’ FISCO power supplies		**N/A**
G.3	FISCO field devices		
G.3.1	General		**N/A**
G.3.2	Additional requirements of ‘ia’ and ‘ib’ FISCO field devices		**N/A**
G.3.3	Additional requirement of ‘ic’ FISCO field devices		**N/A**
G.3.4	Terminator		**N/A**
G.3.5	Simple apparatus		**N/A**
G.4	Marking		**N/A**
G.4.1	Examples of marking		**N/A**

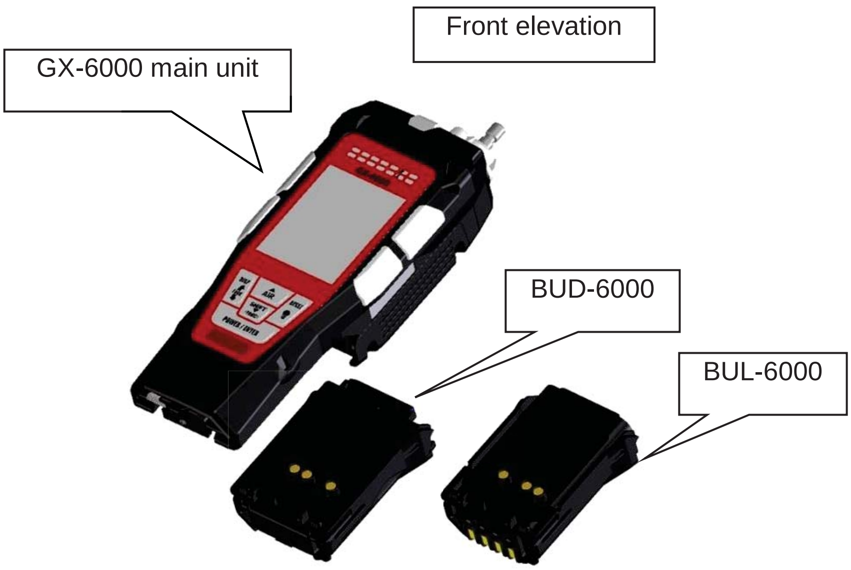
Annex H (Informative)	Ignition testing of semiconductor limiting power supply circuits

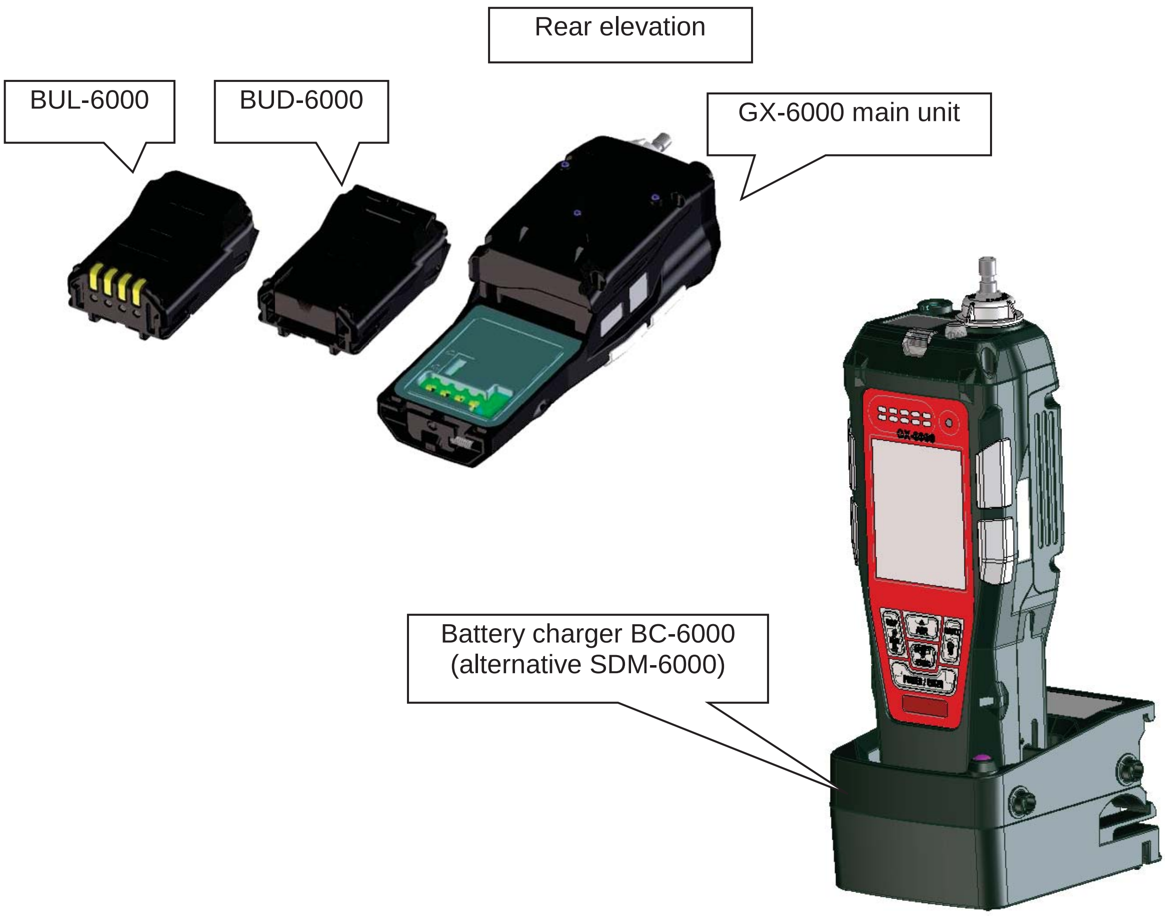
Measurement Section, including Additional Narrative Remarks

APPENDIX A: Description of product

A.1 General Technical description

GX-6000 main unit & Battery unit





EUT (equipment under test) is the portable gas monitor GX-6000 intended to measure maximum six gases with six sensors. Standard type of EUT unit measures four gases with four sensors for general combustible gases (LEL), Oxygen (O2), Hydrogen Sulfide (H2S) and Carbon Monoxide (CO). Remaining two slots are used for Smart Sensors which consist of sensor part and dedicated circuit board. Different types of detection principle are applied for Smart Sensors which up to two sensors can be installed into the GX-6000. Gas is sampled by a built-in micro pump.
Ambient temperature range for use: -20°C to 50°C
Ambient temperature range during charging: 0 °C to 40°C (Non-hazardous area only)

The battery can be selected between either Li-ion battery or alkaline dry battery. Li-ion battery unit is called BUL-6000 and alkaline dry battery unit is called BUD-6000. BC-6000 is battery charger module. Both battery units are designed so replacement can be performed by the end user with no use of tools. However replacement is only allowed in non-hazardous areas. Warnings and safety info are provided.

BUL-6000 Li-ion battery unit
Two parallel connected Li-ion cells used in battery pack BP-6000 are of type 18650, two parallel cells size Ø18x65mm from manufacturer:
- MAXELL model INR18650PB1
- SONY model US18650VT3
- SDI model INR18650-15M

The cells are placed in plastic (PC) case. The case is filled with epoxy resin, or silicon compound. Encapsulation prevent the battery to have any contact with external gases. Nominal battery voltage is 3.8V and the peak open circuit voltage is 4.2V according to table 11 of IEC60079-0.
Hence U_{bat_therm} = 3.8V (for thermal ignition assessment and rating of components),
U_{bat_spark} = 4.2V (for spark ignition assessment)

This battery unit is charged at less than 4.2V (CCCV) by the exclusive battery charger BC-6000, alternative SDM-6000. Electronic design of both charger modules are identically. The difference is module's shape/form. Assessments performed for BC-6000 is representative for SDM-6000 module.

BUD-6000 alkaline battery unit
Three series connected alkaline manganese AA batteries, type LR6 manufactured by TOSHIBA. Nominal battery voltage is 1.5V and the peak open circuit voltage is 1.65V according to table 11 of IEC60079-0. Eventual occurring of battery cell leakage cannot invalidate the creepage distances of the safety components, since no safety components are placed on the battery PCB.
Hence U_{bat_therm} = 1.5 x 3 =4.5V, and U_{bat_spark} = 1.65 x 3 = 4.95V

Backup battery type SR616 manufactured by SONY

The apparatus is legibly marked (ref. drawing M4-4777-01-01K) with the following:
・II 1 G Ex ia IIC T4 Ga
・Ambient temperature range
・Manufacturers Model/Type designation
・Serial number (coded in INST. No. on the label and explained in the safety information)
・Name of the manufacturer
・IECEx Certificate number
・Read manual for safety info

The instruction manual contains the following warnings:
・WARNING:"DO NOT CHARGE IN HAZARSOUS LOCATION"
・WARNING:"DO NOT CHARGE IT EXCEPT BY GENUINE CHARGER"
・WARNING: "DO NOT REPLACE BATTERY UNIT IN HAZARDOUS LOCATION"
・WARNING:"DO NOT REPLACE DRY BATTERIES IN HAZARDOUS LOCATION"
・WARNING: "DO NOT ATTEMPT TO DISASSEMBLE OR ALTER THE INSTRUMENT"
・Use only battery unit type BUD-6000 with three series connected Alkaline Manganese AA batteries, type LR6 manufactured by Toshiba, or use chargeable battery unit type BUL-6000.

The following block diagrams are demonstrating complete protection concept of EUT, E3-6991-5361-10-01K & E4-6991-5395-80-01K. Refer also to general block diagram document E3-6991-5393-30-01K

EUT are divided in following parts, BC-6000/SDM-6000 charger, BUL-6000 (Li-ion) & BUD-6000 (alkaline) battery units & main unit. Main unit consists of Main PCB, Sensor PCB and LCD. They are then divided into following blocks of circuits for assessments, Main circuit including backup-battery, Pump circuit (pump type RP-12), Buzzer circuit (piezoelectric device Buzzer type BZ-9K), Motor circuit (vibration motor type A3BE-MT4), LCD circuit (LCD module type BTD-128160B-FBWB) and Sensor-circuit (S_sen1 and S-sen2 circuits are identical)

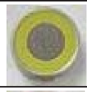
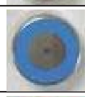
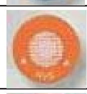
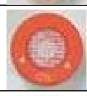
Series resistors are used for current and power limitation of the battery and for segregation between the various voltage areas on the main PCB and battery PCB. Several double zener diode combinations are used for voltage limitation of the internal circuits.

By use of triplicate controllable semiconductors (Field Effect Transistor), the shunt voltage limiters (Q1, Q2, Q3, ZD1, ZD2, ZD3, R1, R2, R3 on the Li-ion battery PCB) are composed and the voltage supplied to the charger circuit is limited. This application is considered to be adequate protection in term of limiting transients. Refer to Appendix A.6 for assessments of the charger circuit by which reference voltage for assessments of internal circuits behind the charger circuits is determined to be 4.2V. And also that fault conditions of charger circuit cause no risk which invalidates the type of protection.

S-SEN1 & S_SEN2 circuits are identical, therefore assessments for Sensor1 circuit are representative for both of S-SEN1 & S_SEN2.

The charger modules BC-6000 & SDM-6000 are included in this investigation and are assessed based on U_m= 250V. The AC/DC power adapter is not part of this investigation..

Table list of sensors

		Measuring gas	Sensor type	Detection principle	
Standard four gas	1	Combustible gas (LEL)	Combustible gas sensor type NC-6264A	Catalytic combustion	
	2	Oxygen (O2)	Oxygen sensor	Galvanic cell	
	3	Hydrogen Sulfide (H2S)	Toxic gas sensor	Electrochemical	
	4	Carbon Monoxide (CO)	Toxic gas sensor	Electrochemical	
Smart Sensor	5	VOC	Smart sensor type PIS (Mini PID sensor used)	PID	
	6	Toxic gases	Smart sensor type ESS (Internal toxic gas sensor)	Electrochemical	
	7	Carbon Dioxide (CO2) or Combustible gas	Smart sensor type DES (T- 3/4 BPA Lamp used)	Infrared ray (IR)	
	8	Oxygen	Smart sensor type OSS (Internal oxygen sensor used)	Galvanic cell	

A.2 Spark ignition considerations

Assessment performed for BUD-6000 only and is representing the least favourable situation with highest U_{bat}. Assessment cover the use of BUL-6000 as well

A.2.1 Resistive spark ignition

Sensor1 circuit (representative results for both S-SEN1 & S_SEN2 circuits)
The maximum output voltage U_{o_sens11} available from the battery is 4.95V.
The maximum voltage from the IC11 (TPS61020 Step-up DC/DC converter) is limited by ZD11, ZD12, to maximum voltage of U_{o_sens12} = 5.36V, which should be taken into account for the spark ignition compliance.
The output current I_{o_sens1} is limited by R_{i_sens1}
R_{i_sens1} = (RS11 + RS12 + RS13 + RS14 + RS15) - 1% = 6.435Ω.
$I_{o\_sens1} = U_{bat\_spark} / (R_{i\_sens1})$ = 4.95V / 6.435Ω = 0.770A.
$P_{o\_sensor} = U_{bat\_therm}^2 / (4 \times R_{i\_sens1}) = 4.5V^2 / (4 \times 6.435\Omega)$ = 787mW.

Pump circuit (Pump type RP-12)
The maximum output voltage U_{o_pump1} available from the battery is 4.95V.
The maximum voltage of $U_{o\_pump2} = U_{o\_main2}$ = 5.36V, which should be taken into account for the spark ignition compliance.
R_{i_pump} = (RS31 + RS32 + RS33 + RS34 + RS35) - 1% = 6.435Ω.
$I_{o\_pump} = U_{bat\_spark} / (R_{i\_pump})$ = 4.95V / 6.435Ω = 0.770A.
$P_{o\_pump} = U_{bat\_therm}^2 / (4 \times R_{i\_pump}) = 4.5V^2 / (4 \times 6.435\Omega)$ = 787mW.

Motor circuit (Vibration motor type A3BE-MT4)
The maximum output voltage U_{o_motor1} available from the battery is 4.95V.
The maximum voltage of $U_{o\_motor2} = U_{o\_main2}$ = 5.36V
R_{i_motor} = (RS51 + RS52) - 1% = 23.76Ω.
$I_{o\_motor} = U_{bat\_spark} / R_{i\_motor}$ = 4.95V / 23.76Ω = 0.209A.
$P_{o\_motor} = U_{bat\_therm}^2 / (4 \times R_{i\_motor}) = 4.5V^2 / (4 \times 23.76\Omega)$ = 214mW.

Buzzer circuit (Buzzer type BZ-9K)
The maximum output voltage $U_{o\_buzzer1}$ available from the battery is 4.95V.
The maximum input voltage U_{I_buzzer} available from main circuit is 5.36V. However the max voltage is clamped down to 5.2V by ZD41 to ZD48. Hence, the maximum output voltage $U_{o\_buzzer2}$ = 5.20V.
The maximum voltage from the IC41 (TPS61041 Step-up DC/DC converter) is limited by ZD45, ZD46 to maximum voltage of $U_{o\_buzzer3}$ = 12.3V
R_{i_buzzer} = (RS41 + RS42 + RS43) - 1% = 13.95Ω.
$I_{o\_buzzer} = U_{bat\_spark} / R_{i\_buzzer}$ = 4.95V / 13.95Ω = 0.355A.
$P_{o\_buzzer} = U_{bat\_therm}^2 / (4 \times R_{i\_buzzer}) = 4.5V^2 / (4 \times 13.96\Omega)$ = 259mW.

Main circuit
The maximum output voltage U_{o_main1} available from the battery is 4.95V.
The maximum voltage from the IC71 (TPS61020 Step-up DC/DC converter) is limited by ZD71, ZD72. Hence maximum voltage of U_{o_main2} = 5.36V, which should be taken into account for the spark ignition compliance.
R_{i_main} = (RSA1 – RSA5 // RSB1 – RSB5 // RSC1 – RSC5) - 1% = 4.455Ω.
$I_{o\_main} = U_{bat\_spark} / R_{i\_main}$ = 4.95V / 4.455Ω = 1.112A.
$P_{o\_main} = U_{bat\_therm}^2 / (4 \times R_{i\_main}) = 4.5V^2 / (4 \times 4.455\Omega)$ = 1137mW.

LCD circuit
The maximum input voltage U_{I_lcd1} available from main.cir 5.36V.
Input 5.36V from MAIN.circuit to LCD.circuit is clamped down to 5.20V by ZD61 to ZD68.
Hence, the maximum output voltage U_{o_lcd1} = 5.20V.
The charge pump circuit is built in the LCD driver (ST75256), and the voltage is boosted to a maximum of ±10 times. The maximum output voltage U_{o_lcd2} = 5.20V x 10 = 52.0V and -52.0V.
In order to reduce the voltage of the capacitor C62 in the LCD driver, zeners ZD57 to ZD60 is used.
The maximum output voltage (for C62) U_{o_lcd3} = 17.7V and -17.7V.
R_{i_lcd} = (RS61 // RS62 // RS63 // RS64 // RS65) -1% = 24.31Ω.
$I_{o\_lcd} = U_{bat\_spark} / (R_{i\_main} + R_{i\_lcd})$ = 4.95V / (4.455Ω + 24.31Ω) = 0.173A.
$P_{o\_lcd} = U_{bat\_therm}^2 / (4 \times (R_{i\_main} + R_{i\_lcd})) = 4.5V^2$ / (4 x (4.455Ω + 24.31Ω)) = 176mW.

Backup battery (placed on Main PCB)
The maximum open circuit voltage for Silver oxide battery, type SONY SR616, according to table 11 of IEC60079-0 is U_{backup_spark} = 1.63V.
Normal voltage according to table 11 of IED60079-0 is U_{backup_therm} = 1.55V which should be used for thermal analysis and rating of components.
The output current I_{o_backup} is limited by RS10.
The backup battery is protected from charging by diode D7
R_{i_backup} = R10 - 1% = 990Ω.
$I_{o\_backup} = U_{o\_backup\_spark} / R_{i\_backup}$ = 1.63V / 990Ω = 1.7mA.
$P_{o\_backup} = U_{backup\_therm}^2 / (4 \times R_{i\_backup}) = 1.55V^2$ / (4 x 990Ω) = 0.7mW.

Battery charger circuit (For BUL-6000 only in safe area)
The exclusive chargers of GX-6000 are BC-6000 and SDM-6000.
For power input of battery charger, AC adaptor with 12Vdc output shall be used. The input of AC adaptor is specified to max 220Vac but has Um = 250V. A shunt voltage limiting circuit together with a fuse is used as protection from Um. Fuse In = 1.6A is used. The maximum current of charging circuit is limited to I_{o_charge} = 1.6A x 1.7 = 2.72A.
The charge current of the battery is functional limited to 1.5A by charging control IC during recharge. The battery voltage is limited to 4.2V by function of charging control IC at recharging. U_{bat_charge} = 4.2V.

Ref. drawing no. E3-6991-5361-10-01K
Based on the highest assessed current 1.112A which max source voltage higher than 5V is allowed (ref figure A.1 of IEC60079-11), the result is therefore within the acceptable level.

A.2.2 Inductive spark ignition

Sensor1 circuit (representative results for both S-SEN1 & S_SEN2 circuits)
The effective internal inductance is L_{sens1} = 13uH
Based on I_{o_sens1} = 0.770A, the maximum allowed inductance is L = 59.9uH ($L = 2E / I^2$ = 2 x 40uJ / (1.5 x 0.770A)^2) according to figure A.6 of IEC60079-11.

Pump circuit (Pump type RP-12)
The effective internal inductance of the pump motor is 59.8uH maximum.
Taken into account the minimum resistance of the motor, the current through the windings is I_{o_pump} = 4.95V / (6.435Ω + 11.0Ω) = 0.284A. The maximum allowed inductance is L = 440uH ($L = 2E / I^2$ = 2 x 40uJ / (1.5 x 0.284A)^2).

Motor circuit (Vibration motor type A3BE-MT4)
The effective internal inductance of the vibration motor is 350uH maximum.
Taken into account the minimum resistance of the motor, through a windings is I_{o_motor} = 4.95V / (23.76Ω + 80Ω) = 0.048A. The maximum allowed inductance is L = 15622uH ($L = 2E / I^2$ = 2 x 40uJ / (1.5 x 0.048A)^2)

Buzzer circuit (Buzzer type BZ-9K)
The effective internal inductance is L_{buzzer} = 13uH
Based on I_{o_buzzer} = 0.355A, the maximum allowed inductance is L = 282uH ($L = 2E / I^2$ = 2 x 40uJ / $(1.5 \times 0.355)^2$).

Main circuit
The effective internal inductance is L_{mainr} = 6.11uH
Based on I_{o_main} = 1.112A, the maximum allowed inductance is L = 28.7uH ($L = 2E / I^2$ = 2 x 40uJ / $(1.5 \times 1.112A)^2$).

A.2.3 Capacitive spark ignition

Sensor1 circuit (representative results for both S-SEN1 & S_SEN2 circuits)
The effective internal capacitance is C_{sens1} = 41.2uF (Type-ESS)
Based on U_{o_sens12} = 5.36V, the maximum allowed external capacitance is C = 65uF (ref. Table A.2 of IEC60079-11. This capacitance in smart sensor1 circuit is effectively separated from the main circuit by RS81 – RS87 (of min 1kΩ each)

Pump circuit (Pump type RP-12)
The effective internal capacitance is C_{pump} = 5.0uF
Based on U_{o_pump2} = 5.36V, the maximum allowed external capacitance is C = 61uF.
This capacitance in pump circuit is effectively separated from the other circuit by RS37 - RS39 (of min 10kΩ each)

Motor circuit (Vibration motor type A3BE-MT4)
The effective internal capacitance is C_{motor} = 2.2uF
Based on U_{o_motor2} = 5.36V, the maximum allowed external capacitance is C = 61uF.
This capacitance in motor circuit is effectively separated from the main circuit by RS59 (10kΩ).

Buzzer circuit (Buzzer type BZ-9K)
The effective internal capacitance is C_{buzzer} = 12.1uF (including buzzer capacitance).
Based on $U_{o\_buzzer2}$ = 5.2V, the maximum allowed external capacitance is C = 79uF.
Based on $U_{o\_buzzer3}$ = 12.3V, the maximum allowed external capacitance is C = 1.28uF.
Since the capacitance of the buzzer circuit is above the maximum allowed value of table A.2 at 12.3V, capacitor C41 with a value of 11uF is infallibly connected to input resistance RS43 and can hence be deducted from the capacitance that could be charged to a 12.3V level which results in a $C_{buzzer\_12.3V}$ = 1.02µF.
This capacitance in buzzer circuit effectively separated from the main circuit by RS47 – RS49 (of min 10kΩ each)

Main circuit
The effective internal capacitance is C_{main} = 38.4uF (Main PCB + Sensor PCB)
Based on U_{o_main2} = 5.36V, the maximum allowed external capacitance is C = 61uF.

LCD circuit
The effective internal capacitance is C_{lcd1} = 5.17uF (C61).
Based on U_{o_lcd1} = 5.20V, the maximum allowed external capacitance is C = 79uF.
The effective internal capacitance is C_{lcd2} = 200pF (internal capacitor of LCD driver).
Based on U_{o_lcd2} = 52V, the maximum allowed external capacitance is C = 0.0183uF (18300pF).
The effective internal capacitance is C_{lcd3} = 36.3nF (C62).
Based on U_{o_lcd3} = 17.7V, the maximum allowed external capacitance is C = 0.327uF (327nF)

A.2.4 Combination of inductive and capacitive spark ignition

Sensor1 circuit
It is not possible that L and C are combined after step up.
U_{o_sens11} = 4.95V, allowed C = 100uF, used C = 41.2uF, used / allowed ratio = 41.2%.
I_{o_sens1} = 0.770A, allowed L = 59.9uH, used L = 13uH, used / allowed ratio = 21.8%.

Pump circuit
U_{o_pump1} = 4.95V, allowed C = 100uF, used C = 5.0uF, used / allowed ratio = 5.0%.
I_{o_pump} = 0.284A, allowed L = 440uH, used L = 59.8uH, used / allowed ratio = 13.6%.

Motor circuit
U_{o_motor1} = 4.95V, allowed C = 100uF, used C = 2.2uF, used / allowed ratio = 2.2%.
I_{o_motor} = 0.048A, allowed L = 15622uH, used L = 350uH, used / allowed ratio = 22.4%

Buzzer circuit
Same as that of a sensor circuit, it is not possible that L and C are combined after step up.
$U_{o\_buzzer1}$ = 4.95V, allowed C = 100uF, used C = 12.1uF, used / allowed ratio = 12.1%.
I_{o_buzzer} = 0.355A, allowed L = 282uH, used L = 13uH, used / allowed ratio = 4.7%.

Main circuit
Same as that of a sensor circuit, it is not possible that L and C are combined after step up.
U_o = 4.95V, allowed C = 100uF, used C = 38.4uF used / allowed ratio = 38.4%.
I_o = 1.112A, allowed L = 28.7uH, used L = 6.11uH used / allowed ratio = 21.3%.

The maximum values of Li and Ci are less than 50% of each allowed value

A.2.5 Shunt short-circuit (crowbar) spark ignition

No crowbar device used.

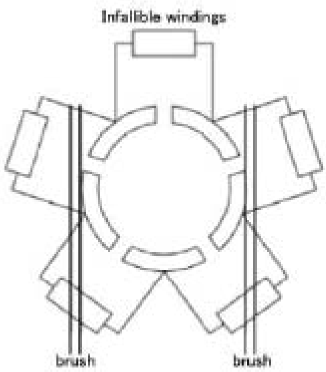
A.2.6 Other spark ignition considerations

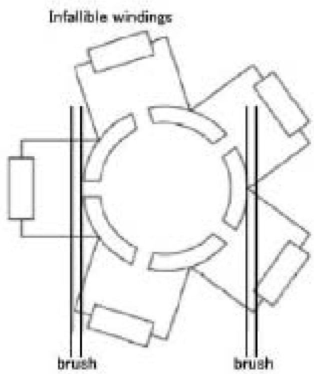
Pump RP-12: (Internal motor of pump type A12B-09-SS)

Pumps are not assessed as infallible windings. However max and min of inductance & resistance is taken into account in assessments of the most severe ignition condition (situation where the winding is disconnected or short-circuited).

The motor coil resistance is taken as an infallible resistance to protect it' s inductance. The minimum motor coil resistance and maximum motor coil inductance of A12B-09-SS are as follows:

case1: one commutator segment active. *case2: two commutator segments active.*





Rmin 13.1 _ / Lmax 59.8µH Rmin 11.0 _ / Lmax 49.8 µH

The range of the motor coil resistance and the motor coil inductance are as follows.
Rmin = 11.0 _ - 13.1 _ , Lmax = 49.8 µH - 59.8 µH
The worst value is Rmin = 11.0 _ and Lmax = 59.8 µH respectively.

Vibration motor is assessed as for pump motor by which worst combination of internal inductance and resistance have been considered. See Appendix A.2.1 to A.2.4.

Piezoelectric device: Buzzer type BZ-9K. Ci = 22nF @ 30% → 28.6nF

The buzzer is infallible connected to protective zener diodes ZD49, 50, 51 and 52. This is assessed against open circuit failure by the following:
• The infallible connection consists of two wires in parallel. These wires are soldered to a 2 mm track, which is infallible connected to zener diodes ZD49, 50, 51 and 52.
• The buzzer has been verified to comply with IEC 60079-11 clause 10.7 by applying an impact of 1 kg weight dropped from a height of 0.7 m on the outside of the enclosure twice. Buzzer wires did not break and the protective components were not affected.
• Spark energy assessment.
- Voltage across buzzer is clamped by ZD40 to ZD52, V = 17.5V (Vz + Vf)
- E = ½ x C x V2 = ½ x 28.6nF x $17.5V^2$ = 4.38µJ < 50µJ (limit for IIC. Ref clause 10.7 of IEC60079-11: 2011). Buzzer wiring is documented in Appendix A.3.2

A.3 Thermal ignition considerations

A.3.1 Refer to temperature measurements which are performed and are documented in Appendix B.3. Only least favourable cases are considered.

A.3.2 Wiring within intrinsically safe apparatus for Group I and Group II

Ref. ExTR11.0038.00

<u>Battery (BUD-6000)</u>
Connection to alkaline batteries by means of a number of spring which have a diameter of 0.6mm. The maximum permissible current according to table 3 of IEC 60079-11 for temperature class T4 at an ambient of 40 °C for a wire with a diameter of 0.5mm is 7.7 A and therefore is acceptable for temperature class T4.

<u>Battery (BUL-6000)</u>
Connection to battery units by means of a number of internal spring which have a diameter of 2.5mm. The maximum permissible current according to table 3 of IEC 60079-11 for temperature class T4 at an ambient of 40 °C for a wire with a diameter of 0.5mm is 7.7 A and therefore is acceptable for temperature class T4. BUL-6000 is totally encapsulated.

<u>Pump wire</u>
Ref. M4-4181-61-01K Pump RP-12. Information reviewed and recognized. Wire type is UL style 1571 AWG28, max length 48mm.

<u>Buzzer wire</u>
Ref. E4-6991-5008-70-01K. Information reviewed and recognized. Wire type is UL1571 AWG32, max length 45mm, two wires in parallel for the connection of the buzzer.

EUT used in general suitable wiring and connectors.

A.3.3 Tracks on printed circuit boards for Group I and Group II

Suitable PCB used. PCB info are documented in different PCB drawings, e.g. E3-6991-5372-80-01A (Main PCB). Thickness: 1.6mm. Two layers and multi layers PCB used. CTI : 100 above. Thickness copper film & VIA’s : 35um. Minimum conductor width : 0.2mm. Information reviewed and recognized.

A.3.4 Intrinsically safe apparatus and component temperature for Group III

Not group III equipment

A.4 Rating of components

Series resistors are used for current and power limitation of the battery and for segregation between the various voltage areas on the main PCB and battery PCB. Several double zener diode combinations are used for voltage limitation of the internal circuits. Safety factor (W1 / W2) ≥ 1.5 is documented in the tables below.

Component designation	Value	Rating used (W2)	Maximum rating (W1) @ 60 °C	$\frac{W1}{W2}$	Calculation
Sensor1_circuit (Same as S_SENS2)					
RS11…RS15	1.3Ω / 1% 1W	0.630 W	1 W	1.58	Pd = $U_{bat\_therm}^2$/ (RS11...RS15) = 4.5^2/(1.3x5) -1% / 5
RS81,82,85 RS86,87	10k Ω / 0.5%, 0.33W	2.1 mW	0.33 W	>100	Pd = $U_{bat\_therm}^2$ / RS81 = 4.5^2/ 10k -0.5%
RS83,84	1k Ω / 1% 0.25 W	21 mW	0.25 W	11	Pd = $U_{bat\_therm}^2$ / RS83 = 4.5^2 / 1 k -1%
ZD11,12	1SMB5918 Uzmax = 5.36V / 3W Tjmax = 150 °C	0.787 W	1.538 W	1.9	Pd = P_{o_sens1} Rth(l-a) = 33.5 °C /W , $R_{th(j-l)}$ = 25.0 °C /W , Rth(j-a) = 58.5 °C /W W1= (T_{jmax}-T_a) / $R_{th(j-a)}$ = (150-60) / 58.5= 1.538
Pump circuit					
RS31…RS35	1.3Ω / 1% 1W	0.630 W	1 W	1.58	Pd = $U_{bat\_therm}^2$/ (RS31...RS35) = 4.5^2/(1.3x5) -1% / 5
RS37,38,39	10k Ω / 0.5% 0.33 W	2.1 mW	0.33 W	>100	Pd = $U_{bat\_therm}^2$ / RS37 = 4.5^2 / 10 k -0.5%
Buzzer circuit					
RS41...RS43	4.7Ω / 1% 0.75W	0.484 W	0.75 W	1.54	Pd = $U_{bat\_therm}^2$/ (RS41...RS43) = 4.5^2/(4.7x3) -1% / 3
RS47,48,49	10k Ω / 0.5% 0.33W	2.1 mW	0.33 W	>100	Pd = $U_{bat\_therm}^2$ / RS47 = 4.5^2/ 10k -0.5%
ZD41,42,43, ZD44,47,48	KDZ4.7B Uzmax = 5.2V / 1W	0.363 W	0.72 W	1.9	Pd = P_{o_buzzer} W1 = 0.72W @60°C (see.datasheet Pd-Ta)
ZD45,46	KDZ11B Uzmax = 12.3V / 1W	0.363 W	0.72 W	1.9	Pd = P_{o_buzzer}
ZD49,50 ZD51,52	KDZ15B Uzmax = 16.5V / 1W	0.363 W	0.72 W	1.9	Pd = P_{o_buzzer}
Motor circuit					
RS51,52	12Ω / 1% 0.75W	0.427 W	0.75 W	1.7	Pd = $U_{bat\_therm}^2$/ (RS51...RS52) = 4.5^2/(12x2) -1% / 2
RS59	10k Ω / 0.5% 0.33 W	2.1 mW	0.33 W	>100	Pd = $U_{bat\_therm}^2$ / RS59 = 4.5^2 / 10 k -0.5%
Main circuit					
RSA1...RSA5 RSB1...RSB5 RSC1...RSC5	2.7Ω / 1% 0.5W	0.304 W	0.5 W	1.6	Pd = $U_{bat\_therm}^2$/ (RSA1...RSA5) = 4.5^2 / (2.7x5) -1% / 5
RS78,79	10k Ω / 0.5% 0.33 W	2.1 mW	0.33 W	>100	Pd = $U_{bat\_therm}^2$ / R61 = 4.5^2/ 10 k -0.5%
ZD71,72	1N5338B Uzmax = 5.36V / 5W Tjmax = 200°C	1.137 W	3.733 W	3.2	Pd = P_{o_main} $R_{th(l-a)}$ = 27.5 °C /W (measured) and $R_{th(j-l)}$ = 10 °C /W (manufacturers datasheet and wires of 0.1 inch) $R_{th(l-a)}$ + $R_{th(j-l)}$ = $R_{th(j-a)}$ = 37.5 °C /W W1= (T_{jmax}-T_a) / $R_{th(j-a)}$ = (200-60) / 37.5 = 3.733
LCD circuit					

RS61	62Ω / 1% 1W	0.351 W	1 W	2.8	Pd = $(U_{nat\_therm} / (R_{i\_main}+RS61))^2$ x RS61 = 4.5 / $(4.455+62)^2$ x 62
RS62,65	10k Ω / 0.5% 0.33W	2.1 mW	0.33 W	>100	Pd = $U_{o\_therm}{}^2$ / RS62 = 4.5^2/ 10 k -0.5%
RS63,64	82Ω / 1% 0.75W	0.275 W	0.75 W	2.7	Pd = $(U_{nat\_therm} / (R_{i\_main}+RS63))^2$ x RS63 = 4.5 / $(4.455+82)^2$ x 82
ZD61…70	TFZ5.1B Uzmax = 5.2V / 0.5W	0.176 W	0.36 W	2.0	Pd = P_{o_buzzer} W1 = 0.36W @60°C (see.datasheet Pd-Ta)
ZD57…60	TFZ18B Uzmax =17.7V / 0.5W	0.176 W	0.36 W	2.0	Pd = P_{o_buzzer}
Backup battery circuit					
RS10	1k Ω / 1% 0.25W	2.5 mW	0.25 W	100	Pd = $U_{backup\_therm}{}^2$/ RS10 = 1.55^2/1k -1%
D7	MMSD301 Vr = 30V, If = 200mA	5.36 V 1.7 mA	30 V 200 mA	5.5 >100	U = U_{o_main2} I = I_{o_backup}
BUD-6000					
R1	10k Ω / 0.5% 0.33 W	2.1 mW	0.33 W	>100	Pd = $U_{bat\_therm}{}^2$ / R1 = 4.5^2/ 10 k -0.5%
BUL-6000					
R1,2	200Ω / 1% 0.25W	0.073 W	0.25 W	3.4	Pd = $U_{bat\_therm}{}^2$/ R1 = 3.8^2/ 200 -1%
R3	470Ω / 1% 0.25W	0.032 W	0.25 W	7.8	Pd = $U_{bat\_therm}{}^2$/ R3 = 3.8^2/ 470 -1%
R10	10k Ω / 0.5% 0.33 W	1.5 mW	0.25 W	>100	Pd = $U_{bat\_therm}{}^2$ / R10 = 3.8^2/ 10 k -1%
R11	2.2k Ω / 1% 0.25 W	0.007 W	0.25 W	35	Pd = $U_{bat\_therm}{}^2$ / R11 = 3.8^2/ 2.2 k -1%
D1,2,3	MBRD1045 Vr = 45V, If = 10A	3.8 V	30 V	7.8	U = U_{bat_therm}

During battery charging or use with charging. (non-hazardous area only)

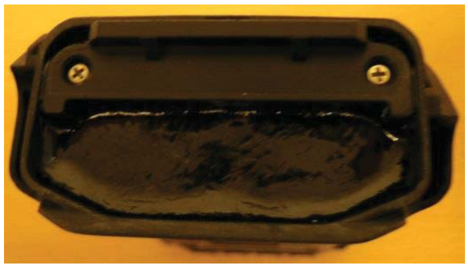
Component designation	Value	Rating used (W2)	Maximum rating (W1) @ 60 °C	W1/W2	Calculation
BUL-6000					
R1,2	200Ω / 1% 0.25W	0.071 W	0.25 W	3.5	Pd = $(U_{i\_charge} / (R1 + R28_{\_BC\text{-}6000}))^2$ x R1 = $(17.8/ (200 + 750))^2$ x 200
R3	470Ω / 1% 0.25W	0.074W	0.25 W	3.3	Pd = $(U_{i\_charge} / (R3 + R1 + R28_{\_BC\text{-}6000}))^2$ x R3 = $(17.8/ (470 + 200 + 750))^2$ x 470
R10	10k Ω / 1% 0.25 W	1.8 mW	0.25 W	>100	Pd = $U_{bat\_charge}{}^2$/ R10 = 4.2^2/ 10 k -1%
R11	2.2k Ω / 1% 0.25 W	0.146 W	0.25 W	1.7	Pd = $U_{i\_charge}{}^2$/ R11 = 17.8^2/ 2.2 k -1%
D1,2,3	MBRD1045 Vr = 45V, If = 10A $R_{TH\text{-}JC}$ = 2.43 ˚C/W T_{rise} = 24.6 ˚C VF@10A = 0.57 V, Tjmax = 175 ˚C.	17.8 V 2.72 A 1.56 W	30 V 10 A 45 W	1.7 3.6 28	U = Um I=Im Pd = Vf x Im = 0.57 V x 2.72 A = 1.56 W Pmax-diode@65˚C = $(T_{jmax} - Ta - T_{diode\text{-}rise})$ / $R_{TH\text{-}JC}$ = (175 – 40 – 24.6) / 2.43 = 45 W
BC-6000					
R1…3	120 Ω / 1%	0.034W	0.75 W	22	Pd = $V_{gs\_threshold}{}^2$ / R1 = 2.0^2 / 120 -1%

	0.75 W				
ZD1…3	1SMB5918 Uzmax = 15.8V / 3W	0.266 W	1.538 W	5.7	Pd = I_{zd} x U_{zmax} , I_{zd} = $V_{gs\_threshold}$ / R1 Pd = 2.0 / 120-1% x 15.8
Q1…3*	TPCA8107-H Vgs(th) = 2.0V Ronmax = 37mΩ Pd = 30W Tjmax = 150°C	2.74 W $97A^2S$	1.152 W $1.005A^2S$	22 96	Pd = $(\text{In} \times 1.7)^2 \times R_{onmax} = (1.6 \times 1.7)^2 \times 37m$ $R_{th(j-a)}$ = 78.1 K/W W1=(T_{jmax}-Ta)/$R_{th(j-a)}$=(150-60) / 78.1 = 1.152W I^2t = ((T_{jmax}-Ta) / $R_{th\_transient}$) / R_{onmax} x t = ((150-60) / 25) / 37m x 1 (see datasheet , fig R_{th-Tw})
R28,29	750 Ω / 1% 0.75 W	0.427W	0.75 W	1.7	Pd = $U_{i\_charge}{}^2$/ R28 = 17.8^2 / 750 -1%

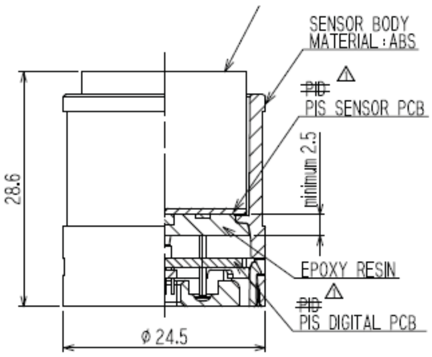
A.5 Encapsulation

A.5.1 The BUL-6000 contains two parallel battery cells, Maxell model INR18650PB (Lithium-ion battery), size : φ18*65 mm (cylindrical shape), rating 3.8V & 1450mAh, max open circuit voltage according to manufacturer = 4.25 V.

This lithium-ion battery has manganese acid on positive electrode side, which prevent the battery from generating heat. This lithium-ion battery does not have a built in “Protection Component (PTC)”. The maximum open-circuit voltage for the Li-ion battery is determined according to IEC 60079-11, clause 10.4: Determination of parameters of loosely specified components. Testing 10 samples of batteries resulted in value of 4.2V which then be used for spark energy analysis. The nominal battery voltage is used for thermal analysis and rating of components. Hence $U_{BATTherm}$ = 3.8 V and $U_{BATTspark\ energy}$ = 4,2 V. However assessments of EUT used with BUD-6000 (max 4.95V) are covering assessments of EUT used with BUL-6000.



The two batteries are placed in a plastic (PC) case. The case is filled with epoxy resin, or silicon-compound, Epoxy resin DP-270 black (3M). Encapsulation prevent ingress of external gases. The compound thickness is significant greater than the required 0.5 mm solid insulation.



A.5.2 The smart sensor type PIS has also partly encapsulation in term of requirements for safety distances. Epoxy resin is used as shown in the dedicated drawing. The encapsulation is checked for compliance with applicable requirements e.g. minimum thickness of 1mm.

A.6 Fuses.

A.6 Fuses and Charging mode

Charging of the batteries is only permitted outside the hazardous area.

Recognized fuse used. Littelfuse 216 series (5 x 20mm) Axial lead, fast acting. UL recognized E10480. In accordance to IEC60127-2, VDE approval 4001383.

The fuse used in battery charger circuit has a rating of I_N = 1.6 A; I_{Break} = 1500 A; U_m = 250 V. The charge input is protected against U_m by the fuse and a shunt voltage limiting circuit with safety components R1, R2, R3, FETs Q1,Q2,Q3 and zener diodes ZD1, ZD2, ZD3. This circuit is designed to have similar function as a crowbar circuit which handles overvoltage fault condition.

The maximum gate threshold voltage of the FET is -2.0 V which means that at this voltage the gate will be triggered and the FET will be switched on. In overvoltage fault condition the 1.7 x 1.6 A will be dissipated for a short period to earth reference (BAT – pol). The fuse will break fault current in short time. Any failure will shut down the charging mode and thereof the charging voltage.

By the shunt voltage limiting circuit, the maximum voltage is limited to be $V_{zd} + V_{gs(th)}$ = 15.8 V + 2.0 V = 17.8 V but under charging mode the Lithium-ion battery pack will pull down the charger voltage to 4.2V. Refer to Appendix C for charging test of batteries. Infallible connections to batteries are provided.

The lithium-ion cells are parallel connected by which one single cell at a time is considered for failure. Total collapse of the charger circuit and failure of both cells at the same time are considered to be unlikely.

Failure of short-circuited R1 → $V_{gs(th)}$ < 2.0V → this leads to normal charging.

Failure of short-circuited ZD1 → $V_{gs(th)}$ > 2.0V → Q1 is triggered leading high current for a short time by which the fuse will break the fault current. Fuse breaks the fault current also when Q1 is short-circuited.

Diodes D1-D3 and safety resistors in line are preventing discharging back to charger circuit or other circuits as well.

Since fault conditions of charging circuit cause shutdown of charger voltage and current break or is leading fault current to earth reference. Internal circuits beyond the charger circuit (ref. Diagram For I. S. Keep For GX-6000 E3-6991-5361-10-01K) will not be impacted.

BUL-6000 battery pack is encapsulated and therefore is exempted for spark ignition requirements. Thermal aspects have been documented by assessments of short-circuited cell.

Due to the assessed situations as mentioned above no safety distances are found necessary for safety components of the charger circuit. Positive terminal of DC input to other circuits is across the recognized fuse which is an appropriate certified device. Wiring is documented in Appendix A.3.2. Internal circuits beyond this charging level (ref. Diagram For I. S. Keep For FI-8000 E3-6991-5361-10-01K) will have 4.2V as reference voltage for assessments.

APPENDIX B: Tests

B.1 Tests of applicable standards

Refer to associated IEC60079-0 test report for documented drop test & surface resistance test.

See General product information. The design used components from similar models which are separately tested and approved. Reference to associated ExTR test reports is indicated in the documented testing. The testing of these specific components is reviewed and recognized. See throughout Appendix B to F of this report.

B.2 Spark ignition test

Higher safety factors achieved and are documented. No spark ignition test is necessary. However see throughout Appendix A to F for evaluation of internal electronics and testing of specific components e.g. batteries and piezoelectric device.

See Appendix A.2.4 to A.2.6. For internal circuits the assessed values of combination of capacitance & inductance are below 50% of the max allowed values. Ref IEC60079-11 cl. 10.1.5.2 b) 2).

See Appendix A.2.6. Internal pump is not assessed as infallible windings. However max inductance and minimum resistance is taken into account in assessments of the most severe ignition condition (situation where the winding is disconnected or short-circuited).

See Appendix A.2.6. Assessments of ignition energy were performed for buzzer (piezoelectric device).

B.3 Temperature measurements

Only least favourable cases are tested taken into account max ambient and other conditions as well. The following listed temperature measurements below are considered as worst situations where highest temperatures of components were achieved. Some specific components are in addition tested for thermal ignition capabilities. Other components should have lower temperatures in fault conditions. See also Appendix A.3

B.3.1 Measured internal temperatures of EUT (For information only. No service temperature is required. See 5.2 of associated IEC60079-0 test report).

Measured Location	ΔT °C	T_{corr} °C ¹)	Remark
GX-6000. Main unit. Normal use	8	58	$T_{a\ max}$ = 50°C
GX-6000. Main unit. Charging	10	50	$T_{a\ max}$ = 40°C
GX-6000. Main unit. Charging & use	14	54	$T_{a\ max}$ = 40°C
BUL-6000. Charging	18	58	$T_{a\ max}$ = 40°C
BUL-6000. Charging & use	18	58	$T_{a\ max}$ = 40°C
Supplementary information: **¹)** Max temperature is corrected for T_{a_max}			

B.3.2 Temperature for small components for Group I and Group II
Only highest achieved temperature for small components is listed.

Maximum power in this circuit is P_{o_main} = 1.137W. According to Table 3a&b of IEC 60079-0 a maximum of 1.2W is allowed at an ambient of 60°C for small components (>=20mm²), wiring and PCB tracks (including the FPC between main PCB to LCD). The temperature test result of the small components of each circuit is as follows.

Sensor1 circuit (representative results for both S-SEN1 & S_SEN2 circuits)

The surface temperature of the small components <20mm² measured while dissipating 0.787W.
This resulted in a maximum temperature rise is 185°C (on ESS SENSOR PCB – D1).
At ambient temperature of 60°C the maximum surface temperature would hence be 245°C which is below the 275°C limit.

1. D1 on ESS SENSOR PCB : Trise = 185°C
2. L1 on ESS SENSOR PCB : Trise = 147°C
3. ZD13 on MAIN PCB : Trise = 122°C

Pump circuit

The surface temperature of the small components <20mm² measured while dissipating 0.787W.
This resulted in a maximum temperature rise is 88°C (MAIN_PCB – Q3). At ambient temperature of 60°C the maximum surface temperature would hence be 148°C which is below the 275°C limit.

Motor circuit

The surface temperature of the small components <20mm² measured while dissipating 0.214W.
This resulted in a maximum temperature rise is 17°C (MAIN_PCB – ZD5). At ambient temperature of 60°C the maximum surface temperature would hence be 77°C which is below the 275°C limit.

Buzzer circuit

The surface temperature of the small components <20mm² measured while dissipating 0.363W.
This resulted in a maximum temperature rise is 49°C (MAIN_PCB – D4).
At ambient temperature of 60°C the maximum surface temperature would hence be 110°C which is below the 275°C limit.

1. D4 on MAIN PCB : Trise = 49°C
2. IC41 on MAIN PCB : Trise = 48°C

Main circuit

The surface temperature of the small components <20mm² measured while dissipating 1.137W.
This resulted in a maximum temperature rise is 204°C (SENSOR_PCB – NF3). At ambient temperature of 60°C the maximum surface temperature would hence be 264°C which is below the 275°C limit.

1. NF1 on MAIN PCB : Trise = 204°C
2. PT1 on MAIN PCB : Trise = 178°C
3. D9 on MAIN PCB : Trise = 156°C
4. Q16 on MAIN PCB : Trise = 127°C
5. Q3 on SENSOR PCB : Trise = 127°C

LCD circuit

The surface temperature of the small components <20mm² measured while dissipating 0.176W.
This resulted in a maximum temperature rise is 33°C (MAIN_PCB – NF4). At ambient temperature of 60°C the maximum surface temperature would hence be 93°C which is below the 275°C limit.

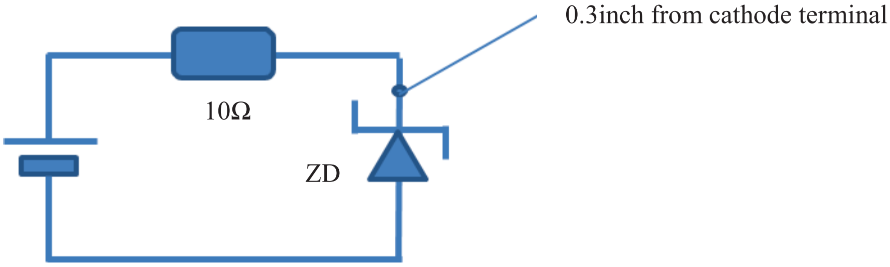
B.3.3 Temperature measurement of shunt zeners

For all shunt zeners used in internal electronics, only worst case of testing of shunt zeners is considered taken into account layouts and other influences with regards to thermal aspects. Max measured values of the worst case is considered to be representative result.

Worst case of shunt zeners for EUT is ZD71 type 1N5338B which is used in Main circuit with max dissipated power 1138mW (from BUD-6000).

The same zener type 1N5338B was used in another model GX-8000 which was tested and covered by test report NL/KEM/ExTR10.0035/00. This testing was reviewed and recognized as representative for the worst case of shunt zeners of this investigation.

Test procedure	Standard reference	Results	Test report ref.
Determination of R_{th} of ZD1	IEC 60079-11 Clause 10.2	ΔT = 39.4K with P = 1.14 W => $R_{th(l-a)}$ = 34.6K/W. Measuring point is 0.3 inch from cathode terminal.	NL/KEM/ExTR10.0035/00 2009-09-25

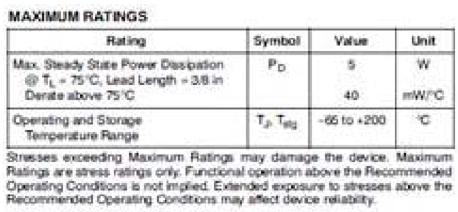


U_{zmax} = 5.36V / 5W, manufacturer ON specification:
$R_{th(j-l)}$ = 16 K/W with 0,3 inch lead length.
T_{jmax} = 200°C

Ta	50°C
dT	10K
T_{amax}	60°C
T_{jmax}	200°C
Pd	5W
Po_max	1.14W
Rth(j-l)	16.0K/W. See Fig. 1
Rth(j-l)	34.6K/W. See result sheet
Rth(j-a)	**50.6K/W**
Max rating	2.767W
2/3 rating	1.84W

Tj = 40.8 + 50 + 1.2 * 16 = 110°C

Measuring point 0.3 in from cathode terminal.


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Max. Steady State Power Dissipation @ T_L = 75°C, Lead Length = 3/8 in Derate above 75°C	P_D	5 40	W mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +200	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

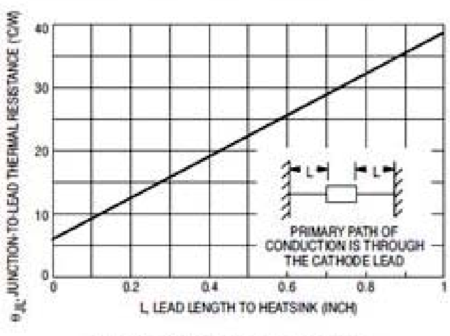


Figure 1. Typical Thermal Resistance

Measured lead temperatures of zener diode “1N5338B” (0.5W to 1.2W). Results from test report no. NL/KEM/ExTR10.0035/00

	Vz (V)	Vr (V)	Iz (A)	Pzd (W)	Ta (degC)	dT (K)	Rth(1-a)
No. 1	0	0	0	0	25,5	0,0	0
	5,094	0,973	0,0973	0,496	40,9	15,4	31,07
	5,104	1,16	0,116	0,595	45,7	20,2	33,97
	5,113	1,356	0,1356	0,693	49,3	23,8	34,33
	5,121	1,554	0,1554	0,796	52,6	27,1	34,05
	5,130	1,756	0,1756	0,901	56,6	31,1	34,52
	5,137	1,946	0,1946	1,000	59,3	33,8	33,81
	5,145	2,133	0,2133	1,097	62,4	36,9	33,62
	5,148	2,212	0,2212	1,139	63,7	38,2	33,55
	5,152	2,328	0,2328	1,199	65,4	39,9	33,27

	Vz (V)	Vr (V)	Iz (A)	Pzd (W)	Ta (degC)	dT (K)	Rth(1-a)
No. 2	0	0	0	0	27,0	0,0	0
	5,032	0,99	0,099	0,498	42,2	15,2	30,51
	5,041	1,189	0,1189	0,599	46,8	19,8	33,03
	5,053	1,389	0,1389	0,702	51,2	24,2	34,48
	5,060	1,572	0,1572	0,795	54,4	27,4	34,45
	5,069	1,778	0,1778	0,901	58,0	31,0	34,40
	5,076	1,967	0,1967	0,998	61,1	34,1	34,15
	5,082	2,155	0,2155	1,095	64,0	37,0	33,78
	5,085	2,238	0,2238	1,138	65,5	38,5	33,83
	5,090	2,358	0,2358	1,200	67,8	40,8	33,99

Max 34,52

B.3.4 Other temperature measurements and thermal ignition test of specific components

Part / Location	**V (V)**	**I (mA)**	**P (mW)**	**ΔT (°C)**	**T (°C) ¹)**	**Limit**	**Remark**
R12-30Ω size 1005 (ESS sensor PCB)	5.06	156	789	72.8	118.5	275	P
R1-10Ω size 1005 (DES digital PCB)	3.14	257	807	105.9	155.9	275	P
R3-3Ω size 3216 (Sensor PCB)	2.44	474	1157	62.3	112.3	275	P
Supplementary information: **¹)** The measured temperature was corrected for max rated ambient (50°C). Only a few cases which may represent the least favourable situations are tested. Test performed on 2015-03-13 in ambient of 22.9°C							

See Appendix B.6 for test of specific components

B.4 Infallible distance & connection measurements

B.4.1 Infallible distances: CR & CL → creepage & clearance. All values are in mm.

Maximum voltage of circuit on the following is below 10V and therefore the following segregation distances shall be applied according to table 5 of IEC 60079-11:

Location *)	CL	CR	Min. ¤)	CTI
Sensor circuits. Voltage area < 10V.				
RS11…RS15 Sens1 circuit to battery	3.2	3.2	1.5	>100
RS21…RS25 Sens2 circuit to battery	3.2	3.2	1.5	>100
RS81…RS87 Sens1 to other circuits	1.6	1.6	1.5	>100
RS91…RS97 Sens2 to other circuits	1.6	1.6	1.5	>100
Pump circuit. Voltage area < 10V.				
RS31…RS35 (to battery)	3.2	3.2	1.5	>100
RS37…RS39 (to other circuits)	1.6	1.6	1.5	>100
Solid insulation (pump body and wiring) **>0.5 ¹)**	—	—	0.5	>100
Motor circuit. Voltage area < 10V.				
RS51, RS52 (to battery)	3.2	3.2	1.5	>100
RS59 (to other circuits)	1.6	1.6	1.5	>100
Buzzer circuit. Voltage area < 10V.				
R41…R43 (to battery)	3.2	3.2	1.5	>100
RS47…RS49 (to other circuits)	1.6	1.6	1.5	>100
Solid insulation (buzzer body and wiring) **>0.5 ¹)**	—	—	0.5	>100
Buzzer. **²)**	—	—	—	—
Main circuit. Voltage area < 10V.				
RSA1…RSA5	1.6	1.6	1.5	>100
RSB1…RSB5	1.6	1.6	1.5	>100
RSC1…RSC5	1.6	1.6	1.5	>100
RS61…RS65	1.6	1.6	1.5	>100
Backup circuit. Voltage area < 10V.				
D7	2.4	2.4	1.5	>100
RS10	1.6	1.6	1.5	>100
BUD-6000. Voltage area < 10V.				
R1	1.6	1.6	1.5	>100
Encapsulated BUL-6000. V_{bat}= 4.2V considered.				
D1-D3 measured across components	1.0	1.0	0.5	>100
R1 to adjacent tracks	1.3	1.3	0.5	>100
R2 to adjacent tracks	1.3	1.3	0.5	>100
R3 measured across components	2.3	2.3	0.5	>100
R10 measured across components	2.3	2.3	0.5	>100
R11 to adjacent tracks	0.5	0.5	0.5	>100
Voltage areas of Um				
Charger circuit	**³)**	**³)**	**³)**	>175

Supplementary information:
***)** Distances across component and to adjacent tracks are checked.
¤) Wiring & body material insulation.
¹) All internal wiring aspects such as arrangement or solid insulation are checked and recognized. See also Appendix A.3.2.
²) The buzzer and it's wiring is assessed and is documented in Appendix A.3.2 and A.2.6.
³) Assessment of charger circuit is documented in Appendix A.6. No safety distances are required for R1 to R3. Positive terminal of DC input to other circuits is across the recognized fuse which is an appropriate certified device. Wiring is documented in Appendix A.3.2.

B.4.2 Infallible connections

Connection	Method *)	Comment
Sensor circuits		
ZD11, ZD12 to IC11	2 mm track	35 µm
ZD21, ZD22 to IC12	2 mm track	35 µm
ZD11, ZD12, ZD21, ZD22 to 0V	2 mm track	35 µm
Buzzer circuit		
ZD45 – ZD46 to safety resistors in line	2 mm track	35 µm
ZD45 – ZD46 to 0V	2 mm track	35 µm
ZD41 – ZD44 & ZD47 – ZD48 to safety resistors in line	2 mm track	35 µm
ZD41 – ZD44 & ZD47 – ZD48 to 0V	2 mm track	35 µm
ZD49 – ZD52 to CN4 (Main PCB)	2 mm track	35 µm
ZD49 – ZD52 to 0V (Main PCB)	2 mm track.	35 µm
Main circuit		
ZD71 – ZD72 to IC71	2 mm track & single 2 mm circumference via	35 µm
ZD71 – ZD72 to 0V	2 mm track & single 2 mm circumference via	35 µm
LCD circuit		
ZD57 – ZD60 to CN6 (LCD) & 0V	2 mm track.	35 µm
ZD61 – ZD70 to safety resistors in line	2 mm track.	35 µm
ZD61 – ZD70 to 0V	2 mm track.	35 µm
BC-6000		
R1, R2, R3 to F1 and source terminal of Q1, Q2, Q3	2 mm track	35 µm
R1, R2, R3 to ZD1, ZD2, ZD3	2 mm track	35 µm
R1, R2, R3 to gate terminal of Q1, Q2, Q3	1mm track [1])	35 µm
ZD1,ZD2,ZD3 and Q1,Q2,Q3 to 0V	2 mm track	35 µm
BUL-6000		
D1-D3 & R1, R2, R11 to B+	2 mm track [2])	35 µm
R10 & CN1-1 to B+	2 mm track	35 µm
B- to 0V	2 mm track	35 µm
Wiring to buzzer & pump	[3])	-

Supplementary information:
*) Required minimum width of track/connection is checked. Larger track width is documented in Layout-documents. Refer to List of Descriptive documents
[1]) Use of triplicate controllable semiconductors. Open-circuiting is considered as one countable fault. Situations of two countable faults at a time is assessed.
[2]) Min 2mm track/connections between those components are not required but are used. The connections help to reduce temperature on components.
[3]) Wiring is documented in Appendix A.3.2

B.5 Dielectric strength test

Suitable (UL approved) insulated wiring used. No dielectric strength test is found necessary.

B.6 Test of specific components.

- Appendix C: Testing of batteries
- Appendix D: Testing of lamp part (T- 3/4 BPA in DES sensor)
- Appendix E: Testing of combustible sensor NC6264A
- Appendix F: Assessment of the smart sensor type PIS

B.6.1 Test of batteries

Battery testing is documented by Test reports NL/KEM/ExTR10.0035/00 & NL/DEK/ExTR13.0075/00. See Appendix C.

B.6.2 Test of Lamp part type OL-82708PA

Testing of Lamp part type OL-82708PA which is used in DES sensor, is documented by Test report NL/DEK/ExTR12.0033/00. See Appendix D.

B.6.3 Test of sensors

Listed below are different types/models of sensors which are included in this investigation. They are sorted into following detection principles (See Appendix A.1 for details). Electrochemical, Galvanic cell, Catalytic combustion, PID, Infrared ray (IR). The sensor types in a) and b) are standard gas sensors (See Appendix A.1 for details).

a) The Oxygen sensor used “Galvanic cell” detection principle, ref. M4-4080-82-07K. The toxic gas sensors used “Electrochemical” detection principle, ref. M4-4084-92-03K & M4-4084-30-08K. These type of sensors consist of no energy storing/generating components/parts in the sensors. Only internal wiring has been considered and is included in temperature assessment/test in Appendix A.3 & B.3. Based on the design and dedicated application these types of sensor need no further assessment.

b) The combustible gas sensor NC6264A used “Catalytic combustion” detection principle. This sensor type consists only internal coil but no other components. The NC6264A sensor is a separately Ex certified device and the testing is documented in NL/KEM//ExTR07.0057. Applicable requirements are considered for this sensor. Associated test reports were reviewed and recognized for compliance of this investigation. Results of testing are copied to Appendix E.

c) The smart sensor type ESS consists of a small electronic PCB and a toxic gas sensor. The toxic gas sensor is considered in a), “Electrochemical” detection principle is used. The ESS sensor circuit/electronics consists no safety components and therefore is treated as part of the Sensor circuit. This circuit is included in temperature assessment/test in Appendix A.3 & B.3. Refer to dedicated files in List of descriptive documents.

d) The smart sensor type DES consist of small DES digital PCB & DES sensor PCB including the T-3/4 BPA Lamp, “Infrared ray (IR)” detection principle is used. Refer to files numbered 28 to 31 in List of descriptive documents. Both circuits of DES digital PCB & DES sensor PCB used no safety components and therefore are treated as part of the main circuit. These circuits are included in temperature assessment/test in Appendix A.3 & B.3.
The T- 3/4 BPA Lamp is a separately Ex certified device which testing is documented in ExTR12.0033. Associated test reports were reviewed and recognized for compliance of this investigation. The testing is extracted and copied into this report, see Appendix D of this report.

e) The smart sensor type OSS consists of a small electronic PCB and Oxygen sensor. The Oxygen sensor is considered in a), “Electrochemical” detection principle is used. The OSS sensor circuit/electronics consists no safety components and therefore is treated as part of the Sensor circuit. This circuit is included in temperature assessment/test in Appendix A.3 & B.3. Refer to dedicated files in List of descriptive documents.

f) The smart sensor type PIS consist of two small PCB, PIS digital PCB and PIS sensor PCB, and the separately certified Mini PID sensor. The Mini PID sensor is covered by certificate 07ATEX0060U and associated test reports GB/BAS/ExTR07.0056/00. Additional assessment for intrinsic safe connection is documented in Appendix F.

Appendix C

Appendix C.1 Separately tested batteries

Results from test report no. NL/KEM/ExTR10.0035/00

B.3 Determination of parameters of loosely specified components

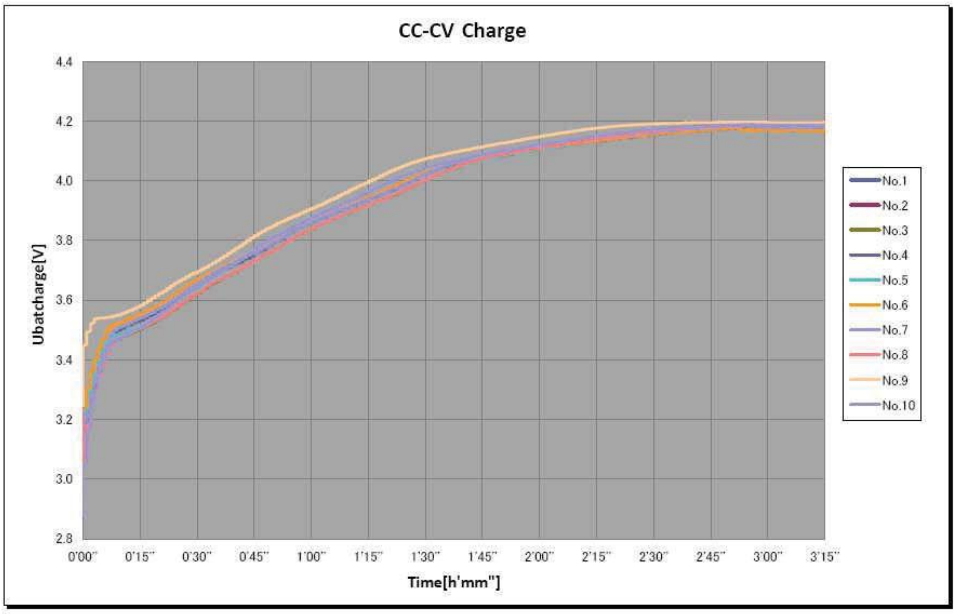
Test procedure	Standard reference	Results	Test report ref. (date of test)
Determination of maximum battery voltage during charging	IEC 60079-11 Clause 3.6.6	A voltage measurement has been done over the two batteries inside the GX-8000 on 10 different cells and combination while charging the batteries. The maximum voltage was: 4.25 V	2009-11-02, 2009-06-3,4,5

Measurement result of Ubatcharge

2009/11/2
RIKEN KEIKI Co.,Ltd.

Charge current (CC): 1.5A
Charge voltage(CV):4.2V
Charger IC:LTC4002-4.2(LT)

	Umax
No.1	4.187V
No.2	4.180V
No.3	4.187V
No.4	4.181V
No.5	4.188V
No.6	4.198V
No.7	4.188V
No.8	4.180V
No.9	4.198V
No.10	4.189V
MAX	4.198V
AVG	4.188V
sigma	0.0065V
AVG+3σ	4.204V



The maximum voltage during battery charge with 1,5 A, is verified in section B.5.

B.3 Battery test report

Test procedure	Standard reference	Results	Test report ref. (date of test)
Determination of maximum battery temperature when shorted and leakage	IEC 60079-11 Clause 10.5 and 23.8	On 3 types of batteries:, Primary battery Alkaline LR6 manufactured by Toshiba, secondary Lithium-ion battery type INR18650PB manufactured by Maxell and primary battery Lithium manganese dioxide, type CR1220.	2008-04-22, 2009-06-3,4,5, 2010-04-19
Determination of maximum battery temperature when shorted and leakage	IEC 60079-11 Clause 10.5	Secondary Lithium-ion battery type US18650VTC3 manufactured by Sony and type INR18650-15M manufactured by SDI. No leakaqe after testinq.	NUDEK/ExTR 13.0075/00

B.2.1 Test conducted

Equipment Tested:	Primary Battery cell Alkaline type LR6 manufactured by Toshiba
Date of Test (yyyy/mm/dd):	2008-04-22 (refer to report NL/KEM/ExTR08.0019/00)
Clause and Standards:	Clause 10.5, IEC 60079-11

B.5.1 Test procedures

10.5.1 General:

[X] Non rechargeable cells shall be checked if they are newly supplied cells from the cell manufacturer and fully charged (e.g. with a voltage test for a short period with a certain load)

10.5.2 Electrolyte leakage test for cells and batteries:

Ten test samples are subjected to the most onerous of the following: [X]

short circuit until discharged;
[NA] application of input or charging currents within the manufacturer's recommendations; [NA]
charging a battery within the manufacturer's recommendations with one cell fully discharged or suffering from polarity reversal.

The test samples shall be placed with any case discontinuities, for example seals, (the + pole in most cases) facing downward or in the orientation specified by the manufacturer of the device, over a piece of blotting paper for a period of **at least 12 h** after the application of the above tests.

10.5.3 Spark ignition and surface temperature test of cells and batteries:

[NA] Spark ignition assessment or testing shall be carried out at the cell or battery external terminals using a gas mixture for Gas group IIA/IIB/IIC including/excluding safety factor.

[X] The short circuit current is determined taking the most onerous value of short-circuit current from a test of 10 samples of the cell/battery

[X] The maximum surface temperature is be determined as follows. All current-limiting devices external to the cell or battery shall be short-circuited for the test. Any external sheath (of paper or metal, etc.) not forming part of the actual cell enclosure shall be removed for the test. The temperature shall be determined on the outer enclosure of each cell or battery and the maximum figure taken.

10.5.4 Battery container pressure test:

[NA] Five samples of the battery container shall be subjected to a pressure test to determine the venting pressure. Pressure shall be applied to the inside of the container. The pressure is to be gradually increased until venting occurs. The maximum venting pressure shall be recorded and shall not exceed 30 kPa. The maximum recorded venting pressure shall be applied to a sample of the battery container for a period of at least 60 s.

B.1.2 Test conditions

10.5.1 General:

When a short-circuit is required for test purposes the resistance of the short-circuit link, excluding connections to it, either shall not exceed 3 mΩ or have a voltage drop across it not exceeding 200 mV or 15 % of the cell e.m.f. The short-circuit shall be applied as close to the cell or battery terminals as practicable. This resistance should be measured before and after a short circuit test and recorded in the lab report.

10.5.2 Electrolyte leakage test for cells and batteries:

The electrolyte leakage test shall be conducted at the most onerous temperature for this type of cell which might require a number of additional test (and hence additional samples) before the real test can be started. For this cell the most onerous temperature is determined at 55 ºC.

10.5.3 Spark ignition and surface temperature test of cells and batteries:

Since the temperature behavior of batteries is considered to be non-linear the temperature test is conducted at the highest ambient temperature (see IEC 60079-11 cl. 10.2).
For this apparatus the maximum ambient temperature is 55 ºC.

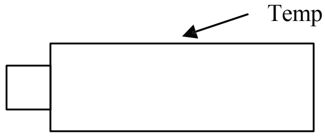
10.5.4 Battery container pressure test:

Not applicable

B.1.3 Results

The wire resistance of the shorted batteries was 2 mΩ before the test and remained 2 mΩ after test.

Cell number	10.5.2 Electrolyte leakage	10.5.3 a) Short circuit current	10.5.3 b) Temperature test			
			Temp Battery	Toven	Tamb	deltaT
1	**Y**	8,2 A	114,8	54,1		61,7
2	N	7,5 A	120	55,4		**65,8**
3	N	8,8 A	108,1	58,8		54,7
4	**Y**	8,5 A	115,9	55,7		60,5
5	N	8,4 A	111,5	55,1		57,3
6	N	8,2 A	112	58,2		54,1
7	N	7,8 A	114,1	58,3		57,1
8	N	**9 A**	116,3	58,1		59,2
9	N	8,5 A	116,3	55,3		62,5
10	N	8 A	120,9	60,5		62,3



[ ] no electrolyte leakage
[ ] no ignition during spark ignition test
[ ] no drop in pressure during battery container test
[ ] no visible damage or permanent deformation after battery container test

B.5 Battery pack test report (continued)

Equipment Tested:	Secondary Lithium-ion battery cell INR18650PB manufactured by Maxell
Date of Test (yyyy/mm/dd):	2009-06-3,4,5
Clause and Standards:	Clause 10.5, IEC 60079-11

IEC 60079-11 – Clause 10.5
Test for Lithium ion cells (chargeable)

Project no.: <u>212431400</u>
Product: Li-ion pack test
technician: R.Rouwenhorst
Test conducted on: June 3, 4, 5, 2009

Manufacturer: EMC Systems Corp.
Type designation: Lab
Sample no.: 107452
Test report page no.:

Cell types

60079-0 : 2007, clause 23.3 Cell types:

[**x**] Only cell types referred to in published IEC cell standards having known characteristics shall be used. Tested Lithium-ion cell types not in table **11 secondary cells**. Manufacturing battery cell type **with negative electrode material is Lithium, nominal voltage is 3,7 V, maximum open-circuit voltage is 4,17 V (measured), by manufacterer 4,25 V.**

60079-11:2006 – Clause 10.4 Determination of parameters of loosely specified components

[**x**] Tests are in accordance with the appropriate international standard, being:IEC60079-11, sub 7.1 and 10.4 Ten unused samples of the component shall be obtained from any source or sources of supply and their relevant parameters shall be measured. Tests shall normally be carried out at, or referred to, the specified maximum ambient temperature, for example 40 °C, but where necessary, temperature-sensitive components, for example nickel cadmium cells/batteries, shall be tested at lower temperatures to obtain their most onerous conditions.

The most onerous values for the parameters, not necessarily taken from the same sample, obtained from the tests on the 10 samples shall be taken as representative of the component.

Lithium-ion battery tested on 10 samples during charge cycles: **nominal voltage is 3,7V (just after fully charged) , maximum open-circuit voltage is 4,17 V, maximum current is not measured.**

Test procedure:

10.5.1 General:

[**x**] Rechargeable cells or batteries shall be fully charged with a current of **0,870 A** for a period of at least **100 min** and then discharged at least twice with a current of **1,45 A** before any tests are carried out. On the second discharge, or the subsequent one as necessary, the capacity of the cell or battery shall be confirmed as being within its manufacturer's specification to ensure that tests can be carried out on a fully charged cell or battery which is within its manufacturer's specification.

Discharge duration = Capacity / Discharge Current = **1450 mAh / 1450 mA = 60 min**.
Charge duration = Capacity / Charge Current = **1450 mAh / 0,870 mA = 100 min**.

10.5.2 Electrolyte leakage test for cells and batteries:

Ten test samples are subjected to the most onerous of the following:

[**x**] short circuit until discharged; at an ambient temperature from 50 + 5 degrees, without the external battery protection components, this according to EN 60079-11, clause 10.5.3 b). Prepare cells with caution:

- Prepare single cells, each with a switch for shortage (< 3mΩ resistance end-to-end)
- Prepare, mount thermocouples on each cell. Put cells each in blotting paper.
- Pre heat prepared cells in oven on ambient temperature + 5 degrees.
- After all cells are at ambient temperature, put all prepared cells outside the building.
- Connect thermocouples to temperature storage equipment, and start measurement.
- Close the switch(es) and leave the cells immediately.
- Wait until temperature drops around room temperature.
- Store all temperature results and check cell leakage on blotting paper.

The test samples shall be placed with any case discontinuities, for example seals, (the + pole in most cases) facing downward or in the orientation specified by the manufacturer of the device, over a piece of blotting paper for a period of **at least 12 h** after the application of the above tests.

10.5.3 Spark ignition and surface temperature test of cells and batteries:

[ ] Spark ignition assessment or testing shall be carried out at the cell or battery external terminals using a gas mixture for Gas group IIA/IIB/IIC including/excluding safety factor.

[ ] The short circuit current is determined taking the most onerous value of short-circuit current from a test of 10 samples of the cell/battery

[ ] The maximum surface temperature is be determined as follows. All current-limiting devices external to the cell or battery shall be short-circuited for the test. Any external sheath (of paper or metal, etc.) not forming part of the actual cell enclosure shall be removed for the test. The temperature shall be determined on the outer enclosure of each cell or battery and the maximum figure taken.

10.5.4 Battery container pressure test:

[ ] Five samples of the battery container shall be subjected to a pressure test to determine the venting pressure. Pressure shall be applied to the inside of the container. The pressure is to be gradually increased until venting occurs. The maximum venting pressure shall be recorded and shall not exceed 30 kPa.The maximum recorded venting pressure shall be applied to a sample of the battery container for a period of at least 60 s.

Test equipment: see attached equipment list

Test conditions:

10.5.1 General:

When a short-circuit is required for test purposes the resistance of the short-circuit link, excluding connections to it, either shall not exceed 3 mΩ or have a voltage drop across it not exceeding 200 mV or 15 % of the cell e.m.f. The short-circuit shall be applied as close to the cell or battery terminals as practicable.
This resistance should be measured before and after a short circuit test and recorded in the lab report.

10.5.2 Electrolyte leakage test for cells and batteries:

The electrolyte leakage test shall be conducted at the most onerous temperature for this type of cell which might require a number of additional test (and hence additional samples) before the real test can be started.
For this cell the most onerous temperature is determined at **55 ºC**.

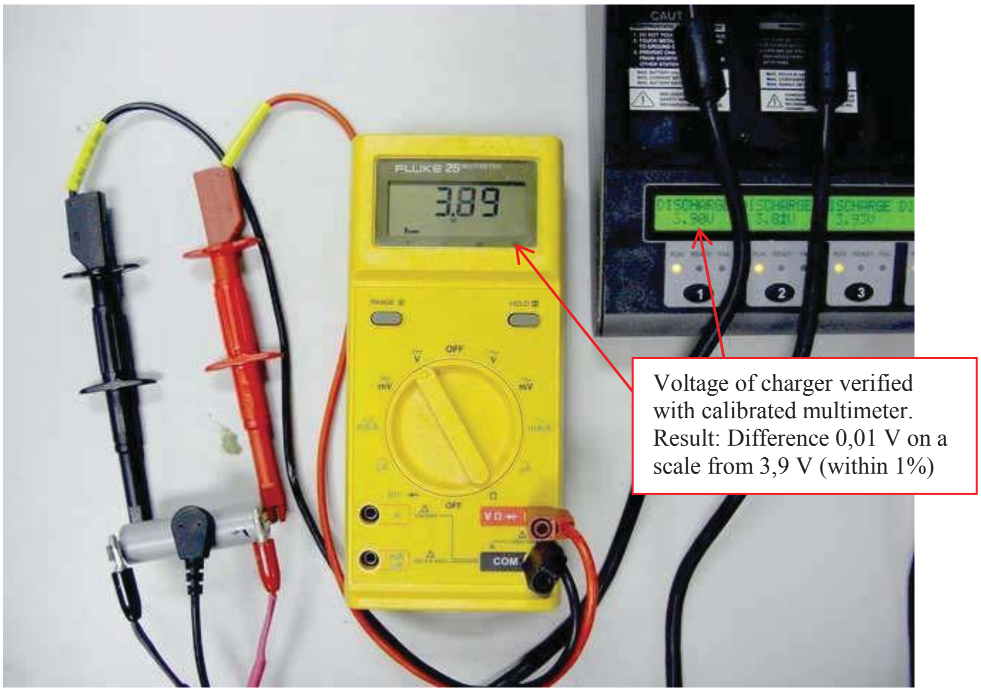
10.5.3 Spark ignition and surface temperature test of cells and batteries:

Since the temperature behaviour of batteries is considered to be non-linear the temperature test is conducted at the highest ambient temperature (see IEC 60079-11 cl. 10.2).

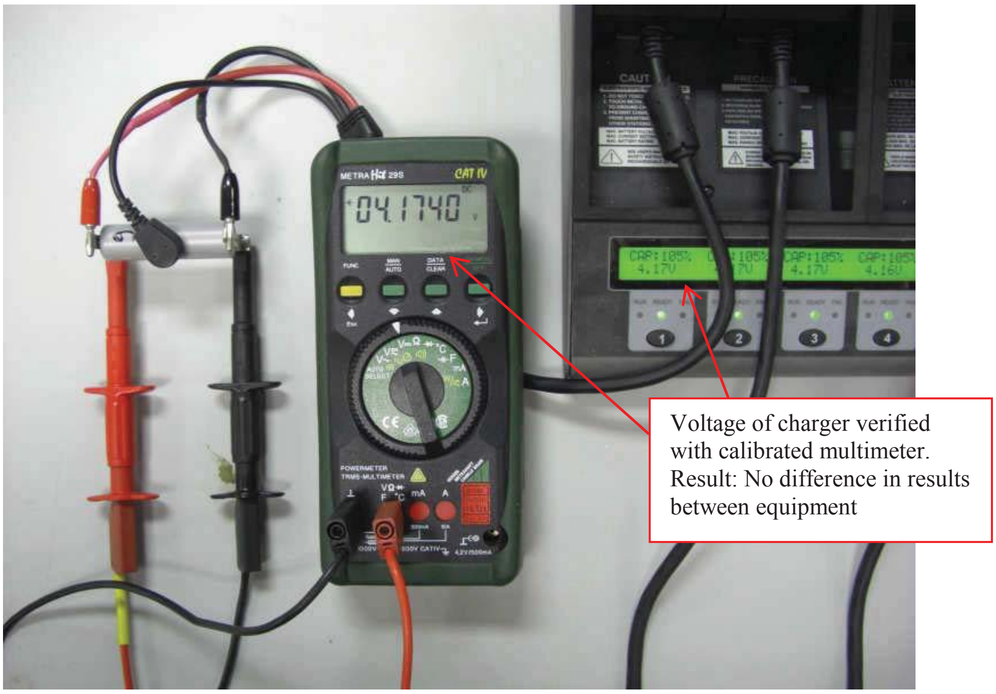
For this apparatus the maximum ambient temperature is **50 ºC**.

Test results charging batteries
(60079-11:2006 – Clause 10.4 Determination of parameters of loosely specified components)

Measurement of current and voltages by li-ion charger (when discharging with 1,5 A)

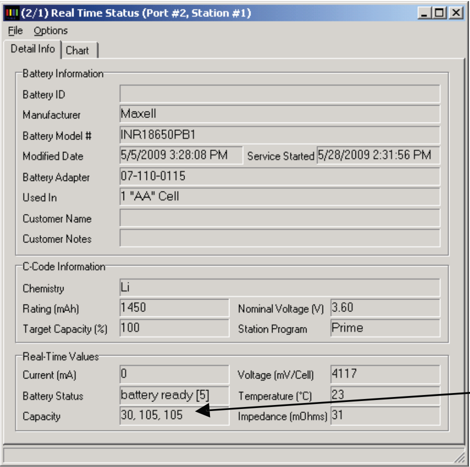


Measurement of current and voltages by li-ion charger (battery 9, fully charged)

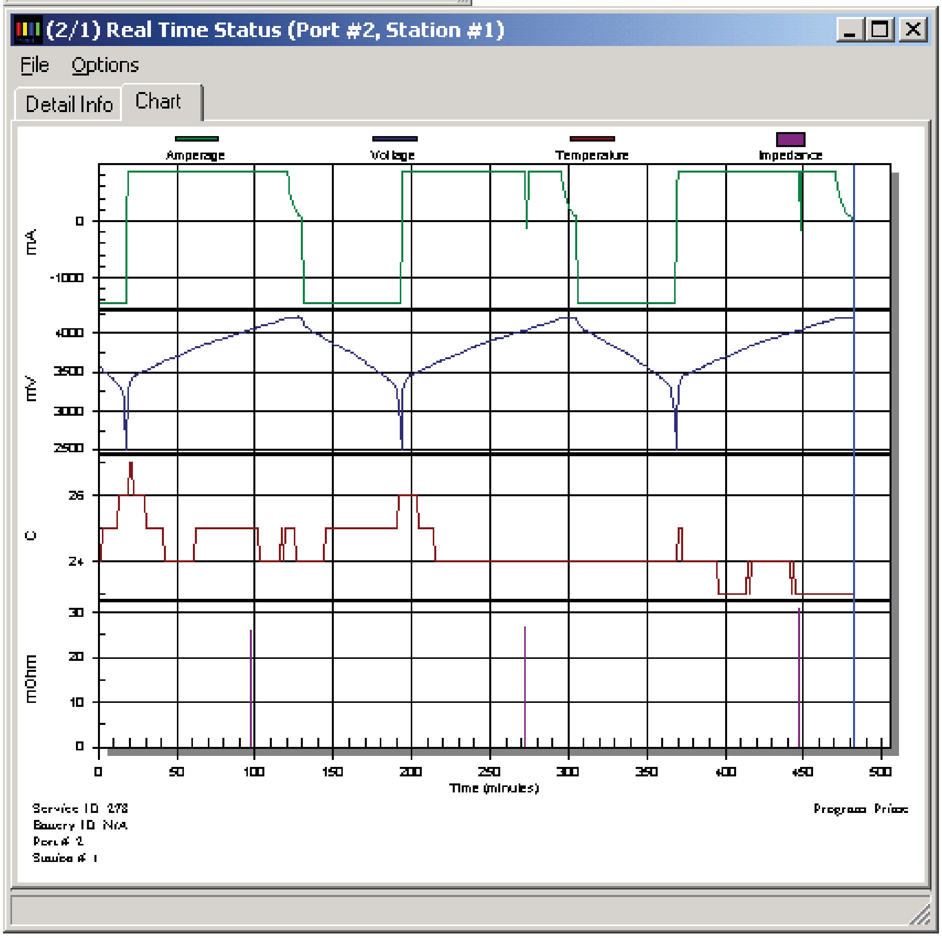


Multimeter, number: ORS 118263, Calibrated on 2008-06-30 (due July 2009)

Charging results Battery 1:



Capacitance is 5% more than 1450mAh stated by the manufacturer, which result is satisfactory.



battery results of batteries 2 to 10 are comparable.
The maximum voltage at 1,5 A battery charge remain below 4,2 V.

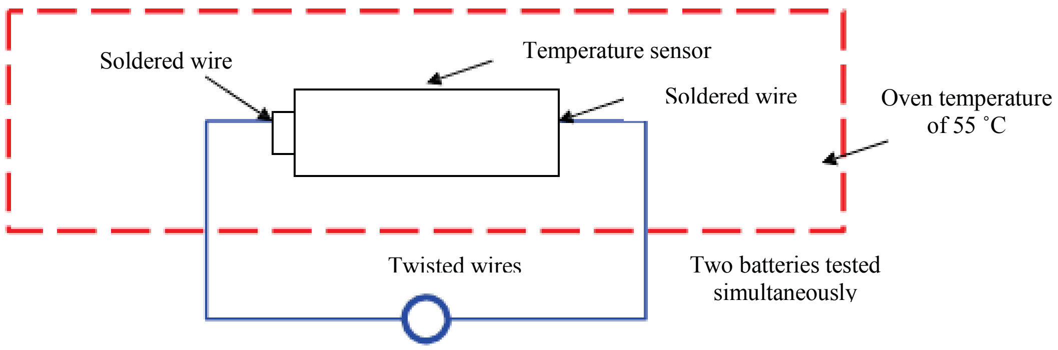
Battery capacitance
Discharge duration = Capacity / Discharge Current = 1450 mAh / 1500 mA = 58 min, actually measured 61 min.
Thus the capacitance is 61 min / 58 min = 5% more capacitance than 1450mAh, which result is satisfactory.

Test results (10.5.2 Electrolyte leakage test for cells and batteries)
Short circuit resistance is 2 mΩ measuread before and after test.

Cell no.	10.5.2 Electrolyte leakage	Battery cell discharge graph no. / reference number	10.5.3 b) Temperature test		
			temperature [˚C]		Oven* "ambient" Temperature [˚C] Absolute
			Max.	**delta**	
1	none	1 / 13332	69,5	**14,5**	55,0
2	yes	1 / 13332	94,0	**40,5**	53,5
3	none	2 / 13335	65,4	**10,5**	54,9
4	none	2 / 13335	65,7	**10,3**	55,4
5	yes	3 / 13339	125,7	**70,6**	55,1
6	none	3 / 13339	130,1	**74,5**	55,6
7	none	4 / 13346	70,6	**16,2**	54,4
8	none	4 / 13346	66,8	**11,0**	55,8
9	none	5 / 13367	64,0	**10,1**	53,9
10	none	5 / 13367	<u>128,7</u>	**<u>74,8</u>**	53,9

* Note: measured just before the short from each battery cell

Schematic of battery test



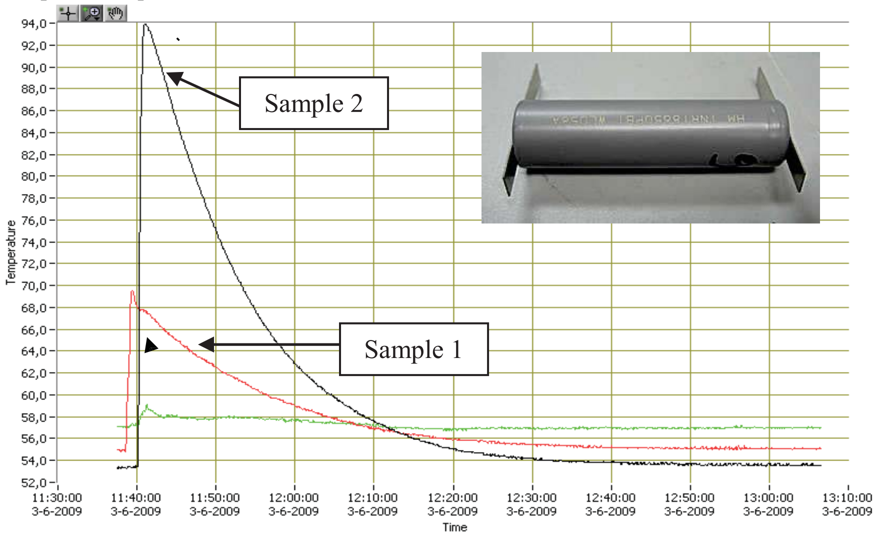
Conclusion

The maximum temperature rise because cell short is **74,8 ˚K**, measured at an ambient temperature of 55 ˚C. **Two samples showed some electrolyte leakage after test.**

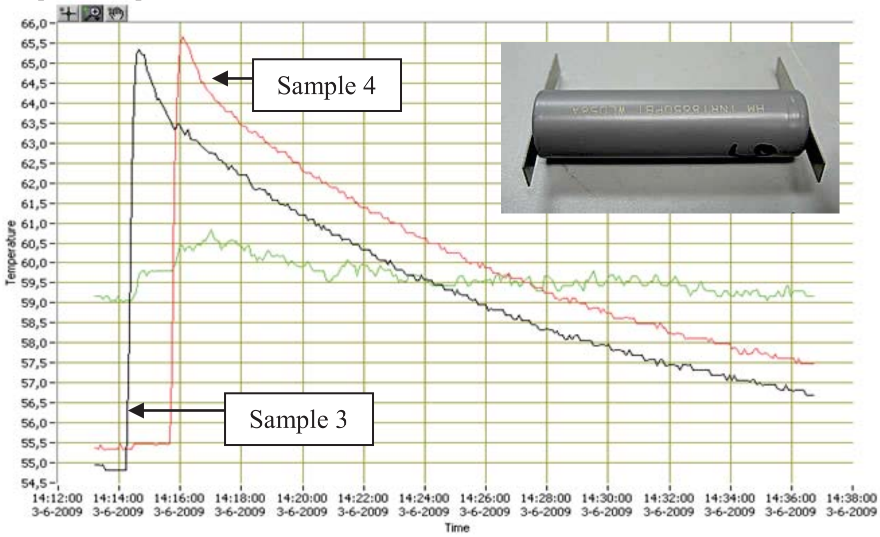
[ ] no electrolyte leakage
[ ] no ignition during spark ignition test
[ ] no drop in pressure during battery container test
[ ] no visible damage or permanent deformation after battery container test [**x**]
[x] other**: FAIL on electrolyte leakage on two samples.**

Equipment:
Temperature measurement: LabDAQ 2 2.5.1, TS-043, Calibrated on 2009-01-27 (due date 2010-01) Other equipment: Oven, multimeter ORS 110570

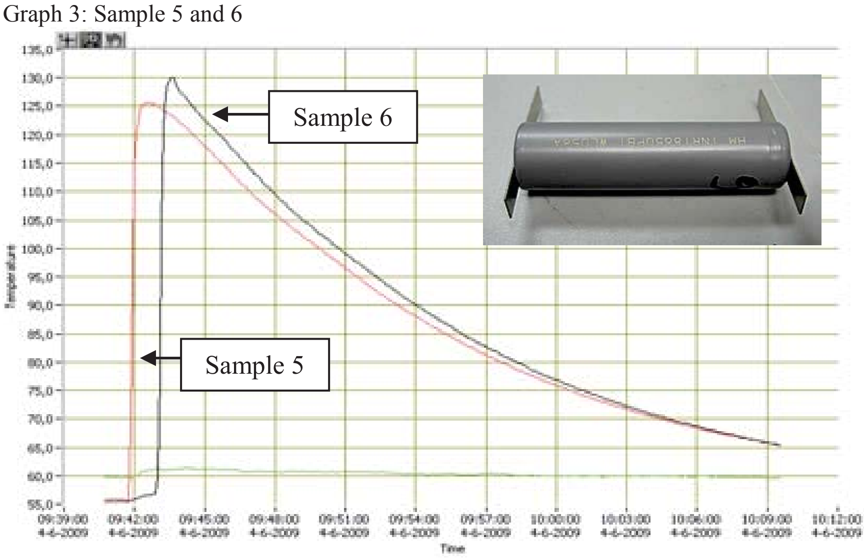
Graph 1: Sample 1 and 2



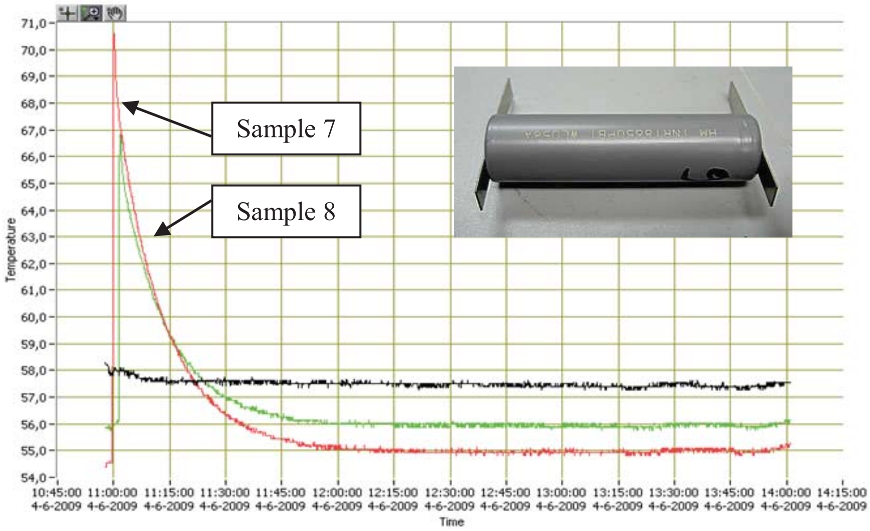
Graph 2: Sample 3 and 4



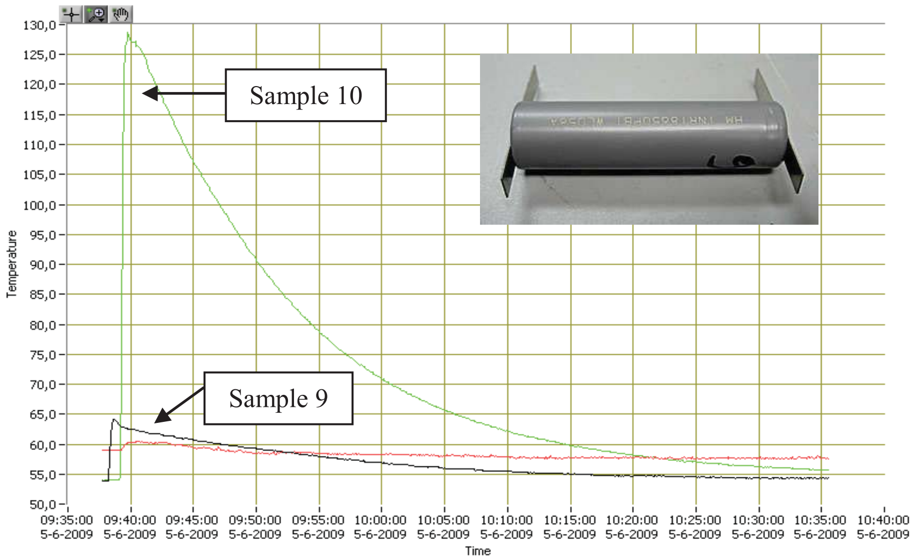
Graph 3: Sample 5 and 6



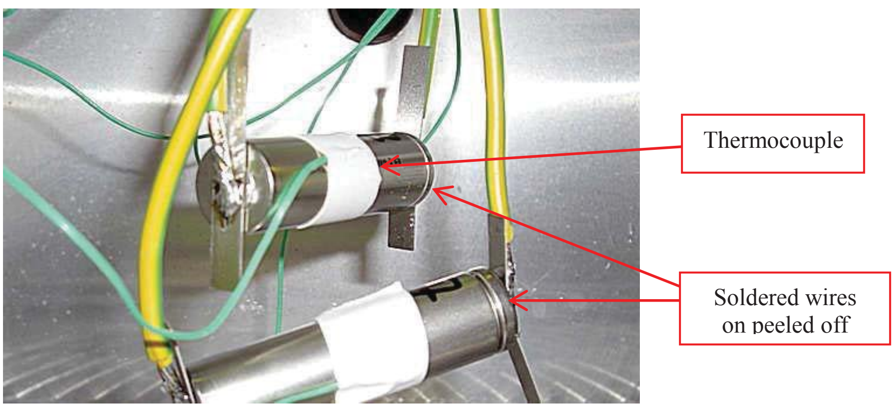
Graph 4: Sample 7 and 8



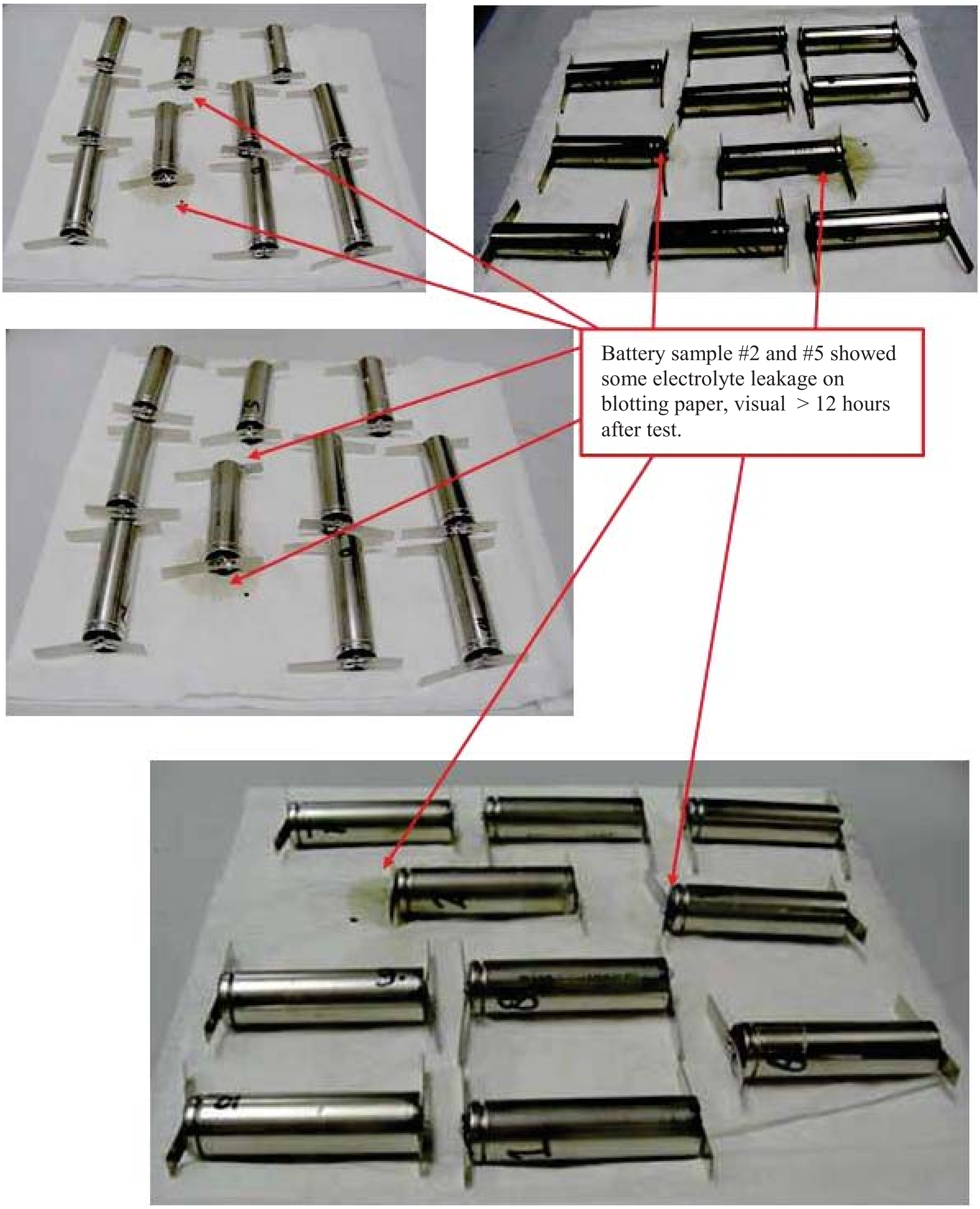
Graph 5: Sample 9 and 10



Pictures during test
Batteries 7 and 8 just before start of temperature test



Electrolyte Leakage test, minimal 12 hours after test.



Temperature test at T_{amb} = 60 ˚C

The battery packs have been tested with following result: Maximum temperature

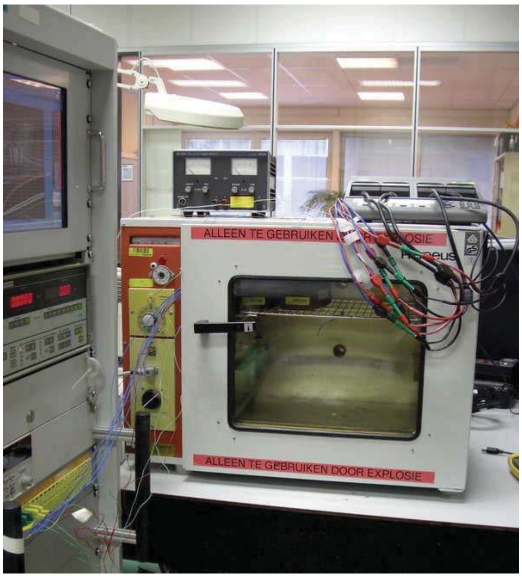
rise of the cell under encapsulation: 40,2 ˚K

Maximum temperature rise for the safety diode components inside the encapsulation: 24,6 ˚K

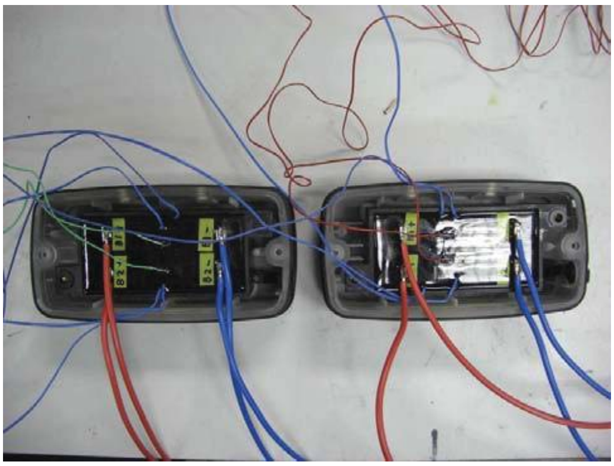
Maximum temperature rise for the safety R5A to R5F components inside the encapsulation: 21,5 ˚K Maximum temperature rise of the battery pack on the surface of the encapsulation: 30,1 ˚K.

Unfortunately has one cells failed during the test (probably we have made a short prior to the short circuit of the test) but the result of the other three cells is satisfactory.

See also pictures and graphs below:

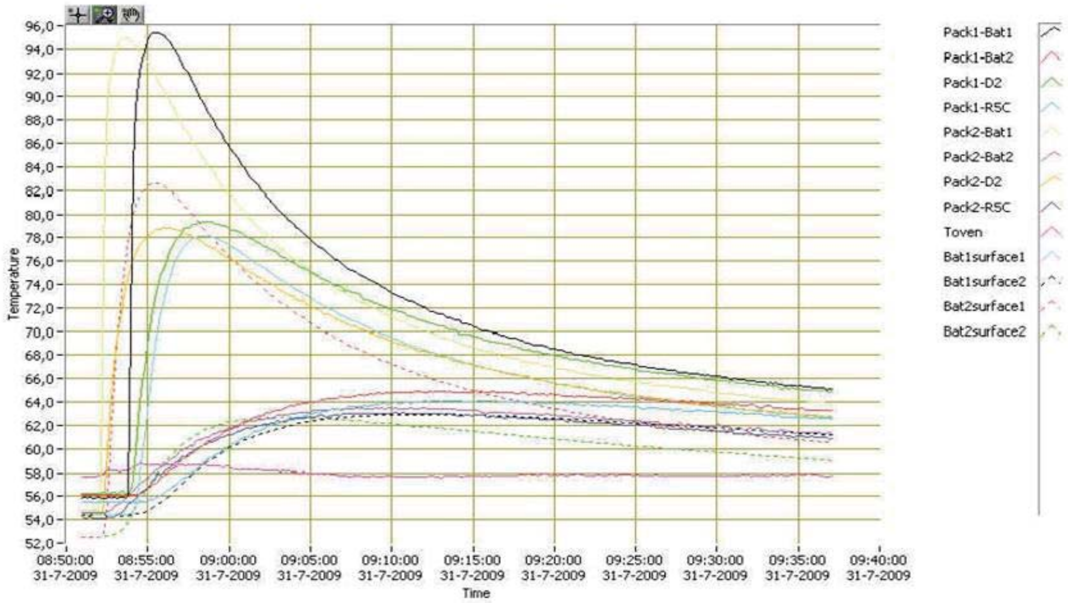


The temperature of the batteries is measured direct after the batteries are completely charged and shorted instantly, to realize the highest possible power dissipation during short of a battery.

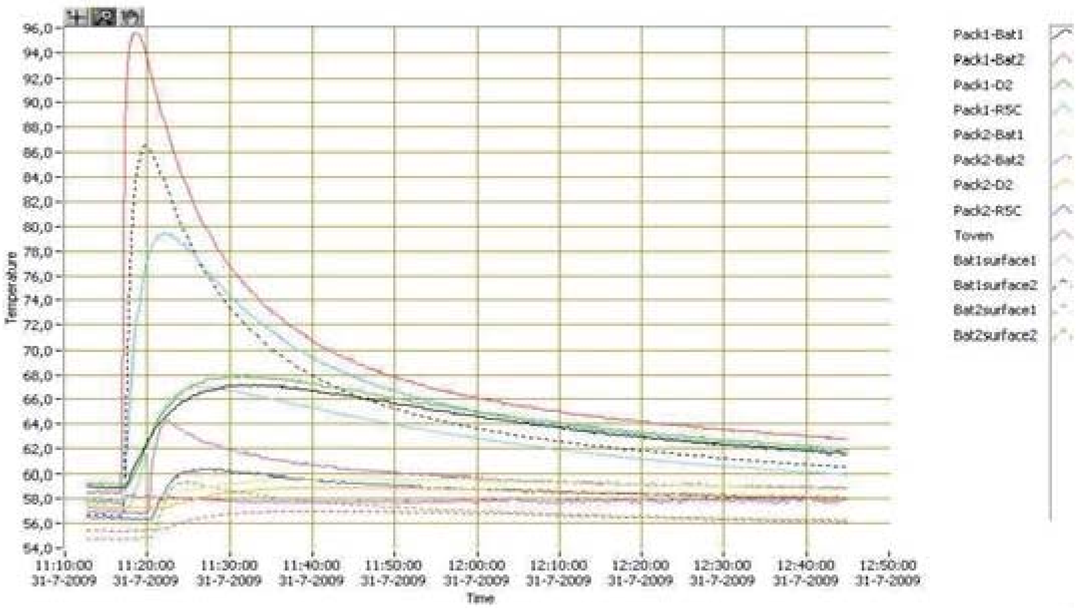


During test the battery pack BP-8000 part has been placed inside of the BUL-8000 enclosure at an ambient temperature of 60˚C.

Temperature measurements at ambient temperature of 60 ˚C Temperature graph when battery 1 in the battery pack 1 and 2 is shorted.



Temperature graph when battery 2 in the battery pack 1 and 2 is shorted.



Results from test report no. NL/DEK/ExTR13.0075/00

Tests of IEC 60079-11

1.1 Tests for cells and batteries

Equipment Tested:	10 cells of each type
Date of Test (dd/mm/yyyy):	2013-08 to 2013-09
Standard and Clause:	IEC 60079-11:2011. clause 10.5

Description

The following cells are measured:

Li-Ion cells::	
Manufacturer:	Type:
Sony	US18650VTC3
Samsung - SDI	1NR18650-15M

Test procedure:

10.5.1 General:

[X] Rechargeable cells or batteries are fully charged with a current of 750 m A (0.5 C) for a period of at least 2 hours min and then discharged at least twice with a current of 300 mA (0.2 C) before any tests are carried out. On the second discharge, or the subsequent one as necessary, the capacity of the cell or battery was confirmed as being within its manufacturer's specification to ensure that tests can be carried out on a fully charged cell or battery which is within its manufacturer's specification.

10.5.2 Electrolyte leakage test for cells and batteries:

Ten test samples are subjected to the most onerous of the following: [X]

short circuit until discharged;

[ ] application of input or charging currents within the manufacturer's recommendations; [ ] charging a battery within the manufacturer's recommendations with one cell fully discharged or suffering from polarity reversal.

The test samples shall be placed with any case discontinuities, for example seals, (the + pole in most cases) facing downward or in the orientation specified by the manufacturer of the device, over a piece of blotting paper for a period of **at least 12 h** after the application of the above tests.

10.5.3 Spark ignition and surface temperature test of cells and batteries:

[ ] Spark ignition assessment or testing shall be carried out at the cell or battery external terminals using a gas mixture for Gasgroup IIA/IIB/IIC including/excluding safety factor.

[ ] The short circuit current is determined taking the most onerous value of short-circuit current from a test of 10 samples of the cell/battery

[X] The maximum surface temperature is determined as follows. All current-limiting devices external to the cell or battery shall be short-circuited for the test. Any external sheath (of paper or metal, etc.) not forming part of the actual cell enclosure is removed for the test. The temperature is determined on the outer enclosure of each cell or battery and the maximum figure taken.

10.5.4 Battery container pressure test:

[ ] Five samples of the battery container shall be subjected to a pressure test to determine the venting pressure. Pressure shall be applied to the inside of the container. The pressure is to be gradually increased until venting occurs. The maximum venting pressure shall be recorded

and shall not exceed 30 kPa.The maximum recorded venting pressure shall be applied to a sample of the battery container for a period of at least 60 s.

Test conditions:

10.5.1 General:

When a short-circuit is required for test purposes the resistance of the short-circuit link, excluding connections to it, either shall not exceed 3 mΩor have a voltage drop across it not exceeding 200 mV or 15 % of the cell e.m.f. The short-circuit shall be applied as close to the cell or battery terminals as practicable.

The 3 mΩ is achieved by connecting/soldering short wires directly to the poles.

10.5.2 Electrolyte leakage test for cells and batteries:

The electrolyte leakage test shall be conducted at the most onerous temperature for this type of cell which migth require a number of additional test (and hence additional samples) before the real test can be started.

For this apparatus the maximum ambient temperature is 60 ºC.

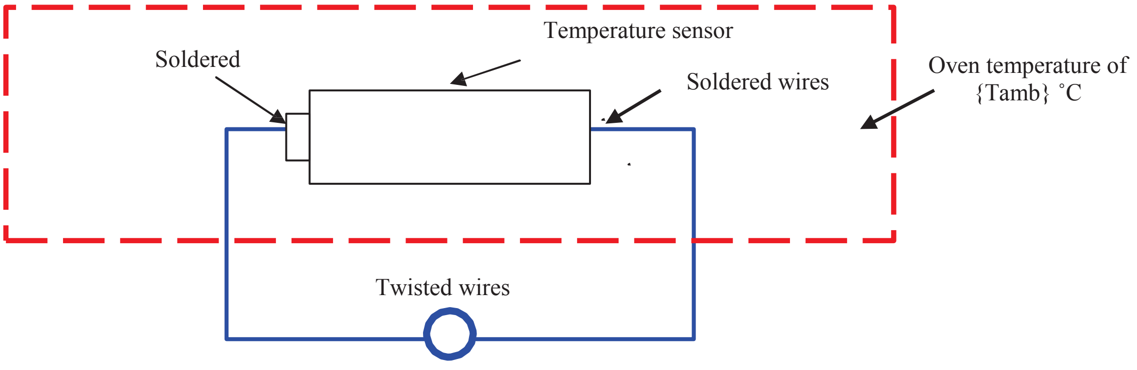
10.5.3 Spark ignition and surface temperature test of cells and batteries:

The short circuit current measurement is determined by measuring the peak voltage over a resistor of 5 mΩ.

Since the temperature behaviour of batteries is considered to be non-linear the temperature test is conducted at the highest ambient temperature (see IEC 60079-11 cl. 10.2).

For this apparatus the maximum ambient temperature is 60 ºC.

Schematic of battery test



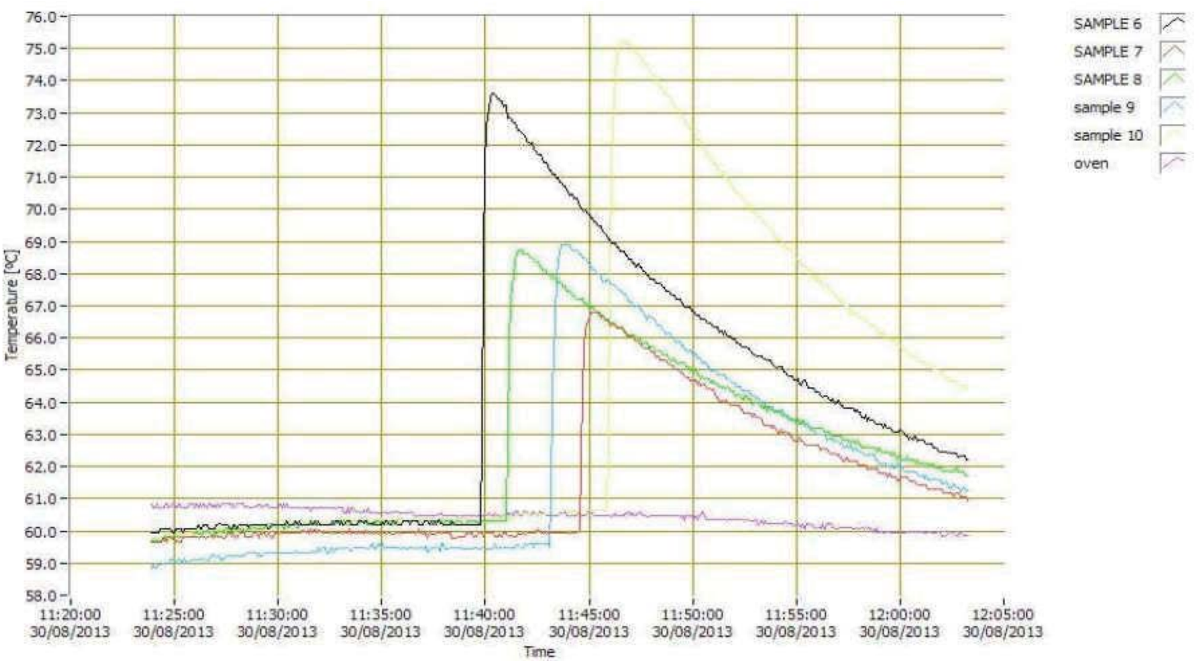
Conclusion

The maximum temperature rise of one of the types during short circuit at 60 ºC ambient temperature is 24.6 K. No samples have leaked their electrolyte. The details of the test are shown on the next pages.

Sony US18650VTC3:

Cell number	10.5.1 capacity of the cell	10.5.2 Elektrolyte leakage	10.5.3 a) Short circuit current	10.5.3 b) Temperature test			
				T Cell start	T Cell max	T amb	DeltaT (Tmax - Tstart)
1	> 100 %	No		60.0	69.5	60.2	9.5
2	> 100 %	No		59.3	73.5	60.2	14.2
3	> 100 %	No		59.3	77.0	60.2	17.7
4	> 100 %	No		59.6	75.4	60.2	15.8
5	> 100 %	No		60.2	69.0	60.2	8.8
6	> 100 %	No		60.2	73.6	60.9	13.4
7	> 100 %	No		60.0	66.8	60.9	6.8
8	> 100 %	No		60.3	68.7	60.9	8.4
9	> 100 %	No		59.6	68.9	60.9	9.3
10	> 100 %	No		60.6	75.3	60.9	14.7

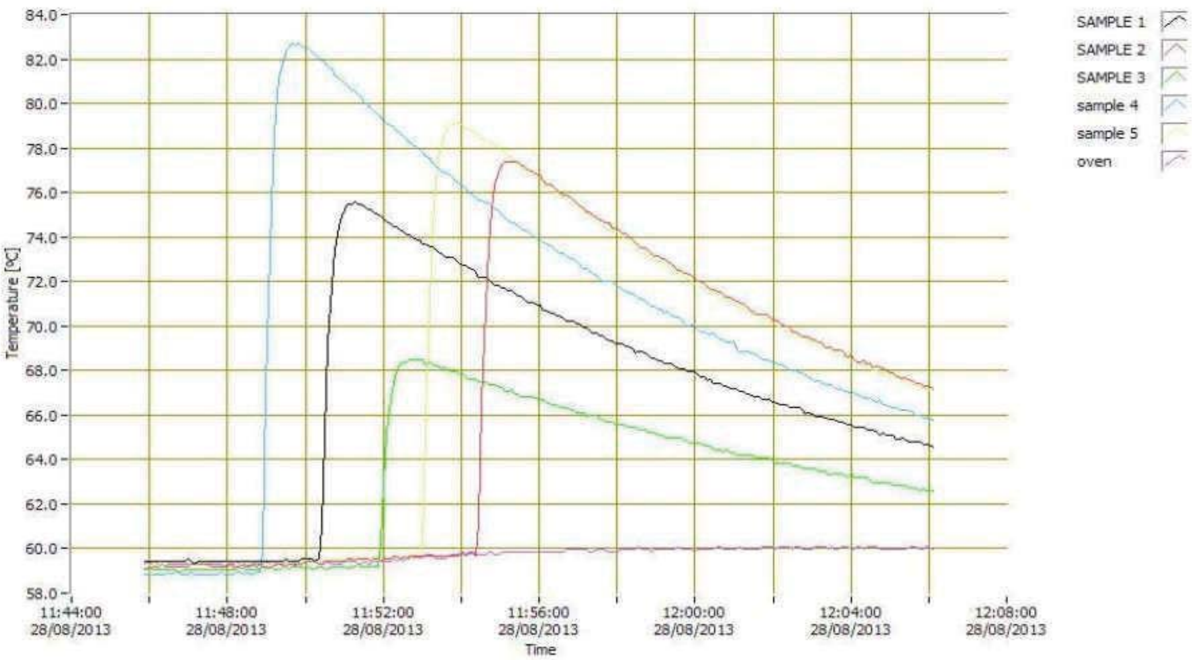
Figure of Temperature graph:



Samsung - SDI 1NR18650-15M:

Cell number	10.5.1 capacity of the cell	10.5.2 Elektrolyte leakage	10.5.3 a) Short circuit current	10.5.3 b) Temperature test			
				T Cell start	T Cell max	T amb	DeltaT (Tmax - Tstart)
1	>100 %	No		59.3	75.6	60.1	16.3
2	>100 %	No		59.1	77.4	60.1	18.3
3	>100 %	No		59.0	68.5	60.1	9.5
4	>100 %	No		58.8	82.7	60.1	23.9
5	>100 %	No		59.3	79.2	60.1	19.9
6	>100 %	No		59.8	75.7	61.2	15.9
7	>100 %	No		59.8	71.9	61.2	12.1
8	>100 %	No		59.9	72.0	61.2	12.1
9	>100 %	No		59.3	69.5	61.2	10.2
10	>100 %	No		60.1	84.7	61.2	24.6
11	>100 %	No		60.4	77.6	60.2	17.2

Figure of Temperature graph:



Appendix C.2 Testing of batteries type Sony SR616 performed by Presafe AS

Equipment Tested:	Batteries type Sony SR616 (Silver oxide)
Date of Test:	All tests performed in period 2015-03-10 to 2015-03-13
Clause and Standards:	Clause 10.5 of IEC60079-11: 2011 (EN60079-11: 2012)

Cl. 10.5.3. a) Spark ignition of cells.

All cells are measured to 1.597V open-circuit. No spark ignition assessment is required since peak open-circuit voltage is less than 4.5V

Cl. 10.5.3 Two test case were considered. Ten new samples are used for each test case (total 20 samples used). The linear correction for max rated ambient is considered to give worst results than if test was performed at max rated ambient.

Case 1: Surface temperature of cells during short-circuiting. Ambient = 23.6°C.										
Case 1. Sample no.	1	2	3	4	5	6	7	8	9	10
Measured T (°C) **1)**	29.2	28.8	28.6	28.2	27.7	27.4	29.9	30.3	27.2	31.2
ΔT	5.6	5.2	5.0	4.6	4.1	3.8	6.3	6.7	3.6	7.6
Corrected T (°C) **2)**	55.6	55.2	55	54.6	54.1	53.8	56.3	56.7	53.6	57.6
Leakage **3)**	No	No	No	No	No	No	No	No	No	No
Case 2: Surface temperature of cells during abnormal charging. Ambient = 22.6°C										
Case 2. Sample no.	1	2	3	4	5	6	7	8	9	10
Current (mA) **4)**	3.50	3.54	3.51	3.52	3.54	3.51	3.51	3.50	3.52	3.52
Measured T (°C) **5)**	23.8	23.9	23.8	23.9	23.9	23.8	23.8	23.8	23.8	23.9
ΔT	1.2	1.3	1.2	1.3	1.3	1.2	1.2	1.2	1.2	1.3
Corrected T (°C) **2)**	51.2	51.3	51.2	51.3	51.3	51.2	51.2	51.2	51.2	51.3
Leakage **3)**	No	No	No	No	No	No	No	No	No	No

Supplementary information:

1) The measured maximum temperature is achieved at the start of test due to the peak short-circuited current, then it is falling during the discharging. The measured peak current were in the range of 55-65mA but is falling very fast to about 3mA (after approximately 30s)

2) T is corrected for max rated ambient

3) Refer to Cl. 10.5.2 of IEC60079-11: 201. All samples were placed in 50°C heat chamber in12h after the short-circuiting test.

4) Abnormal charging current at input of 5.37V. Diode D7 at backup battery Sony SR616 was short-circuited. Abnormal charging current is slowly falling during test.

5) Test performed until achieved thermal equilibrium

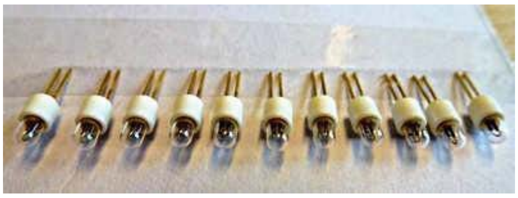
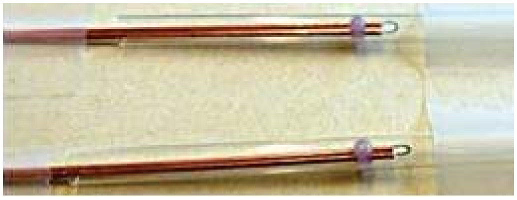
Cl. 10.5.4 Battery container pressure test. No external container other than the cell itself. No test is found necessary based on review of design.

Appendix D

Results from test report no. NL/DEK/ExTR12.0033/00
Test item: Lamp part type OL-82708PA, "lamp with bulb" and "lamp without bulb", for IR DETECTOR type DE-3123.

TABLE OF CONTENTS

1.1 Overview of samples

No	Description	
#1		Only the lamp part OL-8270BPA with the glass bulb (received 10 pcs, used a total of 5 pcs for test)
#2		The lamp part OL-8270BPA without the glass bulb (received 10 pcs, used a total of 5 pcs for test)
#3		NL/DEK/ExTR12.0033/00 Picture of complete sample IR DETECTOR type DE-3123, containing lamp part #1. For information only.

1.2 Test sequence

The following tests are performed, see table below.

Sample no	#1	#2	#3
Test			
60079-0			
Small component ignition test	X	X	N/A

1.3 Small component ignition test

Equipment Tested:	Sample No #1 and #2. For each Sample No #X five identical sample parts are tested. The lamp part OL-8270BPA are part of IR DETECTOR type DE-3123. A current through the lamp-wire caused the lamp-wire to break, which showed the lamp-
Date of Test (yyy/mm/dd):	2012-04-13
Standard and Clause:	IEC 60079-0:2011. clause 26.5.3

Description
The samples were tested to demonstrate that they do not cause thermal ignition of a flammable mixture in accordance with clause 5.3.3 item a). The test has been performed in the presence of a specified gas/air mixture for T4 as described below
The component shall be tested under normal operation, or under the fault conditions specified in the standard for the type of protection which produces the highest value of surface temperature. The test shall be continued either until thermal equilibrium of the component and the surrounding parts is attained or until the component temperature drops. Where component failure causes the temperature to fall, the test shall be repeated five times using five additional samples of the component. Where, in normal operation or under the fault conditions specified in the standard for the type of protection, the temperature of more than one component exceeds the temperature class of the equipment, the test shall be carried out with all such components at their maximum temperature.

Test conditions
The purpose of this test is to determine at which conditions the gas sensor would not cause a thermal ignition. The results of this test should give the conditions for the circuits of the apparatus in which the sensor is intended to be used. A program has been set up to determine which various conditions would apply.

Test sequence for the lamp part, Sample No #1 and #2:
- Heat up the explosion proof enclosure to 75 ˚C (25 K above maximum ambient temperature)
- Inject 1cc of diethyl ether into the explosion proof enclosure
- Wait 15 seconds so the diethyl ether can create an explosive atmosphere
- Switch on the power supply to the sensor and turn up the power supply up slowly till the wire of the lamp wire lights up (to a certain voltage up to a point where the wire will not break yet).
- Turn up the power supply slowly till the wire of the lamp breaks.
- Switch on power source for the spark generator
- Ignition should occur within 15 seconds.

This sequence is repeated 5 times on 2 different samples (#1 with bulb and #2 without bulb) of the lamp part. The appearance of a cool flame is considered as an ignition. Detection of ignition is either:

[x] audio / visual, for ignition and breaking the lamp wire.
[x] Ampere meter, showing an interruption of the current through the lamp wire.
[ ] by measurement of temperature.

If no ignition occurs during a test, the presence of the flammable mixture is verified by igniting the mixture by some other means.

Pictures of test bench for small component ignition test.

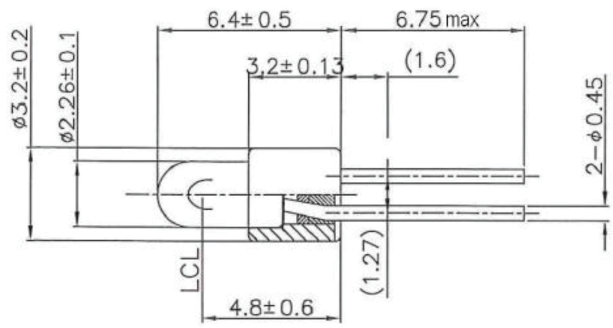
Results of sensors
5 samples of the lamp part with bulb (#1) and 5 samples without bulb (#2) are tested. The sensor voltage could be turned up till the lamp wire was broken at about 17 V for lamp with bulb and about 4 V for lamp without bulb. To test if an explosive mixture was still present; it was successfully ignited by a spark plug after the test. In total 10 samples were tested in this way.

Conclusion
Pass, the results meet the requirements:

- None of the 2 x five samples caused an ignition during the test.
- After each test it was shown that the mixture was ignitable

The lamp cannot become an ignition source for gas group T4, because the lamp wire will break without ignition.

Model	: OL-8270BPA
Design Voltage	: 5V
Design Current	: 115mA±10%
Brightness (MSCP)	: 0.15MSCP±25%
Filament Shape	: C-2R
Base color	: WHITE
Manufacturer	: Oshino Lamps Limited



Appendix E

Results from test report no. NL/KEM/ExTR07.0057/00
Test item: Sensor type NC-6264A

Total 15 samples, provided with the sensor wire but without the sintered metal cover, were used for testing. The absence of cover allows immediate access of the test gas to the sensor wire.
Functionally the sintered metal cover will be placed, but for compliance with the requirements for intrinsic safety it is not required.

The wire of the gas sensor is a small air coil and its resistance increases at increasing temperature (i.e. at increasing current). Capacitance is not present between the connections, so the inductance is the decisive factor.

The maximum current which flow through the coil without causing the open-circuit, is less than 150mA at 4V. At this level and higher values the coil will be open-circuited. For this condition maximum 1.5mH is allowed. The coil inductance is 20 µH and is negligible low with respect to the limit of 1.5mH.
Higher current might appear for a very short time (just at the moment of open-circuiting of the coiled wire). When dissipated power is increased by more than (4Vx0. l50A) 0.6W, the coiled wire will be open-circuited, having at that moment an inductance of 20 µH.

Ignitibility of an inductive circuit:
Based on a value of 20 µH per Figure A.6 of IEC 60079-11 the following combinations would be allowed (including safety factor of 1.5):

Voltage U [VJ	4	8	12	16	18	20	22	24 & up
Current I [mAJ	1730	1300	1270	670	440	320	250	180

In each case the supplied power is much higher than 0.6 W. Consequently the coil will be open circuited (at maximum 20 µH) before any ignition due to an inductive spark would occur.

Ignitability of a resistive circuit
For a maximum power dissipation of P = 0.6 W that will occur in the coiled wire, the following combinations of maximum voltage and current would apply (I=0.6/U):

Voltage U [VJ	4	12	15	20	25	30	35	40	45	50	55	60
Current I [mAJ	150	20	40	30	24	20	17	15	14	12	11	10

Maximum allowed combinations per Figure A.1 of IEC 60079-11:

Voltage U [VJ	4	12	15	20	25	30	35	40	45	50	55	60
Current I [mAJ	3300	3330	900	309	158	101	73	57	45	40	36	30

The values of the combinations based on the 0.6 W are far below the ones per Figure A.1 of IEC 60079-11 (including safety factor of 1.5), consequently ignition will not occur.

In addition, when the coiled wire would be compared with a fuse, its cold resistance may be used for determining the current that flows at a specific voltage. The cold resistance of the wire is 4.6 Ohm (see Section Bl.1). This would lead at 4 V to a current of 870 mA (4V/4,60hm). According to the table above based on the maximum inductance of 20 µH of the coiled wire this is not ignitive.
At currents above 150 mA, so certainly at the aforementioned value the coil evaporated or melted already, making the inductance ineffective.

Small component ignition test

- Gas sensor type N 6264A which sintered metal cover were removed (i.e. the sensor "wire" is directly accessible for the environment).
- For pre-tests a number of units have been used. As the unit broke down just above the desired conditions, the final conclusive tests were performed on five samples.

Date of test: 2007.06.07 and 28.06.07

Standards: IEC 60079-0:2004 and IEC 60079-11: 2006

Test Procedure

The purpose of this test is to determine at which conditions the gas sensor would not cause a thermal ignition (note: for avoidance of spark ignition annex A of IEC 60079-11 has been used).

The results of this test should give the conditions for the circuits of the apparatus in which the sensor is intended to be used. A program has been set up to determine which various conditions would apply.

Pre-tests:

- The cold resistance of the wire is about 4.6 Ohm (measured at about 23°C and <5 mA).
- With increasing current the resistance of the wire raised up to about 25Ω (order of magnitude at 75°C ambient temperature, just before open circuit).
- Just before open circuit the current is about 140 mA
- The sensor were open-circuited when voltages above 3V were applied.
- The inductance of the coiled wire of the sensor is approximately 20µH (at 23°C ambient temperature)
- The capacitance is negligible.

Test conditions:

- The sensor was connected with wires soldered to the copper connection plates.
- The sensor was placed in the center of the test chamber.
- The supply was capable of delivering 10V and 5A.
- Temperature in the test chamber 75°C (safety factor achieved by increasing the applicable ambient temperature of 50°C by a factor of 1.5).
- A small quantity of diethyl ether was released in the test chamber.
- After the diethyl ether was evaporated sufficiently, the voltage was gradually raised from 0V up to break down (open-circuit) of the wire occurred.
- Immediately after break down of the wire, the mixture in the test chamber was tested for its ignition ability

B.1.1 Results

At the pre-tests the following typical values were noted

Voltage across the sensor wire [V]	1	2	3	3.3	> 3...4
Current [mA]	85	125	145	135	Open-circuited

The voltage is raised gradually within a few seconds and is measured across the sensor wire.

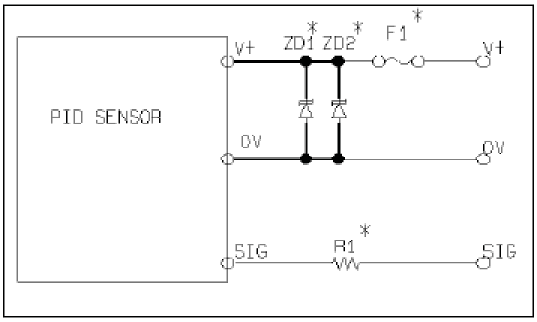
Sample No.	1	2	3	4	5
Voltage [V]	3.0	3.0	3.0	3.1	3.0
Current [mA]	130	130	130	145	145

None of the five samples caused ignition during this process.
The mixture of each test were verified for ignition after the open-circuiting of coil.

Appendix F: Smart sensor type PIS Assessment

The Mini PID sensor used inside smart sensor type PIS, is separately Ex certified device which is covered by certificate 07ATEX0060U and associated test reports GB/BAS/ExTR07.0056/00. Marking code of Mini PID sensor is Ex ia IIC T4 for ambient range up to 60°C. The device is investigated for intrinsic safe connection to EUT.

Sensor1 circuit: Uo: 5.36V Io: 0.77° Po: 0.787W	⇨	PIS Digital PCB	⇨	PIS Sensor PCB: Shunt voltage: 4.94V Fuse: 125mA (x1.7) Resistor: 1kΩ (5.36V)	⇨	Mini PID Sensor Ui: 5V Ii: 220mA



The PIS sensor is provided with two PCB as shown above whereof protection is located in PIS sensor PCB. Zeners, fuse and safety resistor is provided as power limiting devices.

<u>Input line:</u>

I_{max} = 125mA x 1.7 = 213mA.

P_{max} = 4.94V x 213mA = 1.05W.

<u>Signal line:</u>

I = 5.36V / 1kΩ@1% = 5.42mA → P_{R1} = 30mW

Uo < Ui	**Io < Ii**	**Po < Pi**	**Remark**
4.94V < 5V	213mA < 220mA	0.787W < 1.1W	Safe connection
I_{R1}	**P_{R1}**	**P (rating of R1)**	**Safety factor**
5.42mA	30mW	250mW	8.7x
Supplementary information:			

Safety distances of R1 is documented. Voltage area 5.36V:

Location	**Measured CR**	**Measured CL**	**Required**	**Remark**
R1 (measured to adjacent tracks)	0.85	0.85	> 0.5 *)	Pass. CTI ≥ 100
Supplementary information: *) Encapsulated part. See Appendix A.5.2				

Another shunt device (double zeners) is also provided internal in Mini PID sensor so in fact this connection has two times of double zeners (total four zeners used at input lines).

The PIS digital PCB used no safety components and therefore are treated as part of the Sensor circuit which is covered by the temperature assessment/test in Appendix B.3.

Intrinsic safe connection to Mini PID sensor is hereby documented. Refer also to certificate 07ATEX0060U and associated test reports GB/BAS/ExTR07.0056/00.

IECEx TEST REPORT
IEC 60079
Electrical equipment for explosive gas atmospheres
Part 26: Equipment with equipment protection level (EPL) Ga

ExTR Reference Number...............:	NO/PRE/ExTR15.0012/00
ExTR Free Reference Number ......:	D0001494-00
Complied by + signature (ExTL) ....:	Hien Van Le Thanh Hien Van Lethanh
Reviewed by + signature (ExTL)....:	Arne Hortman Arne Hortman
Date of issue ....:	2015-04-21
Ex Testing Laboratory (ExTL) ....:	Presafe AS
Address ....:	Gaustadalléen 30, NO - 0373 Oslo, Norway
Applicant's name ....:	Riken Keiki Co., Ltd
Address ....:	2-7-6 Azusawa, Itabashi, Tokyo 174-8744, Japan
Standard..:	IEC 60079-26:2006, Second edition
Test procedure ....:	IECEx Scheme
Test Report Form No. ....:	ExTR60079-26
TRF Originator................................:	DEKRA EXAM
Master TRF ....:	dated 2006-09

Instructions for Intended Use of Ex Test Report:
This ExTR blank document is to be compiled and reviewed by the ExTL. The ExTR package in which this ExTR is incorporated (comprised of a single ExTR document or multiple ExTR documents) is to be accompanied by a single ExTR Cover Sheet, which is to be approved by the ExCB. ExTR Addendum(s) and/or ExTR Report of National Differences may also supplement this ExTR.

Possible test case verdicts:

- test case does not apply to the test item ....: **N/A** Not applicable
- test item does meet the requirement ....: **P** Pass

General remarks:
The test results presented in this Ex Test Report relate only to the item or product tested.

- "See Attachment #" refers to additional information appended to this document.
- "See appended table" refers to a table appended to this document.
- "See General product information" refers to item 'General product information' in ExTR Cover report.
- "See Copy of marking plate" refers to item 'Copy of marking plate' in ExTR Cover report.
- Throughout this document, a point "." is used as the decimal separator.

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The standard IEC 60079-26: 2006 2nd Edition make reference to IEC 60079-0: 2004 4th edition. However since IEC 60079-0: 2004 4th edition is withdrawn, IEC 60079-0: 2011 6th edition is considered for this investigation.

This investigation is valid for both IECEx and ATEX certification which is handled by Presafe AS. The Ex codes for both ATEX and IECEx certification may appear in associated test reports.

IEC 60079-26			
Clause	Requirement – Test	Result – Remark	Verdict
1	SCOPE		**P**
2	NORMATIVE REFERENCES		
3	TERMS AND DEFINITIONS		
4	REQUIREMENTS FOR DESIGN AND CONSTRUCTION		**P**
4.1	General	Equipment under test is potable gas monitor GX-6000 hereby referred to as EUT. See General product information. Ex ia IIC T4 Ga -20°C ≤ Ta ≤ +50°C	**P**
4.2	Protection measures against ignition hazards of the electrical circuits		
4.2.1	General	EUT is tested for requirements of IEC60079-11: 2011 which the test report is part of this investigation.	**P**
4.2.2	Intrinsic safety as a sole means of protection		**P**
4.2.3	Encapsulation as a sole means of protection		**N/A**
4.2.4	Application of two independent types of protection providing EPL Gb		**N/A**
4.2.5	Application of a type of protection providing EPL Gb and a separation element		
4.2.5.1	General	See 4.1 and 4.2.1	**N/A**
4.2.5.2	Partition walls		**N/A**
4.2.5.3	Requirements depending on the thickness of the partition wall		**N/A**
4.2.5.4	Partition wall combined with a flameproof joint		**N/A**
4.2.5.5	Partition wall combined with an airgap with natural ventilation		**N/A**
4.3	Equipment with moving parts		**P**
4.3.1	Frictional heating	See below.	**P**
4.3.2	Damage arising from failure of moving parts	See 4.2.1. The internal pumps are assessed and are documented in associated IEC60079-11: 2011 test report.	**P**
4.3.3	Light metals		**N/A**
4.4	Isolated conductive components		**N/A**
4.5	Non-conductive enclosures and accessible non-conductive components		**N/A**

IEC 60079-26			
Clause	Requirement – Test	Result – Remark	Verdict
4.5.1	General	Conductive enclosure material is documented in the associated IEC60079-0 test report	**N/A**
4.5.2	Limitation of the size of chargeable non-conductive surfaces		**N/A**
4.5.3	Limitation of the thickness of chargeable non-conductive layers		**N/A**
4.5.4	Provision of a conductive coating		**N/A**

4.6	Process connection	**N/A**

5	TYPE TESTS	**P**

5.1	Standardized types of protection	EPL Ga type of protection. EUT is tested for requirements of IEC60079-11: 2011 as part of this investigation.	**P**

5.2	Separation elements	No such application or parts.	**N/A**

5.3	Temperature evaluation	See 5.1	**P**

6	MARKING		**P**
6.1	General	See 4.1 & Copy of marking plate.	**P**
6.2	Examples of marking		
6.2 a)	Equipment which is intended to be completely installed inside the area requiring EPL Ga	EPL Ga employed for GX-6000. Charger (charging) is located in safe areas. See Copy of marking plate.	**P**
6.2 b)	Associated apparatus, which is installed outside the hazardous area and providing external electrical circuits protected by intrinsic safety "ia", which can be connected to equipment providing EPL Ga	Intrinsically safe portable device is intended use in the hazardous area. Charger circuit is adequately protected and charging is only allowed to be performed in safe areas.	**N/A**
6.2 c)	Equipment which is installed in the boundary wall between an area requiring EPL Ga and the less hazardous area	No such intended use.	**N/A**

7	INFORMATION FOR USE	**P**

ANNEX A (informative)	INTRODUCTION OF AN ALTERNATIVE RISK ASSESSMENT METHOD ENCOMPASSING "EQUIPMENT PROTECTION LEVELS" FOR EX EQUIPMENT		**N/A**
A 0	Introduction		**N/A**
A.1	Historical background		**N/A**

IEC 60079-26			
Clause	Requirement – Test	Result – Remark	Verdict
A.2	General		**N/A**
A.2.1	Coal mining (group I)		**N/A**
A.2.1.1	EPL Ma		**N/A**
A.2.1.2	EPL Mb		**N/A**
A.2.2	Gases (group II)		**N/A**
A.2.2.1	EPL Ga		**N/A**
A 2.2.2	EPL Gb		**N/A**
A 2.2.3	EPL Gc		**N/A**
A.2.3	Dusts (group III)		**N/A**
A.2.3.1	EPL Da		**N/A**
A.2.3.2	EPL Db		**N/A**
A.2.3.3	EPL Dc		**N/A**
A.3	Risk of ignition protection afforded		**N/A**
A.4	Implementation		**N/A**

APPENDIX: Additional construction remarks

4 Requirements for design and construction

4.1 General

4.2 Protection measures against ignition hazards of the electrical circuits

4.2.1 General

4.2.2 Intrinsic safety as a sole means of protection

4.2.3 Encapsulation as a sole means of protection

4.2.4 Application of two independent types of protection providing EPL Gb

4.2.5 Application of a type of protection providing EPL Gb and a separation element

4.2.5.1 General

4.2.5.2 Partition walls

4.2.5.3 Requirements depending on the thickness of the partition wall

4.2.5.4 Partition wall combined with a flameproof joint

4.2.5.5 Partition wall combined with an airgap with natural ventilation

4.3 Apparatus with moving parts

4.3.1 Frictional heating

4.3.2 Damage arising from failure of moving parts

4.3.3 Light metals

4.4 Isolated conductive components

4.5 Non-conductive enclosures and accessible non-conductive components

4.5.1 General

4.5.2 Limitation of the size of chargeable non-conductive surfaces

4.5.3 Limitation of the thickness of chargeable non-conductive layers

4.5.4 Provision of a conductive coating

4.6 Process connection

5 Type tests

5.1 Standardized types of protection

5.2 Separation elements

5.3 Temperature evaluation

6 Marking

6.1 General

6.2 Examples of marking

6.2 a) Equipment which is intended to be completely installed inside the area requiring EPL Ga

6.2 b) Associated apparatus, which is installed outside the hazardous area and providing external electrical circuits protected by intrinsic safety "ia" which can be connected to equipment providing EPL Ga

6.2 c) Equipment which is installed in the boundary wall between an area requiring EPL Ga and the less hazardous area

7 Information for use