






IECEx TEST REPORT COVER

ExTR Reference Number.....:	NO/PRE/ExTR15.0012/05	
ExTR Free Reference Number	SC277576_1	
Compiled by + signature (ExTL)	Gunnar Nielsen	<i>Gunnar Nielsen</i>
Reviewed by + signature (ExTL).....	Stig André Norheim	<i>Stig André Norheim</i>
Endorsed by + signature (ExCB) ...:	Asle Kaastad	<i>Asle Kaastad</i>
Date of issue	2022-11-02	
Ex Testing Laboratory (ExTL).....:	 DNV	
Address	DNV Product Assurance AS Veritasveien 1 1363 Høvik Norway	
Ex Certification Body (ExCB).....:	 DNV	
Address	DNV Product Assurance AS Veritasveien 1 1363 Høvik Norway	
Applicant's name.....:	 RIKEN KEIKI	
Address	RIKEN KEIKI Co., Ltd. 2-7-6, Azusawa, Itabashi-ku, Tokyo, 174-8744, Japan	
Standards associated with this ExTR package	IEC 60079-0: 2017 edition 7 IEC 60079-1: 2014 edition 7 IEC 60079-11: 2011 edition 6	
Clauses considered	All clauses considered	
Test Report Form Number	ExTR Cover_9 (released 2021-09)	
Related Amendments, Corrigenda or ISHs	N / A	
Test item description	Portable Gas Monitor	
Model/type reference	GX-6000 and GX-6100	
Code (e.g. Ex __ II__ T__).....:	Ex ia IIB T4/T3 Ga Ex ia IIC T4/T3 Ga Ex da ia IIC T4/T3 Ga See General Product Information for details.	
Rating	Battery operated. BUL-6000 (rechargeable Li-ion battery unit) or BUD-6000 (Alkaline battery unit). For BUD-6000: use only Toshiba LR6 or Duracell MN1500 AA-batteries.	

ExTR Package Contents

Assembled ExTR documents and Additional reference material:

ExTR Package Contents

Assembled ExTR documents and Additional reference material:

IECEX Test Report Cover

IECEX Test Report: IEC 60079-1, Edition 7

IECEX Test Report Addendum: IEC 60079-0, Edition 7

IECEX Test Report Addendum: IEC 60079-11, Edition 6

Manufacturer's name: RIKEN KEIKI Co., Ltd.

Address: 2-7-6, Azusawa, Itabashi-ku, Tokyo, 174-8744, Japan

Additional location.....: RIKEN KEIKI Co., Ltd.
2-3, Minamisakae-cho, Kasukabe-shi, Saitama, 344-0057, Japan

RIKEN KEIKI NARA MFG. Co., Ltd.
49-1, Abe, Sakurai-shi, Nara, 633-0054, Japan

TOKYO MICRO SEIKI Co., Ltd.
1-15-24, Shingashi, Itabashi-ku, Tokyo, 175-0081, Japan

EBINA DENKI Manufacturing Co., LTD.
23-10, Yananecho, Kawaguchi-shi, Saitama, 333-0864, Japan

Trademark: 

Certificate No. (optional): IECEX PRE 15.0011/06

QAR Reference No. (optional): NO/PRE/QAR19.0018/05

Particulars: Test item vs. Test requirements

Classification of installation and use: Hand-held

Ingress protection: Min. IP20

Rated ambient temperature range (°C).....: $-20^{\circ}\text{C} \leq T_a \leq +50^{\circ}\text{C}$ **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.*

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Use of uncertainty of measurement for decisions on conformity (Decision rule):

No decision rule is specified by the standards associated with this ExTR package, when comparing the measurement result with the applicable limit according to the specification in these standards. The decisions on conformity are made without applying the measurement uncertainty as described in IECEX OD 012 (i.e. "simple acceptance" decision rule, previously known as "accuracy method").

General product information:

This report covers the portable gas monitors GX-6000 and GX-6100, which is used for measuring flammable gas concentration in hazardous location. GX-6000 and GX-6100 are battery-operated handheld portable devices and are built up by anti-electrostatic plastic enclosure with minor metal parts

such as assembly screws. Two alternative battery units may be used, BUL-6000 (rechargeable Li-ion battery) and BUD-6000 (alkaline dry battery). Replacement or charging of battery unit can be performed by end-users and is only allowed in non-hazardous areas. Safety instructions and warnings must be followed. Following parts are also included in the investigation, charger module BC-6000 or SDM-6000, Combustible gas sensor, Toxic gas sensor and Oxygen sensor, Smart sensor type DES, ESS, PIS & OSS.

GX-6000: When the combustible gas sensor is used the gas group is limited to IIB.

GX-6100: Combustible gas sensor, NCR-6309, is used and the gas group is IIC, as sensor is certified as "da".

Ambient temperature range during battery charging: $-0^{\circ}\text{C} \leq T_a \leq +40^{\circ}\text{C}$

GX-6000:

Ex code	Ambient temperature	Combustible gas sensor	Battery
Ex ia IIB T4 Ga	-20°C to $+50^{\circ}\text{C}$	Mounted	BUL-6000
Ex ia IIC T4 Ga	-20°C to $+50^{\circ}\text{C}$	Not mounted	BUL-6000
Ex ia IIB T4 Ga	-20°C to $+50^{\circ}\text{C}$	Mounted	BUD-6000 LR6 (Toshiba)
Ex ia IIC T4 Ga	-20°C to $+50^{\circ}\text{C}$	Not mounted	BUD-6000 LR6 (Toshiba)
Ex ia IIB T3 Ga	-20°C to $+50^{\circ}\text{C}$	Mounted	BUD-6000 MN1500 (Duracell)
Ex ia IIC T3 Ga	-20°C to $+50^{\circ}\text{C}$	Not mounted	BUD-6000 MN1500 (Duracell)

GX-6100:

Ex code	Ambient temperature	Combustible gas sensor	Battery
Ex da ia IIC T4 Ga	-20°C to $+50^{\circ}\text{C}$	Mounted	BUL-6000
Ex ia IIC T4 Ga	-20°C to $+50^{\circ}\text{C}$	Not mounted	BUL-6000
Ex da ia IIC T4 Ga	-20°C to $+50^{\circ}\text{C}$	Mounted	BUD-6000 LR6 (Toshiba)
Ex ia IIC T4 Ga	-20°C to $+50^{\circ}\text{C}$	Not mounted	BUD-6000 LR6 (Toshiba)
Ex da ia IIC T3 Ga	-20°C to $+50^{\circ}\text{C}$	Mounted	BUD-6000 MN1500 (Duracell)
Ex ia IIC T3 Ga	-20°C to $+50^{\circ}\text{C}$	Not mounted	BUD-6000 MN1500 (Duracell)

Details of change (applicable only when revising an existing ExTR package):

Added the model GX-6100, new piezo-electric buzzer, backup battery changed and new BLE module.

Copy of Marking Plate:

GX-6100(LABEL A)

MODEL GX-6100

INST.No.

RIKEN KEIKI Co., Ltd.

2-7-6, Azusawa, Itabashi-ku, Tokyo, 174-8744, Japan

BUL-6000(LABEL B)

MODEL BUL-6000

INST.No.

RIKEN KEIKI Co., Ltd./2-7-6, Azusawa,
Itabashi-ku, Tokyo, 174-8744, Japan

WARNING

Do not charge battery in haz.loc.

BUD-6000(LABEL C)

MODEL BUD-6000

INST.No.

RIKEN KEIKI Co., Ltd./2-7-6, Azusawa,
Itabashi-ku, Tokyo, 174-8744, Japan

WARNING Use only battery types

LR6 TOSHIBA or MN1500 DURACELL

GX-6100, BUL-6000, BUD-6000(LABEL D)



△	Correction
△	記 号

GX-6000(LABEL A)

MODEL GX-6000

INST.No.

RIKEN KEIKI Co., Ltd.

2-7-6, Azusawa, Itabashi-ku, Tokyo, 174-8744, Japan

GX-6000, BUL-6000, BUD-6000(LABEL D)

**Details regarding 'trade agent' / 'local assembler' application in accordance with OD 203:**

N / A

Testing not fully performed by ExTL staff at the above ExTL address:

N / A

National differences considered as part of this evaluation:

N / A

"Specific Conditions of Use" / "Schedule of Limitations":

N / A

Routine tests:

N / A

Date(s) of performance for all testing:

Drop test: 2022.10.05

Test of piezo-electric device: 2022.09.16 (not used in evaluation)

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Technical Documents			
Title:	Drawing No.:	Rev. Level:	Date:
INDEX GX-6000	E3-6991-5470-70-01K	7	2021.07.26
*INDEX GX-6100	E3-6991-5470-70-02K	2	2022.10.11

Note: An * is included before the title of documents that are new or revised.



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

ExTR Reference Number.....: NO/PRE/ExTR15.0012/03
ExTR Free Reference Number: PRJN-238467-2021-PA-NOR
Compiled by + signature (ExTL): Gunnar Nielsen
Reviewed by + signature (ExTL).....: Stig André Norheim
Date of issue: 2021-04-28

Ex Testing Laboratory (ExTL)



Address: DNV Product Assurance AS
Veritasveien 3
1363 Høvik
Norway

Applicant's name.....:



Address: RIKEN KEIKI Co., Ltd.
2-7-6, Azusawa, Itabashi-ku,
Tokyo, 174-8744, Japan

Standard.....: IEC 60079-0:2017, Edition 7.0
Test procedure.....: IECEx System
Test Report Form Number.....: ExTR60079-0_7B_DS (released 2018-01)
Related Amendments, Corrigenda or
ISHs: N/A

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Possible test case verdicts:

- test case does not apply to the test item:N / A
- test item does meet the requirement: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.
- Throughout this document, a comma "," is used as the decimal separator.

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IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
1	Scope		
2	Normative references		
3	Terms and definitions		
4	Equipment grouping		
4.1	General	According to clause 4.3.	Pass
4.2	Group I	Group II.	N / A
4.3	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 IIB/IIC T4/T3 Ga $-20^{\circ}\text{C} \leq T_a \leq +50^{\circ}\text{C}$ See <i>Measurement Section, including Additional Narrative Remarks</i> at the end of the report for details.	Pass
4.4	Group III	Group II.	N / A
4.5	Equipment for a particular explosive gas atmosphere	No particular explosive atmosphere specified.	N / A
5 See also DS 2015/011A	Temperatures		
5.1	Environmental influences		
5.1.1	Ambient temperature	Ex ia IIC T4/T3 Ga $-20^{\circ}\text{C} \leq T_a \leq +50^{\circ}\text{C}$ See <i>Measurement Section, including Additional Narrative Remarks</i> at the end of the report for details.	Pass
5.1.2	External source of heating or cooling	No external sources 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

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
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 and addendum test reports.	Pass
5.3.2	Limitation of maximum surface temperature		
5.3.2.1	Group I electrical equipment	Not Group I electrical equipment.	N / A
5.3.2.2	Group II electrical equipment	See 5.3.1. T4/T3 temperature class assigned and recognized. See Copy of marking plate.	Pass
5.3.2.3	Group III electrical equipment	Not Group III electrical equipment.	N / A
5.3.2.3.1	Maximum surface temperature for EPL Da		N / A
5.3.2.3.2	Maximum surface temperature for EPL Db		N / A
5.3.2.3.3	Maximum surface temperature determined without a layer of dust for EPL Dc		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 and addendum test reports.	Pass
5.3.4	Component temperature of smooth surfaces for Group I or Group II electrical equipment	No such components.	N / A

6	Requirements for all electrical equipment		
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6.1	General	Requirements of IEC60079-11: 2011 considered. Code Ex ia IIB/IIC T4/T3 Ga.	Pass
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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.	N / A
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6.3	Opening times	Excluded by Table 1 of IEC60079-11: 2011	N / A
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6.4	Circulating currents in enclosures (e.g. of large electric machines)	Excluded by Table 1 of IEC60079-11: 2011	N / A
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6.5	Gasket retention	Excluded by Table 1 of IEC60079-11: 2011	N / A
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IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
6.6	Electromagnetic and ultrasonic energy radiating equipment	EUT is not electromagnetic or ultrasonic energy radiating equipment	Pass
6.6.1	General		N / A
6.6.2	Radio frequency sources		N / A
6.6.3	Ultrasonic sources		N / A
6.6.4	Lasers, luminaires, and other non-divergent continuous wave optical sources	The lamp OL-8270BPA is separately Ex certified, test report TxTR12.0033 is documented. See Appendix D in associated IEC60079-11 test report.	Pass

7	Non-metallic enclosures and non-metallic parts of enclosures		
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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.	Pass
7.1.2.2	Plastic materials	See above.	Pass
7.1.2.3	Elastomers	O-ring used but not for Ex safety purpose.	N / A
7.1.2.4	Materials used for cementing	No such parts.	N / A

7.2	Thermal endurance	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
7.2.1	Tests for thermal endurance		N / A
7.2.2	Material selection		N / A
7.2.3	Alternative qualification of elastomeric sealing O-rings		N / A

7.3	Resistance to ultraviolet 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
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7.4	Electrostatic charges on external non-metallic materials		
7.4.1	Applicability	Applied.	Pass
7.4.2	Avoidance of a build-up of electrostatic charge for Group I or Group II	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.	Pass
7.4.3	Avoidance of a build-up of electrostatic charge for Group III	Not Group III equipment.	N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
7.5	Attached external conductive 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 1 of cl. 7.5 of this standard. See appended Table 26.13.	Pass
8	Metallic enclosures and metallic parts of enclosures		
8.1	Material composition	See 8.3 & 24.	Pass
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	Pass
8.4	Group III	Not Group III equipment.	N / A
8.5	Copper Alloys	No copper alloys.	N / A
9	Fasteners	Excluded by Table 1 of IEC60079-11: 2011.	N / A
9.1	General		N / A
9.2	Special fasteners		N / A
9.3	Holes for special fasteners		
9.3.1	Thread engagement		N / A
9.3.2	Tolerance and clearance		N / A
9.4	Hexagon socket set screws		N / A
10	Interlocking devices	No such parts.	N / A
11	Bushings	No such parts.	N / A
12	(Reserved for future use)		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
13 See also DS 2014/001	Ex Components	EUT is not investigated as Ex component.	N / A
13.1	General		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	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
14.1	General		N / A
14.2	Type of protection		N / A
14.3	Creepage and clearance		N / A
15	Connection facilities for earthing or bonding conductors	Requirements of this clause is excluded by Table 1 of IEC60079-11.	N / A
15.1	Equipment requiring earthing or bonding		
15.1.1	Internal earthing		N / A
15.1.2	External bonding		N / A
15.2	Equipment not requiring earthing		N / A
15.3	Size of protective earthing conductor connection		N / A
15.4	Size of equipotential bonding conductor connection		N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
15.5	Protection against corrosion		N / A
15.6	Secureness of electrical connections		N / A
15.7	Internal earth continuity plate		N / A
16	Entries into enclosures	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
16.1	General		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 electric machines	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	General		N / A
17.2	Ventilation		
17.2.1	Ventilation openings		N / A
17.2.2	Materials for external fans		N / A
17.2.3	Cooling fans of rotating electric machines		N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
17.2.3.1	Fans and fan hoods		N / A
17.2.3.2	Construction and mounting of the ventilating systems		N / A
17.2.3.3	Clearances for the ventilating system		N / A
17.2.4	Auxiliary motor cooling fans		N / A
17.2.5	Room ventilating fans		
17.2.5.1	Applicability		N / A
17.2.5.2	General		N / A
17.2.5.3	Fan and fan hoods		N / A
17.2.5.4	Construction and mounting		N / A
17.2.5.5	Clearances for rotating parts		N / A
17.3	Bearings		N / A
18	Supplementary requirements for switchgear	Excluded by Table 1 of IEC60079-11: 2011.	N / A
18.1	Flammable dielectric		N / A
18.2	Disconnectors		N / A
18.3	Group I – Provisions for locking		N / A
18.4	Doors and covers		N / A
19	Reserved for future use		
20	Supplementary requirements for external plugs, socket outlets and connectors for field wiring connection	Excluded by Table 1 of IEC60079-11: 2011.	N / A
20.1	General		N / A
20.2	Explosive gas atmospheres		N / A
20.3	Explosive dust atmospheres		N / A
20.4	Energized plugs		N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
21	Supplementary requirements for luminaires	Excluded by Table 1 of IEC60079-11: 2011.	N / A
21.1	General		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	No such parts.	N / A
22.1	Group I caplights		N / A
22.2	Group II and Group III caplights and handlights		N / A
23	Equipment incorporating cells and batteries		
23.1	General	Refer to associated IEC60079-11 test report for detailed assessments and testing of battery units.	Pass
23.2	Interconnection of cells to form batteries	BUD-6000 & BUL-6000 units & SR616 button cell assessed. See 23.1	Pass
23.3	Cell types	Refer to associated IEC60079-11 test report	Pass
23.4	Cells in a battery	Refer to associated IEC60079-11 test report	Pass
23.5	Ratings of batteries	Refer to associated IEC60079-11 test report	Pass
23.6	Interchangeability	Warnings provided. See General product information and Copy of marking plates. For alkaline batteries only Toshiba LR6 or MN1500 by Duracell (AA size) are allowed to be used. See also 29.13. No other batteries are interchangeable.	Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
23.7	Charging of primary batteries	No charging circuits for dry battery unit BUD-6000.	Pass
23.8	Leakage	Refer to associated IEC60079-11 test report.	Pass
23.9	Connections	Refer to associated IEC60079-11 test report.	Pass
23.10	Orientation	Refer to associated IEC60079-11 test report.	Pass
23.11	Replacement of cells or batteries	Warnings provided. See 29.13 and Copy of marking plates and associated IEC60079-11 test report.	Pass
23.12	Replaceable battery pack	See 23.11.	Pass
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 Product Assurance AS.	Pass
25	Compliance of prototype or sample with documents	EUT is checked for compliance with documentation required by clause 24.	Pass
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.	Pass
26.2	Test configuration	Least favorable test condition considered for each test.	Pass
26.3	Tests in explosive test mixtures	Refer to associated IEC60079-11 test report.	Pass
26.4	Tests of enclosures		
26.4.1	Order of tests		
26.4.1.1	Metallic enclosures, metallic parts of enclosures and glass parts of enclosures	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.	N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
26.4.1.2	Non-metallic enclosures or non-metallic parts of enclosures		
26.4.1.2.1	General		N / A
26.4.1.2.2	Group I equipment		N / A
26.4.1.2.3	Group II and Group III equipment		N / A
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.	Pass
26.4.3	Drop test	See appended table 26.4.3.	Pass
26.4.4	Acceptance criteria	Considered.	Pass
26.4.5 See also DS 2012/003	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.	Pass
26.4.5.2	Acceptance criteria	See above.	Pass

26.5	Thermal tests		
26.5.1	Temperature measurement		
26.5.1.1	General	Refer to associated IEC60079-11 test report.	Pass
26.5.1.2	Service temperature	See 5.2.	Pass
26.5.1.3	Maximum surface temperature	Modified requirements considered. See 5.3.1 to 5.3.3.	Pass
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	Pass
26.5.3.2	Procedure		Pass
26.5.3.3	Acceptance criteria		Pass

26.6	Torque test for bushings	Excluded by Table 1 of IEC60079-11: 2011.	N / A
26.6.1	Test procedure		N / A
26.6.2	Acceptance criteria		N / A

26.7	Non-metallic enclosures or non-metallic parts of enclosures	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
26.7.1	General		N / A
26.7.2	Test temperatures		N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
26.8	Thermal endurance to heat	See 26.7.	N / A
26.9	Thermal endurance to cold	See 26.7.	N / A
26.10	Resistance to UV 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
26.10.1	General		
26.10.2	Light exposure		
26.10.3	Acceptance criteria		N / A
26.11	Resistance to chemical agents for Group I 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 enclosures of non-metallic materials	See appended table 26.13.	N / A
26.14	Measurement of capacitance		
26.14.1	General	See 7.5.	N / A
26.14.2	Test procedure		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
26.17	Transferred charge test	Tested according to clause 26.13.	N / A
26.17.1	Test equipment		N / A
26.17.2	Test sample		N / A
26.17.3	Test procedure		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		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
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.	Pass
28.2	Certificate	Certificate is issued in due course of this investigation.	Pass
28.3	Responsibility for marking	Compliance with applicable requirements of relevant standards is documented.	Pass
29	Marking		
29.1	Applicability	Marking applied.	Pass
29.2	Location	Marking labels are visible on external enclosure.	Pass
29.3	General	See below.	Pass
29.4	Ex marking for explosive gas atmospheres	Ex ia IIB/IIC T4/T3 Ga -20°C ≤ Ta ≤ +50°C See Copy of marking plate and Measurement Section, including Additional Narrative Remarks below.	Pass
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	Boundary wall	EUT not intended for installation in a boundary wall. EUT is hand held.	N / A
29.10	Ex Components	Ex equipment considered.	N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
29.11	Small Ex Equipment and small Ex Components		N / A
29.12	Extremely small Ex Equipment and extremely small Ex Components		N / A
29.13	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.	Pass
29.14	Cells and batteries	Properly marked internally.	Pass
29.15	Electric machines operated with a converter	No such parts.	N / A
29.16	Examples of marking	See Copy of marking plate.	Pass
30	Instructions		
30.1	General	Documentation required by clause 24 of IEC60079-0 & clause 13 of IEC60079-11 is reviewed and recognized for compliance.	Pass
30.2	Cells and batteries	Specific safety instructions are provided with regards to brand & type of battery.	Pass
30.3	Electrical machines	No such parts.	N / A
30.4	Ventilating fans	No such parts.	N / A
30.5	Cable glands	No such parts.	N / A
Annex A (Normative)	Supplementary requirements for cable glands	No cable glands.	N / A
A.1	General		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

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
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		
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	Clamping test		N / A
A.3.1.5	Mechanical strength		N / A
A.3.2	Tests of clamping of armoured cables		
A.3.2.1	Tests of clamping where the armourings are clamped by a device integral to the gland		
A.3.2.1.1	General		N / A
A.3.2.1.2	Clamping test		N / A
A.3.2.1.3	Mechanical strength		N / A
A.3.2.2	Tests of clamping where the armourings are not clamped by a device integral to 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	Identification of cable-sealing rings		N / A
A.5	Instructions		N / A

Annex B (Normative)	Requirements for Ex Components		
Table B.1	Applicability of clauses to Ex Components	Ex equipment considered.	N / A

Annex C (Informative)	Example of rig for resistance to impact test		
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IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
Annex D (Informative)	Electric machines connected to converters		

Annex E (Informative)	Temperature evaluation of electric machines
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Annex F (Informative)	Guideline flowchart for tests of non-metallic enclosures or non-metallic parts of enclosures (26.4)
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Annex G (Informative)	Guidance flowchart for tests of cable glands
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Annex H (Informative)	Shaft voltages resulting in motor bearing or shaft brush sparking Discharge energy calculation
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Measurement Section, including Additional Narrative Remarks (as deemed applicable)

When the combustible gas sensor is used the gas group is limited to IIB.

Ex code	Ambient temperature	Combustible gas sensor	Battery
Ex ia IIB T4 Ga	-20°C to +50°C	Mounted	BUL-6000
Ex ia IIC T4 Ga	-20°C to +50°C	Not mounted	BUL-6000
Ex ia IIB T4 Ga	-20°C to +50°C	Mounted	BUD-6000 LR6 (Toshiba)
Ex ia IIC T4 Ga	-20°C to +50°C	Not mounted	BUD-6000 LR6 (Toshiba)
Ex ia IIB T3 Ga	-20°C to +50°C	Mounted	BUD-6000 MN1500 (Duracell)
Ex ia IIC T3 Ga	-20°C to +50°C	Not mounted	BUD-6000 MN1500 (Duracell)

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

α) 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 60079-1

Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"

ExTR Reference Number : NO/DNV/ExTR21.0088/00
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Compiled by + signature (ExTL).... : Nenad Stanivukovic
Reviewed by + signature (ExTL) ... : Bjørn Spongsveen
Date of issue..... : 2022-07-04

Ex Testing Laboratory (ExTL) :



DNV DNV Product Assurance AS

Address : Veritasveien 1, 1363 Høvik, Norway

Applicant's name : RIKEN KEIKI Co., Ltd.

Address : 2-7-6, Azusawa, Itabashi-ku, Tokyo, 174-8744, Japan

Standard : IEC 60079-1:2014, 7th Edition

Test procedure : IECEx System

Test Report Form Number : ExTR60079-1_7A_DS (released 2019-12)

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, ISO, ISO/IEC or IEC/IEEE Ex standard or technical specification. 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.

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Possible test case verdicts:

- test case does not apply to the test item..... : N / A
- test item does meet the requirement..... : 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.
- Throughout this document, a point "." is used as the decimal separator.

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IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
1	Scope This ExTR considers gas sensors type NCR-6309 for use in “GX-Force” gas detectors.		
2 See also DS2010/006A	Normative references		
3 See also DS 2015/015	Terms and definitions		
4	Level of protection (equipment protection level, EPL)		
4.1	General	Level of protection “db” (EPL Ga)	Pass
4.2 See also DS2015/016A	Requirements for level of protection “da”	<p>The sensor assessed is a catalytic sensor to be used in a portable gas detector</p> <ul style="list-style-type: none"> - Internal volume < 1 cm³ - The electrical conductors are potted in the enclosure and assessed for clause 6, -The breather is assessed for clause 10 and casted in the enclosure wall, leaving no gap and secured with a rim on both sides. -Supply is by an Ex ia circuit. Maximum dissipated power < 3.3 W -The flame non-transmission test was performed with 50 ignitions for each test gas. 	Pass
4.3	Requirements for level of protection “db”	Not evaluated.	N/A
4.4	Requirements for level of protection “dc”	Not evaluated.	N/A
5	Flameproof joints		

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
5.1	General requirements	<p>The flameproof joints comply with the requirements of clause 5.</p> <p>Specific condition of use in the certificate will apply:</p> <p>“X” - The flameproof joints are not intended to be repaired.</p> <p>A limitation and advisory marking are applied:</p> <p>"This product is an explosion-proof product and is not to be disassembled or modified with the exception of specified parts."</p> <p>Plastic enclosure, which does not require corrosion protection.</p> <p>For design details see drawing: M3-4463-10-02K</p>	Pass
5.2 See also DS 2015/018	<p>Non-threaded joints</p> <p>Relevant for:</p> <ol style="list-style-type: none"> 1. The multi-step joint between enclosure halves. 2. Cemented joints of electrical contacts. 3. Cemented joint of breather element. 		
5.2.1	Width of joints (L)	The multi-step joint requirements applied see 5.9 below.	Pass
5.2.2	Gap (i)	The multi-step joint requirements applied see 5.9 below.	Pass
5.2.3 See also DS 2015/018	Spigot joints	No spigot joints.	N/A
5.2.4	Holes in joint surfaces		
5.2.4.1	General	See 5.2.3 above.	N/A
5.2.4.2	Flanged joints with holes outside the enclosure (see Figures 3 and 5)	See 5.2.3 above.	N/A
5.2.4.3	Flanged joints with holes inside the enclosure (see Figure 4)	See 5.2.3 above.	N/A
5.2.4.4	Spigot joints where, to the edges of the holes, the joint consists of a cylindrical part and a plane part (see Figure 6)	See 5.2.3 above.	N/A
5.2.4.5	Spigot joints where, to the edges of the holes, the joint consists only of the plane part (see Figures 7 and 8), in so far as plane joints are permitted (see 5.2.7)	See 5.2.3 above.	N/A
5.2.5	Conical joints	No conical joints.	N/A

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
5.2.6	Joints with partial cylindrical surfaces (not permitted for Group IIC)	No partial cylindrical surfaces as per fig. 9a.	N/A
5.2.7	Flanged joints for acetylene atmospheres	No flanged joints.	N/A
5.2.8	Serrated joints	No serrated joints.	N/A
5.2.9	Multi-step joints	<p>The joint 1 between enclosure halves assessed as multi-step joint consists of three adjacent segments where path changes direction two times by 90°.</p> <p>Length of the joints L</p> <p>Segment 1 (L1) -specified: min 2.65 mm -measured: 2.75 mm</p> <p>Segment 2 (L2) -specified: 0.48 mm -measured: 0.50 mm</p> <p>Segment 3 (L3) -specified: min 3.35 mm -measured: 3.5 mm</p> <p>Construction gaps ic</p> <p>Segment 1 (ic1) and 3 (ic3) -specified: max. 0.10 mm -measured: 0.10 mm</p> <p>Segment 2 (ic2) -specified: 0.05 mm -measured: 0.05 mm</p> <p>“X” - The flameproof joints are not intended to be repaired.</p> <p>See Comment 2 at the end of this report.</p>	Pass
5.3	Threaded joints	No threaded joints.	N/A
5.4	Gaskets (including O-rings)	O-rings doesn't have influence to flameproof joints dimensions.	Pass
5.5	Equipment using capillaries	No capillaries used.	N/A
6	Sealed joint		
6.1 See Also DS 2015/015	Cemented joints		

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
6.1.1	General	The joints between the in-casted breather and the Cap and between the electrical contacts and Base are cemented joints. Since the joint is formed by injection molding, the molding parameters are relevant here, these are found on drawing M3-4463-10-02K.	Pass
6.1.2	Mechanical strength	The breather is fixed with a rim on top and under it. The contacts are fixed by their multi-turn shape. These joints are not intended to be opened. Tests done on the breather: An overpressure test on two samples with the breather blocked before ageing. An overpressure test on two samples with the breather blocked after ageing. Tests on the in-casted contacts: An overpressure test on two samples, before ageing, with the breather replaced by plate. An overpressure test on two samples with the breather replaced by plate after ageing. The mechanical strength is provided by enclosure. It isn't dependent upon the cement. The cement is blocked and secured and it is not part of the external wall of the enclosure. See 15.2.3.2 below and report 60079-0.	Pass
6.1.3	Width of cemented joints	Internal volume is $\ll 10 \text{ cm}^3$. The width of the cemented joints: Joint 2. Contacts -required: 3 mm -specified: min. 3.9 mm -verified: min. 3.9 mm Joint 3. Breather -required: 3 mm -specified: min. 3.66 mm -verified: min. 3.66 mm See Comment 2.2 at the end of this report.	Pass
6.2	Fused glass joints		
6.2.1	General	Not fused glass joints.	N/A
6.2.2	Width of fused glass joints	Not applicable.	N/A
7	Operating rods	No operating rods.	N/A
8	Supplementary requirements for shafts and bearings	No shafts and bearings.	N/A
9	Light-transmitting parts	No light-transmitting parts.	N/A

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
10	Breathing and draining devices which form part of a flameproof enclosure		
10.1	General	Breather device is part of enclosure used for exchange of hazardous atmosphere for gas sampling. Types of breather with pressed metal wire element used. The breathers are tested to withstand overpressure and flame propagation without deformation.	Pass
10.2	Openings for breathing or draining	Not a such construction.	Pass
10.3	Composition limits	Stainless steel only.(Cu content < 0.1%)	Pass
10.4	Dimensions	Breathing devices and their parts are fully specified in the descriptive drawings with appropriate tolerances. Press metal wire element -diameter: 10 ± 0.1 , thickness: 1.66 ± 0.1 mm	Pass
10.5	Elements with measurable paths	No such elements.	N/A
10.6	Elements with non-measurable paths	See Annex B (below).	Pass
10.7	Removable devices		
10.7.1	General	The breather can't be removed.	N/A
10.7.2	Mounting arrangements of the elements	See above.	N/A
10.8	Mechanical strength	Constructed such a way that prevents any risk of the mechanical damage. The position of breather element is fully protected by "detector enclosure" which considered as "guard". See report 60079-0 for the Impact test.	Pass
10.9	Breathing devices and draining devices when used as Ex components	Breathing devices aren't going to be used as Ex components.	N/A
11	Fasteners and openings	The Sensor does not have fasteners or openings, it is completely closed with an incasted breather and cemented electrodes.	N/A

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
12 See also DS 2012/004	Materials		
12.1	Tests prescribed by Clauses 14 to 16	Equipment tested according to clause 14 to 16	Pass
12.2	Assembly of multiple flameproof enclosures	No multiple flameproof enclosures.	N/A
12.3	Intercommunicating enclosure compartments	No intercommunicating compartments.	N/A
12.4	Use of cast iron	Cast iron not used.	N/A
12.5	Use of liquids	Liquids not used.	N/A
12.6	Insulating materials for Group I apparatus	Group I not evaluated.	N/A
12.7	Zinc content	No Zn content.	Pass
12.8	Copper or copper alloys in explosive gas atmospheres containing acetylene	No copper or copper alloys used.	Pass
13	Entries for flameproof enclosures	No entries.	N/A
14	Verification and tests	See 60079-0 report for maximum surface temperature determination.	Pass
15	Type tests		

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
15.1	General	<p>Breather element and cemented joints were excluded from testing because they were tested before. (refer to reports NL/DEK/ExTR17.0047/00-02).</p> <p>Subject of the additional testing (performed in this report) was flameproof joint 1 in test sequence as follows:</p> <ol style="list-style-type: none"> 1. Overpressure test 2. Test for non-transmission performed on samples which have been used for previous test sequence. <p>See comment 1, 3 and 4 at the end of this report.</p>	Pass

15.2	Tests of ability of the enclosure to withstand pressure		
15.2.1	General	The equipment has been tested according to the requirements in clauses 15.2.3 and 15.3 No permanent deformation was observed. The units tested according to clause 15.2.3 was also subjected to the test for flame non-transmission with satisfactory result.	Pass
15.2.2	Determination of explosion pressure (reference pressure)		
15.2.2.1	General	Determination of explosion pressure considered impracticable due to extremely small internal volume of the gas sensor.	N/A
15.2.2.2	Test procedure	See 15.2.2.1 above.	N/A
15.2.2.3	Rotating electrical machines	Not a rotating electrical machine.	N/A
15.2.2.4	Pressure-piling	Group IIC tested.	N/A
15.2.2.5	Apparatus intended for use in a single gas	Not evaluated.	N/A
15.2.3	Overpressure test		
15.2.3.1	General	Performed by first method.	Pass
15.2.3.2	Overpressure test - First method (static)	<p>Tested acc. value from Table 8 (Relative pressures for small equipment) Volume << 10 cm³ gas group IIC, for low ambient temperature: -40 °C: (value 10 bar x 1.45 = 14.5 bar applied.</p> <p>See Comment 3 at the end of this report.</p>	Pass
15.2.3.3	Overpressure test - Second method (dynamic)	First method used.	N/A

15.3	Test for non-transmission of an internal ignition		
15.3.1	General	Flame transmission didn't occur. See Comment 4 at the end of this report.	Pass
15.3.2	Electrical equipment of groups I, IIA and IIB		
15.3.2.1	Test gap and test gas	Not evaluated.	N/A

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
15.3.2.2	Increasing of gaps for test	Not evaluated.	N/A
15.3.2.3	Number of tests and acceptance criterion	Not evaluated.	N/A
15.3.3	Electrical apparatus of group IIC		
15.3.3.1	General	All the test performed according to the second method. See 15.3.3 below and Comment 4 at the end of this report.	Pass
15.3.3.2	First method – Testing by increased test gap	Not used.	N/A
15.3.3.3	Second method – Testing by increased pressure	The test gaps provided were 90% -100% of construction gaps. Test gas mixture acetylene (7.5 ± 1)% and H ₂ -hydrogen (27.5 ± 1.5)% volume in air used. Fifty ignition have been done with each test gas at pre-compression pressure (1510-1530 mbar) and normal ambient temperature See Comment 4 at the end of this report.	Pass
15.3.3.4	Third method – Testing by oxygen enrichment of test gases	Not used.	N/A
15.3.3.5	Number of tests for single piece production	Not a single piece production.	N/A
15.4	Tests of flameproof enclosures with breathing and draining devices		
15.4.1	General	Tests carried out acc. the test sequence described in 15.1 above: Determined maximum test pore size of the breather elements was min. 85% of the specified maximum bubble test pore size.	Pass
15.4.2	Tests of ability of the enclosure to withstand pressure		
15.4.2.1	General	Tests have been made in accordance with 15.2 with following additions and modifications.	Pass
15.4.2.2	Replacement of breathing and draining devices	See 15.2.2.1	N/A
15.4.2.3	Overpressure test	Thin flexible membrane has been fitted in each of the tested breather elements. No permanent deformation or damage observed after the test.	Pass
15.4.3	Thermal tests		
15.4.3.1	Test procedure	Tested per 15.4.4.2 5 times with both gases, surface temperature measure. Because of the small size of the Sensor ignition on one location. No forced flow. No ventilating or sampling system. See 14 (above) and Comment 1 at the end of this report.	Pass

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
15.4.3.2	Acceptance criterion	No continuous burning observed. Temperature increase measured: 8.4 K (with C ₂ H ₂)	Pass
15.4.4	Tests for non-transmission of an internal ignition		
15.4.4.1	General	The test made according to 15.3 including the following additions and modifications	Pass
15.4.4.2	Test procedure	Breather elements are tested as part of the gas sensor enclosure with ignition on one location due to small size of the gas sensor.	Pass
15.4.4.3	Non-transmission test for breathing and draining devices		
15.4.4.3.1	General	Tests performed according to (Group IIC with non-measurable paths) the “Method B”.	Pass
15.4.4.3.2	Method A – Testing by increased pressure	Not applied.	N/A
15.4.4.3.3	Method B – Testing by oxygen enrichment of test gases	The non-transmission tests are performed with: 40% H ₂ , 20% O ₂ and N ₂ 10% C ₂ H ₂ , 24% O ₂ and N ₂ See 15.3.3.4	Pass
15.4.4.4	Acceptance criterion	No flame transmission occurred.	Pass
15.5	Tests for “dc” devices	Not applicable.	N/A
16	Routine tests		
16.1	General		
16.1.1	Overview	Routine tests not required.	N/A
16.1.2	Routine overpressure test – first method	Not applicable.	N/A
16.1.3	Routine test – second method	Not applicable.	N/A
16.1.4	Routine test – empty enclosure & parts of enclosure	Not applicable.	N/A
16.2 See also DS 2015/015	Enclosures not incorporating a welded construction	The enclosure does not have a welded construction and has an internal volume << 10 cm ³ , a routine test isn't required.	Pass
16.3 See also DS 2015/015	Enclosures incorporating a welded construction	Not applicable.	N/A
16.4	Bushings not specific to one flameproof enclosure	Not applicable.	N/A

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
16.5	Acceptance criteria	Not applicable.	N/A
16.6	Batch testing	Not applicable.	N/A
17	Switchgear for Group I	Not a switchgear.	N/A
18	Lampholders and lamp caps	Not a lamp holder or lamp cap.	N/A
19	Non-metallic enclosures and non-metallic parts of enclosures		
19.1	General	Flameproof joint 1 includes two non-metallic faces of the joint.	Pass
19.2	Resistance to tracking and creepage distances on internal surfaces of the enclosure walls	The electrodes are molded directly in the plastic of the base part. Between 2 elements: CTI: 175 V, voltage: 3.7 V, distance 3.6 mm. Because in normal operation there is no potential difference between the electrodes of one element; creepage will not occur.	Pass
19.3	Requirements for type tests	a) Due to small size ref. pressure determination is impracticable. b) Overpressure tests performed on samples after tests per 60079-0, see 15.2.3 c) Non-transmission tests performed on samples after tests per 60079-0, see 15.3.3.4 d) Erosion by flame not required, see 19.4 e) Not required, see above.	Pass
19.4	Test of erosion by flame	The internal volume is $\ll 50 \text{ cm}^3$.	Pass
20	MARKING		
20.1	General	“da”	Pass
20.2	Caution and warning markings	No caution or warning marking required.	Pass
20.3	Informative markings	No informative markings required.	Pass

IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
21	Instructions	See 60079-0 report.	Pass
Annex A (Normative)	Additional requirements for crimped ribbon elements and multiple screen elements of breathing and draining devices	No crimped ribbon and multiple screen elements	N/A
Annex B (Normative)	Additional requirements for elements, with non-measurable paths, of breathing and draining devices		
B.1	Sintered metal elements	No sintered elements.	N/A
B.2	Pressed metal wire elements		
B.2.1	Construction	Matrix consists of five layers made from different combination of stainless steel wire braid mesh and diameter. (FP100 and FP75)	Pass
B.2.2	Specifications	The wire diameters and mesh size are specified for each layer in the matrix. (ref dwg M3-4463-10-02K) Density of st.st. 316: 7.95 g/cm ³ . The specific density of the breather is 5.2 g/cm ³ . Resulting in a ratio of 0.65 This is accepted since the pressed wire element is also sintered which will give an increase of density.	Pass
B.2.3	Bubble test pore size	Performed on three samples. Design: 139.3 µm. All samples > 85% Test per 15.4.3 performed with 133 µm.	Pass
B.2.4	Density	Performed on 8 pieces being 5.041 g in total. Result: 5.139 g/cm ³ this is regarded within the margin. See B.2.2 and Appendix B.	Pass
B.2.5	Open porosity and or fluid permeability	With the defined and checked pore size and density of the breather the functionality is sufficiently secured.	Pass
B.2.6	Identification	a) Stainless steel SUS316 b) Max. pore size: 139.3 µm c) Min. density: 5.2 g/cm ³ d) Thickness: 1.66 ± 0.1 mm, Diameter: 10 mm e) Wire diameter, see B.2.2 f) N/A see B.2.5	Pass
B.3	Metal foam elements	No metal foam elements.	N/A
Annex C (Normative)	Additional requirements for flameproof entry devices	Not applicable.	N/A
Annex D (Normative)	Empty flameproof enclosures as Ex components	Not applicable.	N/A

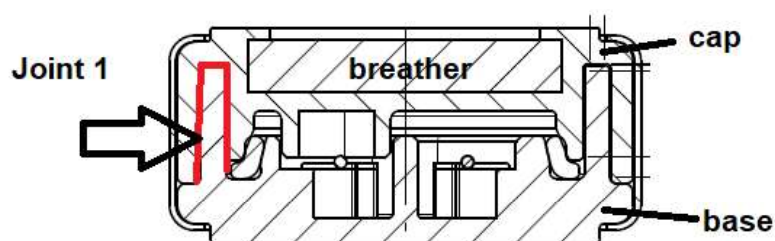
IEC 60079-1			
Clause	Requirement – Test	Result – Remark	Verdict
Annex E (Normative)	Cells and batteries used in flameproof “d” enclosures	Not applicable.	N/A
Annex F (Informative)	Mechanical properties for screws and nuts		
Annex G (Normative) See also DS 2019/003	Additional requirements for flameproof enclosures with an internal source of release (containment system)	Not applicable.	N/A
Annex H (Normative)	Requirements for machines with flameproof “d” enclosures fed from converters	Not applicable.	N/A

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

1. General description

The subject of the testing is gas sensor, type NCR-6309, consists of two catalytic elements in a flameproof enclosure. The gas sensor is to be used in the portable gas detectors GX force which are no part of this assessment. The gas sensor is fed by an Ex i signal from the gas detector.

The gas sensor consists of two plastic enclosure halves (the Cap and the Base) permanently fixed together metallic rim. A stainless steel breather element is enclosed in the cap by injection moulding.



Picture 1. Flameproof enclosure of the gas sensor NCR-6309

This report is based on NL/DEK/ExTR17.0047/00-02 test reports. Subject of additional testing (in this report) was flameproof joint 1 (multi-step joint).

2. Flameproof joints

The enclosure consists of one multi-step joint and two cemented joints. As shown on picture 2 below. The requirements for group IIC have been considered.

Date	2022-03-20
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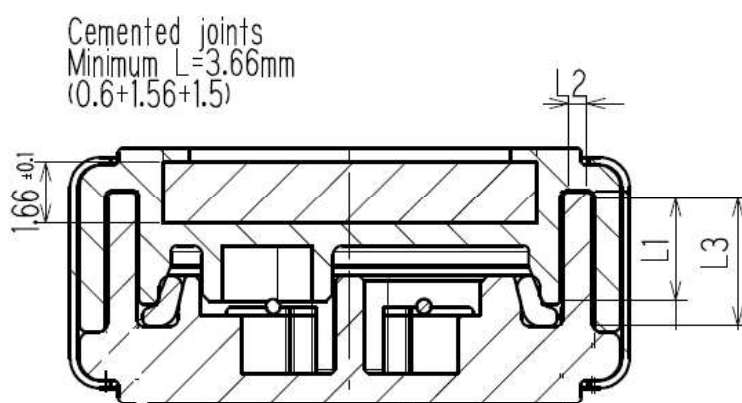
Samples	Breather - type pressed metal wire element D23 (PPS) no. 39, (2-1)
Equipment	No
Digital calliper	P0021
Micrometer 0-25mm (self cal.) standard reference 25 mm	P0284

2.1 Multi-step joint

Joint 1. Cap – Base

Table 1. Multi-step joint (declared and verified measures)

Segment	Lx min (specified)	Lx (measured)	Gap (ic) (specified)	Gap (ic) (measured)
1	2,65	2.75	0,10	0,10
2	0,48	0.50	0,05	0,05
3	3,35	3.5	0,10	0,10



Picture 2. Flameproof enclosure of the gas sensor NCR-6309

2.2 Cemented Joints

Cemented Joint 2 - "Cemented joints of electrical contacts.

Cemented joints Clause 6.1.3 Table 2	Requirement [mm]	Specification [mm]	Verification [mm]
Width	≥ 3 mm	3.9	3.9

Cemented Joint 3 - "Cemented joint of breather element.

Cemented joints Clause 6.1.3 Table 3	Requirement [mm]	Specification [mm]	Verification [mm]
Width	≥ 3 mm	3.6	3.6

3. Overpressure Test

Date	2020-03-16
Sample	3-1, 3-2 (Sensors especially prepared for FNT).
Equipment	No
Pressure gauge	P0223

There was no any damage observed or leakage through the cemented joints.

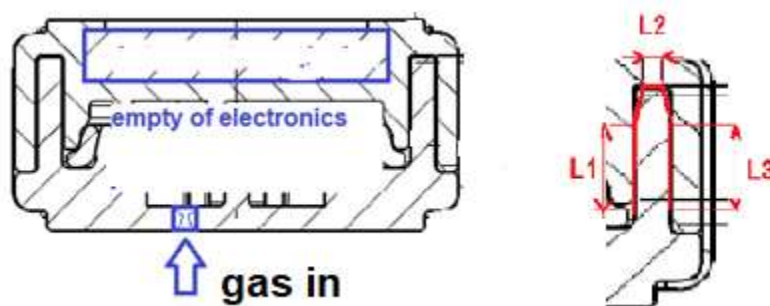
Test performed on normal ambient temperature. Sensor head tested empty, the wire mesh was covered with thin membrane from the inner side. Test performed in four test rounds.

The overpressure test was made at 14.5 bar. This pressure was held for 60 s The ambient temperature during test was +20°C.

4. Non-transmission of an Internal Ignition Test

Date	2022-04-29 to 2022-05-17
Sample	3-3 (Sensor especially prepared for FNT)
Equipment	No
Oxygen analyzer	P0114
Oxygen Transmitter	P0115
Pressure meter	P0027
Barrometer&thermometer	P0083

Subject of the test was Joint 1 (multi-step joint) as shown on picture 3 below. Test gap provided a follows:



Picture 3. Especially prepared sample of the gas sensor NCR-6309 enclosure for flame non-transmission test

Verification of the specially prepared sample for Flame Non-transmission test.

Multistep joint (declared and verified measures)

Segment	Lc max	Le (reduced)	Gap (ie)	Comment
1	1,95	74%	0,10	100%
2	0,35	73%	0,05	100%
3	2,5	75%	0,10	100%

No flame transmission out of enclosure occurred during the non-transmission tests.

The test arrangement used e (see picture 3 above) ignition point was located on gas inlet.

The gas mixture was measured at the gas outlet from the both sample and external chamber prior to each internal ignition. The internal mixture was ignited by spark plug.

The test was made at pre-compression pressure (1500-1530 mbar) and normal ambient temperature of 20°C, 5 times with each gas mixture, for Acetylene within the range by (7.4 to 7.9)% volumetric ratio to air and with Hydrogen by (27.0 to 27.5)% volumetric ratio to air.

Mixture in external enclosure verified the same as in the test sample before each ignition..

Gas A: acetylene

Gas B: hydrogen

Lab temp and pressure: +21C, 1012-1015 mbar.

Lab temp and pressure: +21C, 1004-1007 mbar.

Ignition no	O ₂ %	Pressure	Result	Ignition no	O ₂ %	Pressure	Result
1	19.40	1520	Pass	1	15.29	1500	Pass
2	19.38	1520	Pass	2	15.28	1500	Pass
3	19.37	1520	Pass	3	15.27	1500	Pass
4	19.37	1530	Pass	4	15.25	1500	Pass
5	19.37	1530	Pass	5	15.25	1500	Pass
6	19.37	1520	Pass	6	15.24	1500	Pass
7	19.36	1530	Pass	7	15.24	1500	Pass
8	19.36	1520	Pass	8	15.24	1500	Pass
9	19.36	1520	Pass	9	15.24	1500	Pass
10	19.36	1520	Pass	10	15.24	1510	Pass
11	19.36	1520	Pass	11	15.24	1510	Pass
12	19.35	1520	Pass	12	15.24	1510	Pass
13	19.35	1530	Pass	13	15.23	1510	Pass
14	19.35	1530	Pass	14	15.23	1500	Pass
15	19.35	1520	Pass	15	15.23	1500	Pass
16	19.35	1520	Pass	16	15.23	1500	Pass
17	19.34	1530	Pass	17	15.23	1510	Pass
18	19.34	1520	Pass	18	15.23	1510	Pass
19	19.34	1530	Pass	19	15.23	1510	Pass
20	19.34	1530	Pass	20	15.23	1510	Pass
21	19.34	1530	Pass	21	15.22	1500	Pass
22	19.34	1530	Pass	22	15.22	1500	Pass
23	19.34	1530	Pass	23	15.22	1510	Pass
24	19.33	1520	Pass	24	15.22	1500	Pass
25	19.33	1530	Pass	25	15.22	1500	Pass
26	19.33	1520	Pass	26	15.22	1500	Pass
27	19.33	1520	Pass	27	15.22	1510	Pass
28	19.33	1520	Pass	28	15.22	1510	Pass
29	19.33	1520	Pass	29	15.22	1510	Pass

30	19.33	1520	Pass	30	15.21	1510	Pass
31	19.33	1520	Pass	31	15.21	1510	Pass
32	19.32	1520	Pass	32	15.21	1510	Pass
33	19.32	1520	Pass	33	15.21	1510	Pass
34	19.32	1530	Pass	34	15.21	1510	Pass
35	19.32	1520	Pass	35	15.21	1510	Pass
36	19.32	1520	Pass	36	15.21	1510	Pass
37	19.32	1520	Pass	37	15.21	1510	Pass
38	19.32	1520	Pass	38	15.21	1510	Pass
39	19.32	1520	Pass	39	15.20	1510	Pass
40	19.31	1530	Pass	40	15.20	1510	Pass
41	19.31	1520	Pass	41	15.20	1510	Pass
42	19.31	1520	Pass	42	15.20	1510	Pass
43	19.31	1520	Pass	43	15.20	1510	Pass
44	19.31	1530	Pass	44	15.20	1510	Pass
45	19.31	1520	Pass	45	15.20	1510	Pass
46	19.31	1520	Pass	46	15.20	1510	Pass
47	19.31	1520	Pass	47	15.20	1510	Pass
48	19.30	1520	Pass	48	15.20	1510	Pass
49	19.30	1520	Pass	49	15.19	1510	Pass
50	19.30	1520	Pass	50	15.19	1510	Pass



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

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ExTR Free Reference Number.....:	D0001494-00	
Compiled by + signature (ExTL).....:	Hien Van Le Thanh	<i>Hien Van Le Thanh</i>
Reviewed by + signature (ExTL).....:	Arne Hortman	<i>Arne Hortman</i>
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, 6 th 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.

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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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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 (L_o/R_o) 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 $V_{\text{peak open-circuit}}=1.65\text{V}$, $V_n=1.5\text{V}$ Li-ion/BUL-6000: $V_{\text{peak open-circuit}}=4.2\text{V}$, $V_n=3.8\text{V}$ Button cell (silver oxide) Sony SR616: $V_{\text{peak open-circuit}}=1.63\text{V}$, $V_n=1.55\text{V}$	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 $U_m=250\text{V}$ 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	Windings 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

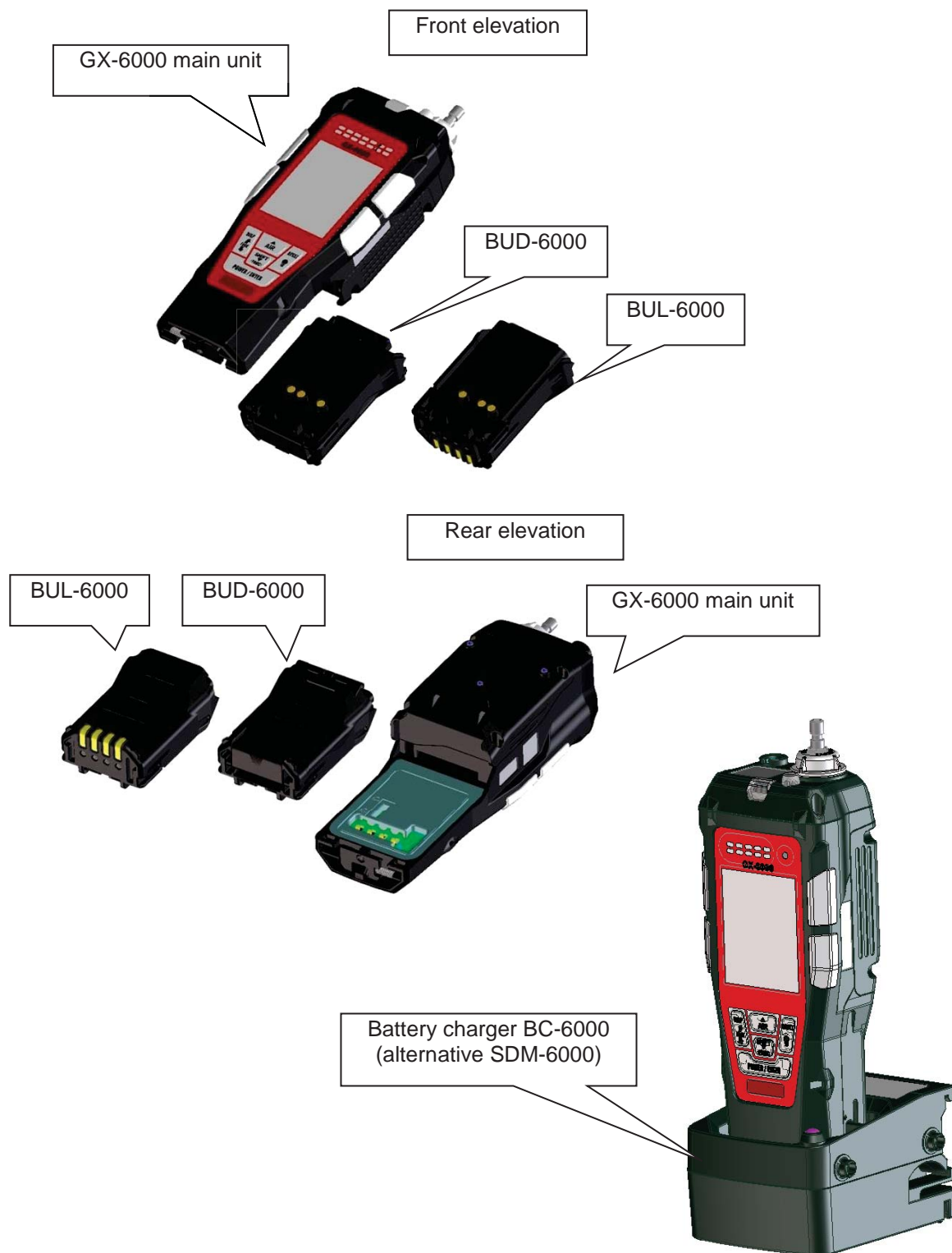
Annex H (Informative)	Ignition testing of semiconductor limiting power supply circuits
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Measurement Section, including Additional Narrative Remarks

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 $U_{bat_therm} = 1.5 \times 3 = 4.5V$, and $U_{bat_spark} = 1.65 \times 3 = 4.95V$

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}

$$R_{i_sens1} = (RS11 + RS12 + RS13 + RS14 + RS15) - 1\% = 6.435\Omega.$$

$$I_{o_sens1} = U_{bat_spark} / (R_{i_sens1}) = 4.95V / 6.435\Omega = 0.770A.$$

$$P_{o_sensor} = U_{bat_therm}^2 / (4 \times R_{i_sens1}) = 4.5V^2 / (4 \times 6.435\Omega) = 787mW.$$

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.

$$R_{i_pump} = (RS31 + RS32 + RS33 + RS34 + RS35) - 1\% = 6.435\Omega.$$

$$I_{o_pump} = U_{bat_spark} / (R_{i_pump}) = 4.95V / 6.435\Omega = 0.770A.$$

$$P_{o_pump} = U_{bat_therm}^2 / (4 \times R_{i_pump}) = 4.5V^2 / (4 \times 6.435\Omega) = 787mW.$$

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 $U_{o_motor2} = U_{o_main2} = 5.36V$

$$R_{i_motor} = (RS51 + RS52) - 1\% = 23.76\Omega.$$

$$I_{o_motor} = U_{bat_spark} / R_{i_motor} = 4.95V / 23.76\Omega = 0.209A.$$

$$P_{o_motor} = U_{bat_therm}^2 / (4 \times R_{i_motor}) = 4.5V^2 / (4 \times 23.76\Omega) = 214mW.$$

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 $U_{o_buzzer3} = 12.3V$

$$R_{i_buzzer} = (RS41 + RS42 + RS43) - 1\% = 13.95\Omega.$$

$$I_{o_buzzer} = U_{bat_spark} / R_{i_buzzer} = 4.95V / 13.95\Omega = 0.355A.$$

$$P_{o_buzzer} = U_{bat_therm}^2 / (4 \times R_{i_buzzer}) = 4.5V^2 / (4 \times 13.96\Omega) = 259mW.$$

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.

$$R_{i_main} = (RSA1 - RSA5 // RSB1 - RSB5 // RSC1 - RSC5) - 1\% = 4.455\Omega.$$

$$I_{o_main} = U_{bat_spark} / R_{i_main} = 4.95V / 4.455\Omega = 1.112A.$$

$$P_{o_main} = U_{bat_therm}^2 / (4 \times R_{i_main}) = 4.5V^2 / (4 \times 4.455\Omega) = 1137mW.$$

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 $U_{o_lcd2} = 5.20V \times 10 = 52.0V$ 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 $-17.7V$.

$R_{i_lcd} = (RS61 // RS62 // RS63 // RS64 // RS65) - 1\% = 24.31\Omega$.

$I_{o_lcd} = U_{bat_spark} / (R_{i_main} + R_{i_lcd}) = 4.95V / (4.455\Omega + 24.31\Omega) = 0.173A$.

$P_{o_lcd} = U_{bat_therm}^2 / (4 \times (R_{i_main} + R_{i_lcd})) = 4.5V^2 / (4 \times (4.455\Omega + 24.31\Omega)) = 176mW$.

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 IEC60079-0 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

$R_{i_backup} = R10 - 1\% = 990\Omega$.

$I_{o_backup} = U_{o_backup_spark} / R_{i_backup} = 1.63V / 990\Omega = 1.7mA$.

$P_{o_backup} = U_{backup_therm}^2 / (4 \times R_{i_backup}) = 1.55V^2 / (4 \times 990\Omega) = 0.7mW$.

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 $U_m = 250V$. A shunt voltage limiting circuit together with a fuse is used as protection from U_m . Fuse $I_n = 1.6A$ is used. The maximum current of charging circuit is limited to

$I_{o_charge} = 1.6A \times 1.7 = 2.72A$.

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 ignitionSensor1 circuit (representative results for both S-SEN1 & S_SEN2 circuits)

The effective internal inductance is $L_{sens1} = 13\mu H$

Based on $I_{o_sens1} = 0.770A$, the maximum allowed inductance is $L = 59.9\mu H$ ($L = 2E / I^2 = 2 \times 40\mu J / (1.5 \times 0.770A)^2$) 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 $I_{o_pump} = 4.95V / (6.435\Omega + 11.0\Omega) = 0.284A$. The maximum allowed inductance is $L = 440\mu H$ ($L = 2E / I^2 = 2 \times 40\mu J / (1.5 \times 0.284A)^2$).

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 $I_{o_motor} = 4.95V / (23.76\Omega + 80\Omega) = 0.048A$. The maximum allowed inductance is $L = 15622\mu H$ ($L = 2E / I^2 = 2 \times 40\mu J / (1.5 \times 0.048A)^2$).

Buzzer circuit (Buzzer type BZ-9K)

The effective internal inductance is $L_{\text{buzzer}} = 13\mu\text{H}$

Based on $I_{\text{o_buzzer}} = 0.355\text{A}$, the maximum allowed inductance is $L = 2E / I^2 = 2 \times 40\mu\text{J} / (1.5 \times 0.355)^2$.

Main circuit

The effective internal inductance is $L_{\text{mainr}} = 6.11\mu\text{H}$

Based on $I_{\text{o_main}} = 1.112\text{A}$, the maximum allowed inductance is $L = 2E / I^2 = 2 \times 40\mu\text{J} / (1.5 \times 1.112\text{A})^2$.

A.2.3 Capacitive spark ignitionSensor1 circuit (representative results for both S-SEN1 & S_SEN2 circuits)

The effective internal capacitance is $C_{\text{sens1}} = 41.2\mu\text{F}$ (Type-ESS)

Based on $U_{\text{o_sens12}} = 5.36\text{V}$, the maximum allowed external capacitance is $C = 65\mu\text{F}$ (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 1k Ω each)

Pump circuit (Pump type RP-12)

The effective internal capacitance is $C_{\text{pump}} = 5.0\mu\text{F}$

Based on $U_{\text{o_pump2}} = 5.36\text{V}$, the maximum allowed external capacitance is $C = 61\mu\text{F}$.

This capacitance in pump circuit is effectively separated from the other circuit by RS37 - RS39 (of min 10k Ω each)

Motor circuit (Vibration motor type A3BE-MT4)

The effective internal capacitance is $C_{\text{motor}} = 2.2\mu\text{F}$

Based on $U_{\text{o_motor2}} = 5.36\text{V}$, the maximum allowed external capacitance is $C = 61\mu\text{F}$.

This capacitance in motor circuit is effectively separated from the main circuit by RS59 (10k Ω).

Buzzer circuit (Buzzer type BZ-9K)

The effective internal capacitance is $C_{\text{buzzer}} = 12.1\mu\text{F}$ (including buzzer capacitance).

Based on $U_{\text{o_buzzer2}} = 5.2\text{V}$, the maximum allowed external capacitance is $C = 79\mu\text{F}$.

Based on $U_{\text{o_buzzer3}} = 12.3\text{V}$, the maximum allowed external capacitance is $C = 1.28\mu\text{F}$.

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 11 μF 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

$C_{\text{buzzer_12.3V}} = 1.02\mu\text{F}$.

This capacitance in buzzer circuit effectively separated from the main circuit by RS47 – RS49 (of min 10k Ω each)

Main circuit

The effective internal capacitance is $C_{\text{main}} = 38.4\mu\text{F}$ (Main PCB + Sensor PCB)

Based on $U_{\text{o_main2}} = 5.36\text{V}$, the maximum allowed external capacitance is $C = 61\mu\text{F}$.

LCD circuit

The effective internal capacitance is $C_{\text{lcd1}} = 5.17\mu\text{F}$ (C61).

Based on $U_{\text{o_lcd1}} = 5.20\text{V}$, the maximum allowed external capacitance is $C = 79\mu\text{F}$.

The effective internal capacitance is $C_{\text{lcd2}} = 200\text{pF}$ (internal capacitor of LCD driver).

Based on $U_{\text{o_lcd2}} = 52\text{V}$, the maximum allowed external capacitance is $C = 0.0183\mu\text{F}$ (18300pF).

The effective internal capacitance is $C_{\text{lcd3}} = 36.3\text{nF}$ (C62).

Based on $U_{\text{o_lcd3}} = 17.7\text{V}$, the maximum allowed external capacitance is $C = 0.327\mu\text{F}$ (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 $C = 100\mu F$, used $C = 41.2\mu F$, used / allowed ratio = 41.2%.

$I_{o_sens1} = 0.770A$, allowed $L = 59.9\mu H$, used $L = 13\mu H$, used / allowed ratio = 21.8%.

Pump circuit

$U_{o_pump1} = 4.95V$, allowed $C = 100\mu F$, used $C = 5.0\mu F$, used / allowed ratio = 5.0%.

$I_{o_pump} = 0.284A$, allowed $L = 440\mu H$, used $L = 59.8\mu H$, used / allowed ratio = 13.6%.

Motor circuit

$U_{o_motor1} = 4.95V$, allowed $C = 100\mu F$, used $C = 2.2\mu F$, used / allowed ratio = 2.2%.

$I_{o_motor} = 0.048A$, allowed $L = 15622\mu H$, used $L = 350\mu H$, 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 $C = 100\mu F$, used $C = 12.1\mu F$, used / allowed ratio = 12.1%.

$I_{o_buzzer} = 0.355A$, allowed $L = 282\mu H$, used $L = 13\mu H$, 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 $C = 100\mu F$, used $C = 38.4\mu F$ used / allowed ratio = 38.4%.

$I_o = 1.112A$, allowed $L = 28.7\mu H$, used $L = 6.11\mu H$ used / allowed ratio = 21.3%.

The maximum values of L_i and C_i 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

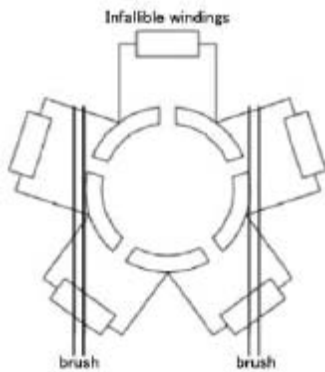
Pump RP-12: (Internal motor of pump type A12B-09-SS)

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).

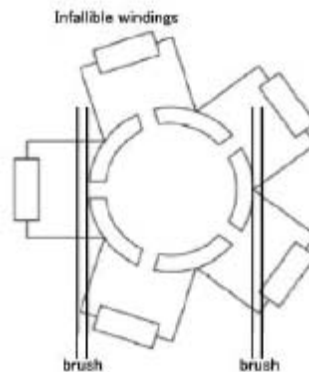
The motor coil resistance is taken as an infallible resistance to protect its inductance. The minimum motor coil resistance and maximum motor coil inductance of A12B-09-SS are as follows:

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, $V = 17.5V (V_z + V_f)$
 - $E = \frac{1}{2} \times C \times V^2 = \frac{1}{2} \times 28.6nF \times 17.5V^2 = 4.38\mu J < 50\mu J$ (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

Battery (BUD-6000)

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.

Battery (BUL-6000)

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.

Pump wire

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

Buzzer wire

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	$Pd = U_{bat_therm}^2 / (RS11...RS15)$ $= 4.5^2 / (1.3 \times 5) - 1\% / 5$
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	$Pd = P_{o_sens1}$ $R_{th(l-a)} = 33.5 \text{ °C / W}$, $R_{th(j-l)} = 25.0 \text{ °C / W}$, $R_{th(j-a)} = 58.5 \text{ °C / W}$ $W1 = (T_{jmax} - T_a) / R_{th(j-a)} = (150-60) / 58.5 = 1.538$
Pump circuit					
RS31...RS35	1.3Ω / 1% 1W	0.630 W	1 W	1.58	$Pd = U_{bat_therm}^2 / (RS31...RS35)$ $= 4.5^2 / (1.3 \times 5) - 1\% / 5$
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	$Pd = U_{bat_therm}^2 / (RS41...RS43)$ $= 4.5^2 / (4.7 \times 3) - 1\% / 3$
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	$Pd = P_{o_buzzer}$ $W1 = 0.72W \text{ @ } 60^\circ C \text{ (see.datasheet Pd-Ta)}$
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	$Pd = U_{bat_therm}^2 / (RS51...RS52)$ $= 4.5^2 / (12 \times 2) - 1\% / 2$
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	$Pd = U_{bat_therm}^2 / (RSA1...RSA5)$ $= 4.5^2 / (2.7 \times 5) - 1\% / 5$
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	$Pd = P_{o_main}$ $R_{th(l-a)} = 27.5 \text{ °C / W}$ (measured) and $R_{th(j-l)} = 10 \text{ °C / W}$ (manufacturers datasheet and wires of 0.1 inch) $R_{th(l-a)} + R_{th(j-l)} = R_{th(j-a)} = 37.5 \text{ °C / W}$ $W1 = (T_{jmax} - T_a) / R_{th(j-a)} = (200-60) / 37.5 = 3.733$
LCD circuit					

RS61	62Ω / 1% 1W	0.351 W	1 W	2.8	$Pd = (U_{nat_therm} / (R_{i_main} + RS61))^2 \times RS61$ $= 4.5 / (4.455 + 62)^2 \times 62$
RS62,65	10k Ω / 0.5% 0.33W	2.1 mW	0.33 W	>100	$Pd = U_{o_therm}^2 / RS62$ $= 4.5^2 / 10\text{ k} - 0.5\%$
RS63,64	82Ω / 1% 0.75W	0.275 W	0.75 W	2.7	$Pd = (U_{nat_therm} / (R_{i_main} + RS63))^2 \times RS63$ $= 4.5 / (4.455 + 82)^2 \times 82$
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	$Pd = U_{backup_therm}^2 / RS10$ $= 1.55^2 / 1\text{ k} - 1\%$
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	$Pd = U_{bat_therm}^2 / R1$ $= 4.5^2 / 10\text{ k} - 0.5\%$
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	$Pd = U_{bat_therm}^2 / R10$ $= 3.8^2 / 10\text{ k} - 1\%$
R11	2.2k Ω / 1% 0.25 W	0.007 W	0.25 W	35	$Pd = U_{bat_therm}^2 / R11$ $= 3.8^2 / 2.2\text{ k} - 1\%$
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	$Pd = (U_{i_charge} / (R1 + R28_{BC-6000}))^2 \times R1$ $= (17.8 / (200 + 750))^2 \times 200$
R3	470Ω / 1% 0.25W	0.074W	0.25 W	3.3	$Pd = (U_{i_charge} / (R3 + R1 + R28_{BC-6000}))^2 \times R3$ $= (17.8 / (470 + 200 + 750))^2 \times 470$
R10	10k Ω / 1% 0.25 W	1.8 mW	0.25 W	>100	$Pd = U_{bat_charge}^2 / R10$ $= 4.2^2 / 10\text{ k} - 1\%$
R11	2.2k Ω / 1% 0.25 W	0.146 W	0.25 W	1.7	$Pd = U_{i_charge}^2 / R11$ $= 17.8^2 / 2.2\text{ k} - 1\%$
D1,2,3	MBRD1045 Vr = 45V, If = 10A R _{TH-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	$U = U_m$ $I = I_m$ $Pd = V_f \times I_m = 0.57\text{ V} \times 2.72\text{ A} = 1.56\text{ W}$ $P_{max-diode@65^\circ\text{C}} = (T_{jmax} - T_a - T_{diode-rise}) / R_{TH-JC} = (175 - 40 - 24.6) / 2.43 = 45\text{ W}$
BC-6000					
R1...3	120 Ω / 1%	0.034W	0.75 W	22	$Pd = V_{gs_threshold}^2 / R1 = 2.0^2 / 120 - 1\%$

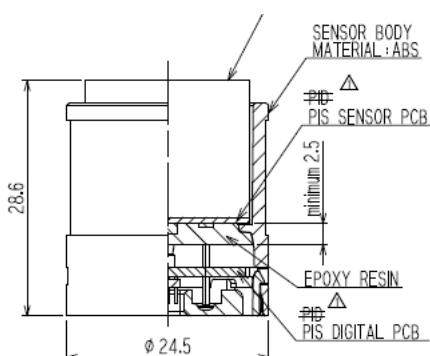
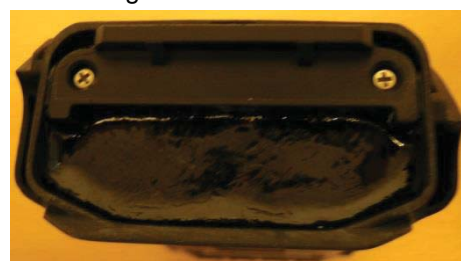
	0.75 W				
ZD1...3	1SMB5918 $U_{zmax} = 15.8V / 3W$	0.266 W	1.538 W	5.7	$P_d = I_{zd} \times U_{zmax}$, $I_{zd} = V_{gs_threshold} / R1$ $P_d = 2.0 / 120-1\% \times 15.8$
Q1...3*	TPCA8107-H $V_{gs(th)} = 2.0V$ $R_{onmax} = 37m\Omega$ $P_d = 30W$ $T_{jmax} = 150^\circ C$	2.74 W 97A ² S	1.152 W 1.005A ² S	22 96	$P_d = (I_n \times 1.7)^2 \times R_{onmax} = (1.6 \times 1.7)^2 \times 37m$ $R_{th(j-a)} = 78.1 K/W$ $W1 = (T_{jmax} - T_a) / R_{th(j-a)} = (150-60) / 78.1 = 1.152W$ $I^2 t = ((T_{jmax} - T_a) / R_{th_transient}) / R_{onmax} \times t$ $= ((150-60) / 25) / 37m \times 1$ (see datasheet , fig R_{th-Tw})
R28,29	750 Ω / 1% 0.75 W	0.427W	0.75 W	1.7	$P_d = U_{i_charge}^2 / R28$ $= 17.8^2 / 750 -1\%$

A.5 Encapsulation

A.5.1 The BUL-6000 contains two parallel battery cells, Maxell model INR18650PB (Lithium-ion battery), size : $\phi 18 \times 65$ 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 $I_N = 1.6 \text{ A}$; $I_{Break} = 1500 \text{ A}$; $U_m = 250 \text{ V}$. 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 $1.7 \times 1.6 \text{ A}$ 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 $V_{zd} + V_{gs(th)} = 15.8 \text{ V} + 2.0 \text{ V} = 17.8 \text{ V}$ but under charging mode the Lithium-ion battery pack will pull down the charger voltage to 4.2 V . 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 $\rightarrow V_{gs(th)} < 2.0 \text{ V} \rightarrow$ this leads to normal charging.

Failure of short-circuited ZD1 $\rightarrow V_{gs(th)} > 2.0 \text{ V} \rightarrow$ 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 4.2 V 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	$T_{a\ max} = 50^{\circ}\text{C}$
GX-6000. Main unit. Charging	10	50	$T_{a\ max} = 40^{\circ}\text{C}$
GX-6000. Main unit. Charging & use	14	54	$T_{a\ max} = 40^{\circ}\text{C}$
BUL-6000. Charging	18	58	$T_{a\ max} = 40^{\circ}\text{C}$
BUL-6000. Charging & use	18	58	$T_{a\ max} = 40^{\circ}\text{C}$
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 $P_{o_main} = 1.137\text{W}$. 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 ($\geq 20\text{mm}^2$), 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.

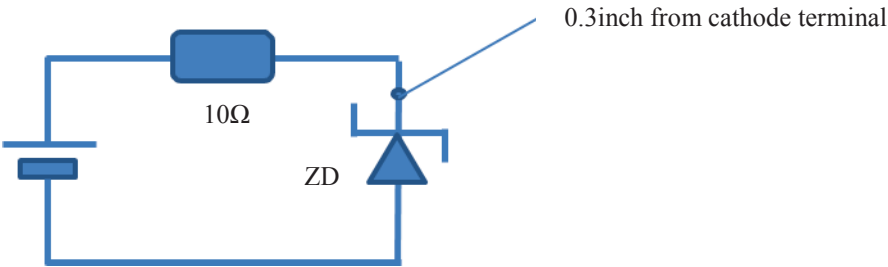
B.3.3 Temperature measurement of shunt zeners

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	$\Delta T = 39.4K$ with $P = 1.14\text{ W} \Rightarrow R_{th(j-a)} = 34.6K/W$. Measuring point is 0.3 inch from cathode terminal.	NL/KEM/ExTR10.0 035/00 2009-09-25



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

$T_a = 50^{\circ}C$
 $dT = 10K$
 $T_{amax} = 60^{\circ}C$
 $T_{jmax} = 200^{\circ}C$
 $P_d = 5W$

$P_{o_max} = 1.14W$
 $R_{th(j-l)} = 16.0K/W$. See Fig. 1
 $R_{th(j-l)} = 34.6K/W$. See result sheet
 $R_{th(j-a)} = 50.6K/W$
Max rating $2.767W$
2/3 rating $1.84W$

$T_j = 40.8 + 50 + 1.2 * 16 = 110^{\circ}C$

Measuring point 0.3 in from cathode terminal.

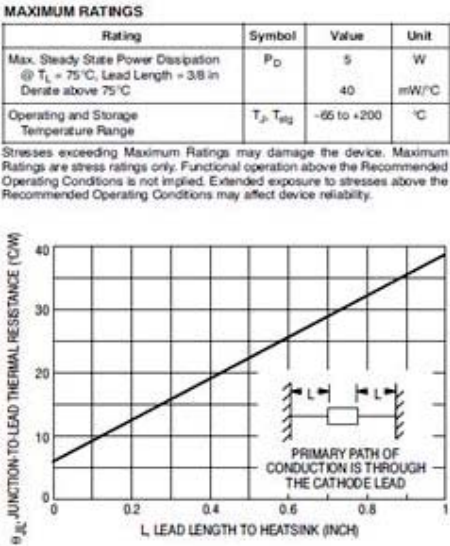


Figure 1. Typical Thermal Resistance

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

	V _Z (V)	V _R (V)	I _Z (A)	P _{Zd} (W)	T _a (degC)	dT (K)	R _{th} (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

	V _Z (V)	V _R (V)	I _Z (A)	P _{Zd} (W)	T _a (degC)	dT (K)	R _{th} (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

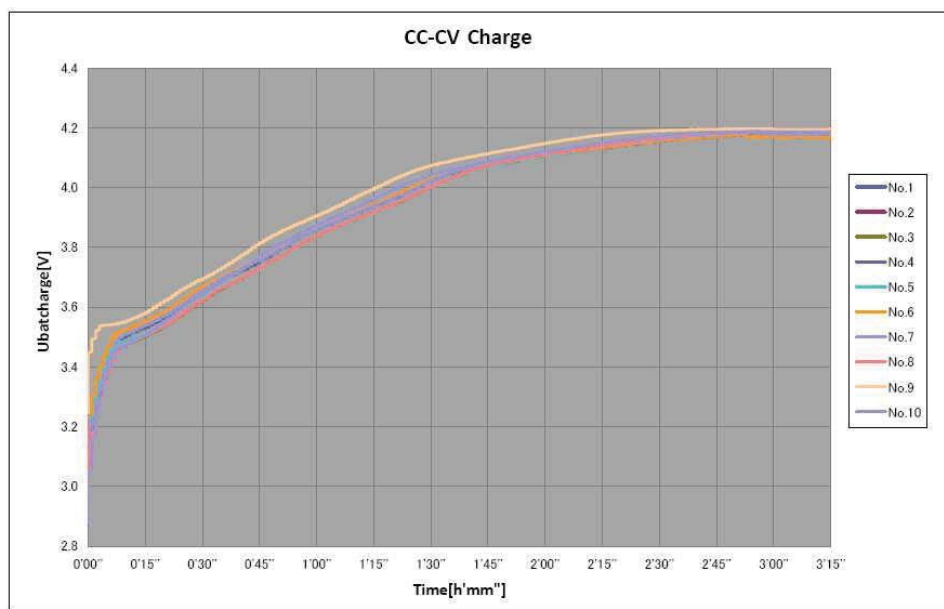
Test procedure	Standard reference	Results	Test report ref. (date of test)
Determination of maximum battery voltage during charging	IEC 60079-11 Clause 3.6.6	A voltage measurement has been done over the two batteries inside the GX-8000 on 10 different cells and combination while charging the batteries.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

Measurement result of Ubatchcharge

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

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

	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+3 σ	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 leakage after testing.	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 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 °C.

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 °C.

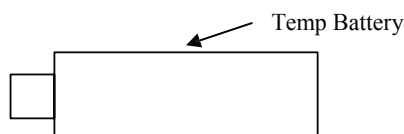
10.5.4 Battery container pressure test:

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.: 212431400**Product:** Li-ion pack test**technician:** R.Rouwenhorst**Test conducted on:** June 3, 4, 5, 2009
no.:**Manufacturer:** EMC Systems Corp.**Type designation:** Lab**Sample no.:** 107452**Test report page****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 manufacturer 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 ($< 3\text{m}\Omega$ 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 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 $3\text{ m}\Omega$ 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 °C**.

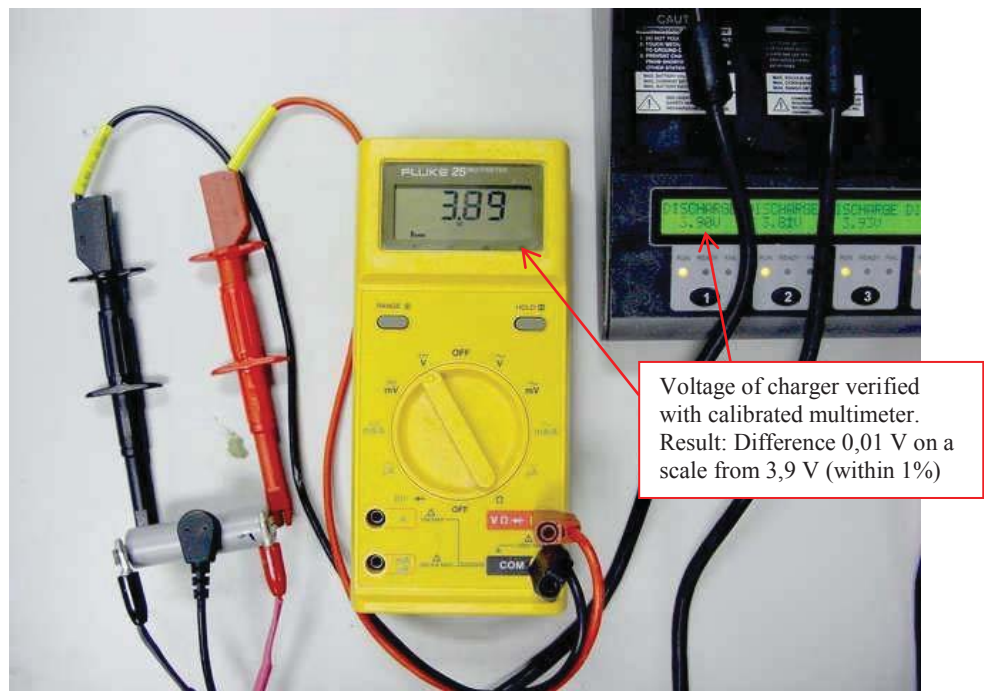
10.5.3 Spark ignition and surface temperature test of cells and batteries:

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).

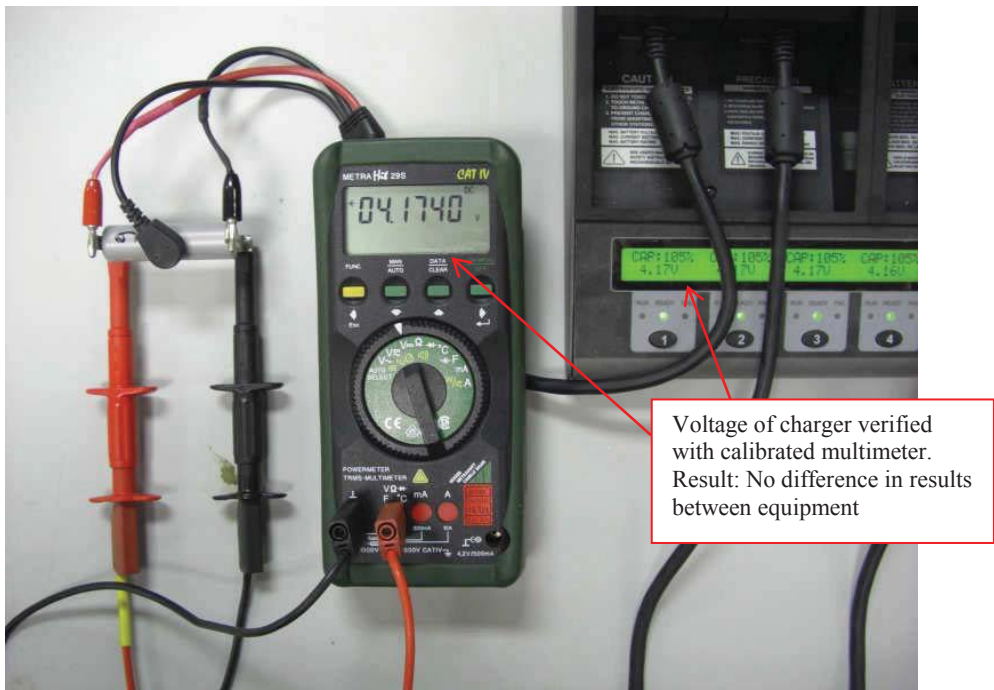
For this apparatus the maximum ambient temperature is **50 °C**.

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)

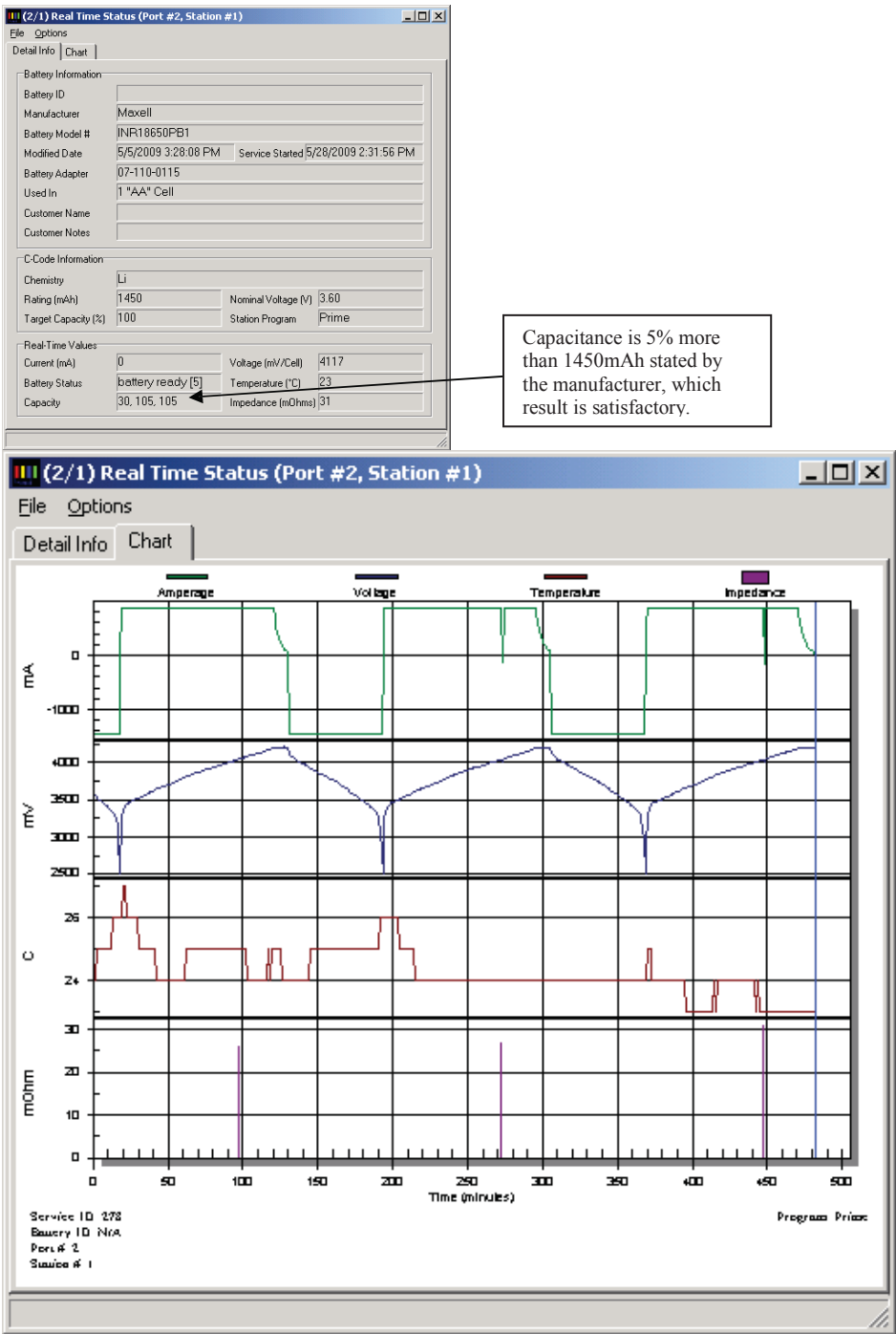


Measurement of current and voltages by li-ion charger (battery 9, fully charged)



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

Charging results Battery 1:



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

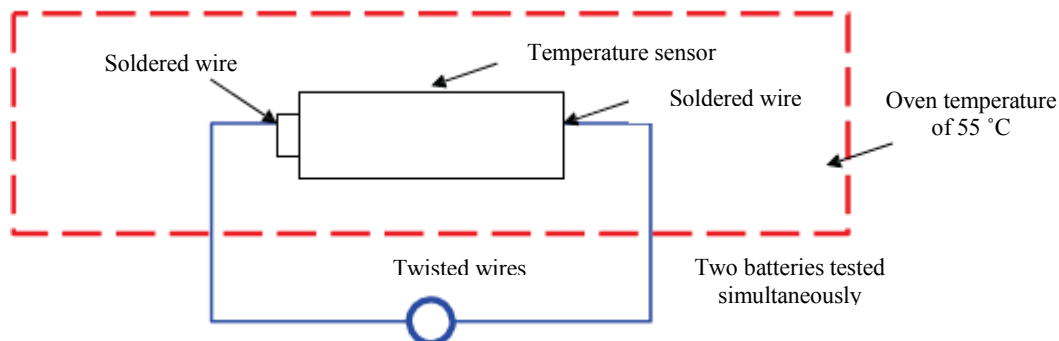
Battery capacitance
Discharge duration = Capacity / Discharge Current = 1450 mAh / 1500 mA = 58 min, actually measured 61 min.
Thus the capacitance is 61 min / 58 min = 5% more capacitance than 1450mAh, which result is satisfactory.

Test results (10.5.2 Electrolyte leakage test for cells and batteries)

Short circuit resistance is 2 mΩ measured 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**

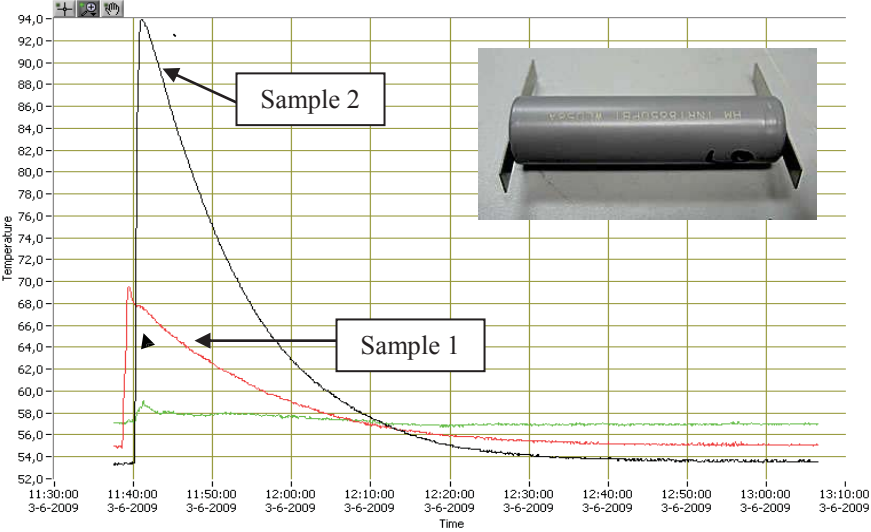
The maximum temperature rise because cell short is **74,8 °K**, measured at an ambient temperature of 55 °C. **Two samples showed some electrolyte leakage after test.**

- [] 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.**

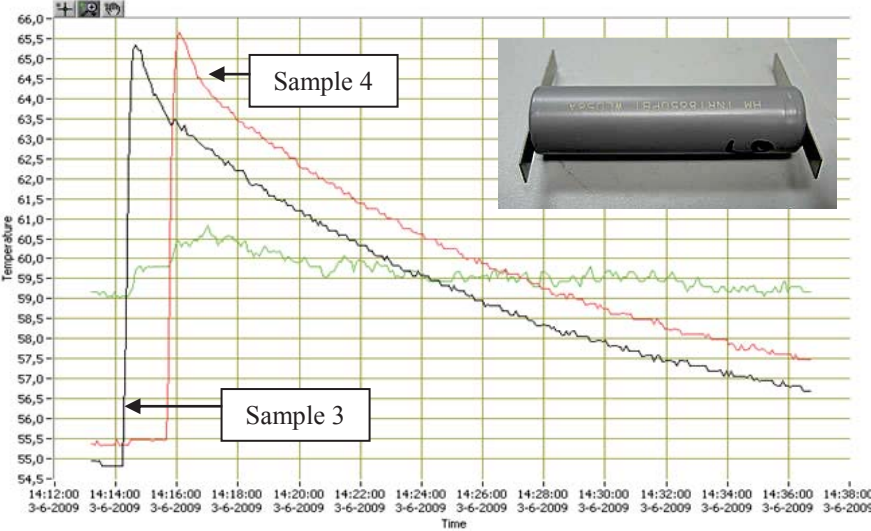
Equipment:

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

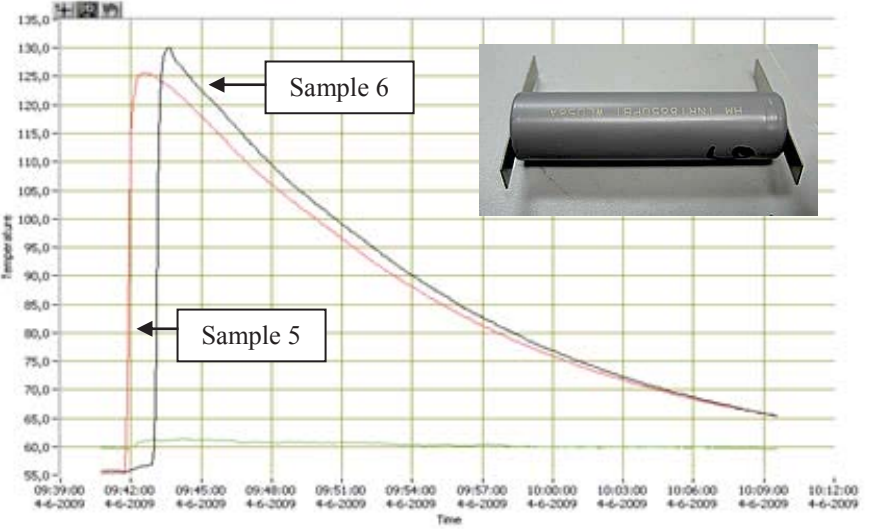
Graph 1: Sample 1 and 2



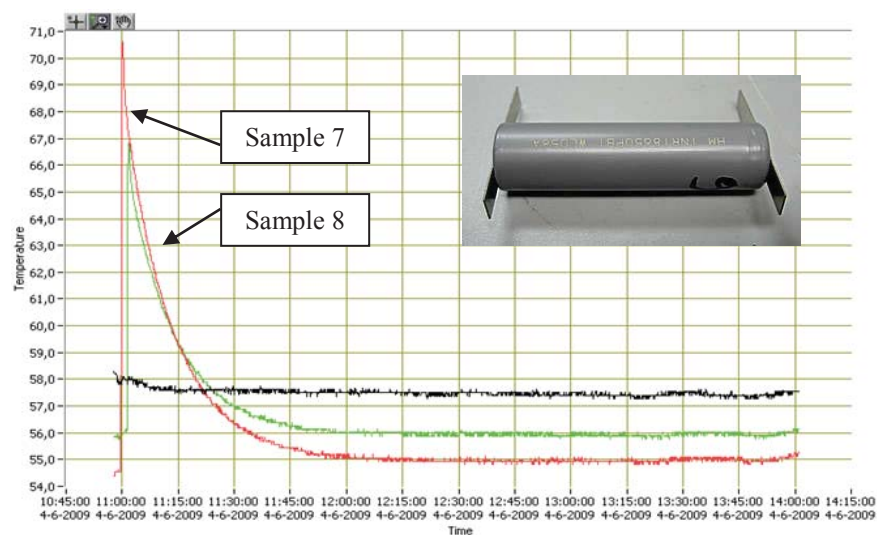
Graph 2: Sample 3 and 4



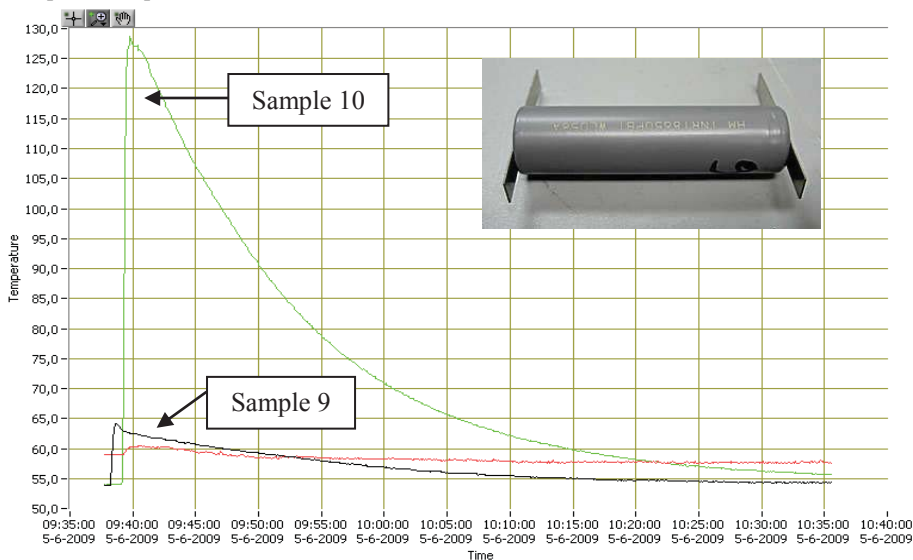
Graph 3: Sample 5 and 6



Graph 4: Sample 7 and 8

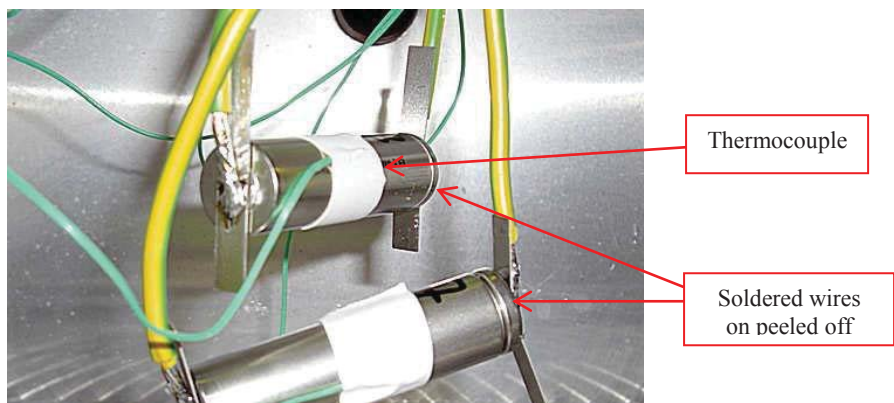


Graph 5: Sample 9 and 10

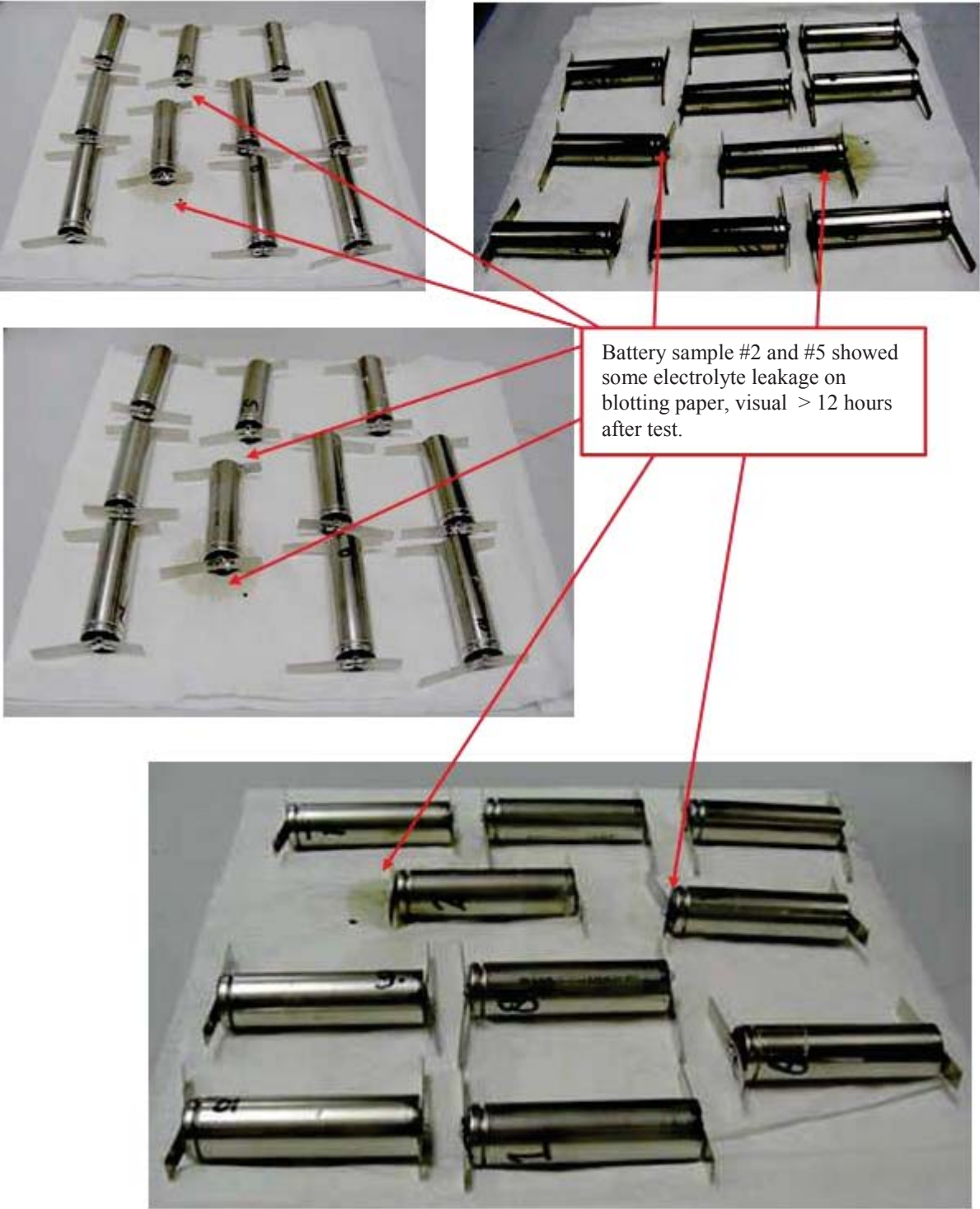


Pictures during test

Batteries 7 and 8 just before start of temperature test



Electrolyte Leakage test, minimal 12 hours after test.



Temperature test at $T_{amb} = 60^{\circ}\text{C}$

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

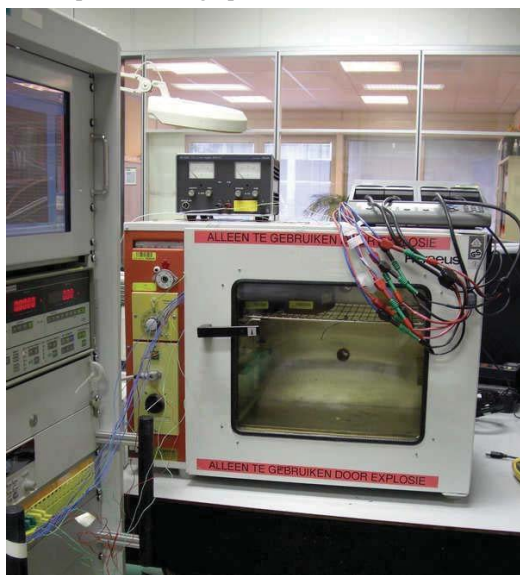
rise of the cell under encapsulation: $40,2^{\circ}\text{K}$

Maximum temperature rise for the safety diode components inside the encapsulation: $24,6^{\circ}\text{K}$

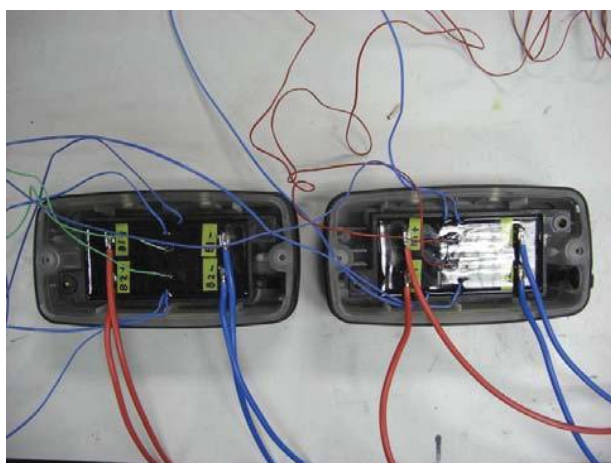
Maximum temperature rise for the safety R5A to R5F components inside the encapsulation: $21,5^{\circ}\text{K}$ Maximum temperature rise of the battery pack on the surface of the encapsulation: $30,1^{\circ}\text{K}$.

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:

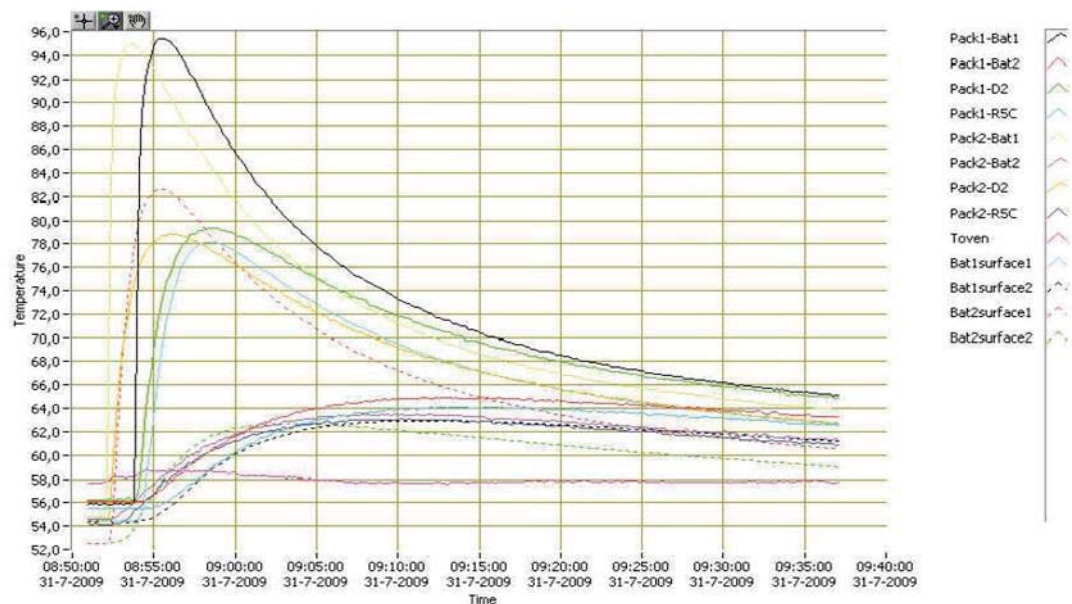


The temperature of the batteries is measured direct after the batteries are completely charged and shorted instantly, to realize the highest possible power dissipation during short of a battery.

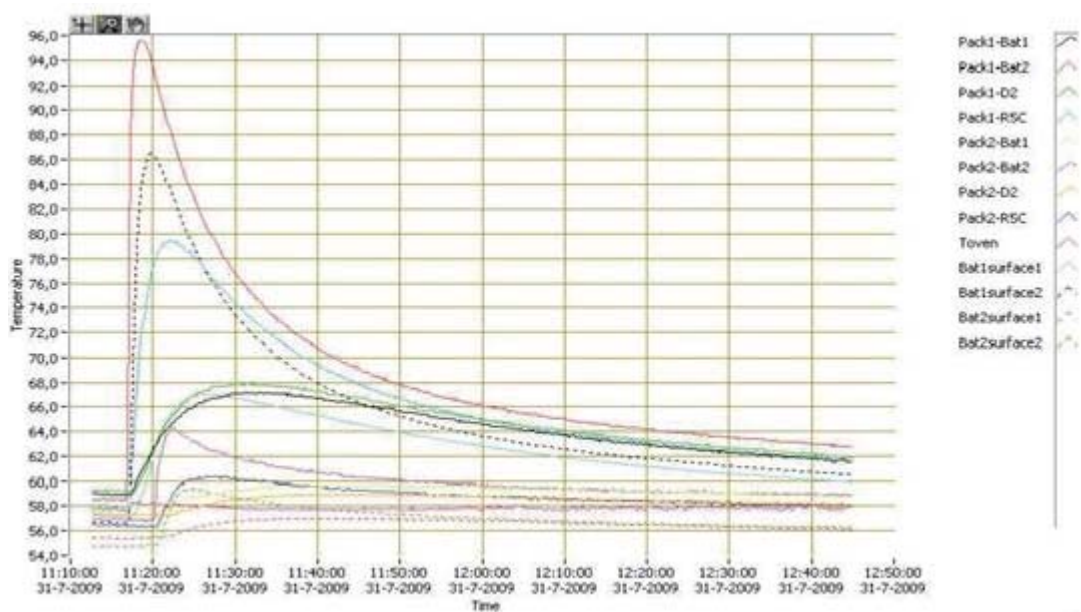


During test the battery pack BP-8000 part has been placed inside of the BUL-8000 enclosure at an ambient temperature of 60°C .

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:*

- ☒ 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: ☒

- ☐ 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
- ☒ 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 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.

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 might 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 °C.

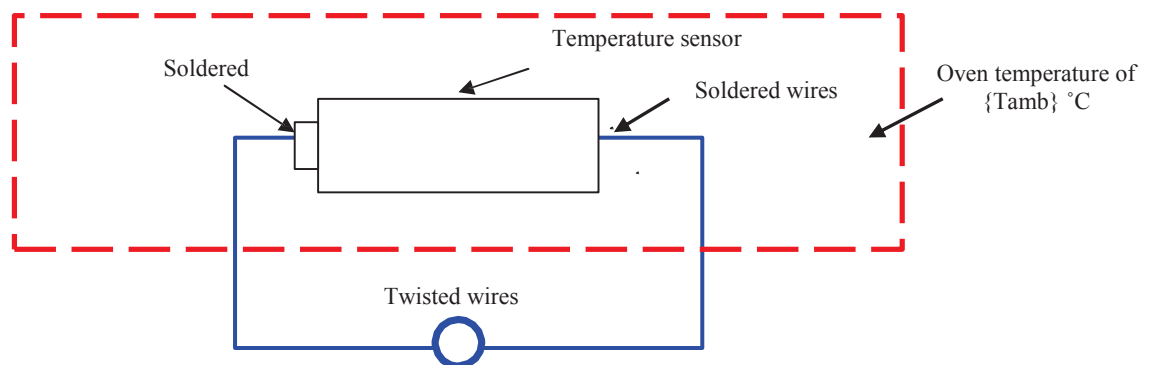
10.5.3 Spark ignition and surface temperature test of cells and batteries:

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 °C.

Schematic of battery test



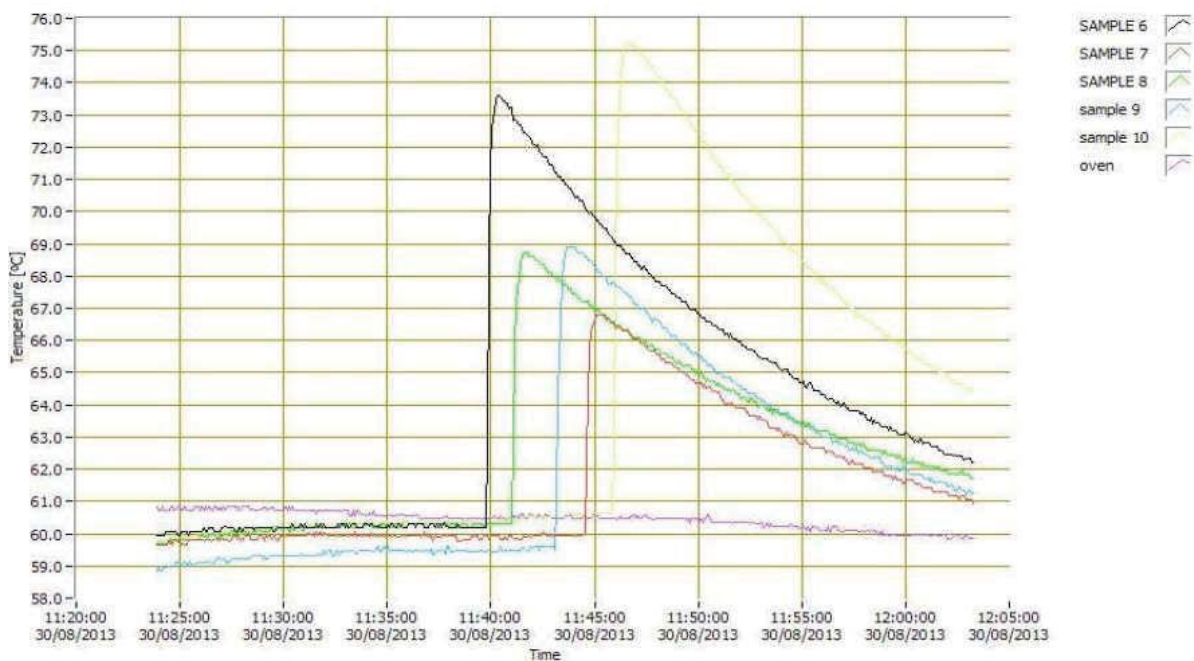
Conclusion

The maximum temperature rise of one of the types during short circuit at 60 °C 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:

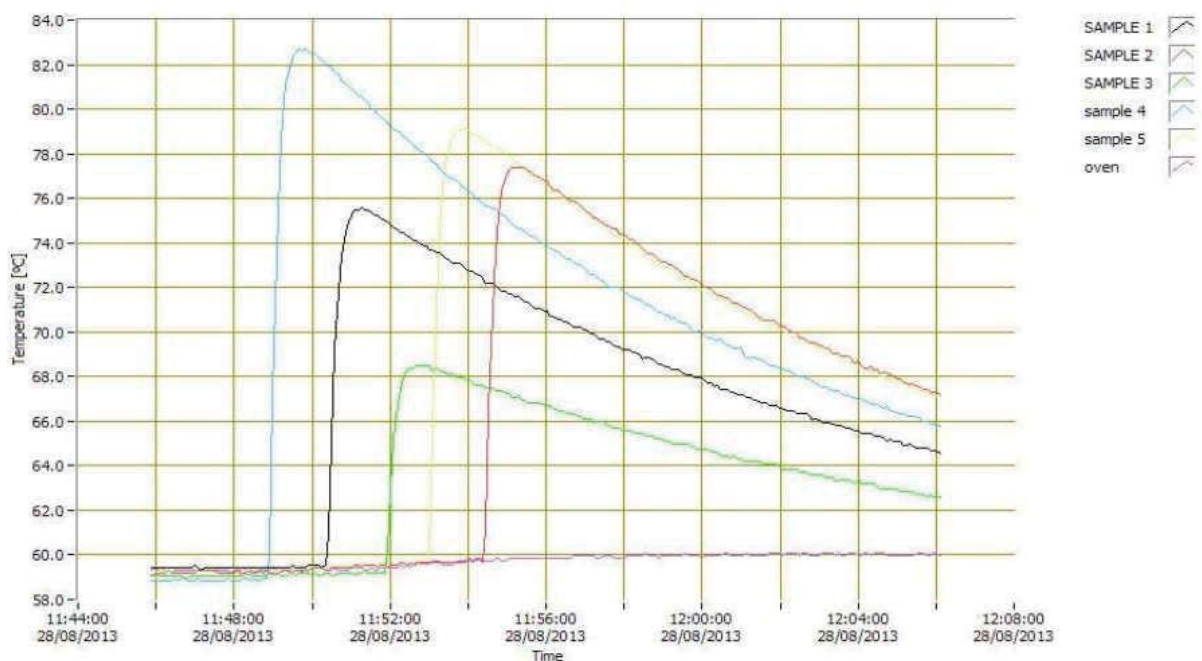


Samsung - SDI

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 in 12h 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	Test Samples and test sequence	3
1.1	Overview of samples.....	3
1.2	Test sequence	3
1.3	Small component ignition test	4

1.1 Overview of samples

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

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.

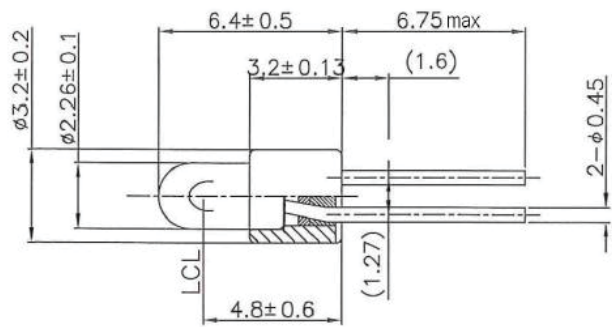
Conclusion

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 μ H 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 (4Vx0.150A) 0.6W, the coiled wire will be open-circuited, having at that moment an inductance of 20 μ H.

Ignitibility of an inductive circuit:

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

Voltage U [V]	4	8	12	16	18	20	22	24 & up
Current I [mA]	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 μ H) 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 [V]	4	12	15	20	25	30	35	40	45	50	55	60
Current I [mA]	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 [V]	4	12	15	20	25	30	35	40	45	50	55	60
Current I [mA]	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 B1.1). This would lead at 4 V to a current of 870 mA (4V/4,6Ohm). According to the table above based on the maximum inductance of 20 μ H 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.

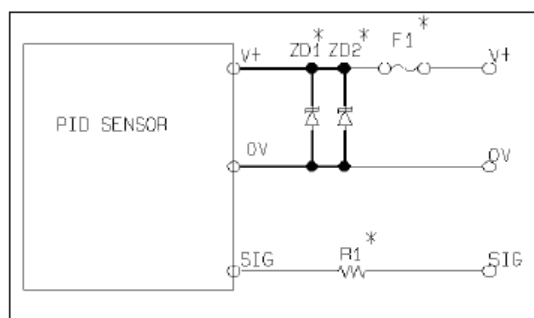
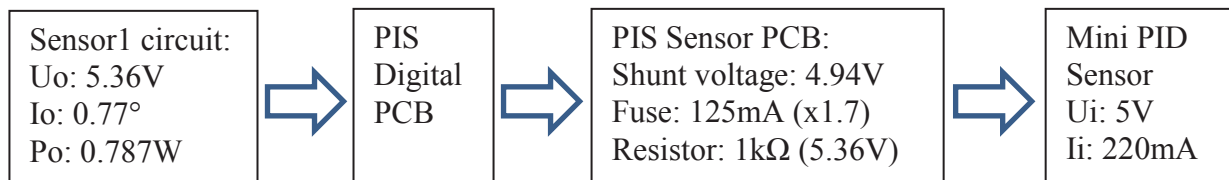
Sample No.	1	2	3	4	5
Voltage [V]	3.0	3.0	3.0	3.1	3.0
Current [mA]	130	130	130	145	145

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.



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.

Input line:

$$I_{\max} = 125\text{mA} \times 1.7 = 213\text{mA}$$

$$P_{\max} = 4.94\text{V} \times 213\text{mA} = 1.05\text{W}$$

Signal line:

$$I = 5.36\text{V} / 1\text{k}\Omega @ 1\% = 5.42\text{mA} \rightarrow P_{R1} = 30\text{mW}$$

Uo < Ui	Io < Ii	Po < Pi	Remark
4.94V < 5V	213mA < 220mA	0.787W < 1.1W	Safe connection
IR1	PR1	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 ADDENDUM

ExTR Reference Number : NO/PRE/ExTR15.0012/05

ExTR Free Reference Number : SC277576_1

Compiled by + signature (ExTL) : Gunnar Nielsen

Reviewed by + signature (ExTL) ... : Stig André Norheim

Date of issue : 2022-11-02

Ex Testing Laboratory (ExTL) :



Address : DNV Product Assurance AS
Veritasveien 1
1363 Høvik
Norway

Applicant's name..... :



Address : RIKEN KEIKI Co., Ltd.
2-7-6, Azusawa, Itabashi-ku,
Tokyo, 174-8744, Japan

Standards..... : IEC 60079-0: 2017 edition 7
IEC 60079-1: 2014 edition 7
IEC 60079-11: 2011 edition 6

Test Report Form Number..... : ExTR Addendum_3 (released 2018-02)

Related Amendments, Corrigenda
or ISHs : N / A

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Possible test case verdicts:

- test case does not apply to the test item :N / A

- test item does meet the requirement :Pass

General remarks:

The test results presented in this ExTR Addendum relate only to the item or product tested, and are only valid when considered together with the related Ex Test Report that was previously issued, along with any previously issued ExTR Addendums for the same item or product.

Only clauses and manufacturer's documents impacted by this document are detailed.

- "(see Attachment #)" refers to additional information appended to this document.
- "(see appended table)" refers to a table appended to this document.
- Throughout this document, a [comma](#) is used as the decimal separator.

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Clause	Requirement – Test	Result – Remark	Verdict
IEC 60079-0:			
4.3	Group II	Model GX-6100 is grouped as IIC.	Pass
5.1.1	Ambient temperature	Model GX-6100: $-20^{\circ}\text{C} \leq T_a \leq +50^{\circ}\text{C}$	Pass
5.2	Service temperature	Model GX-6100: Stand by : 150mA/4.5V/675mW When gas is detected : 170mA/4.5V/810mW (maximum power) Due to the low power consumption the service temperature is considered to be \approx ambient temperature.	Pass
5.3.1	Determination of maximum surface temperature	Model GX-6100: 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 B.1 in measurement section below.	Pass
5.3.2.2	Group II electrical equipment	See 5.3.1. T4 and T3 temperature class assigned and recognized. See Copy of marking plate.	Pass
5.3.3	Small component temperature for Group I or Group II electrical equipment	Model GX-6100: 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 B.1 in measurement section below.	Pass
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 or PET84. All material have surface resistance of less than $1\text{G}\Omega$. See appended table 26.13. All smaller parts of regular plastic material have surface area less than 400mm^2 . Refer to drawing M2-4777-01-01K. Same material as previous tested for model GX-6000.	Pass
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 1 of cl. 7.5 of this standard. See appended Table 26.13 Clip: To attach the EUT to person's clothes. The clip itself is mounted to conductive plastic material. Discharges to approaching earthed objects are not expected as it is attached to a person.	Pass
23	Apparatus incorporating cells and batteries	Evaluation for new back-up battery (Seiko SSI MS421R): the battery itself has a very small capacity, 1,5mAh, and is considered as a capacitor in this evaluation. The physical dimensions is 4,8mm (diameter), 2,1mm (height) and 0,11g (standard mass). Main battery package, BUD-6000 and BUL-6000: no changes.	Pass

Clause	Requirement – Test	Result – Remark	Verdict
23.3	Cell types	Secondary battery, MS421R:SII considered as a capacitor.	N / A
23.5	Ratings of batteries	Charging voltage of the secondary battery is 3.1V. 3.3V-D3, Vf (0.2V). It charges through 3.1V and the internal switch of IC5. The battery is protected by the serial resistor, RS10 (3kΩ). Maximum discharge, $I = 3,3V / 3k\Omega = 1,1mA$ Charging voltage according to datasheet: 2.9V to 3,3V. Maximum discharge current according to datasheet: 10mA Range of temperature: -20°C to +50°C.	Pass
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 Product Assurance AS.	Pass
25	Compliance of prototype or sample with documents	EUT is checked for compliance with documentation required by clause 24.	Pass
26.4.2	Resistance to impact	Impact test is exempted for enclosure but is performed according to the testing of the built-in buzzer, piezoelectric device type FT-27T-3.2A1. Refer to IEC60079-11 part of test report.	Pass
26.4.3	Drop test	Two samples were tested. Each of them dropped four times from a height of 1m to a concrete floor. Ambient temperature was -27°C. EUT was kept in -27°C for ≈24 hours prior to the test. Result: no visible damages to the enclosures.	Pass
26.4.5.1	Test procedure	Requirements of IP20 is checked and recognized for compliance. Higher IP rating is not covered by this investigation.	
26.5.1	Temperature measurement	Refer to IEC60079-11 part of test report.	Pass
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.	Pass
28.2	Certificate	Certificate is issued in due course of this investigation.	Pass

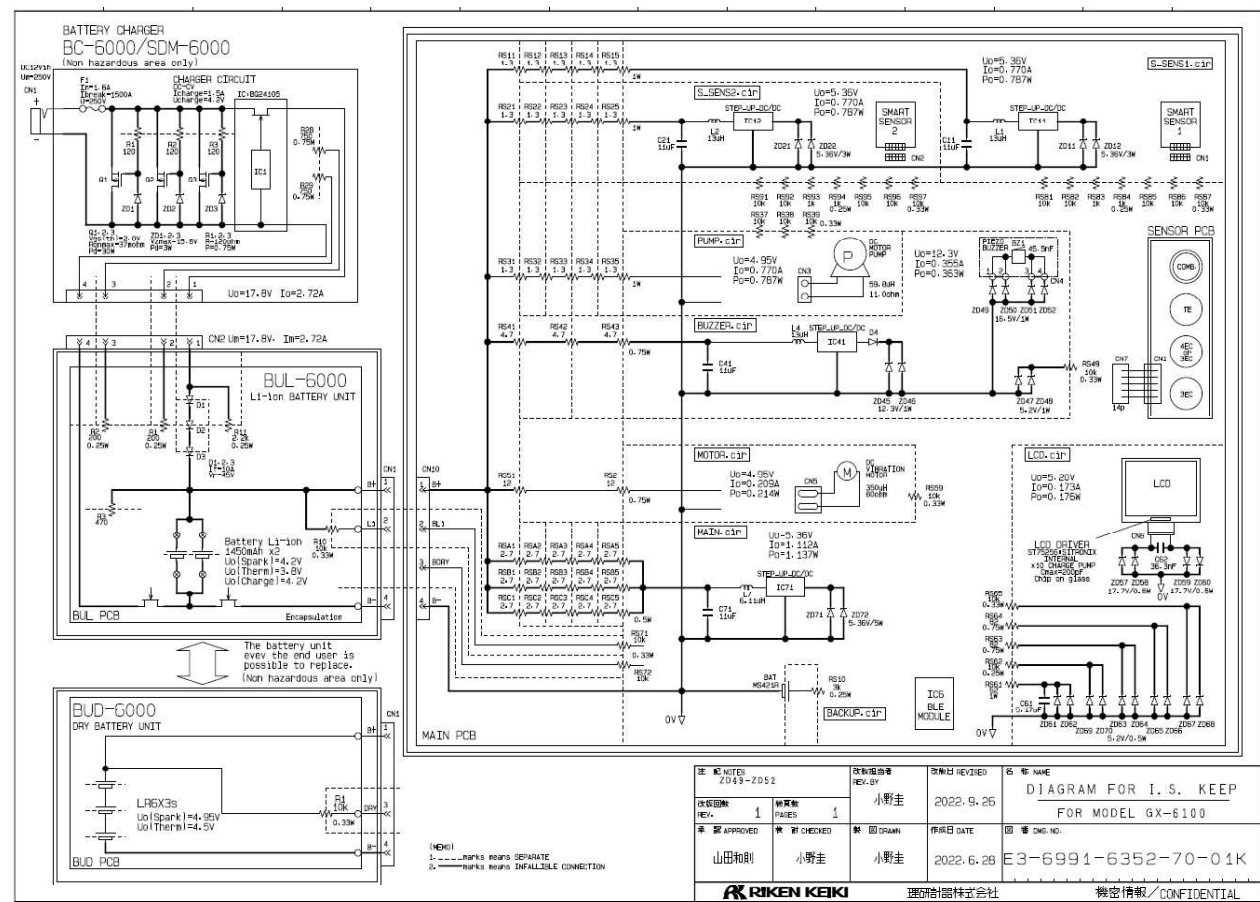
Clause	Requirement – Test	Result – Remark	Verdict
29.3	Marking, general	a) RIKEN KEIKI Co., Ltd b) Model GX-6100 c) Serial number is INST No. on the label, and its explanation is described in the last part of the safety information. d) IECEx DNV 15.0011, Presafe 15ATEX6171X and DNV 22UKEX25912X. e) No “X marking” in IECEx certificate. (ATEX and UKEX include “X”.) f) See below g) N / A	Pass
29.4	Ex marking for explosive gas atmospheres	Ex ia IIB T4/T3 Ga -20°C ≤ Ta ≤ +50°C Ex ia IIC T4/T3 Ga -20°C ≤ Ta ≤ +50°C Ex da ia IIC T4/T3 Ga -20°C ≤ Ta ≤ +50°C	Pass
29.14	Cells and batteries	Properly marked internally.	Pass
30.1	General	Documentation required by clause 24 of IEC60079-0 & clause 13 of IEC60079-11 is reviewed and recognized for compliance.	Pass
30.2	Cells and batteries	Specific safety instructions are provided with regards to brand & type of battery.	Pass
IEC 60079-1:			
The catalytic combustion sensor is already tested and certified in NO/DNV/ExTR21.0088. DNV free reference number is PRJN-313142-2021-PA-NOR/00.			
IEC 60079-11:			
5.6.2	Temperature for small components for Group I and Group II	New BLE module, : ref. DNV project PRJN-3131-42-2021-PA-NOR. Refer to appendix A.1 and B.1 for details.	Pass
7.4.1	Primary and secondary cells and batteries - general	See clause 23 of the IEC 60079-0 part of the report.	N / A
7.4.2	Battery construction	a) Sealed battery (coin cell).	Pass
7.4.3	Electrolyte leakage and ventilation	The enclosure is not sealed. The standard mass is only 0,11g for the back-up battery.	Pass
7.4.4	Cell voltages	See clause 23 of the IEC 60079-0 part of the report.	N / A

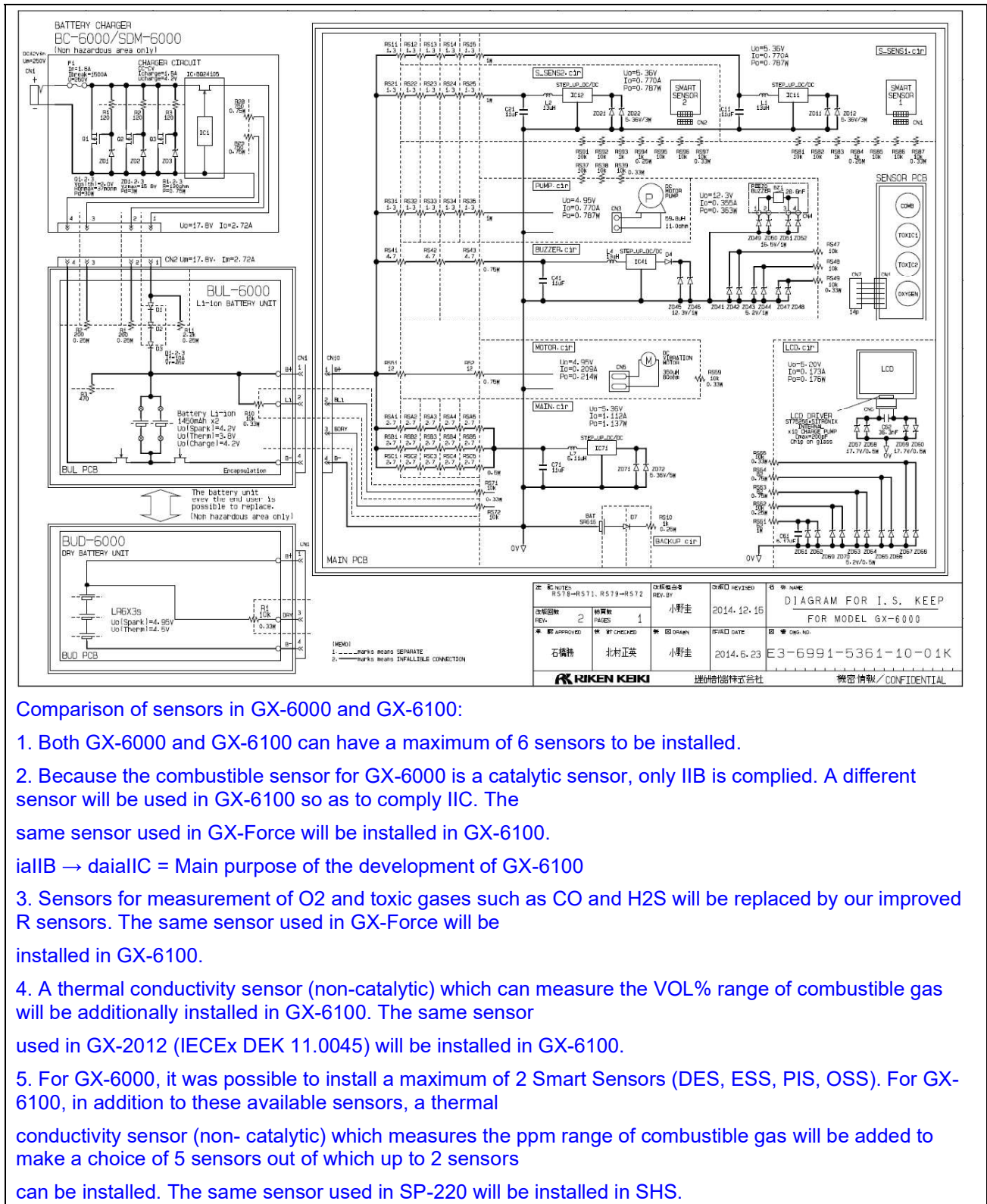
Clause	Requirement – Test	Result – Remark	Verdict
7.7	Piezo-electric devices	<p>Piezo element: Cre-sound FT-27T-3.2A1 Capacitance stated in documentation: 35nF ± 30% = 45,5nF.</p> <p>The piezo-electric device is unfailable connected to 2 x 2 zener diodes (ZD49 to ZD52). Zener value is maximum 16,5V. $V_f = 0,75V$. Total voltage = 17,25V.</p> $E = 0,5 \times C \times U^2 = 0,5 \times 45,5nF \times 17,25V^2 = 6,8\mu J$ $6,8\mu J < 50\mu J \rightarrow IC$	Pass
10.5	Tests for cells and batteries	See clause 23 of the IEC 60079-0 part of the report.	N / A

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

The differences between the GX-6000 and GX-6100 in terms of intrinsically safe explosion protection are shown in red in the diagram below. The other parts are the same in terms of configuration and constants.

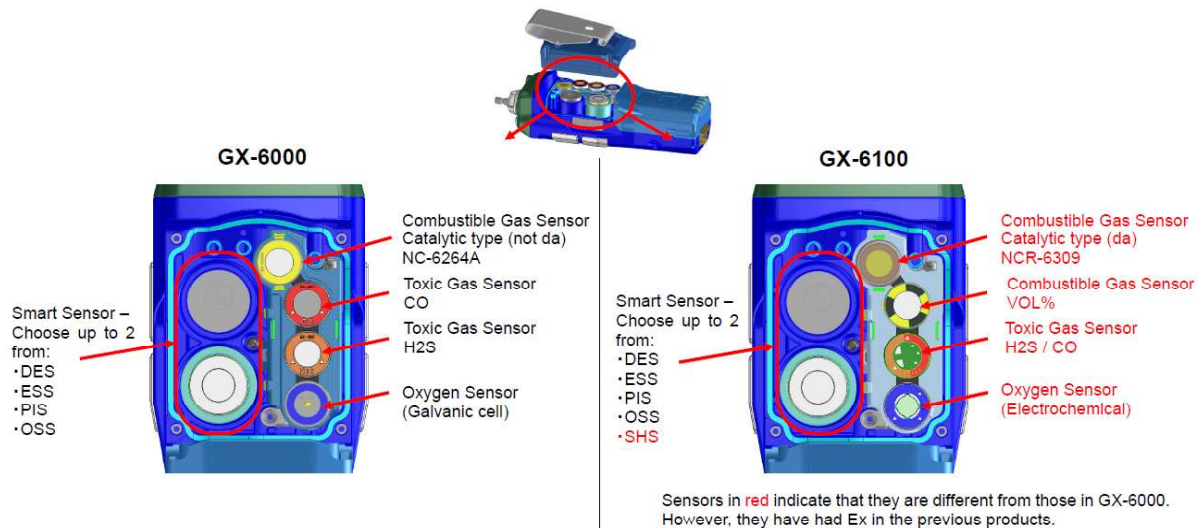
- (1) For sensors, please refer "Comparison of sensors in GX-6000 and GX-6100" below.
- (2) The piezoelectric buzzer has been discontinued, therefore the parts have been changed.
- (3) The backup battery was changed from a primary battery to a secondary battery (MS421R:SII).
- (4) The same BLE module as in the GX-Force is installed (IECEx DNV 22.0029X).






Comparison of sensors in GX-6000 and GX-6100:

1. Both GX-6000 and GX-6100 can have a maximum of 6 sensors to be installed.
2. Because the combustible sensor for GX-6000 is a catalytic sensor, only IIB is complied. A different sensor will be used in GX-6100 so as to comply IIC. The same sensor used in GX-Force will be installed in GX-6100.
IIB → IIC = Main purpose of the development of GX-6100
3. Sensors for measurement of O₂ and toxic gases such as CO and H₂S will be replaced by our improved R sensors. The same sensor used in GX-Force will be installed in GX-6100.
4. A thermal conductivity sensor (non-catalytic) which can measure the VOL% range of combustible gas will be additionally installed in GX-6100. The same sensor used in GX-2012 (IECEX DEK 11.0045) will be installed in GX-6100.
5. For GX-6000, it was possible to install a maximum of 2 Smart Sensors (DES, ESS, PIS, OSS). For GX-6100, in addition to these available sensors, a thermal conductivity sensor (non-catalytic) which measures the ppm range of combustible gas will be added to make a choice of 5 sensors out of which up to 2 sensors can be installed. The same sensor used in SP-220 will be installed in SHS.



		GX-6000				GX-6100				
		Measuring gas	Sensor type	Detection principle	Form	Measuring gas	Sensor type	Detection principle	Form	Ex. model Cert.No.
Standard four gas	1	Combustible gas (LEL)	NC-6264A	Catalytic Combustion		Combustible gas (LEL)	R-sensor NCR-6309	Catalytic Combustion [da]		GX-Force IECEX DNV 22.0029X DNV 22 ATEX 05201X
	2	Oxygen (O2)	Oxygen Sensor	Galvanic cell		Oxygen (O2)	R-sensor 3EC	Electro Chemical		GX-Force IECEX DNV 22.0029X DNV 22 ATEX 05201X
	3	Hydrogen Sulfide (H2S)	Toxic gas Sensor	Electro Chemical		Hydrogen Sulfide / Carbon Monoxide (H2S / CO)	R-sensor 4EC	Electro Chemical		GX-Force IECEX DNV 22.0029X DNV 22 ATEX 05201X
	4	Carbon Monoxide (CO)	Toxic gas Sensor	Electro Chemical		Combustible gas (VOL%)	TE-7561	Thermal Conductivity		GX-2012 IECEX DEK 11.0045 DEKRA 11 ATEX 0123
Smart Sensor	5	VOC	Smart Sensor TYPE-PIS	PID		VOC	Smart Sensor TYPE-PIS	PID		GX-6000 IECEX PRE 15.0011 Presafe 15 ATEX 6171X
	6	Toxic gases	Smart Sensor TYPE-ESS	Electro Chemical		Toxic gases	Smart Sensor TYPE-ESS	Electro Chemical		GX-6000 IECEX PRE 15.0011 Presafe 15 ATEX 6171X
	7	Carbon Dioxide (CO2) or Combustible gas	Smart Sensor TYPE-DES	NDIR		Carbon Dioxide (CO2) or Combustible gas	Smart sensor TYPE-DES	NDIR		GX-6000 IECEX PRE 15.0011 Presafe 15 ATEX 6171X
	8	Oxygen (O2)	Smart Sensor TYPE-OSS	Galvanic cell		Oxygen (O2)	Smart Sensor TYPE-OSS	Galvanic cell		GX-6000 IECEX PRE 15.0011 Presafe 15 ATEX 6171X
	9	-	-	-	-	Combustible gas (ppm)	Smart Sensor TYPE-SHS*	Semi Conductor		SP-220 IECEX PRE 15.0060 Presafe 15 ATEX 7188X

* The SH-8661 sensor is installed inside the SHS sensor.

A.1 Temperature assessment for L4 (part of IC6 / BLE module – EYSHJN) (Test performed in DNV project number PRJN-313142-2021-PA-NOR, for GX-Force)

1) Evaluated at maximum power.

The maximum power of the GX-Force is 0.7513W and the test result is a temperature rise of 145°C.

As the maximum power of the GX-6100 is 1.137W, the temperature rise is $1.137W / 0.7513W \times 145^\circ C = 219.5^\circ C$.

Ambient temperature 50°C

Result: $219.5^\circ C + 50^\circ C = 269.5^\circ C < 275^\circ C$

(2) Since the power is constant even after boosting the voltage, it is considered before boosting.

The maximum power of the BLE module section is

From $U_0 = 4.5 \text{ V}$ of the dry cell battery and the composite resistance of 4.455Ω from current limiting resistors RSA1 to RSC5

$$P_{o_th} = (4.5 \text{ V} / 4.455 \Omega) \times 4.5 \text{ V} / 4 = 1.137 \text{ W.}$$

GX-6100 connected to BLE module through limiting resistor 4.455Ω at 4.5 V power supply

GX-Force is connected to the BLE module with a power supply of 3.8 V through a limiting resistor 4.4Ω ($\approx 4.455 \Omega$) \Rightarrow temperature rise 145°C at this time.

Therefore, the temperature rise of the BLE module of the GX-6100 is $(4.5\text{V}/3.8\text{V})^2 \times 145^\circ\text{C} = 203.4^\circ\text{C}$

Result: $203.4^\circ\text{C} + 50^\circ\text{C} = 254.4^\circ\text{C} < 275^\circ\text{C}$

See test in B.1 below.

B.1 Test conducted Temperature test of L4 (part of IC6 / BLE module – EYSHJN)
(Test performed in DNV project number PRJN-313142-2021-PA-NOR, for GX-Force)

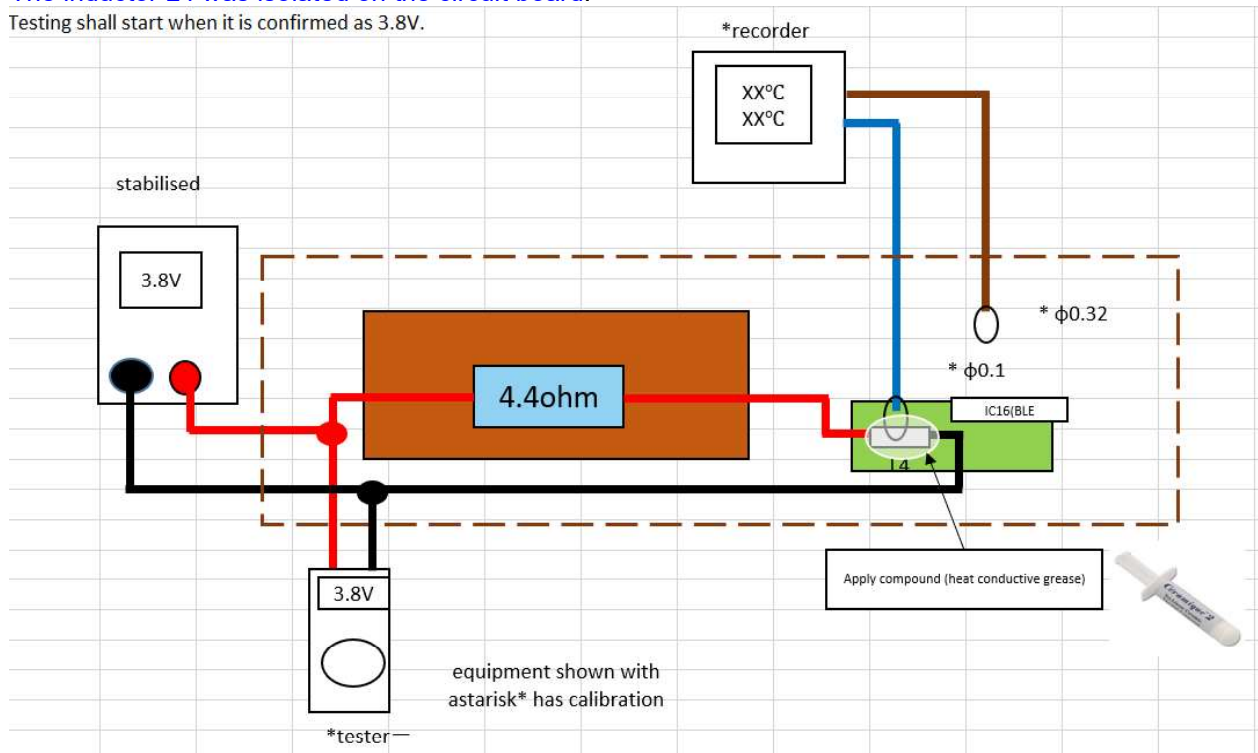
Equipment Tested:	L4 (inductor) as a part of the hybrid component IC6
Date of Test (yyyy/mm/dd):	2022/05/19
Clause and Standards:	10.2 of IEC 60079-11: 2011

B.1.1 Test procedures

According to clause 7.6.h of IEC 60079-11: 2011 the resistance of an inductor at failure shall be between nominal value (0.34Ω) and 0 .

The inductor L4 was isolated on the circuit board.

Testing shall start when it is confirmed as 3.8 V .



$$R = 4.37 \Omega \quad U = 3.8 \text{ V}$$

B.7.2 Results

$T_{\text{measured}} = 171^{\circ}\text{C}$ $T_{\text{a-max}} = 60^{\circ}\text{C}$ $T_{\text{a}} = 26^{\circ}\text{C}$ $\Delta T = 145\text{K}$
 $T_{\text{max}} = 145\text{K} + 60^{\circ}\text{C} = 205^{\circ}\text{C}$
 $205^{\circ}\text{C} < 275^{\circ}\text{C} \rightarrow T_4$

