IECEx TEST REPORT COVER

ExTR Reference Number..... :	NO/DNV/ExTR21.0088/00
ExTR Free Reference Number ..... :	PRJN-313142-2021-PA-NOR
Compiled by + signature (ExTL) .... :	Gunnar Nielsen
Reviewed by + signature (ExTL).... :	Bjørn Spongsveen
Endorsed by + signature (ExCB) ... :	Asle Kaastad
Date of issue ..... :	2022-07-04
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 Co., Ltd.
Address..... :	2-7-6, Azusawa, Itabashi-Ku, Tokyo, 174-8744, Japan
Standards associated with this ExTR package ..... :	IEC 60079-0:2017 ed. 7 IEC 60079-1:2014 ed. 7 IEC 60079-11:2011 ed. 6
Clauses considered ..... :	All clauses considered
Test Report Form Number..... :	ExTR Cover_9 (released 2021-09)
Related Amendments, Corrigenda or ISHs ..... :	IEC 60079-28 ISH1:2019
Test item description..... :	Portable gas detector
Model/type reference ..... :	GX-Force Three different gas sensors are used: Model ESR-A1DP: measures CO/H_2S (electrochemical principle) Model ESR-X13P: measures O_2 (electrochemical principle) Model NCR-6309: measures flammables (catalytic)
Code (e.g. Ex __ II__ T__)..... :	Ex da ia IIC T4 Ga (Including flammable sensor.) Ex ia IIC T4 Ga (Not including flammable sensor.)
Rating..... :	Battery powered, single secondary cell Panasonic type NCR18650GA. Nominal voltage: 3,6V Maximum open circuit voltage: 4,2V The charging terminal is USB TYPE C, and only a use of a charger exclusively specified for it, IEC60950-certified SELV power supply, or IEC62368-1-certified ES1 power supply is approved for charging. Charging method is CCCV. (Charging only in non-hazardous area.) Charging terminal, Um: 6V

ExTR Package Contents
Assembled ExTR documents and Additional reference material:
IECEx Test Report Cover
IECEx Test Report: IEC 60079-0, Edition 7
IECEx Test Report: IEC 60079-1, Edition 7
IECEx Test Report: IEC 60079-11, Edition 6

Manufacturer's name .....:	RIKEN KEIKI Co., Ltd.
Address .....:	2-7-6, Azusawa, Itabashi-Ku, Tokyo, 174-8744, Japan
Trademark .....:	RIKEN KEIKI Co., Ltd.
Certificate No. (optional) .....:	IECEx DNV 22.0029X
QAR Reference No. (optional) .....:	NO/PRE/QAR19.0018/03

Particulars: Test item vs. Test requirements

Classification of installation and use ..... :	Hand-held
Ingress protection .....:	IP20
Rated ambient temperature range (°C).....:	T_{amb} : -20°C to +60°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.*

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

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:

GX-Force is a portable suction type gas detector which can measure 4 kinds of gases. For gas sensors, electrochemical type and catalytic type are used. For the battery, one cell of 18650 type lithium ion secondary battery is used, which must be charged in a non-hazardous location. Users will never have to replace the battery.

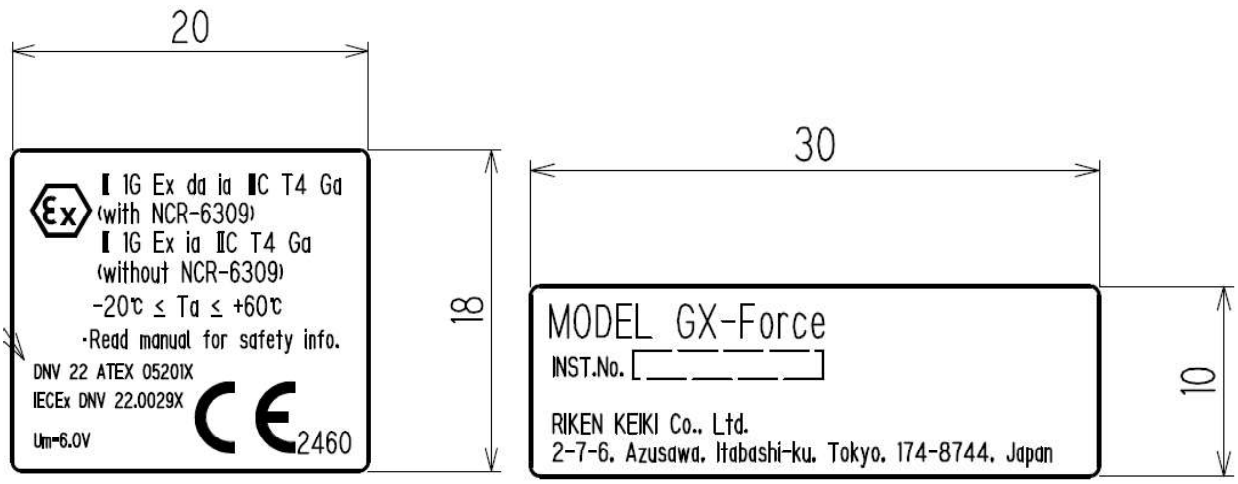
This unit contains 2 buttons, LCD display screen, and LEDs for alarm on both sides and top. Internally, one each pump, buzzer, and vibration motor are mounted. When the power is supplied, the pump will be activated for suction, and the unit starts gas detection. Gas concentration is always displayed on the LCD screen. When a gas is detected, the indicator value on the LCD screen goes up, and when it reaches to the alarm level, LED buzzer, vibration motor will be activated and notify the user that the gas was detected.

The sensors to be mounted are electrochemical type and catalytic type. The electrochemical type sensor detects CO (carbon monoxide), H_2S (hydrogen sulfide), and O2 (oxygen). The catalytic type sensor

detects flammable gases. It uses catalyst, and therefore needs to apply with “da”.

Charging shall be done in a non-hazardous location. The charging terminal is USB TYPE C, and only a use of a charger exclusively specified for it, IEC60950-certified SELV power supply, or IEC62368-1-certified ES1 power supply is approved for charging. Charging method is CCCV, and a control is performed by a dedicated IC. Rechargeable temperature range is between +10°C and +40°C.

Copy of Marking Plate:



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:

- Pump, Riken Keiki RP-12, is already certified in IECEx PRE 17.0070/Presafe 17ATEX11584.
- Battery, Panasonic NCR18650GA, is already tested in NO/PRE/ExTR20.0043.
- Vibration motor, LEXIN LE4A3GS1G4, is already certified in IECEx DEK 17.0050X/DEKRA 17ATEX0103X.

Enclosure materials:

- PC L-1225Z100M: is already certified in IECEx DEK 17.0050X/ DEKRA 17 ATEX0103X.
- TPE LSB9959R: is already certified in IECEx DEK 11.0045/DEKRA 11 ATEX0123.
- PET PE84-0.125t: is already certified in IECEx PRE 17.0020/ Presafe 17 ATEX9760.

National differences considered as part of this evaluation:

N / A

“Specific Conditions of Use” / “Schedule of Limitations”:

Charging terminal, Um: 6,0.

Routine tests:

N / A

Date(s) of performance for all testing:

IEC 60079-0:

Test no.	Clause	Description	Date
1	26.14	Measurement of capacitance	2022/01/25
2	26.4.3	Drop test	2022/01/26
3	26.4.5	IP20	2022/01/26
4	26.5.1	Temperature measurement ref. report NL/DEK/ExTR17.0047/00-02	N / A
5	26.8 26.9	Thermal endurance	2022/01/07 to 2022/02/08

IEC 60079-1

Test no.	Clause	Description	Date
1	5	Flameproof joints	2022/03/20
2	15.2.3	Overpressure test	2022/03/16
3	15.3	Non-transmission of an Internal Ignition Test	2022/04/29 to 2022/05/17

IEC 60079-11

Test no.	Clause	Description	Date
1	6.3.4 & 6.3.8	Separation distances (creepage and clearance)	2022/02/03 & 2022/02/28
2	7.7 & 10.7	Piezo-electric device (buzzer)	2022/02/03
3	8.8.b.2	Measurement of infallible tracks	2022/06/21
4	8.8.b.3	Measurement of infallible vias	2022/06/21
5	10.5.2, 10.5.3.a & 10.5.3.b	Battery testing (IECEx TR NO/PRE/ExTR20.0043/00)	N / A
6	10.2	Temperature test of 0603 component	2022/03/09
7	10.2	Temperature test of L4 (part of IC16 / BLE module)	2022/05/19

Technical Documents			
Title:	Drawing No.:	Rev. Level:	Date:
* INDEX GX-Force	E4-6991-6235-70-01K	8	2022.06.16

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

		DRAWING NAME	DRAWING No.	REV	DATE
	1	BLOCK DIAGRAM GX-Force	E4-6991-6236-40-01K	0	2021.10.6
	2	DIAGRAM FOR I.S. KEEP GX-Force	E3-6991-6230-10-01K	2	2022.6.3
	3	OUTER STRUCTURE GX-Force	M2-4777-31-01K	3	2022.4.15
	4	DETAIL DRAWING 1 GX-Force	M3-4777-31-01K	2	2022.4.15
	5	DETAIL DRAWING 2 GX-Force	M3-4777-31-02K	1	2022.4.15
	6	SCHEMATIC MAIN PCB GX-Force	E3-6991-6237-10-01K	1	2022.1.14
	7	SCHEMATIC MAIN PCB GX-Force	E3-6991-6237-10-02K	0	2021.10.6
	8	SCHEMATIC MAIN PCB GX-Force	E3-6991-6237-10-03K	1	2022.1.14
	9	SCHEMATIC MAIN PCB GX-Force	E3-6991-6237-10-04K	1	2022.1.14
	10	PARTS LIST OF MAIN PCB GX-Force	PLT-6991-6237-10 (1/4)	2	2022.6.3
	11	PARTS LIST OF MAIN PCB GX-Force	PLT-6991-6237-10 (2/4)	0	2021.11.18
	12	PARTS LIST OF MAIN PCB GX-Force	PLT-6991-6237-10 (3/4)	1	2022.1.14
	13	PARTS LIST OF MAIN PCB GX-Force	PLT-6991-6237-10 (4/4)	1	2022.1.14
	14	MAIN PCB GX-Force	E3-6991-6237-10-01A	1	2022.1.17
	15	MAIN PCB GX-Force	E3-6991-6237-10-02A	1	2022.1.17
	16	BP-Force	M3-4777-31-03K	0	2021.11.26
	17	PROTECT PCB BP-Force	E3-6991-6238-90-01K	1	2022.1.24
	18	PUMP RP-12	M4-4181-61-03K	1	2022.2.3
	19	3EC SENSOR TYPE-ESR	M4-4482-02-01K	2	2018.3.29
	20	4EC SENSOR TYPE-ESR	M4-4488-19-01K	2	2018.3.29
*	21	COMBUSTIBLE GAS SENSOR NCR-6309	M3-4463-10-02K	7	2022.6.16
	22	LABEL GX-Force	M4-4777-31-01K	2	2022.3.24
	23	Safety information	-	3	2022.3.24

注記 NOTES 21.		改版担当者 REV. BY	改版日 REVISED	名称 NAME
改版回数 REV. 8	総頁数 PAGES 1	古舘優作	2022.6.16	INDEX / GX-Force
承認 APPROVED	検討 CHECKED	製図 DRAWN	作成日 DATE	図番 DWG. NO.
北村正英	小野圭	古舘優作	2021.10.6	E4－6991－6235－70－01K

RIKEN KEIKI 理研計器株式会社 機密情報／CONFIDENTIAL

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

ExTR Reference Number..... :	NO/DNV/ExTR21.0088/00
ExTR Free Reference Number..... :	PRJN-313142-2021-PA-NOR
Compiled by + signature (ExTL) .... :	Gunnar Nielsen
	Nenad Stanivukovic
Reviewed by + signature (ExTL).... :	Bjørn Spongsveen
Date of issue ..... :	2022-07-04
Ex Testing Laboratory (ExTL)..... :	DNV
Address..... :	DNV Product Assurance AS 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 60079-0:2017, Edition 7.0
Test procedure..... :	IECEx System
Test Report Form Number..... :	ExTR60079-0_7C_DS (released 2021-10)
Related Amendments, Corrigenda or ISHs	N / A

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.

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- "(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 **DS 2021/004**	Scope		
2	Normative references		
3 **DS 2020/002**	Terms and definitions		
4	Equipment grouping		
4.1	General	According to clause 4.3.	Pass
4.2	Group I	Not for Group I.	N / A
4.3	Group II	IIC	Pass
4.4	Group III	Not for Group III.	N / A
4.5	Equipment for a particular explosive gas atmosphere	Certified for Group IIC.	N / A
5 **DS 2016/002** **DS 2015/011A**	Temperatures		
5.1	Environmental influences		
5.1.1	Ambient temperature	T_{amb} : -20°C to +60°C	Pass
5.1.2	External source of heating or cooling	No external sources of heating or cooling.	N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
5.2 **DS 2020/006**	Service temperature	Service temperature for Gas Sensor, Type NCR-6309 was determined to +69.3°C at the ambient temperature +60°C (ΔT=9.3K) Current and power consumption in normal use (stated by customer): - in normal use Current consumption ・・・85mA Power consumption ・・306mW - when alarm is activated Current consumption ・・・110mA Power consumption ・・・396mW Service temperature will be ≈ to ambient temperature.	Pass

5.3	Maximum surface temperature		
5.3.1	Determination of maximum surface temperature	Determined according to clause 5.3.3, 26.5.1 and IEC 60079-11. Maximum surface temperature for Gas Sensor, Type NCR-6309 was determined to +79.3°C at the ambient temperature +60°C (ΔT=19.3K) taking into the consideration results of thermal tests (see 60079-1 report). (T=79.3+8.4 x 1.2 =89.38 < 135-5 (T4) [℃]	Pass
5.3.2	Limitation of maximum surface temperature		
5.3.2.1	Group I electrical equipment	Not for Group I.	N / A
5.3.2.2	Group II electrical equipment	T4	Pass
5.3.2.3	Group III electrical equipment	Not for Group III.	N / A
5.3.2.3.1 **DS 2020/006**	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	See appendix A.3 of the IEC 60079-11 report for details.	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

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
6.1	General	According to IEC 60079-0, IEC 60079-1 and IEC 60079-11. In addition according to these relevant industrial standards: EN 50270 - Electromagnetic compatibility - Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen EN IEC 63000 - Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	Pass
6.2	Mechanical strength of equipment	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. The gas sensor, Type NCR-6309, is protected by impact by enclosure parts which considered as “guard”.	Pass
6.3	Opening times	For “ia”: Excluded by table 1 of IEC 60079-11. Sensor, Type NCR-6309, can’t be opened.	N / A
6.4	Circulating currents in enclosures (e.g. of large electric machines)	For “ia”: Excluded by table 1 of IEC 60079-11. No circulating currents.	N / A
6.5	Gasket retention	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. Sensor, Type NCR-6309, can’t be opened, Ex protection doesn’t rely on the gasket.	N / A
6.6	Electromagnetic and ultrasonic energy radiating equipment		
6.6.1	General		Pass

<table>
<tr><th colspan="4">IEC 60079-0</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td>6.6.2</td><td>Radio frequency sources</td><td>Component IC16 is a BLE Module EYSHJN [TAIYO YUDEN].
Chip : Nordic nRF52832
Internal C = 1.5uFmax, L=0neg. (nano Henry range)
<table>
<tr><th>Symbol</th><th>Description</th><th>Min.</th><th>Typ.</th><th>Max.</th><th>Units</th></tr>
<tr><td>Fop</td><td>Operating frequencies</td><td>2402</td><td></td><td>2480</td><td>MHz</td></tr>
<tr><td>PLL_{chsp}</td><td>PLL channel spacing</td><td></td><td>1</td><td></td><td>MHz</td></tr>
<tr><td>Df_{BLE2M}</td><td>Frequency deviation @ BLE 1Mbps</td><td></td><td>+/-250</td><td></td><td>kHz</td></tr>
<tr><td>Df_{BLE2M}</td><td>Frequency deviation @ BLE 2Msps</td><td></td><td>+/-500</td><td></td><td>kHz</td></tr>
<tr><td>P_{RF}</td><td>Maximum output power</td><td></td><td>4</td><td>6</td><td>dBm</td></tr>
<tr><td>P_{RFC}</td><td>RF power control range</td><td></td><td>24</td><td></td><td>dB</td></tr>
<tr><td>P_{RFCR}</td><td>RF power accuracy</td><td></td><td></td><td>+/-4</td><td>dB</td></tr>
<tr><td>P_{RF1}</td><td>1st Adjacent Channel Transmit Power 1 MHz</td><td></td><td>-25</td><td></td><td>dBc</td></tr>
<tr><td>P_{RF2}</td><td>2nd Adjacent Channel Transmit Power 2 MHz</td><td></td><td>-50</td><td></td><td>dBc</td></tr>
<tr><td>PRX_{MAX}</td><td>Maximum received signal strength at < 0.1% PER</td><td></td><td>0</td><td></td><td>dBm</td></tr>
<tr><td>P_{SENS,IT,1M,BLE}</td><td>Receiver sensitivity 1Msps BLE Ideal transmitter <=37bytes (0.1% BER)</td><td></td><td>-94</td><td></td><td>dBm</td></tr>
<tr><td>P_{SENS,IT,2M,BLE}</td><td>Receiver sensitivity 2Msps BLE Ideal transmitter Packet length<=37bytes</td><td></td><td>-91</td><td></td><td>dBm</td></tr>
</table>
Maximum output RF power: 6dBm = 4mW
4mW < 2W
Frequency: 2,4GHz
2,4GHz → 9kHz to 60GHz</td><td>Pass</td></tr>
<tr><td>6.6.3</td><td>Ultrasonic sources</td><td>No ultrasonic sources in EUT.</td><td>N / A</td></tr>
<tr><td>6.6.4
DS 2018/004</td><td>Lasers, luminaires, and other non-divergent continuous wave optical sources</td><td>LEDs for alarm on both sides and top. These LEDs are divergent and not continuous.
According to IEC 60079-28 ISH1:2019 divergent light sources are not applicable to IEC 60079-28.</td><td>N / A</td></tr>
</table>

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

7.1	General	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. Enclosure of the gas sensor, Type NCR-6309, made from two plastic parts with cemented joint (in between).	Pass
7.1.1	Applicability		
7.1.2 DS 2011/002A	Specification of materials		
7.1.2.1	General	Descriptive documents describe the materials used for manufacturing the enclosure.	Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
7.1.2.2	Plastic materials	Excluded by table 1 of IEC 60079-11. Annex F is not used. Panel sheet: a) U-CORPORATION Co., Ltd. b) PET PE84-0.125t, transparent. Protector (main part of material): a) Riken Technos Corp. b) TPE LSB9959R, black. There are also superficial areas made of other materials, but these are only external parts covering the bottom/top case. Electrostatic charging is considered for these materials, see clause 7.4.2 for details. “Gas Sensor, Type NCR-6309, enclosure” a) DIC Corporation b) PPS FZ1130-D5 (PPS GF30%), natural color. c) no surface treatment d) RTI: +130°C e) N/A (won’t be exposed to UV)	Pass
7.1.2.3	Elastomers	For Ex “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. A gasket is used between main part of the enclosure (front) and the lid (back). The gasket is kept in place even if the enclosure is opened. The enclosure and lid is mounted together by the use of four screws. (The enclosure shall not be opened by the customer.)	N / A
7.1.2.4	Materials used for cementing	For Ex “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. Cementing is not used for the external enclosure. Sensor, Type NCR-6309: The joints between the in-casted breather and the Cap and between the electrical contacts and Base are cemented joints. Since the joints are formed by injection molding (from the same material as enclosure) the molding parameters are relevant (specified in drawing M3-4463-10-02K).	Pass

7.2	Thermal endurance		
7.2.1	Tests for thermal endurance	See clause 26.7.1 below.	Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
7.2.2	Material selection	The RTI and COT of the materials specified are satisfactory with respect to minimum ambient temperature and maximum service temperature (see 7.1.2.2 and 7.1.2.4 above). See clause 26.5.1.2.	Pass
7.2.3	Alternative qualification of elastomeric sealing O-rings	No O-rings evaluated as part of Ex protection.	N / A

7.3	Resistance to ultraviolet light	Teijin Limited PC L-1225Z100M (black and clear): UL 746C: f1.	Pass

7.4	Electrostatic charges on external non-metallic materials		
7.4.1	Applicability	Enclosure is made of non-metallic materials.	Pass
7.4.2	Avoidance of a build-up of electrostatic charge for Group I or Group II	a) Panel sheet: U-corporation Co., Ltd, PET PE84-0.125t, surface resistance less than 1GΩ. See Measurement Section, including Additional Narrative Remarks for details. Protector (main part of material): Riken Technos Corp., TPE LSB9959R, surface resistance less than 1GΩ. See Measurement Section, including Additional Narrative Remarks for details. b) Several individual areas which are less than 400mm^2. See “measurement section” at the end of the report for details. c) N / A d) N / A e) N / A f) N / A g) N / A	Pass
7.4.3	Avoidance of a build-up of electrostatic charge for Group III	No dust certification.	N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
7.5	Attached external conductive parts	Nipple is metallic material and conductive.  Tested according to clause 26.14. See Measurement Section, including Additional Narrative Remarks for details. Screws and metallic parts less the size of the screws will present a capacitance of not more than 3pF, according to NOTE 1. These parts are also situated such that discharges to approaching earthed objects are not expected.	Pass
8	Metallic enclosures and metallic parts of enclosures	Enclosure made of non-metallic materials.	N / A
8.1	Material composition		N / A
8.2	Group I		N / A
8.3	Group II		N / A
8.4	Group III		N / A
8.5	Copper Alloys		N / A
9	Fasteners	For “ia”: Excluded by table 1 of IEC 60079-11. No fasteners used on gas sensor, Type NCR-6309, enclosure. Two parts of enclosure are permanently fixed together by metallic rim.	N / A
9.1	General		
9.2	Special fasteners		
9.3	Holes for special fasteners		
9.3.1	Thread engagement		
9.3.2	Tolerance and clearance		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
9.4	Hexagon socket set screws		
10	Interlocking devices	For “ia”: Excluded by table 1 of IEC 60079-11. Interlocking devices are not used.	N / A
11	Bushings	For “ia”: Excluded by table 1 of IEC 60079-11. EUT is not a bushing.	N / A
12	(Reserved for future use)		
13 **DS 2014/001** **DS 2021/006**	Ex Components	EUT is not an Ex component. No Ex components are used in the certification.	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 **DS 2020/002**	Ex Component certificate		N / A
14	Connection facilities	For “ia”: Excluded by table 1 of IEC 60079-11. No external connections to gas sensor, Type NCR-6309.	N / A
14.1	General		N / A
14.2	Type of protection		N / A
14.3	Creepage and clearance		N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
15	Connection facilities for earthing or bonding conductors	For "ia": Excluded by table 1 of IEC 60079-11. Battery powered equipment.	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
15.5	Protection against corrosion		N / A
15.6	Secureness of electrical connections		N / A
15.7	Internal earth continuity plate		N / A
16 **DS 2017/001**	Entries into enclosures	For "ia": Excluded by table 1 of IEC 60079-11. Annex F is not used. No entries to gas sensor, Type NCR-6309.	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

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
16.6 **DS 2018/002**	Temperature at branching point and entry point		N / A
16.7	Electrostatic charges of cable sheaths		N / A
17	Supplementary requirements for electric machines	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. EUT is not an electrical machine.	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
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	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. EUT is not a switchgear.	N / A
18.1	Flammable dielectric		N / A
18.2	Disconnectors		N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
18.3	Group I – Provisions for locking		N / A
18.4	Doors and covers		N / A
19	Reserved for future use		
20 **DS 2020/007**	Supplementary requirements for external plugs, socket outlets and connectors for field wiring connection	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. EUT is handheld. No field wiring connections, but there is a USB-C terminal for charging of the battery in non-hazardous area.	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
21	Supplementary requirements for luminaires	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. EUT is not a luminaire.	N / A
21.1 **DS 2020/001**	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	EUT is not a caplight or handlight.	N / A
22.1	Group I caplights		N / A

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
22.2	Group II and Group III caplights and handlights		N / A
23	Equipment incorporating cells and batteries		
23.1	General	EUT is powered by a single secondary cell. The cell is tested in NO/PRE/ExTR20.0043/00. See appendix B of IEC 60079-11 report for details.	Pass
23.2	Interconnection of cells to form batteries	Only a single cell is used.	N / A
23.3 **DS 2019/002**	Cell types	According to table 14: Type system: Lithium ion Positive electrode: (NCA) Li(NiCoAl)O2 Electrolyte: Liquid solution Negative electrode: Carbon Voltage: 3,6V Maximum open circuit voltage: 4,2V	Pass
23.4	Cells in a battery	Single cell.	Pass
23.5	Ratings of batteries	Ambient temperature discharge: -20°C to + 60°C Ambient temperature charge: +10°C to + 45°C Ambient temperature for EUT: -20°C to + 60°C Max discharge current for the battery is 8A. Nominal discharge for EUT is: 85mA Discharge when alarm is activated: 110mA	Pass
23.6	Interchangeability	Only one single battery in EUT.	Pass
23.7	Charging of primary batteries	Primary cells are not used.	N / A
23.8	Leakage	Tested according to clause 10.5.2 of IEC 60079-11. No leakage occurred.	Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
23.9	Connections	 Connections according to manufacturer's recommendations.	Pass
23.10	Orientation	Battery orientation is not important for safe operation.	Pass
23.11	Replacement of cells or batteries	User shall never replace the battery.	N / A
23.12	Replaceable battery pack	The battery is not replaceable.	N / A
24	Documentation	Manufacturer has prepared documentation that details the Ex safety of the equipment according to IEC 60079-0, IEC 60079-1 and IEC 60079-11.	Pass
25	Compliance of prototype or sample with documents	Test samples complies with the documentation.	Pass
26 **DS 2017/005**	Type tests		
26.1	General	Tested according to IEC 60079-0, IEC 60079-1 and IEC 60079-11. No any test judged as unnecessary (no justification records). Thermal testing of gas sensor, Type NCR-6309, is accepted based on reports NL/DEK/ExTR17.004/00-02 See Comment 4 at the end of this report. All test equipment is regular, calibrated, measurements are considered without any significant detrimental effect.	Pass
26.2	Test configuration	EUT is tested in the configuration considered to be the most unfavourable.	Pass
26.3	Tests in explosive test mixtures	Tested according to specifications of IEC 60079-1.	Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
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	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. Applicable tests in the following order for gas sensor, Type NCR-6309: - maximum surface temperature - test for resistance to impact, - tests required by type protection.	Pass
26.4.1.2	Non-metallic enclosures or non-metallic parts of enclosures	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. Applicable tests in the following order for gas sensor, Type NCR-6309: - service temperature, - surface temperature, - thermal endurance test, - drop test - tests required by type protection.	Pass
26.4.1.2.1	General		Pass
26.4.1.2.2	Group I equipment	Not for Group I.	N / A
26.4.1.2.3	Group II and Group III equipment		Pass
26.4.2 **DS 2020/001**	Resistance to impact	For “ia”: Excluded by table 1 of IEC 60079-11. Annex F is not used. Gas sensor, Type NCR-6309,: Not applicable for hand held equipment.	N / A
26.4.3	Drop test	4 drop tests on two different test samples are performed from a height of 1m onto a concrete surface. Ambient temperature: -45°C for 24 hours prior to the tests. The actual tests were also performed in this temperature. See Measurement Section, including Additional Narrative Remarks test 2 for details.	Pass
26.4.4	Acceptance criteria	Only superficial scratches to the enclosure after drop tests. No damages.	Pass
26.4.5 **DS 2012/003**	Degree of protection (IP) by enclosures		
26.4.5.1	Test procedure	Tested according to IEC 60529 after drop tests.	Pass
26.4.5.2	Acceptance criteria	≥IP20 See Measurement Section, including Additional Narrative Remarks test 3 for details.	Pass

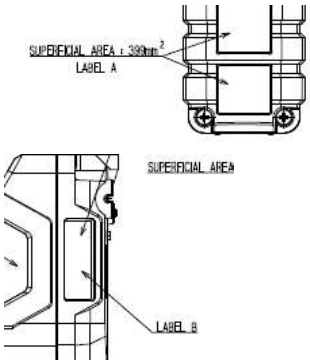
IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
26.5	Thermal tests		
26.5.1	Temperature measurement		
26.5.1.1	General	For Gas sensor, Type NCR-6309, See 26.1 above.	Pass
26.5.1.2	Service temperature	The service temperature rise is measured to (∆T=9.3K) on the (plastic) enclosure of the of the gas sensor, Type NCR-6309. See Comment 4 at the end of this report.	Pass
26.5.1.3	Maximum surface temperature	See appendix A and B of the IEC 60079-11 report for details. Maximum surface temperature determined to +79.3°C, for the gas sensor, Type NCR-6309, taking in to the consideration results of the thermal testing x1.2 (acc to 60079-1 15.4.3.1) See 26.1 above and Comment 4 at the end of this report.	Pass
26.5.2	Thermal shock test	For "ia": Excluded by table 1 of IEC 60079-11. Annex F is not used. Not applicable for gas sensor, Type NCR-6309.	N / A
26.5.3	Small component ignition test (Group I and Group II)	Small component ignition test not necessary to perform.	N / A
26.5.3.1	General		N / A
26.5.3.2	Procedure		N / A
26.5.3.3	Acceptance criteria		N / A

26.6	Torque test for bushings	No bushings.	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	For "ia": Excluded by table 1 of IEC 60079-11. Annex F is not used.	Pass
26.7.1	General	Applicable to plastic body and cemented joint of gas sensor, Type NCR-6309.	Pass
26.7.2	Test temperatures	Gas sensor, Type NCR-6309: Low test temperature: -25°C to -30°C High test temperature: +80°C to +95°C	Pass

26.8 **DS 2020/003**	Thermal endurance to heat	Gas sensor, Type NCR-6309: Test conditions used: Endurance to heat and moisture applied for - 672 h at +90±2ºC and 90±5%RH, See Comment 5 at the end of this report.	Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
26.9	Thermal endurance to cold	Gas sensor, Type NCR-6309: Thermal endurance to cold performed prior to the drop tests. - 24±2 h at -60ºC, after reconditioning of 24-72 h at +20±ºC and 50±10% RH. See Comment 5 at the end of this report.	Pass
26.10	Resistance to UV light		
26.10.1	General		N / A
26.10.2	Light exposure		N / A
26.10.3	Acceptance criteria	Not applicable	N / A
26.11	Resistance to chemical agents for Group I equipment	Group II.	N / A
26.12	Earth continuity	Battery powered equipment.	N / A
26.13	Surface resistance test of parts of enclosures of non-metallic materials	Measurement Section, including Additional Narrative Remarks.	Pass
26.14	Measurement of capacitance		
26.14.1	General	A metallic nipple is isolated from earth.	Pass
26.14.2	Test procedure	Average capacitance: 1,4pF 1,4pF < 3pF → EPL Ga and gas group IIC. See test 1 in Measurement Section, including Additional Narrative Remarks for details.	Pass
26.15	Verification of ratings of ventilating fans	No ventilating fans in EUT.	N / A
26.16	Alternative qualification of elastomeric sealing O-rings	Alternative qualifications not used.	N / A
26.17	Transferred charge test		
26.17.1	Test equipment		N / A
26.17.2	Test sample		N / A
26.17.3	Test procedure		N / A
27	Routine tests	None	N / A
28	Manufacturer's responsibility		

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
28.1	Conformity with the documentation		Pass
28.2 **DS 2020/002** **DS 2021/005**	Certificate	DNV has prepared the certificate.	Pass
28.3	Responsibility for marking	Manufacturer's responsibility.	Pass
29 **DS 2012/005A** **DS 2017/007** **DS 2021/005** **DS 2021/006**	Marking		
29.1	Applicability		Pass
29.2	Location		Pass
29.3	General	a) RIKEN KEIKI Co., Ltd. b) MODEL GX-Force c) INST.No is serial number d) DNV 22 ATEX 05201X IECEx DNV 22.0029X e) X f) Ex da ia IIC T4 Ga Ex ia IIC T4 Ga g) Read manual for safety info.	Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
29.4	Ex marking for explosive gas atmospheres	a) Ex b) da ia ia c) IIC d) T4 e) Ga f) -20°C ≤ Ta ≤ +60°C	Pass
29.5	Ex marking for explosive dust atmospheres	No dust certification.	N / A
29.6	Combined types (or levels) of protection	da ia	Pass
29.7	Multiple types of protection		N / A
29.8	Ga equipment using two independent Gb types (or levels) of protection	da ia	N / A
29.9	Boundary wall	Hand held equipment.	N / A
29.10 **DS 2004/006A** **DS 2012/006A** **DS 2012/008**	Ex Components	EUT is not an Ex component.	N / A
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		N / A
29.14	Cells and batteries	The battery shall not be replaced by user.	N / A
29.15	Electric machines operated with a converter	EUT is not an electrical machine.	N / A
29.16	Examples of marking		Pass

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
30 **DS 2021/006**	Instructions		
30.1	General	- Ex marking - List of standards - Certificate numbers - Ambient temperature - Conditions for charging the battery - Address to manufacturer - Safety information - Use - Maintenance - Product configuration - Alarm activation	Pass
30.2	Cells and batteries	The battery shall not be replaced by user. Charging conditions are specified.	Pass
30.3	Electrical machines	EUT is not an electrical machine.	N / A
30.4	Ventilating fans	EUT is not a ventilating fan.	N / A
30.5	Cable glands	EUT is not a cable gland.	N / A
Annex A (Normative) **DS 2017/001**	Supplementary requirements for cable glands	EUT is not a cable gland.	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
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

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict
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		N / A
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 **DS 2019/005**	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	EUT is not an Ex component.	N / A

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

Annex D (Informative)	Electric machines connected to converters

Annex E (Informative)	Temperature evaluation of electric machines

IEC 60079-0			
Clause	Requirement – Test	Result – Remark	Verdict

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

Annex G (Informative)	Guidance flowchart for tests of cable glands

Annex H (Informative)	Shaft voltages resulting in motor bearing or shaft brush sparking Discharge energy calculation

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

7.4.2.a / 26.13)

§ 26.13	Surface resistance test	Pass
Part	Test condition	Remark
PET PE84-0.125t	24h pre-conditioning: 23°C & 50% rth. 500V insulation test in 60s duration. 10s rise/fall time.	2.375MΩ (<1GΩ)
Supplementary information: Test performed in NO/PRE/ExTR17.0021/01 / IECEx PRE 17.0020.		

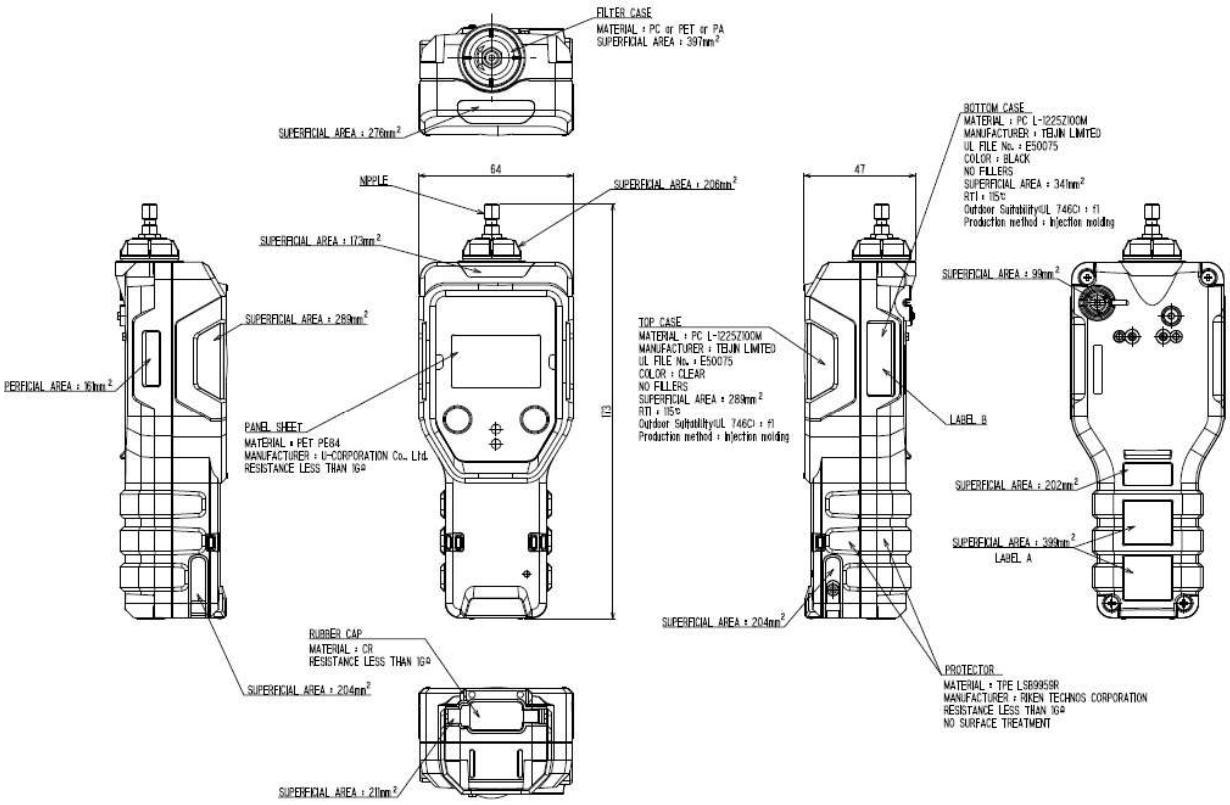
7.4.2.a)

Ref. ExTR reference No. NL/DEK/ExTR11.0038/02:

3.1.12 Plastic electrostatic hazard assessment and tests

Enclosure is at least IP20 and made of conductive materials: LSB9959R, ABS/PC ESC9448N and the window is made of PET 300R. All materials have a surface resistance of less than 1 GΩ, refer to drawing M2-4775-96-01K.

7.4.2.b)



1 Measurement of capacitance

Equipment Tested:	Complete test sample / nipple
Date of Test (yyyy/mm/dd):	2022/01/25
Clause and Standards:	26.14 of IEC 60079-0: 2017

1.1 Test procedures

The test sample was conditioned for 1,5 hours in 25°C and 50% RH.

1.2 Results

Test 1:
Stray capacitance 3-5mm above nipple and unearthed metal plate: 6,8pF
Measured capacitance between nipple and un-earthed metal plate: 7,8pF
Δ capacitance: 1pF

Test 2:
Stray capacitance 3-5mm above nipple and unearthed metal plate: 6,7pF
Measured capacitance between nipple and un-earthed metal plate: 8,3pF
Δ capacitance: 1,6pF

Test 3:
Stray capacitance 3-5mm above nipple and unearthed metal plate: 6,5pF
Measured capacitance between nipple and un-earthed metal plate: 8,0pF
Δ capacitance: 1,5pF

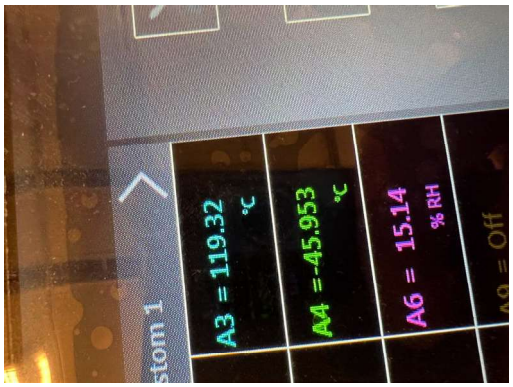
Average capacitance = (1pF + 1,6pF 1,5pF) / 3 = 1,4pF → 1,4pF < 3pF

2 Drop test

Equipment Tested:	GX-Force (test sample 7 and 8)
Date of Test (yyyy/mm/dd):	2022/01/26
Clause and Standards:	26.4.3 of IEC 60079-0: 2017

2.1 Test procedures

4 drop tests on two different test samples are performed from a height of 1m onto a concrete surface. Ambient temperature: -45°C for 24 hours prior to the tests. The actual tests were also performed in this temperature (inside freezer).



(Temperature measured on channel A4.)

2.2 Results

Only superficial scratches to the enclosure after drop tests. No damages to invalidate the protection.

3 IP20

Equipment Tested:	GX-Force (test sample 7)
Date of Test (yyyy/mm/dd):	2022/01/26
Clause and Standards:	26.4.5 of IEC 60079-0: 2017

3.1 Test procedures

Test probe for IP20 was used to determine the ingress protection, after the test sample was drop tested.

3.2 Results

The test probe could not enter the enclosure in any place. Ingress protection is IP20 or better.

4 Temperature measurement

Equipment Tested:	Gas Sensor NCR-6309
Date of Test (yyyy/mm/dd):	See report NL/DEK/ExTR17.0047/00-02
Clause and Standards:	26.5.1 of IEC 60079-0: 2017

The service temperature has been measured and then calculated to +69.3°C (∆T=9.3K) on the external (plastic) surface of the gas sensor at the highest ambient temperature of +60°C.

The highest surface temperature has been measured and then calculated to +79.3°C (∆T=19.3K) on the pressed metal wire of the (breather element) of the gas sensor at the highest ambient temperature of +60°C.

5 Thermal endurance

Equipment Tested:	Gas Sensor NCR-6309 3-1, 3-2, 3-3, 3-4 and 3-5 (Sensors especially prepared for FNT)
Date of Test (yyyy/mm/dd):	2022-01-07 to 2022-02-08
Clause and Standards:	26.8 and 26.9 of IEC 60079-0:2017
Instruments	
Climatic chamber	P0188
Data logger	P0327

Samples placed in an environmental chamber and subjected for the test in the following conditions:

5.1.1 Thermal Endurance to Heat and Moisture

- 672 h (28 days) at +90ºC and 90% RH.

The test started 2022-01-07 at 10:00 h and ended 2022-02-04 at 15:00 h in chamber P0188.

Total time: 672 h

Visual result: No any visible damage or changes on samples was observed.

4.1.3 Thermal Endurance to Normal

After Thermal endurance to heat and moisture, all of samples were left to cool down to temperature approximately +20ºC.

Reconditioning started on temperature +20ºC and 50% RH.

Recondition started 2022-02-04 at 19:00 h until 2022-02-07 at 10:30 h,

Total thermal endurance to normal time: 51.5 h

4.1.4 Thermal Endurance To Cold

The endurance to cold performed at -46 to -47ºC and started 2022-02-07 at 10:30 h until 2022-02-08 at 12:00 h in P0190.

Total time: 25.5 h.

Visual result: No any visible damage or changes on samples was observed.

IECEx TEST REPORT
IEC 60079-1
Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"

ExTR Reference Number ..... :	NO/DNV/ExTR21.0088/00
ExTR Free Reference Number..... :	PRJN-313142-2021-PA-NOR
Compiled by + signature (ExTL).... :	Nenad Stanivukovic
Reviewed by + signature (ExTL) ... :	Bjørn Spongsveen
Date of issue..... :	2022-07-04
Ex Testing Laboratory (ExTL) ..... :	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)

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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”	The sensor assessed is a catalytic sensor to be used in a portable gas detector - 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	The flameproof joints comply with the requirements of clause 5. Specific condition of use in the certificate will apply: “X” - The flameproof joints are not intended to be repaired. A limitation and advisory marking are applied: "This product is an explosion-proof product and is not to be disassembled or modified with the exception of specified parts." Plastic enclosure, which does not require corrosion protection. For design details see drawing: M3-4463-10-02K	Pass
5.2 See also **DS 2015/018**	Non-threaded joints Relevant for: 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	The joint 1 between enclosure halves assessed as multi-step joint consists of three adjacent segments where path changes direction two times by 90°. Length of the joints L Segment 1 (L1) -specified: min 2.65 mm -measured: 2.75 mm Segment 2 (L2) -specified: 0.48 mm -measured: 0.50 mm Segment 3 (L3) -specified: min 3.35 mm -measured: 3.5 mm Construction gaps ic Segment 1 (ic1) and 3 (ic3) -specified: max. 0.10 mm -measured: 0.10 mm Segment 2 (ic2) -specified: 0.05 mm -measured: 0.05 mm “X” - The flameproof joints are not intended to be repaired. See Comment 2 at the end of this report.	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 << 10 cm³. 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 fussed 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 in-casted 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	Breather element and cemented joints were excluded from testing because they were tested before. (refer to reports NL/DEK/ExTR17.0047/00-02). Subject of the additional testing (performed in this report) was flameproof joint 1 in test sequence as follows: 1. Overpressure test 2. Test for non-transmission performed on samples which have been used for previous test sequence. See comment 1, 3 and 4 at the end of this report.	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)	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. See Comment 3 at the end of this report.	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_2H_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% H2, 20% 02 and N2 10% C2H2, 24% 02 and N2 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 cm³, 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 <<50 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/cm³. The specific density of the breather is 5.2 g/cm³. 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

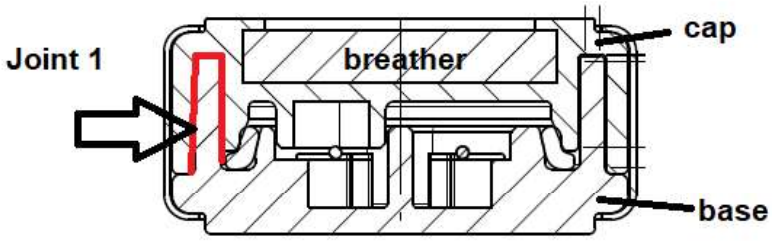
IEC 60079-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
Annex E (Normative)	Cells and batteries used in flameproof “d” enclosures	Not applicable.	N/A
Annex F (Informative)	Mechanical properties for screws and nuts		
Annex G (Normative) See also DS 2019/003	Additional requirements 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

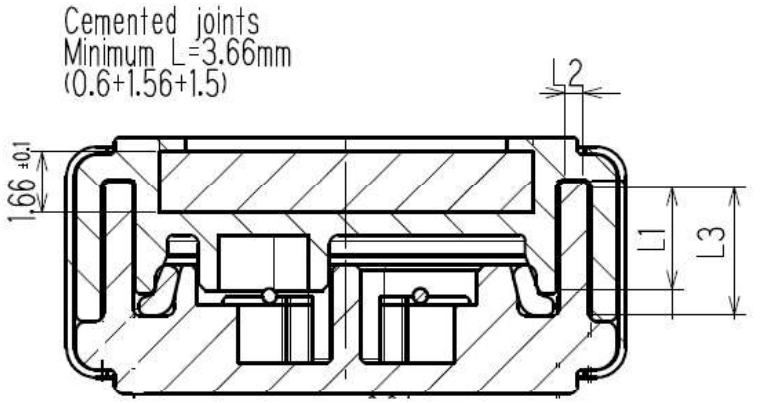
Samples	Breather - type pressed metal wire element D23 (PPS) no. 39, (2-1)
Equipment	No
Digital calliper	P0021
Micrometer 0-25mm (self cal.) standard reference 25 mm	P0284

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

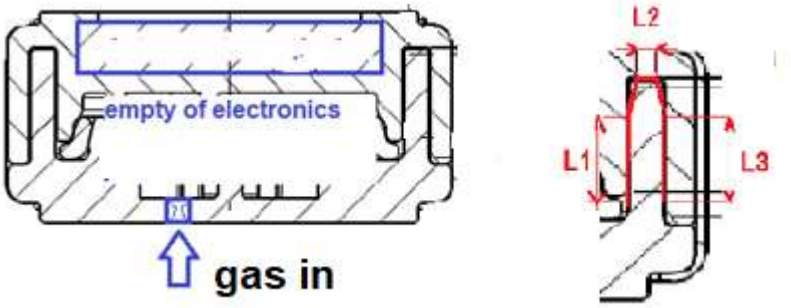
There was no any damage observed or leakage through the cemented joints.

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

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

Gas B: hydrogen

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"

ExTR Reference Number .....:	NO/DNV/ExTR21.0088/00
ExTR Free Reference Number.....:	PRJN-313142-2021-PA-NOR
Compiled by + signature (ExTL).....:	Gunnar Nielsen
Reviewed by + signature (ExTL) ....:	Bjørn Spongsveen
Date of issue.....:	2022-07-04
Ex Testing Laboratory (ExTL) .....:	
Address .....:	DNV Product Assurance AS 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 60079-11:2011, 6th Edition
Test procedure .....:	IECEx System
Test Report Form Number .....:	ExTR60079-11_6B_DS (released 2021-10)

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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.

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.

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

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
1	Scope		
2 **DS 2010/006A**	Normative references		
3	Terms and definitions		
4	Grouping and classification of intrinsically safe apparatus and associated apparatus	According to IEC 60079-0.	Pass
5	Levels of protection and ignition compliance requirements of electrical apparatus		
5.1	General	Battery powered handheld equipment. The EUT has a USB-C contact for charging of the single secondary cell. Um for the USB-C is 6,0V. Due to the low Um voltage the EUT is “X” marked.	Pass
5.2	Level of protection "ia"	Refer to Appendix A.1 for details.	Pass
5.3	Level of protection "ib"	Level of protection "ia".	N / A
5.4	Level of protection "ic"	Level of protection "ia".	N / A
5.5	Spark ignition compliance	Refer to Appendix A.2 for details.	Pass
5.6	Thermal ignition compliance		
5.6.1	General	Refer to Appendix A.3 for details.	Pass
5.6.2 **DS 2015/009** **DS 2015/016A**	Temperature for small components for Group I and Group II	Refer to Appendix A.3.1 for details. T4 @ +60°C	Pass
5.6.3	Wiring within intrinsically safe apparatus for Group I and Group II	Refer to Appendix A.3.2 for details.	Pass
5.6.4	Tracks on printed circuit boards for Group I and Group II	Refer to Appendix A.3.3 for details.	Pass

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
5.6.5 **DS 2020/006**	Intrinsically safe apparatus and component temperature for Group III	Not for Group III.	N / A

5.7	Simple apparatus	EUT is not a simple apparatus.	N / A

6	Apparatus construction

6.1	Enclosures		
6.1.1	General	Enclosure of EUT is ingress protection classified according to IEC 60529.	Pass
6.1.2	Enclosures for Group I or Group II apparatus		
6.1.2.1	General	Table 5 is used.	Pass
6.1.2.2	Apparatus complying with Table 5	≥IP20 EUT is drop tested prior to IP test.	Pass
6.1.2.3 **DS 2019/006**	Apparatus complying with Annex F	Table 5 is used instead of Annex F.	N / A
6.1.3	Enclosures for Group III apparatus	Not for Group III.	N / A

6.2	Facilities for connection of external circuits		
6.2.1	Terminals	No terminals for connection of external circuits in EUT.	N / A
6.2.2	Plugs and sockets	USB-C socket for charging of the battery in non-hazardous area.	Pass
6.2.3	Determination of maximum external inductance to resistance ratio (*Lo/Ro*) for resistance limited power source	EUT is not a power source for other circuits.	N / A
6.2.4	Permanently connected cable	No permanently connected cables for external circuits.	N / A
6.2.5	Requirements for connections and accessories for IS apparatus when located in the non-hazardous area	USB-C socket for charging of the battery in non-hazardous area. Um: 6,0V. Internally this connection is named CN1. The Um voltage will not take the safety components beyond 2/3 of their ratings.	Pass

6.3	Separation distances		
6.3.1	General	Alternative separation distances in Annex F are not used. Distances according to Table 5 are considered.	Pass
6.3.2	Separation of conductive parts	Separation distances between different parts of the intrinsically safe circuit. The requirements of this clause are considered during the evaluation of the circuit and layout.	Pass

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
6.3.2.1	Distances according to Table 5	Separation distance requirements of Table 5 are considered and evaluated. See Appendix B.1 for details.	Pass
6.3.2.2	Distances according to Annex F	Alternative separation distances are not used.	N / A
6.3.3	Voltage between conductive parts	Maximum voltage for the battery powered circuit are: From single battery cell: 4,2V maximum open circuit voltage. After step-up circuit to buzzer circuit: 4,2V x 3 = 12,6V Zener diodes ZD1 to ZD4 from buzzer circuit: max. 4,8V.	Pass
6.3.4	Clearance	See Appendix B.1 for details.	Pass
6.3.5	Separation distances through casting compound	Casting compound is not used.	N / A
6.3.6	Separation distances through solid insulation	Solid insulation is not used.	N / A
6.3.7	Composite separations	Composite separations are not used.	N / A
6.3.8	Creepage distance	See Appendix B.1 for details.	Pass
6.3.9	Distance under coating	Coating is not used.	N / A
6.3.10	Requirements for assembled printed circuit boards	a) N / A Coating is not used. b) N / A Coating is not used. c) Considered in the evaluation of separation distances.	Pass
6.3.11	Separation by earthed screens	Earthed screens are not used.	Pass
6.3.12	Internal wiring	Internal wiring will not affect the separation distances due to its layout.	N / A
6.3.13	Dielectric strength requirement	Battery powered equipment with non-metallic enclosure.	N / A
6.3.14	Relays	Safety relays are not used.	N / A
6.4	Protection against polarity reversal	The secondary battery cell is fixed and shall not be replaced by customer.	N / A
6.5	Earth conductors, connections and terminals	Battery powered equipment.	N / A
6.6	Encapsulation	Encapsulation is not used.	N / A
6.6.1	General		N / A
6.6.2	Encapsulation used for the exclusion of explosive atmospheres		N / A

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
7	Components on which intrinsic safety depends		
7.1 **DS 2004/003** **DS 2018/005A**	Rating of components	Resistors and zener diodes are used as safety components. The safety factor of at least 1,5 is satisfied. Refer to Appendix A.4 for details.	Pass
7.2	Connectors for internal connections, plug-in cards and components	Not possible with incorrect connections. 	Pass
7.3	Fuses	The fuse, F1, is used in the charging circuit. A current of 0,75A x 1,7 is considered to flow continuously when the equipment is located in the non-hazardous area. The cold resistance of the fuse is not used. The fuse is connected to the USB-C socket and will not carry current when the EUT is located in the hazardous area. Therefore encapsulation of the fuse is not required. Thin film chip fuse not for replacement (soldered to the circuit board). Um = 6,0V Breaking capacity for the fuse: 50V / 63A. In = 0,75A	Pass
7.4	Primary and secondary cells and batteries		
7.4.1	General	One single cell of Panasonic NCR18650GA. This battery has been tested in NO/PRE/ExTR20.0043/00. Test data in this report are copies from the test data from NO/PRE/ExTR20.0043/00. The battery shall not be replaced by the user or be charged in hazardous area.	Pass
7.4.2 **DS 2010/003**	Battery construction	The battery is sealed.	Pass

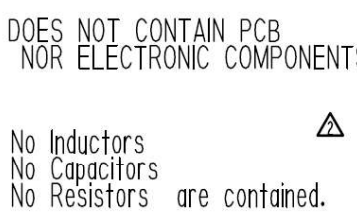
IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
7.4.3	Electrolyte leakage and ventilation	No electrolyte spillage. The battery has been tested according to clause 10.5.2. Encapsulation is not used. EUT satisfy the requirements for "ia" and Group IIC. Requirement for hydrogen concentration does not apply. The enclosure of the EUT is not sealed, but lid and enclosure is fixed together with four screws. Only one single cell inside enclosure. The cell is sealed.	Pass
7.4.4	Cell voltages	According to table 14: Type system: Lithium ion Positive electrode: (NCA) $Li(NiCoAl)O_2$ Electrolyte: Liquid solution Negative electrode: Carbon Voltage: 3,6V Maximum open circuit voltage: 4,2V	Pass
7.4.5	Internal resistance of cell or battery	Internal resistance: 24mΩ	Pass
7.4.6	Batteries in equipment protected by other types of protection	No other types of protection. Only intrinsic safety.	N / A
7.4.7	Batteries used and replaced in explosive atmospheres	The battery shall not be replaced.	N / A
7.4.8	Batteries used but not replaced in explosive atmospheres	The battery doesn't need current-limiting devices to ensure the safety of the battery itself.	Pass

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
7.4.9	External contacts for charging batteries	a) The current from the battery to the external charging contact is limited by the safety resistors RS2, RS3, RS4 and RS5. These resistors are mounted in parallel. Rp = (30 II 30 II 470 II 470) x 0,99Ω = 13,96Ω Maximum voltage from EUT to charging contact is 4,8V (ZD1, ZD2, ZD3, ZD4 – buzzer circuit). I = 4,8V / 13,96Ω = 344mA According to Table A.1: 3,33A@12,1V is permitted. 344mA < 3,33A If the current should be made from the maximum voltage in the buzzer circuit (4,2V x 3 = 12,6V) named VBZ it will be reduced by the serial safety resistors RS11 and RS12. R = (8,2 + 8,2) x 0,99Ω = 16,2Ω I = 12,6V / 16,2Ω = 776mA According to Table A.1: 2,51A@12,6V is permitted. 776mA < 2,51A In addition one parallel track has three serial connected blocking diodes (D1, D2 and D3). This is the buzzer circuit. b) N / A EUT satisfies sub-clause “a”.	Pass

7.5 **DS 2015/007**	Semiconductors		
7.5.1	Transient effects	Battery powered equipment. No transient effects.	N / A
7.5.2	Shunt voltage limiters	a) D1, D2, D3 are diodes connected in series. 1,5 in safety factor is applied. See appendix A.4.3 for details. b) Zener diodes are used in the buzzer circuit to clamp the voltage to a maximum of 4,8V. 1,5 in safety factor is applied. See appendix A.4.2 for details.	Pass
7.5.3	Series current limiters	See sub-clause 7.5.2.a above and appendix A.4.3 for details.	Pass

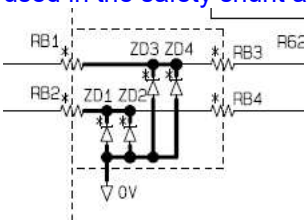
7.6 **DS 2012/009** **DS 2016/002**	Failure of components, connections and separations	The information and requirements in this clause, including sub-clauses, are considered in the assessment of the circuits and layout for EUT.	Pass

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
7.7	Piezo-electric devices	There is one piezo-electric device in the circuit (BZ1). It's used as a buzzer. This device is tested according to clause 10.7. E = 0,5 x 42,9nF x 18,9V2 = 7,67µJ 7,67µJ < 50µJ → IIC See appendix B.2 for details.	Pass

7.8	Electrochemical cells for the detection of gases	Different types of electrochemical cells for the detection of different gases are used. <table><tr><td>Detection Principle</td><td>Electrochemical</td><td>Electrochemical</td></tr><tr><td>Model</td><td>ESR-A1DP</td><td>ESR-X13P</td></tr><tr><td>Measured Gas</td><td>CO/H2S</td><td>O2</td></tr></table>There are no circuit board or electronic components in these cells. Ref. document M4-4482-02-01K and M4-4488-19-01K  Electrochemical evaluation: With reference to ExTAG DS 2002/001A 2007 09 25: Typical values under worst-case-condition have been reported) to be: 1,25V – 50mA – 1A (short circuit peak / capacitive) – 300mW *Sometimes the maximum output values for sensors for toxic gases can only be reached with lethal concentrations. It is recommended to assess the characteristics only in the range of warning levels* If the sensors are stand-alone-equipment they could be assessed to be simple apparatus. According to this clause the addition of power shall not be considered for thermal assessment. Voltage and current for 100% conditions (most servere condition) for these t wo cells are: Voltage: 0,1V Current 0,5mA No further evaluation for these cells are considered.	Pass

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
8	Infallible components, infallible assemblies of components and infallible connections on which intrinsic safety depends		
8.1	Level of Protection “ic”	Level of protection “ia”.	N / A
8.2	Mains transformers	No mains transformers. Battery powered equipment.	N / A
8.2.1	General		N / A
8.2.2	Protective measures		N / A
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 in the equipment.	N / A
8.4	Infallible windings	No infallible windings in EUT.	N / A
8.4.1	Damping windings		N / A
8.4.2	Inductors made by insulated conductors		N / A
8.5	Current-limiting resistors	Chip metal film resistors are used as safety components. They are all rated according to clause 7.1, with at least 1,5 safety factor. See appendix A.4.1 for details.	Pass
8.6 **DS 2003/003**	Capacitors	No capacitors are used as safety components.	N / A
8.6.1	Blocking capacitors	No blocking capacitors.	N / A
8.6.2	Filter capacitors	No filter capacitors.	N / A
8.7	Shunt safety assemblies		
8.7.1	General	The Zener diodes ZD1, ZD2, ZD3 and ZD4 are used as safety components. These are coupled 2 and 2 in parallel on the two tracks to buzzer circuit. Se appendix A.4.2 for details.	Pass

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
8.7.2	Safety shunts	The Zener diodes ZD1, ZD2, ZD3 and ZD4 are used as safety shunts. In the buzzer circuit it is a piezo driver, IC4, (charge pump) which multiplies the input voltage. Ref. datasheet: ■RECOMMENDED OPEARATING CONDITION (Ta=25°C) PARAMETER / SYMBOL / CONDITIONS / MIN / TYP / MAX / UNIT Operating Voltage / VIN / 1x Mode, 2x Mode / 2.3 / 3.0 / 5.0 / V 1x Mode, 2x Mode, 3x Mode / 2.3 / 3.0 / 3.4 ■ELECTRICAL CHARACTERISTICS (Ta=25°C, V_{IN}=3V, C_1=100nF, C_2=100nF, C_{OUT}=100nF, C_{PIEZO}=15nF, DIN=4kHz) PARAMETER / SYMBOL / CONDITIONS / MIN / TYP / MAX / UNIT Output Voltage / V_{OUT1} / 1x Mode / 2.8 / - / 3 / V V_{OUT2} / 2x Mode / 5.2 / - / 6 / V V_{OUT3} / 3x Mode / 7.2 / - / 9 / V Maximum output voltage is 9V. The Zener diodes limit the voltage to the circuits connected to the buzzer circuit, to a maximum voltage of 4,8V.	Pass
8.7.3	Shunt voltage limiters	No shunt voltage limiters.	N / A

8.8	Wiring, printed circuit board tracks, and connections	a) Wires are not used as infallible connections in EUT. b) 2: Infallible tracks (single tracks) are used in the safety shunt assembly.  See appendix B.3 for details. 3: Infallible vias (single) are used in the safety shunt assembly. The vias connect the anodes of the Zener diodes to GND layer. See appendix B.4 for details. c) 3: The soldered joints of the Zener diodes to the PCB are according to the component's manufacturer recommendations.	Pass

8.9	Galvanically separating components	No galvanically separating components.	N / A
8.9.1	General		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

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
9	Supplementary requirements for specific apparatus	EUT is not a diode safety barrier, a FISCO apparatus or a handlight/caplight.	N / A
9.1	Diode safety barriers		
9.1.1	General		N / A
9.1.2	Construction		
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		N / A
9.3	Handlights and caplights		N / A
10	Type verifications and type tests		
10.1 **DS 2013/002**	Spark ignition test		
10.1.1	General	Spark ignition testing is not performed. EUT is assessed by using figures and tables in annex A of IEC 60079-11. 1,5 safety factor is considered in the assessment. Refer to Appendix A.2 for details.	Pass
10.1.2	Spark test apparatus	Spark ignition testing is not performed.	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 **DS 2018/005A**	Safety factors	1,5	Pass
10.1.5	Testing considerations		
10.1.5.1	General		Pass
10.1.5.2	Circuits with both inductance and capacitance	Refer to Appendix A.2.4 for details.	Pass

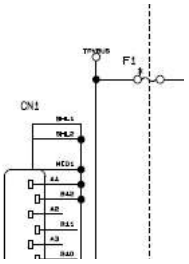
IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
10.1.5.3	Circuits using shunt short-circuit (crowbar) protection	Refer to Appendix A.2.5 for details.	N / A
10.1.5.4	Results of spark test		N / A

10.2	Temperature tests	See appendix B for temperature tests and appendix A for temperature assessment of small components.	Pass

10.3	Dielectric strength tests	EUT is battery powered. No use of blocking capacitors, optocouplers or transformers.	N / A

10.4	Determination of parameters of loosely specified components	No such components are used in safety assessment.	N / A

10.5	Tests for cells and batteries		
10.5.1	General	The battery cells are tested in IECEx test report NO/PRE/ExTR20.0043. Test results for electrolyte leakage test are copied from that report.	Pass
10.5.2	Electrolyte leakage test for cells and batteries	See appendix B.5 for details.	Pass
10.5.3	Spark ignition and surface temperature of cells and batteries	See appendix B5 and B6 for details.	Pass
10.5.4	Battery container pressure tests	The battery cell is sealed.	N / A

10.6	Mechanical tests		
10.6.1	Casting compound	Casting compound is not used.	N / A
10.6.2	Determination of the acceptability of fuses requiring encapsulation	The fuse, F1, is mounted close to the USB-C charging contact (CN1), and is a part of the charging circuit. The fuse will only carry current when located in non-hazardous area. 	N / A
10.6.3	Partitions	EUT has no partitions.	N / A

10.7	Tests for intrinsically safe apparatus containing piezoelectric devices	The buzzer, BZ1, is a piezo electric device. See appendix B.2 for details.	Pass

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
10.8	Type tests for diode safety barriers and safety shunts	Battery powered equipment. No transients.	N / A
10.9	Cable pull test	No external cables.	N / A
10.10	Transformer tests	No transformers in EUT.	N / A
10.11	Optical isolators tests	No optical isolators in EUT.	N / A
10.11.1	General		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
10.11.3.4	Current limited short-circuit current test		N / A
10.11.3.5	Dielectric strength test		N / A
10.12	Current carrying capacity of infallible printed circuit board connections	Tracks and vias are according to requirements in the standard. Tests are not necessary to perform.	N / A
11	Routine verifications and tests	EUT is not a diode safety barrier or incorporate a transformer.	N / A
11.1	Routine tests for diode safety barriers		
11.1.1	Completed barriers		N / A
11.1.2	Diodes for 2-diode “ia” barriers		N / A
11.2	Routine tests for infallible transformers		N / A

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
12	Marking		
12.1	General	Marked according to IEC 60079-0. No intrinsically safe parameters to be marked.	Pass
12.2	Marking of connection facilities	No connection facilities for use in hazardous area.	N / A
12.3	Warning markings	a) Secondary cells. b) Battery is not to be replaced. c) EUT satisfies sub-clause “7.4.9.a”. d) EUT do not require current limiting devices to ensure the safety of the battery itself.	N / A
12.4	Examples of marking		Pass
13	Documentation	According to IEC 60079-0. a) No parameters for entity concept. b) N / A c) Um: 6VDC. d) The battery should be charged with the dedicated AC adapter or by power from IEC60950-certified SELV power source, or IEC62368-1-certified ES1 power source. The maximum voltage from the charger shall not exceed 6.0Vdc. e) N / A (battery powered). f) N / A g) Ambient temperature is part of certification. h) Annex F is not used.	Pass
Annex A (Normative)	Assessment of intrinsically safe circuits		
A.1	Basic criteria		Pass
A.2	Assessment using reference curves and tables		Pass
A.3	Examples of simple circuits		Pass
A.4	Permitted reduction of effective capacitance when protected by a series resistance		Pass
Annex B (Normative)	Spark test apparatus for intrinsically safe circuits	Spark test apparatus is not used for this certification.	N / A
B.1	Test methods for spark ignition		

IEC 60079-11			
Clause	Requirement – Test	Result – Remark	Verdict
B.1.1	Principle		N / A
B.1.2	Apparatus		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	Encapsulation is not used.	N / A
D.1	Adherence		N / A
D.2	Temperature		N / A

Annex E (Informative)	Transient energy test		

Annex F (Normative)	Alternative separation distances for assembled printed circuit boards and separation of components	Annex F is not used.	N / A
F.1	General		N / A
F.2 **DS 2019/006**	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	Not for FISCO certification.	N / A
G.1	Overview		N / A
G.2	Apparatus requirements		
G.2.1	General		N / A
G.2.2	FISCO power supplies		
G.2.2.1	General		N / A

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

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

Measurement Section, including Additional Narrative Remarks

APPENDIX A: Description of product

A.1 General overview

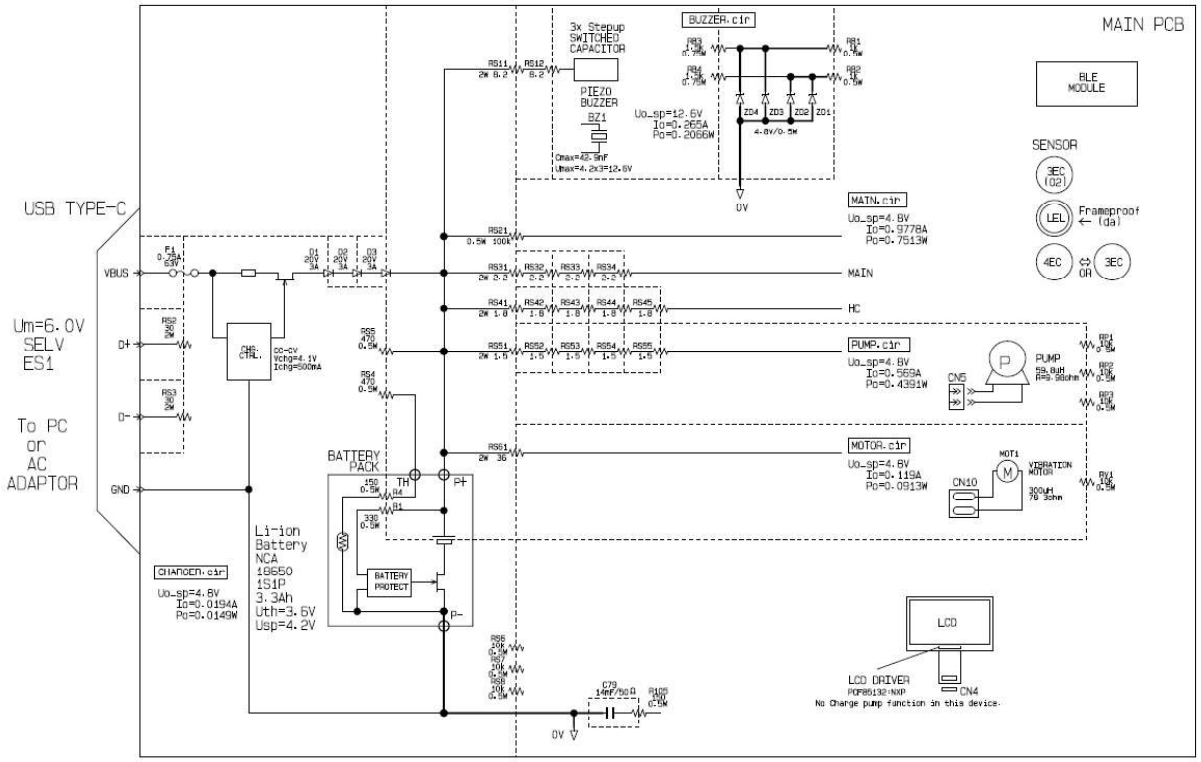
Equipment under test (EUT) is a gas detector named GX-Force. It is hand-held, powered by 1 secondary cell, and comes with three different gas detection cells. EUT is equipped with a buzzer (piezo-electric), pump, vibration motor, low energy Bluetooth module (BLE), LCD screen and LEDs for alarm.

Additional information:

- Pump, RIKEN KEIKI RP-12, is already certified in IECEx PRE 17.0070/Presafe 17ATEX11584.
- Battery, Panasonic NCR18650GA, is already tested in NO/PRE/ExTR20.0043.
- Vibration motor, LEXIN LE4A3GS1G4, is already certified in IECEx DEK 17.0050X/DEKRA 17ATEX0103X.

A detailed explanation for the different circuits below.

IS safety diagram (overview):



AC adapter:

This specific AC adapter (Mass Power Electronic Limited S018) can be used for charging the battery. Copy of certificates are stored in project folder at ExTL.

2.5 Safety Standards

The power supply shall be certified by following international regulatory standards.

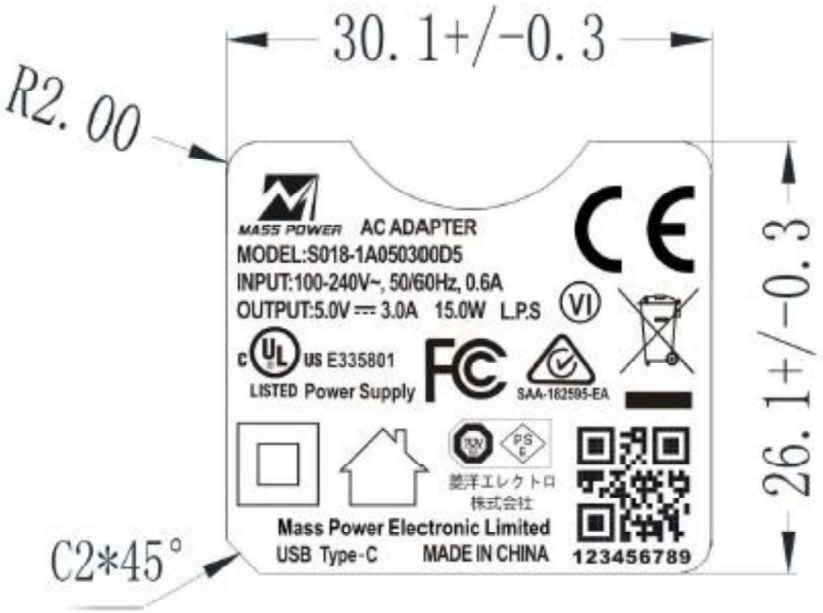
Item	Country	Status	Safety standard
CE	Europe	Approved	EN62368-1
GS	Germany	Approved	EN62368-1
UL/cUL	America / Canada	Approved	UL 62368 and CAN/CSA
SAA	Australia/New Zealand	Approved	AS/NZS 62368.1
CCC	China	Approved	GB4943
TUV Mark	United Kingdom	---	BS EN60950-1
PSE	Japan	Approved	J60950-1
KCC	Korea	---	K60950
CB	Global	Approved	IEC62368-1

2.2.1 Output voltage and current

Rated output voltage (V)	Nominal output voltage (V)	Voltage range (V)	No load (A)	Min load (A)	Rated load(A)	Max. load (A)	Rated output power(W)
5	5.2	4.9-5.5	0	0	3	*	15

The power supply output voltage must stay within the limits specified in table 2 when operating at steady state

5.2 Label Drawing



Charging circuit:
The battery shall only be charged in non-hazardous area , and not replaced. It shall be charged with the dedicated AC adapter (Mass Power S018), by power from IEC 60950 (Information technology equipment – Safety) certified SELV power source or IEC 62368-1 (Audio/video, information and communication technology equipment - Part 1: Safety requirements) certified ES1 (ES1 equal to SELV) power source. The maximum voltage from the charger shall not exceed 6,0VDC (Um: 6,0VDC). The charging contact is USB-C. The charging circuit will only be operative in the non-hazardous area.
The USB-C contact is named CN1 by RIKEN KEIKI. It has 3 tracks going to the circuit in addition to GND. Track 1 is protected by fuse F1 (0,75A x 1,7 = 1,275A), track 2 protected by resistor RS2 (30Ω x 0,99 = 29,7Ω) and track 3 protected by resistor RS3 (30Ω x 0,99 = 29,7Ω). Track 4 is GND.
After the charging circuit there are 6 tracks going to the battery pack and the remaining circuits. So the non-active charging circuit in hazardous area is protected by the parallel coupled resistors RS4, RS5, RS6, RS7 and RS8. These resistors are also in parallel with three serial coupled blocking diodes, D1, D2 and D3. The current to the buzzer circuit, main circuit, pump circuit and motor circuit is further reduced with safety resistors. By this construction the USB-C contact is not capable of delivering hazardous spark energy to the environment in hazardous area.
See appendix A.2 for details.

Battery circuit/pack:
Contains one secondary cell. Maximum voltage is 4,2V. Nominal voltage is 3,6V. This circuit has its own pcb named protect pcb. Protect pcb is connected to main pcb with the contact CN2 (3 pins).
Pin 1 (P+): Connection to positive signal from charger, + polarity on battery and main circuit. The connection to the charger goes through the three diodes, D1, D2 and D3. There is also a connection to the protect IC through the resistor R1 (330Ω ± 1%).
Pin 2 (TH): Connection to negative signal from charger through R4 (150Ω ± 1%) and to the protect IC and negative polarity on battery. There is also a thermistor in series with R4 (RT1).
Pin 3 (P-): Connection to negative pole on battery and to the 0V on main pcb. It's connected to the same tracks as pin 2 (TH), but after the safety resistor and thermistor.
Maximum current between P+ and P- will be through the safety resistor R1.
See appendix A.2 for details.

Buzzer circuit:

Connection between Buzzer circuit (VBZ) and battery is through the resistors RS11 and RS12 (8,2Ω x 0,99 x 2 = 16,2Ω). Between buzzer and main circuit (IC12) there are connection named PB4 and PB5. These connections are protected by resistors (RB1 + RB3) II (RB2 + RB4) = 1kΩ x 0,99 x 2 II 1kΩ x 0,99 x 2= 990Ω, and parallel coupled Zener diodes ZD1, ZD2, ZD3 and ZD4, U = maximum 4,8V. The buzzer circuit include a step-up piezo driver (3 x U = 3 x 4,2V = 12,6V).

Pump circuit:
This circuit contains a pump (RP-12) for suction of gas in the surrounding atmosphere to be used in the gas analyse. The pump is connected to the pump circuit with the connection CN5.
Pump circuit is connected to the battery through the resistors RS51, RS52, RS53, RS54 and RS55 (R = 1,5Ω x 0,99 x 5 = 7,4Ω.
In addition the pump circuit is connected to the main circuit through the parallel coupled resistors RP1, RP2 and RP3 (R = (10kΩ x 0,995) / 3 = 3316Ω)
Pump, RIKEN KEIKI RP-12, is already certified in IECEx PRE 17.0070/Presafe 17ATEX11584. All results for the specific pump are copied from that project.

Motor circuit:
Vibration motor, LEXIN LE4A3GS1G4, is already certified in IECEx DEK 17.0050X/DEKRA 17ATEX0103X.
The circuit itself is powered by the battery through the resistor RS61 (36Ω x 0,99 = 35,64Ω). In addition the circuit is connected to main circuit through the resistor RV1 (10kΩ x 0,995 = 9950Ω).

LCD:
There is a LCD screen connected to the main board (CN4). There is none charge pump function in the LCD driver. The polarity is not reversed.

BLE Module (IC16): Bluetooth 5.0 low energy module. It uses the chip Nordic nRF52832 (512kB Flash, 64kB RAM). The chip itself contains maximum 1,5µF and negligible inductance. It's connected to main circuit by CN9. The module itself is named IC16.

Main circuit:
The main circuit is connected to all of the other circuits, but the current is reduced by the use of safety resistors. There are mainly three tracks from the battery to the main circuit.
VBAT: RS21 → 100kΩ x 0,99 = 99000Ω
VMAIN: RS31, RS32, RS33, RS34 in series → 2,2Ω x 0,99 x 4 = 8,71Ω
VHC: RS41, RS42, RS43, RS44, RS45 in series → 1,8Ω x 0,99 x 5 = 8,91Ω
The three different tracks must be considered to be in parallel. Rp3 = 99000Ω II 8,71Ω II 8,91Ω = 4,4Ω
In addition the main circuit connection to the other circuits:
Buzzer circuit: RB1 II RB2 = 1kΩ x 0,99 II 1kΩ x 0,99 = 495Ω
Pump circuit: RP1, RP2 and RP3 (R = (10kΩ x 0,995) / 3 = 3316Ω)
Motor circuit: RV1 (10kΩ x 0,995 = 9950Ω).
Rtotal = 4,4Ω II 495Ω II 3316Ω II 9950Ω = 4,35Ω
The connections to the other circuits (buzzer, pump and motor) are negligible.

A.2 Spark ignition considerations
A.2.1 Resistive spark ignition

Charging circuit:
(This evaluation is for the USB-C contact to not deliver delivering hazardous spark energy in Ex zone.)
Maximum voltage from battery is, U: 4,2V (maximum open circuit voltage).
Minimum resistance to limit the current is, R = RS4 II RS5 II RS6 II RS7 II RS8 = 470Ω x 0,99 II 470Ω x 0,99 II 10kΩ x 0,995 II 10kΩ x 0,995 II 10kΩ x 0,995 = 217,4Ω
Maximum current, I = 4,2V / 217,4Ω = 19,4mA.
In addition the current will be limited by the cold resistance of F1 in parallel with RS2 and RS3, but this resistance is negligible, and is not considered in this evaluation.
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 19,4mA
12,1V > 4,2V

Battery circuit/pack:
Maximum voltage from battery is, U: 4,2V (maximum open circuit voltage).
Minimum resistance to limit the current is, R = R1 = 330Ω x 0,99 = 326,7Ω
Maximum current, I = 4,2V / 326,7Ω = 12,9mA.
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 12,9mA
12,1V > 4,2V
Maximum voltage between P+ and Th is, U: 4,2V (maximum open circuit voltage).
Minimum resistance to limit the current is, R = R4 = 150Ω x 0,99 = 148,5Ω
Maximum current, I = 4,2V / 148,5Ω = 28,3mA.
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 28,3mA
12,1V > 4,2V
P + is limited by the resistors connected to the other circuits.

Buzzer circuit:
Maximum voltage to buzzer circuit from battery, U = 4,2V
Minimum resistance between buzzer circuit and battery, R = RS11 + RS12 = 8,2Ω x 0,99 x 2 = 16,2Ω
Maximum current to buzzer from battery, I = 4,2V / 16,2Ω = 260mA
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 260mA
12,1V > 4,2V
Maximum voltage due to the step-up driver, U = 4,2V x 3 = 12,6V.
Maximum current if 100% efficiency of step-up converter, I = 260mA / 3 = 8,7mA
According to table A.1 a current of 2,51 is permitted @12,6V and 1,5 safety factor.
2,51A > 86,7mA
Maximum voltage from buzzer to main circuit, U (ZD1, ZD2, ZD3 and ZD4) = 4,8V + 1,0V (VR) = 5,8V
Minimum resistance from buzzer to main circuit @ 5,8V, R = RB1 II RB2 = 1kΩ x 0,99 II 1kΩ x 0,99 = 495Ω
Maximum current from buzzer circuit and main circuit, I = 5,8V / 495Ω = 11,8mA
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 11,8mA
12,1V > 5,8V
Total current to the buzzer circuit will be current from battery + current from main circuit = 260mA + 4,2V / (495Ω x 2) = 260mA + 5mA = 265mA
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 265mA
12,1V > 4,2V

Pump circuit:
Maximum voltage to buzzer circuit from battery, U = 4,2V
Minimum resistance between pump circuit and battery is RS51, RS52, RS53, RS54 and RS55 in series (R = 1,5Ω x 0,99 x 5 = 7,4Ω). In addition current from the main circuit through the parallel coupled resistors RP1, RP2 and RP3 (R = (10kΩ x 0,995) / 3 = 3316Ω).
Rp = 7,4Ω II 3316Ω = 7,38Ω
Maximum current to the pump circuit, I = 4,2V / 7,38Ω = 569mA
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 569mA
12,1V > 4,2V

Motor circuit:
Maximum voltage to buzzer circuit from battery, U = 4,2V
Minimum resistance from battery and main circuit is, R = RS61 II RV1 = 36Ω x 0,99 II 10kΩ x 0,995 = 35,51Ω.
Maximum current, I = 4,2V / 35,51Ω = 119mA
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 119mA
12,1V > 4,2V

Main circuit:
Maximum voltage to buzzer circuit from battery, U = 4,2V

Minimum resistance, R = 4,35Ω
Maximum current, I = 4,2V / 4,35Ω = 966mA
Maximum current from buzzer circuit and main circuit, I = 5,8V / 495Ω = 11,8mA
Total, I = 966mA + 11,8mA = 977,8mA
(Current from motor and pump circuits are negligible.)6,4
According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 978mA
12,1V > 4,2V

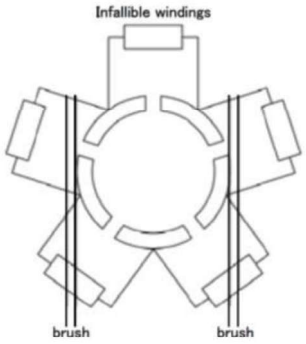
A.2.2 Inductive spark ignition

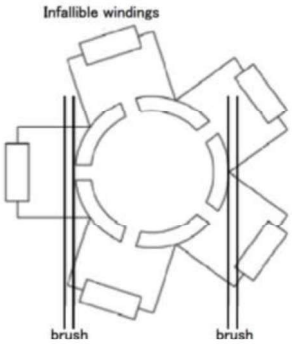
Charging circuit:
No inductors. Inductance from components such as ferrite bead, ICs and tracks is negligible @19,4mA and 1,5 safety factor.
Maximum inductance permitted according to figure A.6, L = 40µJ / (0,5 x (19,4mA x 1,5)^2) = 94,4mH.

Battery circuit/pack:
No inductors. Inductance from components and tracks is negligible @28,3mA and 1,5 safety factor.
Maximum inductance permitted according to figure A.6, L = 40µJ / (0,5 x (28,3mA x 1,5)^2) = 44,4mH.

Buzzer circuit:
No inductors. Inductance from components and tracks is negligible @260mA and 1,5 safety factor.
Maximum inductance permitted according to figure A.6, L = 40µJ / (0,5 x (265mA x 1,5)^2) = 506µH.

Pump circuit:
No inductance in the pump circuit except for the inductance in the pump itself.
Pump motor:
Micro pump type RP-12: (Internal motor of pump is type A12B-09-SS). The pump type was used in other product from manufacturer whereof it was assessed in Presafe project D0001494-00.
The pump's motor has windings. The motor coil resistance is taken as an resistance to protect it' s inductance. The minimum motor coil resistance and maximum motor coil inductance of A12B-09-SS are as follows.
case1:one commutator segment active. case2:two commutator segments active.





Rmin 13.1Ω / Lmax 59.8µH Rmin 11.0Ω / Lmax 49.8µH
The range of the motor coil resistance and the motor coil inductance are as follows.
Rmin = 11.0Ω - 13.1Ω, Lmax = 49.8µH - 59.8µH (9,98Ω stated by RIKEN KEIKI.)
The worst value is Rmin = 11.0Ω and Lmax = 59.8µH respectively.
The effective internal inductance of a pump motor coil is Lmax=59.8µH max. And the minimum resistance of a pump motor coil is Rmin = 9,98Ω .
Minimum resistance, R = 7,38Ω (pump circuit) + 9,98Ω = 17,36Ω
Maximum current in coil, I = 4,2V / 17,36Ω = 242mA.
Maximum inductance permitted according to figure A.6, L = 40µJ / (0,5 x (242mA x 1,5)2) = 607µH.
607µH > 59,8µH

Motor circuit:
No inductance in the pump circuit except for the inductance in the motor itself.
Vibration motor, LEXIN LE4A3GS1G4, is already certified in IECEx DEK 17.0050X/DEKRA 17ATEX0103X.

According to datasheet:

＊温度20℃，相対湿度65%の条件下にて測定のこと。

4-7	Terminal Resistance 端子間抵抗	+65℃	133 Ω ± 10%
		+20℃	115 Ω ± 10%
		-25℃	93 Ω ± 10%
		-40℃	87 Ω ± 10%
4-8	Inductance インダクタンス	+65℃	240μH以下
		+20℃	275μH以下
		-25℃	295μH以下
		-40℃	300μH以下

Maximum inductance in the moter: 300µH.
Minimum cold resistance in motor: 78,3Ω
Total resistance in the circuit is, R = 78,3Ω + 35,51Ω = 113,81Ω
Maximum current through the motor coil, I = 4,2V / 113,81Ω = 36,9mA
Maximum inductance permitted according to figure A.6, L = 40µJ / (0,5 x (36,9mA x 1,5)^2) = 26,1mH.
26,1mH > 300µH

BLE module:
The BLE module has a inductance of 10,8nH (L3 and L4). Maximum current to the BLE module is, I = 978mA.
Maximum inductance permitted according to figure A.6, L = 40µJ / (0,5 x (978mA x 1,5)^2) = 37µH.
37µH > 10,8nH

Main circuit:
No inductance in the main circuit board except for ferrite beads (NF2, NF21, NF22, NF23, NF31, NF32, NF33 and NF41). In addition the inductance in BLE module, 10,8nH.
Maximum inductance permitted according to figure A.6, L = 40µJ / (0,5 x (978mA x 1,5)^2) = 37,2µH.
37µH > 10,8nH

A.2.3 Capacitive spark ignition

Charging circuit:

Capacitor	Capacitance			Tolerance	Capacitance	Capacitance incl. tolerance
	Micro	Nano	Pico			
C1, C2, C3, C11, C12, C13, C14, C15, C16, C17, C18	120			0	1,20E-04	1,20E-04
IC2			7	0	7,00E-12	7,00E-12
IC3			26	0	2,60E-11	2,60E-11
					1,20E-04	1,20E-04

According to table A.2 a maximum capacitance of 136µF is permitted at a voltage of 4,8V x 1,5 = 7,2V.
136µF > 120µF

Battery circuit/pack:

Capacitor	Capacitance			Tolerance	Capacitance	Capacitance incl. tolerance
	Micro	Nano	Pico			
C1, C2, C3	1,6			0	1,60E-06	1,60E-06
					1,60E-06	1,60E-06

According to table A.2 a capacitance of 420µF is permitted @ 4,2V x 1,5 = 6,3V.
420µF > 1,6µF.

Buzzer circuit:

Capacitor	Capacitance			Tolerance	Capacitance	Capacitance incl. tolerance
	Micro	Nano	Pico			
C51, C52, C53	1			0	1,00E-06	1,00E-06
BZ1		42,9		0	4,29E-08	4,29E-08
					1,04E-06	1,04E-06

According to table A.2 a capacitance of 1,15µF is permitted @ 12,6V x 1,5 = 18,9V.
1,15µF > 1,04µF

Pump circuit:

Capacitor	Capacitance			Tolerance	Capacitance	Capacitance incl. tolerance
	Micro	Nano	Pico			
C31, C32, C33, C34, C35, C36	8			0	8,00E-06	8,00E-06
					8,00E-06	8,00E-06

According to table A.2 a capacitance of 47µF is permitted @ 4,8 x 1,5 = 7,2V.
136µF > 8µF

Motor circuit:

Capacitor	Capacitance			Tolerance	Capacitance	Capacitance incl. tolerance
	Micro	Nano	Pico			
C54, C55	5			0	5,00E-06	5,00E-06
					5,00E-06	5,00E-06

According to table A.2 a capacitance of 47µF is permitted @ 4,8 x 1,5 = 7,2V.
136µF > 5µF

BLE module:
Maximum capacitance in the chip, C = 1,5µF.

Main circuit:

Capacitor	Capacitance			Tolerance	Capacitance	Capacitance incl. tolerance
	Micro	Nano	Pico			
C21, C22, C23, C24, C25, C26, C41, C42, C43, C44, C45, C61, C62, C63, C64, C65, C66, C67, C68, C69, C71, C72, C73, C74, C75, C76, C77, C78, C81, C82, C83, C84, C85, C86, C87, C91, C92, C93, C94, C95, C96, C97, C98, C101, C102, C103, C104, C105, C106, C107, C110, C111, C112, C113, C114, C115, C116, C117, C118, C120, C121, C122, C123, C124, C125, C126, C130, C131, C132, C133, C134,	120			0	1,20E-04	1,20E-04

C135, C136, C140, C141, C142, C143, C144, C145, C151, C152, C153, C155, C160, C161, C162, C163, C164, C165, C166, C167, C171, C172, C173, C174						
					1,20E-04	1,20E-04

In addition the capacitance from IC16 (BLE module), 1,5µF
According to table A.2 a capacitance of 136µF is permitted @ 4,8 x 1,5 = 7,2V.
136µF > 121,5µF
In addition there will be capacitance from other circuits. The current is reduced by safety resistors:
Buzzer circuit: RB1 II RB2 = 1kΩ x 0,99 II 1kΩ x 0,99 = 495Ω → I = 4,8V / 495Ω = 9,7mA
Pump circuit: RP1, RP2 and RP3 (R = (10kΩ x 0,995) / 3 = 3316Ω) → I = 4,8V / 3316Ω = 1,5mA
Motor circuit: RV1 (10kΩ x 0,995 = 9950Ω) → I = 4,8V / 9950Ω = 0,5mA
Charger circuit: The current will be limited by the resistors to the main circuit, R = 4,4Ω → I = 4,8V / 4,4Ω = 1,091A
In addition C79 (14mF) that must be discharged through R105 → I = 4,8V / (150Ω x 0,99) = 4,8V / 148,5Ω = 32,4mA

Total, I = 9,7mA + 1,5mA + 0,5mA +1,091A + 32,4mA = 1,136A @4,8V. According to table A.1 a current of 3,33A is permitted @12,1V and 1,5 safety factor.
3,33A > 1,136A
12,1V > 4,8V

Information for C79: This is a small supercapacitor with a nominal and discharge capacity of 4,0µAh and a electrostatic capacity of maximum 14mF. The minimum internal resistance of the capacitor is 50Ω.
I = 4,8V / 50Ω = 96mA → 96mA < 3,33A. In addition the current will be reduced by safety resistor R105.
Due to the very small capacitance of the capacitor (4,0µAh) and the high impedance it is considered not necessary to do temperature measurements on the component. The unique ceramic packaging with superior air-tightness is used. As the result, it offers leakage resistance and humidity resistance. Total weight of the capacitor is 0,025g.

A.2.4 Combination of inductive and capacitive spark ignition

Charging circuit:
No combination of inductance and capacitance.

Battery circuit/pack:
No combination of inductance and capacitance.

Buzzer circuit:
No combination of inductance and capacitance.

Main circuit:
No inductance in the main circuit board except for ferrite beads (NF2, NF21, NF22, NF23, NF31, NF32, NF33 and NF41). BLE module has an inductance of 10,8nH. Maximum permitted inductance is 37µH. 10,8nH is only 0,35% of permitted inductance.

Pump circuit:
Capacitance: 136µF > 8µF → 5,9%

Inductance: 607µH > 59,8µH → 9,9%
Both inductance and capacitance are below 50% of permitted values. No further assessment is necessary.

Motor circuit:
Capacitance: 136µF > 5µF → 3,7%
Inductance: 26,1mH > 300µH → 1,2%
Both inductance and capacitance are below 50% of permitted values. No further assessment is necessary.

A.2.5 Shunt short-circuit (crowbar) spark ignition
No crowbars in the circuit.

A.2.6 Other spark ignition considerations
N / A

A.3 Thermal ignition consideration
Maximum nominal voltage from the battery pack, U: 3,6V
Maximum open circuit voltage: 4,2V
Maximum voltage from the buzzer circuit, U: 5,8V. (As the charge pump does not have 100% efficiency this is not considered.)
Maximum ambient temperature, Ta = +60°C

A.3.1 Temperature for small components for Group I and Group II
Charging circuit:
The power to the charging circuit is limited by the resistors RS4, RS5, RS6, RS7 and RS8 in parallel.
R = 470Ω x 0,99 II 470Ω x 0,99 II 10kΩ x 0,995 II 10kΩ x 0,995 II 10kΩ x 0,995 = 217,4Ω
Voltage from battery is, U: 3,6V
Maximum power, P = ($3,6V^2$ / 217,4Ω) / 4 = 14,9mW
For components >20mm^2: 14,9mW < 1,2W → T4
For components <20mm^2: Rth = (275°C - 60°C) / 14,9mW = 14429K/W → Actual Rth for a component is much less than 14429K/W → T4

Battery circuit/pack:
Voltage from battery is, U: 3,6V
Minimum resistance to limit the current is, R = R1 = 330Ω x 0,99 = 326,7Ω
Maximum power, P = ($3,6V^2$ / 326,7Ω) / 4 = 10,0mW.

Voltage between P+ and Th is, U: 3,6V
Minimum resistance to limit the current is, R = R4 = 150Ω x 0,99 = 148,5Ω
Maximum power, P = ($3,6V^2$ / 148,5Ω) / 4 = 21,9mW.
For components >20mm^2: 21,9mW < 1,2W → T4
For components <20mm^2: Rth = (275°C - 60°C) / 21,9mW = 9818K/W → Actual Rth for a component is much less than 9818K/W → T4

P + is limited by the resistors connected to the other circuits.

Buzzer circuit:
Voltage to buzzer circuit from battery, U = 3,6V
Minimum resistance between buzzer circuit and battery, R = RS11 + RS12 = 8,2Ω x 0,99 x 2 = 16,2Ω
Maximum power to buzzer from battery, P = ($3,6V^2$ / 16,2Ω) / 4 = 200mW

Maximum power from buzzer circuit to main circuit, P = ($3,6V^2$ / (16,2Ω + 495Ω) / 4 = 6,4mW
or
Maximum power from main circuit to buzzer circuit, P = ($3,6V^2$ / 495Ω) / 4 = 6,6mW

Total power to the buzzer circuit will be power from battery + power from main circuit = 200mW + 6,6mW = 206,6mW
For components >20mm^2: 206,6mW < 1,2W → T4

For components <20mm^2: Rth = (275°C - 60°C) / 206,6mW = 1041K/W. Rth for R62 (0603) is 350K/W. → 350K/W < 1041K/W → T4

Pump circuit:
Voltage to buzzer circuit from battery, U = 3,6V
Minimum resistance between pump circuit and battery is RS51, RS52, RS53, RS54 and RS55 in series (R = 1,5Ω x 0,99 x 5 = 7,4Ω). In addition current from the main circuit through the parallel coupled resistors RP1, RP2 and RP3 (R = (10kΩ x 0,995) / 3 = 3316Ω).
Rp = 7,4Ω II 3316Ω = 7,38Ω
Maximum power to the pump circuit, P = (3,6V^2 / 7,38Ω) / 4 = 439,1mW
For components >20mm^2: 439,1mW < 1,2W → T4
For components <20mm^2: Rth = (275°C - 60°C) / 439,1mW = 490K/W. Rth for Q6 (1,6mm x 1,6mm > 0603) is approx. 350K/W. → 350K/W < 490K/W → T4

Motor circuit:
Voltage to buzzer circuit from battery, U = 3,6V
Minimum resistance from battery and main circuit is, R = RS61 II RV1 = 36Ω x 0,99 II 10kΩ x 0,995 = 35,51Ω.
Maximum power, P = (3,6V^2 / 35,51Ω) / 4 = 91,3mW
(Power from main circuit and RV1 (10kΩ) is negligible.)
For components >20mm^2: 91,3mW < 1,2W → T4
For components <20mm^2: Rth = (275°C - 60°C) / 91,3mW = 2354K/W. Rth for Q6 (1,6mm x 1,6mm > 0603) is approx. 350K/W. → 350K/W < 498K/W → Actual Rth for a component is much less than 9818K/W → T4

Main circuit:
Voltage to buzzer circuit from battery, U = 3,6V
Minimum resistance, R = 4,35Ω
Maximum power, P = (3,6V^2 / 4,35Ω) / 4 = 744,9mW
In addition power from the buzzer circuit, P = 6,4mW
(Power from pump and motor circuits are negligible.)
Total power, P = 744,9mW + 6,4mW = 751,3mW
For components >20mm^2: 751,3mW < 1,2W → T4
For components <20mm^2: Rth = (275°C - 60°C) / 751,3mW = 286K/W. Components in size 1206, 0805 and SOT-23 have Rth less than 286K/W → T4
R21, R22, R23, R24, R25, R26, R31, R32, R33, R34, R35, R36, R51, R52, R53, R54, R55, R56, R71, R72, R73, R74, R75, R76, R77, R75, R76, R77, R79, R80, R81, R82, R83, R84, R85, R86, R87, R88, R89, R90, R91, R92, R93, R94, R95, R96, R101, R102, R103, R104, R106, R107, R108, R109, R111, R112, R121,R122, R123, R124, R125, R126, R127, R128, R129, R130, R131, R132, R141, R142, R143, R144, R145, R151, R152, R153, R154, R155, R156, R157, R158, R159, R160, R161, R162, R163, R164, R165, R166, R167, R168, R169, R170, R171, R172, R173, R174, R175, R176, R178, R181, R182, R183, R184, R185, R186, R191, R192, R193, R194, R195, R196, R201, R202, R203, R204, R206, R211, R212, R213, R214, R215, R216, R217, R220, R221, R222, R223, R224, R225, R226, R227, R231, R232, R233, R234: 1608 /0603. See appendix B.6 for test details → T4
PS1: Pressure sensor. The measuring bridge resistors are >10kΩ each.
D5, D6, D7, D8, D8, D9, D10, D11: Schottky diode, VR 30V, VF 0,37V, 0,8mm x 1,2mm. Maximum power, P = 0,37V x (3,6V / 4,35Ω) = 307mW. Package size is between 0402 and 0603, Rth ≈ 600K/W. T = 60°C + 600K/W x 307mW = 245°C → T4
Q3: 1,6mm x 1,6mm is larger than a 0603 component, so the test in appendix B.6 will be representative.
Q4: 2,0mm x 2,0mm, this component is larger than a 0805 component, and will have a Rth less than 250K/W.
Q8, Q9, Q10, Q11, Q14, Q15, Q16: 2,0mm x 2,1mm, this component is larger than a 0805 component, and will have a Rth less than 250K/W.
Q13: 2,0mm x 2,0mm, this component is larger than a 0805 component, and will have a Rth less than 250K/W.
IC3, IC6, IC7, IC9, IC11: SOT-23
IC5: 2,9mm x 1,6mm, this component is larger than a 0805 component, and will have a Rth less than 250K/W.

IC10: 3,1mm x 3,1mm, this component is larger than a 0805 component, and will have a Rth less than 250K/W.
IC12: >20mm^2
IC13: 3,9mm x 5,05mm (footprint) > 20mm^2 surface area.
IC14: 3,81mm x 4,8mm (footprint) > 20mm^2 surface area.
IC15: 27mm^2 > 20mm^2
IC16: Hybrid circuit, including 0201 inductors. See appendix B.7 for temperature measurement test.
IC17: 5mm x 5mm (footprint) > 20mm^2 surface area.
IC18, IC22: larger than a SOT-23 package component, and will have a Rth less than 250K/W.
IC19, IC20: 3mm x 3mm (footprint) > 20mm^2 surface area.
IC21: 2,0mm x 2,0mm, this component is larger than a 0805 component, and will have a Rth less than 250K/W.
NF21, RF22, NF23, NF31, NF32, NF33, NF41: 0402, beads, jumper or resistors: Maximum supply to main circuit is 751,3mW and 3,6V. For beads DC resistance is 2,2Ω and current rating is 200mA@125°C. The component is already tested in RIKEN KEIKI project NO/PRE/ExTR15.0012/00. *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 – BLM15HD182 - 0402). At ambient temperature of 60°C the maximum surface temperature would hence be 264°C which is below the 275°C limit. Also 0402 resistor is tested in the same project @807mW → ΔT 105,9K.
TH1: 1608 = 0603 component, so the test in appendix B.6 will be representative.

A.3.2 Wiring within intrinsically safe apparatus for Group I and Group II
Maximum power to the different circuits:
Buzzer circuit: 206,6mW
Pump circuit: 439,1mW
Motor circuit: 91,3mW
Main circuit: 751,3mW
Maximum ambient temperature: +60°C.
According to NOTE 5 of Table 2: When the maximum power does not exceed 1,2W (ref. Table 4 of IEC 60079-0) the wiring can be assigned a temperature classification of T4.
Wiring from battery to pcb is AWG 22 = 0,34mm^2. According to table 2 a current of 7,7A is permitted @+40°C with a cross-sectional area of 0,196mm^2. Maximum current to all circuits added together is 978mA + 12,9mA + 28,3mA + 260mA + 569mA +119mA = 1,97A. 7,7A > 1,97A
Wiring to pump from pcb is AWG 28 = 0,08mm^2. According to table 2 a current of 3,7A is permitted @+40°C with a cross-sectional area of 0,0314mm^2. Maximum current to the pump is, I = 3,6V / 7,38Ω = 488mA.
488mA < 3,7A and 0,08mm^2 > 0,0314mm^2

A.3.3 Tracks on printed circuit boards for Group I and Group II
Maximum power to the different circuits:
Buzzer circuit: 206,6mW
Pump circuit: 439,1mW
Motor circuit: 91,3mW
Main circuit: 751,3mW
Maximum ambient temperature: +60°C.
According to clause 5.6.4: When the maximum power does not exceed 1,2W (ref. Table 4 of IEC 60079-0) the wiring can be assigned a temperature classification of T4.
The current from the battery will be reduced by the current limiting resistors, and the track width is 1mm → 5,9A / 2 / 1,2 = 2,45A permitted current → 2,45A > 1,97A (see calculation in A.3.2 above).

A.3.4 Intrinsically safe apparatus and component temperature for Group III
N / A – no dust certification.

A.4 Rating of components
A.4.1 Resistors
Um when charging: 6,0V

Charging circuit:
RS2, RS3: 30Ω, 1%, 2W, 200V → P = (6V^2 / (30Ω x 0,99)) x 1,5 = 1,82W → 2W > 1,82W
RS4, RS5: 470Ω, 1%, 0,5W, 200V → P = (6V^2 / (470Ω x 0,99)) x 1,5 = 116mW → 0,5W > 116mW
RS6, RS7, RS8: 10kΩ, 0,5%, 0,5W, 200V → P = (6V^2 / (10kΩ x 0,995)) x 1,5 = 6mW → 0,5W > 6mW

Buzzer circuit:
RS11, RS12: 8,2Ω, 1%, 2W, 200V → These two resistors are connected in series. Due to the serial coupled diodes, D1, D2 and D3 (with a VF of 0,43V) maximum voltage will be, V = (6V – 0,43V) / 2 = 2,79V over each resistor. P = ($2{,}79V^2$ / (8,2Ω x 0,99)) x 1,5) = 1,44W → 2W > 1,44W
RB1, RB2: 1kΩ, 0,5%, 0,5W, 200V → P = ($6V^2$ / (1kΩ x 0,995)) x 1,5 = 55mW → 0,5W > 55mW
RB3, RB4: 1,5kΩ, 1%, 0,75W, 200V → P = ($4{,}8V^2$ / (1,5kΩ x 0,99)) x 1,5 = 8mW → 0,75W > 8mW

Pump circuit:
RS51, RS52, RS53, RS54, RS55: 1,5Ω, 1%, 2W, 200V → These five resistors are connected in series. Due to the serial coupled diodes, D1, D2 and D3 (with a VF of 0,43V) maximum voltage will be, V = (6V – 0,43V) / 5 = 1,12V over each resistor. P = ($1{,}12V^2$ / (1,5Ω x 0,99)) x 1,5) = 1,27W → 2W > 1,27W
RP1, RP2, RP3: 10kΩ, 0,5%, 0,5W, 200V → P = ($6V^2$ / (10kΩ x 0,995)) x 1,5 = 6mW → 0,5W > 6mW

Motor circuit:
RS61: 36Ω, 1%, 2W, 200V → Due to the serial coupled diodes, D1, D2 and D3 (with a VF of 0,43V) maximum voltage will be, V = 6V – 0,43V = 5,57V over the resistor. P = ($5{,}57V^2$ / (36Ω x 0,99)) x 1,5) = 1,31W → 2W > 1,31W
RV1: 10kΩ, 0,5%, 0,5W, 200V → P = ($6V^2$ / (10kΩ x 0,995)) x 1,5 = 6mW → 0,5W > 6mW

Main circuit:
RS21: 100kΩ, 1%, 0,5W, 200V → P = ($6V^2$ / (100kΩ x 0,99)) x 1,5 = 0,5mW → 0,5W > 0,5mW
RS31, RS32, RS33, RS34: 2,2Ω, 1%, 2W, 200V → These four resistors are connected in series. Due to the serial coupled diodes, D1, D2 and D3 (with a VF of 0,43V) maximum voltage will be, V = (6V – 0,43V) / 4 = 1,40V over each resistor. P = ($1{,}40V^2$ / (2,2Ω x 0,99)) x 1,5) = 1,35W → 2W > 1,35W
RS41, RS42, RS43, RS44, RS45: 1,8Ω, 1%, 2W, 200V → These five resistors are connected in series. Due to the serial coupled diodes, D1, D2 and D3 (with a VF of 0,43V) maximum voltage will be, V = (6V – 0,43V) / 5 = 1,12V over each resistor. P = ($1{,}12V^2$ / (1,8Ω x 0,99)) x 1,5) = 1,06W → 2W > 1,06W
R105 (in series with capacitor C79): 150Ω, 1%, 0,5W, 200V → P = ($6V^2$ / (150Ω x 0,99)) x 1,5 = 364mW → 0,5W > 364mW

Battery circuit:
R1: 330Ω, 1%, 0,5W, 200V → P = ($6V^2$ / (330Ω x 0,99)) x 1,5 = 166mW → 0,5W > 166mW
R4: 150Ω, 1%, 0,5W, 200V → P = ($6V^2$ / (150Ω x 0,99)) x 1,5 = 364mW → 0,5W > 364mW

A.4.2 Shunt voltage limiters
Zener diodes are used in the buzzer circuit to clamp the voltage to a maximum of 4,8V (two and two parallel coupled).

P/N	Symbol						
	Zener Voltage:V_Z(V)			Dynamic Impedance:Z_Z(Ω)		Reverse Current:I_R(μA)	
	MIN.	MAX.	I_Z(mA)	MAX.	I_Z(mA)	MAX.	V_R(V)
TFZV 2.0B	2.020	2.200	20	140	20	120	0.5
TFZV 2.2B	2.220	2.410	20	120	20	120	0.7
TFZV 2.4B	2.430	2.630	20	100	20	120	1.0
TFZV 2.7B	2.690	2.910	20	100	20	100	1.0
TFZV 3.0B	3.010	3.220	20	80	20	50	1.0
TFZV 3.3B	3.320	3.530	20	70	20	20	1.0
TFZV 3.6B	3.600	3.845	20	60	20	10	1.0
TFZV 3.9B	3.890	4.160	20	50	20	5	1.0
TFZV 4.3B	4.170	4.430	20	40	20	5	1.0
TFZV 4.7B	4.550	4.800	20	25	20	5	1.0

They are rated 0,5W. The current to the zener diodes are limited by safety resistors (RB1 II RB3 for ZD3 II ZD4 and RB2 II RB4 for ZD1 II ZD2) for one zener couple and RB2, RB3 and RB4. 1,5 in safety factor is applied.
ZD1, ZD2, ZD3, ZD4: 4,8V, 0,5W → P = ((6V / (1kΩ x 0,995 II 1,5kΩ x 0,99)) x UZ) x 1,5 = (6V / 595,7Ω) x 4,8V x 1,5 = 73mW → 0,5W > 73mW. Due to the large safety factor (SF = 500mW / 49mW = 10,3) rating test is considered not to be necessary.

A.4.3 Series current limiter
D1, D2, D3 are diodes connected in series. Maximum current in lead direction is secured by the fuse F1. 1,5 in safety factor is applied.
If diodes = 3A
Vr diodes = 20V
Ifuse = 0,75A x 1,7 = 1,275A
Maximum voltage in circuit = 12,6V

3A > 1,275A x 1,5 = 1,92A
20V > 12,6V x 1,5 = 18,9V

A.4.4 _____
IC16 (hybrid circuit) circuit diagram and bom:

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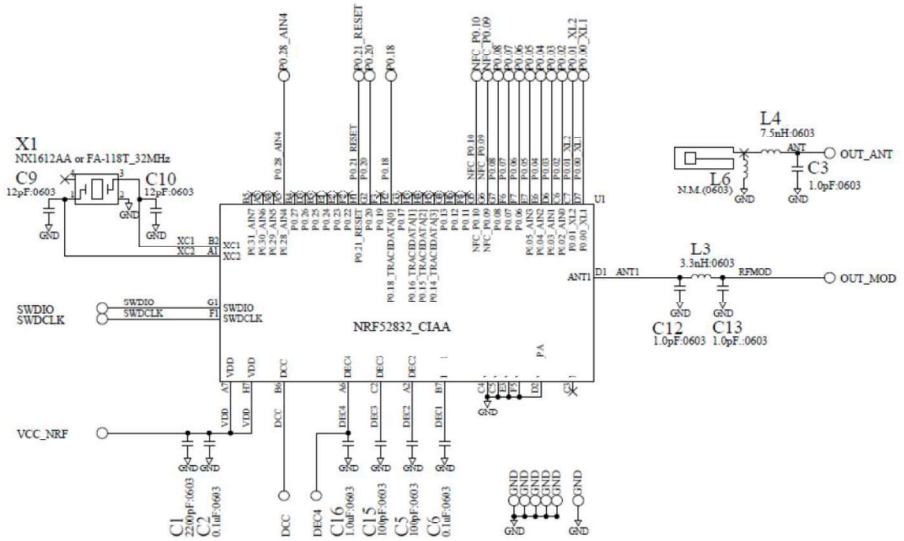
REV	ECO	APPROVED	DESCRIPTION	DATE



APPROVED:	Title	Document No.
CHECKED :	Circuit schematic	EYSHJN
DRAWN		
DESIGNED:		(1/1)

TAIYO YUDEN CO.,LTD.

Parts No.	Description	Parts name and standard	Supplier	Remark
C1	CAPACITOR	LMK063 BJ222 KP-F or Equivalent	TAIYO YUDEN or other supplier	
C2 C6	CAPACITOR	JMK063 BJ104 KP-F or Equivalent	TAIYO YUDEN or other supplier	
C3 C12 C13	CAPACITOR	GRM0334C1E or Equivalent	MURATA or other supplier	
C5 C15	CAPACITOR	UMK063 CH101JT-F or Equivalent	TAIYO YUDEN or other supplier	
C9 C10	CAPACITOR	TMK063 CH120 JP-F or Equivalent	TAIYO YUDEN or other supplier	
C16	CAPACITOR	JMK063ABJ105MP-F or Equivalent	TAIYO YUDEN or other supplier	
L3	INDUCTOR	HK 0603 or Equivalent	TAIYO YUDEN or other supplier	
L4	INDUCTOR	HK 0603 or Equivalent	TAIYO YUDEN or other supplier	
X1	CRYSTAL	FCX-07L (32MHz) or Equivalent	RIVER ELETEC or other supplier	
U1	IC	nRF52832	NORDIC	
PCB1	PCB	PB-150197	MEIKO	
CASE1	CASE	GTC097-KFT	KOBAYASHI SPRING	

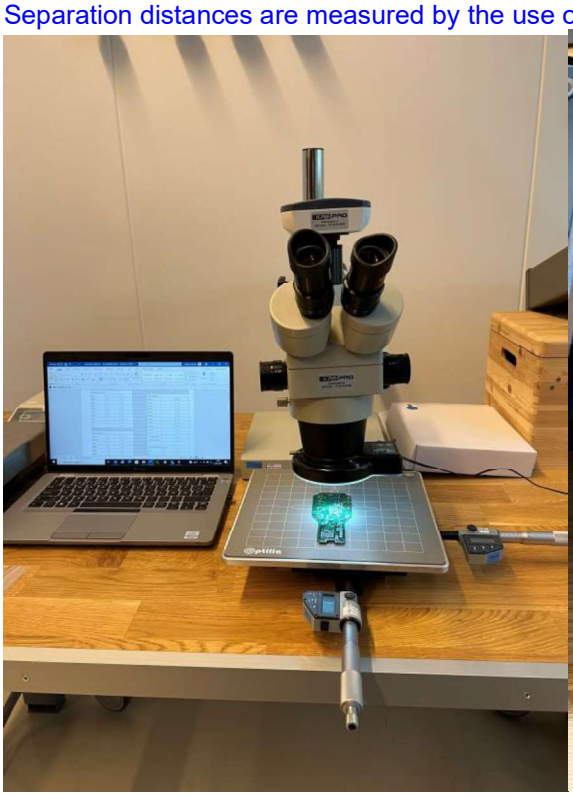
APPENDIX B: Tests

B.1 Separation distances (creepage and clearance)

Equipment Tested:	Layout of circuit board
Date of Test (yyyy/mm/dd):	2022/02/03 and 2022/02/28
Clause and Standards:	6.3.4 and 6.3.8 of IEC 60079-11: 2011

B.1.1 Test procedures

Separation distances are measured by the use of microscope and micrometers on circuit board.



B.1.2 Results

Creepage and clearance separation distances

Designation	Distance [mm]	Requirement [mm]		Designation	Distance [mm]	Requirement [mm]
Charging circuit:				RV1	2,2	≥1,5
RS2	1,8	≥1,5				
RS3	1,8	≥1,5		Main circuit:		
RS4	2,4	≥1,5		RS21	2,2	≥1,5
RS5	2,5	≥1,5		RS31	1,8	≥1,5
RS6	2,4	≥1,5		RS32	1,8	≥1,5
RS7	2,4	≥1,5		RS33	1,8	≥1,5
RS8	2,4	≥1,5		RS34	1,8	≥1,5
D1	1,5	≥1,5		RS41	1,7	≥1,5
D2	1,5	≥1,5		RS42	1,7	≥1,5
D3	1,5	≥1,5		RS43	1,7	≥1,5
				RS44	1,7	≥1,5
Buzzer circuit:				RS45	1,8	≥1,5
RS11	1,9	≥1,5		R105	2,0	≥1,5
RS12	2,7	≥1,5				
RB1	2,1	≥1,5		Battery/protect circuit:		
RB2	2,2	≥1,5		R1	2,0	≥1,5
RB3	2,4	≥2		R4	2,0	≥1,5

RB4	2,2	≥2				
Pump circuit:						
RS51	3,1	≥1,5				
RS52	2,0	≥1,5				
RS53	1,8	≥1,5				
RS54	1,8	≥1,5				
RS55	1,9	≥1,5				
Motor circuit:						
RS61	1,7	≥1,5				

Separation distances between tracks and components [mm]. Requirements ≥1,5 mm:

Battery/protect circuit:

- Between R4 and RT1: 2,0

Charger circuit:

- Between D2 and RS42: 1,6

Buzzer circuit:

- Between RS11 and R22: 2,1

Pump circuit:

- Between RS54 and RS55: 1,5

Main circuit:

- Between RS31 and RS34: 1,6
- Between RS42 and RS43: 1,5
- Between RS43 and R16: 1,6

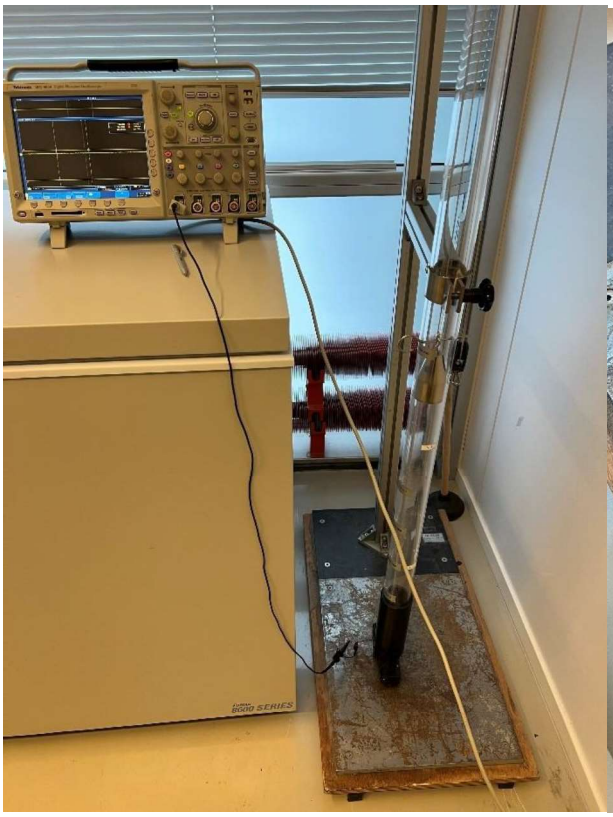
B.2 Piezo-electric device (buzzer)

Equipment Tested:	BZ1
Date of Test (yyyy/mm/dd):	2022/02/03
Clause and Standards:	7.7 and 10.7 of IEC 60079-11: 2011

B.2.1 Test procedures

The piezoelectric devize (BZ1) was isolated from the other components in the circuit (IC4 was removed). Wires were soldered to the + and – soldering pads on the pcb.

2 resistance to impact tests were performed on the surface of the enclosure. The impacts hit as close as possible to BZ1. Maximum voltage was measured by the use of a oscilloscope.

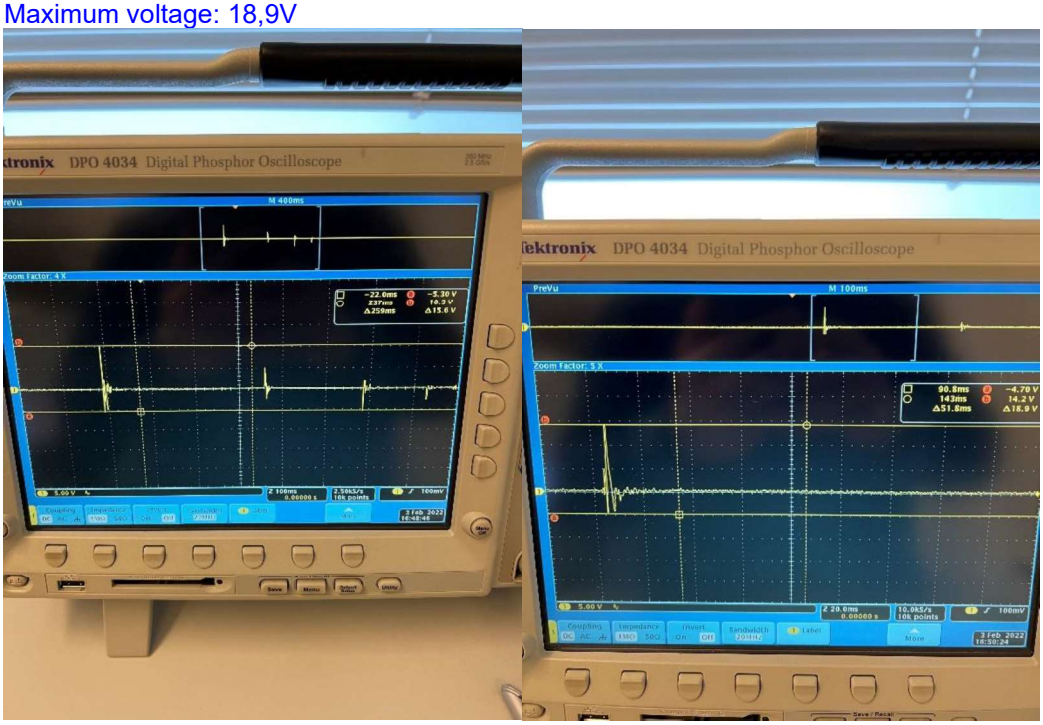


B.2.2 Results

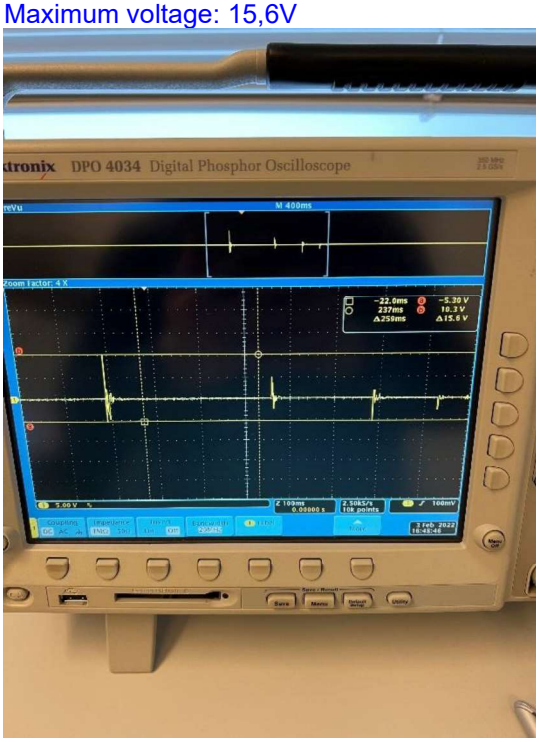
Measured capacitance: 34,37nF

Claimed maximum capacitance in bom: 42,9nF

Test 1:
Maximum voltage: 18,9V



Test 2:
Maximum voltage: 15,6V

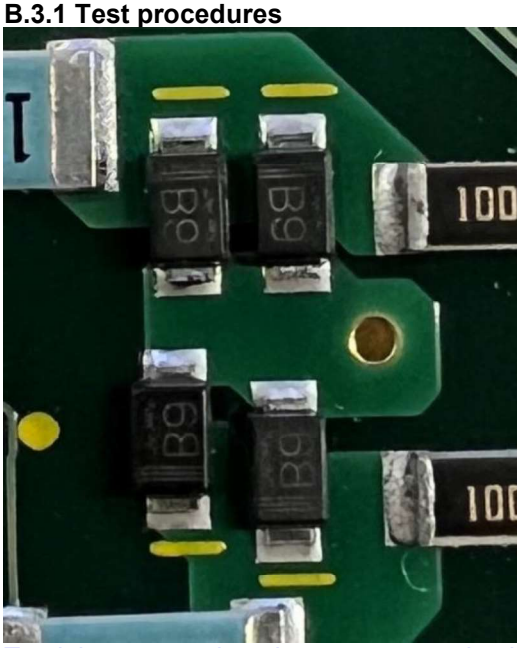


Result:
E = 0,5 x 42,9nF x 18,9V2 = 7,67µJ
7,67µJ < 50µJ → IIC

B.3 Measurement of infallible tracks

Equipment Tested:	Safety shunt assembly tracks, ZD1-ZD4
Date of Test (yyyy/mm/dd):	2022/06/21
Clause and Standards:	8.8.b.2 of IEC 60079-11:2011

B.3.1 Test procedures



Track is measured on the most narrow by the use of a microscope and micrometer.

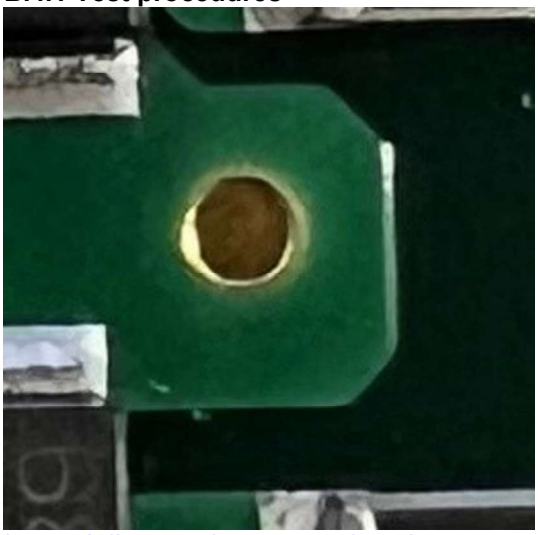
B.3.2 Results

Minimum = 2,2mm
Requirement: ≥2,0mm

B.4 Measurement of infallible vias

Equipment Tested:	Safety shunt assembly vias, ZD1-ZD4 anodes to GND
Date of Test (yyyy/mm/dd):	2022/06/21
Clause and Standards:	8.8.b.3 of IEC 60079-11:2011

B.4.1 Test procedures



Internal diameter is measured on the most narrow by the use of a microscope and micrometer.

B.4.2 Results

Internal diameter = 0,7mm
Circumference = 3,14 x 0,7mm ≈ 2,2mm
Requirement: ≥2,0mm

B.5 Battery testing

Equipment Tested:	Panasonic NCR18650GA (single cell)
Date of Test (yyyy/mm/dd):	Date of issue for ExTR: 2020-03-30
Clause and Standards:	10.5.2, 10.5.3.a and 10.5.3.b of IEC 60079-11: 2011

B.5.1 Test procedures

Tested according to 10.5.3.a and 10.5.3.b and 10.5.2. Test results are copied from IECEx TR NO/PRE/ExTR20.0043/00.

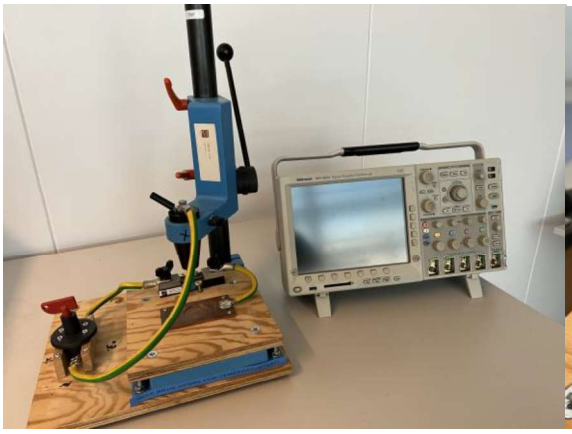
B.5.2 Results

Panasonic NCR18650GA:

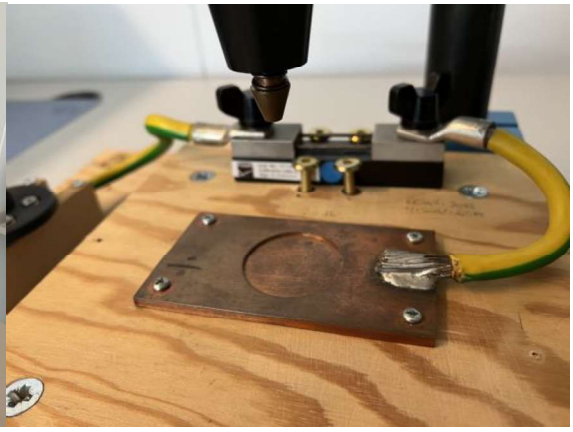
Spark ignition testing, clause 10.5.3. a:

No.	Open circuit voltage [V]	Resistance of short circuit link [mΩ]	Measured voltage over short circuit link [mV]	Short circuit current (I = U / R) [A]	Internal resistance (R = U / I) [mΩ]
1	4,139	2	300	150	28
2	4,127	2	324	162	25
3	4,127	2	320	160	26

4	4,128	2	334	167	25
5	4,139	2	328	164	25
6	**4,137**	**2**	**340**	**170**	**24**
7	4,138	2	320	160	26
8	4,126	2	324	162	25
9	4,143	2	322	161	26
10	4,132	2	324	162	25

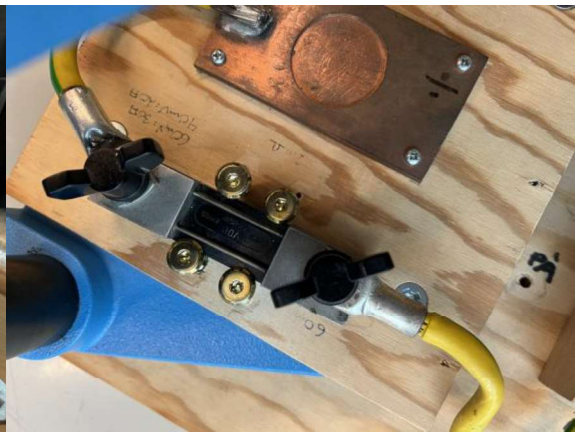


Overview.



The cell is placed between the contact points.

Probe for oscilloscope measures voltage drop over shunt resistor. Short circuit current is then calculated (I = U / R).



Calibrated shunt resistor of 2mΩ.

Surface temperature testing, clause 10.5.3.b (single cell, see also appendix B.6):

No.	Ambient temperature [°C]	Measured temperature [°C]	Delta temperature [K]	Max. ambient temperature [°C]	Temperature class
1	60	89	29	60	T5
2	**60**	**103**	**43**	**60**	**T4**
3	60	96	36	60	T5
4	60	89	29	60	T5
5	60	87	27	60	T5

6	60	91	31	60	T5
7	60	93	33	60	T5
8	60	90	30	60	T5
9	60	85	25	60	T5
10	60	89	29	60	T5

NOTE: the temperature tests are done without an enclose upon customer request. Due to the large safety margin (32K) T4 is accepted.

A thermal camera is used to find the hottest point on the cell, so the thermal couple can be placed at the correct area. The thermal couple is fixed to the cell and temperature rise is measured by temperature meter.

Note: the temperature rise is measured by thermal couple and not the thermal camera.

Electrolyte leakage testing, clause 10.5.2:
The ten test cells are placed over a piece of blotting paper.
Test duration ≥12 hours.

Results:

Maximum short circuit current (if required): 170A

Minimum internal resistance: 24mΩ

Maximum temperature rise: 43K

Visible sign of electrolyte on the blotting paper or on the external surfaces of the test samples: No

Comments:

Discharged with 2,5A, and a cut off voltage of 2,5V.
Rated capacity: 3300mAh

B.6 Temperature test of 0603 component

Equipment Tested:	R73 (0603 - 33Ω)
Date of Test (yyyy/mm/dd):	2022/03/09
Clause and Standards:	10.2 of IEC 60079-11: 2011

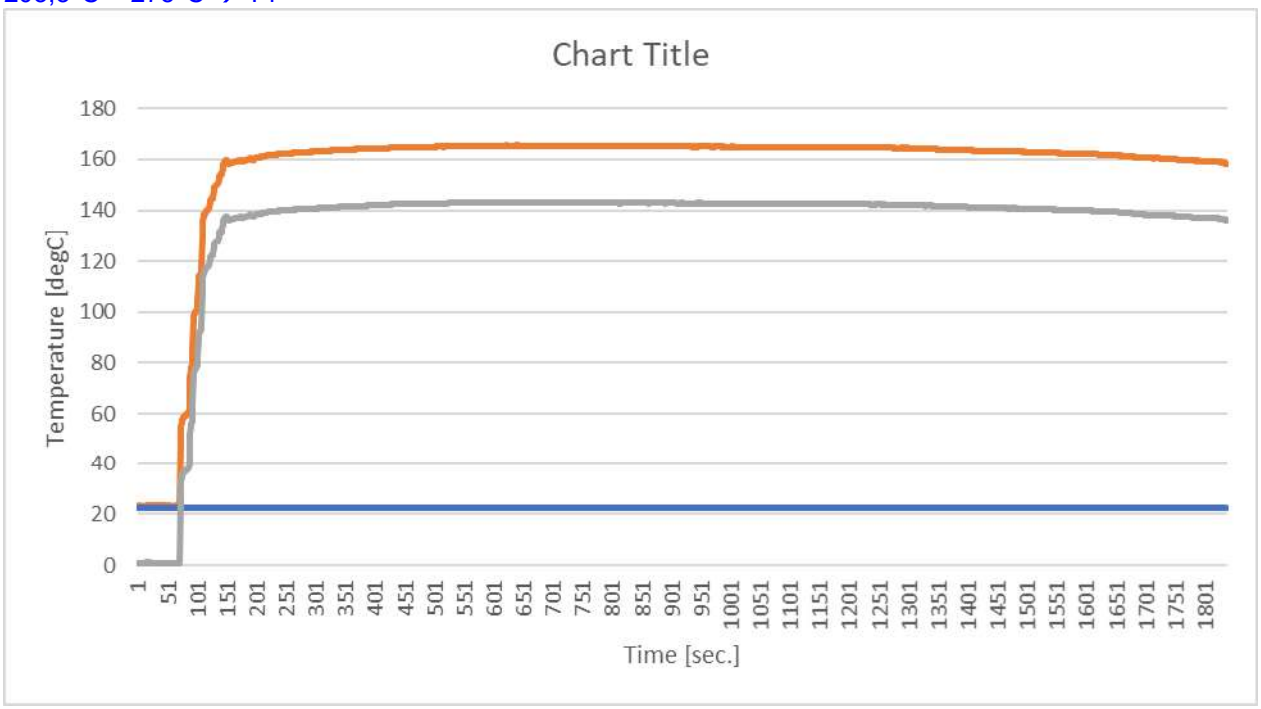
B.6.1 Test procedures

Component tested: R73 (33Ω). The component was isolated so all current supplied to it will float through this specific component. Connection wires were attached to CN6 and CN8 on the opposite site. Tracks had to be cut to isolate the component.
R73 was chosen to be tested as it has less cooling area connected to the soldering pads (very thin tracks).
Thermocouple attached to the component had a diameter of 0,08mm.

B.6.2 Results

Power dissipated of R73, P = 825mW
Ta: 22,3°C
Tmeasured = 165,6°C
ΔT = 143,3K
143,3K + 60°C = 203,3°C

203,3°C < 275°C → T4

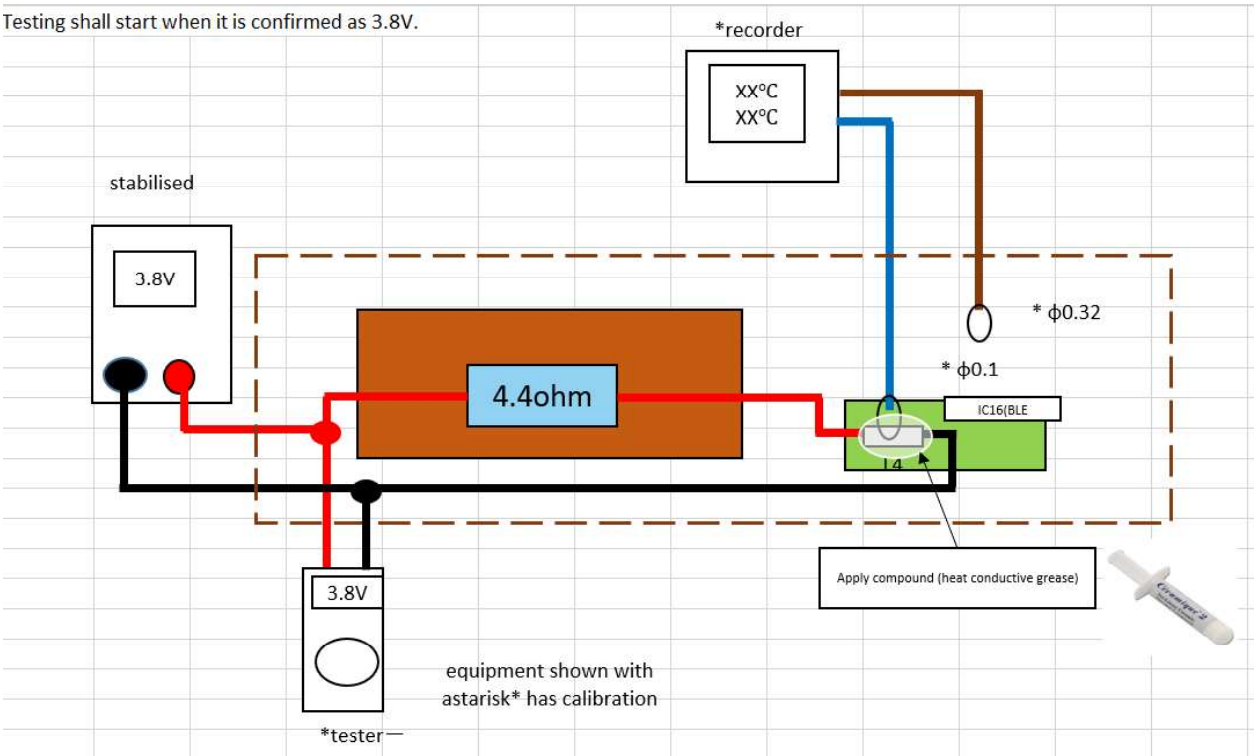


B.7 Test conducted Temperature test of L4 (part of IC16 / BLE module)

Equipment Tested:	L4 (inductor) as a bart of the hybrid component IC16
Date of Test (yyyy/mm/dd):	2022/05/19
Clause and Standards:	10.2 of IEC 60079-11: 2011

B.7.1 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.



R = 4,37Ω U = 3,8V

B.7.2 Results

Tmeasured = 171°C Ta-max = 60°C Ta = 26°C ΔT = 145K
Tmax = 145K + 60°C = 205°C
205°C < 275°C → T4