

**TESTS UNDERTAKEN AND REPORT PREPARED BY
CSA GROUP TESTING UK LIMITED**

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**TESTING OF CROWCON XGARD IQ INTELLIGENT GAS DETECTOR
AND TRANSMITTER**

Report No. **N70063398**

January 2019
Commercially in confidence

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Vibration testing report, carried out by TRW Limited (trading as Conekt)



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TEST REPORT

ISSUED BY CSA GROUP TESTING UK LIMITED

TESTING OF CROWCON XGARD IQ INTELLIGENT GAS DETECTOR AND TRANSMITTER

Carried out by CSA Group Testing UK Ltd on behalf of;

Crowcon Detection Instruments Ltd
172 Brook Drive
Milton Park
Abingdon
OX144SD

Report No **N70063398**

Project Nos: 70063398

Commercially in confidence
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1 INTRODUCTION

Two Crowcon Xgard IQ Intelligent Gas Detector and Transmitter units with Oxygen sensors were submitted to CSA Group Testing UK Ltd on 1st December 2016 for testing to check compliance with the requirements of BS EN 50104:2010 for the detection and measurement of Oxygen – performance requirements and test methods. Each unit had a hand written CSA number and # unit number written to the rear of the unit and on each sensor. The units submitted were capable of measuring oxygen deficiency and enrichment.

Sample set received on the 1st December 2016 identified as:-

Model Number	Detector Serial number	Detector CSA designation	Sensor Model Number	Sensor Serial Number	Sensor CSA designation
XIQ-ZZ-S1-011-H-R-A	498557/01-003	#21	XIQ-AG	498557/03-001	#25
XIQ-ZZ-S1-011-H-R-A	498557/01-007	#22	XIQ-AG	498557/03-002	#28

The original sensor, serial number 498557/03-001 (CSA #25), was found to be defective and was returned to the manufacturer and a replacement sensor, serial number W262369/01-001 (CSA #37), was received at CSA on the 8th February 2017. The new sensor was fitted to detector unit #21.

The majority of testing was carried out using test sample #22 with sensor #28. The stability test was performed using the test sample #21 and sensor #37. This report refers to the performance of the test samples when tested against the agreed programme. It does not imply that any other samples or products necessarily comply with the requirements of the test programme. In addition, whilst this report maybe freely reproduced as a complete document it may not be abstracted.

The tests were performed over the period February 2017 to June 2018.

The manufacturer's specified measuring range for the sensor was 0.0 to 30.0 % Oxygen. For the purposes of the testing the measuring range used was 0.0 to 25.0 % according to the standard.

Initial tests indicated that errors from the 4 to 20 mA output were outside specification at some points. The manufacturer was informed, however they requested that testing should continue. Tests reported on pages 8 to 18 of this report were using the original 4 to 20 mA output.

The updated unit was received back at CSA on 18th September 2017, after which the Calibration and Power Supply Variations tests were repeated. It was deemed not necessary to repeat any of the other previously performed tests as they were comparative tests.

The manufacturer stated that the modifications were made to the main board ECAD 000028. A 2.4 V Nexperia BZT52H-B2V4 Zener diode was added in the path to ground in series using 2 link wires. This raises the common mode voltage input voltage to the amplifier in the 4 to 20 mA feedback loop. The unit was recalibrated by the manufacturer using a 250 Ohm resistor at 24 V. Document reference number ENG-001046 vs 4 11/09/2017.

Test clauses 5.4.3, 5.4.7 and 5.4.16 performed with RS485 and HART ports connected with software, connecting cables and Modem supplied by the manufacturer.

HART software: 475 HART Simulator Version 6.3 (IS pins) with Modem Procomsol HM-USB-ISO SN: 410724

MODBUS RS485 Software: Modbus tester 2 with USB-RS485-WE-1800-BT cable (pc connector) @ 38400 Baud continuous.

Xgard IQ firmware : Main V1 i1.04, Sensor V1 i1.00, Display V1 i1.03

XgardIQ installation, operating and maintenance instructions manual reference : M070030/SF issue 1 September 2015.

Notes on Alarm, Fault and Relay function:

Alarm set points were 19.0% Oxygen falling and 22.5% Oxygen rising unless otherwise required by the standard.

Alarms were regarded as functioning normally when activated and latched (unless otherwise stated) on application of the test gas.

Fault indicator and Fault Relay were regarded as functioning normally unless initiated by any fault condition.

All relays were regarded as functioning normally when the relay switched in conjunction with any alarm condition. The alarm function was verified in each test gas by measuring the resistance across the alarm relays in order to ascertain their open/closed status.

Flashing alarm icons 1 and 2 and red LED (on for alarm one and flashing for alarm 2) function was also observed.

2 RESULTS SUMMARY

The numbers in parentheses are the relevant clause numbers from BS EN 50104: 2010.

<u>BS EN 50104:2010</u> <u>Clause number</u>	<u>Comment</u>
Unpowered Storage (5.4.2)	
Preparation of apparatus before testing (5.2.2)	Meets Criteria (b Apparatus having integral sensors)
Initial preparation of apparatus (5.4.3.)	PASS
Calibration adjustment and repeatability and calibration curve (5.4.3)	PASS
Repeatability (5.4.3)	PASS
Operation below the measuring range (5.4.25)	PASS
Alarm set points (5.4.6)	PASS
Stability (5.4.4.1)	PASS
Orientation (5.4.12.2)	PASS
Warm up time (5.4.15)	PASS
Time of response (5.4.16)	PASS
Power Supply Variations (5.4.19)	PASS
Dust (5.4.22)	PASS
Drop test (5.4.14)	N/A
Temperature (5.4.7)	PASS
Pressure (5.4.8)	PASS
Humidity (5.4.9)	PASS
Air velocity (5.4.10)	PASS
Battery capacity (5.4.18)	N/A
Poisons and other gases (5.4.23.2)	PASS
Vibration (5.4.13)	PASS (See report Appendix, test performed at Conekt)

Data reference: Project book for 70063398 (Oxygen).

3 DETAILED TEST RESULTS

The gas mixtures were prepared using gas mixing pumps outputting Oxygen in Nitrogen mixtures generated by diluting Premier grade Oxygen X47S with X47S grade Nitrogen. For the pressure test, cylinder mixtures of Oxygen in Nitrogen were used. The tests were performed under the following conditions unless otherwise stated:

ambient temperature	15 to 25°C
gas humidity	50 ± 20 % rh
power supply	24 V dc
ambient pressure	860 to 1080 mbar

Unless otherwise stated Alarm, Fault and Relay functions were normal throughout each test.

Unpowered Storage Clause 5.4.2

Unit #22, Sensor #28 and Unit #21, Sensor #37 exposed to the following conditions:

- A temperature of -20 ±3°C for 24 h
Ambient temperature for 24 h
- A temperature of +40 ±2°C for 24 h
Ambient temperature for 24 h

Test – Calibration curve

Unit #22, Sensor #28

Standard and clause reference - BS EN 50104:2010, clause 5.4.3.2

Acceptance criteria - $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater

Note, $\pm 2.5\%$ of measuring range would equate to a variation in error of 0.625% (v/v) of Oxygen

Note, a result shown in the table in the format does not meet the acceptance criteria detailed.

Applied gas, % Oxygen	Display			4 to 20 mA output		
	% Oxygen	Error, % Oxygen	Error, % range	% Oxygen	Error, % Oxygen	Error, % range
0.0	0.0	0.00	0.00	0.06	0.06	0.23
6.25	5.8	-0.45	-1.80	5.37	-0.88	-3.51
12.5	12.4	-0.10	-0.40	12.09	-0.41	-1.64
18.75	18.8	0.05	0.20	18.54	-0.21	-0.83
25.0	25.0	0.00	0.00	24.77	-0.23	-0.93
18.75	18.8	0.05	0.20	18.60	-0.15	-0.60
12.5	12.4	-0.10	-0.40	12.08	-0.42	-1.69
6.25	5.8	-0.45	-1.80	5.44	-0.81	-3.24
12.5	12.4	-0.10	-0.40	12.14	-0.36	-1.46
18.75	18.8	0.05	0.20	18.60	-0.15	-0.62
25.0	25.0	0.00	0.00	24.89	-0.11	-0.42
18.75	18.8	0.05	0.20	18.63	-0.12	-0.49
12.5	12.4	-0.10	-0.40	12.10	-0.40	-1.59
6.25	5.8	-0.45	-1.80	5.41	-0.84	-3.35
12.5	12.4	-0.10	-0.40	12.08	-0.42	-1.67
18.75	18.8	0.05	0.20	18.58	-0.17	-0.67
25.0	25.0	0.00	0.00	24.89	-0.11	-0.42
18.75	18.8	0.05	0.20	18.60	-0.15	-0.61
12.5	12.4	-0.10	-0.40	12.09	-0.41	-1.66
6.25	5.8	-0.45	-1.80	5.43	-0.82	-3.29
0.0	0.0	0.00	0.00	0.07	0.07	0.27

Note, test repeated on page 18 post 4 to 20 mA modifications.

Lab book reference : page 17

Test – Calibration curve (as part of the Stability test)

Unit #21, Sensor #37

Standard and clause reference - BS EN 50104:2010, clause 5.4.3.2

Acceptance criteria - $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater

Note, $\pm 2.5\%$ of measuring range would equate to a variation in error of 0.625% (v/v) of Oxygen

Applied gas, % Oxygen	Display			4 to 20 mA output		
	% Oxygen	Error, % Oxygen	Error, % range	% Oxygen	Error, % Oxygen	Error, % range
0.0	0.0	0.00	0.00	0.12	0.12	0.49
6.25	6.3	0.05	0.20	6.15	-0.10	-0.41
12.5	12.7	0.20	0.80	12.49	-0.01	-0.06
18.75	18.8	0.05	0.20	18.63	-0.12	-0.49
25.0	24.9	-0.10	-0.40	24.68	-0.32	-1.29
18.75	18.9	0.15	0.60	18.68	-0.07	-0.26
12.5	12.7	0.20	0.80	12.55	0.05	0.19
6.25	6.3	0.05	0.20	6.16	-0.09	-0.37
12.5	12.7	0.20	0.80	12.49	-0.01	-0.03
18.75	18.9	0.15	0.60	18.70	-0.05	-0.18
25.0	24.9	-0.10	-0.40	24.70	-0.30	-1.19
18.75	18.9	0.15	0.60	18.73	-0.02	-0.07
12.5	12.7	0.20	0.80	12.48	-0.02	-0.07
6.25	6.3	0.05	0.20	6.15	-0.10	-0.41
12.5	12.7	0.20	0.80	12.48	-0.02	-0.06
18.75	18.9	0.15	0.60	18.66	-0.09	-0.36
25.0	24.9	-0.10	-0.40	24.72	-0.28	-1.12
18.75	18.9	0.15	0.60	18.67	-0.08	-0.33
12.5	12.7	0.20	0.80	12.50	0.00	-0.01
6.25	6.3	0.05	0.20	6.16	-0.09	-0.37
0.0	0.0	0.00	0.00	0.09	0.09	0.34

Acceptance criteria met.

Lab book reference : pages 18 to 19

Test – Repeatability

Standard and clause reference - BS EN 50104:2010, clause 5.4.3.3

Acceptance criteria - Standard deviation shall be smaller than $\pm 0.1\%$ (v/v) of oxygen or $\pm 1\%$ of measuring range.

Note, $\pm 1\%$ of measuring range would equate to a Standard deviation of 0.25% (v/v) of Oxygen

Applied gas, % Oxygen	Display % Oxygen	4 to 20 mA % Oxygen
21.0	21.0	20.15
21.0	21.0	20.16
21.0	21.0	20.18
21.0	21.0	20.18
21.0	21.0	20.15
21.0	21.0	20.16
21.0	21.0	20.14
21.0	21.0	20.17
21.0	21.0	20.13
21.0	21.0	20.15
Stdev.	0.00	0.016
12.5	12.5	11.68
12.5	12.5	11.72
12.5	12.5	11.70
12.5	12.5	11.70
12.5	12.5	11.70
12.5	12.5	11.69
12.5	12.5	11.68
12.5	12.5	11.68
12.5	12.5	11.68
12.5	12.5	11.69
Stdev.	0.00	0.012
23.0	23.0	22.17
23.0	23.0	22.14
23.0	23.0	22.11
23.0	23.0	22.07
23.0	23.0	22.12
23.0	23.0	22.07
23.0	23.0	22.09
23.0	23.0	22.09
23.0	23.0	22.08
23.0	23.0	22.07
Stdev.	0.00	0.033

Acceptance criteria met.

Lab book reference : page 7

Test – Stability**Unit #21, Sensor #37**

Standard and clause reference - BS EN 50104:2010, clause 5.4.4.1

Acceptance criteria – variation shall not exceed $\pm 0.4\%$ (v/v) of oxygen or $\pm 5\%$ of measuring range.

Note, $\pm 5\%$ of measuring range would equate to a variation of 1.25% (v/v) of Oxygen

Week	Indication (Gas applied 12.50 % O ₂)	4 to 20 mA Calculated (Gas applied 12.50 % O ₂)	Indication (Gas applied 21.00 % O ₂)	4 to 20 mA Calculated (Gas applied 21.00 % O ₂)	Indication (Gas applied 23.00 % O ₂)	4 to 20 mA Calculated (Gas applied 23.00 % O ₂)
initial	12.7	12.54	21.0	20.85	23.0	22.80
1	12.7	12.55	21.1	20.85	23.0	22.85
2	12.7	12.56	21.1	20.92	23.0	22.84
3	12.7	12.55	21.0	20.89	23.0	22.76
4	12.7	12.46	21.0	20.83	23.0	22.81
5	12.7	12.54	21.1	20.90	23.0	22.83
6	12.7	12.47	21.0	20.83	23.0	22.73
7	12.7	12.55	21.0	20.87	23.0	22.76
8	12.7	12.50	21.0	20.86	23.0	22.78
9	12.7	12.50	21.0	20.84	23.0	22.79
Max Deviation	0	0.10	0.1	0.09	0	0.12

Acceptance criteria met.

Lab book reference : pages 20 to 24

Test - Operation at or below limit of measuring range

Standard and clause reference - BS EN 50104:2010, clause 5.4.25

Acceptance criteria - Variation of the indication from that determined prior to the test shall not exceed $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater.

Note, $\pm 2.5\%$ of measuring range would equate to a variation of $\pm 0.625\%$ (v/v) of Oxygen.

Operation below the measuring range (5.4.25) Post nitrogen application test gas 12.5% O ₂	During the application of nitrogen, the low alarm remained operational. After removal from nitrogen, the apparatus returned to normal operation within 5 mins. Pre nitrogen application test gas reading = 12.4% O ₂	
	Time after removal from nitrogen	Instrument reading % O ₂
	30 s	9.5
	1 min	12.0
	2 min	12.4
	3 min	12.4
	4 min	12.4
	5 min	12.4
	Final	12.4
Operation below the measuring range (5.4.25) Post nitrogen application test gas 21.0% O ₂	During the application of nitrogen, the low alarm remained operational. After removal from nitrogen, the apparatus returned to normal operation within 5 mins. Pre nitrogen application test gas reading =21.0% O ₂	
	Time after removal from nitrogen	Instrument reading % O ₂
	30 s	17.6
	1 min	20.5
	2 min	20.9
	3 min	21.0
	4 min	21.0
	5 min	21.0
	Final	21.0
Operation below the measuring range (5.4.25) Post nitrogen application test gas 23.0% O ₂	During the application of nitrogen, the low alarm remained operational. After removal from nitrogen, the apparatus returned to normal operation within 5 mins. Pre nitrogen application test gas reading =23.0% O ₂	
	Time after removal from nitrogen	Instrument reading % O ₂
	30 s	18.5
	1 min	22.3
	2 min	22.9
	3 min	23.0
	4 min	23.0
	5 min	23.0
	Final	23.0

Acceptance criteria met.

Lab book reference : pages 8 to 10

Test - Alarm Set point (s)

Standard and clause reference - BS EN 50104:2010, clause 5.4.6

Acceptance criteria - The alarm shall activate following the application of the reference air or the standard test gas.

For increasing oxygen concentration, alarms are set to 10% below the relative volume fraction of the reference air.

For decreasing oxygen concentration, alarms are set to 10% above the relative volume fraction of the standard test gas.

Testing carried out for both test gases 12.5% and 23.0% Oxygen using reference air 21.0% Oxygen.

Alarm set points (5.4.6)	
Alarm 1 and 2 set to 18.9% O ₂ (12.5 % O ₂ increasing)	Alarms activated at 18.9% O ₂ when 21.0 % O ₂ applied, alarms latched and reset
Alarm 1 and 2 set to 13.8% O ₂ (21.0% O ₂ decreasing)	Alarms activated at 13.8% O ₂ when 12.5% O ₂ applied, alarms latched and reset
Alarm 1 and 2 set to 22.8% O ₂ (21.0% O ₂ increasing)	Alarms activated at 22.8% O ₂ when 23.0 % O ₂ applied, alarms latched and reset
Alarm 1 and 2 set to 22.8% O ₂ (23.0% O ₂ decreasing)	Alarms activated at 22.8% O ₂ when 21.0% O ₂ applied, alarms latched and reset

Note : Manufacturer's t90 ~ 10 s, all alarms activated before 20s,

Acceptance criteria met.

Lab book reference : pages 11 to 16

Test - Orientation

Standard and clause reference - BS EN 50104:2010, clause 5.4.12.2

Acceptance criteria - Variation of the indication in zero test gas or reference air, and standard test gas shall not exceed $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater.

Note, $\pm 2.5\%$ of measuring range would equate to a variation of $\pm 0.625\%$ (v/v) of Oxygen.

position	Applied % Oxygen	Display, % Oxygen	Variation of indication % Oxygen	4 to 20 mA output, calculated % Oxygen	Variation of indication 4 to 20 mA output % Oxygen
90° nominal	12.5	12.5	N/A	12.17	N/A
90° nominal	21.0	21.0	N/A	20.82	N/A
90° nominal	23.0	23.0	N/A	22.86	N/A
75° (z)	12.5	12.5	0.0	12.16	-0.01
75° (z)	21.0	21.0	0.0	20.81	0.00
75° (z)	23.0	23.0	0.0	22.87	0.01
105° (z)	12.5	12.5	0.0	12.16	0.03
105° (z)	21.0	21.0	0.0	20.88	0.06
105° (z)	23.0	23.0	0.0	22.87	0.00
90° nominal	12.5	12.5	N/A	12.14	N/A
90° nominal	21.0	21.0	N/A	20.82	N/A
90° nominal	23.0	23.0	N/A	22.87	N/A
90° nominal	12.5	12.4	N/A	12.12	N/A
90° nominal	21.0	21.0	N/A	20.81	N/A
90° nominal	23.0	23.0	N/A	22.85	N/A
75° (x)	12.5	12.4	0.0	12.12	0.00
75° (x)	21.0	21.0	0.0	20.82	0.00
75° (x)	23.0	23.0	0.0	22.86	0.00
105° (x)	12.5	12.4	0.0	12.11	0.00
105° (x)	21.0	21.0	0.0	20.85	0.06
105° (x)	23.0	23.0	0.0	22.86	0.04
90° nominal	12.5	12.4	N/A	12.11	N/A
90° nominal	21.0	21.0	N/A	20.80	N/A
90° nominal	23.0	23.0	N/A	22.83	N/A

Note: Manufacturers recommended orientation is mounted to a flat surface or mounting pipe, with the sensor pointing down. Therefore orientation around the Y axis is not applicable. For X and Z axis, no limits stated by the manufacturer therefore units tested at an inclination of $\pm 15^\circ$ from nominal used.

Note: In the above table some of the variations reported for the 4 to 20 mA output are subject to rounding errors of 0.01 % Oxygen.

Acceptance criteria met.

Lab book reference : page 25

Test - Warm-up time

Standard and clause reference - BS EN 50104:2010, clause 5.4.15

Acceptance criteria - The apparatus shall warm-up in zero test gas or reference air to give a final indication to within a volume fraction of $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range, whichever is greater, in a time not more than 2 minutes. No false alarms shall be generated.

Note, $\pm 2.5\%$ of measuring range would equate to a variation of $\pm 0.625\%$ (v/v) of Oxygen.

Time to reach 20.8% Oxygen = 1 minute 8 seconds

Test carried out in 20.9% O₂.

From unpowered to stable state.

No false alarms.

Acceptance criteria met.

Lab book reference : page 26

Test – Time of Response

Standard and clause reference - BS EN 50104:2010, clause 5.4.16

Acceptance criteria - A value of 20% of the total measured value change shall be reached within 10 s (t20), and a value of 90% of the total measured change shall be reached within 45 s (t90).

Gas Application	t20	t90
20.9 % O ₂ to 12.5 % O ₂	6 s	14 s
12.5 % O ₂ to 20.9 % O ₂	4 s	15 s
20.9 % O ₂ to 23.0 % O ₂	3 s	7s
23.0 % O ₂ to 20.9 % O ₂	4 s	9 s

RS485 and HART function: Normal

Acceptance criteria met.

Lab book reference : pages 26 to 27

Test – Power supply variations

Standard and clause reference - BS EN 50104:2010, clause 5.4.19

Acceptance criteria - Variation of the indication at the highest and lowest supply voltage shall not exceed $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater. No false alarm shall be activated. All output functions shall work properly.

Note, $\pm 2.5\%$ of measuring range would equate to a variation of $\pm 0.625\%$ (v/v) of Oxygen

Voltage Applied V	Current output Load Ohms	Applied % Oxygen	Display, % Oxygen	variation of indication % Oxygen	4 to 20 mA output, calculated % Oxygen	Variation of indication for 4 to 20 mA output % Oxygen
24.005	100.02	12.5	12.4		12.12	
24.006	100.02	21.0	21.0		20.80	
24.006	100.02	23.0	23.0		22.82	
30.011	1000.14	23.0	23.0	0.0	22.67	0.12
30.010	1000.14	21.0	21.0	0.0	20.63	0.13
30.010	1000.14	12.5	12.4	0.0	11.96	0.10
14.005	471.78	12.5	12.4	0.0	12.06	0.10
14.004	471.78	21.0	21.0	0.0	20.76	0.13
14.003	471.78	23.0	23.0	0.0	22.79	0.12

RS485 and HART function: Normal

No false alarms.

The manufacturer specified the following maximum output loads for the various supply voltages;

1000 Ω at 30 V

800 Ω at 24 V

467 Ω at 14 V

Acceptance criteria met.

Lab book reference : pages 29 to 30

Note, test repeated on page 19 of this report, post 4 to 20 mA modifications.

Test – Dust

Standard and clause reference - BS EN 50104:2010, clause 5.4.22

Acceptance criteria - Variation of the indication in zero test gas or reference air, and standard test gas shall not exceed $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater. The increase in t_{90} shall be less than 10 s.

Note, $\pm 2.5\%$ of measuring range would equate to a variation of $\pm 0.625\%$ (v/v) of Oxygen.

Initial readings

Applied % Oxygen	Display, % Oxygen	4 to 20 mA output, calculated % Oxygen
12.5	12.4	12.09
21.0	21.0	20.86
23.0	23.0	22.89

Sensor restricted by 50%

Applied % Oxygen	Display, % Oxygen	4 to 20 mA output, calculated % Oxygen	Variation of indication from initial display, % Oxygen	Variation of indication from initial 4 to 20 mA, % Oxygen
12.5	12.4	12.06	0.0	-0.03
21.0	21.0	20.79	0.0	-0.07
23.0	23.0	22.83	0.0	-0.06

Response test with sensor restricted by 50%

Gas Application	t_{90} s	response test t_{90} s	variation from response test t_{90} s
20.9 % O ₂ to 12.5 % O ₂	14	14	0
12.5 % O ₂ to 20.9 % O ₂	18	15	3
20.9 % O ₂ to 23.0 % O ₂	14	7	7
23.0 % O ₂ to 20.9 % O ₂	18	9	9

Acceptance criteria met.

Lab book reference : page 31

Test – Temperature

Standard and clause reference - BS EN 50104:2010, clause 5.4.7

Acceptance criteria - Variation of the indications from that at 20°C in zero test gas or reference air, and standard test gas shall not exceed $\pm 0.5\%$ (v/v) of oxygen or $\pm 5\%$ of the measuring range whichever is the greater.

Note, $\pm 5\%$ of measuring range would equate to a variation of 1.25% (v/v) of Oxygen

Temperature °C	Display @ 12.5 % Oxygen	4 to 20 mA output, calculated 12.5% Oxygen	Display @ 21.0 % Oxygen	4 to 20 mA output, calculated 21.0% Oxygen	Display @ 23.0 % Oxygen	4 to 20 mA output, calculated 23.0% Oxygen
20	12.4	12.10	21.0	20.75	23.0	22.79
-10	12.3	12.10	20.9	20.75	22.9	22.77
20	12.5	12.14	21.1	20.89	23.1	22.85
-20	12.3	12.08	20.8	20.74	22.7	22.68
20	12.5	12.19	21.1	20.88	23.1	22.89
40	12.5	12.14	21.2	20.97	23.3	23.05
20	12.4	12.11	21.0	20.81	23.0	22.86
50	12.5	12.11	21.1	20.79	23.2	22.92
20	12.4	12.13	21.0	20.83	23.0	22.83

RS485 and HART function: Normal

Acceptance criteria met.

Lab book reference : pages 32 to 35

At this stage of the testing the manufacturer requested the unit to be returned for modifications to the 4 to 20 mA output function.

Test – Calibration curve

Repeat test post 4 to 20 mA modifications by the manufacturer (See Page 7)

Standard and clause reference - BS EN 50104:2010, clause 5.4.3.2

Acceptance criteria - $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater

Note, $\pm 2.5\%$ of measuring range would equate to a variation in error of 0.625% (v/v) of Oxygen

Applied gas, % Oxygen	Display			4 to 20 mA output		
	% Oxygen	Error, % Oxygen	Error, % range	% Oxygen	Error, % Oxygen	Error, % range
0.0	0.0	0.00	0.00	-0.03	-0.03	-0.13
6.25	5.9	-0.35	-1.40	5.86	-0.39	-1.57
12.5	12.4	-0.10	-0.40	12.39	-0.11	-0.45
18.75	18.8	0.05	0.20	18.80	0.05	0.19
25.0	24.9	-0.10	-0.40	25.00	0.00	0.00
18.75	18.8	0.05	0.20	18.81	0.06	0.23
12.5	12.4	-0.10	-0.40	12.40	-0.10	-0.41
6.25	5.8	-0.45	-1.80	5.80	-0.45	-1.82
12.5	12.4	-0.10	-0.40	12.39	-0.11	-0.43
18.75	18.8	0.05	0.20	18.75	0.00	0.01
25.0	24.9	-0.10	-0.40	24.97	-0.03	-0.13
18.75	18.8	0.05	0.20	18.80	0.05	0.21
12.5	12.4	-0.10	-0.40	12.40	-0.10	-0.40
6.25	5.9	-0.35	-1.40	5.85	-0.40	-1.61
12.5	12.4	-0.10	-0.40	12.40	-0.10	-0.42
18.75	18.8	0.05	0.20	18.79	0.04	0.16
25.0	24.9	-0.10	-0.40	24.97	-0.03	-0.13
18.75	18.8	0.05	0.20	18.80	0.05	0.21
12.5	12.4	-0.10	-0.40	12.42	-0.08	-0.31
6.25	5.9	-0.35	-1.40	5.85	-0.40	-1.59
0.0	0.0	0.00	0.00	-0.03	-0.03	-0.14

RS485 and HART function: Normal

Acceptance criteria met.

Lab book reference : pages 36 to 37

Test – Power supply variations

Repeat test post 4 to 20 mA modifications

Standard and clause reference - BS EN 50104:2010, clause 5.4.19

Acceptance criteria - Variation of the indication at the highest and lowest supply voltage shall not exceed $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater. No false alarm shall be activated. All output functions shall work properly.

Note, $\pm 2.5\%$ of measuring range would equate to a variation in error of 0.625% (v/v) of Oxygen

The Power Supply Variations test was repeated to check the 4 to 20 mA output function using the manufacturer's revised maximum and minimum operating voltage range and maximum load restrictions on the 4 to 20 mA output. See page 15.

Voltage Applied V	Current output Load Ohms	Applied % Oxygen	Display, % Oxygen	variation of indication, % Oxygen	4 to 20 mA output, calculated % Oxygen	Variation of indication 4 to 20 mA output % Oxygen
24.007	100.019	12.5	12.4		12.38	
24.007	100.019	21.0	21.0		20.95	
24.007	100.019	23.0	23.0		22.96	
14.007	399.6	23.0	22.9	0.0	22.83	-0.05
14.007	399.6	21.0	21.0	0.0	20.87	0.01
14.007	399.6	12.5	12.4	0.0	12.36	-0.03
30.007	499.35	12.5	12.4	0.0	12.33	-0.03
30.007	499.35	21.0	21.0	0.0	20.88	0.01
30.007	499.35	23.0	22.9	0.0	22.78	-0.05

RS485 and HART function: Normal

The manufacturer specified the following maximum output loads for the various supply voltages;

500 Ω at 30 V

500 Ω at 24 V

400 Ω at 14 V

Acceptance criteria met.

Lab book reference : pages 38

Test – Pressure

Standard and clause reference - BS EN 50104:2010, clause 5.4.8

Acceptance criteria - Variation of the indications from that at 100 kPa shall not exceed $\pm 22\%$ of the measured value at 100 kPa or $\pm 0.2\%$ (v/v) of oxygen, whichever is the greater.

Note, $\pm 22\%$ of the measured value 12.4%, 21.6% and 23.0% oxygen would equate to a variation of 2.73%, 4.75% and 5.06% (v/v) of Oxygen respectively.

Pressure mbar	Applied % Oxygen	Display, % Oxygen	variation of indication, % Oxygen	4 to 20 mA output, calculated, % Oxygen	Variation of indication 4 to 20 mA output, % Oxygen
1000	Zero grade air	21.6	n/a	21.62	n/a
1200	Zero grade air	21.8	0.2	21.86	0.24
1000	Zero grade air	21.6	0.0	21.58	-0.04
1000	Zero grade air	21.6	n/a	21.61	n/a
800	Zero grade air	21.4	-0.2	21.40	-0.21
1000	Zero grade air	21.6	0.0	21.58	-0.03
1000	12.5	12.4	n/a	12.32	n/a
1200	12.5	12.5	0.1	12.44	0.12
1000	12.5	12.4	0.0	12.35	0.03
1000	12.5	12.4	n/a	12.34	n/a
800	12.5	12.2	-0.2	12.11	-0.23
1000	12.5	12.4	0.0	12.32	-0.02
1000	23.1	23.0	n/a	22.99	n/a
1200	23.1	23.3	0.3	23.26	0.27
1000	23.1	23.0	0.0	22.99	0.00
1000	23.1	23.0	n/a	22.99	n/a
800	23.1	22.7	-0.3	22.68	-0.31
1000	23.1	23.0	0.0	22.99	0.00

Acceptance criteria met.

Lab book reference : pages 39 to 41

Test – Humidity

Standard and clause reference - BS EN 50104:2010, clause 5.4.9

Acceptance criteria - Variation of the indications from that at 50 % r.h. shall not be more than $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of the measuring range whichever is the greater

Note, $\pm 2.5\%$ of measuring range would equate to a variation in error of 0.625% (v/v) of Oxygen

Display data

Applied % Oxygen Humidity corrected	% r.h.	Display % Oxygen	error, % Oxygen	Δ error, % oxygen	error, % range	Δ error, % range
12.53	50	12.8	0.27	N/A	1.08	N/A
21.20	50	21.5	0.30	N/A	1.20	N/A
23.13	50	23.6	0.47	N/A	1.88	N/A
12.58	20	12.7	0.12	-0.15	0.48	-0.60
21.12	20	21.2	0.08	-0.22	0.32	-0.88
23.13	20	23.2	0.07	-0.40	0.28	-1.60
12.53	50	12.8	0.27	N/A	1.08	N/A
21.20	50	21.6	0.40	N/A	1.60	N/A
23.13	50	23.6	0.47	N/A	1.88	N/A
12.52	90	12.9	0.38	0.11	1.52	0.44
20.98	90	21.7	0.72	0.32	2.88	1.28
23.12	90	24.0	0.88	0.41	3.52	1.64

4 to 20 mA output data

Applied % Oxygen Humidity corrected	% r.h.	calculated 4 to 20 mA, % Oxygen	error, % Oxygen	Δ error, % oxygen	error, % range	Δ error, % range
12.53	50	12.85	0.32	N/A	1.29	N/A
21.20	50	21.50	0.30	N/A	1.21	N/A
23.13	50	23.50	0.37	N/A	1.48	N/A
12.58	20	12.59	0.01	-0.31	0.04	-1.25
21.12	20	21.17	0.05	-0.25	0.21	-1.00
23.13	20	23.23	0.10	-0.27	0.41	-1.07
12.53	50	12.78	0.25	N/A	0.98	N/A
21.20	50	21.57	0.37	N/A	1.47	N/A
23.13	50	23.56	0.43	N/A	1.73	N/A
12.52	90	12.85	0.33	0.08	1.31	0.32
20.98	90	21.67	0.69	0.32	2.76	1.29
23.12	90	23.95	0.83	0.39	3.30	1.58

Acceptance criteria met.

Lab book reference : pages 42 to 48

Test – Air Velocity

Standard and clause reference - BS EN 50104:2010, clause 5.4.10

Acceptance criteria - $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater

Note, $\pm 2.5\%$ of measuring range would equate to a variation in error of 0.625% (v/v) of Oxygen

Applied % Oxygen	Orientation	Display, % Oxygen	Display variation, % Oxygen	4 to 20 mA output, calculated % Oxygen	4 to 20 mA variation, % Oxygen	Velocity m/s
20.90	90° to flow	20.8	n/a	20.79	n/a	0.00
20.90	90° to flow	20.8	0.0	20.78	0.00	3.00
20.90	90° to flow	20.8	0.0	20.77	-0.01	0.00
20.90	facing flow	20.8	n/a	20.81	n/a	0.00
20.90	facing flow	20.8	0.0	20.83	0.02	3.00
20.90	facing flow	20.8	0.0	20.81	-0.02	0.00
20.90	away from flow	20.8	n/a	20.81	n/a	0.00
20.90	away from flow	20.8	0.0	20.81	0.00	3.00
20.90	away from flow	20.8	0.0	20.81	0.00	0.00
20.90	90° to flow	20.9	n/a	20.91	n/a	0.00
20.90	90° to flow	20.9	0.0	20.92	0.02	6.00
20.90	90° to flow	20.9	0.0	20.91	-0.01	0.00
20.90	facing flow	20.9	n/a	20.91	n/a	0.00
20.90	facing flow	20.9	0.0	20.93	0.02	6.00
20.90	facing flow	20.9	0.0	20.92	-0.01	0.00
20.90	away from flow	20.9	n/a	20.89	n/a	0.00
20.90	away from flow	20.9	0.0	20.81	-0.08	6.00
20.90	away from flow	20.9	0.0	20.88	0.07	0.00
12.50	90° to flow	12.5	n/a	12.45	n/a	0.00
12.50	90° to flow	12.5	0.0	12.46	0.01	3.00
12.50	90° to flow	12.5	0.0	12.43	-0.03	0.00
12.50	facing flow	12.5	n/a	12.41	n/a	0.00
12.50	facing flow	12.5	0.0	12.41	0.00	3.00
12.50	facing flow	12.5	0.0	12.41	-0.01	0.00
12.50	away from flow	12.5	n/a	12.52	n/a	0.00
12.50	away from flow	12.5	0.0	12.50	-0.01	3.00
12.50	away from flow	12.5	0.0	12.52	0.02	0.00
12.50	90° to flow	12.5	n/a	12.48	n/a	0.00

Applied % Oxygen	Orientation	Display, % Oxygen	Display variation, % Oxygen	4 to 20 mA output, calculated % Oxygen	4 to 20 mA variation, % Oxygen	Velocity m/s
12.50	90° to flow	12.5	0.0	12.48	0.01	6.00
12.50	90° to flow	12.5	0.0	12.49	0.00	0.00
12.50	facing flow	12.5	n/a	12.42	n/a	0.00
12.50	facing flow	12.5	0.0	12.46	0.05	6.00
12.50	facing flow	12.5	0.0	12.41	-0.05	0.00
12.50	away from flow	12.5	n/a	12.50	n/a	0.00
12.50	away from flow	12.5	0.0	12.51	0.00	6.00
12.50	away from flow	12.5	0.0	12.50	0.00	0.00
23.00	90° to flow	23.0	n/a	23.03	n/a	0.00
23.00	90° to flow	23.0	0.0	23.05	0.01	3.00
23.00	90° to flow	23.0	0.0	23.04	-0.01	0.00
23.00	facing flow	23.0	n/a	23.05	n/a	0.00
23.00	facing flow	23.0	0.0	23.04	0.00	3.00
23.00	facing flow	23.0	0.0	23.04	0.00	0.00
23.00	away from flow	23.0	n/a	22.98	n/a	0.00
23.00	away from flow	23.0	0.0	23.00	0.02	3.00
23.00	away from flow	23.0	0.0	22.99	-0.01	0.00
23.00	90° to flow	23.0	n/a	22.98	n/a	0.00
23.00	90° to flow	23.0	0.0	22.97	0.00	6.00
23.00	90° to flow	23.0	0.0	22.97	-0.01	0.00
23.00	facing flow	23.0	n/a	23.03	n/a	0.00
23.00	facing flow	23.0	0.0	23.04	0.01	6.00
23.00	facing flow	23.0	0.0	23.05	0.01	0.00
23.00	away from flow	23.0	n/a	23.01	n/a	0.00
23.00	away from flow	23.0	0.0	23.00	-0.01	6.00
23.00	away from flow	23.0	0.0	23.03	0.03	0.00

Acceptance criteria met.

Lab book reference : pages 49 to 67

Test - Poisons and other gases

Standard and clause reference - BS EN 50104:2010, clause 5.4.23.2

Acceptance criteria - At the beginning and at the end of the application of the carbon dioxide test gas, the deviation of the indication from the initial indication in pure reference air or in pure standard test gas shall not exceed $\pm 0.4\%$ (v/v) of oxygen or $\pm 5\%$ of measuring range whichever is the greater. The change of oxygen volume fraction shall be compensated when determining the deviation.

Note, $\pm 5\%$ of measuring range would equate to a variation of 1.25% (v/v) of Oxygen.

Applied % Oxygen	Display prior to CO ₂ application	4 to 20 mA output, calculated % Oxygen	Display after CO ₂ Application	4 to 20 mA output, calculated % Oxygen	Deviation of indication Display % Oxygen	Deviation of indication 4 to 20 mA,% Oxygen
12.5	12.5	12.48	12.5	12.43	0.0	-0.05
21.0	21.0	21.07	21.0	20.96	0.0	-0.11
23.0	23.0	23.03	22.9	22.94	-0.1	-0.09

Acceptance criteria met.

Lab book reference : pages 68 to 71

Test – Vibration (See Appendix)

Standard and clause reference - BS EN 50104:2010, clause 5.4.13

Acceptance criteria – During the vibration test, the apparatus shall not suffer loss of function and shall not give a false alarm or fault signal. The apparatus shall not suffer damage resulting in a hazard or loss of function.

The variation of the indication in zero test gas or reference air, and standard test gas from that determined prior to the test shall not exceed $\pm 0.2\%$ (v/v) of oxygen or $\pm 2.5\%$ of measuring range whichever is the greater.

Note, $\pm 2.5\%$ of measuring range would equate to a variation in error of 0.625% (v/v) of Oxygen

Applied % Oxygen	Display prior to vibration test	4 to 20 mA output, calculated % Oxygen	Display after vibration test	4 to 20 mA output, calculated % Oxygen	Deviation of indication Display % Oxygen	Deviation of indication 4 to 20 mA,% Oxygen
12.5	12.2	12.15	12.2	12.16	0.0	0.01
Reference air	20.3	20.27	20.3	20.32	0.0	0.05
23.1	22.9	22.93	22.9	22.97	0.0	0.04

Throughout the vibration tests the unit did not give any false alarms or fault signals, or show any signs of damage.

Acceptance criteria met.

Lab book reference : pages 72 to 73

4 UNCERTAINTY

The uncertainty of the concentration of the gas test gas mixtures generated using mixing pumps was ± 1.5 % relative, +1 ppm.

The maximum uncertainty of the concentration of the gas test gas mixture supplied for the pressure test was ± 0.2 % relative.

The uncertainty of the humidity readings was ± 2.5 % RH

The uncertainty of the temperature reading was ± 0.7 °C

The uncertainty of the time measurements was ± 2 seconds

The uncertainty of the pressure measurements was ± 3.2 mbar

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95 %.

The uncertainty evaluation has been carried out in accordance with UKAS requirements.

-- End of Test Report --

Appendix

Vibration test report (6 pages)

Carried out by carried out by TRW Limited (trading as Conekt)



0332

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Test Report No. 70574A

Sinusoidal Vibration Testing of Xgard IQ Gas Detectors.

Summary:

The Xgard IQ Gas Detectors completed the required sinusoidal vibration test. On completion of the test a visual inspection showed no apparent signs of damage or deterioration to the Xgard IQ Gas Detectors.
The Xgard IQ Gas Detectors were returned to CSA Group.

Date: 26th June 2018

Author:

..... **R Guryn - Senior Engineer**

Authorised:

..... **G Morgan - Technical Specialist**

The results described in this report are applicable to the samples examined and should not necessarily be taken as representative of a larger sample distribution.

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1. Introduction

Distribution: Mr. Joe Prince

Customer: CSA Group

Address: Unit 6, Hawarden Industrial Park
Hawarden
CH5 3US

Order Number: Proforma Number 489

Objectives: To subject the Xgard IQ Gas Detectors to Sinusoidal Vibration Testing..

2. Samples/Test Items

Job Number(s): 70574

Date Received: 7th June 2018

Identification: Test units identified as shown in Table 1:

Unit Description	Identification Number	
Xgard IQ Gas Detector	498557 / 01 - 006	#24
Xgard IQ Gas Detector	498557 / 01 - 007	#22
Xgard IQ Gas Detector	498557 / 01 - 008	#23
Xgard IQ Gas Detector	498557 / 01 - 010	#29

Table 1: Unit Identification

3. Test Details

Quote/Test Plan Number: 70574-1

Preparation: Visual inspection performed prior to the test.

Specifications: Sinusoidal vibration testing as per CSA supplied extract from EN50104:2010 section 5.4.13.2.2 Procedure 1 and EN45544 section 5.4.4.1.2.2
Testing in general accordance with BSEN60068-2-6: 2008.

Date of Test/Investigation: 7th - 8th June 2018

Equipment:

Equipment	Manufacturer	Identification No	Calibration Due Date
Vibrator (V2664)	LDS	D0005	16/11/2018
Vibration Controller	Data Physics	D0051	15/05/2019
Charge Amplifier	LDS	D0402	18/12/2018
Accelerometer	Brüel & Kjær	D0975	11/04/2019
Accelerometer	Brüel & Kjær	D0976	11/04/2019
Torque Wrench	Norbar	D0149	CBU
Torque Wrench	Torque Leader	D0089	CBU
Torque Calibrator	Norbar	D0092	24/09/2018
Cubic Fixture	Conekt	D0597	Not Required

Table 2: Conekt Test Equipment

Equipment	Manufacturer	Asset No
PSU (1)	Tti	11910
PSU (2)	Tti	11916
Multimeter	Fluke	11953
Multimeter	Fluke	11924
Resistor	-	50243

Table 3: CSA Group Test Equipment

Procedure:

The Xgard IQ Gas Detector units were mounted on to a cubic fixture using M6 screws tightened to a torque of 16 Nm. The fixture was mounted on to the vibration shaker using M8 screws tightened to a torque of 30 Nm. Testing was carried out in 2 batches. A single unit in batch 1 was tested to EN50104:2010 (see Table 4). A further 3 off units were tested together in batch 2 to EN45544 (see Table 5). The units were rotated around the cubic fixture for the required orientations (see Figure 1 and 2)

The sequence of testing is shown in Table 5

Throughout the sinusoidal vibration testing the Xgard IQ Gas Detectors were powered and monitored by CSA Group.

Testing was carried out at ambient temperature.

Figures 1 and 2 show the test arrangement.

Sinusoidal Vibration to EN50104:2010	
10 - 30 Hz	1.0 mm Peak to Peak
31 - 150 Hz	19.6 m/s ² peak
Sweep Rate	10 Hz / min
Duration	1 hour per plane
Control Method	Average of 2 points

Table 4: Sinusoidal Vibration Test Profile

Sinusoidal Vibration to EN45544	
10 - 31.5 Hz	1.0 mm Peak to Peak
31.5 - 150 Hz	19.6 m/s ² peak
Sweep Rate	0.5 Octave per minute
Duration	1 hour per plane
Control Method	Average of 2 points

Table 5: Sinusoidal Vibration Test Profile

Axis	Unit	Sinusoidal Vibration Test Profile	Run No.
Y	498557 / 01 - 007	EN50104:2010	1
X	498557 / 01 - 007	EN50104:2010	2
Z	498557 / 01 - 007	EN50104:2010	3
Z	498557 / 01 - 008	EN45544	1
X	498557 / 01 - 006	EN45544	1
Y	498557 / 01 - 010	EN45544	1
Y	498557 / 01 - 008	EN45544	2
Z	498557 / 01 - 006	EN45544	2
X	498557 / 01 - 010	EN45544	2
X	498557 / 01 - 008	EN45544	3
Y	498557 / 01 - 006	EN45544	3
Z	498557 / 01 - 010	EN45544	3

Table 6. Sequence of Testing.

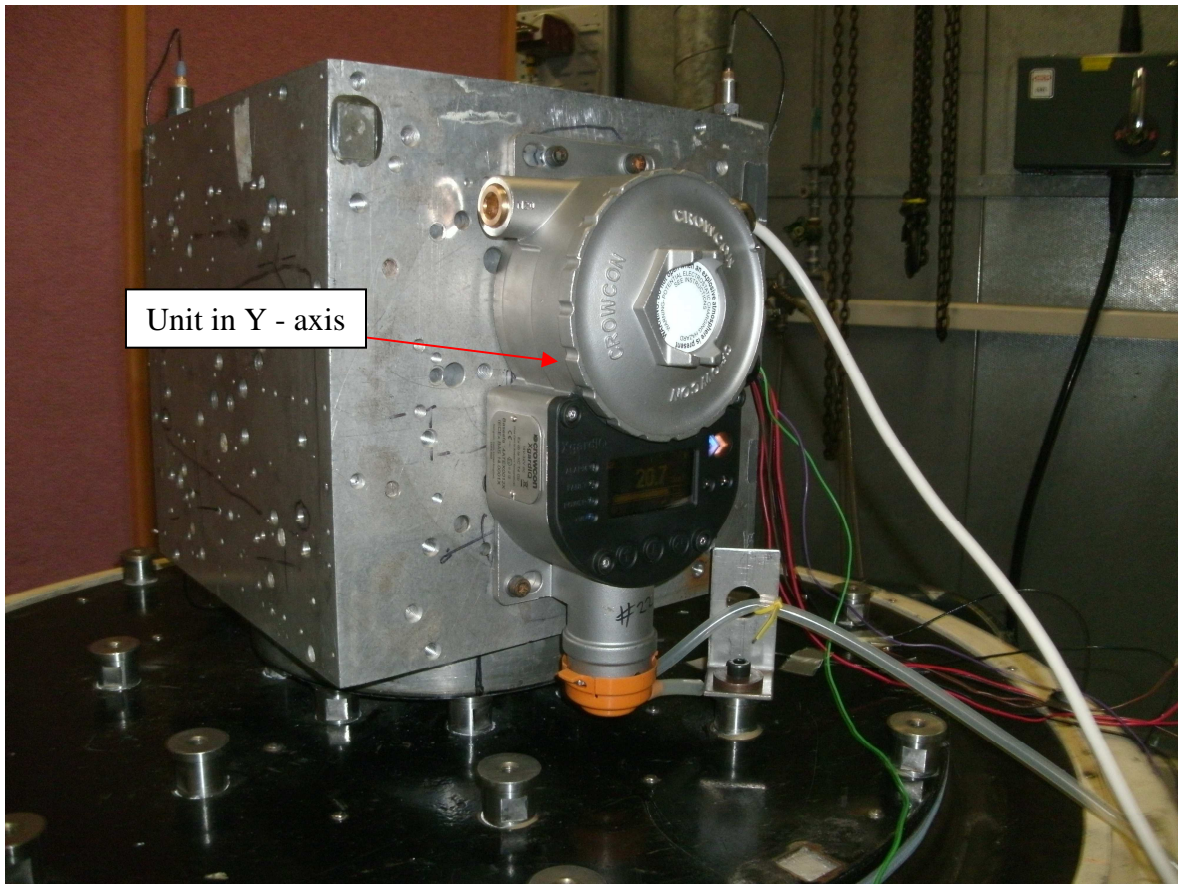


Figure 1: Xgard IQ Gas Detector (ID No. 498557 / 01 - 007) mounted in the Y Axis (Batch 1)

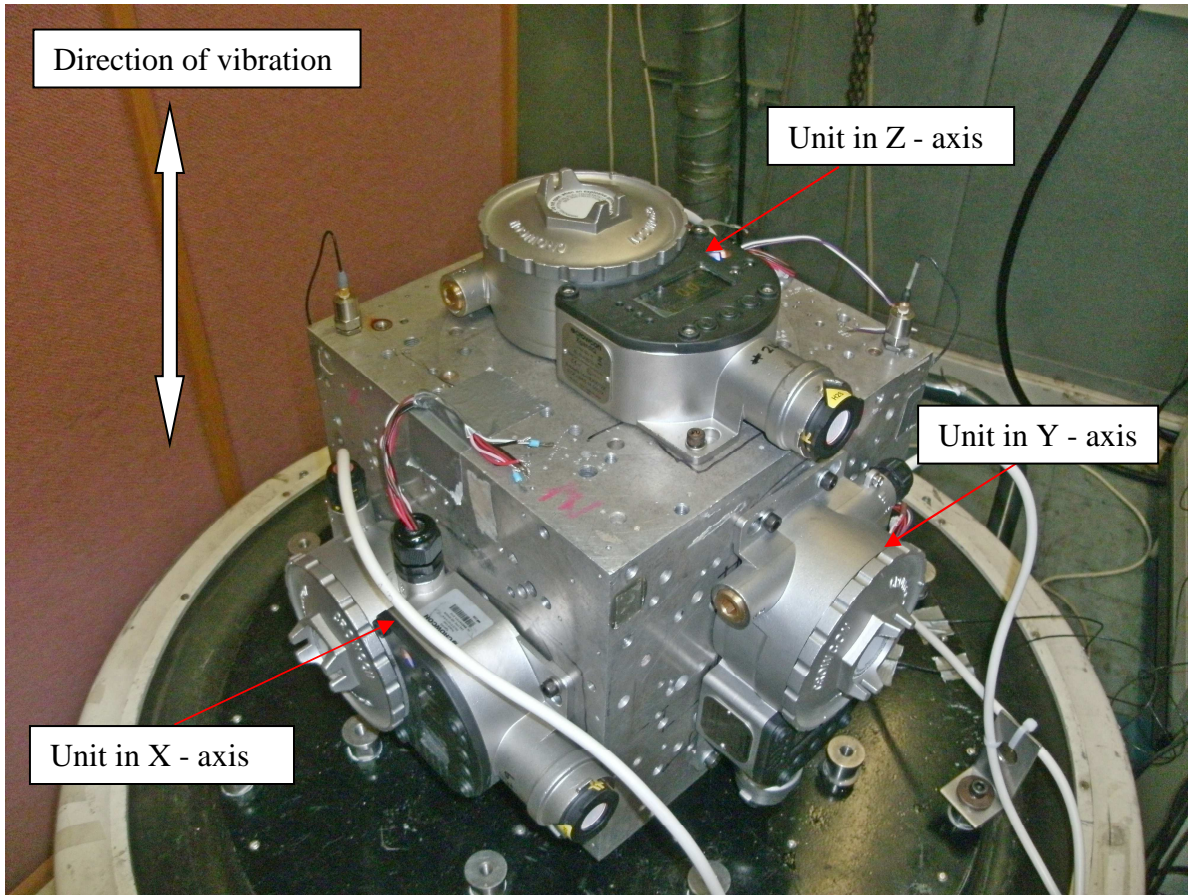


Figure 2: Xgard IQ Gas Detectors setup (Batch 2)

Measurement Uncertainty:

	Uncertainty of Measurement
Acceleration	± 5.2%
Frequency	± 1.3%
Time	± 1.0%

Table 6: Measurement Uncertainty

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, which provides a level of confidence of approximately 95%.

It has been assumed that the uncertainty is calculated at ambient temperature.

Results

The Xgard IQ Gas Detectors completed the required sinusoidal vibration testing.

On completion of the test a visual inspection showed no apparent signs of damage or deterioration to the Xgard IQ Gas Detectors.

The Xgard IQ Gas Detectors were returned to CSA Group.

Figure 3 shows the actual control plot from the Sinusoidal Vibration test (EN50104:2010)

Figure 4 shows the actual control plot from the Sinusoidal Vibration test (EN45544)

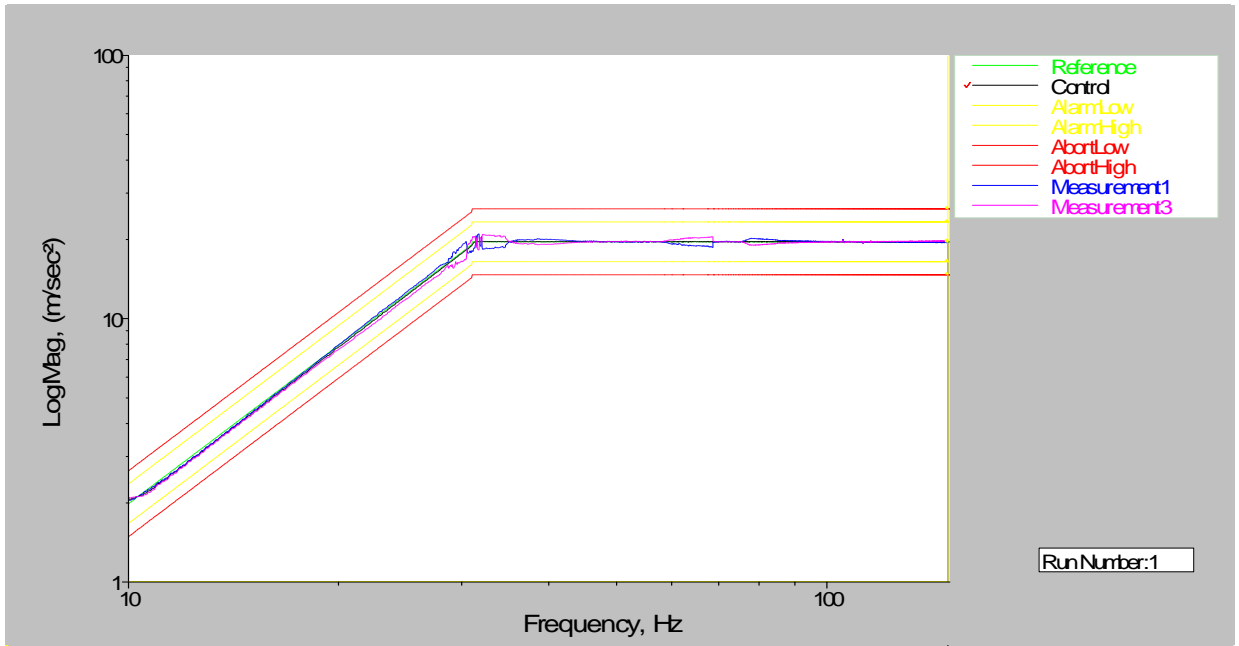


Figure 3: Control plot from Sinusoidal Vibration test (EN50104:2010)

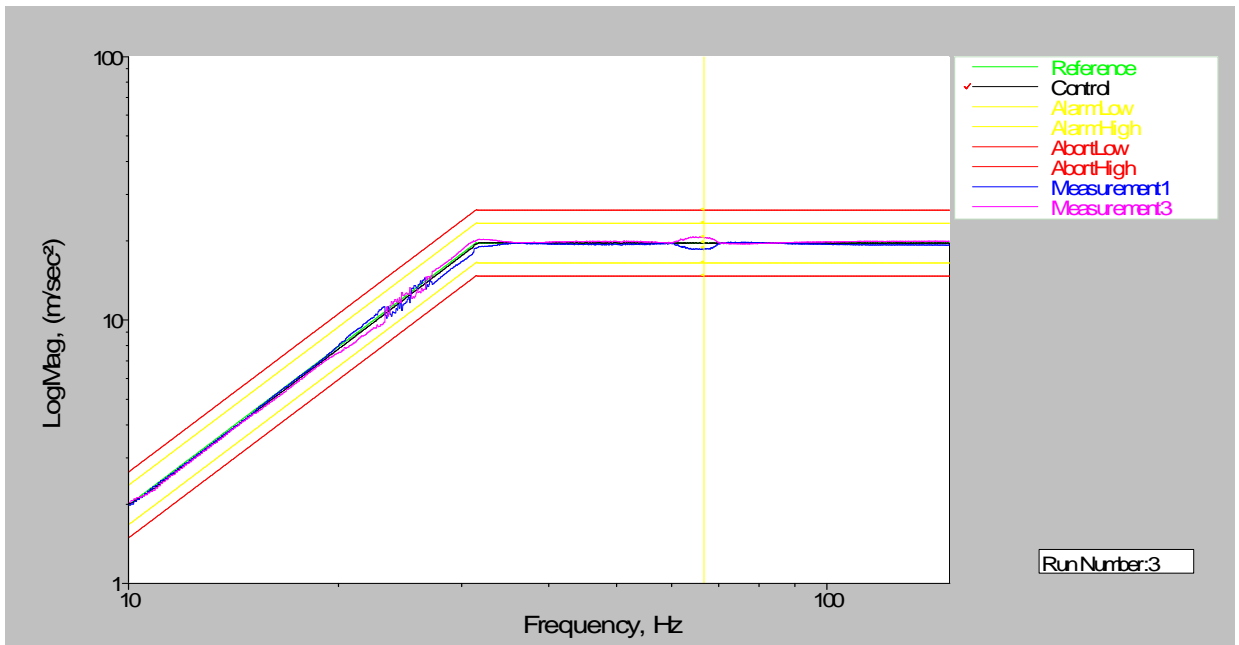


Figure 4: Control plot from the Sinusoidal Vibration test (EN45544)

— End of Report —