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FLAME DETECTOR PERFORMANCE TESTING

FINAL REPORT

Consisting of 15 Pages

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1.0 INTRODUCTION

The objective of this program was to determine the ability of flame detectors submitted by Sense-WARE Fire and Gas Detection BV, to detect flames from the following fuels: Silane, Hydrogen, Methane, Propane, and IPA. Detectors were exposed to either a burner or pan fire depending on the test fuel. For each fuel and detector type, the maximum distance was determined for which the detectors alarmed within 10 s of being exposed to the flames. Tests were performed in triplicate. The results presented in this report apply only to the materials tested, in the manner tested, and not to any similar materials or material combinations.

2.0 FACILITY

All setup and testing were performed at Southwest Research Institute's (SwRI's) Fire Technology Department, located in San Antonio, Texas. The test facility selected for this evaluation consists of a 40 × 60 ft building with a ceiling height of 40 ft. The building has a concrete floor, metal roof, and metal siding and is exhausted to a pollution abatement system. The test fire was located in the northwest corner of the test building. Testing was performed along the diagonal length of the building, with a maximum distance of 59 ft (18 m) between the detectors and the center of the test fire.

3.0 TEST FIRE

The following test fuels used for this evaluation were: Silane, Hydrogen, Methane, Propane, and IPA. Property details for each fuel are provided below in Table 1.

Table 1. Fuel Properties.

Name	Silane	Hydrogen	Methane	Propane	IPA
CAS No.	7803-62-5	133-74-0	74-82-8	74-98-6	67-63-0
Chemical Formula	SiH ₄	H ₂	CH ₄	C ₃ H ₈	C ₃ H ₈ O
Molecular Weight	32.12 g/mol	1.01 g/mol	16.04 g/mol	44.1 g/mol	60.10 g/mol
Boiling Point	-112 °C	-253 °C	-162 °C	-42 °C	80.37 °C
Melting Point	-185 °C	-259 °C	182 °C	-188 °C	89 °C
Flammability Limits	1.4% 96%	4% 74%	5% 15%	2.2% 9.6%	2%....12.7%
Safety Concerns	Highly Flammable, Toxic	Flammable	Flammable	Flammable	Highly Flammable

Three different setups were used in this testing series. For the IPA fire, a 1 ft³ carbon steel pan containing IPA was used. For hydrogen, methane, and propane, a 1 ft³ sand burner was used. A 1-in. pipe was used to conduct testing for silane gas. The setups were chosen and/or adjusted to give the required plume size as specified in Table 2 below. All the fuel sources were placed at the back of the test building to maximize the distance to the detector.

Table 2. Plume Size.

Fuel	Detector Type	Fire Plume Size (Height × Diameter)
Silane	UV/ IR	50 × 20 cm
Hydrogen	UV/ IR	75 × 25 cm
IPA	UV/ IR	30.5 × 30.5 cm (pan size)
	IR3	30.5 × 30.5 cm (pan size)
Methane	UV/ IR	75 × 25 cm
	IR3	75 × 25 cm
Propane	UV/ IR	75 × 25 cm
	IR3	75 × 25 cm

4.0 TEST SAMPLES

SwRI received four detectors on November 22, 2022, from Sense-WARE Fire and Gas Detection BV. Two sensors were identified as *IR3-109/ICZ* and two as *UV/IR-210/ICZ*. Also provided were the associated power supplies (alarm signal outputs), and mounting hardware for testing. The detectors were installed into a holder which was mounted on top of a cart which allowed the distance to be changed quickly. The internal hardware of the detector that was tested had the following information:

- Sense-Ware Model: 22122180 IR3 Module
- Sense-Ware Model: 22122181 IR3 Module
- Sense-Ware Model: 22121613 UV/IR Module
- Sense-Ware Model: 22121614 UV/IR Module



Figure 1. Test Samples.

5.0 TEST PROCEDURE

IPA was used in a 12 × 12 in. (L × W) fire pan. The pan was filled with IPA such that the flame plume was the requested size as shown in Table 2. The location of the fire pan was adjusted so that the center of the fire plume is at the same height as the flame detectors.

Hydrogen, methane, propane, and silane were all provided from a respective compressed gas cylinder equipped with a regulator. For hydrogen, methane, and propane the gas line ran from the regulator out a 1 in. pipe into a 12 × 12 in. (L × W) sand burner. For silane, the gas line ran from the regulator out a 1 in. pipe oriented upward. Gas flow was controlled to give the required plum height as shown in Table 2.

The flame detectors were setup on a mobile cart, positioned so that they viewed the test flame directly (on axis view angle). A piece of cardboard was used as a radiant shield for the detector and was removed at the beginning and replaced at the end of each test run. Table 3 below describes the starting distances for each fuel type by detector type.

Table 3. Test Matrix (All on Axis).

Fuel	Detector Type	Initial Distance
Silane	UV/ IR	9.8 ft (3 m)
Hydrogen	UV/ IR	32.8 ft (10 m)
IPA	UV/ IR	59 ft (18 m)
	IR3	59 ft (18 m)
Methane	UV/ IR	39.4 ft (12 m)
	IR3	49.2 ft (15 m)
Propane	UV/ IR	39.4 ft (12 m)
	IR3	49.2 ft (15 m)

Testing began at the distances provided above. If the detector failed to see the flame, the detector was moved towards the fire in 0.5 m (1.6 ft) increments, until the detector responded in less than 10 s. If the detector responded to the flame, then the detector was moved away from the flame in 0.5 m (1.6 ft) increments until it failed to see the flame in less than 10 s. The following general test procedure was followed:

1. Detector and equipment moved to appropriate location and adjusted to point directly at the test flame.
2. Detector covered with cardboard shield.
3. Fire ignited
4. Fire allowed to stabilize for at least 30 s.
5. SwRI data acquisition system started.
6. Detector uncovered.
7. Response time recorded by SwRI DAQ.
8. Shield replaced.
9. Repeat Steps 5-8 until tested three times in that location.
10. Move detectors to next location and repeat Steps 1-9 until the maximum distance is determined at which the detectors respond within 10 s.
11. Repeat Steps 1-10 for each fuel.

6.0 RESULTS

SwRI's Fire Technology Department performed testing of Sense-WARE Fire and Gas Detection BV on December 13-16, 2022, in San Antonio, Texas. Tables 4 – 9 provide the response times for the test runs. Bolded lines are the distance that the detector alarmed within the response time specified by the client and in triplicate. Photographic documentation can be found in Appendix A. Equipment calibration documentation is provided in Appendix B.

Table 4. Summary of Test Results.

Fuel	Detector Type	Maximum Distance With Detection ≤ 10 s
Silane	UV/ IR	3 m
Hydrogen	UV/ IR	9 m
IPA	UV/ IR	14.5 m
	IR3	18 m
Methane	UV/ IR	11.5 m
	IR3	18 m
Propane	UV/ IR	14 m
	IR3	18 m

Table 5. Test Results for Silane.

Distance (m)	Response Time (s)	
	UV/ IR (SN: 22121613)	UV/ IR (SN: 22121614)
3	8.62	9.52
3	8.96	9.09
3	10.63	8.94
10	9.65	10.4
10	12.42	ND
10	11.58	11.64
10	ND	11.58
10	ND	ND
10.5	8.82	10.47
10.5	10.45	10.54
10.5	9.02	14.64
10.5	13.32	ND
11	ND	ND
11	9.58	12.52
11	8.75	11.21
11	ND	14.98
11.5	ND	ND
11.5	ND	ND
11.5	ND	13.61

ND: No detection or did not detect within 15 s.

Table 6. Test Results for Hydrogen.

Distance (m)	Response Time (s)	
	UV/ IR (SN: 22121613)	UV/ IR (SN: 22121614)
8	10.59	11.14
8.5	9.61	9.86
8.5	10.34	9.78
8.5	10.12	10.68
9	9.71	9.91
9	9.79	9.59
9	9.78	10.08
9.5	9.61	9.67
9.5	10.01	10.24
9.5	10.29	10.22
10	10.21	10.29
10	10.52	10.14
10	9.88	10.52
15	11.29	10.86
17.5	9.87	11.14
17.5	10.63	10.69
17.5	11.96	12.06
18	12.4	14.97
18	ND	11.97
18	11.5	12.82

ND: No detection or did not detect within 15 s.

Table 7. Test Results for IPA.

Distance (m)	Response Time (s)			
	IR3 (SN: 22122180)	IR3 (SN: 22122181)	UV/ IR (SN: 22121613)	UV/ IR (SN: 22121614)
14	1.86	2.8	1.85	0.51
14	7.37	5.66	5.65	1.28
14	0.89	0.55	1.73	2.48
14	8.8	8.71	10.26	10.53
14	8.11	8.01	8.83	9.25
14	7.98	7.73	7.89	8.04
14.5	7.98	7.95	ND	9.04
14.5	9.28	9.19	ND	10.38
14.5	8.32	8.2	9.66	10.24
14.5	0.47	1.55	9.59	5.89
14.5	1.5	1.02	7.91	4.62
14.5	0.46	1.3	6.94	5.35
14.5	1.09	0.43	ND	1.36
15	1.32	1.11	ND	3.48
15	1.21	0.87	ND	2.93
15	8.19	8.36	ND	ND
15	7.81	7.88	ND	ND
15	8.07	8.01	ND	ND
15.5	0.72	0.63	ND	ND
16	1.33	1.3	ND	6.65
16.5	0.75	0.74	ND	ND
17	0.42	0.57	ND	ND
17.5	0.12	0.21	ND	ND
18	50.8*	50.84*	ND	ND
18	0.5	0.53	ND	ND
18	0.29	0.43	ND	ND

ND: No detection or did not detect within 15 s.

Table 8. Test Results for Methane.

Distance (m)	Response Time (s)			
	IR3 (SN: 22122180)	IR3 (SN: 22122181)	UV/ IR (SN: 22121613)	UV/ IR (SN: 22121614)
11.5	7.86	8.11	9.13	8.27
11.5	7.39	7.64	8.52	8.84
11.5	8	8.34	7.17	7.7
12	7.85	8.53	10.12	7.95
12	8.4	8.74	ND	12.39
12	8.53	7.65	10.08	9.43
12.5	8.65	8.16	ND	ND
12.5	7.93	8.57	ND	12.95
12.5	8.03	8.68	ND	13.34
13	8.12	7.58	ND	ND
13	9.67	7.91	ND	ND
13	7.83	8.72	ND	9.83
13.5	7.75	7.18	ND	ND
13.5	7.74	8.55	ND	ND
13.5	7.81	7.47	ND	ND
14	8.41	7.99	ND	ND
14	8.66	8.23	ND	ND
14	7.92	8.74	ND	ND
14.5	7.4	8.39	ND	ND
14.5	8.66	8.23	ND	ND
14.5	8.83	8.66	ND	ND
15	8.21	8.17	ND	ND
15	8.04	7.95	ND	ND
15	8.18	8.02	ND	ND
15.5	8.45	8.43	ND	ND
15.5	8.05	8.08	ND	ND
15.5	8.71	8.69	ND	ND
16	7.83	7.94	ND	ND
16	7.69	7.78	ND	ND
16	8.31	8.36	ND	ND
16.5	8.33	8.54	ND	ND
16.5	8.1	8.36	ND	ND
16.5	7.8	8.07	ND	ND
17	8.7	7.81	ND	ND
17	7.66	8.01	ND	ND
17	8.81	9.21	ND	ND
17.5	7.16	7.65	ND	ND
17.5	8.61	7.88	ND	ND
17.5	7.92	8.28	ND	ND
18	8.61	8.18	ND	ND
18	7.3	8.15	ND	ND
18	8.62	7.95	ND	ND

ND: No detection or did not detect within 15 s.

Table 9. Test Results for Propane.

Distance (m)	Response Time (s)			
	IR3 (SN: 22122180)	IR3 (SN: 22122181)	UV/ IR (SN: 22121613)	UV/ IR (SN: 22121614)
14	8.45	7.93	7.55	9.82
14	8.28	7.8	7.94	7.44
14	8.27	7.88	8.42	7.33
14.5	8.8	8.02	10.97	7.67
14.5	8.9	8.13	ND	9.22
14.5	8.71	8.07	7.84	10.91
15	8.55	7.73	ND	11.86
15	8.16	7.5	9.13	8.69
15	8.61	7.86	ND	ND
15.5	7.64	7.49	ND	ND
15.5	8.62	8.39	ND	ND
15.5	7.86	7.65	11.85	ND
16	8.03	7.76	ND	ND
16	7.78	7.65	9.91	8.02
16	8.57	8.69	ND	ND
16.5	8.46	8.41	ND	ND
16.5	7.76	7.74	ND	ND
16.5	8.46	8.46	ND	ND
17	8.05	7.99	ND	ND
17	8.47	8.32	ND	ND
17	8.85	7.56	ND	ND
17.5	8.3	8.34	ND	ND
17.5	8.69	8.81	ND	ND
17.5	8.83	8.98	ND	ND
18	8.2	8.54	ND	ND
18	8.8	7.76	ND	ND
18	7.51	7.73	ND	ND

ND: No detection or did not detect within 15 s.

APPENDIX A
PHOTOGRAPHIC DOCUMENTATION
(CONSISTING OF 3 PAGES)



Figure A-1. IPA Fire Source Setup.



Figure A-2. Hydrogen, Methane, Propane Fire Source Setup.



Figure A-3. Silane Fire Source Setup.



Figure A-4. Detector Samples (As Received).



Figure A-5. Tested Detectors.

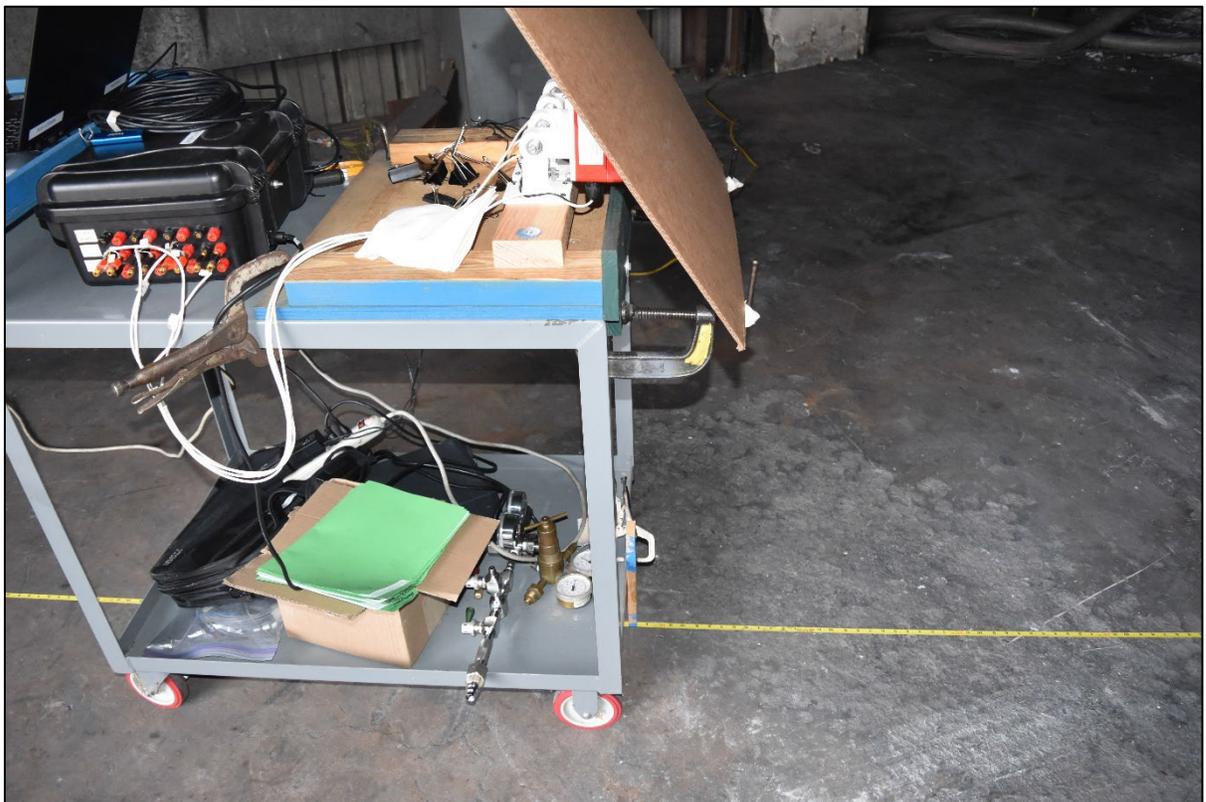


Figure A-6. Flame Detector Setup with Radiant Shield in Place.

APPENDIX B
EQUIPMENT CALIBRATION DOCUMENTATION
(CONSISTING OF 1 PAGE)

Table B-1. Calibration Documentation.

Item	Manufacturer	Model	Serial No.	Calibration Due*
DAQ DC Voltage Input Module (Detector Alarm)	National Instrument	NI 9213	1F583F1	05/11/2023
Tape Measure – 300 ft (Detector Distance)	Stanley	34-762	N/A	N/A

*Annual Calibration Cycles