



Video Image Detection and Optical Flame Detection for Industrial Applications

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Objective

Evaluate flame detection technologies:

- Comparative study of performance
- Challenging fire scenarios
- Nuisance source rejection





Approach

- Experimentally test detectors
 - Multiple Viewing Distances and Angles
 - Multiple Fuels
 - Different Fire Configurations
 - Multiple Optical Obstructions
 - Nuisance/Interference Sources

Test Setup

- Indoor laboratory
- Detectors at 25 ft. and 50 ft. from fires at a height of 10 ft.
- Detectors on-axis and 45° off-axis alignments
- Instrumented hood for fire heat release rate
- Uniform background behind test fires



Detection Systems

ID	Type
OFD-A	Multi-spectrum IR
OFD-B	Multi-spectrum IR
OFD-C	Multi-spectrum IR
OFD-UV	UV
VID-A	VID (older model)
VID-B	VID (new model)

The devices have reported specifications of being able to alarm to a 0.3 x 0.3 m (1 x 1 ft) n-heptane pan fire within 5 seconds at distances ranging from 15 m (50 ft) to 61 m (200 ft)





Open Pool Fires

1 ft² pan at a height of 2 ft.



n-Heptane Pool
(72 kW)



Diesel Pool
(48 kW)



Lube Oil Pool
(37 kW)

Open Gas Jet Fires

Natural Gas and Propane

Natural Gas Fires (~40 kW)



Vertical



Perpendicular
horizontal



Parallel
horizontal

Open Lubricant Oil Spray Fires (48 kW)



Vertical



Perpendicular horizontal



Parallel
horizontal



Small Open Fire Results

- All multi-spectrum IR not equal
 - Pools: 40% to 100% detection
 - Gas jets: 25% to 100% detection
 - Lube oil sprays: 11% to 100% detection
- Natural gas and lube oil spray fires generally most difficult
 - Lube sprays: VID no device greater than 56%.



Small Open Fire Detection Results

		All small open fires (31 tests)
Devices	Viewing Condition	Alarm Time (sec) (Alarm %)
OFD-A	50 ft on-axis	13 (77%)
	50 ft off-axis	46 (106%)
	25 ft on-axis	12 (100%)
	25 ft off-axis	21 (100%)
OFD-B	50 ft on-axis	13 (100%)
	50 ft off-axis	26 (100%)
	25 ft on-axis	12 (100%)
	25 ft off-axis	12 (100%)
OFD-UV	50 ft on-axis	16 (100%)
	50 ft off-axis	21 (89%)
	25 ft on-axis	7 (100%)
	25 ft off-axis	8 (100%)
OFD-C	50 ft on-axis	21 (100%)
	50 ft off-axis	82 (104%)
	25 ft on-axis	22 (97%)
	25 ft off-axis	20 (100%)
VID-A	50 ft on-axis	27 (48%)
	50 ft off-axis	62 (42%)
	25 ft on-axis	26 (81%)
	25 ft off-axis	42 (77%)
VID-B	50 ft on-axis	30 (71%)
	50 ft off-axis	37 (58%)
	25 ft on-axis	26 (87%)
	25 ft off-axis	28 (55%)

Larger Instantaneous Fire Events



Propane Line Burner
(248 kW peak)

n-Heptane Spray Fire
(612 kW peak)



6 ft
(1.8 m)



Large Fire Observations

- Propane: 100% detection except:
 - OFD-C at 25 ft. on-axis – 0%
 - OFD-C at 25 ft. off-axis – 50% (209 s)
 - VID – 0 to 67% for all but one
- n-Heptane:
 - UV: 100% detection (6s)
 - Multi-spectrum IR: 5 not able to detect, 2 reduced performance (33% and 67%)
 - VID: none able to detect
 - **ALL had 100% of SMALL n-HEPTANE POOL**

Impinged Flames

n-Heptane pool

vertical lube oil spray

vertical natural gas jet



horizontal lube
oil spray

natural gas
jet

Impinged Flames



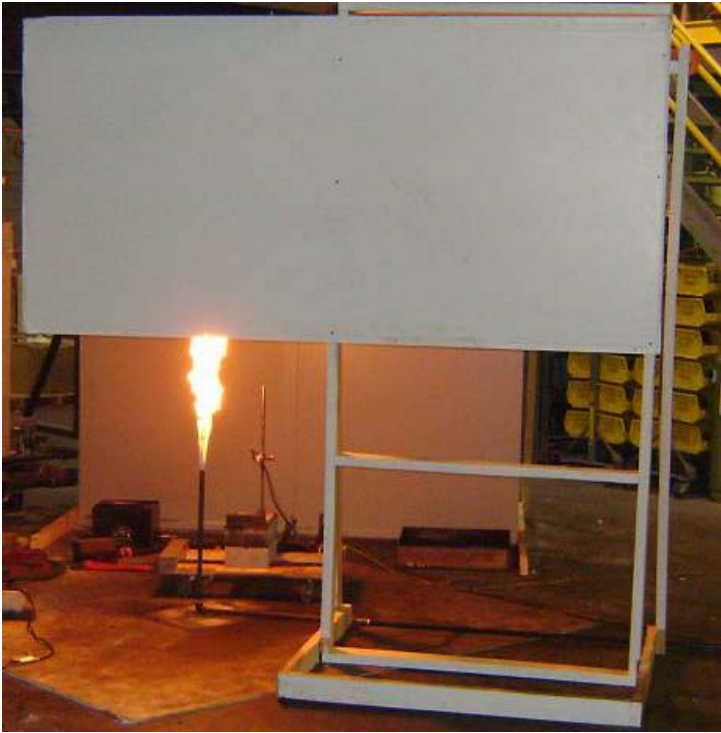
- Fires are different and Detector responses change
- Generally slightly lower HRR
 - Except horizontal lube oil spray which ignited oil on the duct and increased size
- Impinged n-Heptane pool detected by all, except
 - 1 VID-A 50 ft. off-axis no alarm 1 of 3 fires
 - 2x to 3x increase in alarm times for all devices

Impinged Flames

- UV unaffected except for some longer alarm times
- Multi-spectrum IR:
 - Majority unaffected
 - Except off-axis at 50 ft for several models
- VID detectors most affected:
 - Reduced detection for gas jet and lube oil spray impinged fires
 - Many cases 100% to 0 %



Obstructed Fires



Vertical Natural Gas Jet

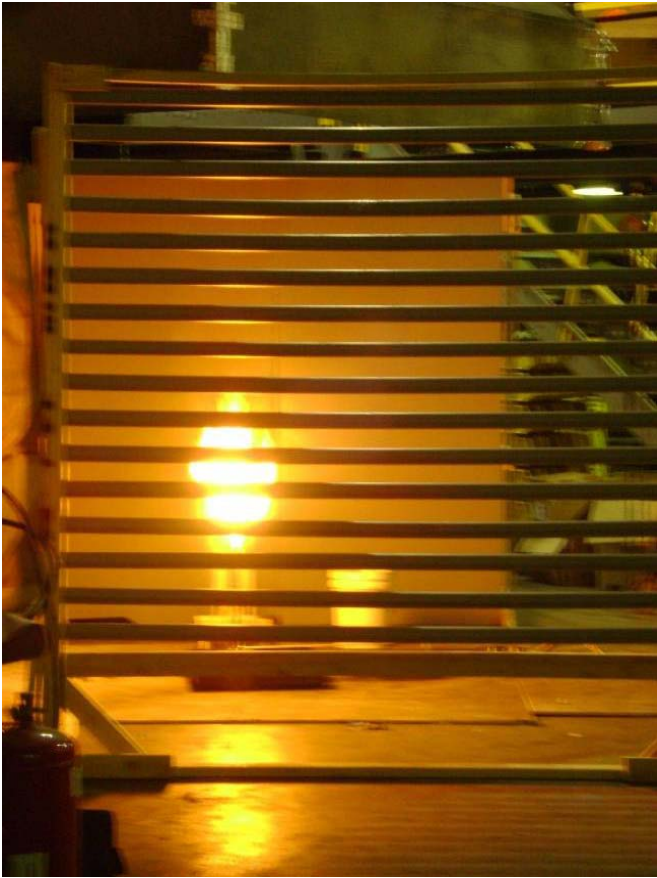


Vertical Lube Oil Spray

Obstructed Fires



Vertical Lube Oil Spray



n-Heptane Pool Fire

Obstructed Fires



- UV: detected 100% of obstructed fires
- Multi-spectrum IR:
 - All showed some decrease in detection
 - Particularly at 50 ft (0% to 100%)
- VID:
 - Large impact on performance
 - Horizontal wall and pipes greatest impact
 - 10 of 16 devices never alarmed
 - Best was 46% for VID-B 50 ft. on-axis

Nuisances/Blinding

- Test ability to avoid false alarms
- Test ability to detect flame during simultaneous exposure



Arc welding



Metal grinding
natural gas jets



Metal torch cutting

Nuisances/Blinding



Bright light sources with
natural gas jet flame



300°C hot surface with
n-Heptane pool fire

False Alarm

- Most detectors immune to most nuisance sources
 - No alarms to metal grinding or bright lights
 - OFD-C alarm to the lights during setup
- UV alarm to any spark (welding, cutting, ignition >2s)
- OFD-B and VID-B at 25 ft alarmed to welding (33%)
- OFD-A and OFD-C at 25 ft alarmed to torch cutting (33%)
- OFD-C alarm to blackbody with swinging arm motion





Blinding Effects (Fire with Nuisance Source)

- Overall, little effect on detection performance
- Metal grinding slightly improved performance of OFD-A and OFD-C at 50 ft. off-axis and VID-A
- OFD-C failed to alarm to flame at 25 ft. when bright lights present
- 300°C steel surface affected some devices:
 - Increased alarm times for OFD-A (50 ft. off-axis) and OFD-C (25 ft. on and off-axis)
 - ~30 seconds to 2.5-5 minutes

Conclusions

- Multi-spectrum IR detectors not equal
 - Differ in ability to detect
 - Differ in time to detection
 - Differ in nuisance source/blinding resistance
- Flame impingement and obstructions can substantially reduce performance for some detectors
- Exposure to larger, instantaneous fires proved difficult for several detectors

