



Operating Manual
FL5000 Multi-Spectrum Flame Detector



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Print Spec: 10000005389 (EO)
CR: 800000064609

! WARNING!

These instructions must be provided to users before use of the product and retained for ready reference by the user. Read this manual carefully before using or maintaining the device. The device will perform as designed only if it is used and maintained in accordance with the manufacturer's instructions. Otherwise, it could fail to perform as designed, and persons who rely on this device could sustain serious injury or death.

The warranties made by MSA with respect to the product are voided if the product is not installed and used in accordance with the instructions in this manual. Please protect yourself and your employees by following the instructions.

Please read and observe the WARNINGS and CAUTIONS inside. For additional information relative to use or repair, call 1-800-MSA-2222 during regular working hours.

The Declaration of Conformity can be found under the following link: <https://MSAsafety.com/DoC>.

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General Monitors

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1 Safety Regulations

WARNING!

CORRECT USE

- Do NOT install or operate the device until you read and understand the instructions, warnings and cautions in this manual.
- Repair or alteration of the device beyond the procedures described in the user guide or by anyone other than a person authorized by MSA, could cause the unit to fail to perform properly. Use only genuine MSA replacement parts when performing any maintenance procedures described in the user guide. Substitution of components can seriously impair performance of the unit, alter intrinsic safety characteristics or void agency approvals.
- Repair or alteration of the device beyond the scope of the maintenance instructions in this manual or by anyone other than MSA or MSA-approved service personnel can cause incorrect operation of the device and put persons who use this device for their safety at risk of serious injury or death.

HAZARDOUS ENVIRONMENT

General

- The FL5000 is rated Explosion Proof (XP) for use in hazardous locations.
- Do NOT remove the cover from the device when the device is in operation or in an explosive atmosphere.
- Conduit seals or suitably approved Ex d glands must be used to preserve the explosion proof safety of the FL5000 and help prevent ingress of water or gas from the conduit systems. When Ex d cable glands are utilized, shielded cable must also be used. For Class I, Division I locations, a conduit seal must be installed within 18 inches of the enclosure per NEC regulations.
- For Class I, Division I locations, install a conduit seal within 18 in. (46 cm) of the device enclosure.
- Must be used with the blanking plug supplied with the detector which is suitably certified.
- Use ONLY a damp cloth to clean the device. Otherwise, electrical shock or ignition from ESD can occur.
- Toxic, combustible, and flammable gases and vapors are dangerous. Extreme caution should be used when these hazards are present.
- For dimensional information about flameproof joints, contact MSA.

Specific Conditions of Use (X) / Schedule of Limitations

- The flamepaths of the equipment are not intended to be repaired. Consult the manufacturer if repair of the flamepath joints is necessary.
- The surface of the FL5000 Flame Detector may store electrostatic charge and become a source of ignition in applications with a low relative humidity <~30% relative humidity where the painted surface is relatively free of surface contamination such as dirt, dust, or oil. Cleaning of the painted surface should only be done with a damp cloth.
- Consult the manufacturer for genuine replacement housing to base fasteners. M6x1x25mm Hexagonal Socket head fasteners with a minimum of ISO 4762 Grade A4 Class 70 are acceptable alternatives.

ELECTRICAL SAFETY

- An approved electrician must do electrical wiring.
- All wiring must satisfy the requirements of the applicable National Electrical Code (NEC), Canadian Electrical Code (CEC), and local electrical safety codes.
- Make sure that field connections to the FL5000 are applicable for the location and obey the wiring requirements of the NEC, CEC, and local electrical safety codes.
- The End User shall use supply connection wiring which must be rated 5°C above the maximum service temperature.
- The external earthing connection consists of cable lug with 928-333 stainless steel screw, the terminals are suitable for connection of a wire of at least 4 mm².

- The internal terminals are suitable for connection of a wire equal to or greater than the power input wiring and at a minimum of 1 mm² conductor.
- An End-Of-Line (EOL) resistor with a maximum power dissipation of up to 0.6 W may be fitted in the circuit inside the enclosure.
- The device may only be powered by a power supply unit with a limited energy electric output in accordance with CAN/CSA-C22.2 No. 61010-1-12 / UL Std. No. 61010-1 (3rd Edition) chapter 6.3.1/6.3.2 and 9.4 or class 2 according to CSA 223/UL 1310.
- The FL5000 contains components that can be damaged by static electricity. In order to avoid static electricity, special care must be taken when wiring the system to ensure that only the connection points are touched.

OPERATION

- Do not install or operate a device that is damaged.
- Install the device in a location away from conditions (such as high-pressure steam) where electrostatic charge can collect on nonconducting surfaces. This equipment uses an external nonmetallic coating. If extreme levels of electrostatic charge collect, ignition can occur.
- Make sure that there is no physical blockage from permanent objects such as structures and equipment or temporary objects such as personnel and vehicles in the sensor's field of view. If there is physical blockage in the sensor's field of view, the device cannot accurately monitor the area for flame.
- Make sure that there is no ice, dirt, or debris on the optical window. Blockage of the optical window can result in a Fault condition.
- Keep the device safe from vibration and mechanical shock, which can cause damage.
- Do NOT connect or disconnect equipment when power is supplied to the device. Doing so can result in serious damage to the equipment. The warranty does not apply to equipment that is damaged in this way.
- The device has components that can be damaged by electrostatic discharge (ESD). When you do work with the device wiring, be careful to touch only the connection points. The warranty does not supply coverage for components that are damaged by ESD.
- The CSA Mark applies to process control functions only.
- Through engineering design, testing, manufacturing techniques, and rigid quality control, MSA supplies the finest flame detection systems available. The user must recognize his responsibility for maintaining the flame detection system in operational condition.
- Silicone Room Temperature Vulcanization (RTV) is not an approved moisture barrier. If used, damage to internal components will arise.
- Damage to the FL5000 housing where any internal components or protective seals are broken, compromises the safety and usability of the device. An FL5000 with a damaged or open housing should not be used in a hazardous environment. Such damage includes fractures in the housing, cracks in any internal components, or cracks in the protective seals.

RADIO INFORMATION

Bluetooth

- This product incorporates Bluetooth[®] wireless technology. The Bluetooth word mark and logos are registered trademarks owned by Bluetooth SIG, Inc., and any use of such marks by MSA is under license. Other trademarks and trade names are those of their respective owners.
- The RF radiation power used to activate the RFID tag antenna shall not exceed 6 Watts for EPL Group I applications or 2 Watts for EPL Group IIC applications.

FCC and ISED Notice for US and Canada

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

1 Safety Regulations

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

You are cautioned that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with CAN ICES-003(B) / NMB-003(B) and Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Contains Transmitter Module FCC ID: T7V1780 and IC: 216Q-1780

European Conformity According to RED (2014/53/EU)

Radio Equipment meets the requirements of the Radio Equipment Directive 2014/53/EU and the UK Radio Equipment Regulations 2017 No. 1206, as amended.

| Radio | Power | Frequency |
|-----------|-----------|------------------------|
| Bluetooth | ≤ 8.0 dBm | 2.400 GHz - 2.4835 GHz |

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20 cm from all persons.

Failure to follow these warnings can result in serious personal injury or death.

CAUTION!

- Keep cover tight while circuits are alive.
- Do not open when an explosive atmosphere is present.

Failure to follow these cautions can result in minor or moderate injury.

2 Quick Start Instructions

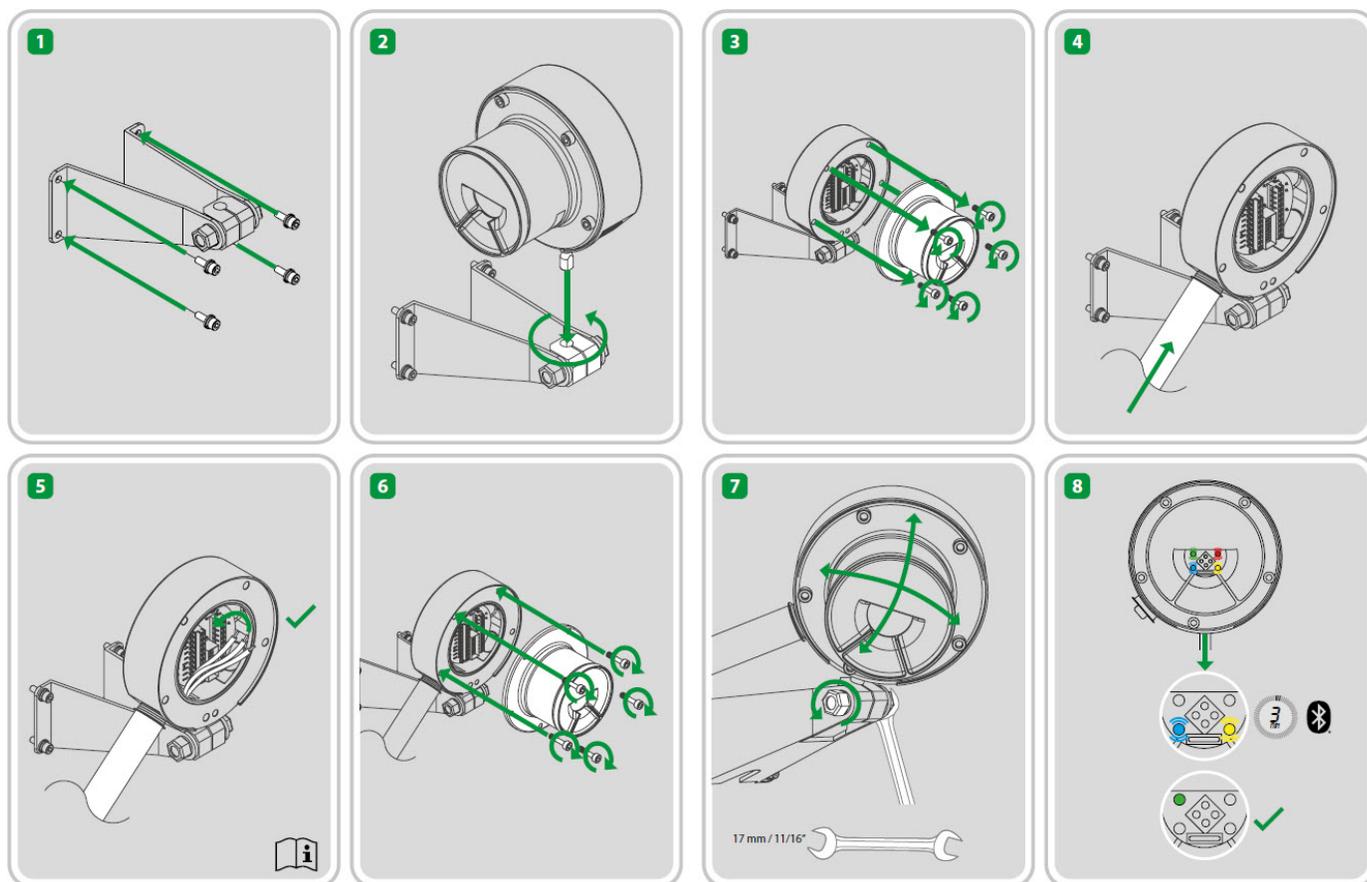


Figure 1 FL5000 Quick Start Insert

1. Electrical Connection

- a. Loosen the captive screws (A) located on the Optical Housing Assembly.
- b. Pull the Optical Housing Assembly from the Base Housing Assembly to separate, gently rocking from side to side if necessary to loosen the connector's grip.
- c. Wire the unit to the site-wiring.
- d. Fit the Optical Housing Assembly to the Base Housing Assembly.
- e. Tighten the captive screws (A) located on the Optical Housing Assembly.

NOTICE

Do not unscrew the field wiring board from the base housing assembly for wiring.

2. Mounting

- a. Choose a location for mounting, ensuring that all proper requirements for safety and use are met. See [5.4 Detector Mounting and Installation](#) for a list of mounting location concerns/warnings.
- b. Assemble the bracket by connecting the center clamp bit to the bracket with the included screw, washer and nut set.
- c. Attach the Detector as shown in [Figure 2](#) below.

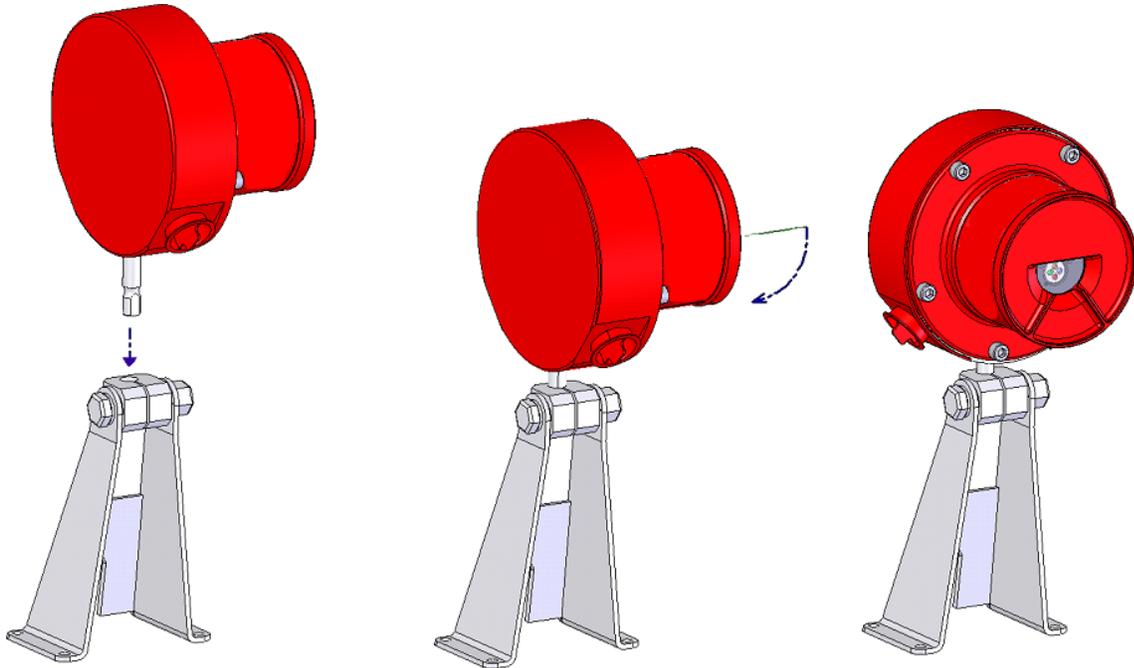


Figure 2 Mounting Instruction

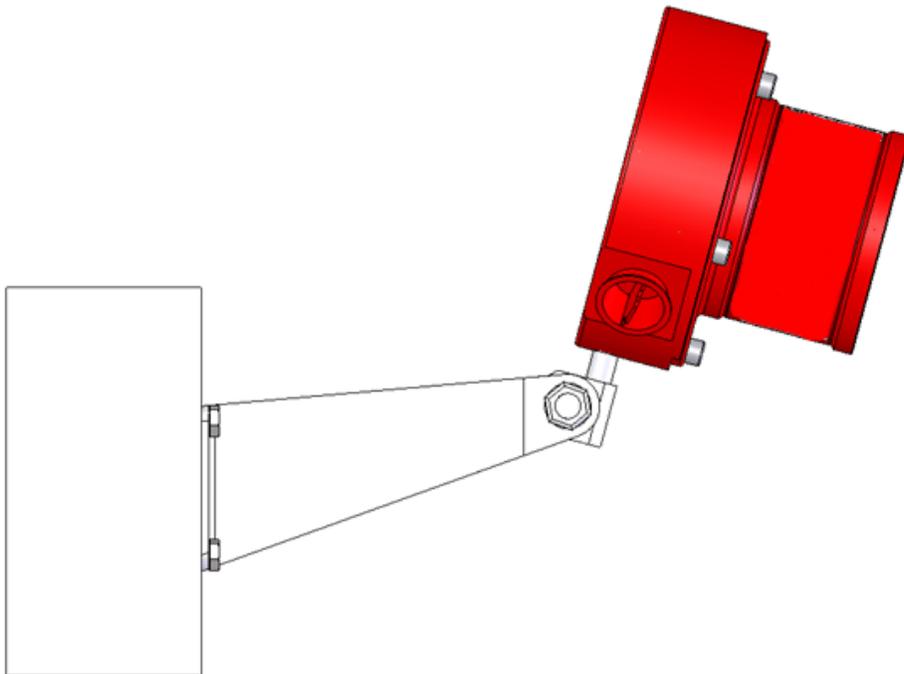


Figure 3 Wall Mounting Assembly

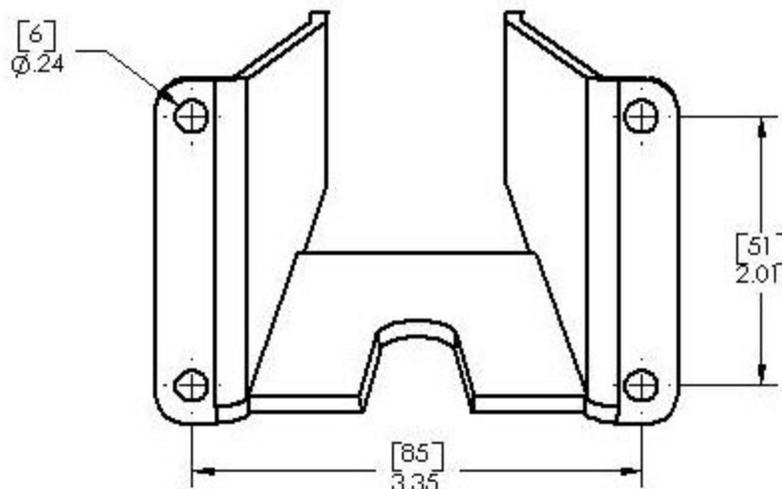


Figure 4 Bracket Assembly

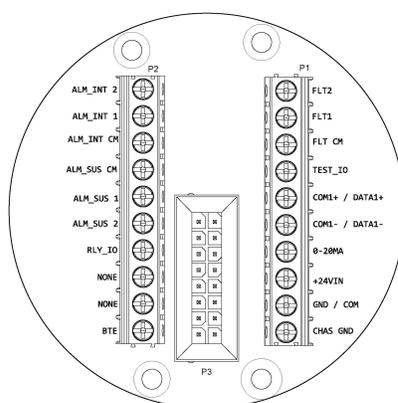


Figure 5 Field Terminations

3. Power

- a. Ensure that all wiring is correct and unit is safe to power up.
- b. Connect unit to a 24 VDC power source.
- c. The unit will go through a power up delay of approximately 15 seconds. This includes LED activity. See [5.8 Powering the FL5000](#) for additional information.
- d. Upon completion, Bluetooth will be activated. If a device is not connected or once a device is disconnected from the FL5000, the Bluetooth activated state will time out within 3 minutes and revert to flame detection mode. See [3.3 Bluetooth Connectivity](#) for details and LEDs confirming mode changes.

CAUTION!

While Bluetooth mode is active, the FL5000 cannot perform its safety function.

NOTE: If Bluetooth isn't needed, refer to [3.3 Bluetooth Connectivity](#) for steps to disable Bluetooth via DIP switch. This will enable the unit to skip the Bluetooth activation phase on start up.

3 Device Overview

The FL5000 is a Multi-Spectrum Flame Detector. The FL5000 employs state-of-the-art infrared (IR) detectors and an advanced flame detection algorithm leveraging a sophisticated artificial neural network (ANN) based signal processing to produce a system that is highly immune to false alarms caused by lightning, sunlight reflection, arc-welding, hot objects, and other sources of radiation. In addition, the FL5000 can see through most smoky type fires.

The FL5000 is certified as explosion proof for use in hazardous locations. It can also be used for general-purpose, non-hazardous applications.

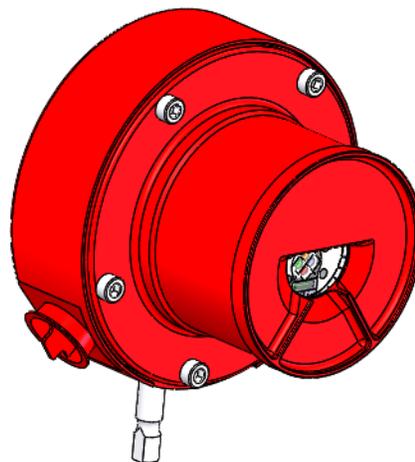


Figure 6 FL5000 Front View

3.1 Features

| Feature | Description |
|--|--|
| High False Alarm Immunity | Provides reliable flame detection performance by utilizing advanced flame detection algorithms to minimize false alarms. Refer to 9.1.3 False Alarm Stimuli Performance for more details on the behavior of the instrument in the presence of false stimuli. |
| Wide Field of View (FOV) | Encompasses a large area of detection with uniform sensing and no blind spots. |
| Modular Design | Results in low maintenance and reduced total cost of ownership. |
| Compact Unitized Design | Enhances ease of installation and maintenance. |
| Continuous Optical Path Monitoring (COPM) | Regularly monitors the optical path to ensure the window is not dirty. |
| 0-20 mA Analog Output | Transmits alarm and fault indication to a remote display, computer, or other device such as an alarm, dispensing device, or master controller. |
| Modbus RS-485 User Interface | Provides the capability to operate the FL5000 remotely. This interface allows the user to remotely change the alarm and warning relay settings, clear selected faults, clear error counters, change baud rates, and change formats for serial communication lines. |
| HART 7 Protocol | The HART equipped FL5000 supports the HART communication protocol version 7. Using this protocol, users transmit diagnostics, settings, and other device status information that improves the efficiency of remote communication. |

NOTE: FL5000 HART should not be used with General Monitors TA402A and FL802 Controllers.

3.2 Applications

The FL5000 provides flame detection for a wide range of applications, including, but not limited to the following:

| Industries | Sample Applications | Industries | Sample Applications |
|---------------------|---------------------------|-------------------|---------------------------------|
| Oil and Gas | On and Offshore Platforms | Chemical Plants | Process Buildings |
| Gas Pipelines | Compressor Buildings | Loading Terminals | Trucking On / Off Loading Areas |
| Airports / Military | Airplane Hangars | Petrochemical | Process Areas |
| Gas Turbines | Turbine Enclosures | Refineries | Tank Farms and Process Areas |

3.3 Bluetooth Connectivity

NOTE: Bluetooth is enabled by factory default. If Bluetooth is not needed, it can be deactivated by opening the unit and setting the Bluetooth DIP switch to disabled. This switch is inside the FL5000, see [5.7 Switch Selectable Options](#). During configuration change using Bluetooth communication, the device will not be capable of performing the intended safety function. It is recommended that the password-protection feature be activated to prevent accidental or deliberate changes of the device configuration potentially affecting device operation.

To connect to the FL5000 using Bluetooth:

1. Power up the FL5000.
 - a. All LEDs will flash during the startup procedure.
2. After the unit startup is completed, the Bluetooth search mode will begin:
 - a. When the unit is in Bluetooth search mode, the **Blue LED will flash slowly** and the **Yellow LED will remain solid**.

CAUTION!

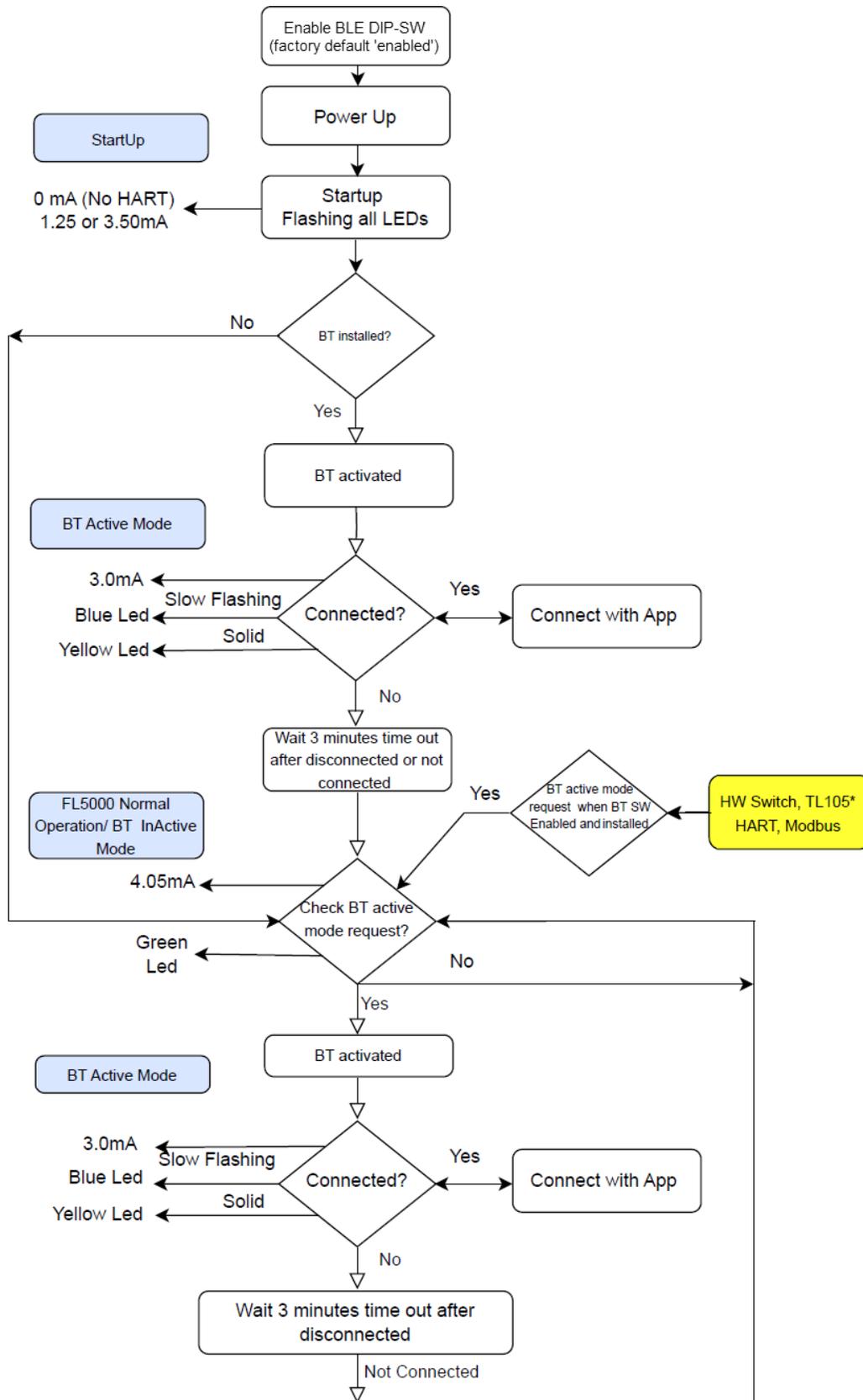
While Bluetooth is active, the FL5000 cannot perform its safety function.

3. Connect your device via the Flame Connect App (follow the App instruction steps to connect a device).
 - a. The App will require a password to access the FL5000. The default password is 345678.
4. If a device is not connected or Bluetooth connectivity use is complete and the device is disconnected from the FL5000, the Bluetooth search mode will time out within 3 minutes and revert to flame detection mode.
 - a. Flame detection mode is shown to be active when a **steady green LED (with heartbeat)** is showing on the FL5000. This means that the detector is now performing its safety function.
 - b. Other than at startup, Bluetooth cannot be accessed unless by hardware switch (custom option by request), Flame Test through the Test Lamp ([4.3.1 Test Lamp](#)), HART Command or Modbus Command.
 - c. Bluetooth can also be accessed by shorting terminal 1 (BTE) Bluetooth to (GND) Ground for a minimum duration of 10 seconds and a maximum duration of 60 seconds.

NOTE: If Bluetooth is not functioning, ensure the Bluetooth DIP switch is enabled by opening the FL5000 unit the and checking the [5.7 Switch Selectable Options](#). If the DIP switch is enabled, check that the Bluetooth flex cable and connectors are fully seated.

3 Device Overview

Activating Bluetooth Module from different switches.



* TL105: For Non-Latching alarm setup only, BT will be activated after the successful test lamp process completed (after TL105 test lamp alarm).

4 Principles of Operation

The FL5000 is a discriminating Multi-Spectrum Flame Detector, which makes use of infrared sensors for different IR wavelengths and characteristics. This combination provides a flame detection system, which is highly immune to false alarms.

The advanced flame detection algorithm classifies the output signals from the detector as either fire or no-fire. The unit then produces the following output signals:

- 0 to 20 mA signal (3.5 or 1.25 to 20 mA with optional HART protocol)
- INSTANT ALARM relay contact
- SUSTAINED ALARM relay contact
- FAULT relay contact
- RS-485 Modbus output

NOTE: Refer to [5 Installation](#) for more information on detector outputs.

NOTE: FL5000 device firmware version is available for viewing via HART Communications, Flame Connect App, or FL5000 Tunes.

4.1 LED Operation Mode Definitions

Four light emitting diodes (LEDs) are visible on the front detector window. These LEDs provide a visual indication that corresponds with the detector's outputs. The following LED flashing sequences indicate various operating conditions:

| Device Status | Standard Mode | |
|-----------------|---------------|-------------------------------------|
| No Power | ALL LEDs | OFF |
| Power up | ALL LEDs | Blink alternately for 15 seconds |
| Ready | Green LED | ON with heartbeat (5s ON, 0.5s OFF) |
| | Yellow LED | OFF |
| | Red LED | OFF |
| | Blue LED | OFF |
| Instant Alarm | Green LED | OFF |
| | Yellow LED | OFF |
| | Red LED | Blinking slowly (1 Hz) |
| | Blue LED | OFF |
| Sustained Alarm | Green LED | OFF |
| | Yellow LED | OFF |
| | Red LED | ON |
| | Blue LED | OFF |
| COPM Fault | Green LED | OFF |
| | Yellow LED | Blinking slowly (1 Hz) |
| | Red LED | OFF |
| | Blue LED | OFF |

| Device Status | Standard Mode | |
|---|---------------|------------------------------------|
| Low Voltage, Code or Data, Checksum Fault | Green LED | OFF |
| | Yellow LED | ON |
| | Red LED | OFF |
| | Blue LED | OFF |
| Test Mode Activated | Green LED | 0.9s ON, 0.1s OFF |
| | Yellow LED | OFF |
| | Red LED | OFF |
| | Blue LED | OFF |
| Test Mode Warning | Green LED | Alternate blinking slowly (1 Hz) |
| | Yellow LED | OFF |
| | Red LED | Alternate blinking slowly (1 Hz) |
| | Blue LED | OFF |
| Test Mode Alarm | Green LED | Alternate blinking slowly (2.5 Hz) |
| | Yellow LED | OFF |
| | Red LED | Alternate blinking slowly (2.5 Hz) |
| | Blue LED | OFF |
| Bluetooth Search Mode | Green LED | OFF |
| | Yellow LED | ON |
| | Red LED | OFF |
| | Blue LED | Alternate blinking slowly (1 Hz) |
| Bluetooth Connect Mode | Green LED | OFF |
| | Yellow LED | ON |
| | Red LED | OFF |
| | Blue LED | ON |

4.2 Continuous Optical Path Monitoring - COPM Circuitry

A self-testing feature called Continuous Optical Path Monitoring (COPM) checks the optical path, the detector(s), and the related electronic circuitry once every 2 minutes. If foreign material on the front surface of the FL5000 blocks the COPM light from reaching the detector(s) for four minutes, the unit will indicate FAULT.

The optical FAULT outputs are a signal, de-energizing of the FAULT relay, and Modbus (RS-485) output signal. If in the 'HART 1.25 mA' setting (default), the FL5000 provides a 2.0 mA fault output. If in the 'HART 3.5 mA' setting, the FL5000 provides a 3.5 mA fault output. The setting can be selected via HART or Modbus command.

After a COPM FAULT, a COPM check is performed every twenty seconds. The COPM will resume a once per 2-minute check only after the obstruction is removed. For general information and current levels go to [5.6.8 Analog Output](#).

NOTE: Because the optical path is checked once every 2 minutes and requires two check failures to produce a FAULT, it may take up to 4 minutes for the unit to detect an obstruction.

WARNING!

Dirty or partially blocked windows can significantly reduce the detector's field of view and detection distance.

Failure to follow this warning can result in serious personal injury or death.

NOTE: Flame detector will still perform its safety functions, if possible, in COPM FAULT.

4.3 Test Mode Initiation

NOTE: The FL5000 will not detect a flame while in Test Mode.

The FL5000 has the ability to initiate a special Test Mode, which enables the user to test the response of the unit without the use of a flame source. Once the Test Mode has been activated it responds to the Test Lamp as a simulated flame source.

There are four options for enabling Test Mode on the FL5000:

1. Flashing the Test Lamp (4.3.1 Test Lamp)
2. HART command (4.3.2 HART Command)
3. Modbus command (4.3.3 Modbus Command or Grounding Test Wire)
4. Grounding the test wire (4.3.3 Modbus Command or Grounding Test Wire)

Each time the Test Mode is activated and the Test Lamp is successfully detected, regardless of which option is used, the FL5000 maintains a timestamp of the test. This timestamp is available to the user via Modbus registers 0x30 to 0x3A. For Modbus register information, please refer to the Modbus manual maintenance event log.

4.3.1 Test Lamp

The Test Lamp is a battery operated, rechargeable, test source specifically designed to test General Monitors' IR Flame Detection Systems. It consists of a high-energy broadband radiation source that emits sufficient energy in the infrared spectra to activate the IR detector. To simulate a fire, the TL105 Test Lamp automatically flashes a signal that the FL5000 recognizes. The lamp must be set to rotary switch position "4" to be recognized by the FL5000.

Operating Instructions

- The FL5000 has the ability to be put into a special test mode activated state by momentarily grounding the test mode pin on the unit or by issuing a Modbus write command to register 0x4A.
- The unit will respond by going into this test mode activated state and by blinking a unique flashing pattern with the green LED on for 0.9 seconds and off for 0.1 seconds. The analog current output will respond by outputting 1.5 mA (3.5 mA with HART and small HART current disabled).
- While the FL5000 is activated in test mode via the Test Lamp, the FL5000 will detect the TL105 Test Lamp as a flame source.
 - The analog output and relays will respond as if a flame were present.
 - The analog output will rise from 1.5 mA (3.5 mA with HART and small HART current disabled) to 16 mA (warning condition) and then to 20 mA (alarm).
 - Relays will trip.
 - In addition, an alternating red/green LED blink pattern is displayed.
- By momentarily grounding the test mode pin a second time, or by re-issuing a Modbus write command to register 0x4A, or after a 3-minute time out, the unit will return to normal operation in the Ready state.
- The TL105 Test Lamp triggers the FL5000 into test mode, causing an alarm condition.

It is important to begin a series of flame detector checks with a fully charged Test Lamp. Stand between 10 and 35 feet from the FL5000 that is to be tested and aim the Test Lamp directly into the detector window. Press the ON button and be sure the high intensity pulsing beam strikes the detector face squarely. Hold the Test Lamp as steady as possible.

To conserve charge, do not operate the Test Lamp longer than is necessary to test each channel.

When the battery level drops below the level required to maintain the proper intensity of the lamp, an internal low voltage circuit will shut the lamp off until the battery has been recharged. Please refer to the TL105 Test Lamp manual for complete operating instructions.

Recharging Instructions

Insert the charging plug into the receptacle. Complete recharging takes 3.5 hours minimum.

NOTE: Charging must be carried out in a non-hazardous area. The charging receptacle is located inside the housing adjacent to the ON button. To gain access, it is necessary to unscrew the knurled plug from the body of the unit. The plug is secured to the ON button by a safety strap to keep it from being lost. Replace the plug after charging is complete.

It is recommended that the Test Lamp be kept on charge when not in use to prevent excessive battery discharge. The batteries may be charged an average of 500 times before the battery pack must be replaced.

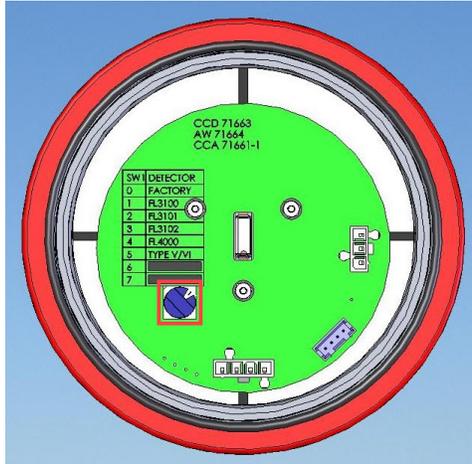


Figure 7 Functional Board Located Under TL105 Lamp Assembly

For FL5000, use position 4.

| Flame Detector to Test | Rotary Switch Setting | Maximum Distance to Detector (ft) | Results |
|------------------------|---|---|---|
| FL4000H/FL5000 |  | 35 (High Sensitivity) 18 (Medium Sensitivity) 8 (Low Sensitivity) | FL4000H/FL5000 triggers into alarm mode |

NOTE: Reference MANTL105 manual for additional information.

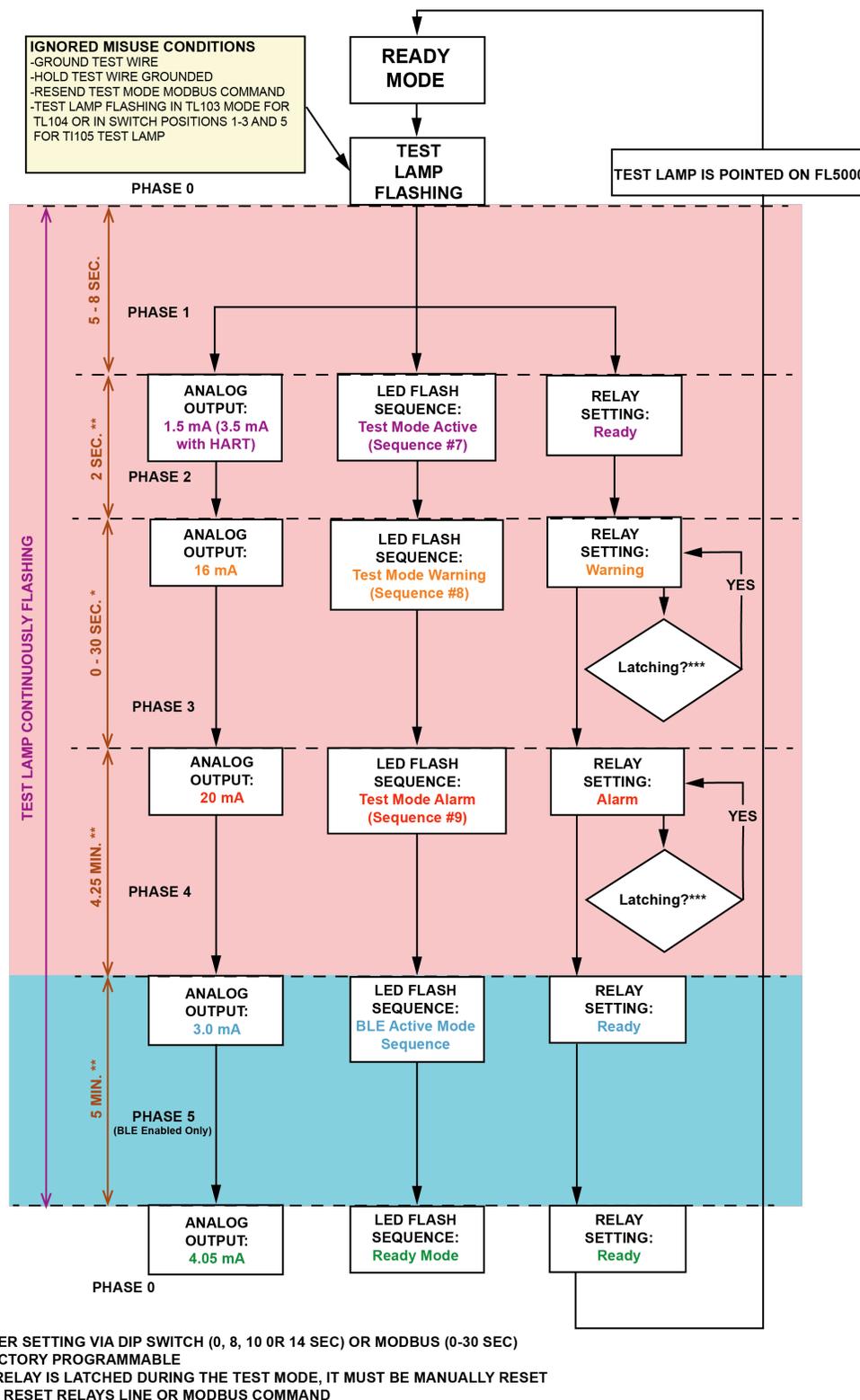


Figure 8 Test Lamp Flashing Option (Auto-Detection)

When the unit is in Operational Mode, the FL5000 recognizes the Test Lamp as a trigger to activate the Test Mode. Within 5-8 seconds of the Test Lamp flashing, the FL5000 will detect the simulated flame source, drop the analog output to 1.5 mA (3.5 mA with HART and small HART current disabled), and change the LED flashing to indicate “Test Mode Activated” shown in [4.1 LED Operation Mode Definitions](#). The relay setting will remain at “Ready” during this operation.

Further continuous flashing of the Test Lamp in Test Mode enables the following sequence of events:

4 Principles of Operation

After 2 seconds in Test Mode (Phase 2):

- the FL5000 indicates an Instant Alarm condition by:
 - setting the analog output to 16 mA
 - changing the LED flashing to indicate "Test Mode Instant Alarm"
 - setting the relay to Instant Alarm State.
-

After a user-selectable time delay of 0-30 seconds¹(Phase 3):

- the FL5000 displays an Sustained Alarm condition by:
 - setting the analog output to 20 mA
 - changing the LED flashing to indicate "Test Mode Sustained Alarm"
 - setting the relay to Sustained Alarm State.
-

After 4.25 minutes in Sustained Alarm mode (Phase 4):

- the unit will return to Ready Mode by:
 - dropping the analog output to 4.05 mA
 - restoring the LED flashing to "Ready"
 - setting the relay to Ready state.
-

After 5 minutes, if Bluetooth is enabled (Phase 5):

- the unit will indicate Bluetooth activity by:
 - setting the analog output to 3.0 mA
 - changing the LED flashing sequence to Bluetooth Active mode
 - setting the relay to Ready state.
-

NOTE: After the test is initiated via the Test Lamp, all other commands are ignored until the Test Mode is over.

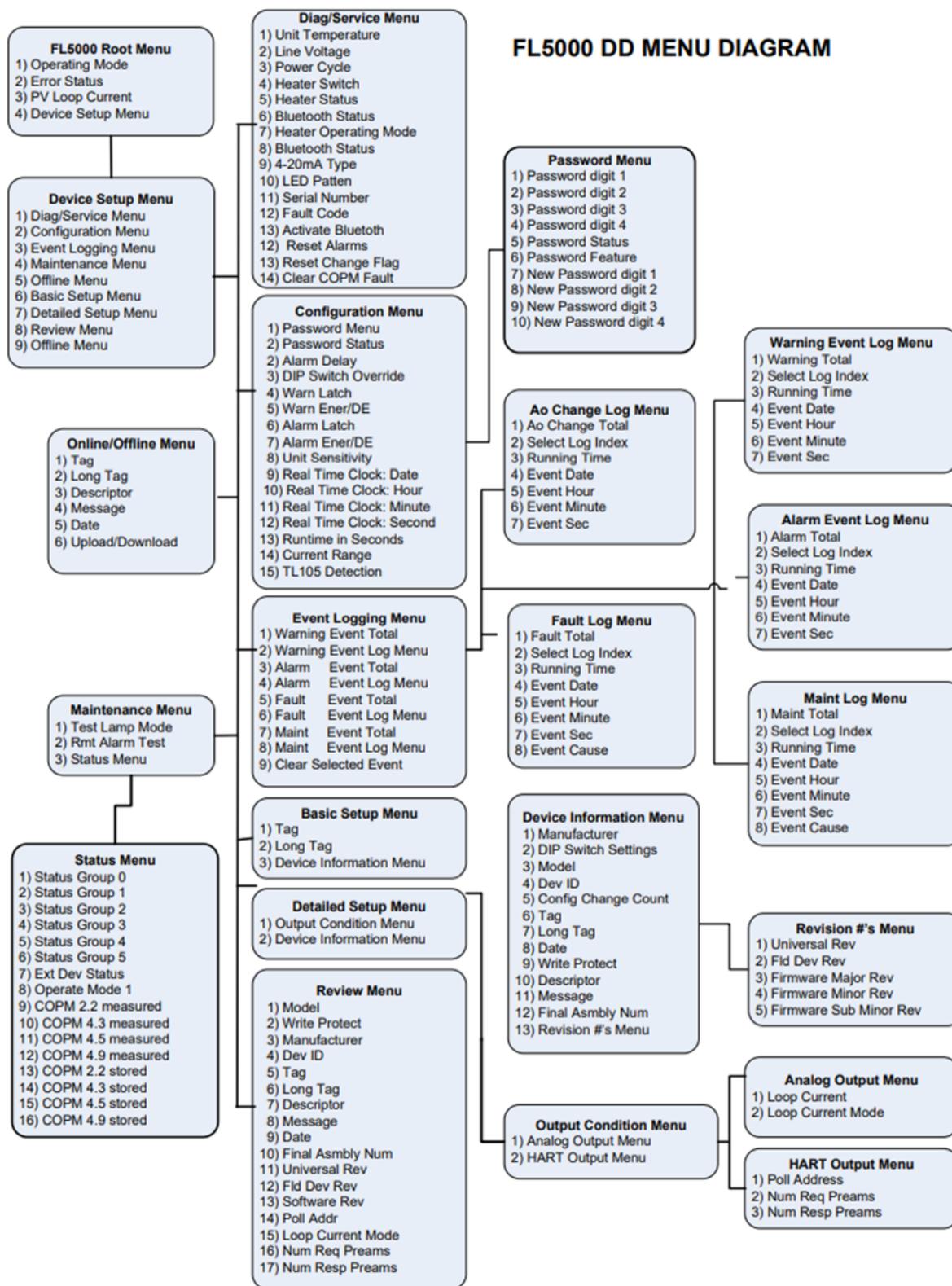
- While in Test Mode, the unit will not detect flames.
- Interruption of the Test Lamp flashing for more than 3 seconds will result in termination of the test sequence and a return to Ready Mode (Phase 0).

If a relay is latched, it must be manually reset via the reset relays line or a Modbus command. There is a 10 second restart delay. After the unit returns to Ready State from Phase 4, the unit waits for 10 seconds before a subsequent Test Lamp transition back to Phase 1.

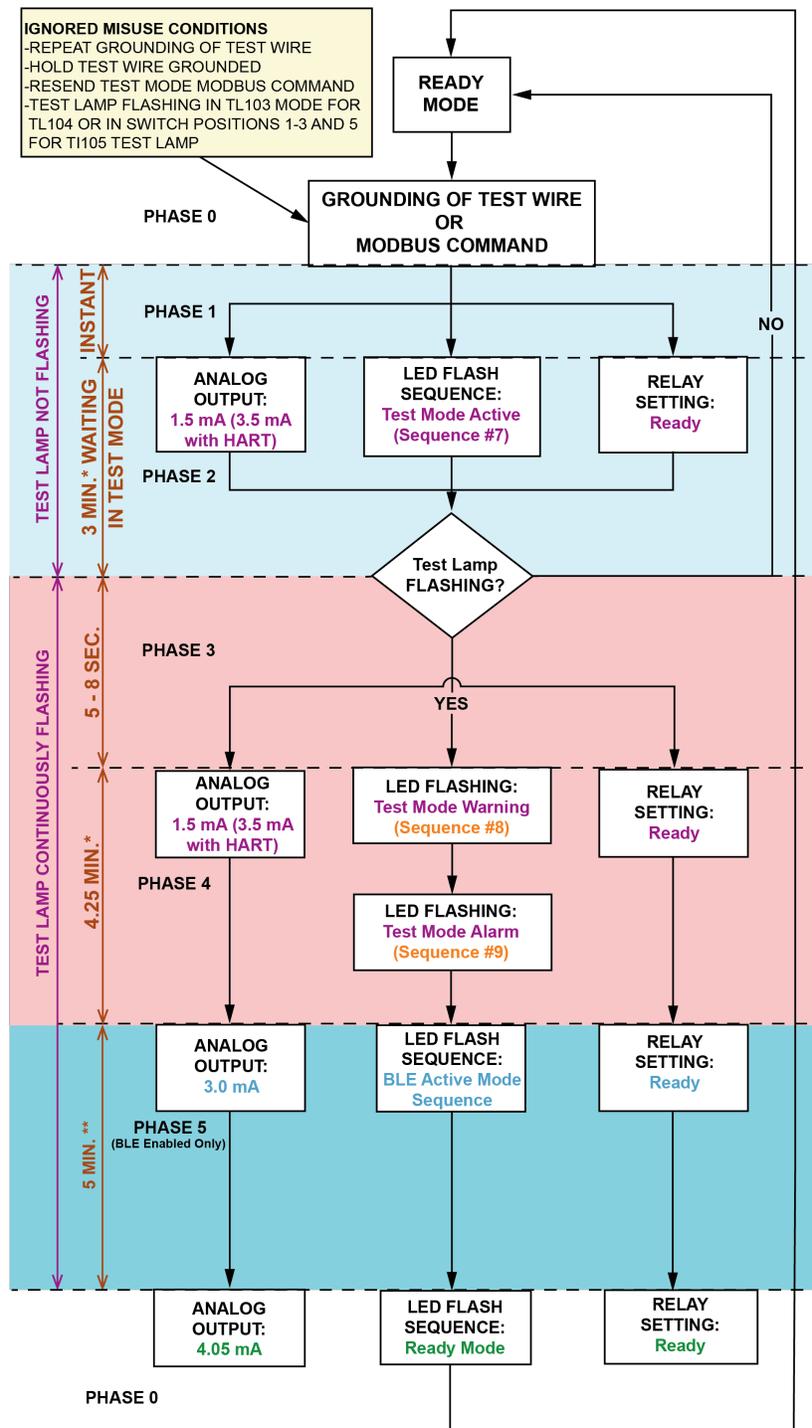
¹Time delay can be set through Modbus to any value between 0 and 30 seconds, and via dipswitch to 0, 8, 10 or 14 seconds.

4.3.2 HART Command

For Test Mode Initiation via HART Command, please refer to the FL5000 HART Manual (PN 10242587).



4.3.3 Modbus Command or Grounding Test Wire



* FACTORY PROGRAMMABLE

Figure 9 Grounding of Test Wire or Modbus Command Options

Momentary grounding of a test wire or the Modbus test-mode-enable command causes the FL5000 to enter Test Mode. Initiation of Test Mode is indicated by the analog output dropping to 1.5 mA (3.5 mA with HART and small HART current disabled) and LED flashing in sequence shown in 4.1 LED Operation Mode Definitions.

If initiating Test Mode via grounding of test wire or Modbus command, the Test Mode times out in 3 minutes.

Flashing of the Test Lamp in the Test Mode enabled via test wire or Modbus results in the following sequence of events:
 After 5-8 seconds of the Test Lamp flashing in Phase 3:

- the FL5000 goes into Phase 4:
 - indicates 1.5 mA (3.5 mA with HART and small HART current disabled) at the analog output
 - changes the LED flashing to indicate “Test Mode Activated”

After 4.25 minutes in Phase 4:

- the FL5000 returns to Ready Mode:
 - indicates 4.3 mA at the analog output
 - restores the LED flashing to “Ready”.

After 5 minutes, if Bluetooth is enabled (Phase 5):

- the unit will indicate Bluetooth activity by:
 - setting the analog output to 3.0 mA
 - changing the LED flashing sequence to Bluetooth Active mode
 - setting the relay to Ready state.

NOTE: After the test is initiated via wire or Modbus; all other commands are ignored until the Test Mode is over.

- While in Test Mode, the unit will not detect flames.
- Interruption of the Test Lamp flashing for more than 3 seconds will result in termination of the test sequence and a return to Ready Mode (Phase 0).

4.4 Window Heater Operation

The window heater will turn on and off at certain temperatures to remove the water vapor on the window glass. The user can disable the window heater with the Window Heater Disabled switch, see [5.7 Switch Selectable Options](#).

5 Installation



The FL5000 contains components that can be damaged by static electricity. Always wear grounding apparel when handling or installing the unit.

Failure to follow this caution can result in minor or moderate injury.

The basic steps in a typical installation are listed in the sections below. The installation process may vary depending on the exact site configuration.

- Only personnel trained and qualified in the HART communication protocol may install and use the HART configuration of the FL5000 detector.
- Only trained and authorized users can configure the FL5000.
- The FL5000 flame detector is to be installed in accordance with NFPA 72 requirements.
- When used with certified fire alarm control units equipped with 4-wire smoke detector circuits, the FL5000 should be reset by temporarily removing the supply voltage for at least 70 ms with a decline of operation voltage of no less than 3 VDC.

5.1 Unpacking Equipment

All equipment is packaged in shock absorbing containers that protect against physical damage. The contents should be carefully removed and checked against the enclosed packing list.

If any damage has occurred or there is any discrepancy in the order, please contact MSA.

NOTE: Each FL5000 is completely tested at the factory; however, a system check is required upon initial start-up to guarantee system integrity.



Sustainability Tip:

Be sure to recycle the FL5000 packaging according to your local environmental regulations.

5.2 Required Tools

| Tool | Use |
|--|---|
| 5 mm Allen wrench | Fasten / remove front assembly from base (not included) |
| Flat-head screwdriver 3/16 inch (5 mm) maximum | Connect wires into the Terminal Block (not included) |
| Adjustable wrench | To make conduit and cable gland connections (not included) |
| Torque wrench (needed if mounted) | To tighten the mounting clamp (the torque spec is 50 ft-lbs so a 17mm or 11/16" wrench is required) |

5.3 Detector Location Guidelines

Several variables are involved in selecting locations to install detectors. The following guidelines should be considered in regard to particular conditions at the site where the unit(s) is being installed:

- [5.3.1 Optical Sensitivity Range](#)
- [5.3.2 Detector Field of View](#)
- [5.3.3 Environmental Factors](#)

5.3.1 Optical Sensitivity Range

The distance at which the detector will respond to a flame is a function of the intensity of that flame. The maximum distance is 310 ft (95 m) for an n-heptane fire with a surface area of 1 ft² (0.092 m²). The following table shows the specified ranges for a given sensitivity setting.

| Sensitivity Setting | Specified Range |
|---------------------|-----------------|
| High | 310 ft (95 m) |
| Medium | 140 ft (43 m) |
| Low | 70 ft (21 m) |

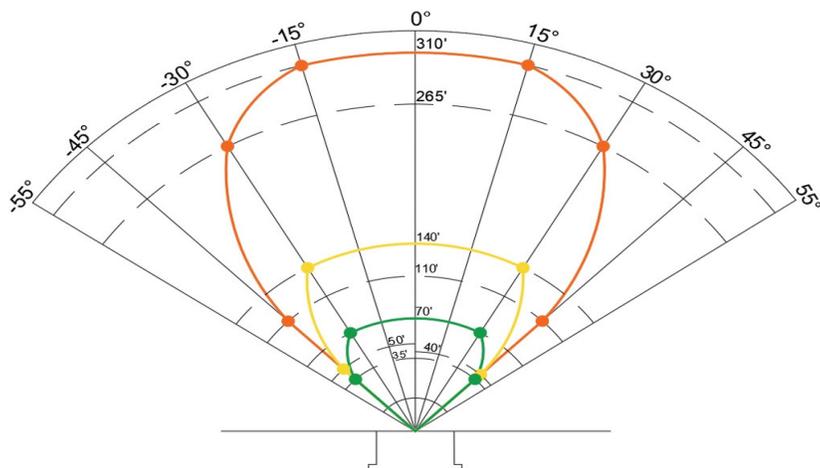
5 Installation

5.3.2 Detector Field of View

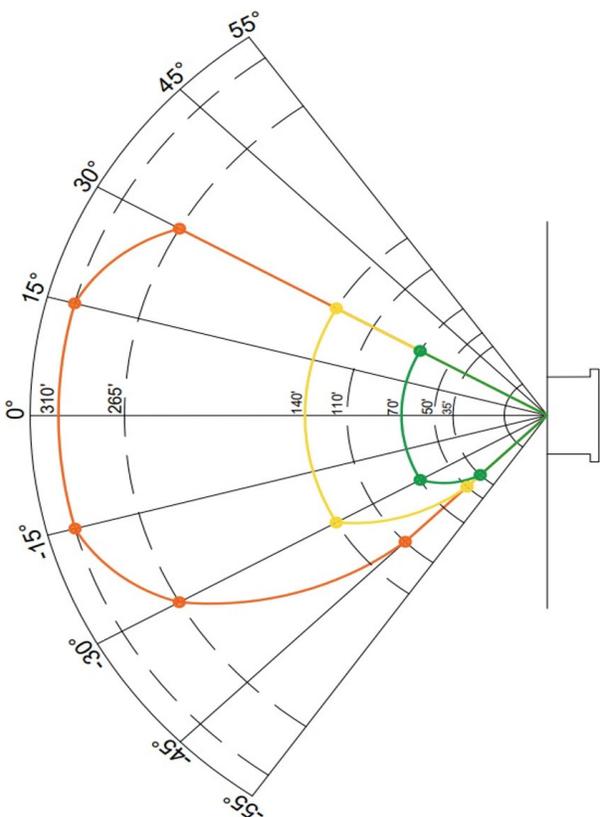
Each FL5000 Flame Detector has a maximum range of 310 feet (95 m).

The FOV has its vertex at the center of the detector. Horizontal FOV is measured in the horizontal plane going through the center axis of the detector, and vertical FOV is measured in the vertical plane going through the same axis. Both horizontal and vertical FOV are defined for high, medium and low sensitivity settings of the FL5000, as shown in the charts below.

n-Heptane (1' x 1')



| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 310' | 140' | 70' |
| +15° | 310' | 140' | 70' |
| -15° | 310' | 140' | 70' |
| +30° | 265' | 140' | 70' |
| -30° | 265' | 140' | 70' |
| +45° | 110' | 40' | 35' |
| -45° | 110' | 50' | 35' |



| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 310' | 140' | 70' |
| +15° | 310' | 140' | 70' |
| -15° | 310' | 140' | 70' |
| +30° | 265' | 140' | 70' |
| -30° | 265' | 140' | 70' |
| -45° | 110' | 40' | 35' |

Figure 10 n-Heptane Field of View

The following fuels have been tested and their applicable field of view charts and sensitivity details can be viewed in [9 Certifications](#).

| | |
|-----------------|---------------------|
| Heptane | JP4 (2' x 2') |
| Gasoline | JP5 (1' x 1') |
| Methanol | JP5 (2' x 2') |
| Methane | JP8 (1' x 1') |
| Butane | JP8 (2' x 2') |
| Propane | Jet A (1' x 1') |
| Ethane | Jet A (2' x 2') |
| Ethanol | Marina Fuel |
| Crude Oil | Kerosene |
| Ethylene Glycol | Xylene |
| Isopropanol | MEK |
| Diesel | Wood (6" x 6") |
| JP4 (1' x 1') | Cardboard (6" x 6") |

5.3.3 Environmental Factors

- Observe the ambient temperature range for the specific model – refer to [8.2.4 Environmental Specifications](#).
 - For outdoor installations or other areas exposed to intense, direct solar radiation, the detector may reach temperatures above specifications.
 - For this condition, a cover for shade may be required to bring the detector temperature within specifications. As with any cover or object nearby, ensure the field of view of the detector is not obstructed.
- Avoid conditions of ice build up on the optical detector windows. Complete icing-over of the optical detector window can result in fault conditions.
- Modulated reflected sunlight shining at the face of the FL5000 reduces flame detection distance.

5.4 Detector Mounting and Installation

The FL5000 is enclosed in an explosion proof assembly, which is rated for use in the environments specified in Addendum A - Standards and Compliance Certifications.

- The unit should be mounted free from shock and vibration and convenient for visual inspection and cleaning.
- The detector(s) should be tilted downward so that dust or moisture does not accumulate on the sapphire window.
- The detector(s) should be mounted in locations, that prevent people or objects from obscuring the detector's FOV.
- The mounting clamp must be torqued to 50 ft-lbs.

Frequent inspection, cleaning, and sensitivity checking is suggested for detectors mounted in dirty environments. Conduit seal must be within 18" of unit.

Non-hardening thread sealant should be used if the plugs are removed or re-installed in order to preserve ingress protection rating.

NOTICE

The FL5000 conduit entry should be sealed per the Canadian Electrical Code Handbook (Part 1, Section 18-154) and NEC Article 501. Conduit seals or approved Ex d glands prevent water or gas from entering the detector's housing through the conduit entry. Water entering the housing through the conduit entry will damage the electronics and nullify the warranty.

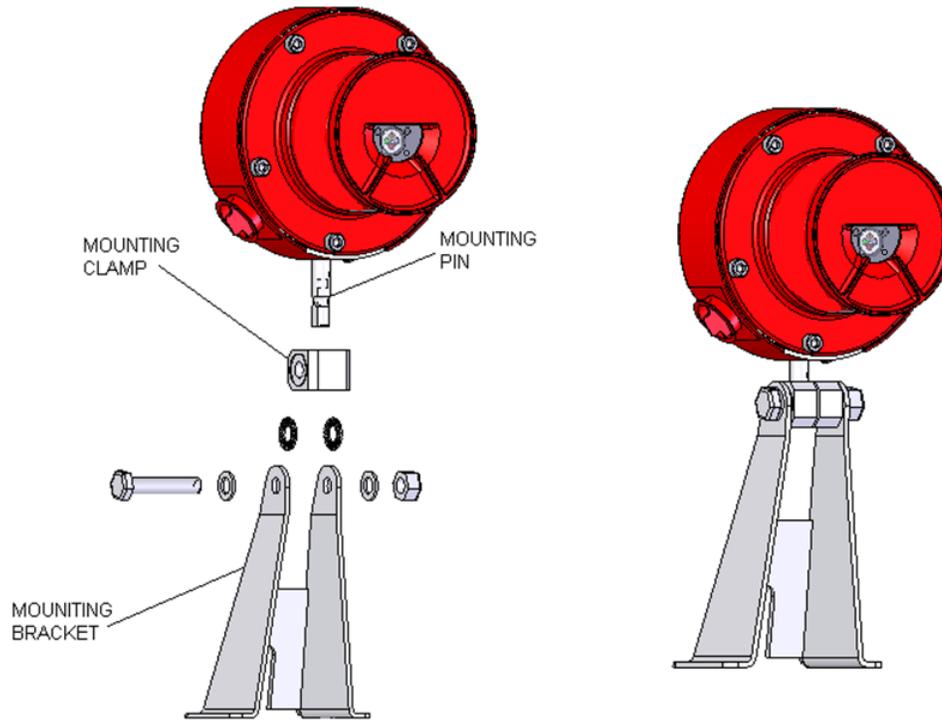


Figure 11 Detector Mounting and Installation

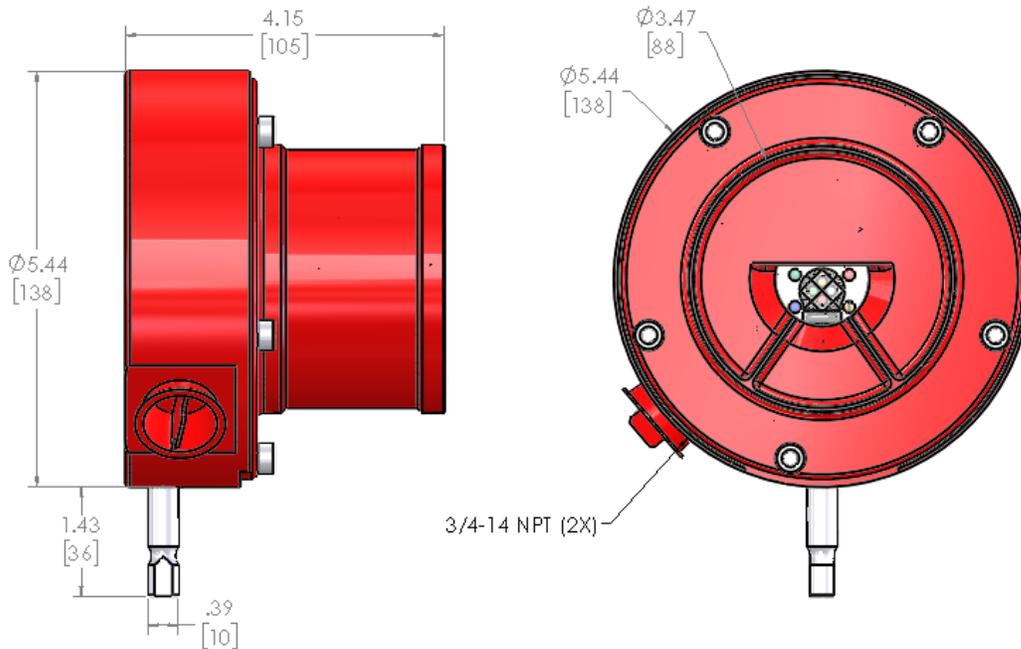


Figure 12 Dimensional Drawing

5.5 Field Wiring Procedure

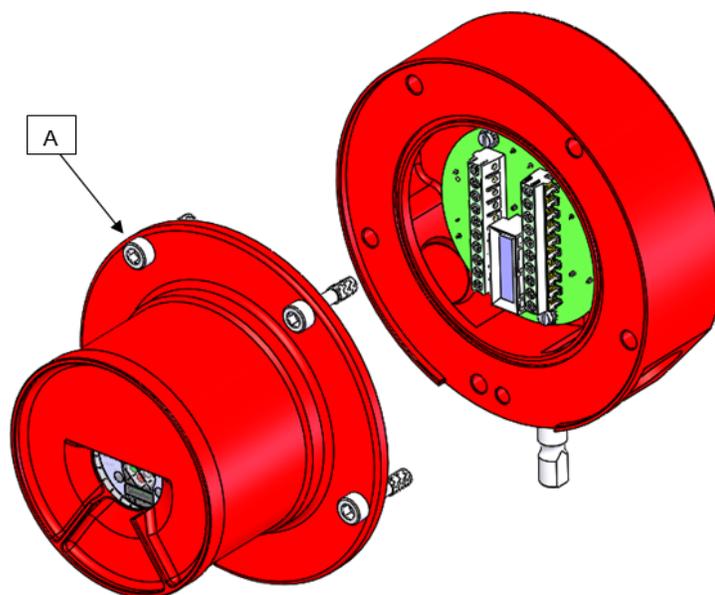


Figure 13 FL5000 Housing

1. Loosen the captive screws (A) located on the Optical Housing Assembly.
2. Pull the Optical Housing Assembly from the Base Housing Assembly to separate, gently rock from side to side if necessary to loosen the connector's grip.
3. Make all necessary wiring connections as described in [5.6 Terminal Connections](#). For an example of wiring, please refer to the connection diagram.
4. Set switch selectable options as described in [5.7 Switch Selectable Options](#).
5. Fit the Optical Housing Assembly to the Base Housing Assembly.
6. Tighten the captive screws (A) located on the Optical Housing Assembly.
7. Check [1 Safety Regulations](#) for warnings and wiring requirements.

NOTICE

Do not unscrew the field wiring board from the base housing assembly for wiring.

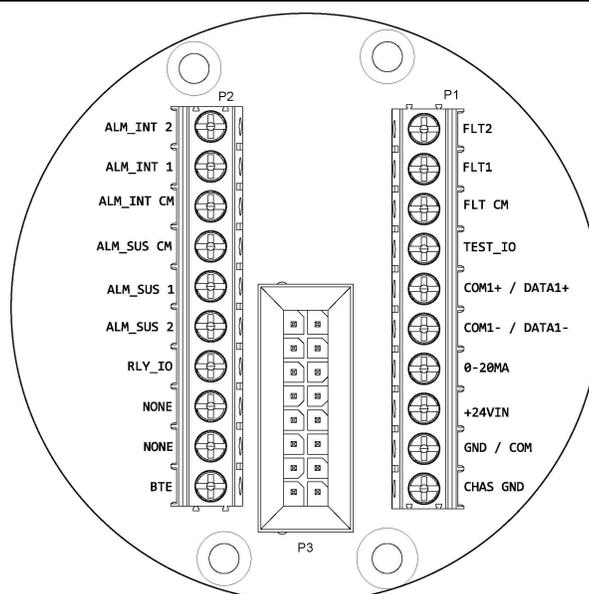


Figure 14 Terminal Connections

5.6 Terminal Connections

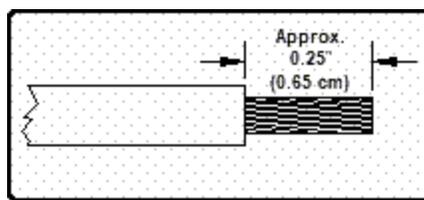


Figure 15 Wire-Strip Lengths

All wire connections are made through the $\frac{3}{4}$ inch (1.9 cm) NPT openings in the Base Housing to the Terminal Block. The Terminal Block is located in the Base Housing Assembly and accepts 14 AWG (2.08 mm²) to 22 AWG (0.33 mm²) stranded or solid-core wire. Each wire should be stripped as shown in the figure above.

To connect the wire to the Terminal Block, insert the conductor into the connection space and tighten the corresponding screw terminal.

There are twenty possible terminal connections:

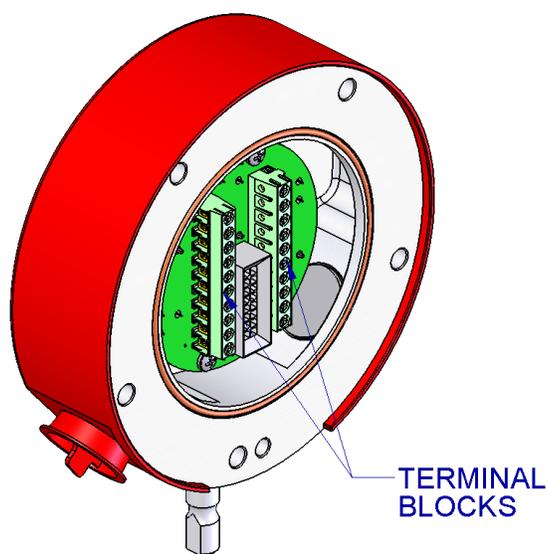


Figure 16 Base Housing and Terminal Blocks

| Terminal Block - P2 | | Terminal Block - P1 | |
|---------------------|----------------------|---------------------|--------------------------------|
| Pin # | Description | Pin # | Description |
| 10 | ALM_INT 2 | 1 | FLT 1 |
| 9 | ALM_INT 1 | 2 | FLT 2 |
| 8 | ALM_INT CM | 3 | FLT CM |
| 7 | ALM_SUS CM | 4 | TEST_IO (Test Mode) |
| 6 | ALM_SUS 1 | 5 | COM1+/DATA1+ |
| 5 | ALM_SUS 2 | 6 | COM1-/DATA1- |
| 4 | RLY_IO (Relay Reset) | 7 | 0-20 mA |
| 3 | NONE | 8 | +24 V _{in} |
| 2 | NONE | 9 | GND/COM |
| 1 | BTE | 10 | CHGND/CHASGND (Chassis Ground) |

NOTE: The FL5000 is backward compatible with the FL4000H. The user can use the top head of the FL5000 plug to plug into the existing base of the FL4000H.

The following sections provide a description and specification for each connection:

- [5.6.1 Sustained Alarm Relay](#)
- [5.6.2 Instant Alarm Relay](#)
- [5.6.4 Fault Relay](#)

5.6.1 Sustained Alarm Relay

| Terminal Block | Connection Point | Block Name | User Relay Settings | |
|----------------|------------------|------------|------------------------|------------------------|
| | | | Normally De-energized | Normally Energized |
| P2 | Term 5 | ALM_SUS 2 | Sustained Alarm NO | Sustained Alarm NC |
| P2 | Term 6 | ALM_SUS 1 | Sustained Alarm NC | Sustained Alarm NO |
| P2 | Term 7 | ALM_SUS CM | Sustained Alarm Common | Sustained Alarm Common |

NOTE: NO = Normally Open; NC = Normally Closed

The connections are to the single pole, double throw (SPDT) SUSTAINED ALARM relay. SUSTAINED ALARM output is time delayed for 0, 8, 10, or 14 seconds. This time delay can be set by Modbus (RS-485) or the user selectable dipswitch per [5.7 Switch Selectable Options](#).

Note that a minimum time delay of 8 seconds can be applied if the flame source is removed within 50% of set delay time from the start of flame. Please refer to [5.7.1 Time Delay Settings](#). If set via Modbus below 8 seconds, the detector may go into alarm even if the flame source is removed within 50% of the delay time.

The SUSTAINED ALARM output can be normally energized or de-energized, latching or non-latching, and these options are also set via Modbus or by a dipswitch. The SUSTAINED ALARM relay contact rating is 8 A @ 24 VDC. Refer to the figure in [5.6.1 Sustained Alarm Relay](#) for all relay connections.

5.6.2 Instant Alarm Relay

| Terminal Block | Connection Point | Block Name | User Relay Settings | |
|----------------|------------------|------------|-----------------------|----------------------|
| | | | Normally De-energized | Normally Energized |
| P2 | Term 8 | ALM_INT CM | Instant Alarm Common | Instant Alarm Common |
| P2 | Term 9 | ALM_INT 1 | Instant Alarm NC | Instant Alarm NO |
| P2 | Term 10 | ALM_INT 2 | Instant Alarm NO | Instant Alarm NC |

NOTE: NO = Normally Open; NC = Normally Closed

Description: These connections are to the SPDT INSTANT ALARM relay. The INSTANT ALARM output is immediate on the FL5000. The INSTANT ALARM output can be normally energized or de-energized, latching, or non-latching. These options are also set via Modbus or by a dipswitch per [5.7 Switch Selectable Options](#). The INSTANT ALARM relay contact rating is 8 A @ 24 VDC.

Refer to the figure in [5.6.1 Sustained Alarm Relay](#) for all relay connections.

5.6.3 Alarm Wiring Relay Protection

Inductive loads (bells, buzzers, relay, contractors, solenoid valves, etc.) connected to the Sustained Alarm, Instant Alarm, and Fault relays must be clamped down as shown on diagrams in [5.6.2 Instant Alarm Relay](#). Unclamped inductive loads can generate voltage spikes in excess of 1000 volts. Spikes of this magnitude will cause false alarms and possible damage.

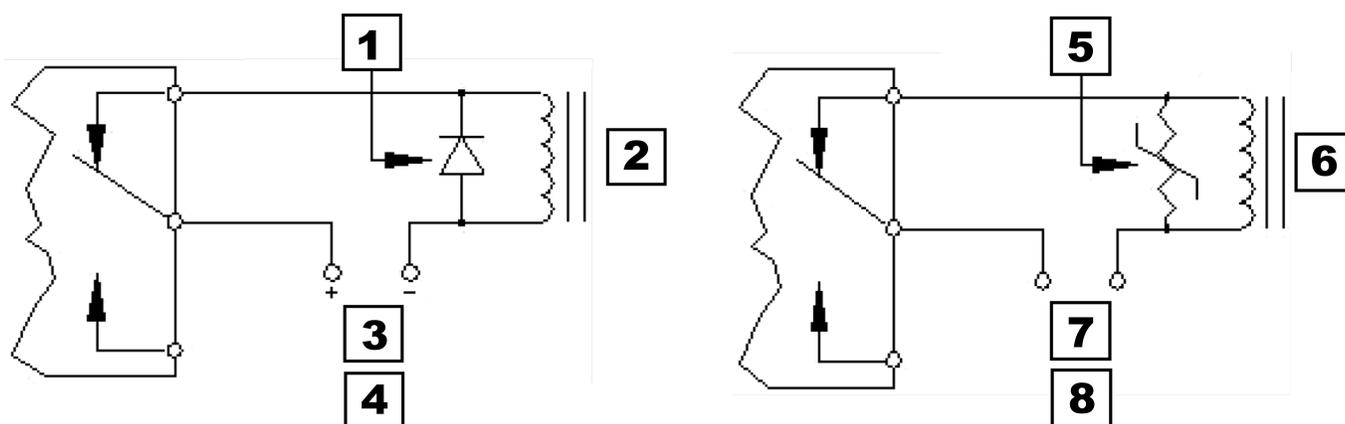


Figure 17 Relay Contacts

| | | | |
|---|---|---|---|
| 1 | General Purpose Rectifier Diode. 1N4005 or Equivalent (Note Polarity) | 5 | Metal Oxide Varistor Rated for 150 VRMS, General Electric V150LA20A or Equivalent |
| 2 | Switched Load Coil -Bell, Buzzer, Relay, Contactor, Solenoid, Valve, etc. | 6 | Switched Load Coil -Bell, Buzzer, Relay, Contactor, Solenoid, Valve, etc. |

5 Installation

| | | | |
|---|---|---|--|
| 3 | DC Control Voltage | 7 | 117 VAC Control Voltage |
| 4 | Protection circuit for relay contacts when switching a DC load. | 8 | Protection circuitt for relay contacts when switching an AC load |

Refer to the figure in [5.6.1 Sustained Alarm Relay](#) for all relay connections.

5.6.4 Fault Relay

| Terminal Block | Connection Point | Block Name | Normally Energized |
|----------------|------------------|------------|--------------------|
| P1 | Term 1 | FLT 2 | Fault NC |
| P1 | Term 2 | FLT 1 | Fault NO |
| P1 | Term 3 | FLT CM | Fault Common |

NOTE: NO = Normally Open; NC = Normally Closed

These connections are to the SPDT FAULT relay. The FAULT output configuration is normally energized and non-latching. This is the standard output configuration and it cannot be changed.

The FAULT circuit will be activated during the time-out function, a low power or loss of power condition, or during a failed COPM check. During these conditions, the FAULT relays will de-energize and the analog output signal will drop to 0 mA (2 mA for COPM Faults, 3.5 mA with HART or 1.25 mA for HART with small current enabled) for the duration of the FAULT. The FAULT relay contact rating is 8 A @ 24 VDC.

Refer to the figure in [5.6.1 Sustained Alarm Relay](#) for all relay connections.

5.6.5 Alarm Reset Terminal

The RESET, when activated, returns a latched SUSTAINED ALARM and/or INSTANT ALARM output that is no longer valid to its original state.

| Terminal Block | Connection Point | Block Name | Setting |
|----------------|------------------|------------|-------------|
| P2 | Term 4 | RLY_IO | Relay Reset |

For this RESET function, place one contact of a SPST (single pole, single throw), normally open, momentary switch to P2 Terminal 4 and the other contact to P1 terminal 9 (GND).

To activate, press and release the switch.

5.6.6 Test Mode Terminal

By connecting one contact of a SPST, normally open, momentary switch to P1 terminal 4 and the other contact to P1 terminal 9 (GND), the user can put the unit into a special test mode.

| Terminal Block | Connection Point | Block Name | Setting |
|----------------|------------------|------------|-----------|
| P1 | Term 4 | TEST_IO | Test Mode |

NOTE: When in test mode via ground wire, the Test Lamp triggers a “ready” condition only.

When the switch is first closed, the mode is set and the FL5000 goes to 1.5 mA or 3.5 mA with HART and small HART current disabled (ready mode) and remains at this value while detecting the Test Lamp. The relays are not activated.

Closing the switch a second time or after approximately 3 minutes, the unit will return to normal operation.

5.6.7 Alarm Test Terminals

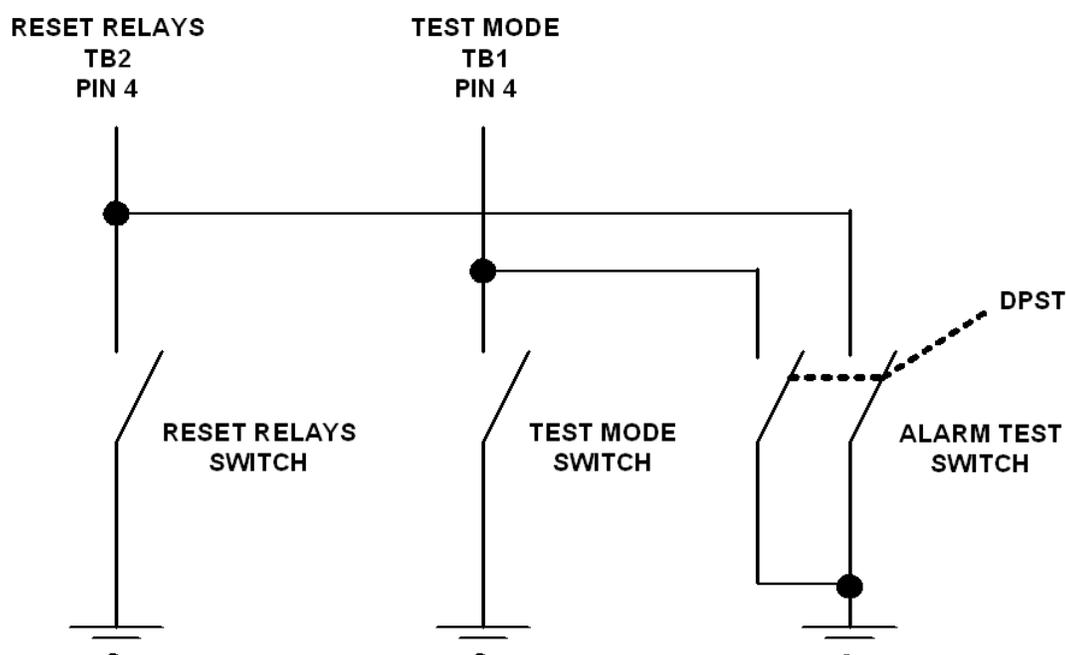
| Terminal Block | Connection Point | Block Name | Setting |
|----------------|------------------|------------|-------------|
| P1 | Term 4 | TEST_IO | Test Mode |
| P2 | Term 4 | RLY_IO | Relay Reset |

By connecting one contact of a DPST, normally open, momentary switch to each of the P1 terminal 4 and P2 terminal 4 simultaneously and the other contact to (GND), the user can perform an Alarm Test per the figure below.

NOTE: The latching INSTANT ALARM and / or SUSTAINED ALARM will have to be reset manually.

Activating this switch for 0 to 14 seconds, depending on the alarm time delay settings, can test the alarm outputs of the Flame Detector. The Alarm Test will activate the INSTANT ALARM and SUSTAINED ALARM relay outputs as well as the appropriate analog output.

The device will remain in this state until the switch is released or until 3 minutes has elapsed.



NOTE: ALL SWITCHES ARE MOMENTARY ON

Figure 18 Wiring Diagram - Reset Relays, Test Mode & Alarm Test

5 Installation

5.6.8 Analog Output

| Terminal Block | Connection Point | Block Name | Setting |
|----------------|------------------|------------|---------------|
| P1 | Term 7 | 0 - 20 mA | Analog Output |

The 0 to 20 mA output is a current signal that corresponds to the following:

| Analog Output | HART (1.25 mA)* | HART (3.5 mA) | HART Disabled/OFF |
|------------------------|-----------------|---------------|-------------------|
| Startup | 1.25 mA | 3.5 mA | 0 to 0.2 mA |
| FAULT Signal | 1.25 mA | 3.5 mA | 0 to 0.2 mA |
| Test Mode | 1.5 mA | 3.5 mA | 1.5 ± 0.2 mA |
| COPM Fault Signal | 2.0 mA | 3.5 mA | 2.0 ± 0.2 mA |
| Ready Signal | 4.05 ± 0.2 mA | 4.05 ± 0.2 mA | 4.05 ± 0.2 mA |
| INSTANT ALARM Signal | 16.0 ± 0.2 mA | 16.0 ± 0.2 mA | 16.0 ± 0.2 mA |
| SUSTAINED ALARM Signal | 20.0 ± 0.2 mA | 20.0 ± 0.2 mA | 20.0 ± 0.2 mA |
| Bluetooth Load | 3.0 mA | 3.0 mA | 3.0 mA |

* HART (1.25 mA) is the default.

NOTE: Refer to the FL5000 Modbus or HART manual for Current Range selection.

- The maximum analog output load is 600 Ω.
- The COPM Fault Signal may also be set to 0 mA at the factory (non HART only).
- Startup mode lasts exactly 15 seconds.

5.6.9 Cable Requirements

0 - 20 mA

For interfacing with 250 Ω input impedance devices, the following maximum cable lengths apply (maximum 50 Ω loop):

| AWG | Feet | Meters |
|-----|-------|--------|
| 14 | 4,500 | 1,370 |
| 16 | 2,340 | 715 |
| 18 | 1,540 | 470 |
| 20 | 970 | 300 |
| 22 | 670 | 205 |

NOTE: When Ex d cable glands are utilized, shielded cable must also be used.

5.6.10 Power

The table below shows the power connections for the FL5000. The supply voltage range is 20 to 32 VDC at the detector (low voltage is detected at 18.5 VDC).

| Terminal Block | Connection Point | Block Name | Setting |
|----------------|------------------|---------------------|--------------------------|
| P1 | Term 8 | +24 V _{in} | +24V _{in} (VDC) |
| P1 | Term 9 | GND/COM | Ground (COM) |

The following maximum cable lengths apply for a +24 VDC supply (maximum 12 Ω loop):

| AWG | mm ² | Feet | Meters |
|-----|-----------------|-------|--------|
| 10 | 5.27 | 6,289 | 1,917 |
| 12 | 3.31 | 3,956 | 1,207 |
| 16 | 1.31 | 1,565 | 478 |
| 18 | 0.823 | 984 | 300 |
| 20 | 0.519 | 620 | 189 |

5.6.11 Modbus (RS-485) Output

The connections for the Modbus output are shown. The Modbus connection is used to either query the unit's status or to configure the unit. For detailed information on Modbus protocol, consult the FL5000 Modbus Manual.

| Terminal Block | Connection Point | Setting |
|----------------|------------------|-----------|
| P1 | Term 5 | COM1+ (A) |
| P1 | Term 6 | COM1- (B) |

5.6.12 Chassis Ground

For proper operation of the detector, the FL5000 must be grounded through a wire to the chassis.

The table shows the terminal block and connection point for the chassis ground terminal. Failure to establish a ground connection can lead to greater susceptibility of the detector to electric surges, electromagnetic interference, and ultimately, damage to the instrument.

| Terminal Block | Connection Point | Block Name | Setting |
|----------------|------------------|-------------------|----------------|
| P1 | Term 10 | CHGND/ CHASGND | Chassis Ground |

5.7 Switch Selectable Options

All settings on the FL5000 are selected via a dipswitch on the Power/Relay board or via Modbus (overrides switch settings).

To set these options:

1. Remove the detector head from the Base Assembly and locate the dipswitch per the Dipswitch Location figure in [5.7.1 Time Delay Settings](#)
2. On the dipswitch, ON/CLOSED means the switch is pushed in on the side labeled ON or CLOSED (opposite the OPEN side).
3. OFF/OPEN means the switch is pushed in on the side with the number corresponding to the switch position or the side labeled OPEN – refer to [5.7.1 Time Delay Settings](#) for dipswitch assignments.

The settings for the INSTANT ALARM and SUSTAINED ALARM outputs are covered in [5.6 Terminal Connections](#).

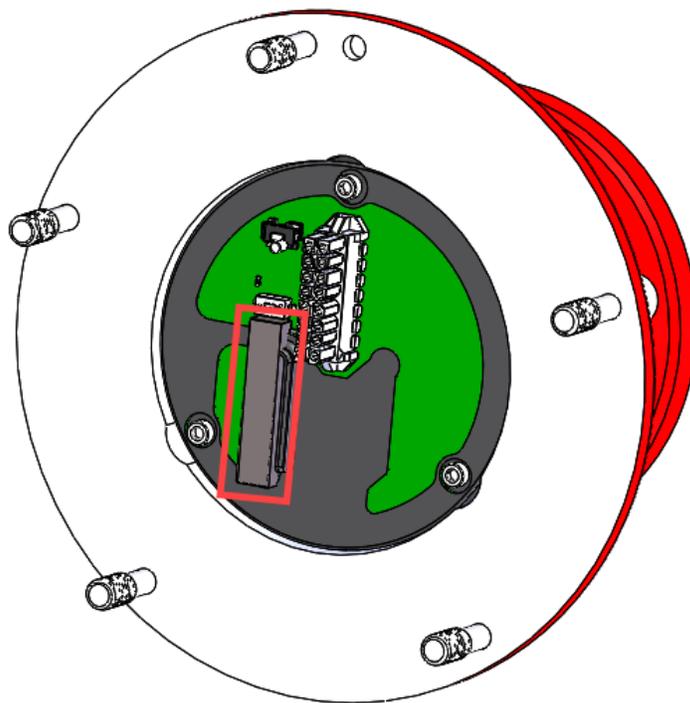


Figure 19 Dipswitch Location

| | Position | | | | | | | | | | | |
|-------------------------------------|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| High Sensitivity | OFF | OFF | - | - | - | - | - | - | - | - | - | - |
| Medium Sensitivity | ON | OFF | - | - | - | - | - | - | - | - | - | - |
| Low Sensitivity | OFF | ON | - | - | - | - | - | - | - | - | - | - |
| 0 Sec Alarm Time Delay | - | - | ON | ON | - | - | - | - | - | - | - | - |
| 8 Sec Alarm Time Delay | - | - | OFF | ON | - | - | - | - | - | - | - | - |
| 10 Sec Alarm Time Delay | - | - | OFF | OFF | - | - | - | - | - | - | - | - |
| 14 Sec Alarm Time Delay | - | - | ON | OFF | - | - | - | - | - | - | - | - |
| Sustained Alarm Non-Latching | - | - | - | - | OFF | - | - | - | - | - | - | - |
| Sustained Alarm Latching | - | - | - | - | ON | - | - | - | - | - | - | - |
| Instant Alarm Non-Latching | - | - | - | - | - | OFF | - | - | - | - | - | - |
| Instant Alarm Latching | - | - | - | - | - | ON | - | - | - | - | - | - |
| Sustained Alarm Normal De-Energized | - | - | - | - | - | - | OFF | - | - | - | - | - |
| Sustained Alarm Normal Energized | - | - | - | - | - | - | ON | - | - | - | - | - |
| Instant Alarm Normal De-Energized | - | - | - | - | - | - | - | OFF | - | - | - | - |
| Instant Alarm Normal Energized | - | - | - | - | - | - | - | ON | - | - | - | - |
| LEDs - Standard Mode | - | - | - | - | - | - | - | - | OFF | - | - | - |
| LEDs - Alternate PEMEX Mode | - | - | - | - | - | - | - | - | ON | - | - | - |
| HART Enabled | - | - | - | - | - | - | - | - | - | OFF | - | - |
| HART Disabled | - | - | - | - | - | - | - | - | - | ON | - | - |
| Window Heater Disabled | - | - | - | - | - | - | - | - | - | - | OFF | - |
| Window Heater Enabled | - | - | - | - | - | - | - | - | - | - | ON | - |
| Test Lamp AO Mode Disabled | - | - | - | - | - | - | - | - | - | - | - | OFF |
| Test Lamp AO Mode Enabled | - | - | - | - | - | - | - | - | - | - | - | ON |

| | |
|--------------|--------|
| BLE Enabled | ON |
| BLE Disabled | OFF |
| AO Sink | Sink |
| AO Source | Source |

5.7.1 Time Delay Settings

When set to a minimum of 8 seconds, Time delay set via dipswitch guarantees that FL5000 will not go into SUSTAINED ALARM mode (20 mA) if the flame source is removed within 50% of set delay time from the start of flame. The unit will go into INSTANT ALARM mode (16 mA) upon seeing a flame source.

5.8 Powering the FL5000

After connecting to a 24 VDC power source, the unit will go through the following on power up:

- all four LEDs (red, yellow, blue, green) will blink in a series for 15 seconds
- the unit will output an analog signal of 0 mA (3.5 mA with HART or 1.25 mA for HART with small current enabled)
- the fault relay will be in the de-energized state

If the unit is configured with relays energized, the relays will de-energize for approximately 0.5 seconds. Upon completion of the power on sequence, the green LED will alternate - on for 5 seconds and off for 0.5 seconds to indicate a READY status.

Refer to [3.3 Bluetooth Connectivity](#) for steps to connect via Bluetooth upon power up.

5.9 Power Up Grounding of the Test and Relay Reset Lines

During power up, grounding the reset relay line for approximately 1 second forces the Modbus parameters on both channels to go to their default values of: 19,200 Baud, 8-N-1 format, Unit ID = 1 and HART short ID will reset to 0.

During power up, grounding the test line for approximately 1 second forces the unit to use the dipswitch settings rather than use the settings stored in the flash memory. These settings are for the energized/de-energized relay state, the alarm delay, and the unit sensitivity.

6 Maintenance

6.1 General Maintenance

Once correctly installed, the unit requires very little maintenance other than regular sensitivity checks and cleaning of the window. MSA recommends that a schedule be established and followed. Do not remove the electronics from the housing. Doing so will void the equipment's warranty.

NOTE: The removal of particulate matter and any film buildup on the Sapphire Window and COPM Reflector is necessary to ensure proper sensitivity of the system. It is recommended that the window and reflector be cleaned at least every 30 days if the detector is located in a particularly dirty environment.

6.2 Cleaning the Sapphire Window

Use Industrial Strength Windex® with Ammonia D (PN 10272-1) to clean the sapphire window. The window is not glass; it is made from sapphire. Do not touch the window or COPM reflector with fingers.

1. Wet a clean, soft, lint-free cloth, tissue or cotton swab with the cleaning solution.
2. Apply the solution to the window only.

NOTE: Do not apply the cleaning solution to the FL5000 housing.

3. Using a dry, unsoiled cloth, wipe until the window is clean.
4. Completely dry the window.
5. Repeat steps 1 through 4 for the reflector.

CAUTION!

Dirty or partially blocked windows can significantly reduce the detectors field of view and detection distance. Do not use a commercial glass cleaner other than Industrial Strength Windex® with Ammonia D.

Failure to follow this caution can result in minor or moderate injury.

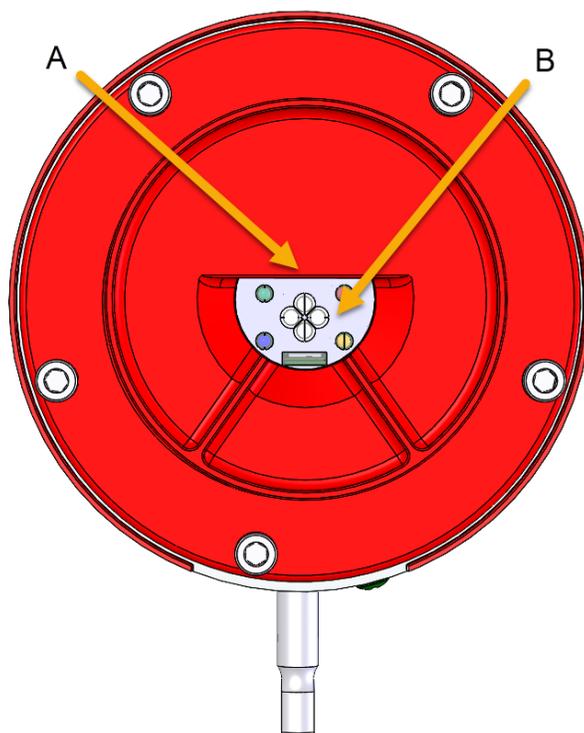


Figure 20 Optical Parts to Clean

(A) - COPM Reflector (Beneath Surface)

(B) - Sapphire Window

6.3 Sensitivity Check

To verify that each detector is functioning correctly, an MSA Test Lamp and/or the ALARM TEST function per [5.6.7 Alarm Test Terminals](#) should be used. Refer to [8.3 Accessories](#) for Test Lamp details.

6.4 Storage

The FL5000 should be stored in a clean, dry area and within the temperature and humidity ranges found in [8.2.4 Environmental Specifications](#).

6.5 Product Disposal and Recycling

At the end of a product's service life, the product shall be disposed of according to local government requirements. **If the product is leased, please return the decontaminated product to MSA or safety product distributor.**

Please help us in conserving resources and protecting the environment by following these disposal and recycling instructions:

- Packaging should be recycled.
- Products used in industrial or fireground applications should be decontaminated according to site policies or local government guidelines.
- Permanently mark the product "Do not use" and render the product unusable to ensure that it cannot be reused by another person.

7 Troubleshooting

This section is intended to be a guide to correcting problems, which may arise in the field. MSA should be contacted for assistance if the corrective action listed does not eliminate the problem. Defective units should be returned to MSA for repair with a complete written description of the problem.

NOTE: If the equipment is under warranty, any repairs performed by persons other than MSA authorized personnel may void the warranty. Please read the warranty statement carefully.

WARNING!

Be sure to inhibit or disconnect external alarm wiring before making any check that might send the unit into alarm.

Failure to follow this warning can result in serious personal injury or death.

| Problem | Possible Cause | Corrective Action |
|--|--|--|
| Analog output signal = 0 mA and green LED in window is off | No DC power to the Unit | Be sure that the +24 VDC is applied with the correct polarity |
| Analog output signal = 0 mA (3.5 or 1.25 mA with HART) and green LED in window is rapidly blinking | Low voltage FAULT (voltage at unit is approximately +18.5 VDC) | Be sure that the unit is powered with at least +24 VDC under load |
| Analog output signal = 0 mA (3.5 or 1.25 mA with HART) and green LED in window is rapidly blinking, +24 VDC verified | Flash Checksum Not OK | Re-cycle power to the unit |
| Analog output signal = 0 mA (3.5 or 1.25 mA with HART) and green LED in window is rapidly blinking, +24 VDC verified OK, power was re-cycled | Flash Checksum Still Not OK | Call MSA customer support |
| Analog output signal = 2 mA (3.5 mA with HART and small current disabled) and green LED in window is slowly blinking | COPM FAULT, dirty or obscured optical path (detector window) | Clean the window and reflector |
| Dipswitch settings do not match those observed in the operation of the detector | Device settings may have been changed by either HART, Modbus or Bluetooth and no longer correspond to those on the dipswitch | Recycle power to the unit while connecting the test IO terminal to ground (refer to 5.9 Power Up Grounding of the Test and Relay Reset Lines). After startup, adjust settings via dipswitch as described in 5.7 Switch Selectable Options . |
| Troubleshooting Bluetooth Errors | | |
| Blue LED is not flashing during start up or manual activation. | BLE dipswitch is off or connection is lost. | Ensure the BLE dipswitch is ON and the BLE connector is completely in its socket. |
| Blue LED is flashing, but the device is not pairing with the FL5000 on the app. | The device is too far away from the FL5000 to connect, or there is a weak signal preventing connection. | Move the user closer to the FL5000 or move to a different location if there is potential sources of interference between the device. |
| Blue LED is on for > 5 minutes after disconnection. | The FL5000 is still connected with the user's device. | Turn off Bluetooth connection on the user's device or recycle the FL5000's power. |

7.1 Final Assembly

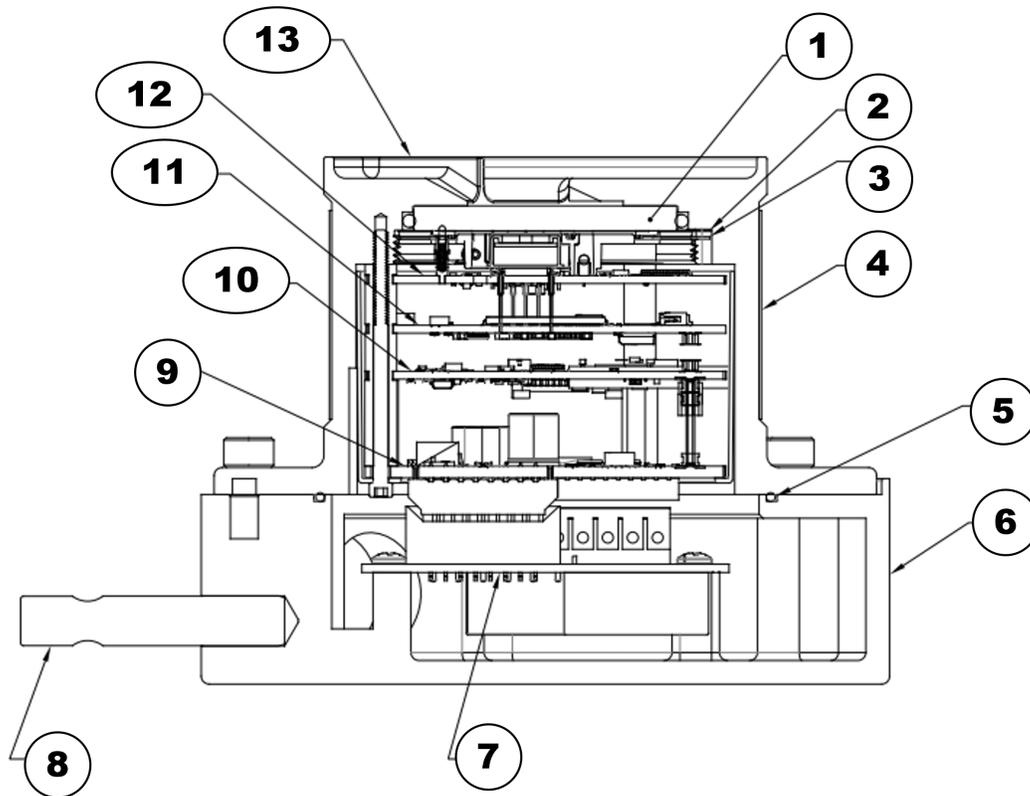


Figure 21 FL5000 Cross-Section View

| | | | |
|---|--------------------|----|-----------------------------|
| 1 | Sapphire Window | 8 | Mounting Pin |
| 2 | EMI Screen | 9 | Modular Power Board |
| 3 | Heater Ring Board | 10 | Modular Communication Board |
| 4 | Label | 11 | Modular Processor Board |
| 5 | O-Ring | 12 | Analog Board |
| 6 | Base Housing | 13 | Optical Housing Assembly |
| 7 | Field Wiring Board | | |

8 Learn More

8.1 Warranty

MSA, the Safety Company warrants that these products will be free from mechanical defect or faulty workmanship for a period of five (5) years from the date of delivery, provided it is maintained and used in accordance with MSA's instructions and/or recommendations.

This warranty does not apply to expendable or consumable parts whose normal life expectancy is less than one (1) year, such as, but not limited to, nonrechargeable batteries, filament units, filter, lamps, fuses, etc. MSA shall be released from all obligations under this warranty in the event that repairs or modifications are made by persons other than its own or authorized service personnel or if the warranty claim results from physical abuse or misuse of the product. No agent, employee, or representative of MSA has any authority to bind MSA to any affirmation, representation, or warranty concerning the goods sold under this contract. MSA makes no warranty concerning components or accessories not manufactured by MSA, but will pass on to the Purchaser all warranties of manufacturers of such components.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, AND IS STRICTLY LIMITED TO THE TERMS HEREOF. SELLER SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.

Exclusive Remedy

It is expressly agreed that the Purchaser's sole and exclusive remedy for breach of the above warranty, for any tortious conduct of the Seller, or for any other cause of action, shall be the repair and/ or replacement at the Seller's option of any equipment or parts thereof, which after examination by the Seller is proven to be defective. Replacement equipment and/or parts will be provided at no cost to the Purchaser, F.O.B. Seller's Plant. Failure of the Seller to successfully repair any nonconforming product shall not cause the remedy established hereby to fail of its essential purpose.

EXCLUSION OF CONSEQUENTIAL DAMAGE

THE PURCHASER SPECIFICALLY UNDERSTANDS AND AGREES THAT UNDER NO CIRCUMSTANCES WILL THE SELLER BE LIABLE TO THE PURCHASER FOR ECONOMIC, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSSES OF ANY KIND WHATSOEVER, INCLUDING BUT NOT LIMITED TO, LOSS OF ANTICIPATED PROFITS AND ANY OTHER LOSS CAUSED BY REASON OF NONOPERATION OF THE GOODS. THIS EXCLUSION IS APPLICABLE TO CLAIMS FOR BREACH OF WARRANTY, TORTIOUS CONDUCT, OR ANY OTHER CAUSE OF ACTION AGAINST THE SELLER.

8.2 Specifications

8.2.1 System Specifications

| | |
|------------------------|---|
| Typical Response Time: | 10 seconds, see 9 Certifications for FM Approval response times |
| Field of View*: | ±30° @ 210 ft (64 m), ±45° @ 110 ft (34 m), 90° total field of view |
| Sensitivity: | 310 ft (95 m), 140 ft (43 m), and 70 ft (21 m) for high, medium, and low sensitivities, respectively. Maximum distance for a 1 square foot (0.093 m ²) n-heptane fire to be reliably detected. For settings see 5.7 Switch Selectable Options . |

* Maximum specified FOV is the angle at which FL5000 can detect the flame at 50% of the maximum specified range. To comply with the directional dependence requirements for EN 54-10:2002, an angle of ± 30° from 0° (0° = Orientation of detector in same axes as flame source) should not be exceeded, based on lab testing at a distance of approximately 5.9 ft (1.8 m).

NOTE: Response Times and Field of View data were obtained from tests with a 1 square foot heptane fire. These are typical values and different results may occur depending on the variation of each fire.

8.2.2 Mechanical Specifications

| | |
|---------------------|---|
| Enclosure Material: | 316 Stainless Steel |
| Color: | Red |
| Finish: | Polyester TGIC Powder Coating |
| Vibration: | Tested to the vibration requirements of FM 3260, EN 54-10 and DNV-CG-0339 (Class A) |

8.2.3 Dimensions

| | |
|----------------------------|--|
| Height: | 4.15" (105 mm) |
| Diameter: | 5.44" (138 mm) Base 3.50" (89 mm) Optical Housing |
| Weight: | 7.6 lbs (3.447 kg) |
| Weight (w/ mount bracket): | 9.125lbs (4.139 kg) |

8.2.4 Environmental Specifications

| | |
|------------------------------|--|
| Operating temperature range: | -40°F to 176°F (-40°C to 80°C) - FM3260 & ULC-ORD-C386 -67°F to 176°F (-55°C to 80°C) - EN54-10 & DNV-CG-0339 |
| Storage temperature range: | -40°F to 176°F (-40°C to 80°C) - FM3260 & ULC-ORD-C386 -67°F to 176°F (-55°C to 80°C) - EN54-10 & DNV-CG-0339 |
| Humidity range: | 0% to 95% RH, non-condensing |
| Maximum use altitude: | 2000 m above sea level |

8.2.5 Electrical Specifications*

| | |
|-----------------------------|--|
| Nominal supply voltage: | 24 VDC (5.7 W with Heater 'OFF', 8.9 W with Heater 'ON') |
| Range: | 20 to 32 VDC |
| Maximum power consumption: | 6.2 W (heater 'OFF') 9.7 W (heater 'ON') |
| Spectral range: | 2 – 5 microns (IR) |
| Maximum output signal load: | 600 Ω @ 24 VDC |

* See [9 Certifications](#) for Certifications

| | HART (1.25 mA) * | HART (3.5 mA) | HART Disabled/OFF |
|-------------------------|-------------------|-------------------|-------------------|
| Output signal range: | 1.25 – 20 mA | 3.5 – 20 mA | 0 to 20 mA |
| FAULT signal: | 1.25 mA | 3.5 mA | 0 to 0.2 mA |
| COPM fault signal: | 2.0 \pm 0.2 mA | 3.5 mA | 2.0 \pm 0.2 mA |
| Ready signal: | 4.05 \pm 0.2 mA | 4.05 \pm 0.2 mA | 4.3 \pm 0.2 mA |
| INSTANT ALARM signal: | 16.0 \pm 0.2 mA | 16.0 \pm 0.2 mA | 16.0 \pm 0.2 mA |
| SUSTAINED ALARM signal: | 20.0 \pm 0.2 mA | 20.0 \pm 0.2 mA | 20.0 \pm 0.2 mA |
| Bluetooth load: | 3.0 mA | 3.0 mA | 3.0 mA |

* HART (1.25 mA) is the default.

NOTE: Refer to the FL5000 Modbus or HART manual for Current Range selection.

| | |
|------------------------|--|
| Relay Contact Ratings: | 8 A @ 24 VDC, Resistive MAX |
| RS-485 Output: | Modbus* - 128 units in series MAX (247 units with repeaters) |
| Baud Rate: | 2400, 4800, 9600, 19200, and 38400 Baud (See Terminal Connections 3-4 for Alarm Output Connections) |
| Status Indicator: | Two LEDs indicate status, fault conditions |

* Modbus Communication field wiring terminals are intended for device setup and programming purposes only.

8.2.6 Product Certification

See [9 Certifications](#) for FM approval (electrical safety, hazardous locations [division/zone], flame performance [FM 3260/ULC-ORD-C386/EN 54-10], functional safety [SIL]), CSA certification (electrical safety, hazardous locations [division]) and DNV certification (maritime).

8.3 Accessories

Additional information is available upon request for any of the accessories below.

8.3.1 Test Lamp with Charger - PN TL105-1001

Due to the advanced discrimination of the FL5000, the TL105 Test Lamp was developed. The Test Lamp is a battery operated, rechargeable, test source specifically designed to test General Monitors' IR Flame Detection Systems. It consists of a high-energy broadband radiation source that emits sufficient energy in the infrared spectra to activate the IR detector. To simulate a fire, the TL105 Test Lamp automatically flashes a signal that the FL5000 recognizes.

For full instructions see [4.3.1 Test Lamp](#).



Figure 22 Test Lamp Accessory

8.3.2 Mounting Bracket - PN 71370-1

A mounting bracket is available to mount the FL5000 to a wall, pole, etc. The mounting bracket design allows for optical alignment adjustments when utilizing to a fixed installation. Please refer to [Figure 11 Detector Mounting and Installation](#).



Figure 23 Mounting Bracket Accessory

8.3.3 Rain Guard - PN 712004-1

To install the Rain Guard accessory:

1. Before assembling the Rain Guard to the flame detector, place the clamp into the mating groove of the rain guard.
2. Slide the Rain Guard/clamp over the face of the FL5000.

NOTE: The center arrow must align with the center of the front housing.

3. Tighten the hose clamp with a torque driver to 22 in-lb (2.5 N-m).



Figure 24 Rain Guard Accessory

8.3.4 Air Curtain - PN 712881-1

The Model AC45 Compressed Air Curtain accessory protects the optical surfaces of your MSA IR flame detector. It uses positive air pressure to create a protective air curtain that prevents contaminants from settling onto the detector's optical surfaces. See the AC45 Air Curtain data sheet and manual for additional details.



Figure 25 Air Curtain Accessory

8.3.5 Field Wiring Connections

3/4" NPT Plug - PN 10177576

A stainless steel, explosion proof conduit 3/4-14 NPT plug.

M25 Plug - PN 10203507

A stainless steel, explosion proof conduit plug.

Thread Adapter - PN 914-196

A stainless steel explosion proof 3/4" NPT Male to M25 Female adapter.

8.3.6 FL4000H Upgrade Kit - PN 10242703

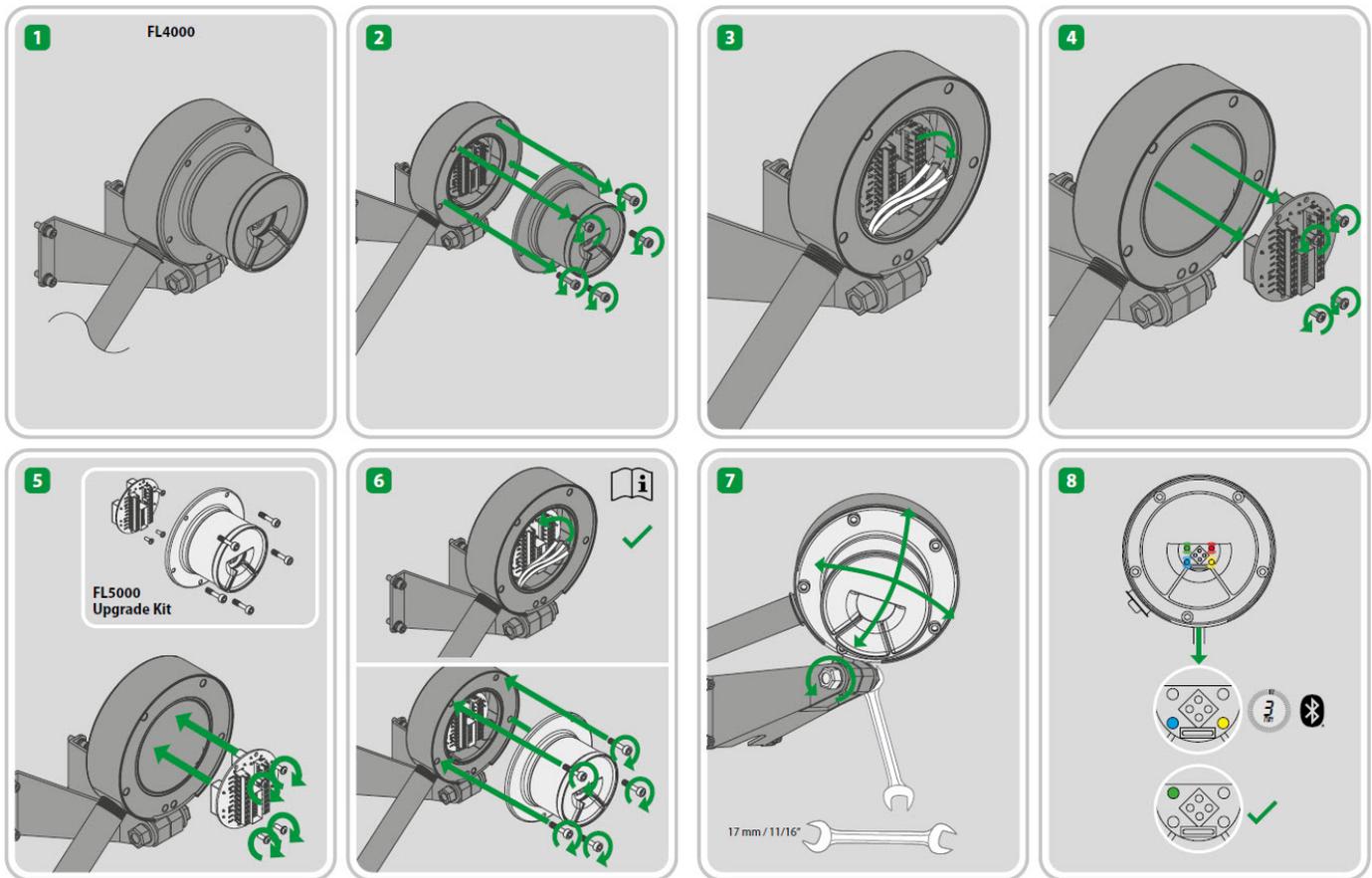


Figure 26 FL4000H Upgrade Kit Quick Start Insert

9 Certifications

Approvals subject to change without notice and may differ based on configuration, part number and/or country. Contact Customer Service or check the approval label on the product for specific approval information.

| Region | Certification | Agency | Primary Standard | Details |
|------------------------|---|--------|--|---|
| United States | Performance FM21US0085X | FM | FM 3260 | See Section 9.1 (High/Med/Low Sensitivity) |
| | Hazardous Location (Division) FM21US0085X | FM | FM 3611, FM 3615, FM 3616 | Class I, Div. 1, Groups B, C, D Class II/III, Div. 1/2, Groups E, F, G Class I, Div. 2, Groups A, B, C, D T4 (-40°C ≤ Ta ≤ +80°C) Type 6P, IP66/67 |
| | Hazardous Location (Zone) FM21US0085X | FM | UL 60079-1, UL 60079-31 | Class I, Zone 1, AEx db IIC T4 Gb Zone 21, AEx tb IIIC T135°C Db -40°C ≤ Ta ≤ +80°C, IP66/67 |
| Canada | Performance FM23CA0006X | FM | ULC-ORD-C386 | See Section 9.1 (High/Med/Low Sensitivity) |
| | Electrical Safety | CSA | UL/CSA 61010-1, CSA C22.2 #94.2 | Pollution Degree 4, Type 6P |
| | Hazardous Location (Division) | CSA | CSA C22.2 #25, #30, #213 | Class I, Div. 1, Groups B, C, D Class II/III, Div. 1, Groups E, F, G T4 (-40°C ≤ Ta ≤ +80°C), IP66/67 Class I, Div. 2, Groups A, B, C, D T4 (-50°C ≤ Ta ≤ +80°C), IP66/67 |
| | Hazardous Location (Zone) FM23CA0006X | FM | CSA C22.2 #60079-1, #60079-31 | Ex db IIC T4 Gb, Ex tb IIIC T135C Db, -40°C ≤ Ta ≤ +80°C, IP66/67 |
| European Union & UK | Performance (Construction Product Regulation) 1725-CPR-UKE1019 2809-CPR-E0030 | FM | EN 54-10 | See Section 9.1 (Class 1 for High & Medium Sensitivity, Class 2 for Low Sensitivity) |
| | Performance (EMC Directive) | FM | EN 50130-4 | Compliant |
| | Hazardous Location (ATEX Directive) FM21ATEX0049X FM21UKEX0215X | FM | EN 60079-1, EN 60079-31 | II 2 G Ex db IIC T4 Gb, II 2 D Ex tb IIIC T135C Db, -55°C ≤ Ta ≤ +80°C, IP66/67 |
| Brazil | NCC YY.NNNN | NCC | ABNT NBR IEC 60079-0, ABNT NBR IEC 60079-1, ABNT NBR IEC 60079-31 | II 2 G Ex db IIC T4 Gb, II 2 D Ex tb IIIC T135C Db, -55°C ≤ Ta ≤ +80°C, IP66/67 |
| International | Hazardous Location IECEX FMG 21.0020X | FM | IEC 60079-1, IEC 60079-31 | Ex db IIC T4 Gb, Ex tb IIIC T135C Db, -55°C ≤ Ta ≤ +80°C, IP66/67 |
| | SIL Capability | FM | IEC 61508 Series | SIL 2 & SIL 3 Capable |

NOTE: For Special Conditions of Safe Use (X) see [1 Safety Regulations](#).

9 Certifications

9.1 Flame Performance FM3260, ULC-ORD-C386, EN 54-10

9.1.1 On-Axis Performance

The table below shows the response characteristics of the FL5000 in the presence of false alarm sources. The table below shows the FM approval characteristics.

| Fuel | Fire Size | Fire Distance ft (m), Average Response Time (seconds) by Sensitivity Setting for Instant Alarm : Sustained Alarm | | |
|-----------------|-----------------------|--|-------------------|------------------|
| | | High | Medium | Low |
| n-Heptane | 1' x 1' (0.3m x 0.3m) | 5 (1.5), 8 : 9 210 (64), 11 : 12 265 (81), 12 : 13 310 (95), 14 : 15 | 140 (43), 10 : 11 | 70 (21), 6 : 7 |
| Gasoline | 1' x 1' (0.3m x 0.3m) | 160 (49), 12 : 13 | 140 (43), 11 : 12 | 60 (18), 6 : 7 |
| Methanol | 1' x 1' (0.3m x 0.3m) | 160 (49), 15 : 16 | 70 (21), 10 : 11 | 25 (7.5), 5 : 6 |
| Methane | 32" (0.8) Plume | 180 (55), 11 : 12 | 90 (27), 7 : 7 | 40 (12), 6 : 7 |
| Butane | 32" (0.8) Plume | 160 (49), 14 : 15 | 90 (27), 10 : 11 | 50 (15), 10 : 11 |
| Propane | 32" (0.8) Plume | 180 (55), 11 : 12 | 90 (27), 8 : 9 | 40 (12), 6 : 7 |
| Ethane | 32" (0.8) Plume | 190 (58), 11 : 12 | 90 (27), 7 : 8 | 40 (12), 6 : 7 |
| Ethanol | 1' x 1' (0.3m x 0.3m) | 170 (52), 10 : 11 | 100 (30), 9 : 10 | 40 (12), 6 : 7 |
| Crude Oil | 1' x 1' (0.3m x 0.3m) | 140 (43), 11 : 12 | 115 (35), 13 : 14 | 50 (15), 11 : 12 |
| Ethelene Glycol | 1' x 1' (0.3m x 0.3m) | 120 (37), 15 : 16 | 50 (15), 7 : 8 | 20 (6), 9 : 10 |
| Isopropanol | 1' x 1' (0.3m x 0.3m) | 180 (55), 13 : 14 | 120 (37), 10 : 11 | 50 (15), 6 : 7 |
| Diesel | 1' x 1' (0.3m x 0.3m) | 140 (43), 13 : 14 | 80 (24), 11 : 12 | 40 (12), 6 : 7 |
| JP4 | 1' x 1' (0.3m x 0.3m) | 160 (49), 13 : 14 | 100 (30), 9 : 10 | 60 (18), 9 : 10 |
| JP4 | 2' x 2' (0.6m x 0.6m) | 170 (52), 12 : 13 | 110 (34), 7 : 8 | 50 (15), 6 : 7 |
| JP5 | 1' x 1' (0.3m x 0.3m) | 150 (46), 14 : 15 | 120 (37), 11 : 12 | 50 (15), 6 : 7 |
| JP5 | 2' x 2' (0.6m x 0.6m) | 200 (61), 13 : 14 | 160 (49), 10 : 11 | 70 (21), 9 : 10 |
| JP8 | 1' x 1' (0.3m x 0.3m) | 170 (52), 12 : 13 | 120 (37), 12 : 13 | 60 (18), 6 : 7 |
| JP8 | 2' x 2' (0.6m x 0.6m) | 180 (55), 12 : 13 | 135 (41), 13 : 14 | 55 (17), 7 : 8 |
| Jet Fuel A | 1' x 1' (0.3m x 0.3m) | 180 (55), 11 : 12 | 120 (37), 12 : 13 | 60 (18), 7 : 8 |
| Jet Fuel A | 2' x 2' (0.6m x 0.6m) | 170 (52), 12 : 13 | 130 (40), 12 : 13 | 70 (21), 7 : 8 |
| Marina Fuel | 1' x 1' (0.3m x 0.3m) | 190 (58), 14 : 14 | 170 (52), 11 : 12 | 70 (21), 8 : 9 |
| Kerosene | 1' x 1' (0.3m x 0.3m) | 160 (49), 13 : 14 | 140 (43), 12 : 13 | 50 (15), 7 : 8 |
| Xylene | 1' x 1' (0.3m x 0.3m) | 150 (46), 11 : 12 | 80 (24), 14 : 15 | 50 (15), 6 : 7 |
| MEK | 1' x 1' (0.3m x 0.3m) | 170 (52), 9 : 10 | 140 (43), 10 : 11 | 60 (18), 6 : 7 |
| Wood | 6" x 6" (0.2 x 0.2) | 80 (24), 14 : 15 | 60 (18), 9 : 9 | 25 (7), 9 : 10 |
| Cardboard | 6" x 6" (0.2 x 0.2) | 90 (27), 12 : 13 | 70 (21), 10 : 11 | 20 (6), 6 : 7 |

In general, the operator should try to avoid exposing the detector to false alarm sources. Many false stimuli such as welding or heaters emit high amounts of IR radiation, which tend to degrade the performance of the instrument.

EN54-10 Classification

The table below shows the FM Approved EN54-10 classifications and extended distance claims.

| Sensitivity | Classification | Fuel | Size | Distance ft (m) | Avg. Response Time (seconds) |
|--------------------|-----------------------|-----------------------|---------------------------|----------------------------|--|
| High | Class 1 (≥25 m) | n-Heptane/ Toluene | 330mm x 330mm x 50mm deep | 210 (64) | Instant Alarm: 6 Sustained Alarm: 7 |
| High | Class 1 (≥25 m) | Methylated Spirits | 0.5m x 0.5m x 50mm deep | 210 (64) | Instant Alarm: 9 Sustained Alarm: 10 |
| Medium | Class 1 (≥25 m) | n-Heptane/ Toluene | 330mm x 330mm x 50mm deep | 140 (43) | Instant Alarm: 5 Sustained Alarm: 6 |
| Medium | Class 1 (≥25 m) | Methylated Spirits | 0.5m x 0.5m x 50mm deep | 150 (46) | Instant Alarm: 10 Sustained Alarm: 11 |
| Low | Class 1 (≥25 m) | n-Heptane/ Toluene | 330mm x 330mm x 50mm deep | 85 (26) | Instant Alarm: 5 Sustained Alarm: 6 |
| Low | Class 2 (≥17 m) | Methylated Spirits | 0.5m x 0.5m x 50mm deep | 57 (17) | Instant Alarm: 16 Sustained Alarm: 17 |

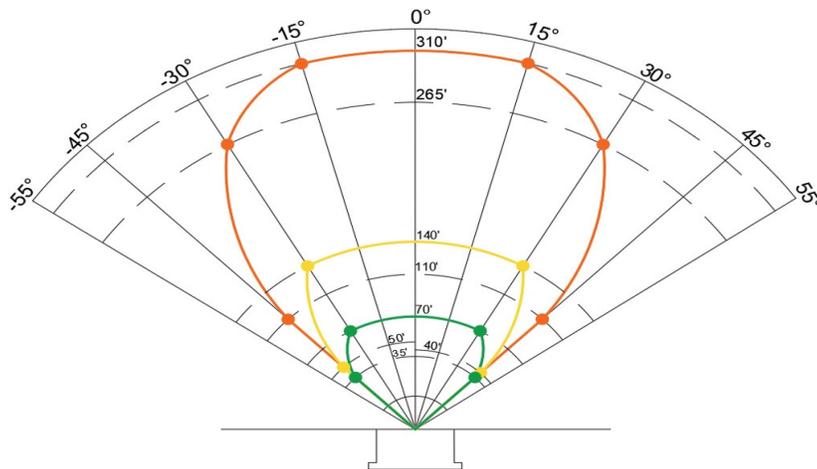
9.1.2 Field of View Performance

The FM Approved FL5000 Flame Detector has a maximum range of 310 feet (95 m).

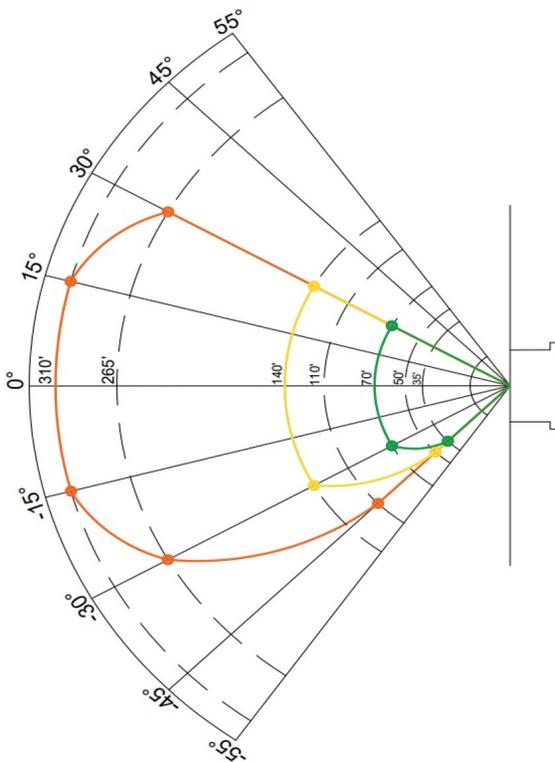
The FOV has its vertex at the center of the detector. Horizontal FOV is measured in the horizontal plane going through the center axis of the detector, and vertical FOV is measured in the vertical plane going through the same axis. Both horizontal and vertical FOV are defined for high, medium and low sensitivity settings of the FL5000, as shown in the charts below.

NOTE: Maximum specified FOV is the angle at which FL5000 can detect the flame at 50% of the maximum specified range. To comply with the Directional Dependence requirements for EN 54-10:2002, an angle of $\pm 30^\circ$ from 0° (0° = orientation of detector in same axes as flame source) should not be exceeded, based on lab testing at a distance of approximately 3.3 ft (1.0 m).

n-Heptane (1' x 1')

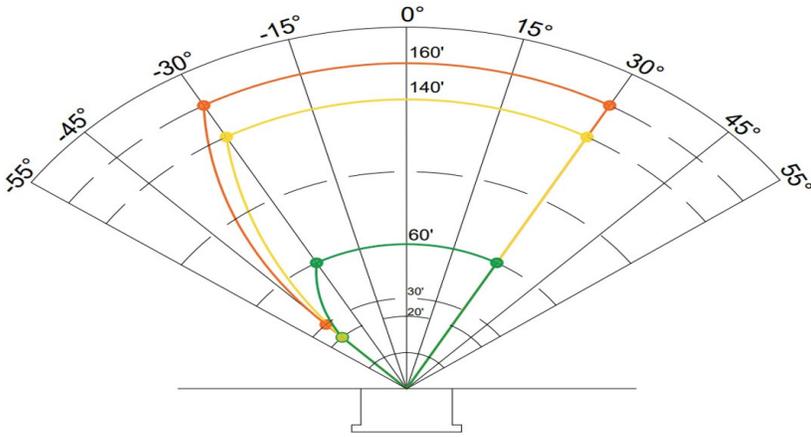


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 310' | 140' | 70' |
| +15° | 310' | 140' | 70' |
| -15° | 310' | 140' | 70' |
| +30° | 265' | 140' | 70' |
| -30° | 265' | 140' | 70' |
| +45° | 110' | 40' | 35' |
| -45° | 110' | 50' | 35' |

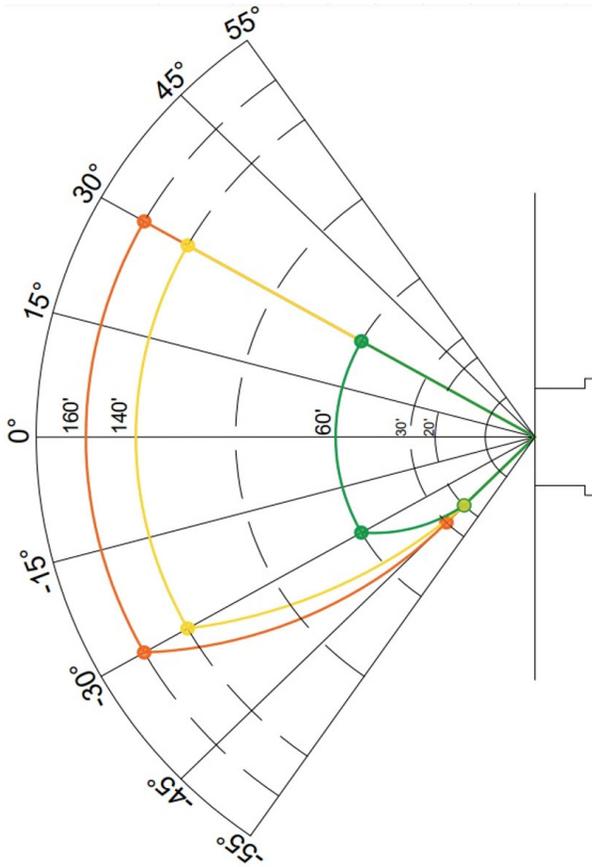


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 310' | 140' | 70' |
| +15° | 310' | 140' | 70' |
| -15° | 310' | 140' | 70' |
| +30° | 265' | 140' | 70' |
| -30° | 265' | 140' | 70' |
| +45° | 110' | 40' | 35' |
| -45° | 110' | 50' | 35' |

Gasoline (1' x 1')

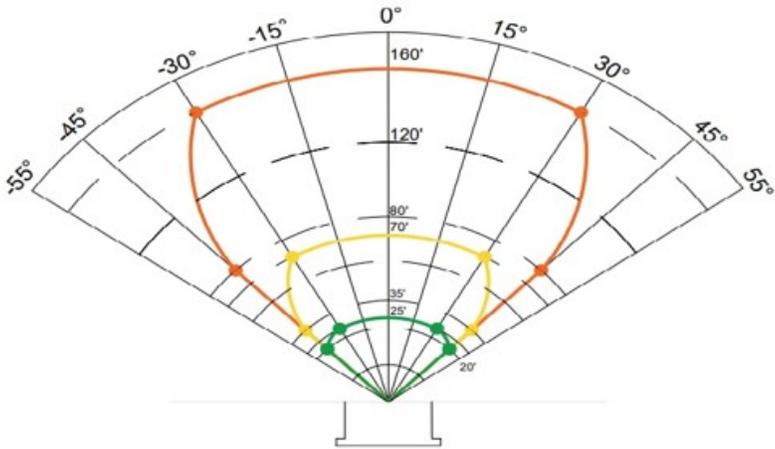


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 160' | 140' | 60' |
| + 30° | 160' | 140' | 60' |
| - 30° | 160' | 140' | 60' |
| + 45° | -- | -- | -- |
| - 45° | 30' | 20' | 20' |

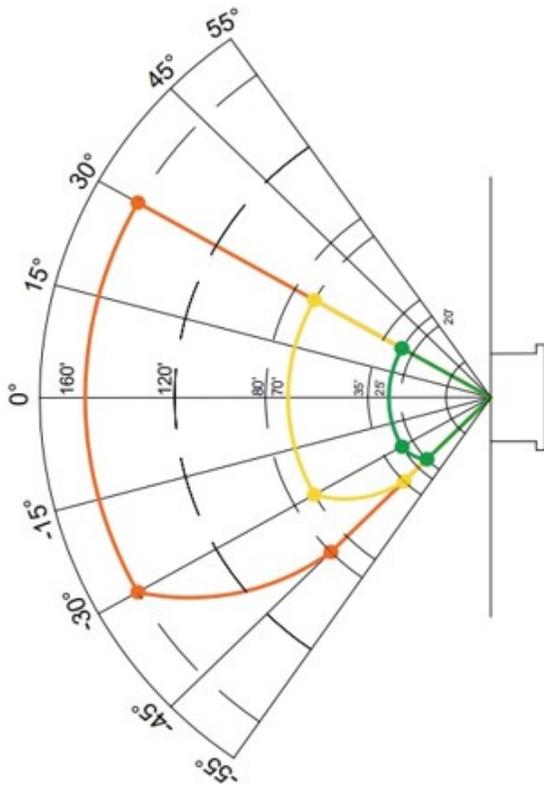


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 160' | 140' | 60' |
| + 30° | 160' | 140' | 60' |
| - 30° | 160' | 140' | 60' |
| - 45° | 30' | 20' | 20' |

Methanol (1' x 1')

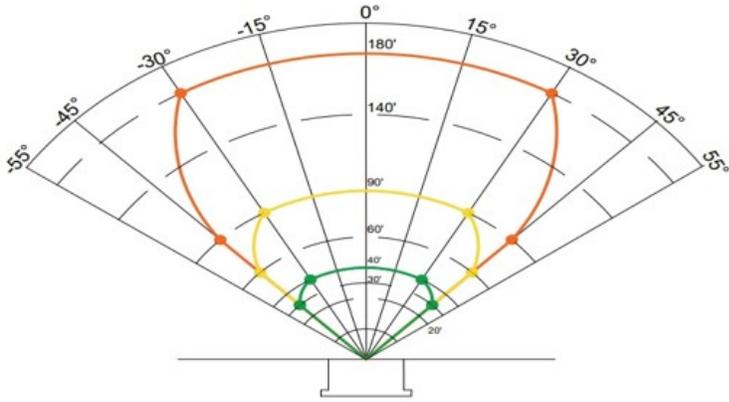


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 160' | 70' | 25' |
| + 30° | 160' | 70' | 25' |
| - 30° | 160' | 70' | 25' |
| + 45° | 80' | 35' | 20' |
| - 45° | 80' | 35' | 20' |

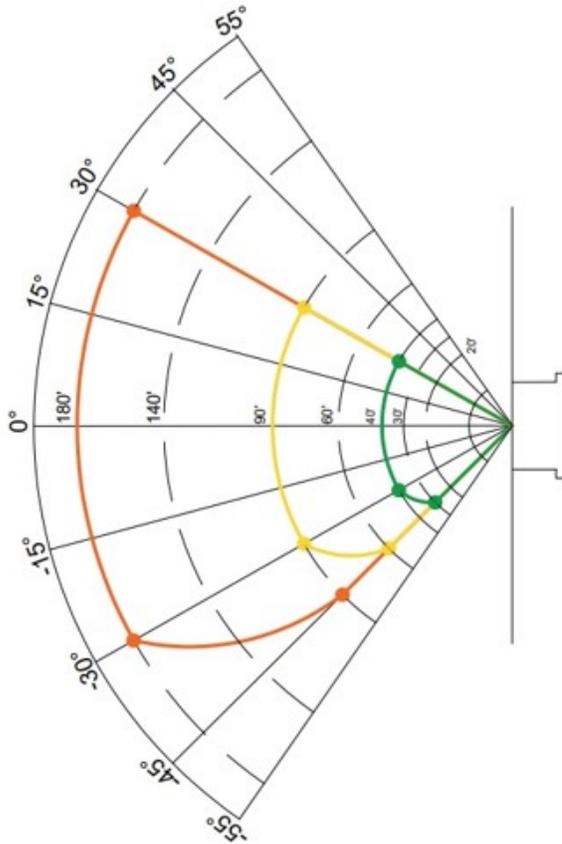


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 160' | 70' | 25' |
| + 30° | 160' | 70' | 25' |
| - 30° | 160' | 70' | 25' |
| - 45° | 80' | 35' | 20' |

Methane (32" Plume)

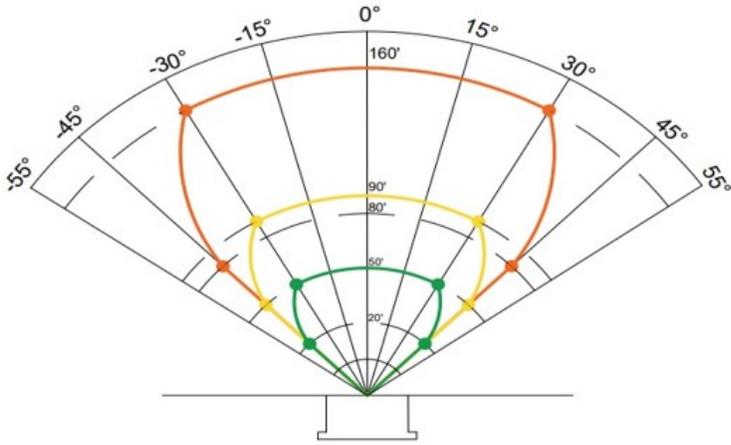


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 180' | 90' | 40' |
| + 30° | 180' | 90' | 40' |
| - 30° | 180' | 90' | 40' |
| + 45° | 90' | 60' | 30' |
| - 45° | 90' | 60' | 30' |

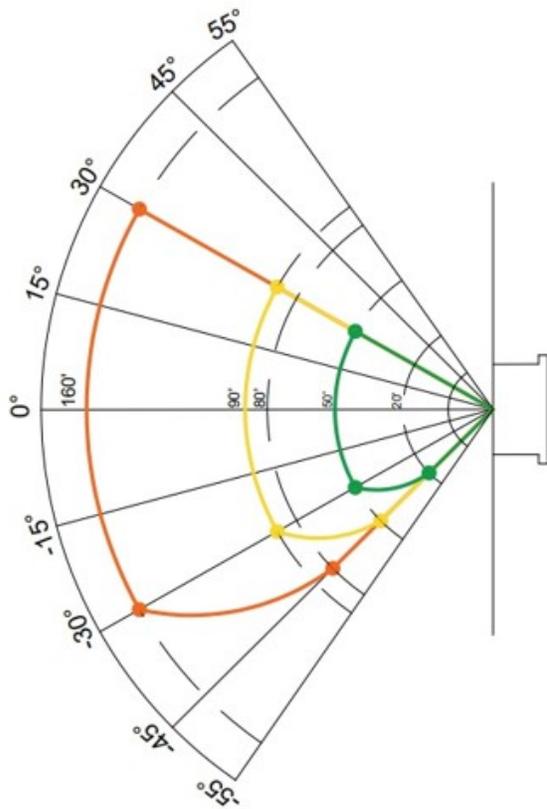


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 180' | 90' | 40' |
| + 30° | 180' | 90' | 40' |
| - 30° | 180' | 90' | 40' |
| - 45° | 90' | 60' | 30' |

Butane (32" Plume)

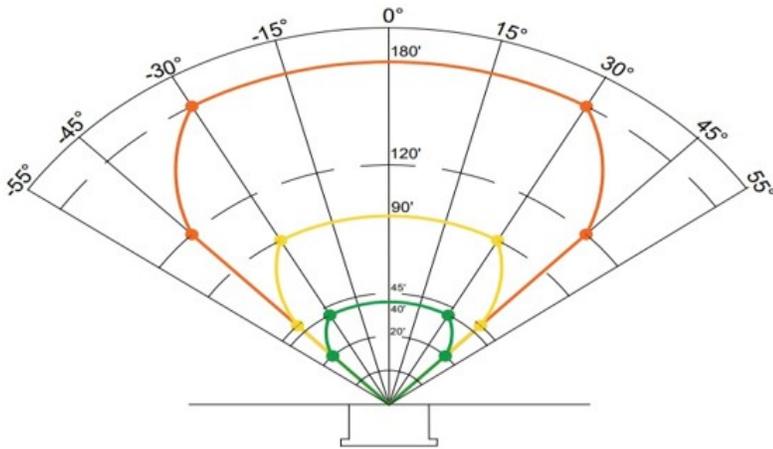


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 160' | 90' | 50' |
| + 30° | 160' | 90' | 50' |
| - 30° | 160' | 90' | 50' |
| + 45° | 80' | 50' | 20' |
| - 45° | 80' | 50' | 20' |

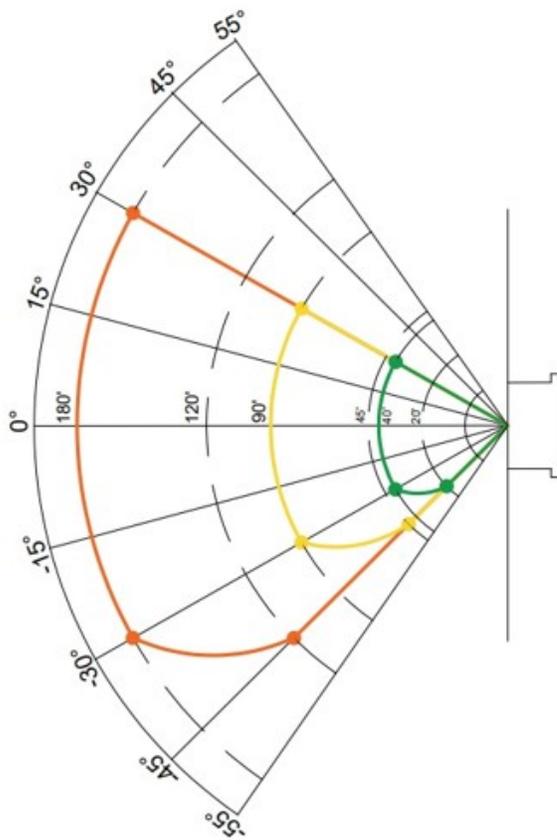


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 160' | 90' | 50' |
| + 30° | 160' | 90' | 50' |
| - 30° | 160' | 90' | 50' |
| - 45° | 80' | 50' | 20' |

Propane (32" Plume)

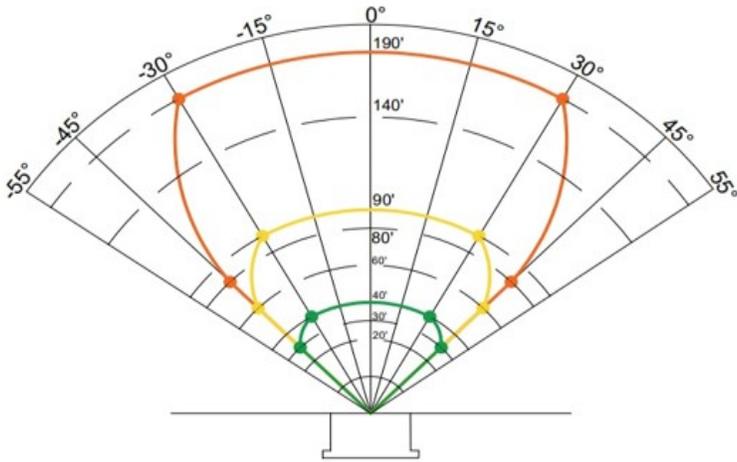


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 180' | 90' | 40' |
| + 30° | 180' | 90' | 40' |
| - 30° | 180' | 90' | 40' |
| + 45° | 120' | 45' | 20' |
| - 45° | 120' | 45' | 20' |

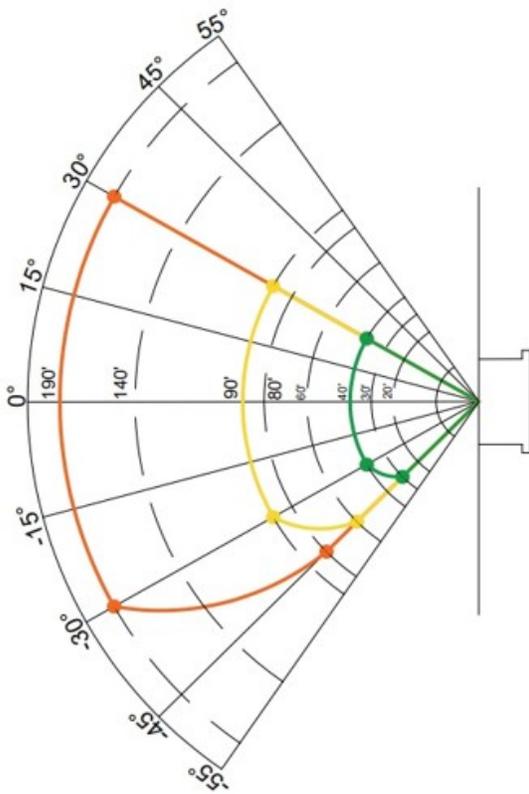


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 180' | 90' | 40' |
| + 30° | 180' | 90' | 40' |
| - 30° | 180' | 90' | 40' |
| - 45° | 120' | 45' | 20' |

Ethane (32" Plume)

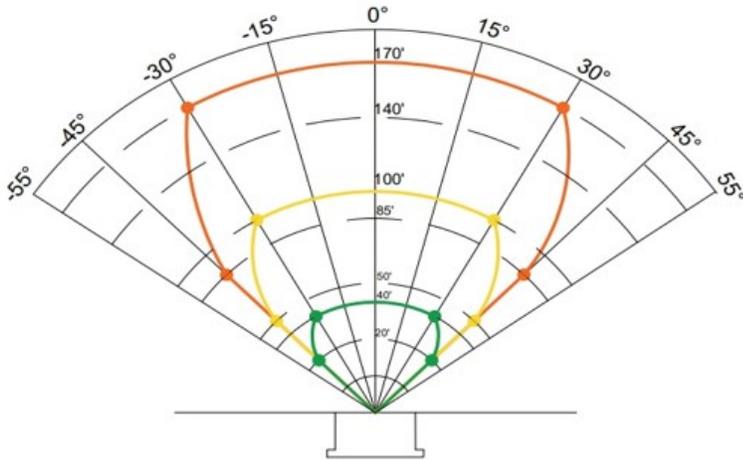


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 190' | 90' | 40' |
| + 30° | 190' | 90' | 40' |
| - 30° | 190' | 90' | 40' |
| + 45° | 80' | 60' | 30' |
| - 45° | 80' | 60' | 30' |

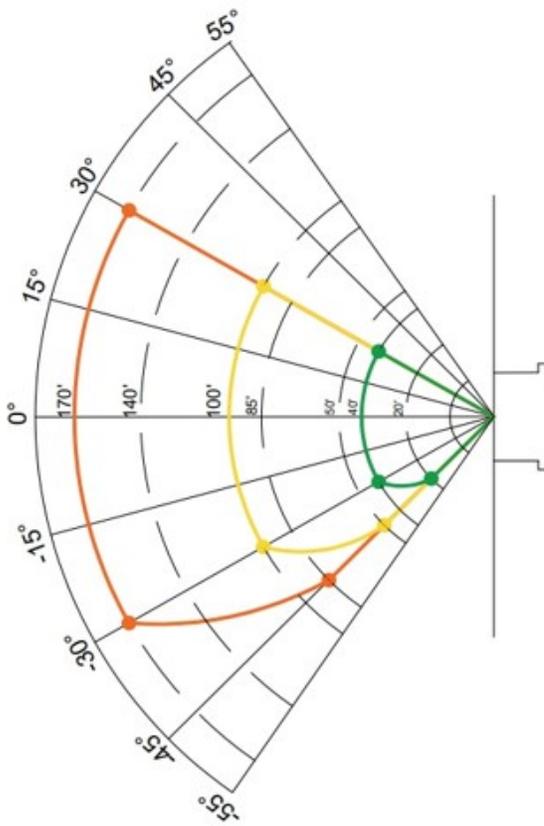


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 190' | 90' | 40' |
| + 30° | 190' | 90' | 40' |
| - 30° | 190' | 90' | 40' |
| - 45° | 80' | 60' | 30' |

Ethanol (1' x 1')

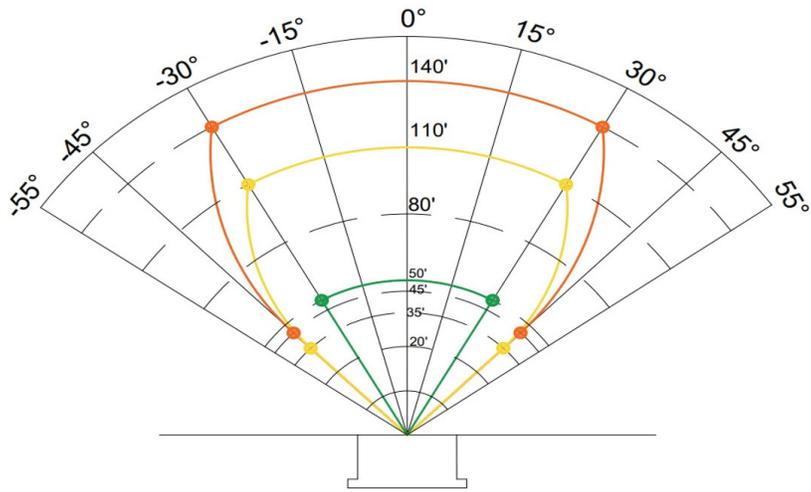


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 170' | 100' | 40' |
| + 30° | 170' | 100' | 40' |
| - 30° | 170' | 100' | 40' |
| + 45° | 85' | 50' | 20' |
| - 45° | 85' | 50' | 20' |

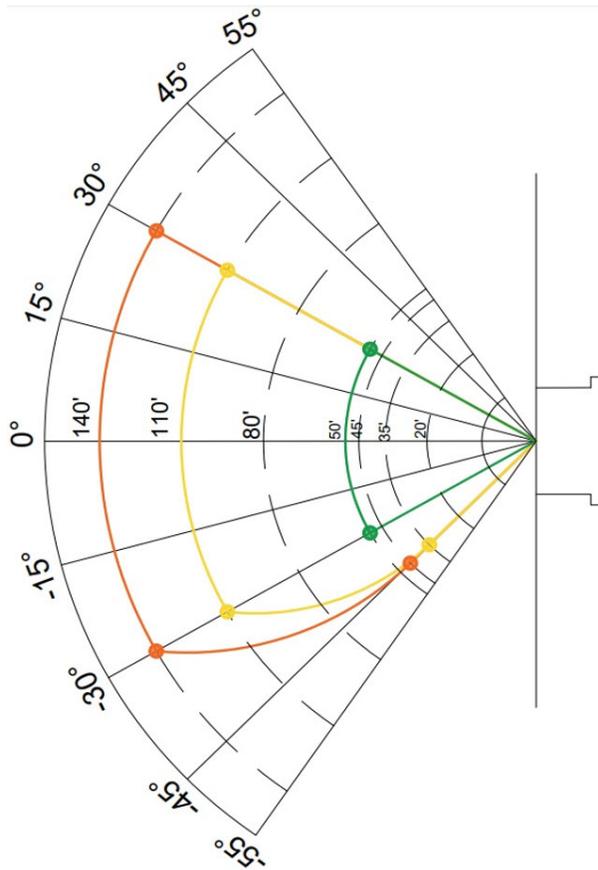


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 170' | 100' | 40' |
| + 30° | 170' | 100' | 40' |
| - 30° | 170' | 100' | 40' |
| - 45° | 85' | 50' | 20' |

Crude Oil (1' x 1')

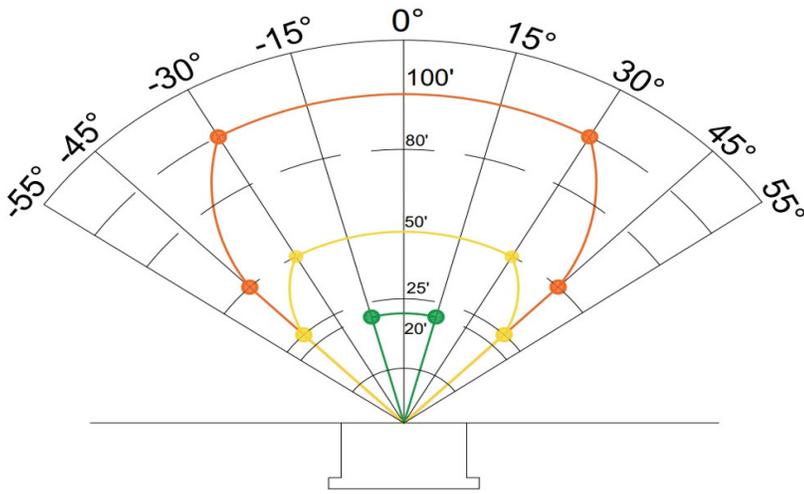


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 140' | 115' | 50' |
| + 30° | 140' | 110' | 50' |
| - 30° | 140' | 110' | 50' |
| + 45° | 45' | 35' | -- |
| - 45° | 45' | 35' | -- |

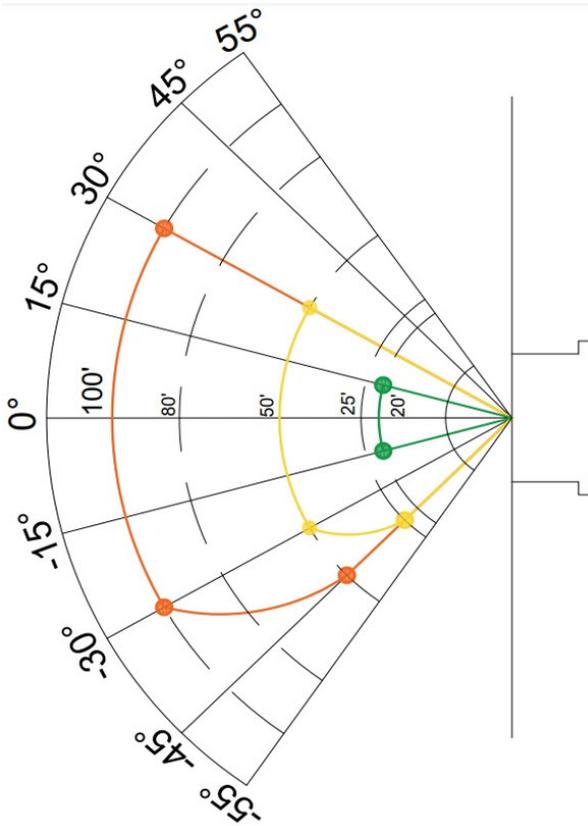


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 140' | 110' | 50' |
| + 30° | 140' | 110' | 50' |
| - 30° | 140' | 110' | 50' |
| - 45° | 45' | 35' | -- |

Ethylene Glycol (1' x 1')

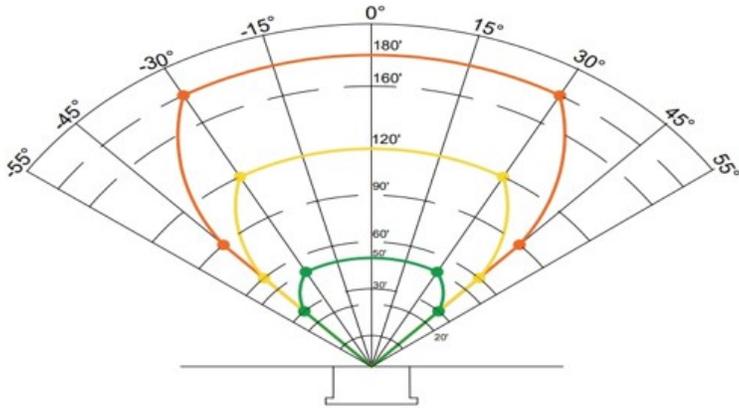


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 120' | 50' | 20' |
| + 30° | 100' | 50' | 20' |
| - 30° | 100' | 50' | 20' |
| + 45° | 50' | 25' | -- |
| - 45° | 50' | 25' | -- |

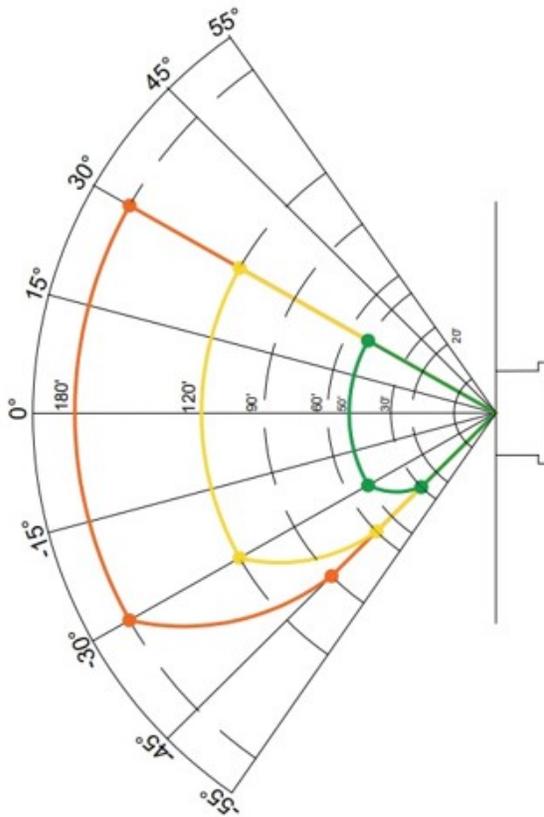


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 100' | 50' | 20' |
| + 30° | 100' | 50' | 20' |
| - 30° | 100' | 50' | 20' |
| - 45° | 50' | 25' | -- |

Isopropanol (1' x 1')

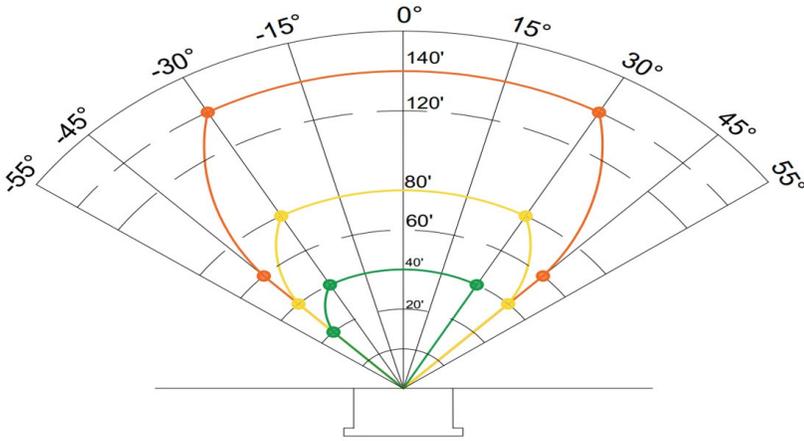


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 180' | 120' | 50' |
| + 30° | 180' | 120' | 50' |
| - 30° | 180' | 120' | 50' |
| + 45° | 90' | 60' | 30' |
| - 45° | 90' | 60' | 30' |

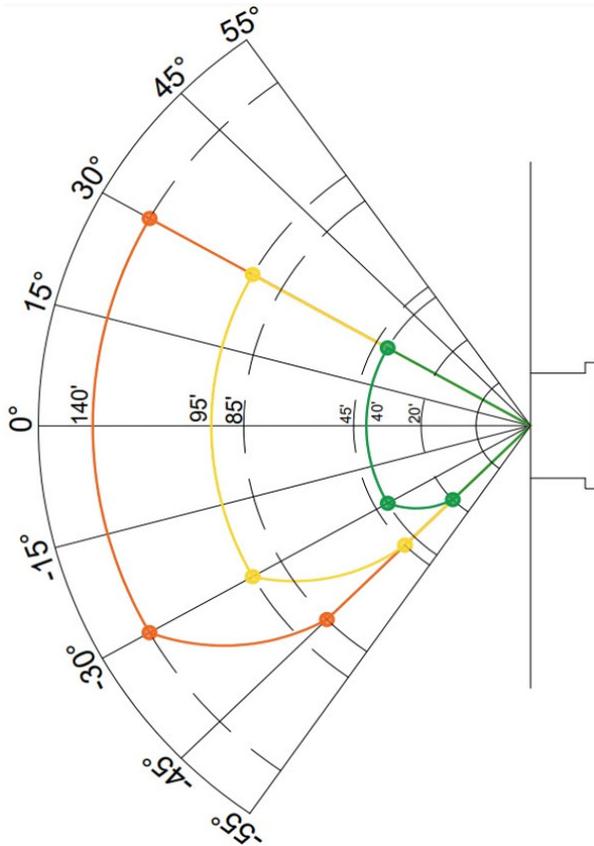


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 180' | 120' | 50' |
| + 30° | 180' | 120' | 50' |
| - 30° | 180' | 120' | 50' |
| - 45° | 90' | 60' | 30' |

Diesel (1' x 1')

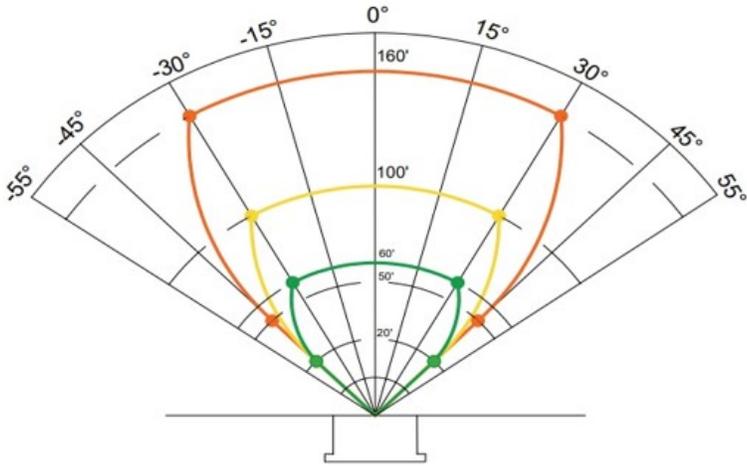


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 140' | 80' | 40' |
| + 30° | 140' | 80' | 40' |
| - 30° | 140' | 80' | 40' |
| + 45° | 60' | 40' | -- |
| - 45° | 60' | 40' | 20' |

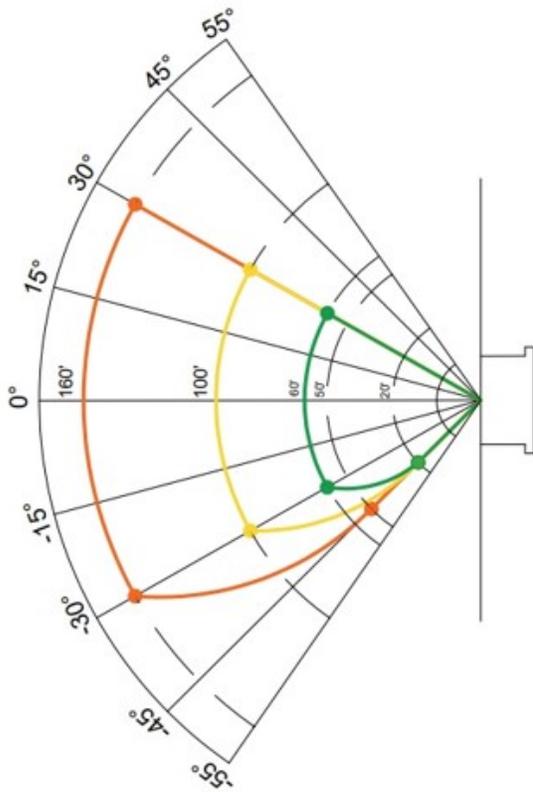


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 140' | 95' | 40' |
| + 30° | 140' | 95' | 40' |
| - 30° | 140' | 95' | 40' |
| - 45° | 85' | 45' | 20' |

JP4 (1' x 1')

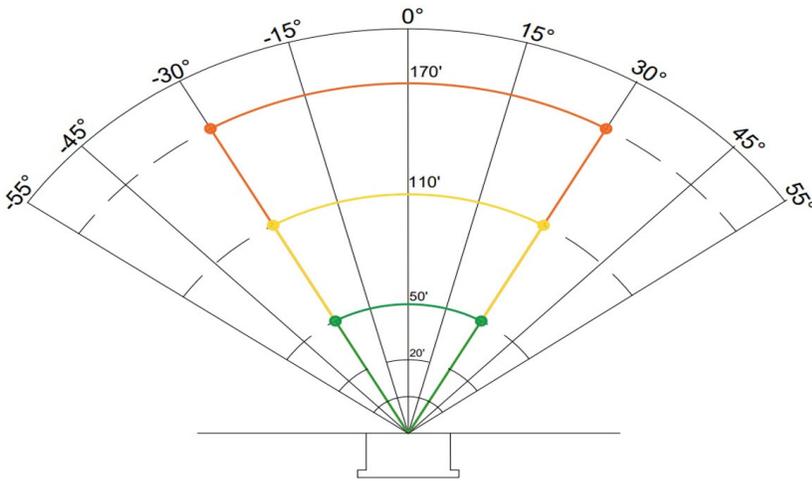


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 160' | 100' | 60' |
| + 30° | 160' | 100' | 60' |
| - 30° | 160' | 100' | 60' |
| + 45° | 50' | 20' | 20' |
| - 45° | 50' | 20' | 20' |

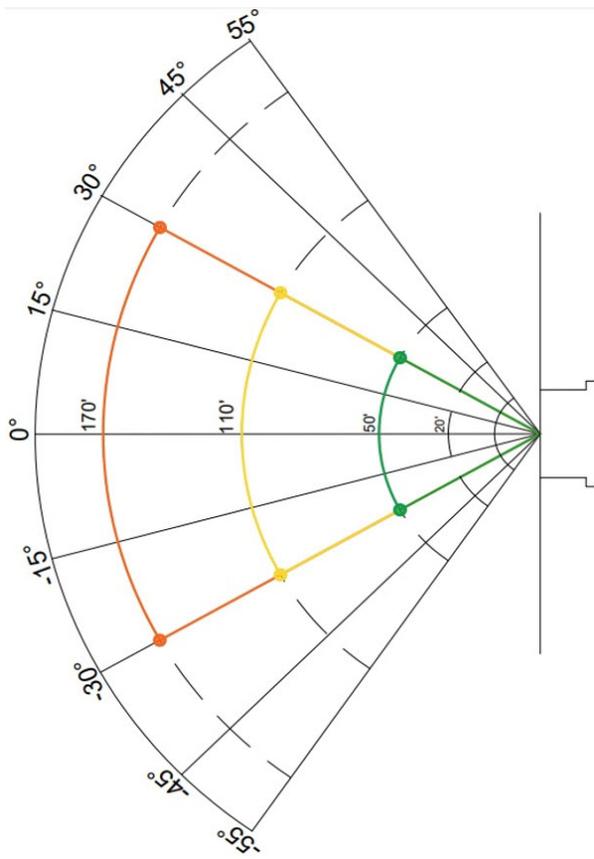


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 160' | 100' | 60' |
| + 30° | 160' | 100' | 60' |
| - 30° | 160' | 100' | 60' |
| - 45° | 50' | 20' | 20' |

JP4 (2' x 2')

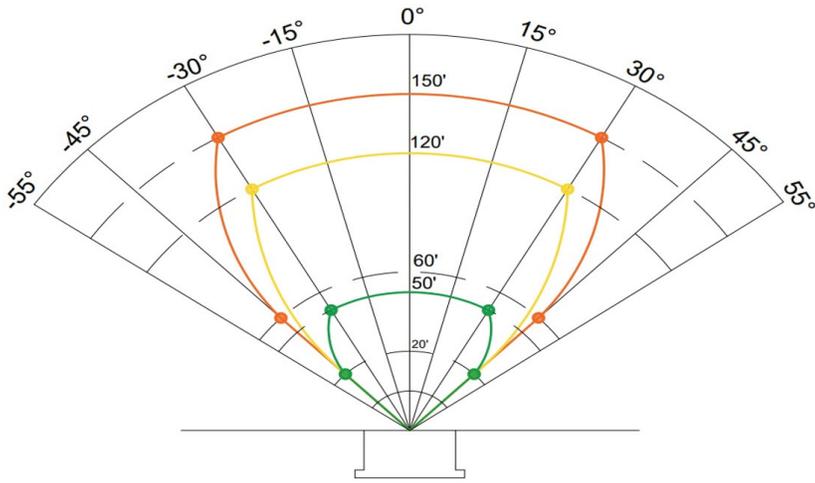


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 170' | 110' | 50' |
| + 30° | 170' | 110' | 50' |
| - 30° | 170' | 110' | 50' |
| + 45° | -- | -- | -- |
| - 45° | -- | -- | -- |

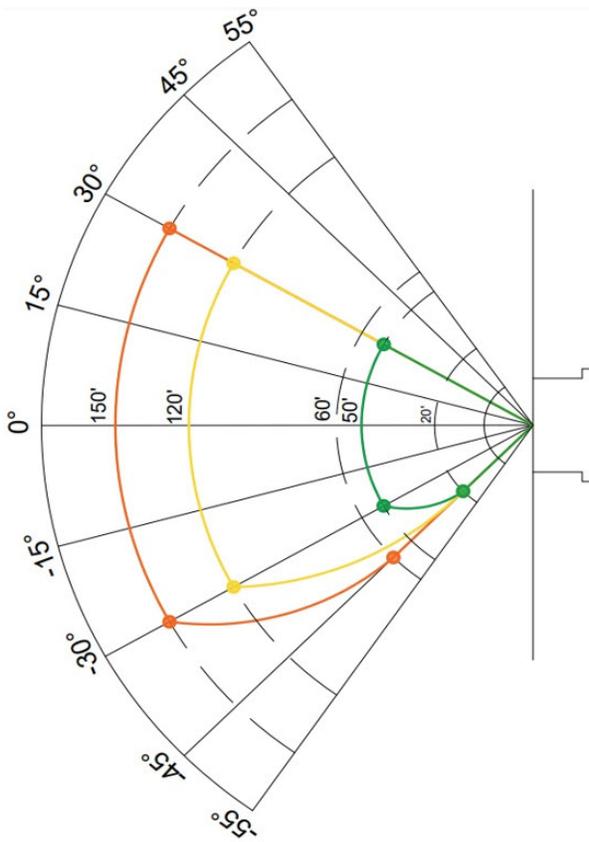


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 170' | 110' | 50' |
| + 30° | 170' | 110' | 50' |
| - 30° | 170' | 110' | 50' |
| - 45° | -- | -- | -- |

JP5 (1' x 1')

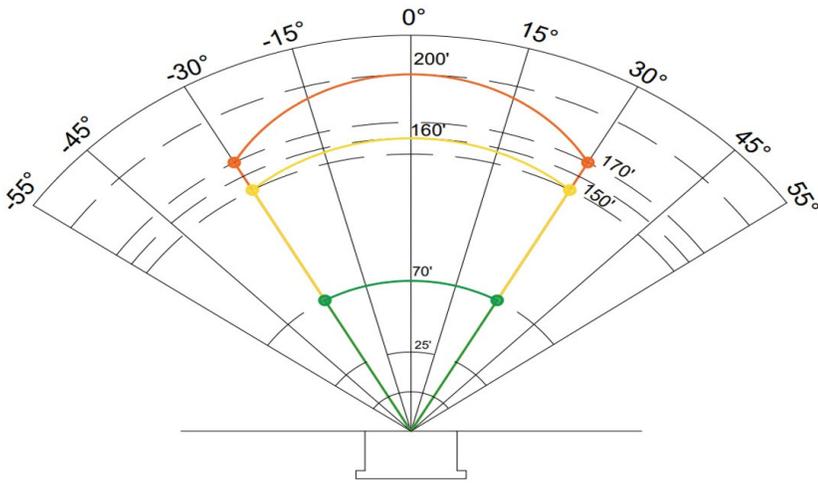


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 150' | 120' | 50' |
| + 30° | 150' | 120' | 50' |
| - 30° | 150' | 120' | 50' |
| + 45° | 60' | 20' | 20' |
| - 45° | 60' | 20' | 20' |

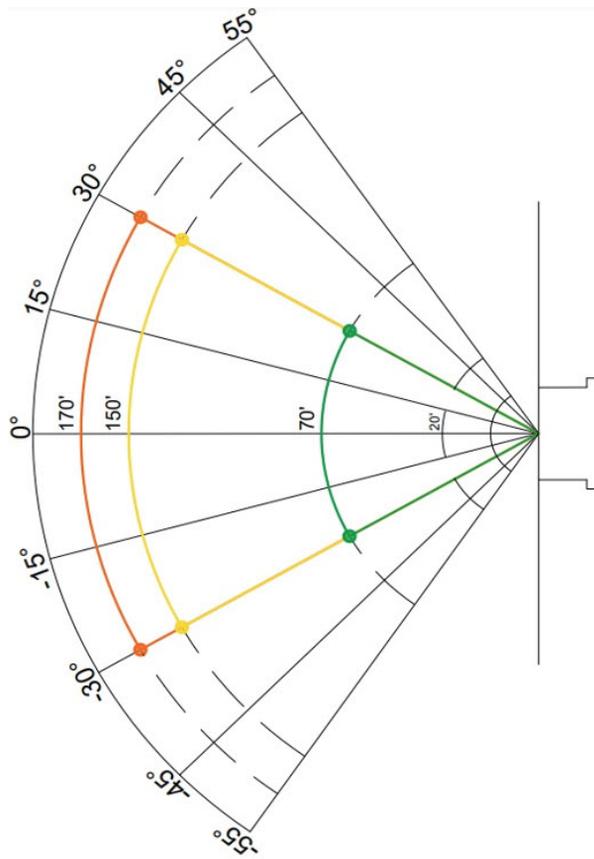


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 150' | 120' | 50' |
| + 30° | 150' | 120' | 50' |
| - 30° | 150' | 120' | 50' |
| - 45° | 60' | 20' | 20' |

JP5 (2' x 2')

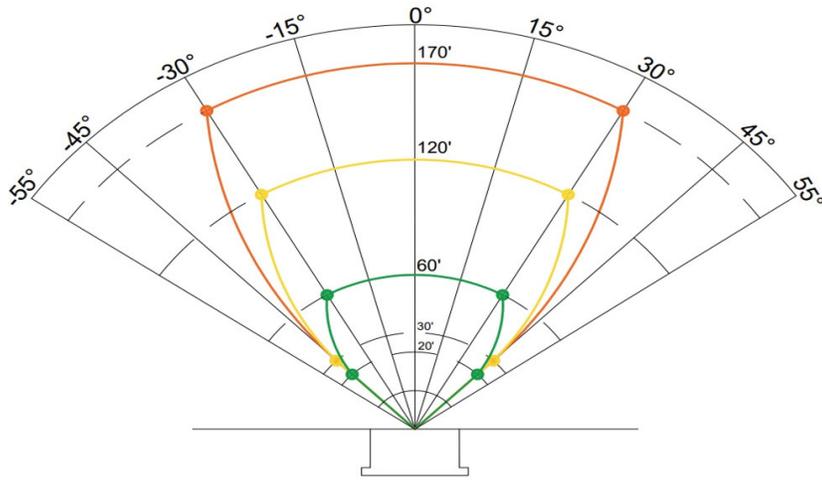


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 200' | 160' | 70' |
| + 30° | 170' | 150' | 70' |
| - 30° | 170' | 150' | 70' |
| + 45° | -- | -- | -- |
| - 45° | -- | -- | -- |

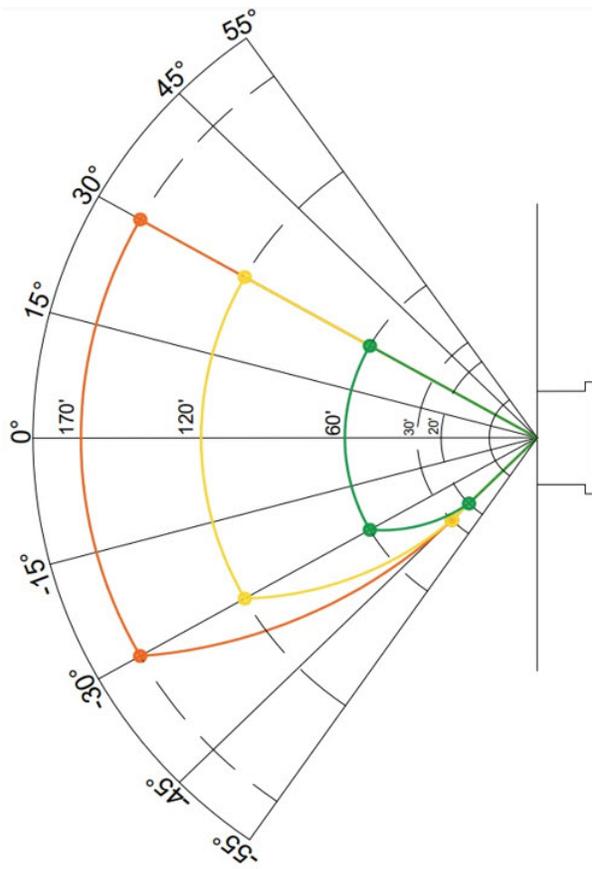


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 170' | 150' | 70' |
| + 30° | 170' | 150' | 70' |
| - 30° | 170' | 150' | 70' |
| - 45° | -- | -- | -- |

JP8 (1' x 1')

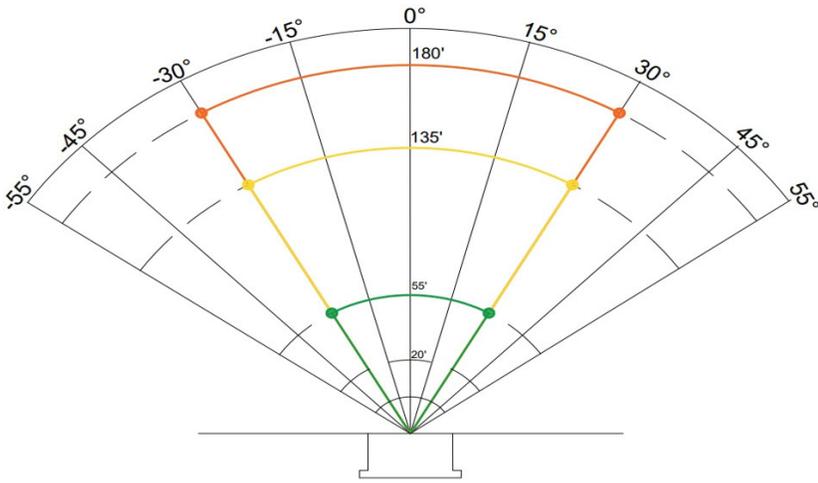


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 170' | 120' | 60' |
| + 30° | 170' | 120' | 60' |
| - 30° | 170' | 120' | 60' |
| + 45° | 30' | 30' | 20' |
| - 45° | 30' | 30' | 20' |

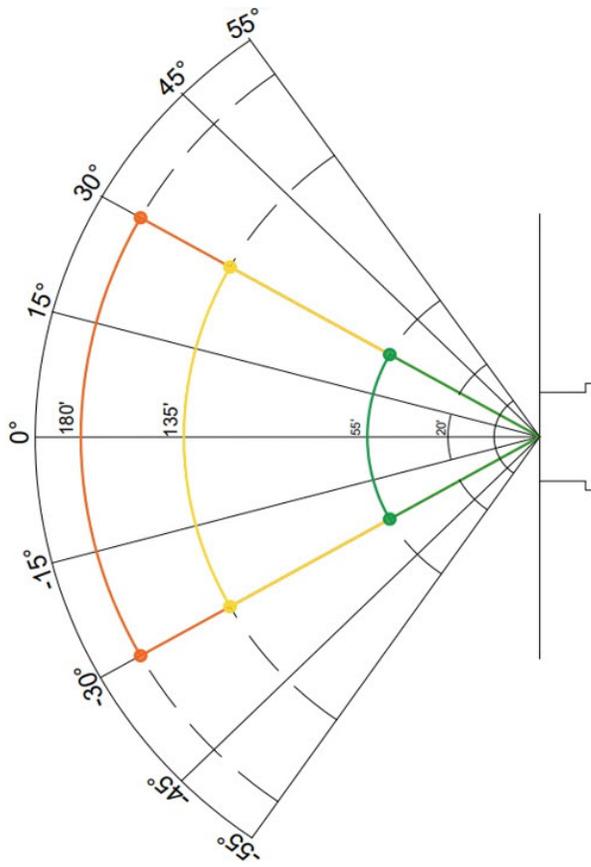


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 170' | 120' | 60' |
| + 30° | 170' | 120' | 60' |
| - 30° | 170' | 120' | 60' |
| - 45° | 30' | 30' | 20' |

JP8 (2' x 2')

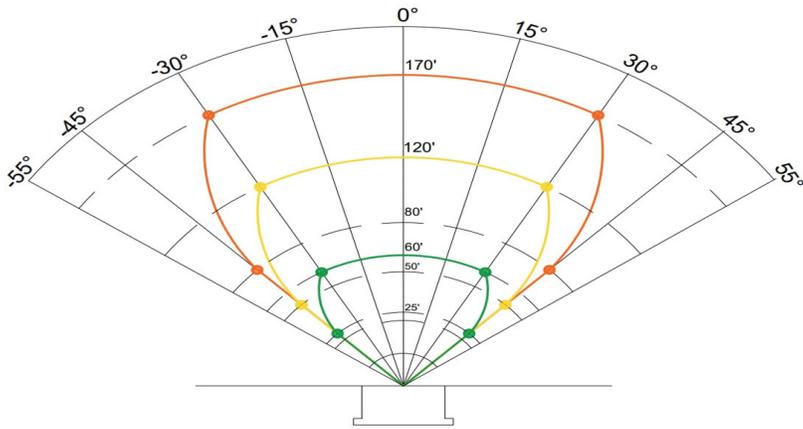


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 180' | 135' | 55' |
| + 30° | 180' | 135' | 55' |
| - 30° | 180' | 135' | 55' |
| + 45° | -- | -- | -- |
| - 45° | -- | -- | -- |

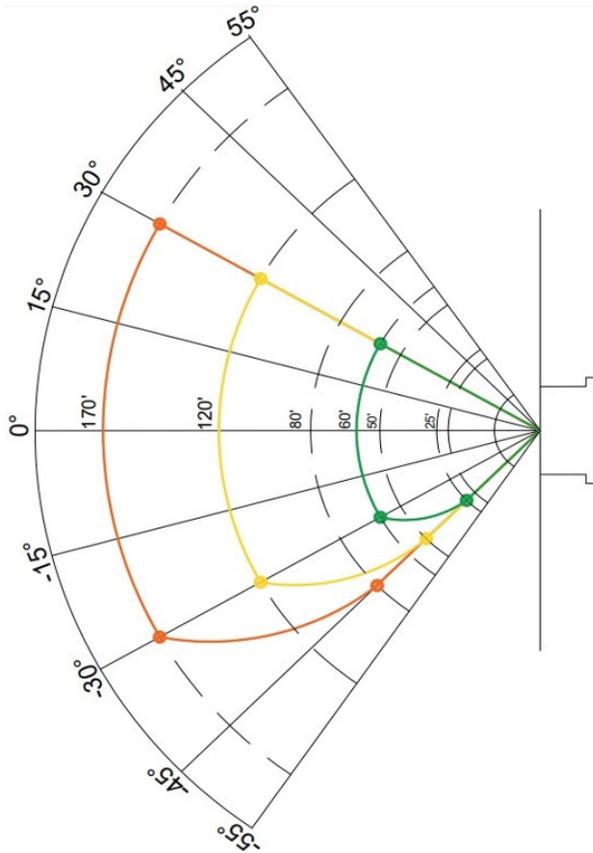


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 180' | 135' | 55' |
| + 30° | 180' | 135' | 55' |
| - 30° | 180' | 135' | 55' |
| - 45° | -- | -- | -- |

Jet Fuel A (1' x 1')

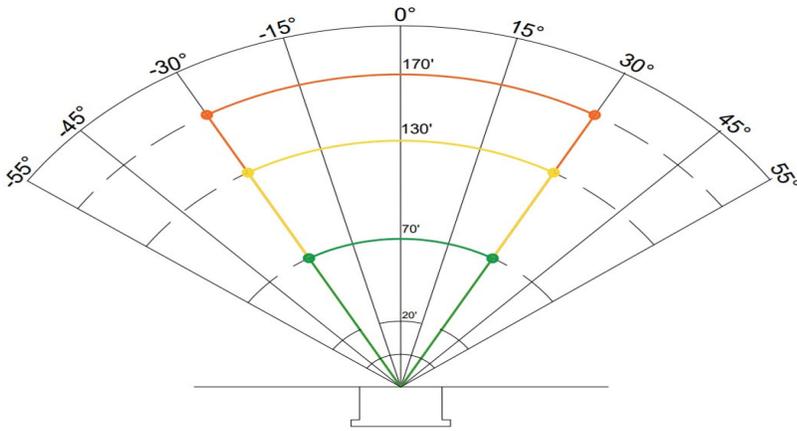


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 180' | 120' | 60' |
| + 30° | 170' | 120' | 60' |
| - 30° | 170' | 120' | 60' |
| + 45° | 80' | 50' | 25' |
| - 45° | 80' | 50' | 25' |

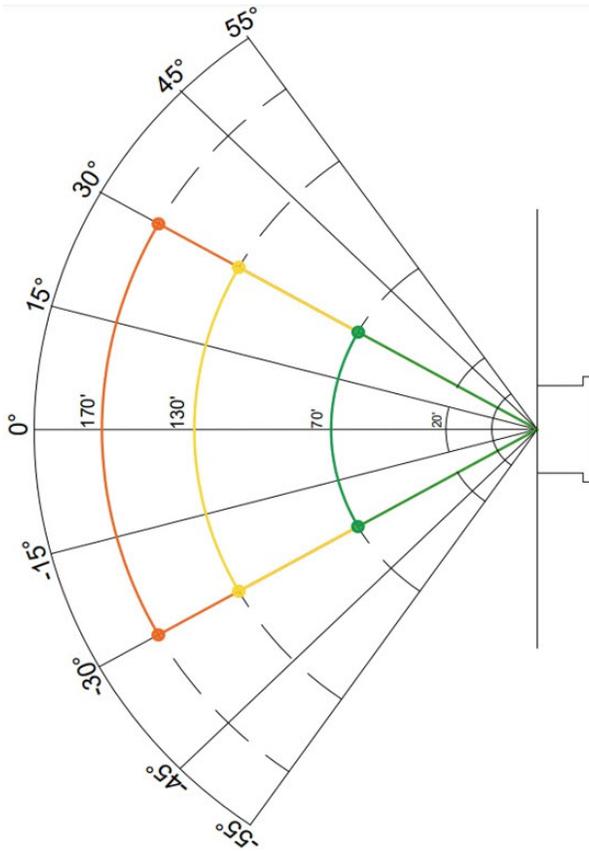


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 170' | 120' | 60' |
| + 30° | 170' | 120' | 60' |
| - 30° | 170' | 120' | 60' |
| - 45° | 80' | 50' | 25' |

Jet Fuel A (2' x 2')

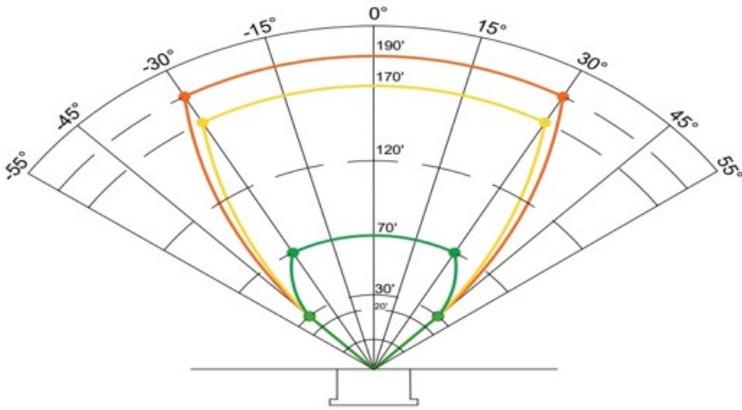


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 170' | 130' | 70' |
| + 30° | 170' | 130' | 70' |
| - 30° | 170' | 130' | 70' |
| + 45° | -- | -- | -- |
| - 45° | -- | -- | -- |

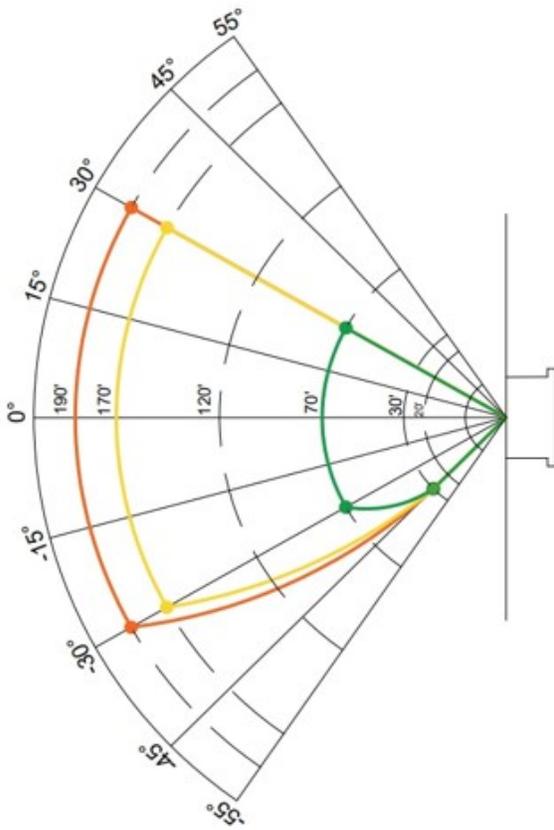


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 170' | 130' | 70' |
| + 30° | 170' | 130' | 70' |
| - 30° | 170' | 130' | 70' |
| - 45° | -- | -- | -- |

Marina Fuel (1' x 1')

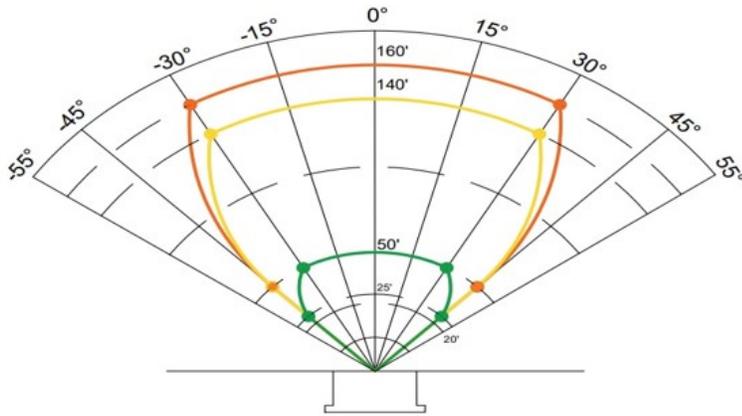


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 190' | 170' | 70' |
| + 30° | 190' | 170' | 70' |
| - 30° | 190' | 170' | 70' |
| + 45° | 30' | 30' | 30' |
| - 45° | 30' | 30' | 30' |

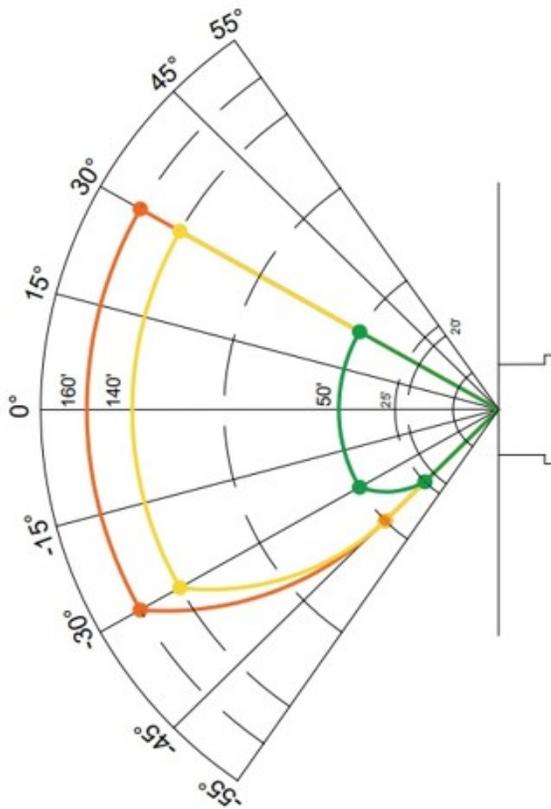


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 190' | 170' | 70' |
| + 30° | 190' | 170' | 70' |
| - 30° | 190' | 170' | 70' |
| - 45° | 30' | 30' | 30' |

Kerosene (1' x 1')

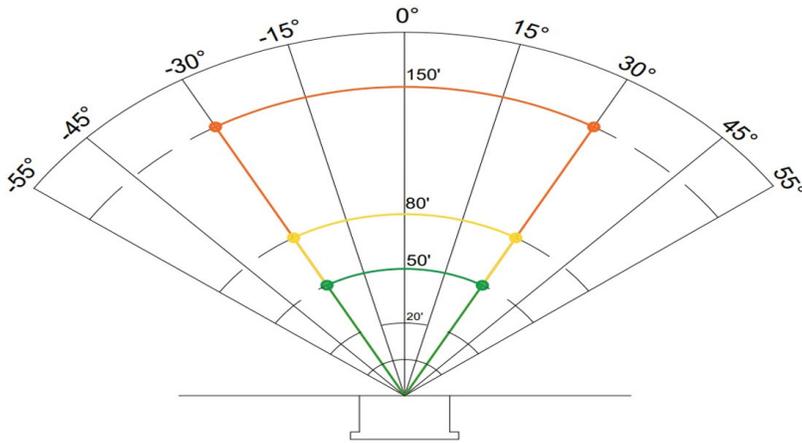


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 160' | 140' | 50' |
| + 30° | 160' | 140' | 50' |
| - 30° | 160' | 140' | 50' |
| + 45° | 50' | 50' | 25' |
| - 45° | 50' | 50' | 25' |

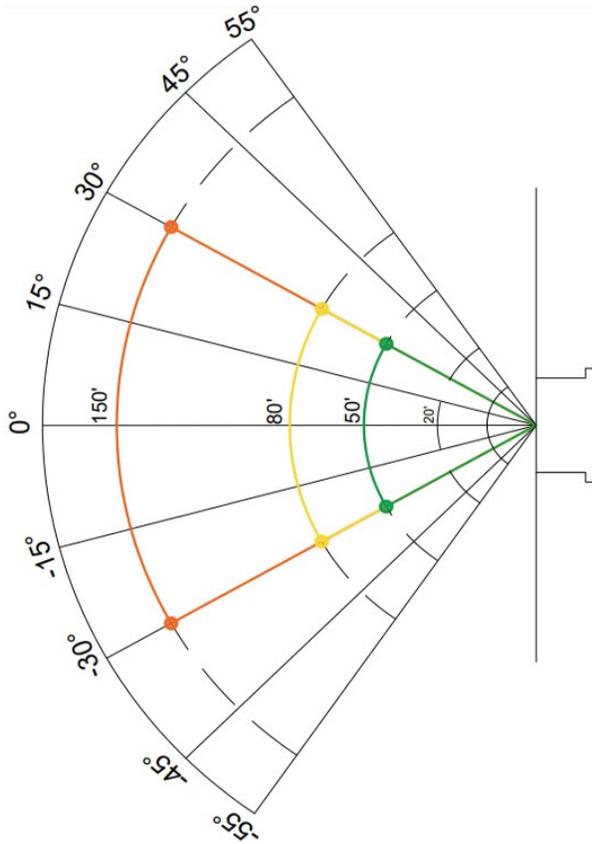


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 160' | 140' | 50' |
| + 30° | 160' | 140' | 50' |
| - 30° | 160' | 140' | 50' |
| - 45° | 50' | 50' | 25' |

Xylene (1' x 1')

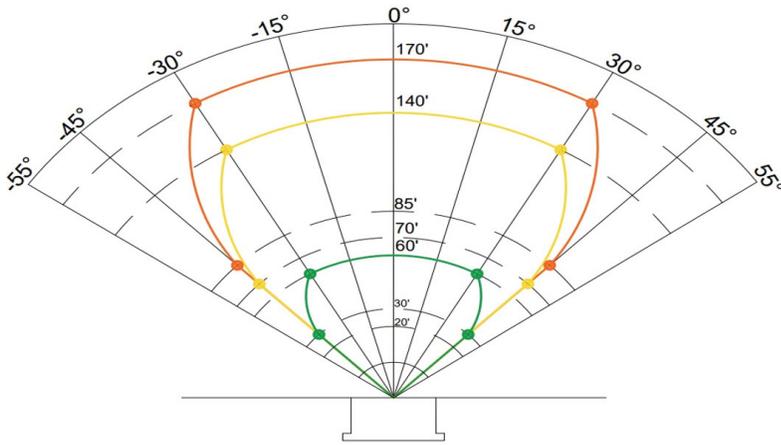


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 150' | 80' | 50' |
| + 30° | 150' | 80' | 50' |
| - 30° | 150' | 80' | 50' |
| + 45° | -- | -- | -- |
| - 45° | -- | -- | -- |

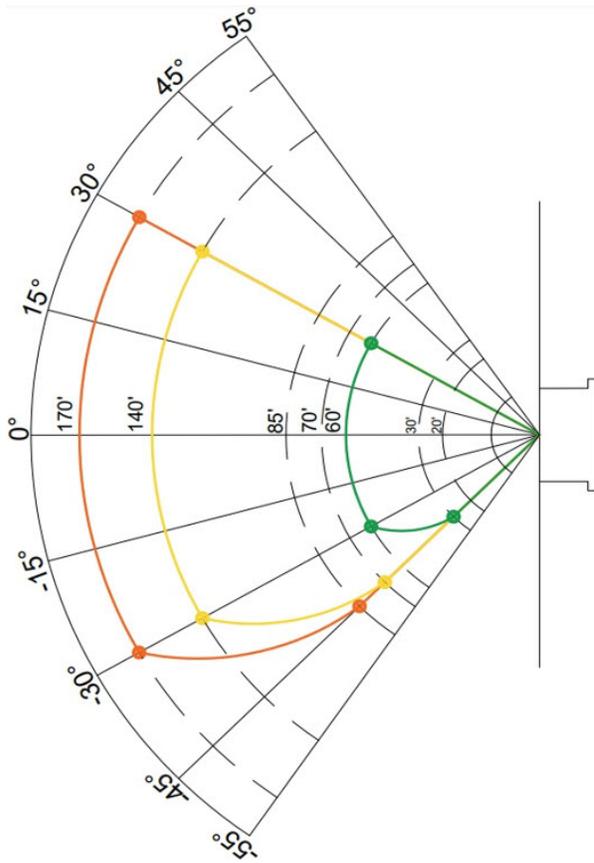


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 150' | 80' | 50' |
| + 30° | 150' | 80' | 50' |
| - 30° | 150' | 80' | 50' |
| - 45° | -- | -- | -- |

MEK (1' x 1')

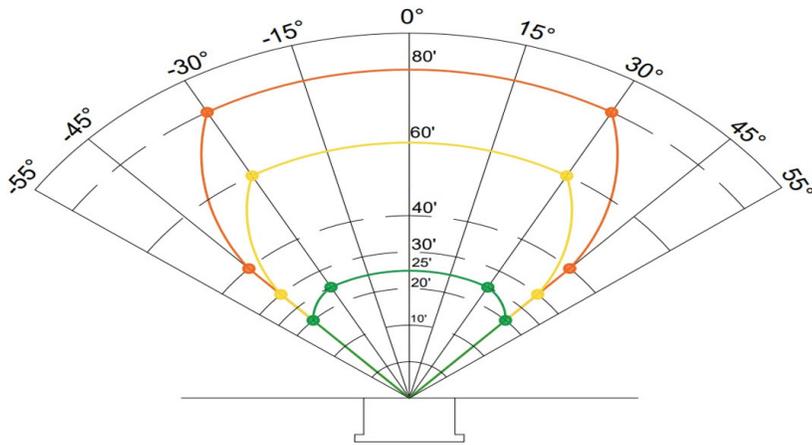


| Horizontal | High | Med | Low |
|------------|------|------|-----|
| 0° | 170' | 140' | 60' |
| + 30° | 170' | 140' | 60' |
| - 30° | 170' | 140' | 60' |
| + 45° | 85' | 70' | 30' |
| - 45° | 85' | 70' | 30' |

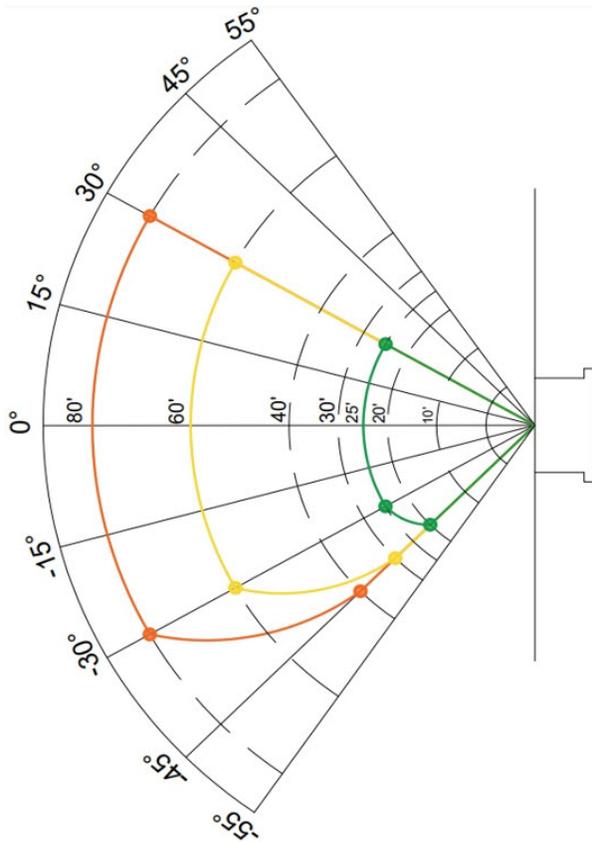


| Vertical | High | Med | Low |
|----------|------|------|-----|
| 0° | 170' | 140' | 60' |
| + 30° | 170' | 140' | 60' |
| - 30° | 170' | 140' | 60' |
| - 45° | 85' | 70' | 30' |

Wood (6" x 6")

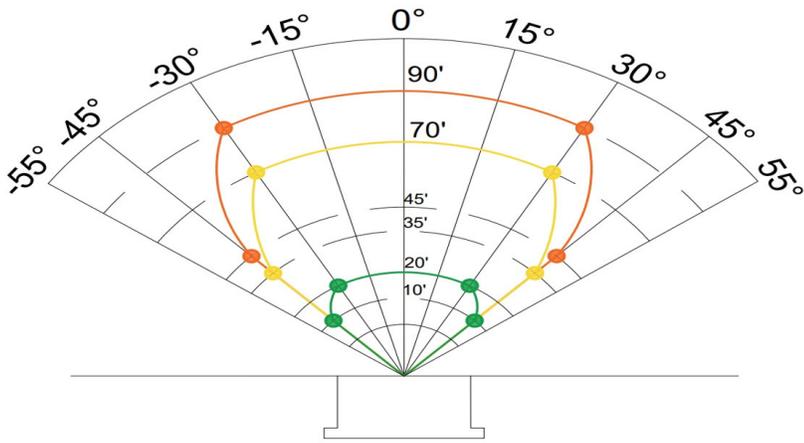


| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 80' | 60' | 25' |
| + 30° | 80' | 60' | 25' |
| - 30° | 80' | 60' | 25' |
| + 45° | 40' | 30' | 20' |
| - 45° | 40' | 30' | 20' |

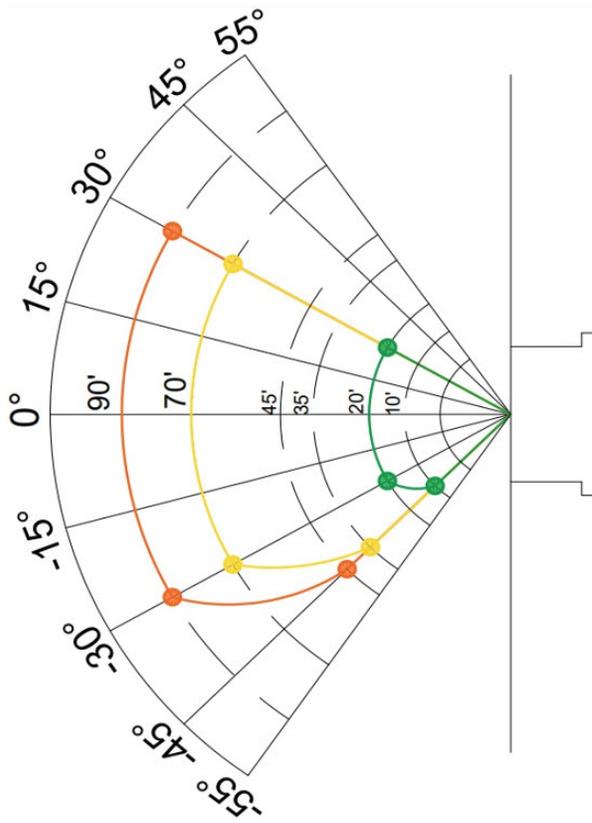


| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 80' | 60' | 25' |
| + 30° | 80' | 60' | 25' |
| - 30° | 80' | 60' | 25' |
| - 45° | 40' | 30' | 20' |

Cardboard (6" x 6")



| Horizontal | High | Med | Low |
|------------|------|-----|-----|
| 0° | 90' | 70' | 20' |
| + 30° | 90' | 70' | 20' |
| - 30° | 90' | 70' | 20' |
| + 45° | 45' | 35' | 10' |
| - 45° | 45' | 35' | 10' |



| Vertical | High | Med | Low |
|----------|------|-----|-----|
| 0° | 90' | 70' | 20' |
| + 30° | 90' | 70' | 20' |
| - 30° | 90' | 70' | 20' |
| - 45° | 45' | 35' | 10' |

9 Certifications

9.1.3 False Alarm Stimuli Performance

The FM approved FL5000 detector is immune to a variety of false alarm sources. Below are representative samples of detector response in the presence of false stimuli.

As a worst case condition the high sensitivity variation was tested to demonstrate no false alarm result without fuel n-Heptane (1' x 1'), equivalent to 0.3 x 0.3 meters. This generated the following:

| False Alarm Source (Modulated and Un-modulated) | False Alarm Distance from Detector ft (m) | n-Heptane (1' x 1') | |
|---|--|--|---|
| | | Fuel Distance from Detector ft (m) | Response Time for Instant Alarm: Sustained Alarm (seconds) |
| Hand Wave | 0.5 (0.15) | --- | --- |
| Sunlight, Direct | --- | --- | --- |
| Sunlight, Reflected, Un-modulated @ 3' | --- | 90 (27) | 16 : 17 |
| Sunlight, Reflected, Modulated @ 10' | --- | 40 (12) | 6 : 7 |
| Sunlight, Reflected, Modulated @ 5' | --- | 30 (9) | 6 : 7 |
| Arc Welding, 200A AC, 7014 rod | 10 (3) | 80 (24) | 9 : 10 |
| Arc Welding, 200A DC+, 7014 rod | 10 (3) | 80 (24) | 6 : 7 |
| Arc Welding, 200A DC-, 7014 rod | 10 (3) | 80 (24) | 7 : 8 |
| Arc Welding, 200A AC, 6012 rod | 10 (3) | 80 (24) | 7 : 8 |
| Arc Welding, 200A DC+, 6012 rod | 10 (3) | 80 (24) | 7 : 8 |
| Arc Welding, 200A DC-, 6012 rod | 10 (3) | 80 (24) | 6 : 7 |
| Arc Welding, 200A AC, 6011 rod | 10 (3) | 80 (24) | 8 : 8 |
| Arc Welding, 200A DC+, 6011 rod | 10 (3) | 80 (24) | 7 : 8 |
| Arc Welding, 200A DC-, 6011 rod | 10 (3) | 80 (24) | 6 : 7 |
| 1500W Electric Radiant Heater (Lakewood), Un-modulated | 12 (3.3) | 80 (24) | 10 : 11 |
| 1500W Electric Radiant Heater (Sear), Un-modulated | 12 (3.3) | 80 (24) | 10 : 11 |
| 1500W Electric Radiant Heater (Sears), Modulated | 10 (3) | 60 (18) | 14 : 15 |
| 6kW Electric Radiant Heater, Un-modulated (Data Set #1) | 18 (5.5) | 60 (18) | 8 : 9 |
| 6kW Electric Radiant Heater, Modulated (Data Set #1) | 20 (6) | 60 (18) | 7 : 8 |
| 6kW Electric Radiant Heater, Un-modulated (Data Set #2) | 10 (3) | 80 (24) | 11 : 12 |
| 6kW Electric Radiant Heater, Modulated (Data Set #2) | 50 (15) | 80 (24) | 7 : 7 |
| 300W Clear Incandescent Lamp | 10 (3) | 80 (24) | 6 : 7 |
| 100W Frost Incandescent Lamp | 2.5 (0.8) | 80 (24) | 7 : 8 |
| 25W Clear Incandescent Lamp | 1 (0.3) | 80 (24) | 8 : 9 |
| 2-30W Fluorescent Lamps, Un-modulated | 1 (0.3) | 80 (24) | 7 : 8 |
| 2-30W Fluorescent Lamps, Modulated | 2 (0.6) | 80 (24) | 7 : 8 |
| 100,000 lux LED Flash Light | 5 (1.5) | 80 (24) | 7 : 8 |
| 100W UV Blacklight Lamp | 10 (3) | 80 (24) | 7 : 8 |
| 70W Sodium Lamp | 10 (3) | 80 (24) | 6 : 7 |
| 250W Sodium Lamp | 10 (3) | 80 (24) | 8 : 9 |

| False Alarm Source (Modulated and Un-modulated) | False Alarm Distance from Detector ft (m) | n-Heptane (1' x 1') | |
|--|--|--|---|
| | | Fuel Distance from Detector ft (m) | Response Time for Instant Alarm: Sustained Alarm (seconds) |
| 150W Shielded Mercury Lamp | 10 (3) | 80 (24) | 6 : 7 |
| 500W Shielded Halogen Lamp, Un-modulated | 10 (3) | 80 (24) | 6 : 7 |
| 500W Shielded Halogen Lamp, Modulated | 15 (4.5) | 80 (24) | 11 : 12 |
| 500W Unshielded Halogen Lamp, Un-modulated | 10 (3) | 80 (24) | 6 : 7 |
| 500W Unshielded Halogen Lamp, Modulated | 15 (4.5) | 80 (24) | 12 : 12 |
| 200C Hot Plate, Un-modulated | 15 (4.5) | 80 (24) | 6 : 7 |
| 200C Hot Plate, Modulated | 15 (4.5) | 80 (24) | 14 : 15 |