

## How to Select a Continuous Solvent Vapor Monitor to meet NFPA 86 requirements

*The National Fire Protection Association (NFPA) establishes fire safety standards, including standards for the safe operation of processes. NFPA 86, the Standard for Ovens and Furnaces, addresses the safe operation of Class A, Class B, Class C and Class D ovens, dryers, and furnaces, thermal oxidizers, and any other heated enclosure used for processing of materials and related equipment*

*Copies of NFPA 86 may be obtained from the National Fire Protection Association.*

*Call toll free to order:*  
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### **Introduction**

This technical note assists operators in selecting a solvent vapor monitoring system that meets the requirements of NFPA 86. The system consists of three integral parts:

- ◆ The gas sample system that delivers the oven atmosphere sample to the analyzer
- ◆ The solvent vapor concentration analyzer
- ◆ The safety logic system that is activated by the analyzer

### **The essential requirements for a reliable solvent vapor analyzer.**

Monitoring requirements are found in section 11.6.10. The areas of concern include:

- ◆ Sample delivery system. 11.6.10.11
- ◆ Speed of Response. 11.6.10.2
- ◆ Accurate calibration and response 11.6.10.5
- ◆ Avoidance of condensation. 11.6.10.11
- ◆ Failsafe malfunction logic. 11.6.10.8
- ◆ Maintenance. 11.6.10.11

Operators must select a sensor that meets all of the requirements. Annex E provides guidance in selecting the appropriate sensor from a list of possible choices. These sensor choices include:

These sensor choices include:

- ◆ Catalytic
- ◆ Infrared
- ◆ Flame Temperature
- ◆ Flame Ionization

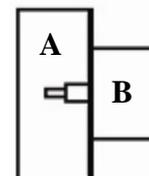
This technical note focuses on how well each of these sensors meets the requirements of the standard.

### **Active sampling system**

It is recommended that process applications employ active sample draw systems to continuously deliver a sample to the solvent vapor monitor. Static sensors placed inside the process are not recommended because, among other drawbacks, it is not possible to prove that a representative sample is being delivered to the sensor.

Annex E states that *“the oven atmosphere should be sampled at a point that best represents the average concentration of solvent vapor in the oven or oven zone. This is usually at the oven exhaust point. The volume of the sample system should be as small as possible and the sample flow rate maximized for fast response of the system. Special precautions, such as heating the sample lines and analyzer to prevent condensation of volatiles in the sample, might be required. The length of the sample line should be minimized by locating the analyzer close to the sample point.”*

Therefore, the best sensor site is on or adjacent to the oven zone’s exhaust ductwork so that the sample line is kept short. Rack-mounted sensors (often found in FID designs) that employ long sample lines should be avoided.



*Accurate process sampling depends on drawing a sample from A, the oven exhaust duct, and delivering it to B, the solvent vapor analyzer, as quickly as possible without losing anything. Therefore: heat the sample system and sensor to avoid condensation; and mount the sensor near the pickup point to eliminate delivery delays.*

## 5 second System Response Time

The caution note found in section 11.6.10.2 warns operators of the need for fast response, stating that in many cases the system “*shall be capable of detecting and responding to process upset conditions to initiate reduction of the vapor concentration before the concentration exceeds 50 percent of the LFL.*” Annex E adds “*It cannot be emphasized too strongly that the solvent vapor concentration measurement system is to have a very fast response time...A response time of as little as 5 seconds might be required*”

System response time is the sum of the sample delivery time plus the sensor response time. This further emphasizes the importance of short sample delivery lines and no sequential sampling. Annex A states “*This response time requires the controller to be located close to the sampling point...and precludes the use of one controller sequentially sampling multiple points.*”

Of the sensor choices listed in Annex E, catalytic sensors have the longest response times. The other sensors have fast responses, but care must be taken to select a sensor that can accurately measure all solvents present in the sample stream.

### Calibration accuracy

Section 11.6.10.5 requires calibration to be valid “*for the application and solvents used.*” If a variety of solvents is used, cross calibrations must be accurate or the sensor must be recalibrated whenever solvents are changed. Calibrations must be made using known concentrations of test gas mixtures.

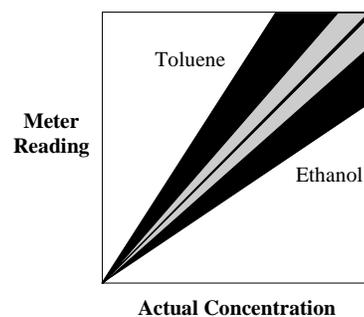
Of the sensor choices listed, catalytic, infrared and flame ionization all have large calibration correction factors for varying solvent types. Annex E states that the calibration response of a catalytic sensor “*does vary significantly for different solvents.*” Similar language is used to describe the response of infrared and flame ionization sensors.

The Annex adds that infrared is recommended only when monitoring single solvent atmospheres.

It is also important to understand that flame ionization detectors (FID) should not be used except in single solvent applications. The FID technology is based on measuring ionized carbon: this method makes it very difficult to convert the response into a meaningful indication of flammability when measuring more than one solvent.

These three sensor types therefore require recalibration whenever solvent formulations are changed. Annex E adds that “*the use of relative response data in making field calibration checks is not recommended.*” Recalibration calls for zero and span checks using known concentrations of test gas mixtures. Also: “*The user should understand how the instrument responds to vapors for which the instrument is not calibrated.*”

Only the flame temperature sensor has a very small change in response when reading varying solvents. This response, called *Universal Calibration*, means that the flame temperature sensor can read varying solvent formulations without recalibration.

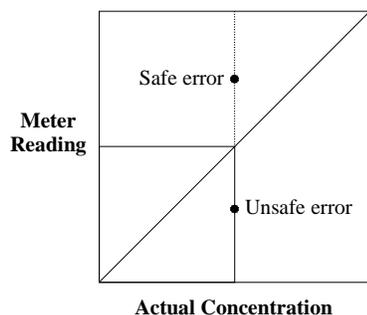


*This chart shows the relative response of different analyzers to ethanol and toluene when the sensor has been calibrated using heptane. Catalytic and infrared response, represented in gray, have a wide error. FID sensors, represented by the wide black band, have the widest response error. The flame temperature sensor (represented by the narrow black line in the center) has a close-to-linear response and the most accurate indication of total flammability.*

## Reading Error

A note in section 11.6.10.6 adds “Where a variety of solvents are used, the solvent to which the controller is least sensitive shall be the primary calibration reference.”

Reading error can be in either a safe or unsafe direction. A reading that is lower than the actual concentration is unsafe because the hazard is greater than displayed. A reading that is higher than actual is considered a “safe” error because the hazard is lower than displayed. But even “safe” errors should be minimized because they produce false alarms and too-early process shutdown.



*Non-linear response creates two types of errors. If the reading is higher than actual, the error is considered a “safe” error. “Safe” errors produce false alarms and false shutdowns. If the reading is lower than actual, it is an unsafe error, because the actual hazard is greater than the displayed reading.*

Only the flame temperature sensor can be calibrated so that all cross-calibration errors are absolutely minimized and in a “safe” direction.

## Avoiding Condensation

Section 11.6.10.11 requires that “the sensor and sample system shall be maintained at a temperature that prevents condensation.”

Condensation of any part of the vaporized sample will create two types of problems. First, if any flammable vapors condense, the readings will be lower than actual (unsafe error). Secondly, any condensation will produce sample line clogging and fouling,

resulting in higher maintenance and system downtime.

Condensation can be avoided by heating the entire sample line and sensor assembly above the condensation temperature of the sample. It is very important to consider not only solvents, but all constituents of the sample, including resins, plasticizers, and other high-molecular-weight compounds present in the sample. In some cases, the temperature required to avoid condensation is above the operating temperature of available heat-traced sample tubing. In these cases, the sensor must be mounted directly onto the process ductwork, with no external sample line.

It is also important to note that sample conditioning (chiller) systems cannot be used in LFL monitoring because they condense flammable vapors, which results in false low readings.

## Failsafe Malfunction Logic

According to section 11.6.10.8, *alarms shall be provided to indicate any sample, flow, circuit or controller power failures.*” The best analyzer design should be failsafe: it will provide malfunction alarm for any and all faults. For greatest safety, the malfunction alarms should shut down the process.

Catalytic sensors cannot provide failsafe malfunction logic because their design requires calibration to prove proper function. Catalytic sensors can be poisoned by coating and corrosive agents, including silicones and plasticizers, compounds often found in solvent vapor oven atmospheres. The only way to know if a catalytic sensor is working correctly is to calibrate it with a known concentration of test gas.

Infrared sensors optics can become fouled by the process environment.

The flame temperature sensor is unaffected by catalytic poisons such as silicone, halogenated hydrocarbons and plasticizers, and has no optics that can be fouled.

Only the flame temperature sensor offers malfunction indication for all faults. If the sensor is not functioning correctly, the operator is notified.

### **Maintenance**

The system should be designed to provide the least amount of downtime, including routine calibration and maintenance of the sampling system and sensor.

Calibration frequency depends on sensor type: catalytic sensors require the most frequent calibration checks. Flame temperature sensors require the least frequent calibration check schedule.

Maintenance time also depends on sensor type and sampling system. Insufficiently heated sampling systems will result in condensation, clogging and excessive maintenance. Flame Ionization (FID) sensors typically require the greatest amount of maintenance, infrared, catalytic and flame temperature have lower maintenance requirements.

### **Factory Mutual Approval**

Factory Mutual applies NFPA 86 when auditing insured facilities for compliance to acceptable safety standards. It is recommended that insured facilities employ FM approved solvent vapor monitoring systems. Please note that the approval must include not only the sensor but the sample delivery system as well.

### **Summary**

Catalytic sensors are not recommended for continuous solvent vapor monitoring.

Infrared sensors are not recommended except in applications where a single solvent is being used.

Flame ionization (FID) sensors are not recommended for LFL monitoring. They are more appropriate for measuring lower ppm concentrations in the exhaust of VOC reduction systems.

To date, the only FM approved sample-delivery and solvent vapor monitoring systems meeting all NFPA 86 requirements are Control Instruments' Flame Temperature Analyzers.

Control Instruments also manufactures infrared analyzers, flame ionization detectors, catalytic area monitors and BTU calorific analyzers.

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For more information regarding NFPA 86 and solvent vapor monitoring, please refer to these additional application notes:

*Understanding NFPA 86: Safety Ventilation and Continuous LFL Monitoring.*

*Using Flammability Analyzers to Protect Thermal Oxidizers.*

*Reducing Fuel Costs in Process Ovens and Dryers which use Solvents.*



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