



The Importance of Flammability Monitoring for the Safety and Performance of Your Printing Line

Industrial fires and explosions happen more frequently than most people think. They cause downtime, property damage, injury and sometimes death. These fires and explosions result from a dangerous mixture of flammable vapors with air and a source of ignition.

- Solvents, chemicals and other sources of flammable vapors and gases are present in many manufacturing, production and converting processes and act as the fuel in process fires or explosions.
- There are many potential sources of ignition which can trigger a fire or explosion: electrical sparks, friction, static discharge, hot surfaces, air streams, and direct-fired burners in ovens and thermal oxidizers. The third element necessary for a fire or explosion is oxygen. Since we can never be guaranteed that an environment will remain completely free of air or of a source of ignition, the most reliable means of preventing fire or explosion is to measure and limit the amount of flammable vapors to a safe level.

Basics of Flammability Measurement

Lower Flammable Limit:

For each flammable substance there is a level of concentration in air, usually expressed as a percent by volume, that is known as its Lower Flammable Limit, LFL, or Lower Explosive Limit, LEL. Below the LFL, the mixture of fuel and air is too lean to support combustion. For example, a mixture of 1.1 percent Hexane in air is equal to 100% of its LFL - just rich enough to propagate a flame.

- As the amount of fuel continues to increase, the mixture will eventually become too rich to burn - there will be too much fuel and not enough Oxygen. This concentration is known as the Upper Flammable Limit, UFL, or the Upper Explosive Limit, UEL.
- Between the LFL and the UFL lies the flammable range where, given a source of ignition, the mixture will readily ignite. While it may be theoretically possible to operate safely at concentrations up to 100% of the LFL, authorities world-wide have established safety regulations which require

operation well below this point.

- Authorities have determined the limit to the solvent concentration in air, the LFL, below which the solvent and air mixture cannot propagate a flame.

Safety Margins:

Almost all safety authorities require a 4:1 margin of safety below the LFL, based on worst-case conditions. This means that enough dilution air must be used to always maintain a concentration of less than 25% of the LFL, according to the National Fire Protection Association standard NFPA 86.

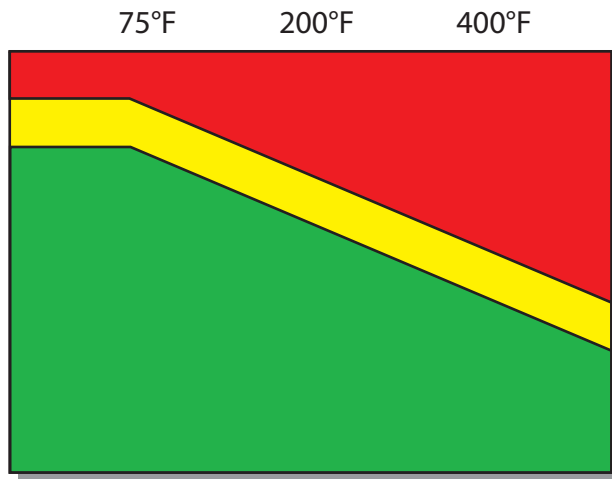
- However, a process dryer or oxidizer is allowed to operate with only a 2:1 safety margin (up to 50% of the LFL), when continuous flammability analyzers are used. The requirements stipulate real-time, fast-response, continuous analyzers connected in such a manner as to trigger corrective action at predetermined alarm points.
- Therefore, unprotected processes, which may normally run at only 10% or 12% LFL to avoid reaching 25% in case of accidental upset, are allowed to operate at much higher vapor concentrations when LFL analyzers are used. The resulting cost savings due to reduced ventilation or increased throughput can be considerable. For example, using the energy of the solvent-laden air through recirculation and damper control can reduce the cost of providing the air at the required temperature for the process.
- There are variations in the Lower Flammable Limit values published by different authorities. These variations may be due to small inaccuracies in test procedures. A comparison of the LFL value for fifty common solvents, published by six different authorities, shows that one-third of the solvents compared disagree by a standard deviation of more than ten percent. Given these differences, the LFL of a substance is certainly not an absolute value and ample allowances should be made to ensure safe operation.

Process Temperatures:

Most published LFL values are calculated at room temperature.

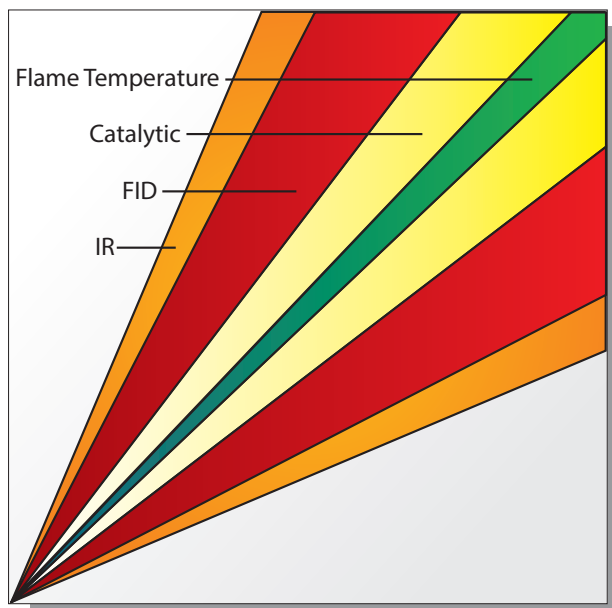


However, as a given mixture is heated, its flammability increases and thus the concentration required to achieve 100% LFL is less. This source of increased danger is often overlooked.



Consider the diagram above. The yellow band indicates 100% of the LFL of a sample mixture, given the degree of uncertainty in published values as previously mentioned. Note how the red area of danger becomes greater as the temperature increases. Note also the green "safe" area. The concentration that was safe at 75°F becomes dangerous at 400°F.

Important Considerations when Choosing an LFL Monitor



Response Accuracy:
There are several technologies used to measure

flammability, and few react the same way to all substances. A sensor or analyzer calibrated to accurately read one substance may be significantly inaccurate for another process component. This variance from perfect accuracy (error) is known as the Response Factor. Variations in response may not pose a significant problem when measuring an atmosphere containing a single substance, but when asked to measure a mixture of different vapors or changing solvent formulations, some technologies will fail noticeably, making for unsafe conditions.

Response Speed:

While accuracy is certainly a prime concern when selecting a flammability analyzer, consideration must also be given to how quickly the sensor will react to changes in the LFL concentration. The analyzer must be able to produce an alarm and initiate corrective actions in time to prevent a disaster.

In addition to the internal response time of the system, it is also important to calculate the time it will take for the sample to reach the analyzer. An analyzer designed to mount directly on a process wall or duct may have a sample delivery delay of only a fraction of a second but a remotely-mounted analyzer with a fifty foot sample line could have a sample delivery delay of 10-15 seconds or more. This delay, added to the analyzer response time and the time to trigger an alarm and effect corrective action (such as e-stop), may be too slow to prevent fire or explosion; it is therefore critically important to calculate the total of these elements and reduce delays in order to achieve an effective measure of safety.

Condensation Issues:

To ensure that the vapor concentration reaching the analyzer is exactly the same as the concentration at the point of origin, the sample must always be kept in a vapor state. The analyzer, the sample line and any other elements of the sample train may have to be heated to keep the sample above its dew point. If allowed to cool, the sample may condense, causing process components to drop-out, which will compromise reading accuracy and potentially result in clogging of the sample train, requiring maintenance and causing downtime.

When determining the operating temperature required for the analyzer and sample line, it is important to calculate the flash points or condensation temperatures of all substances in the sample atmosphere, even those that are not flammable. Any substance can clog the sample line or analyzer if it is allowed to condense.



Failsafe:

A sometimes overlooked aspect when selecting the right analyzer is if it is failsafe. What this means is if the analyzer were to go into a fault condition where the readings can no longer be relied upon, does the analyzer have the capability to alert the operator to this situation. If you're depending on this monitor to keep your people and equipment safe, it must have the ability to alert you if it is not functioning properly.

Typical Flexographic Application Examples

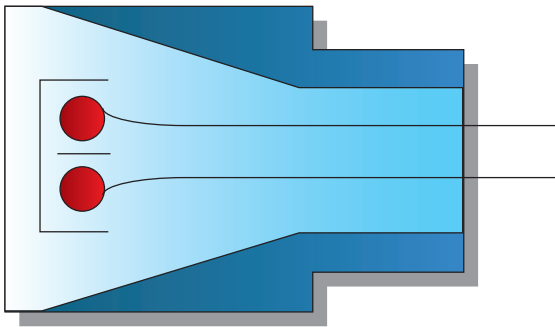
- Drying systems for printing lines.
- Abatement systems such as Oxidizers.

Processes that use flammable solvents can develop explosive concentrations due to failure of coating, metering, ventilation or heating systems, adverse chemical reactions, and human error. LFL monitors are used for safety as well as process efficiency, protecting the system from fire and explosion while also allowing operating at higher vapor concentrations to save costs.

Sensor Choices and How to Decide

Although several different types of sensors are employed as LFL monitors, each has an appropriate application to which it is best suited. Fires and explosions in what was thought to be "protected" equipment can occur without warning when a sensor is not capable of doing the job that had been assigned to it. This is most often caused by a misunderstanding of the different available technologies.

Catalytic Sensors:



Catalytic-bead sensors are constructed of two small wire coils covered with a catalyst. One coil is "active" while the other is rendered inert and acts as a reference. A flow of electrical current through the internal coils heats the catalytic coating to a temperature at which the active coil will react with many flammable vapors and gases. This reaction occurs in the form of surface combustion which in turn causes an increase in the

sensor's temperature. The resulting temperature change is converted into an LFL reading.

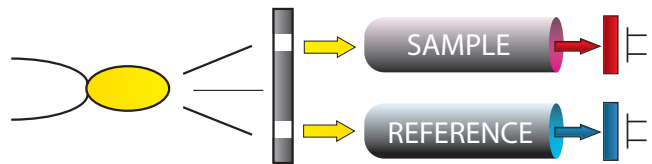
The intensity of the catalytic reaction varies for different flammable substances. Therefore, response factors vary considerably, resulting in potentially inaccurate readings. Calibration correction may be required for each different solvent or solvent mixture used in the process.

Catalytic sensors have slow response times, as much as 15 seconds is not unusual. That slow response alone may eliminate a catalytic sensor from consideration as a process monitoring device.

Catalytic sensors are not failsafe. During operation they cannot detect and alarm all conditions that can cause the sensor to become non-functional. There are fault conditions that can only be detected by performing a calibration. This can lead to a false sense of safety, as it has no means of warning the operator that it is not functioning properly.

Because of these characteristics, catalytic sensors are typically used only as leak detectors. They are generally well suited to area-monitoring applications where response times of ten or more seconds are acceptable; where the atmosphere does not contain condensate, dirt or dust; is not heated and is normally free of flammable vapors.

Infrared Absorption:



Combustible gases absorb infrared radiation at certain characteristic wavelengths. A typical non-dispersive infrared (NDIR) detector passes a source of infrared energy through the sample and measures the energy received by one of two detectors. The active detector responds to wavelengths in the same band as the sample gas, while the other detector measures a reference to compensate for changes within the instrument.

When specific combustible gases are present, they absorb some of the infrared energy and produce a signal in the active detector relative to the reference detector. Energy absorbed by the combustible gas for a given wavelength varies exponentially with the particular gas's absorptivity, the concentration, and the path length.



This means that infrared detectors must be specifically calibrated for a particular gas, and can have very high variations in response factors and linearity for other gases. For this reason, IR devices are often used for the detection of a single combustible gas. The technology can also be used for detecting multiple gases in limited applications if the solvent families have similar response factors, such as the use of Acetates and Alcohols in the Flexographic printing industry.

Flame Temperature:



The flame temperature analyzer measures the amount of heat given off by a pilot flame as it burns in an explosion-proof measuring chamber. The small, well-regulated flame heats the tip of a temperature sensor suspended directly above it.

When a flammable sample is drawn into the measurement chamber it is seen by the pilot flame as an additional source of fuel. This causes the temperature in the area of the pilot flame to increase. Since the meter knows that the increased temperature can only be caused by added fuel (the sample), it rises above zero in direct proportion to the flammability of the sample.

- The dynamics of the flame temperature analyzer give it highly uniform response factors for a wide variety of combustible gases, resulting in readings of unparalleled accuracy.
- The Flame Temperature device is Failsafe: if a malfunction condition occurs, a Fault relay changes state, which is hard-wired to corrective action in the same manner as the Danger relay. This allows the operator to be alerted if a fault condition occurs during operation. Additionally, advanced self-diagnostics tracks performance and displays messages regarding service needed, so that maintenance can be scheduled, avoiding shutdown

due to a Fault condition.

Summary

When selecting a flammability analyzer, it's always a good idea to enlist the advice of a specialist in the field. Do not assume that the analyzer which was correct for a previous job will also be the right choice for another application. Whether new or similar, the specific details of each application need to be examined closely to prevent disaster. The application survey that a manufacturer's technical sales representative or engineer asks you to fill out is a critical part of this selection process. When getting a quote be sure that the company issuing the quote has this information.

Choosing the right kind of instrument can be a detailed task, even for those familiar with the process. The instrument of choice may vary from one application to the next, but the correct process flammability analyzer (one that is fast, accurate, and fail-safe) will optimize your plant safety and production speed.