LFL Monitoring

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LFL control systems are commonly used within our industry to provide a safe and energy efficient method of controlling industrial VOC coating, laminating, and many other applications. For each volatile flammable substance there is a concentration in air (usually expressed as % of volume, known as Lower Flammable Limit – LFL). There are a number of organizations that provide guidance in the area of LFL, which include ASTM E681 Test Method for Flammable Limits & NFPA 325 Guide to Fire Hazard Properties. A specific combination of VOCs and exhaust flow below the LFL concentration is too lean to support combustion. With today's ever increasing energy costs and added concerns about greenhouse gas emissions, this subject becomes even more important to our industry. While lower LFL increases safety of processes, we also realize that higher LFL reduces energy usage. Lower energy usage results in both lower process operating costs, resulting in lower emission control operating costs, and finally lower levels of greenhouse gases.

Safety authorities required a 4:1 margin of safety below the LFL. In NFPA 86 we find they require enough dilution air to always maintain less than 25% of LFL (for systems w/o monitors). By taking the maximum potential application of VOCs this value can be determined and assured. Unless your organization produces one or two products on a consistent basis, this can result in high exhaust rates whenever the line is in operation and that results in high energy costs.

Drying systems (or oxidizers) are allowed to operate with a 2:1 safety margin (50% LFL) when a continuous flammability monitor is used (NFPA 86, 9.2.6.1 and 9.2.8). In order to accomplish this, the monitor must provide real-time data, must provide fast-response, and must be connected in a manner to trigger corrective action at predetermined alarm points. If the monitor is part of an automated design to vary exhaust flow based on LFL levels there must be a redundant system installed as part of the design as required by NFPA. Therefore, for such an automated system, two separate and independent LFL devices must be installed on the controlled exhaust stream.

Historically processes without monitoring equipment typically run at 10% - 12% LFL to avoid reaching 25% in case of accidental upset. By adding monitoring capabilities it allows much higher concentrations to be run. This results in potentially high cost savings in operation of process (as long as higher LEL does not impact product retained VOC limitations).

It should be noted that LFL published values are typically calculated at room temperature. Therefore, when a mixture is heated, its flammability increases and the concentration to achieve 100% LFL is less. Therefore a safe level at 72 degrees may become dangerous at elevated temperatures. This can be seen in added detail by referring to NFPA 86 9.2.5.2, where we see the formula;

$$\mathbf{LEL{^\circ}F = LEL77{^\circ}F[1-0.000436(T{^\circ}F-77{^\circ}F)]}$$

Now that we have covered the basics of LFL monitoring, we can review the various types of detectors that could be utilized. NFPA 86 Annex E, lists 4 types of detectors; Catalytic, Flame Ionization, Flame Temperature, and Infrared. We can now look at each monitor design individually to see what the differences are.

Catalytic detectors are low cost, small size, VOC response specific. When applying them you need to be aware of potential poisons or masking agents within your stream. They are slower in response time, typically 15-20 sec. These devices are typical used for area monitoring not process protection. In this device the sample passes over catalyst, where there is temperature rise from oxidation converted to the appropriate LFL level.

Flame type detectors have higher initial investment cost and require a fuel source for operation. This design requires regular calibration to insure the readings are accurate and provide the required safety. In this design, auto calibration often available to reduce the weekly attention that calibration requires. This design has the ability to sense a wide range of hydrocarbons, which can be ideal for a facility that has many different products being produced on the same line. This design is certainly a proven technology in our industry. It does provide response times down to 1 second and has a high level of accuracy.

Flame ionization (FID) device is designed to be ideal for low LFL ranges. Typically this technology (like catalytic) is used for area sources. Sample conditioning is needed to keep sensing chamber clean. Here you pass a metered sample across a flame, where the oxidation of VOC produces measured signal. The FID design is good for wide LFL ranges.

Infrared detectors are a design that has started to become popular in many industries (primarily in Europe) due to a much lower initial investment cost. This technology does not require fuel source as we see with a traditional flame type detector. This technology does not require oxygen within the stream for proper operation. The key drawback seen for this design is the VOC specific responses. Calibration needs to be done at least once per year and the 2-5 second response time that is found with these units. An added area of concerns is that sample conditioning is needed to keep sensing chamber clean. IR LFL monitors are sensitive to what VOCs are to be monitored and at what levels. This requires specific client inputs into what will be used in the process to insure the proper monitors are supplied. Not only are types of VOCs required, but ratios of each are also required to minimize nuisance alarms. If mixtures are used in the process, IR LFL monitors need to be calibrated for worse case VOC and could limit maximum VOC load for process. One manufacturer of this technology has developed their product to use 4 different parameters to change (automatically) according product code.

LFL Systems can be mounted in many locations. Each location has positive and negative attributes. If you use a duct mounting arrangement you need to protect the sensor from condensation, dirt, heat, and vibration. Duct mounted systems provide faster response time, but can be problematic due to limited access for maintenance. The other option is being remote mounted which adds sample transport time to the safety calculations and may require a heated sample line depending on your VOCs. The positive point of this mounting location is the ease of access.

This leads us to the question at hand, which technology is best for your application? Traditional Flame Type LFL systems are widely used in coating and laminating facilities in North America. The IR LFL systems have proven to be very popular in Europe. Different manufacturers of coating and laminating lines offer one or the other technology. There is no question that the IR LFL is substantially less costly. At the same time there are limitations and you need to be aware of them when looking at this technology. The jury is out on which system is best for your application.