



Flammability Analyzers Versus Flame Ionization Detectors for Process Applications

Why have so many fires and explosions occurred in industrial processes that were believed to have adequate protection against such hazards? In many cases, the wrong analyzer was used, or the sampling method was incorrect. Selecting the correct analyzer - and obtaining an accurate sample - is essential to maintaining a safe process.

Ideally, the analyzer will have an accurate response to a broad range of flammables, will be able to operate in high temperature process environments, and will have a fail-safe design. This paper will compare two analyzers, and explain why only one analyzer, a flammability analyzer, meets all of the safety requirements for process applications.

The Need for Continuous LFL Monitoring

Fire and safety laws require that process ovens and dryers be designed not to exceed 25% of the lower flammable limit (% LFL). When continuous monitoring is employed, however, the process may be designed to operate at flammable concentrations up to 50% LFL (and provide system shutdown above 50% LFL). The use of continuous analyzers not only greatly improves safety, but also reduces operating costs.

Measuring Flammability

Any analyzer used to prevent explosions in a process application must accurately measure the total flammability of the process atmosphere, which consists of: Volatile Organic Compounds (VOCs) including alcohols, halogens, aromatic and aliphatic hydrocarbons; fuels used to heat the process (such as natural gas, propane and hydrogen); and carbon monoxide, a by-product of inefficient combustion.

A flammability analyzer measures the total flammability of the sample in the 0 to 100% LFL range. A carefully metered pilot flame incinerates the sample; the resulting change in flame characteristics is proportional to the total concentration of flammable vapors present. The PrevEx, our flammability analyzer, proprietary flame temperature technology assures an accurate and linear response.

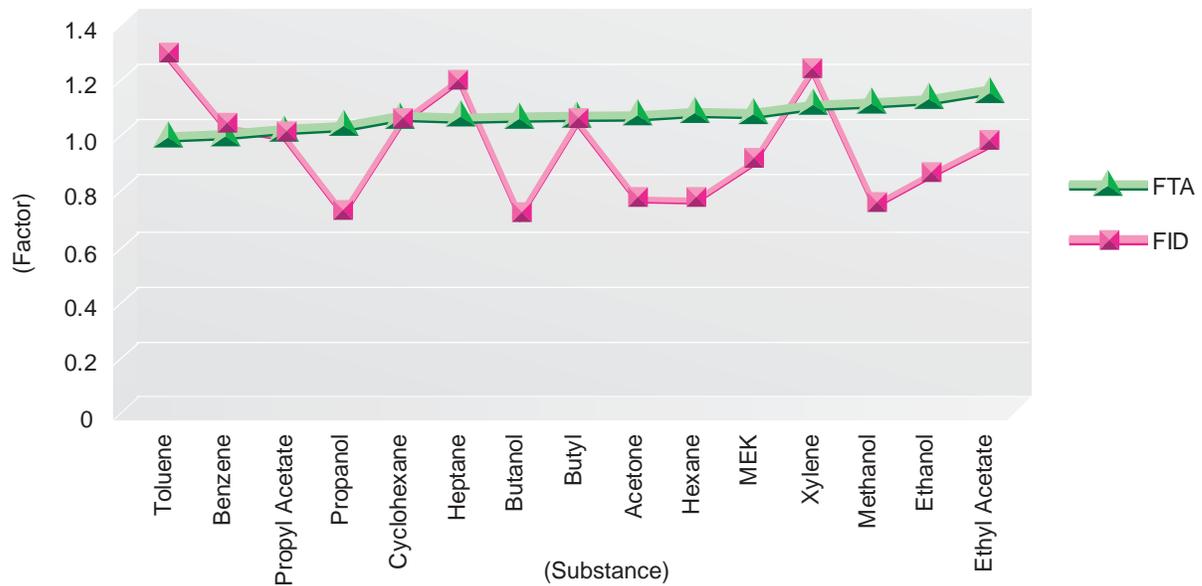
A flame ionization detector measures ionized carbon; it does not measure total flammability. A carefully metered pilot flame incinerates hydrocarbons in the sample – the resulting ionized carbon passes through an electrical field, creating a current flow proportional to the amount of ionized carbon present. An electrometer measures this current flow, and the resulting electrometer output is amplified and displayed, typically as a parts-per-million (PPM) meter reading. The FID signal is sometimes translated into a 0 to 100% LFL meter reading, but this translation is complicated and prone to error because parts-per-million (PPM) is only a fraction of the LFL concentration.

Calibration of the Analyzer

The best way to calibrate any analyzer is with a known concentration of the solvent vapor mixture being used in the process. Furthermore, this mixture should be sampled at the process temperature, because LFL values are lower at elevated temperatures. The task of using heated solvent mixtures for calibration is difficult, and so a more easily handled reference gas is typically used. When a reference gas is used for calibration, the analyzer meter reading must be adjusted to account for differences in the analyzer's response to the reference gas versus the actual solvent vapor mixture at process temperature. Fire and Safety codes require that the resulting readings must be accurate to +/-10%.



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As shown in the graph above a flammability analyzer (FTA) meets this requirement. It's calibrated using a reference gas resulting in meter readings that are accurate within +/-3% of full scale or +/-10% of applied gas.

Depending on its design, a FID can have a reading error as large as -50% to +150%. There are several reasons for this:

1. Many processes employ more than one solvent. When a sample contains more than one solvent, safety codes require that the analyzer be calibrated to the vapor to which it is least sensitive. This causes the analyzer to overreact to the other solvents in the sample, generating a high reading known as a "safe-side" error. Safe side errors are problematic because they produce nuisance alarms, making it impossible to operate a dryer at its intended speed. Users learn to ignore nuisance alarms, which can result in a catastrophic event.
2. Because the FID is measuring the current flow created by ionized carbon produced when the sample is incinerated, converting this signal to a % LFL meter reading is not a direct measure of the flammable hazard present in the process.
3. Different solvent molecules have differing numbers of carbons. If more than one solvent is used in the process, then the exact recipe of that solvent mixture must be known in order to calculate a correction factor to convert the signal into a meter reading.
4. If the process oven or dryer produces many products using different solvent recipes, then the FID must be recalibrated whenever the product being manufactured is changed. Managing these corrections factors is difficult.
5. FID analyzers consist of capillaries as part of their flow system. Capillaries are small and are prone to clog by sample particulate or moisture, reducing sample flow which could result in lower than actual readings. There is no indication of a clogged capillary to alert the user that the analyzer has failed.
6. Not all solvent vapors respond to FID incineration in the same manner. For example, not all of the carbon in a halogenated hydrocarbon is ionized when incinerated; therefore the meter reading will be inaccurate (too low). On the other hand, oxygenated hydrocarbons such as isopropyl alcohol tend to produce higher readings in FIDs.
7. A non hydrocarbon flammable sample (ie. hydrogen fuel or CO) will go undetected, causing a FID to grossly under report flammability.



Sample Accuracy

Process atmospheres are typically heated to high temperatures. If any portion of the sample is lost in the sample delivery system, the analyzer will read lower than actual – an unsafe condition. Therefore, sample lines must be heated to avoid condensation (sample loss). They should be short to minimize response time. It is also best that sample lines are as straight as possible, to prevent clogging and sample delivery delay.

A flammability analyzer is a rugged industrial instrument that mounts directly onto the process, thus allowing for the shortest, straightest sample line possible. The entire sample train is heated above the dew point of the process to prevent any portion of the sample from condensing.

Because most FIDs cannot be mounted directly onto the process, their sample lines must be longer, which creates longer sample delivery times. Often the sample lines are unheated, or not sufficiently heated, which creates sample drop loss and unsafe readings. In addition, the sample can clog in the FID capillaries, also resulting in sample loss.

Failsafe

Because the analyzer allows the process to operate above 25% LFL, it is vital that any failure of that analyzer results in a fail-safe condition. Flammability analyzers are fail-safe. A fault relay de-energizes whenever any of the following occur: controller electrical failure; loss of system power; loss of heat; loss of flow through the flame cell; and downscale readings caused by loss of flame or fuel.

FIDs are not fail-safe because the capillaries in the sample train can clog gradually without any warning or relay action.

Summary

Although some manufacturers offer FIDs for use as flammability analyzers in process applications, they are not recommended. Control Instruments' flammability analyzer, the PrevEx, is the most reliable, accurate, fail-safe design for continuous use in process applications.

Here are some questions to consider when selecting an analyzer to monitor flammable gases in process:

1. Are there non-hydrocarbon flammable substances present in the sample?
2. If measurement is for %LFL, are measured readings directly reported in % LFL?
3. For the Flammable(s) to be measured, now and in the future, how different is the response of one to another?
4. Are there halogenated hydrocarbons present?
5. Are there different isomers of aromatic hydrocarbons present?
6. Will there ever be a need to measure the flammability of different VOC's with the same number of hydrocarbons?
7. Is there a requirement for a FAIL-SAFE Analyzer?
8. What happens when the sample flow system clogs?
9. Are all sample wetted parts heated to match the dew point of your process?