

UV flame sensors: how to know your flame is on

How rapid response, rugged UV flame monitoring is safeguarding gas turbines and fired process equipment



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Executive summary

Flame sensors are crucial to the safe operation and maintenance of harsh, high temperature gas turbines and fired process equipment such as steam methane reformers, boilers, drying kilns and industrial ovens. Fired process equipment and gas turbines for power generation use combustible fuels such as natural gas, diesel, and refinery gas. Flame supervision when using such combustible fuels is crucial to safety and regulatory compliance. Knowing the flame is on and functioning correctly, as well as flame out conditions that trigger automatic fuel shut-off, ensures safe operations, and sustains manufacturing profits.

Traditional flame sensors, however, can burn out in combustion's harsh, high temperature conditions, thus introducing unnecessary risks, unplanned downtime and the potential for escalating repair and operating costs. These older sensors sometimes require an additional purge air for sensor cooling, adding additional operating costs. Further, older, lower temperature flame sensor technologies are not suited for harsh environments. This creates an unknown flame condition and exposes operators to the preventable potential for steep costs and serious, often irreversible consequences. If a flame out condition occurs, flame sensor output informs the safety integrated system to rapidly turn off fuel valves and avoid uncombusted gas build-up that can create the potential for an explosion.

In the challenging environments present in fired equipment operations, new, rugged UV flame sensors can withstand temperatures up to 325°C and respond within milliseconds. Rugged UV flame sensors are the apt solution for proactive protection and prevention in the harsh environments of fired process equipment and power generation operations.



Flame monitoring improves safety

Monitoring the flame signal to ensure that the flame is on is one of the most important safeguards in gas turbines and fired process equipment such as boilers, drying kilns and industrial ovens. A flame detector ensures a known flame condition and automates fuel shut off in flameout conditions to better protect our environment and mitigate risks of catastrophic industrial manufacturing events to make our world a safer place. These are valuable benefits, however, they can only be realized when appropriately designed flame detectors provide on-going monitoring – and proactive management – of flame conditions.

Unplanned downtime is the bane of manufacturing. In fact, a recent [study](#) reveals that zero unplanned downtime is a top priority for 72% of industrial companies. Power generation and fired equipment operations rely on two key levers to sustain uptime and profitable manufacturing:

1. *Managing and minimizing maintenance costs*
2. *Maximizing machine availability for production*

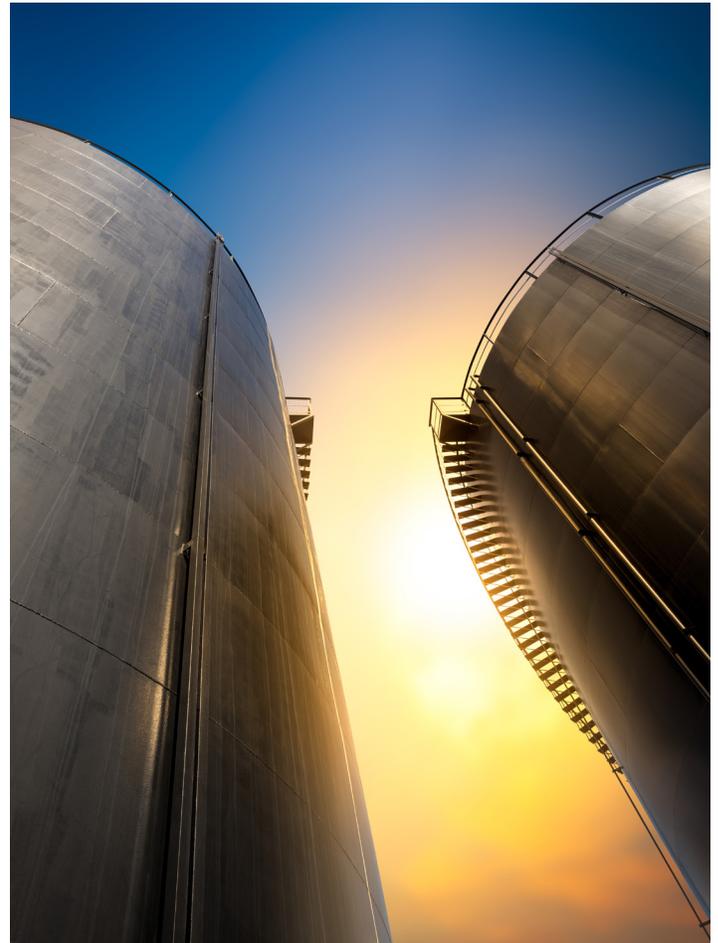
Ensuring that a flame is lit enables the achievement of these two goals as it mitigates enormous risk while reaping significant benefits. Conversely, when industrial flames go unchecked and are unknowingly extinguished, it is the potential “first domino” that triggers costly large-scale catastrophic events – within seconds of flameout.

Monitoring flames to prevent flameout consequences, however, is tricky business. Historically, manual checks have been used to inspect flames, however, once the flame is out, the hydrocarbon fuel build up and potential for catastrophic

Gas turbine example. Gas turbine example. In gas turbine operations, water cooling systems have traditionally been used to keep the flame sensors from overheating. Water-cooled sensors, while used broadly in gas turbines, operate at lower temperatures, require installation and maintenance of water lines and can incur higher maintenance issues. Thus, gas turbines are an ideal application for next generation, rugged, high temperatures UV flame sensors that can minimize equipment and maintenance vulnerabilities, maximize ease of use, and boost reliability. In fact, it is gas turbine requirements that spurred much of the innovation for developing high temperature, robustly designed UV flame sensors. As a result, leading gas turbine operators have adopted UV flame sensors that employ high temperature, high vibration remote UV sensing to enhance reliability and maintain safety.

and fatal explosions develops rapidly, making manual intervention unsafe. Thus it is vital to implement automated flame supervision that prompts the control system to quickly stop the fuel supply when a flameout is detected.

Traditional flame sensor electronics, however, can burn out in harsh, high temperature industrial environments and subsequently introduce unnecessary risks, unplanned events and the potential for escalating repair and operating costs. When traditional flame sensors do burn out, plants often operate without any flame detection systems in place – introducing unnecessary vulnerability and operational risk.



The bottom line is this: At all times and without exception or negative tradeoffs, fired equipment operators must know with confidence the flame condition.

Why flame sensors are crucial

Inherently, combustion processes are higher risk operations due to the combination of extreme temperatures and flammable fuels. Undetected flameouts can lead to highly undesirable outcomes that compound quickly such as increased downtime and maintenance/repair costs and dangerous – sometimes fatal – explosions if uncombusted fuel gas builds up inside a firebox or turbine.

Combustion explosions. In catastrophic examples of undetected flameout and subsequent hydrocarbon fuel build up, explosions can occur. See steam methane reformer example on this page for one real-world example of a combustion explosion that may have been prevented by proper flame sensing technology.

Unplanned downtime and maintenance/repair costs.

A [survey](#) of industrial manufacturers estimates that 82% of industrial companies have experienced unplanned downtime during the past 3 years. Unplanned downtime carries a steep cost. Production interruptions translate into hours or days of unplanned downtime incurring lost revenue coupled with concurrent spikes in repair, labor, and overhead costs.

It is universally agreed that the cost of unplanned downtime is expensive, although getting to a precise estimate is an elusive calculation. Cost estimates range from a cross-industry average of \$250,000/hour (per [Aberdeen](#)) up to \$3 million/hour for the automotive industry (per [Simultech Media](#)). (Yes, \$3 million per hour is not a typo). At the most conservative cost estimate of \$250,000/hour and assuming 8 hours/year of unplanned downtime, fired equipment and power generation operations could incur more than \$2 million annually of incremental costs stemming from unplanned downtime.

“82% of industrial companies have experienced unplanned downtime during the past 3 years at a conservatively estimated cost of \$2 million per annum.”

Steam methane reformer example. Consider the example of steam methane reformers where high operating temperatures require flame supervision only during start-up cycles. Dangerous build-up and ignition of uncombusted fuel has resulted in dangerous explosions, incurring significant damage, personal injury and downtime. During plant start-up in one example, large amounts of uncombusted natural gas fuel accumulated in the radiant section of the steam methane reformer. The fuel exploded and destroyed the radiant section of the steam methane reformer. Two operators were seriously injured and the operation was shut down for an entire 11 months. The steam methane reformer was re-built with a integrated safety system, automatic fuel valves, and flame sensors. The flame sensors, however, were insufficient to withstand the high temperatures in the penthouse of the steam methane reformer so the plant operated without flame sensors for multiple years. In 2018, the manufacturer installed a rugged UV flame sensor for use in a qualification test. The sensor performed very well for six months and as a result, the company expanded installation to twenty rugged, UV flame sensors that ensure proper, reliable and comprehensive remote detection of a flame condition.

The ROI of protection. Proper flame monitoring mitigates risks and vulnerabilities in power generation and fired equipment operations. A single vulnerability can rapidly and readily magnify into compounded vulnerabilities, thus proactive protection and prevention delivers significant value. In terms of magnitude, the cost of flame sensor protection is a fraction of capital equipment investments and escalated maintenance and repair costs. Irreversible events such as injury, loss of life, and environmental harm are of paramount importance and inestimable cost. And, safer operations are often cheaper to insure. From multiple perspectives, flame monitoring is a smart, must-have solution in power generation and fired equipment operations.

UV flame sensor technology

Traditional flame sensor solutions are not suited for some harsh, high temperature environments. Using air-cooling systems to prevent sensor burnout introduces significant secondary risks, making traditional flame detectors ineffective for harsh environments.

Next generation, UV flame sensors are designed for combustion's rugged conditions. UV flame sensors that employ high temperature, high vibration remote UV sensing to enhance reliability and performance stand alone as the apt solution for harsh environments. They mandate capabilities such as:

+ **Ultraviolet (UV) flame** detectors to sense the UV wavelengths produced by a flame to signal whether a flame condition exists. UV detectors are not susceptible to black body radiation, preventing "misreads" from hot combustor parts.

+ **Silicon carbide** optical photodiodes to create an ultra-high temperature sensing element that can operate up to 325°C vs. 80°C typical of traditional flame sensors. This prevents sensor burnout and subsequent malfunction from sensor damage and in turn, boosts reliability.

+ **Rapid response times** to proactively prevent intensifying events. Response times for next generation UV flame sensors have evolved to milliseconds – or 4 times faster than the blink of an eye – to ensure quick flameout detection, and avert the potential for combustion explosions from uncombusted fuel.

Rugged, next generation UV flame sensors deliver exponentially more performance than predecessors that are fraught with issues and vulnerabilities, as they were not engineered to withstand harsh, high temperature conditions.



Summary

In the high stakes operation of fired process equipment and power generation, all flame sensors are not created equal. Risks inherent in these harsh, high temperature environments require mitigation as the consequences can be significant and devastating. Specifically engineered, rugged, high temperature, fast response UV flame sensors can withstand temperatures up to 325°C and respond within milliseconds. In power generation and fired process equipment operations, UV flame monitors stand alone as the solution to deliver strong protection and ensure manufacturing profitability, provide environmental security and safeguard lives.

