White Paper

Oil Mist – The Dangerous Blind Spot in Gas Turbine Fire Protection

EMERSON

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Introduction

Due to the dangers associated with gas turbine fires and explosions, operators in the oil and gas and electric power generation industries have learned over the years to protect these pieces of equipment against hazardous material releases. Both onshore and offshore, in public and process power sectors, gas turbine installations use fire and gas monitoring devices as a long established and highly regulated practice. So how is it possible that one of the single greatest threats in gas turbine monitoring is so often overlooked?

Oil mist detection

Most industrial professionals do not realize that oil mist detection is an overlooked hazard related to gas turbine monitoring. Many more fires are produced by oil mist than by natural gas releases. As gas turbine installations age, the probability of enclosure failure and sequent risk of fire and explosion will increase.

Oil mist monitoring is vital for the protection of gas turbines, whose uses include power generation, gas injection, gas lift, waterflood, and gas compression, as well as for monitoring engine crankcases and engine rooms for marine diesel engines. When combined with gas detection, oil mist detection increases the detection efficiency of hazardous material releases, providing early warning of combustible liquid leaks.

The critical problem

Although gas turbine enclosures are fitted with gas detectors, very few have combustible liquid detectors. Consider that in a survey of incidents involving gas turbines in the UK offshore sector, the Health and Safety Executive (HSE) found that approximately 88 percent of the hazardous liquid releases were undetected and 69 percent ignited. Liquid releases are those from liquid fuel like diesel and lube oil. By contrast, 22 percent of combustible gas leaks were undetected and 13 percent ignited. Based on the analysis, the agency concluded that the “standard of liquid leak detection in turbine enclosures is very poor and further expressed that liquid leak detection must be significantly improved. Table 1 shows a summary of gas and liquid leak and ignition figures form an HSE review of offshore gas turbine incidents between 1991 and 2004.

Table 1-1. Hazardous Material Release and Ignition Figures from Gas Turbine Incidents

Fluid	No. of Leaks	Detected	Ignited	Undetected	Ignited
Gas	134	104	1	30	18
Liquid Fuel	61	11	2	50	31
Oil	42	1	1	41	40
Unidentified Fluid	35	Unknown	31	Unknown	Unknown

Source: UK Health and Safety Executive[1]

Figure 1. Fire and explosion risks are major safety concerns for personnel at gas turbines.

Gas turbines are at a high risk of fire and explosions because they operate at high temperatures and continuous vibration of parts results in rapid wear and possible loss of integrity in the piping network. Additionally, large amounts of flammable fluids are present during turbine operation, including lubricating oil from lubricating oil systems and fuels like natural gas, liquid petroleum gas (LPG), refinery gas, gas oil, diesel, and naphtha. Hydrogen and biogas derivatives may also be present as primary or alternate fuels. Diesel or other liquid fuels and lubricating oil have auto ignition temperatures that are significantly lower than that of natural gas. For example, the auto ignition temperature (AIT) of diesel and lube oil is approximately 240°C, while that of methane is 530°C. Since the external surface of a turbine combustion chamber can reach 200 - 400°C, ignition is likely to occur if diesel or lube oil makes contact with surfaces at these temperatures.

Why smoke and gas detectors will not do the job

A number of operators are unaware of oil mist's high hazard potential in gas turbines. Frequently, end users do not realize that oil mist detectors exist, and in truth, there are not a wide range of options. But it is critical to industrial safety that professionals understand the differences in the operating principles of gas and smoke detectors versus oil mist detectors and grasp that what they currently have may not do the job that is needed.

Oil mist devices detect particles ranging from a fraction of a micrometer to tens or hundreds of micrometers. Smoke detectors are designed to detect particulates, but of a different size and type than oil mist. Most smoke detectors are often not sufficiently rugged or resilient to high ambient temperatures for the required placement inside turbine acoustic enclosures.

Combustible gas detectors can be either catalytic bead or infrared (IR). Catalytic bead detectors operate on the principle of combustion in the presence of a catalyst (such as platinum, palladium, and rhodium). As combustible gases oxidize in the presence of a catalyst, they produce heat and the sensor converts the temperature rise to a change in electrical resistance which is linearly proportional to gas concentration. A standard Wheatstone bridge circuit transforms the raw temperature change into a sensor signal. Unlike catalytic detection, the infrared method relies on the absorption characteristics of the gases in the infrared spectrum. Infrared gas detectors consist of an IR light source and light detector to measure the intensity at the absorption wavelength, typically 3.2 – 3.5 µm, and a non-absorbed wavelength, for example, 4.0 µm. If gas is present in the optical path of an infrared light source, it will attenuate the intensity of light. This change in intensity establishes the presence of the gas and provides a measure of gas concentration. Neither combustible infrared nor catalytic bead detection technology is suitable for the detection of pressurized liquid leaks.

Approaches to oil mist detection

When professionals set out to correct the critical lack of monitoring for oil mist in their gas turbines, it is important to understand the choices and differences. Most oil mist detectors are point or open path infrared types.

Open path oil mist detectors separate the receiver and transmitter and employ a reflective mirror to direct the beam to the receiver (Figure 2). The main advantage of these devices is that they cover a large area, since they respond to mist present anywhere along the beam path. Despite their wide area of coverage, the detectors also require frequent maintenance, since mirrors are easily coated with oil or dirt. Neither can they distinguish between a localized high mist density and a more diffuse mist at lower concentrations. Most importantly, the design of the open path makes the detector least accurate when it is most needed – at the moment when the oil mist is released and coats the lens. In addition, the extreme vibration of the rotating turbine can cause sensitive open path detectors to fall out of alignment.

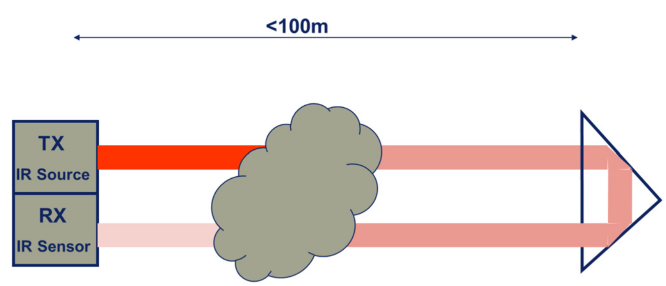

Figure 2. Open path oil mist detection.

Point oil mist detectors determine the concentration or presence of airborne oil droplets by measuring the intensity of light by a laser or light emitting diode that is scattered and absorbed by the droplets. The measurement is based on the principle that any suspension of particles or droplets absorb and scatter a fraction of light that passes through it. In contrast to open path designs, there is no mirror to become compromised by the oil mist nor alignment required for the detector to operate (Figure 3).

Point oil mist detectors continuously monitor the signal that is received, reflected from the measuring cell. Certain models feature single- or dual-beam design, field adjustable zero level of obscuration, and sensitivity settings that allow for fine tuning to optimize performance and reduce false alarms.

Essential Oil Mist Detector Capabilities

Industry professionals need to exercise care when selecting oil mist detectors since confusion exists about effective technology. Based on our experience, effective oil mist detectors should be based on the following factors:

- Point detection technology – The more stable design is not based on a reflective surface that can be compromised by the substance it is detecting.
- High ambient temperature – Ambient temperatures in gas turbine enclosure are 40 - 60 °C on average. Detectors designed to monitor for oil mist must be suitable for this environment and even higher temperatures. Look for a maximum specified operating temperature limit of 65 - 70 °C.

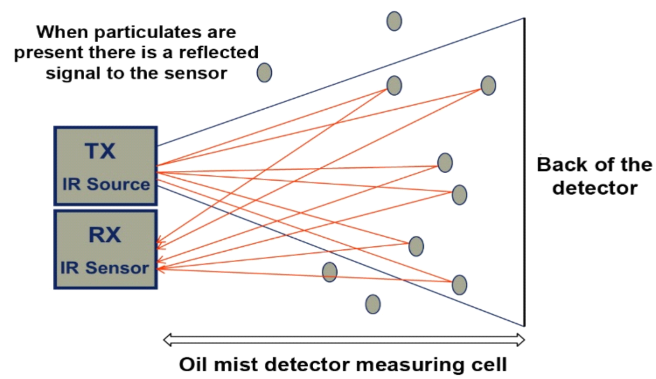

Figure 3. Point oil mist detection.

- Hazardous location capabilities – Gas turbine enclosures are areas where flammable liquids, gases, or vapors exist in sufficient quantities to produce and explosion or fire. As a result, instruments that are placed in these enclosures must be designed for hazardous locations.
- Resilient to vibration – Oil mist detectors must remain stable in environments with vibrating equipment under continuous operation.
- Stainless steel body – As a durable material that is highly resistant to corrosion, stainless steel is well suited for the harsh environments in gas turbine enclosures.

Figure 4. Net Safety Millennium Air Particle Monitor from Emerson™.

Gas turbines are designed for continuous operation. A well-chosen oil mist detector reduces the maintenance burden and the need for unplanned shutdowns. Typical planned maintenance on a turbine is between six months to a year. Any system or device that causes an unplanned shutdown costs the producer money and may result in the end user paying hefty fines for missed output. Oil mist detectors are critical to the safety of people and property, but the choice of technology is also important.

Placement of oil mist detectors

According to the HSE, a best practice is to install oil mist detectors in gas turbine exhaust ducts to provide early warning of flammable liquid leaks. The sensor head is mounted directly into the duct, while the transmitter is placed outside the gas turbine enclosure and usually at eye level. Due to the size of the ducts, more than one device may be required to provide adequate detection coverage. In addition, oil mist detectors are often placed inside the middle turbine casing area but away from the combustor. Large gas turbine enclosures may have between four and six detectors. The placement of oil mist detectors in a gas turbine enclosure is shown in Figure 5.

Early warning allows for the rapid shutdown of the turbine and isolation of fuel or lube oil, minimizing leakage of flammable liquids into the enclosure and consequently minimizing the fire load.

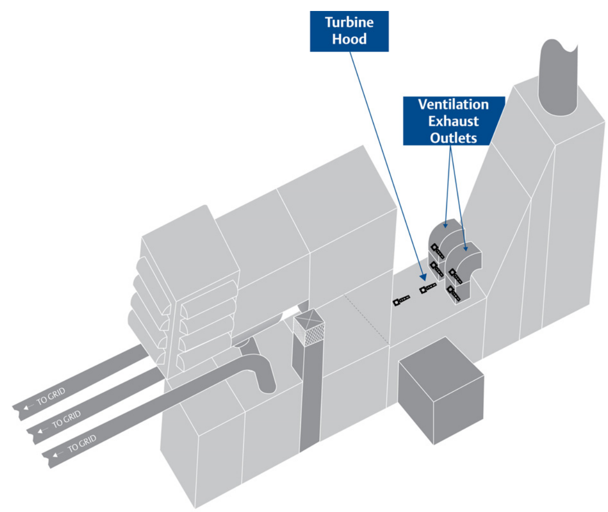

Figure 5. Typical placement of oil mist detectors in gas turbine enclosure.

Conclusion

Combustible liquid releases pose a severe hazard to gas turbine installations. Oil mist detectors have proven effective in detecting releases from diesel and lube oil. Selection of the equipment is critical, given the diversity of oil mist detector designs and the demands placed on the instruments by the gas turbine enclosures' environment and the process units' requirements for continuous operation and annual or semi-annual maintenance. A well-chosen oil mist detector keeps pace with gas turbine usage, mitigating the risk of unplanned shutdowns and reducing operation costs.

[1] *Offshore Information Sheet No. 10/2008: "Fire and explosion hazards in offshore gas turbines." Health and Safety Executive.*

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