Leak Detection in Heat Exchange Systems



Heat exchangers are a common component in industries ranging from food and beverage processing to power generation and chemical manufacturing. When the integrity of a heat exchanger is compromised, cross-contamination between the heating medium and process streams with potentially serious consequences for product quality, equipment reliability, consumer safety, and regulatory compliance.

Early, reliable detection of these leaks is essential. The Kemtrak FL007 fluorescence analyzer provides continuous, real-time fluorescence monitoring specifically designed to detect trace contamination of product streams by hydrocarbons and other fluorophores at concentrations as low as parts per billion (ppb). This application note explains the measurement principle, describes key use cases, and details how the FL007 is deployed for heat exchanger leak detection.

KEY FACT - A heat exchanger leak can go undetected for weeks or months before visible signs appear. By that time, product batches may be contaminated, regulatory limits exceeded, and downstream equipment damaged.

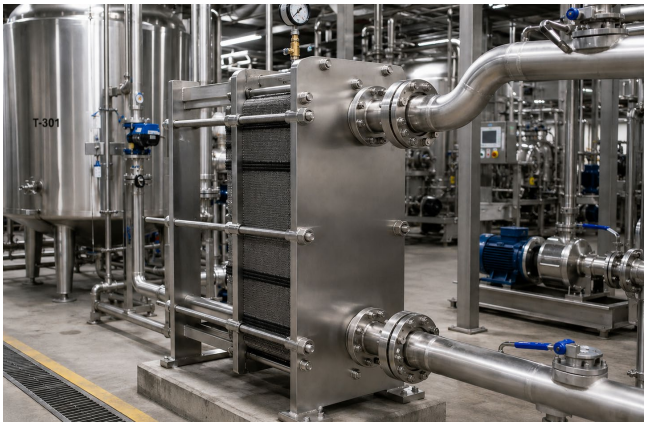
THE CHALLENGE: CONTAMINATION FROM HEAT EXCHANGER LEAKS

Heat exchangers transfer thermal energy between two fluid streams while keeping them physically separated. Failure of internal seals, tube bundles, plate packs, or gaskets allows one stream to migrate into the other. In industrial and food-grade applications, this typically means some form of heat-transfer oil or glycol entering the process stream.

Contamination from heat exchanger leaks presents multiple risks:

- Product spoilage and batch loss in food, beverage, and pharmaceutical processes
- Regulatory violations — the European Food Safety Authority (EFSA) and equivalent agencies mandate monitoring for hydrocarbon contamination in food-contact streams
- Environmental discharge of contaminated water to drain or receiving waterways
- Fouling and damage to downstream equipment such as membranes, ion exchange resins, and analytical instruments
- Worker safety hazards in high-temperature or pressurized systems

The conventional inspection methods of visual checks, periodic sampling, and manual lab analysis cannot provide the continuous, real-time detection necessary to catch leaks before damage is done. Automated inline monitoring with an FL007 addresses this gap.



MEASUREMENT PRINCIPLES: FLUORESCENCE AND SIMULTANEOUS TURBIDITY

The Kemtrak FL007 uses both fluorescence and scattered light techniques to detect contamination in a process stream. Fluorescence is not susceptible to interreference from turbidity and air bubbles, making it ideal for aromatic oil and fluorophore detection. For non-fluorescing fluids such as aliphatic oils that are immiscible in water, a back scattered light technique is an effective detection method although background turbidity and entrained air will have to be taken into account when deployed.



UV Fluorescence

The FL007 exploits a fundamental optical property of petroleum-derived oils and many synthetic lubricants: their aromatic and polyaromatic hydrocarbon (PAH) content causes them to fluoresce when illuminated with ultraviolet light. A stable UV LED light source is directed into the process stream via a fiber optic probe. Aromatic hydrocarbons in the fluid absorb this UV energy and re-emit it as visible fluorescent light at characteristic wavelengths. The intensity of this emitted light, which is directly proportional to the oil concentration, is measured to determine the presence of oil in the stream. Because different oils have different PAH fingerprints, the technique provides high selectivity for hydrocarbon contamination versus clean water.

VIS Fluorescence

For heat exchange fluids such as inhibited glycols, the addition of a small amount of a fluorescing dye such as Fluorescein is an exceptionally effective way to detect small leaks across heat exchangers. The concentration of dye required in the heating fluid depends upon the desired detection limit in the process fluid. For example, a 5 ppm detection limit for glycol (60%) in the process fluid would require the heating fluid to have a dye concentration of at least 120ppm.

Key advantages of fluorescence detection:

- Detection limits in the low ppb range — appropriate for regulatory compliance and early-warning applications
- UV fluorescence is highly selective for hydrocarbons – no transfer medium dye needed
- The fluorescence signal is not generated by common water-treatment chemicals, minerals, or suspended solids that do not fluoresce
- Continuous, real-time output with fast response times for rapid leak detection

Scattered Light Turbidity Measurement

Not all oils fluoresce strongly. Highly refined white mineral oils, some food-grade lubricants, and certain synthetic fluids have low PAH content and produce a weak fluorescence signal. For these non-aromatic or low-PAH oils, the FL007 simultaneously measures turbidity (light scattering) to detect the presence of dispersed oil droplets or emulsified hydrocarbons caused by the heating medium migrating across the exchanger.

Dual-channel fluorescence/turbidity measurement ensures comprehensive coverage of:

- Aromatic oils detected by UV fluorescence
- Fluorescent dyes added for detection/tracing purposes
- Non-aromatic or low-PAH oils detected by turbidity
- Both measurements performed simultaneously



12mm Kemtrak fluorescence probe

Note that when relying on turbidity for non-fluorescent oil detection, entrained gas bubbles or suspended solids can affect the turbidity reading. Process conditions should be considered when interpreting results in such cases.

HEAT EXCHANGER LEAK DETECTION

The FL007 is deployed for heat exchanger monitoring in two primary configurations, depending on the process layout and the criticality of the application.

Realtime Monitoring — Product or Cooling Water Outlet

The most common deployment positions an FL007 fiber optic probe directly in the process stream on the outlet side of the heat exchanger either in the product line or the cooling/heating return.

Typical installation points include

- Cooling water return from lube oil coolers in compressor or turbine packages
- Product water outlet on shell-and-tube heat exchangers in food and beverage processing
- Condensate return lines where steam contacts oil-wetted surfaces
- Process water effluent lines prior to discharge or reuse

The instrument monitors continuously and triggers an alarm when the fluorescence or turbidity signal rises above a user-defined threshold, indicating a leak through the exchanger and providing:

- Immediate detection of leaks as they develop
- Automatic diversion or shutdown of the affected stream before contaminated product reaches packaging or heating medium reaches recycle
- Continuous data logging for trend analysis and predictive maintenance

Differential Monitoring

In applications where background levels of hydrocarbons, other fluorophores, or turbidity are present in the incoming stream, a differential monitoring approach is used. Two FL007 instruments are installed, one upstream and one downstream of the heat exchanger, and their signals combined to provide a differential measurement. A rising differential indicates a leak within the exchanger itself, isolating the alarm from background variation in the feed stream.

THE KEMTRAK FL007 INSTRUMENT

The FL007 is a fiber optic photometer purpose-built for industrial in-line leak detection. Its core design philosophy of separating the electronics from the measurement point using optical fibers makes it uniquely suited to the demanding environments found around heat exchangers.

In the FL007, the LED light source and all sensitive detector electronics are housed in a separate instrument enclosure, separated from the process with 5 meters of optical fiber. Only the inert, chemically resistant fiber optic probe contacts the process fluid.

	Nominal Range	Detection limit / Resolution
UV Fluorescence	0 – 5 ppm PAHphe (ca. 0 – 200 ppm oil in H2O)	1 ppb PAHphe
VIS Fluorescence	0 – 100 ppm (fluorescein)	1 ppb
Turbidity	0 – 10 000 FTU (ca. 0 – 2% oil in H2O)	< ± 0.5 FTU (typ.)

Key Technical Features

The FL007 incorporates several design features that contribute to measurement reliability in continuous service:

- LED-based UV source: No frequent lamp replacement requirements
- No moving parts: All-solid-state design minimizes maintenance and ensures uptime
- Automatic compensation: Internal reference channel corrects for changes in light source intensity

INDUSTRY APPLICATIONS

Food and Beverage Processing

Oil contamination from processing equipment such as compressors, pumps, and gearboxes is regulated under food safety frameworks. The FDA and similar authorities have identified hydrocarbon monitoring as a requirement. The FL007 provides the continuous monitoring needed to demonstrate compliance and to protect product integrity. Alarm outputs can be interlocked with automated divert valves to isolate contaminated product streams instantly.

Power Generation

Turbine lube oil systems use large shell-and-tube coolers. A lube oil leak into the cooling water can result in oil entering cooling towers or environmental waterways. The FL007 monitors the cooling water return for trace hydrocarbon contamination, providing early warning before concentrations reach reportable discharge limits.

Chemical and Petrochemical Processing

In refineries and chemical plants, heat exchangers frequently operate under elevated pressure and temperature. Tube failures can allow process hydrocarbons to enter cooling water circuits. Continuous monitoring with the FL007 protects cooling tower integrity, prevents regulatory exceedances, and provides early indication of tube bundle degradation.

Water Treatment and Municipal Supply

Pumping stations and treatment works use lubricant-containing machinery in close proximity to potable water streams. The FL007 provides the ppb-level sensitivity required to detect trace contamination events before clean water reaches distribution.



Deploying the Kemtrak FL007 for heat exchanger leak detection delivers operational and safety benefits:

- Continuous 24/7 monitoring with no sample conditioning or wet chemistry required
- Fast response: leak events detected in seconds, not hours
- Low detection limits: ppb-level sensitivity for both aromatic and non-aromatic oils
- Minimal maintenance: solid-state LED source with no consumables
- Process safety: fiber optic design allows monitoring in hazardous or high-temperature locations
- Regulatory compliance: supports documentation requirements

GET IN TOUCH

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