CLEAN AIR TASK FORCE

Typology of Common Leaks and Repair Considerations

A shared and consistent understanding of leak types and potential mitigation actions is essential for the effective implementation of LDAR programs. This factsheet summarizes the key points in Section 4 of A Policymaker's Guide to Implementing Leak Detection and Repair for Methane Mitigation. Regulators and operators can use this factsheet to foster a shared understanding of leaks – in terms of what they look like in the field, the types of equipment they are coming from, their root causes, and potential repairs.

Leak typology

The classification of emission sources is critical to accurately identify emissions, determine their regulatory status, and implement effective mitigation measures. Numerous terms are used to describe emission sources and root causes, with many categories partially overlapping.

Spatial characteristics	Point source	Emissions are localized and stationary, with the origin of the emission easily identifiable (e.g., storage tank vent).
	Diffuse source	Emissions are spread out over an area, making it difficult to pinpoint a single localized source (e.g., wastewater pond).
Temporal characteristics	Continuous	Emissions are continuous and uninterrupted at a relatively steady rate over a 24-hour period (e.g., unlit flare or malfunctioning compressor seal).
	Intermittent/single event	Emissions are released sporadically, triggered by specific operational activities or changes in process conditions (e.g., pressure relief valve emissions).
Leak source characteristics	Equipment malfunction	Emissions resulting from mechanical failure or gradual degradation of a leak-tight component (e.g., corroded flange gasket).
	Operational upsets	Emissions resulting from poorly configured process controllers, system error, or operating outside of designed parameters (e.g., valve stuck in "open" position).

Leak types and repair considerations

Repair considerations vary depending on the type of leak, the equipment involved, and the operational and safety context. Leak types can be grouped into categories when planning for appropriate responses and repairs. The leak categories for repair include:

Leak Category	Description	Example
Routine leaks	Occur on standard components and can often be repaired using established maintenance practices without significant operational disruption.	Valve packing leaks, instrument tubing leaks, threaded connection leaks.
Process-critical or safety-related leaks	Involve equipment that plays a critical role in process control. Repairs may require temporary shutdowns or adherence to specific safety protocols.	Pressure relief device leaks, compressor seal leaks, tank thief hatch leaks, large diameter flange leaks, heater or fired equipment leaks.
Structural or access-limited leaks	Originate from components that are physically hard to reach or require specialized access equipment.	Elevated piping or equipment, tank roofs, pipe racks, offshore or remote facilities.

Findings from onsite observations

The table below summarizes the cause of emissions (i.e., what is happening) and the potential causes (i.e., why it's happening) for different component categories **based on CATF's onsite observations during field campaigns and discussions with field personnel.** The table is **intended for illustrative purposes only**, acknowledging that field interpretations and the constraints of OGI technology may lead to inaccuracies. Regulators and operators can use this table to get an idea of what the leaks may look like through OGI footage, potential causes of leaks, and potential repair or mitigation action.

Valves		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Open valve	■ Procedural oversights (e.g., valves left open for convenience between routine gauging and sampling activities, or subtle mechanical wear between maintenance cycles that prevent a tight seal). ■ Degradation of seals, worn packing, or stem interfaces, which can lead to emissions even when valve is closed.	■ Close the valve and verify the seal is gas-tight. ■ Review of operational procedures to ensure valves are consistently and correctly sealed after maintenance or sampling.
Loose, degraded, or broken valve	■ Thermal expansion, vibration, improper installation, equipment malfunction, and general wear, which can create small pathways for gas to gradually begin to leak.	■ Repair the leak immediately through mechanical adjustments or component replacement only if safety and operational protocols allow. ■ Schedule a formal repair for the next maintenance or shutdown period if immediate repair is not possible.
Video examples		

Flanges and bolted connections		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Mechanical adjustment	■ Thermal expansion, vibration, and corrosion, which causes bolts to loosen and gaskets to degrade. Over time, this leads to a gradual loss of tightness at connections, even when piping remains structurally intact.	■ Repair immediately by tightening a bolt or fitting to restore the seal only if safety and operational protocols allow. ■ If tightening fails to stop the emission, the gasket or seal may have internally failed. Schedule a component replacement. ■ Conduct a follow-up OGI inspection to verify that the leak has been fully mitigated under actual process conditions.
 Video examples		
Seals, packing, and dynamic interfaces		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Compressor seal degradation	■ Gradual degradation of sealing interfaces due to corrosion and mechanical wear. These leaks have typically occurred due to compromised internal components, causing gas to leak from primary containment systems.	■ Component replacement, frequent maintenance, or upgrading to materials specifically engineered to withstand the chemical and thermal stress of the process.
Stuffing box leaks	■ Degradation or malfunction in components like gland packing, flange seals, or internal gaskets.	■ Planned replacement of the damaged components or packing. ■ Engineering review to repair damaged infrastructure to restore sealing.
 Video examples		

Process piping and structural components		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Corroded pipeline	■ Damaged and cracked pipeline segments caused by internal or external corrosion, pressure, and/or poor maintenance. Leaks can occur even in pipelines appearing intact because of structural vulnerabilities or gradual material degradation that can create high-pressure pathways for significant, and sometimes hazardous, gas leaks.	■ Specialized engineering or operational review and interventions, such as the full replacement of compromised pipe segments, may be necessary for repair. ■ Flow assurance analysis can be helpful to prevent recurrent mechanical fatigue or material degradation, and ensure long-term containment.
Video examples		
Instrumentation and controls		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Loose or broken gauge	■ Originate at connection points due to improper tightening, degraded seals, or mechanical wear from frequent adjustments (from operators trying to record gauge readings).	■ As a first repair attempt, re-tighten the gauge to restore the seal. ■ Secondary OGI verification is needed to ensure the leak is resolved. ■ If the leakage persists, the gauge seal or the entire unit may require replacement.
Video examples		

Tanks, storage, equipment, and pits		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Open thief hatches and open vents	■ Operational oversight, such as thief hatches on tanks or manways being left unlatched or improperly sealed after gauging or sampling activities. ■ Mechanical wear, including the degradation of internal seals or gaskets.	■ Check that the lid is properly latched, then use OGI to confirm the seal is holding. ■ If a leak persists after the thief hatch is closed, repair or component replacement may be required. ■ For severe cases (e.g., missing lid or damaged structural component), repair may require installing a new hatch or performing roof repairs to restore tank containment.
Structural degradation	■ Severe corrosion, localized structural damage, or internal roof collapse, leading to holes or breaches in the roof or shell of the tank.	■ Tailor repair/mitigation action to the severity of the damage. ■ Minor perforations can be easy to address through reinforcements. Severe degradation can require immediate engineering review to prevent total structural failure.
Video examples		

Pressure release devices		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Poorly tuned or degraded devices	■ Improper tuning of devices (i.e., incorrect set points), allowing methane to be released below intended operating pressures. Some facilities keep set points intentionally low due to concerns about vessel capacity or valve reliability, leading to chronic emissions. ■ Component malfunction or mechanical failure, including damaged or broken valves.	■ Correctly tune and calibrate the device to ensure it remains tightly sealed until the set operating pressure is reached. ■ If emissions persist, component repair or valve replacement may be required. ■ Monitor the device frequently to verify that it operates within its specified range.
Video examples		

Emission control equipment		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Flare failure or malfunction	■ Unlit flares from ignition system or flare tip failure or poor combustion efficiency, allowing methane to be released without combustion. ■ Poor combustion efficiency from inadequate gas composition or flow rates, leading to incomplete destruction of methane.	■ Repair or upgrade the ignition system or flare tip ensuring reliable and efficient flare operation. ■ Conduct an internal inquiry or review to determine if operational changes have affected the gas composition or flow rates beyond the flare's design capacity. ■ Regularly monitor, test, and maintain the pilot system and flare operation.
Video examples		

Actuated device		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Component degradation or controller failure	■ Poor tuning, where the device fails to close/seal completely under most process conditions. ■ Physical damage like internal corrosion and worn-out seals.	■ Recalibrate, repair, or replace damaged internal components or device to ensure that the device can operate within the intended operational parameters. ■ Regularly monitor and maintain devices to reduce emissions from in the long-term.
Video examples		

Vents, open-ended lines, and intermittent sources		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Process vents: Open or poorly closed	■ During pipeline maintenance or pigging activities, emissions are not routed to control devices. Instead, they are vented through open vents or vents that are left partially open or have improper seals. ■ Improper process vent closure after operational activity is complete.	■ Conduct additional checks to ensure the vent valve is fully rotated to the closed position and verify via OGI to confirm the leak has stopped. ■ If the leak persists, the internal components may be compromised by debris or wear, requiring further investigation.
Bad operational practices	■ Temporary modifications or improvised solutions or workarounds (i.e., using buckets to collect condensate from discharge lines).	■ Shift from temporary fixes to implementing robust engineered solutions that align with recognized engineering and best practices. ■ Review field procedures and site conditions to replace leak-prone improvised workarounds with standardized, low-emission solutions.
Structural cracks or gaps in the subsurface wellhead casing	■ Component degradation or mechanical wear	■ Mechanical adjustments, such as tightening flange bolts or repacking the stuffing box, and component replacement to restore sealing and re-establish a gas-tight boundary. ■ Depending on the severity of the structural integrity issues or equipment malfunction, immediate engineering review and intervention to repair or replace major equipment may be required. ■ Conduct a follow-up OGI inspection to verify that the leak has been fully mitigated.
Video examples		

Threaded and mechanical fittings		
Cause of emission observed	Root cause based on CATF observations	Potential repair or mitigation action based on CATF experience
Component degradation or misalignment	■ Vibration-induced loosening, misaligned threading, or seal-tape/compound failure.	■ Component replacement (e.g., fittings, sealing tape) or mechanical adjustment (e.g., tightening).
Video examples		