United States Environmental Protection Agency
Office of Enforcement and Compliance Assurance

Compliance Alert

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EPA Observes Air Emissions from Controlled Storage Vessels at Onshore Oil and Natural Gas Production Facilities

Purpose

The U.S. Environmental Protection Agency (EPA) is publishing this Compliance Alert because EPA and state investigations have identified Clean Air Act compliance concerns regarding significant emissions from storage vessels, such as tanks or containers, at onshore oil and natural gas production facilities. The Alert discusses certain engineering and maintenance practices causing the compliance concerns and potential emissions-reducing solutions. While this Alert provides information intended to help operators and state regulators identify and address compliance concerns, the Alert's engineering and maintenance practices do not equate to or guarantee compliance with federal and state regulations.

Compliance Concerns

This Alert aims to help operators assess whether their vapor control systems are properly designed, sized, operated, and maintained such that emissions from storage vessels may be controlled in compliance with applicable federal and state regulations. For purposes of this Alert, a "vapor control system" includes a closed-top storage vessel, all vent lines leading from the storage vessel, fittings and connectors in the vent lines, any liquid knockout vessels in the vent lines, any pressure relief devices (PRDs) on the vessel or vent lines, and the control device used to combust gas or route gas into the sales line.

> EPA and state inspectors have observed emissions from storage vessel PRDs, such as closed thief hatches and pressure relief valves. Inadequately designed, sized, operated, and/or maintained vapor control systems may not effectively capture and control emissions.

At onshore oil and natural gas production facilities, oil and natural gas is extracted from sub-surface formations through a wellhead and then flows into a separator at varying pressures. The separator divides material from the wellhead into various constituents, such as oil, water, hydrocarbon liquids and natural gas or comingled

Storage vessels at an oil and gas production facility.

liquids and natural gas, depending on the characteristics of the well. The separator has a valve that opens to "dump" the pressurized liquid into a storage vessel. While some storage vessels are designed to operate at pressures greater than atmospheric pressure, most storage vessels currently used for oil and natural gas production are atmospheric storage vessels, which are only designed to operate at or below atmospheric pressure.

Storage vessel emissions at onshore oil and natural gas production facilities are regulated because they contain: (1) large quantities of volatile organic compounds (VOCs) that contribute to the formation of ground-level ozone; (2) hazardous air pollutants (HAPs) such as benzene, a known carcinogen; and (3) methane, a powerful greenhouse gas. Many storage vessels at onshore oil and natural gas production facilities generate emissions that can be safely and economically captured and controlled to protect public health and the environment, and prevent loss of valuable product. Moving from the high-pressure separator to a storage vessel's atmospheric pressure causes gas to "flash" off. In addition to flash emissions, storage vessels also have working emissions caused by liquid level changes in the storage vessel during loading and unloading operations and breathing emissions caused by temperature fluctuations in the storage vessel. State and federal laws require certain facilities to design, install, operate, and maintain effective pollution control measures to minimize the emission of VOCs from storage vessels. Such laws include state permitting and air pollution regulations – many of which are federally-enforceable and collectively referred to as the State Implementation Plan or "SIP" – and the federal New Source Performance Standards for Crude Oil and Natural Gas Production, Transmission and Distribution (NSPS OOOO). NSPS OOOO requires that new, reconstructed, or modified storage vessels with the potential for VOC emissions of equal to or greater than six tons per year reduce VOC emissions by at least 95 percent. That reduction also reduces HAP and methane emissions. The three predominant types of control devices used to comply with the 95 percent control requirement are: (1) enclosed combustion devices; (2) vapor recovery devices; and (3) flares.

> Dump events can overwhelm inadequately designed or sized vapor control systems and create back pressure that causes emissions to escape from PRDs.

Infrared video image showing emissions from a thief hatch on a storage vessel.

EPA and state inspectors have observed numerous instances of detectable emissions from controlled oil and natural gas storage vessels. The primary reasons for these detectable emissions are: (1) inadequate design and sizing of vapor control systems; and (2) inadequate vapor control system operation and maintenance practices. With respect to design and sizing of vapor control systems, the instantaneous peak surge of flash emissions that occurs when pressurized liquid is "dumped" from the separator (or other upstream pressurized vessel) to the atmospheric storage vessel – a "dump event" – can overwhelm an inadequately designed or sized vapor control system and create back pressure that causes VOCs, HAPs, and methane to escape from PRDs (*e.g.*, thief hatches and pressure relief valves (PRVs)). Although this peak surge of flash emissions may be short in duration, flash emissions constitute the majority of storage vessel emissions. Inadequate operation and maintenance practices can prevent a vapor control system from achieving its full control capacity or performance and lead to sustained emissions from storage vessels. Such emissions can be large quantities of flash emissions during dump events and working and breathing losses at all times. For example, vapor line capacity for emissions is reduced if condensed liquid is allowed to accumulate in vent lines. Further, inadequate operation and maintenance practices can also compromise vapor control system performance if emissions are able to circumvent routing to a control device altogether through open thief hatches or improperly seated PRDs. In any of these situations, the storage vessel may be emitting VOCs in excess of federal or state regulations. EPA and its state partners are monitoring these compliance issues.

Engineering Solutions and Maintenance Considerations

There are numerous engineering solutions and maintenance considerations available to address underperforming vapor control systems. This Compliance Alert highlights some options that operators are employing when attempting to address issues with vapor control system performance. This Alert does not present an exhaustive list nor rank the engineering solutions and maintenance considerations presented herein. As with all engineering solutions and maintenance considerations, factors such as safety, protecting public health and the environment, timing, cost, and site limitations should be considered along with applicable regulations.

Reduce Liquid Pressure Prior to Transferring the Liquid to Atmospheric Storage Vessels

Many operators have experience adding multiple stages of separation to reduce the pressure of the liquid in the last stage of separation prior to dumping the pressurized liquid into atmospheric storage vessels. All else being equal, a smaller pressure differential between the last stage of separation and the atmospheric storage vessel will result in less gas being flashed off the liquid during the dump event. Vapor recovery towers, surge bottles, or other comparable intermediate pressurized vessels immediately upstream of the atmospheric storage vessel provide an additional stage of separation. The additional pressure reduction provided by an additional separation stage decreases the change in pressure that will occur when liquid is transferred to the storage vessel and thereby reduces the amount of flash emissions. Reducing flash emissions will typically lower the potential peak flow rate of emissions that a vapor control system needs to handle. This may allow an existing, under-sized vapor control system to remain in place by reducing the flow to a rate that the existing system can handle. This is also a good approach for construction of new systems since it may allow for installation of a smaller, less expensive vapor control system, and it allows additional gas to be routed for sale.

Hydrocarbon staining under a PRV indicating storage vessel over-pressurization.

Reducing flash emissions will typically lower the potential peak flow rate of emissions that a vapor control system needs to handle.

Increase Size of Piping Used for Vent Lines (and Capacity of the Control Device if Necessary)

Many vapor control systems are constructed using piping, and possibly control devices, that are too small to effectively handle instantaneous peak flow emissions. If operators observe emissions from PRDs on their storage vessels equipped with vapor control systems, they could consider reconfiguring the vapor control system by installing larger diameter piping and eliminating potential bottlenecks from the piping (*e.g.*, excessive fittings or pipe length that reduces capacity, etc.). An increase in vent line capacity may result in higher flow rates of gas to the control device, so control device capacity should also be evaluated to ensure that the control device is properly sized for the full range of gas flows. Vapor control systems, whether new or existing, should be designed and sized to handle what the engineering analyses (*e.g.*, modeling) predict to be the worst-case or highest possible peak flow during operating conditions, including dump events. This ensures the vapor control systems can handle the potential peak instantaneous flow of emissions without causing PRDs to open. The system operating pressure may change over the useful life of the well for various reasons, including changes in formation pressure or natural gas sales line pressure. Updated engineering analyses should be conducted as appropriate.

Prevent Liquid Collection in Vent Lines

Vapor control system performance may also be compromised if condensed liquids are allowed to collect in vent lines that route emissions to a control device. Condensed liquid accumulation reduces vapor control system capacity, thereby inhibiting the flow of emissions to the control device, creating backpressure, and triggering the opening of PRDs. Reducing or eliminating low points in the vapor control system's piping configuration and installing knock out drums, drip pots, or other low-point liquid collection systems may restore some vent line capacity without the expense of installing larger diameter piping. However, eliminating liquid collection in vent lines cannot alone prevent the opening of PRDs during normal operations if the unobstructed cross-sectional area of the existing vent lines does not provide sufficient capacity to handle the potential peak flow rate of emissions without building excessive backpressure.

Eliminate Any Unintentional Natural Gas Carry-Through

Unintentional natural gas carry-through to a storage vessel can increase the potential peak flow of emissions to a vapor control system. In certain instances, this will result in continuous vapor flow to a storage vessel (*i.e.*, not just during dump events) and create enough pressure to trigger the extended opening of PRDs. Natural gas can be unintentionally carried through to a storage vessel during a liquid dump event or through a dump valve that is stuck in the open position (*i.e.*, where a valve failed to properly reseat). If operators conclude that unintentional natural gas carry-through is overwhelming a vapor control system, steps should be taken to eliminate such carry-through with maintenance and design changes (*e.g.*, repair or replacement of a stuck dump valve, installation of a vortex eliminator, installation of an appropriately sized separator, or maintaining liquid levels in the separator above a certain level).

Pressure Relief Valves – Ensure Proper Maintenance and Set Points

PRVs function as safety devices to protect against structural damage that can result from over-pressurization and should not open during normal operations. A PRV should be selected, installed, and maintained to ensure proper functioning as an emergency relief valve to maintain safe operation of the atmospheric storage vessel, rather than as a process vent during normal operations. The PRV's set point for opening must be set low enough to protect structural integrity and avoid over-pressurization of the storage vessel, but set high enough to exceed operating pressures experienced inside the storage vessel during normal operations, including flash emissions resulting from dump events. If an operator detects emissions from a PRV, steps should be taken to ensure that the valve has and will reseat properly after opening. Further, if PRVs are opening on a regular basis, the operator should determine the cause(s) and either: (1) increase the set point for the PRV if there is sufficient margin between the set point and the rated pressure of the storage vessel to do so safely and still protect storage vessel integrity; (2) take steps to decrease the operating pressures experienced at the storage vessel (*see* above); or (3) replace the storage vessel with a vessel that is rated to a higher pressure and then increase the set point for the PRV.

Minimize Emissions from Thief Hatches

To minimize emissions from closed thief hatches, operators should install quality thief hatch gaskets that are compatible with the liquids stored and regularly inspect,

Infrared video image of thief hatch emissions.

maintain, and replace the gaskets and all other contact points to ensure a tight seal. Similar to PRVs, thief hatches will open at a pressure set point. The set point should be set low enough to protect against storage vessel over-pressurization and high enough to avoid opening during normal operations, including instances of flash emissions resulting from dump events. Operators should ensure that their liquid pumpers properly close thief hatches after vessel gauging and unloading.

Sampling and Modeling to Estimate the Potential Peak Flow of Emissions

A common approach to vapor control system design is to model the potential peak flow of emissions and size the vapor control system based on those results. Modeling inputs may rely on data from sampling of pressurized liquid obtained from the last stage of separation prior to an atmospheric storage vessel. Quality control procedures during sample collection and analysis are critical to obtaining reliable and accurate sample results. Care should be taken to prevent flashing of emissions during the sample collection procedure to ensure that the integrity of the composition of the pressurized liquid is maintained so that all material is included in the analyzed sample. Inaccurate sampling results could lead operators to underestimate the volume of flash emissions and, thus, under-design and under-size vapor control systems.

> "The EPA is undertaking an enforcement initiative to ensure that natural gas extraction and production activities occur in a manner that protects communities from effects that may threaten health or the environment."
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> *-Cynthia Giles, Assistant Administrator of the EPA's Office of Enforcement and Compliance Assurance*

The California Air Resources Board (CARB) "Test Procedure – Flash Emissions of Greenhouse Gases and Other Compounds from Crude Oil and Natural Gas Separator and Tank Systems" is now being implemented and used by industry as a part of California's mandatory reporting of greenhouse gas emissions. This "CARB Protocol" provides a narrative description of Gas Processors Association Standard 2174 with additional guidance on the maximum rate at which pressurized liquid samples should be pulled to minimize flashing during the sampling process. *See* http://www.arb.ca.gov/cc/reporting/ghg-rep/regulation/mrr-2013-clean.pdf (Appendix B).

Enforcement Settlement with Noble Energy

On April 22, 2015, the EPA, the Department of Justice, and the State of Colorado announced a judicial settlement with Noble Energy that requires innovative solutions designed to evaluate and address VOC emissions from storage vessels due to under-sized vapor control systems and inadequate operation and maintenance practices. This settlement resulted from joint inspections conducted by the EPA and the State of Colorado, which found evidence of emissions coming from PRDs at many storage vessels. Subsequent data analyses indicated that many storage vessels were connected to vent lines with insufficient capacity to route all vapors to combustion devices without causing back pressure to build in the storage vessels and PRDs to open. The settlement provides an example of potential compliance issues that operators may experience if vapor control systems are not properly sized, designed, operated, and maintained. Noble Energy is undertaking the following measures to help ensure compliance with federal and state regulations and reduce emissions:

- ⇒ Conducting engineering evaluations of vapor control systems (including revised emissions modeling), making necessary modifications to ensure the systems are properly-sized, conducting infrared camera inspections to ensure modifications are effective, and conducting a directed inspection and preventative maintenance program to ensure proper upkeep and operation;
- ⇒ Third-party audits of Noble Energy's engineering evaluations and infrared camera inspections at a cross-section of vapor control systems;
- ⇒ Evaluating pressure relief devices and addressing evidence of emissions from those devices;
- ⇒ Installing pressure monitors on a cross-section of vapor control systems to verify storage vessels are not over-pressurized and potentially causing VOC emissions; and
- ⇒ Installing tank truck loadout control systems.

For more information, visit http://www2.epa.gov/enforcement/noble-energy-inc-settlement.

Conclusion

Responsible oil and natural gas exploration and production includes using good engineering practices to: (1) extract and route oil and natural gas to downstream operations for further processing; and (2) capture and route emissions to control devices. Inadequately designed, sized, operated, or maintained vapor control systems can lead to increased emissions of VOCs, HAPs such as benzene, and methane. In some instances, such emissions violate federal or state regulations. In all instances, emissions from underperforming equipment erode public confidence, detract from an operator's social license to operate in that community, and potentially harm public health and the environment.

Potential Approaches for Improving Vapor Control System Performance

⇒ Use multiple stages of separation to operate with a smaller pressure differential between the last stage of separation and the atmospheric storage vessel to reduce flash emissions and the peak flow of emissions during dump events to the storage vessel.

⇒ Install vent piping with a diameter sufficient to handle the instantaneous peak flow of all potential emissions, including flash emissions during dump events.

⇒ Eliminate or reduce vent line low points and install drip pots or other low-point liquid collection systems as needed to avoid reductions to existing vent line capacity caused by liquid accumulation in vent lines.

⇒ If PRDs are opening on a regular basis due to storage vessel pressure, investigate whether unintentional natural gas carry-through could be occurring and take steps to eliminate it. If repeated PRD opening is not due to unintentional natural gas carry-through: (1) increase the PRD set points if there is sufficient margin between the set point and the rated pressure of the storage vessel to do so while continuing to safeguard storage vessel integrity; (2) take steps to decrease the operating pressures experienced at the storage vessel (*see* previous three approaches); or (3) replace the storage vessel with a storage vessel that is rated to a higher pressure and then increase the set points.

⇒ Install quality gaskets on thief hatches and regularly inspect those gaskets and all other contact points to ensure a tight seal, and ensure thief hatches are properly closed after vessel gauging and unloading.

⇒ Ensure that control devices are properly operated and sized to control the full range of gas flows that could be routed to them during different operational periods, including any increased flow rate that may result from retrofits to an existing vapor control system.

***DISCLAIMER**: This Alert puts EPA regulatory requirements in context with plain language. Nothing in this Alert revises or replaces any regulatory provisions, any other part of the Code of Federal Regulations, the Federal Register, or the Clean Air Act. Undertaking engineering or maintenance practices discussed in this document does not equate to or guarantee compliance with the Clean Air Act, its implementing regulations, and associated state and/or local requirements. For more information, visit: www2.epa.gov/compliance.*