

Risk-based Approach for Managing Hydrocarbon Vapor Exposure during Tank Gauging, Sampling, and Maintenance of Onshore Production Facilities

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Introduction

A combination of risk management considerations, practices, and communication can ensure safe operations for tank gauging, sampling, and maintenance of onshore production facilities. This combination of risk management strategies incorporating facility design, operational procedures, and activity-based risk assessment integrated across a life cycle is recommended for safe tank operations.

Risk-based Approach for Managing Hydrocarbon Vapor Exposure during Tank Gauging, Sampling, and Maintenance of Onshore Production Facilities

1 Scope

The scope of this standard covers recommended risk assessment and risk management practices to reduce the potential for acute worker hydrocarbon exposures and related atmospheric risks (i.e. potential oxygen deficiency). Specifically, this recommended practice is limited to onshore production tanks (including flowback tanks) during gauging and sampling, open-top tank sampling, and select tank maintenance activities involving removal or opening of tank appurtenances. While the tools and practices recommended in this document can be useful in other operations, this recommended practice does not specifically apply to downstream, refining, or offshore tank applications.

This standard specifically excludes risk assessment and management practices related to

- a) chronic hydrocarbon exposures,
- b) non-hydrocarbon substances such as hydrogen sulfide, and
- c) opening other process equipment, confined space entry, tank cleaning, or decommissioning activities.

2 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

2.1

communication protocols

A system of rules which allow for two or more entities of a communications system to transmit information.

2.2

flashing losses

The release of entrained gas from a liquid as the pressure on the liquid drops.

2.3

gas-to-oil ratio

The ratio of the gas produced in standard cubic feet to one barrel of oil produced during any stated period.

2.4

hazard

A situation, inherent chemical or physical property with the potential to do harm.

EXAMPLE Flammability, oxygen deficiency, toxicity, corrosivity, stored electrical, chemical or mechanical energy.

2.5

hydrocarbon

HC

Class of organic chemical compounds composed only of the elements carbon (C) and hydrogen (H).

NOTE The carbon atoms join together to form the framework of the compound, and the hydrogen atoms attach to them in many different configurations.

2.6**risk**

A measure of potential injury, environmental damage, or economic loss in terms of both the incident likelihood and the severity of the loss or injury.

2.7**risk assessment**

The identification and analysis, either qualitative or quantitative, of the likelihood and outcome of specific hazard exposure events or scenarios with judgements of probability and consequences.

2.8**stop work authority**

A program designed to provide employees and contract workers with the responsibility and obligation to stop work when a perceived unsafe condition or behavior can result in an unwanted event.

2.9**thief hatch**

A closable aperture in a tank or vessel which are used to take samples of the tanks contents, determining the level of the tank and protect the tank from over pressure and excessive vacuum.

2.10**volatile organic compounds****VOCs**

A chemical class of hydrocarbons that participates in atmospheric photochemical reactions, which have an initial boiling point less than or equal to 250 °C (482 °F) measured at standard atmospheric pressure of 101.3 kPa (14.7 psi).

EXAMPLE Methane, ethane, acetone, acrolein, benzene, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroethane, dichlorobenzenes, dichloropropenes, ethylbenzene, formaldehyde, gasoline, hexachlorobutadiene, n-hexane, styrene, tetrachloroethylene (PERC), toluene, trichloroethylene (TCE), vinyl chloride, and xylenes, to name a few.

3 Hazard Identification**3.1 General**

Hazard identification begins with understanding the source of the natural gas and the processes that can potentially contribute to concentrations of tank vapors. Successful and safe tank management begins with an understanding of the production fluid characteristics, and the influence of process design, operations, and maintenance considerations that can impact risk.

3.2 Fluid Characteristics

Understanding the physical properties of produced VOCs, including hydrocarbons, is essential in identifying potential hazards. Tank contents, including volatile hydrocarbons and other agents such as hydrogen sulfide or benzene, should be considered, and are addressed in [API 49](#), [API 55](#), and [API 68](#). Constituents in produced hydrocarbons can vary significantly across formations, and also as an individual formation is developed over time. Lighter crudes and natural gas condensate can produce increased volatile organic compounds (VOC) exposure potential. Hazard identification approaches should include characterization of the liquid and vapor phase volume and composition, considering the following.

- a) Indicators of expected vapor phase concentrations, such as API gravity and vapor pressure of the produced oil or condensate, percent of VOCs, or gas-to-oil ratio.

- b) Production volume variability over the life cycle of the operation. For example, higher production volumes early in the life cycle of the well can result in higher tank vapor concentrations.
- c) Temperature variability considering both process and environmental conditions. Liquid temperature is an important parameter in determining vapor loss from oil.
- d) Health hazards associated with hydrocarbon vapors such as toxic effects and oxygen deficient conditions. While this document is focused on general volatile hydrocarbon hazards, specific toxics such as benzene and hydrogen sulfide should also be considered.

3.3 Process Design, Operational, and Maintenance Considerations

Process design and operational factors are also essential to understanding potential exposure hazards as they can impact vapor volume and concentrations. Hazard identification approaches should include characterization of process and operational factors (see Annex A checklists). Key factors include, but are not limited to, the following:

- a) equipment sizing relative to anticipated production flow rates;
- b) liquids retention time;
- c) pressure and flow control impacts on separation;
- d) presence or absence of chokes and choke points;
- e) back pressure and pressure relief systems, which may include blanket gas systems, flare systems, etc.;
- f) ability to isolate tanks;
- g) ability to isolate vent lines;
- h) environmental factors including geographic location, temperature, wind speed, altitude, etc.;
- i) maintenance and operating procedures;
- j) maintenance and reliability of process equipment that can influence pressure balance (e.g. pressure relief valves, flare knockout pots, flare flame arrestors, etc.);
- k) emissions controls present.

4 Exposure and Risk Assessment

4.1 General

Risk assessment is a common tool that is embraced by the industry and is applied throughout the life cycle of oil and gas operations. Risk assessment incorporates hazard assessment and exposure assessment, is conducted to identify and manage risk, and plays a key role in safety aspects of facility design as well as safe daily operation. However, this document does not provide a specific formula to the risk assessment process, but instead offers guidance in applying risk assessment principles, and provides hypothetical examples to help demonstrate how various risk assessment tools can be utilized (see Annex B examples). It is important to recognize that risk assessments help characterize the risk and provide information to risk managers to make decisions about actions that may, or may not, be needed to reduce risk.

4.2 Purpose of Exposure and Risk Assessment

Oil field production tanks can present a variety of hazards. The combined makeup of these hazards and how they interact with one another for the particular tank and the state of operations at the time of the activity must be understood to effectively manage risk. The identified hazards (see Section 3) can be dynamic, so hazards should be assessed each time prior to undertaking tank gauging or sampling or conducting tank maintenance so that an accurate risk assessment can be performed, and appropriate risk management measures applied resulting in safe execution of the activity.

Exposure assessment is a key component of risk assessment. Exposure monitoring should be conducted as operations are initiated to establish a baseline assessment and determine the level of control required going forward. Data driven risk assessments take priority over other types of risk assessments specifically when the exposure data is reflective of the current conditions (no changes to process systems, worker tasks, etc.). Direct reading instruments and detector tubes can be utilized by operating personnel to confirm safe operational conditions and warn of unusual or changing conditions. Instruments should be selected and calibrated to cover the range of constituents (indicator compounds) monitored by the selected methods.

When performing a risk assessment, the assessor should focus on the hazards and exposure attributes that could occur under routine as well as non-routine conditions. Information such as the physical and chemical properties of the fluid, production volume, tank configuration, emission controls, and tasks performed should be available for assessment (see Section 3).

4.3 Risk Assessment and Life Cycle Phases

To conduct an exposure-based risk assessment, it is important to consider the life cycle of the well. The life cycle of an oil and gas well consists of many phases including: exploration, appraisal, design, development, production, and decommissioning. A variety of risks exists at each phase that can impact the potential for exposure to high concentrations of VOCs including hydrocarbons. This section focuses on the activities and attributes of the design, development, and production phases that contribute or lead to changes in overall risk.

During the design phase, compressors, separators, storage capacity, and other facility elements are sized and configured based on anticipated production rates and compositions. Some of the key considerations during the design phase have been identified in the Facilities Design Checklist in Annex A. For example, reservoir liquid/gas composition data and modeled flash analyses information can be utilized to predict anticipated vapor volumes at expected production rates to appropriately size separators and storage vessels, and to determine process safety and vapor emissions controls such as flaring systems. The ability to isolate tanks is also an important consideration during this phase, since tanks that share vapor headspace connections can increase the volume of vapor available for release when a sampling or gauging hatch is opened. Additionally, the ability to isolate tanks to be gauged from tanks that are actively being filled can reduce vapors released from open hatches. Where vapor release is expected, mitigation options such as automatic or remote tank sampling and gauging systems can be considered, and are described in more detail in Section 6.

During development phase activities such as flowback, the overall volume and composition of produced gases and liquids will vary, necessitating increased hazard and exposure assessments. For example, increasing flow rates and volatility is important to understand as these factors can affect system backpressures and vapor release rates which can increase risk. During well completion phases, it is important to understand how the transition from temporary facilities to long-term production facilities can impact risks.

Over the course of production, risks can also change as production compositions and volumes change over time. The frequency of formal risk assessment can decrease as production stabilizes. During this phase it is important to continue “field-level” job hazard/job safety assessments, to confirm appropriate equipment, and identify changes in conditions that could influence risk. The Operating Practice Checklist in Annex A outlines some key considerations. For example, when levels are dynamic or tankage is under pressure, or both, additional personal protective