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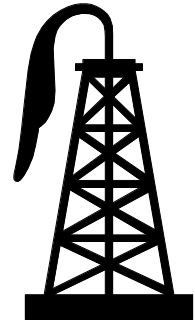
POTENTIAL WASTE GENERATION IN OIL AND GAS OPERATIONS

This chapter provides a general overview of the waste streams associated with various oil and gas operations. The overview is presented in an outline format for easy reference. Separate sections are presented for drilling operations, oil and gas production operations, gas plant operations, and pipeline operations. Examples of wastes potentially generated by each type of operation are included in the overview. The overview may help during a thorough audit of the wastes generated in each operation. Developing a list of the wastes generated in an operation, with a description of the regulatory status of each waste, is an important first step in preparing an effective waste management and minimization plan (Step 7 and Step 8 of the Waste Management Plan, Chapter 2).

DRILLING OPERATIONS 1,9,10

I. Drill site construction and rigging up are conducted in preparation for drilling activities.

- **Wastes: Debris, lubricating oil contaminated soil from heavy equipment (e.g., bulldozers), contaminated rainwater.**



II. Drilling activities include the operation of the rig, a drilling mud system, and drill string to make hole.

- A. The drilling rig is used to handle the drill pipe and bit and to set casing to complete the well. Rig operation and maintenance uses numerous systems and various types of machinery.

- **Wastes: Pipe dope, hydraulic fluids, used oils and oil filters, rigwash, spilled fuel, drill cuttings, drums and containers, spent and unused solvents, paint and paint wastes, sandblast media, scrap metal, solid waste, and garbage.**

B. Drilling fluid (“mud”) is used to maintain hydrostatic pressure for well control, carry drill cuttings to the surface, and cool and lubricate the drill bit. Drilling fluids may be fresh water-based, salt water-based, oil-based, or synthetic-based depending upon the conditions encountered.

1. Water used to make up the drilling fluid (make-up water) may require treatment to remove dissolved calcium and/or magnesium. Soda ash may be added to form a precipitate of calcium carbonate. Caustic soda (NaOH) is added to form magnesium hydroxide.

- **Wastes: Soda ash, calcium carbonate, caustic soda (NaOH), magnesium hydroxide.**

2. Drilling fluid treating chemicals and additives include:

- acids and caustics;
- bactericides;
- defoamers;
- emulsifiers;
- filtrate reducers;
- shale control inhibitors;
- thinners and dispersants;
- weighting materials; and
- lost circulation materials.

Solid additives are usually introduced into the mud system in a mixing (jet or “shotgun”) hopper.

- **Wastes: Drilling fluid additives (used and unused), spilled chemicals, empty containers.**

Other chemical additives for control of mud viscosity and gel strength are mixed in tanks connected to the mud stream.

- **Wastes: Surplus chemicals, spilled chemicals.**

3. Reserve pits receive drill cuttings and solids, used drilling fluids, rigwash, and surface runoff from the drilling location.

- **Wastes: Drill cuttings and solids, used drilling fluids, rigwash.**

(Note: Nonexempt hazardous oil and gas waste should not be allowed to enter the reserve pit.)

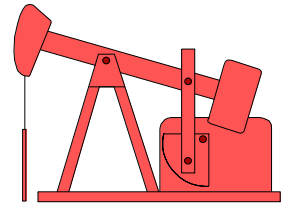
- C. Several devices are used to remove solids from the drilling fluid as it circulates. These include shale shakers, centrifuges, and cone-type desanders/desilters.

- **Wastes: Drill cuttings, sand, mud-weighting materials.**

OIL AND GAS PRODUCTION OPERATIONS ¹

- I. Wells produce oil and/or gas by natural flow or artificial lift.

- A. Flowing wells consist of the wellhead assembly and associated equipment used for well treatment.



- **Wastes: Paraffin, slop oil, oil and produced water-contaminated soils, produced water, scale, treating chemicals, sand, and paint.**

- B. Artificial lift is accomplished by use of beam pumps, gas lift, or submersible pumps.

- **Wastes: Used lubrication oil and filters, gas lift engine fuel, released crude oil (from stuffing box), paraffin, slop oil, produced water contaminated soils, produced water, scale, treating chemicals, sand, and paint.**

- C. Flare pits collect unburned materials from the flare.

- **Wastes: Overflow hydrocarbon condensate, produced water (condensed from flare).**

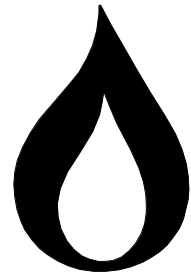
- II. Flowlines (gathering systems) are used to move produced oil to treatment and storage facilities (e.g., tank batteries).
- **Wastes: Paraffin, produced water, treating chemicals, contaminated soil, scale, and other materials collected in pig traps. Scale may be contaminated by naturally occurring radioactive material (NORM).**
- III. Separation and processing are often conducted at points along the gathering system.
- A. Two-phase separation of produced liquids from gases, three-phase separation of produced water from liquid hydrocarbons, and/or gas floatation treatment may be installed.
- **Wastes: Separator bottoms, blowdown, produced sand and scale, skim oil.**
- B. Free water knockouts are used to separate oil and water at appropriate locations in the gathering system.
- **Wastes: Produced water, produced sand and scale, bottom sludges.**
- C. Heater treaters and electrostatic treaters separate emulsified oil and water.
- **Wastes: Produced water, produced sand and scale, bottom sludges, oil absorption media.**
- D. Filtering improves the quality of liquids and produced water.
- **Wastes: Used filters, filter media, backwash.**
- E. Centrifugal desanders remove excessive volumes of produced sand and other solids.
- **Wastes: Produced sand, scale.**

- IV. Tank batteries consist of separation and treatment equipment and storage tanks.
- A. Stock tanks are used to store treated crude oil and produced water. The tanks require periodic cleaning to remove tank bottoms or basic sediment and water (BS&W).
- **Wastes: Produced sand, scale, BS&W.**
- B. Crude oil custody transfer is typically accomplished by moving the oil onto tank trucks via a loading line or into a pipeline.
- **Wastes: Spilled crude oil, crude oil-contaminated soil.**
- V. Handling of produced water is often required in preparation for recycling or proper disposal.
- A. Produced water may be stored in pits for remaining solids and oil separation.
- **Wastes: Solids and additional oil.**
- B. Underground injection, using electric or gas engine powered pumps to pressurize water, is a common method for management of produced water.
- **Wastes: Used lubricating oil and filters, produced water filters and filter media, filter backwash, produced water-contaminated soil, and unused or spent chemicals.**
- VI. Completions and workovers are conducted to facilitate the production of a well.
- A. Workover rigs are used for well completions and well workovers (i.e., treatment and/or stimulation). Workover rigs are generally mobile units.
- **Wastes: Hydraulic fluids, rigwash, spent solvents, used lubricating oil and filters.**
- B. Well workovers may involve recompleting in a different pay zone by deepening the well or plugging back. Operations may generate wastes with the volume and characteristics of drilling operation waste.

- **Wastes: Refer to drilling operations.**
- C. Well treatment and stimulation use various chemicals and products to improve the producing characteristics of a well.
- **Wastes: Drums and containers, weighting agents, surfactants, muds, produced water, acids, frac fluids, inhibitors (scale/corrosion), gel, solvents, and other materials.**
- D. Workover pits are sometimes constructed to receive oil and gas wastes generated during workover operations.
- **Wastes: Drilling solids, drilled cement, liners or contaminated soil and metal (e.g., bridge plugs).**
- VII. Enhanced oil recovery operations (EOR) typically involve the injection of water into a producing formation, as well as injection of certain chemicals.
- **Wastes: Unused or spent chemicals, polymers, etc.**
- VIII. Thermally enhanced oil recovery (TEOR) operations use injected steam for enhanced recovery of crude oil. Steam generators are fueled by crude oil, fuel oil, or natural gas. Feed water is conditioned (softened) to prevent scaling.
- **Wastes: Fuel oil filters, refractory waste, combustion scale, flue duct ash, sulfur dioxide and particulate matter air emissions, sulfur dioxide liquor, spent water-softening resin, water-softener regeneration brine, soft water blowdown, surplus deionized water.**

GAS PRODUCTION AND GAS PLANT OPERATIONS ^{1, 11, 12}

- I. Well treatment is conducted to optimize production and waste such as produced water and sand must be separated from the production stream.
- A. Corrosion inhibitors are chemicals used to counter the reaction between the acid in the gas and the iron of the



tubing or other equipment. Usually it is accomplished at the wellhead, either by batch treatments or continuous injection.

- **Wastes: Surplus chemicals, spilled chemicals.**

B. Hydrate inhibition at the wellhead is accomplished by injection of glycol, ammonia, methanol, or brine.

- **Wastes: Surplus inhibitor chemicals, spilled inhibitor chemicals.**

Also, hydrate inhibition may be accomplished by the use of indirect heaters that use bath solutions containing calcium chloride or glycol.

- **Wastes: Surplus bath chemicals or solution.**

C. Impurities such as sand and excessive amounts of water are sometimes separated at the wellhead.

- **Wastes: Produced sand, produced water.**

II. Gathering systems are used to transport produced gas to a central treatment facility (i.e., gas plant).

A. Scraping or slug catching equipment (separators) on the pipeline removes slugs of liquid (hydrocarbons and/or water). Facilities for handling liquid hydrocarbons may be installed at these locations.

- **Wastes: Produced water and wastes associated with processing of hydrocarbon liquids.**

B. Hydrate inhibition is conducted at appropriate locations in the gathering system.

1. Glycol, ammonia, methanol, or brine are injected to lower the freezing point of water in the flow line.

- **Wastes: Surplus inhibitor chemicals, spilled inhibitor chemicals.**

2. Indirect heaters sometimes use bath solutions containing calcium chloride or glycol.

- **Wastes: Surplus chemicals or solution.**

C. The produced gas is compressed to facilitate its transport to the gas plant.

- **Wastes: Engine cooling water, used lubricating oil, used lubricating oil filters, oil-contaminated soil, spent solvents, oily rags and sorbents.**

III. Gas plant processing removes impurities from the produced gas and, in some cases, includes the fractionation of the treated gas.

A. Oil absorption plants remove hydrocarbon products from natural gas. Oil absorption plants include:

- Stage separators (Economizers)
- Gas chillers
- Rich oil flash tank
- Presaturators
- Accumulators
- Rich oil demethanizers (RODs)

- **Wastes: Surplus or spilled chemicals for hydrate and corrosion inhibition, vessel blowdown.**

B. Dehydration is the removal of water from the produced natural gas and is accomplished by various methods.

1. Ethylene glycol (glycol injection) systems use: a) filters to remove solids from solution prior to reboiler (that removes water) and b) charcoal filters on glycol pump discharge, if the glycol separator is not efficiently removing hydrocarbons.

- **Wastes: Glycol, filters, solids, activated charcoal filter media, filter backwash.**

2. Triethylene glycol (TEG) and diethylene glycol (DEG) systems use an absorber tower (contactor tower).

Also, stripping gas is used for additional water removal to get very high TEG concentration into the contactor tower. Excess stripping gas will increase TEG losses.

Excessively high reboiler temperature may cause decomposition of glycol.

- **Wastes: TEG, DEG (decomposed glycol).**

3. Dry-bed dehydrators use desiccants for the adsorption of water:

Silica gel	Sorbead
Activated alumina	Molecular sieves

Regeneration of desiccants is accomplished by application of hot gas (vaporizes water).

- **Wastes: Spent filter media, spent molecular sieve.**

C. Recovery of natural gas liquids (NGL) is sometimes conducted at the gas plant.

1. Cryogenics may be used to remove NGL. Natural gas liquids (e.g., propane) are used as refrigerants and fuels. Filters are used for gas preparation (gas that is free of impurities is required for process). Electrostatic precipitators are sometimes used. Filtered substances include FeS₂, crude oil, wax, and lube oil.

- **Wastes: FeS₂, slop oil, wax, lube oil, filter media.**

2. Absorption may be used to remove NGL. An absorption oil removes the heavier compounds from the process stream.

- **Wastes: Spent or degraded absorption oil, vessel blowdown.**

D. Gas and product treating includes the removal of sulfur compounds (primarily H₂S) and CO₂ from gas. "Sweetening" processes include adsorption using various amines or a dry bed adsorbent.

1. Amine adsorption is accomplished by passing the gas through the amine liquid where the impurity is dissolved or captured by chemical reaction. The amine can be regenerated. The most common systems use MEA (monoethanolamine) or DEA (diethanolamine). Lean amine is filtered.

- a. The reclaimer removes solids and heat-stable salts (amine degraded in the presence of air) and other MEA/DEA degradation products.
 - b. Charcoal filters may be used to remove liquid contaminants when foaming is a problem. Defoamers may also be added to control foaming.
 - c. The largest amine losses are usually due to: carry-over from contactor due to foaming; continuous small leaks in piping, pump packing, and other fugitive emission points; and sulfur compounds (e.g., COS, CS₂; compounds that cannot be regenerated, see reclaimer above).
 - d. Charcoal filter beds are used to remove corrosion inhibitors, amines, absorber oils, glycol and other sieve contaminants.
 - **Wastes: Released amine, amine filters, filter backwash, reclaimer solids (bottoms), heat-stable salts, other MEA degradation products, iron sponge, charcoal filter media, defoamers, acid gases.**
2. Dry bed adsorption uses one of a variety of absorbent materials (iron sponge is commonly used) to selectively remove sulfur compounds and CO₂.
 - **Wastes: Spent absorbent materials, spent iron sponge, iron sulfide scale.**

IV. Sulfur is removed from the H₂S recovered from the produced gas.

The Claus process is typically used to remove elemental sulfur from the H₂S (acid gas). Tail-gas cleanup systems remove remaining sulfur from the exhaust.

- **Wastes: Emissions resulting from the burning of H₂S gas (e.g. SO₂), released acid gas, catalysts (e.g., activated natural bauxite, aluminum oxide), vessel blowdown, spilled elemental sulfur.**

V. Other Possible Sources of Waste

Volatile organic compound (VOC) emissions - VOCs may be released from the gas processing systems as fugitive emissions and by venting.

Mercury and mercury-contaminated soil - mercury used in instrumentation may be released due to improper storage or maintenance and breakage.

Mercaptans - any of a series of compounds of the general formula RSH, analogous to alcohols and phenols, but containing S in place of O. Mercaptans are added to gas as an odorant.

Slop oil - may include any mixture of oil produced at various locations in the gas processing plant which must be rerun or further processed to be suitable for use.

Plant wastewater - cooling tower blowdown, water-softener blowdown, boiler water blowdown, produced water removed at inlet separator.

PIPELINE OPERATIONS

I. Pipelines transport crude oil and natural gas from the wellhead to storage tanks, gas processing plants, and to market.

A. Routine maintenance on pipelines includes painting, repairing, pigging, and replacing.

- **Wastes: Paraffin, solvents, sand blast media, asbestos, hydrotest water, NORM, hydrocarbon contaminated soil, iron sulfide, scale, pigging waste, scrap pipe, welding wastes, produced sand, produced water, BS&W, and paint waste.**

B. Compressor stations boost the fluid in pipelines to help it travel long distances.

- **Wastes: Lube oil, filter media, hydrocarbon contaminated soil, chemicals, solvents, sand blast media, used filters, filter media,**

scale, NORM, sorbent pads, air emissions, antifreeze, batteries, and stormwater.

C. Corrosion inhibitors are used to minimize the reaction between acid in the fluid and iron in the tubing.

- **Wastes: Surplus chemical, spilled chemicals.**

D. Lead acetate tape is commonly used for detection of acid gases (e.g., H₂S) in pipelines:

- **Wastes: Spent lead acetate tape.**

OPERATIONS IN GENERAL

Several wastes are common to most, if not all, types of oil and gas operations:

- **Contaminated soil:** Any uncontrolled release of chemicals, brine, oil, drilling fluid, or other materials, will result in soil contamination.
- **Used or spent solvents:** Solvents are used in tasks such as cleaning, degreasing, and painting. Unused solvent intended for disposal is considered a waste.
- **Used oil and used oil filters:** Engines and other machinery in all areas of operations require lubricating oil and oil filters.
- **Drums and containers:** Drums and containers are required for delivery and storage of chemicals and materials used in all areas of operations.
- **Sandblast media:** Sandblasting is typically used to prepare equipment for painting and to remove scale from equipment.
- **Paint and paint wastes:** Painting is generally required for maintenance of equipment. Paint thinners, solvents, and unused paint are generated wastes.
- **Pesticides and herbicides:** These chemicals are used to control insects and vegetation at various locations (e.g., drilling locations).

- **Vacuum truck rinsate:** Vacuum trucks recover waste liquids generated by various operations.
- **Radioactive tracers:** Tracers are used to observe downhole fluid or gas movements.
- **Scrap metal:** Scrap metal consists of damaged tubulars or other equipment, crushed drums, remnants of welding operations, cut drill line, etc. Scrap metal may contain naturally occurring radioactive materials (NORM).

API GENERIC LIST OF HAZARDOUS CHEMICAL CATEGORIES FOR THE E&P INDUSTRY

Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires industries to report the use of certain “hazardous” chemicals. The American Petroleum Institute (API) and the Independent Petroleum Association of America (IPAA) have published a guidance document⁸ to assist E&P operators with the preparation of reports required by SARA Title III (311 and 312). This guidance document includes a generic listing of chemicals used in the oil and gas industry. This list is provided as Appendix E and may be used as an additional guide for identifying wastes that can be minimized.

Note: The list refers to the chemicals as “hazardous.” For the purposes of SARA Title II, “hazardous” indicates any chemical required to have a material safety data sheet (MSDS). All chemicals listed in Appendix E are not necessarily hazardous waste as defined by regulations adopted under RCRA.

NOTES