Chapter 24
Off-Gas Oxidation (Thermal/Catalytic)

24-1. General

The process of off-gas oxidation is described in the first section of the chapter. The chapter's second portion is a hazard analysis with controls and control points listed.

24-2. Technology Description

a. Process.

Off-gas oxidation is the incineration of contaminated air or other vapor streams to destroy the contaminants before discharge to the atmosphere. A vapor stream laden with volatile organic compounds (VOCs), produced by a soil vapor extraction (SVE) system or a landfill vent system, is blown through a duct system that contains an ignited natural gas or propane burner. The heat from the fuel combustion oxidizes the combustible components of the VOC stream and the exhaust is stack discharged. The system is designed to meet specified temperature and residence times, depending on the waste stream characteristics, ambient condition, and air permit requirements.

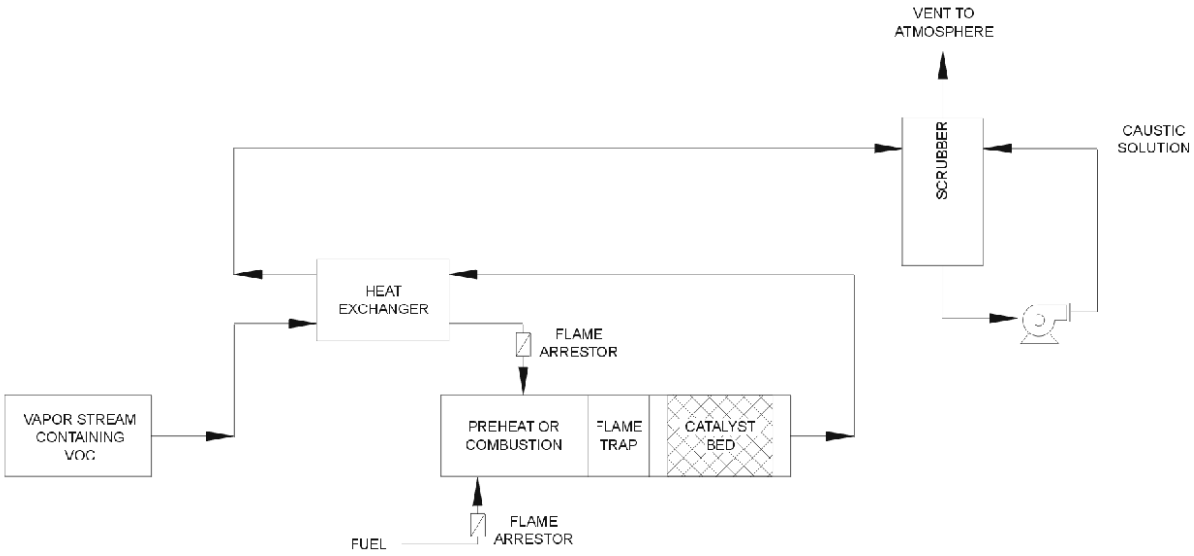

FIGURE 24-1. OFF-GAS OXIDATION (THERMAL/CATALYTIC)

In addition to the burner unit, the treatment system often incorporates catalytic oxidizer units. The unit uses a catalyst on a support, such as alumina, similar to catalytic converters in automobiles. The catalyst lowers the required treatment temperature, thereby reducing the amount of fuel and off-gas treatment required. However, the catalyst can be fouled or poisoned with chemicals such as lead, coke, and tar compounds that can be present in the waste stream. If high concentrations of chlorinated

solvents are present, the catalyst support and the duct work may require special construction to cope with the hydrogen chloride gas and hydrochloric acid generated. Scrubbers may be required to remove the acid before the stream can be exhausted. See Figure 24-1.

24-3. Hazard Analysis

Principal unique hazards associated with off-gas oxidation (thermal/catalytic), methods for control, and control points are described below.

a. Physical Hazards.

(1) *Fire*.
Description. If the Btu value of the waste feed gas is not controlled and is higher than the Btu value of the feed gas for which the unit was designed, the temperature of the unit may exceed its design specifications, resulting in damage to the unit and increase the probability of releasing untreated waste gasses. Operating off-gas oxidizer systems above the design waste gas concentrations or temperature may cause auto-ignition with a resultant flashback of the flame through the waste gas feed piping system to the source.

Control. Controls for fire include:

- Use experienced operators and supervisors and train them in both the flammability characteristics of the waste feed gas, the exposure hazards of the waste feed, and design operating parameters of the off-gas oxidizer.
- Audit and apply proper quality assurance/quality control (QA/QC) to assure work is done as designed.
- Perform a Process Hazard Analysis (PHA) prior to startup and correct deficiencies found.
- Operate the system and waste feed within design parameters.
- Do not allow airflow to exceed the capacity of the system for efficient removal of any solids present in the waste material being treated.
- Do not allow temperatures in the primary combustion chamber to exceed 95% of the ash fusion temperature (as determined by ASTM E953 (R1998) "Standard Test Method for Fusibility of Refuse-Derived Fuel (RFD) Ash") of the solids, if any, in the waste material being treated.
- Monitor and control the catalyst bed temperatures continuously.
- Incorporate flame traps and control valves into the design to prevent source ignition.

CONTROL POINT: Design, Operations, Maintenance

(2) *Noise Hazards*.
Description. Off-gas oxidation units may cause elevated noise levels in the work area from the operation of air blowers, pumps, induced draft and exhaust

fans, high-energy venturi scrubbers, fuel injection ports, and the ignition of fuels within the combustion chamber.

Control. Controls for noise include:

- Refer to UFGS 02180A, "Remediation of Contaminated Soils and Sludges by Incineration," for noise control.
- Establish a hearing conservation program to determine necessary controls and use adequate hearing protection (see 29 CFR 1910.95).
- Train workers in the use of hearing protection and enroll them in the hearing conservation program (see 29 CFR 1910.95).
- Use personal electronic communications devices, such as a duel ear headset with microphone, to overcome ambient noise where communication is critical in high noise areas. The hearing protection/headset combinations are available commercially and should be used where needed.
- Establish vibration and noise-free areas to provide breaks from the vibration and noise, which can cause fatigue and inattention.

CONTROL POINT: Design, Operations

(3) *Flammable/Combustible Fuels*.

Description. Off-gas oxidation usually requires storage of flammable fuels (e.g., propane or natural gas, waste fuels collected from the treatment process) used to fire the off-gas oxidizer. Hazards associated with flammable/combustible fuels are usually associated with a fuel spill or release resulting in worker exposure to liquid state fuels or vaporized fuels, or a fire/explosion hazard.

Control. Controls for flammable/combustible fuels include:

- Use appropriate tanks (equipped with pressure-relief devices and bermed) to help prevent release of material (see 29 CFR 1910.106).
- Locate tanks in an appropriate location on the site.
- Ventilate the storage area adequately to help prevent the accumulation of flammable vapors.
- Use electrical equipment and fixtures that comply with NFPA 70.
- Meet mandatory requirements of NFPA 30, "Flammable and Combustible Liquids Code," NFPA 31, "Installation of Oil Burning Equipment," NFPA 54, "National Fuel Gas Code," or NFPA 58, "Standard for the Storage and Handling of Liquefied Petroleum Gases," for fuel system installation, storage, and testing.
- Permit only trained and experienced workers to work on the off-gas oxidation units.
- Use lock-out and tag-out procedures on all electrical systems during repair or maintenance in the storage area.

CONTROL POINT: Design, Construction, Maintenance

(4) *Electrocution*.
Description. Since off-gas oxidation units operate electrical systems outdoors, workers may be exposed to electrocution hazards if the electrical equipment contacts water, or any of the subunits are not properly wired or grounded.

Control. Controls for electrocution include:
- Verify that drawings indicate the hazardous area classifications as defined in NFPA 70, Chapter 5, section 500.1 through 500.10.
- Use controls, wiring, and equipment that meet the requirements of EM 385-1-1, Section 11, and NFPA 70.
- All electrical work shall be performed in accordance with applicable electrical codes and under the supervision of a state licensed master electrician.
- Use grounded ground-fault protected equipment (equipment wiring equipped with ground fault circuit interrupters (GFCI)).
- Never allow the use of ungrounded temporary wiring during minor maintenance. In addition, use only electrical cords approved for water contact when wet and damp conditions exist.

CONTROL POINT: Design, Construction, Operations, Maintenance

(5) *Transfer Equipment Design*.
Description. Improperly designed systems can corrode or dissolve to a point of failure and cause damage to the facilities or create inhalation exposures or safety hazards.

Control. Controls for transfer equipment design include:
- Use equipment fabricated from materials that are chemically unreactive to the waste gases, fuels, and materials being transferred. Use EM 1110-1-4008, "Liquid Process Piping," and UFGS 15200A, "Liquid Process Piping," for materials selection.
- Install spill or leak detection instruments including alarms if necessary.
- Include containment drip pans or receivers where leaks may occur.

CONTROL POINT:

(6) *Burn Hazards*.
Description. Thermal/catalytic off-gas oxidizers operate at high temperatures, which may result in thermal burns to workers.

Control. Controls for burns include:
- Design the off-gas oxidizer to maximize ease of operation, physical cleaning, and maintenance to include adequately sized and easy access doors and ports where entry is required.
- Perform a Process Hazard Analysis (PHA) prior to startup and correct deficiencies found.

- Perform manufacturer's shutdown and cool down procedures prior to working on, around, or entering oxidizer.
- Develop confined space entry permit and rigorously apply requirements.
- Verify functioning of the manufacturer's temperature safety controls and use according to instructions.
- Use safety barriers to isolate critical sections of the equipment.
- Post signs warning of high temperatures.
- Train workers in the hazards, use heat resistant gloves and protective gear, and permit worker maintenance only after process equipment has cooled.

CONTROL POINT: Design, Operations, Maintenance

(7) *Heated Surfaces*.
Description. Workers may be exposed to infrared radiation hazards associated with working in the vicinity of incinerators. The exposure, depending on the temperature of the equipment, length of exposure, and other variables may increase the risk of cataracts or heat injury.

Control. Controls for heated surfaces include:
- Minimize worker exposure time on or near hot surfaces.
- Use eye protection with the appropriate shade safety glass and reflective radiant heat protective suits if prolonged work near the radiant heat surface or source is required to control both eye and body exposure.
- Install protective barriers to shield work areas.

CONTROL POINT: Operations, Maintenance

(8) *Sunlight/UV Radiation.*
Description. During site activities, workers may be exposed to direct and indirect sunlight and ultraviolet (UV) radiation. Even short-term exposure to sunlight can cause dermal damage and burns. In hot and humid conditions, sunlight can significantly contribute to the heat load, thereby increasing the risk of heat injury such as heat exhaustion, cramps, and heat stroke.

Control. Controls for Sunlight, UV radiation and heat stress include:
- Minimize direct sun exposure by wearing sun hats, long-sleeved shirts, full-length unbloused pants, and by applying UV barrier sunscreen to exposed skin. Loose clothing and sun hats should not be worn around moving parts that may snag the worker and draw him or her into a danger zone. All UV skin barrier creams should be pre-approved. Some creams contain zinc and other constituents that can cause false readings in analytical samples.
- Shade work and break areas, if possible.
- Minimize exposure to heat stress by training the workers in the symptoms of heat stress, practicing the Buddy System, taking frequent breaks, drinking adequate fluids, and working during the cooler part of the day.

- Monitor for heat stress using the physiological or Wet Bulb Globe Temperature (WBGT) Index protocol provided in the most recent publication of the American Conference of Governmental Industrial Hygienists (ACGIH) "TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices."

CONTROL POINT: Operations, Maintenance

(9) *Confined Spaces*.

Description. Workers may be exposed to confined-space hazards when entering the off-gas oxidizer for inspection, maintenance, or repair. Off-gas oxidizers may have additional units to treat the exhaust combustion gases that range in physical and operational complexity, such as the off-gas oxidizer itself, exhaust gas collection/ventilation duct work, and high energy wet scrubbers to remove contaminants such as hydrochloric acid (HCl). Entry can expose workers to high concentrations of chemicals such as heavy metals, CO, H_2S, methane, and vinyl chloride. In addition to chemical exposure, treatment units that require confined space entry may also present significant physical hazards, including high temperatures, engulfment, entanglement, pinch points, oxygen deficiency, electrical, and negative pressure. Death or serious injury can result.

Control. Controls for confined spaces include:

- Design the incinerator and exhaust gas treatment systems to maximize ease of operation, physical cleaning, and preventative maintenance tasks to include accessible, adequately sized access doors and ports; and design to minimize the frequency, duration, and extent of cleaning and maintenance required.
- Develop a pre-entry confined space permit (see 29 CFR 1910.146).
- Rigorously train workers in confined space program requirements, hazards and controls.
- Test the atmosphere within the confined space prior to entry and monitor throughout the work (see 29 CFR 1910.146).
- Design air-handling systems to minimize or eliminate oxygen-deficient locations and rigorously ventilate prior to entry of personnel.
- Perform the manufacturer's shutdown procedures and lock-out/tag-out of electrically energized systems prior to entry.
- Use temperature probes to measure internal temperatures of units prior to opening the units for entry.
- Use air-supplied respirators to control exposure hazards that are immediately dangerous to life or health (IDLH), such as potential exposure to high air concentrations of toxic compounds or asphyxiation where constant mechanical ventilation of the space alone is not sufficient to prevent the buildup of an oxygen deficient or toxic environment.

CONTROL POINT: Design, Operations, Maintenance

(9) *Emergency Wash Equipment*.

Description. Emergency shower/eyewash equipment required per 19 CFR 1910.151 is not always provided with adequate floor drains, thereby creating potential electrical hazards or walking surface hazards during required testing and use.

Control. A control for emergency wash equipment includes:

- See American National Standards Institute ANSI Z 358.1 – 1998: "Emergency Eyewash and Shower Equipment" for design requirements.
- Equip showers/eyewash equipment with functional floor drains to isolate and collect the shower/eyewash water from electrical and slip hazards.

CONTROL POINT: Design

(10) *Design Field Activities.*

Description. Design field activities associated with subsequent construction may include surveying, biological surveys, soil gas surveys, geophysical surveys, trenching, drilling, stockpiling, contaminated groundwater sampling, and other activities. Each of these field activities may expose the survey personnel to physical, chemical, biological, or radiological hazards.

Control. Control for hazards resulting from design field activities include:

- Prepare an activity hazard analysis for design field survey activities. EM 385-1-1, Section 1, provides guidance on developing an activity hazard analysis.
- Train workers in hazards identified.

CONTROL POINT: Design

b. Chemical Hazards.

(1) *Equipment Entry*.

Description. During maintenance or repair, workers entering the unit for cleaning, inspection, or repair of equipment may be exposed to waste materials or incomplete combustion byproducts.

Control. Controls for equipment entry include:

- Assess hazards at the time of confined-space entry (see 29 CFR 1910.146).
- Wear appropriate personal protective equipment (PPE) such as air-supplied respirator and disposable protective coveralls along with the confined space retrieval lifelines. See confined space hazards.

CONTROL POINT: Operations, Maintenance

(2) *Toxic Material Exposure (Feed or Byproducts).*

Description. During operation of the off-gas oxidation unit, workers may be exposed to waste components/toxic materials in the feed vapor and byproducts of combustion, such as carbon monoxide chlorine, hydrochloric acid, dioxin,

dibenzofurans, PCBs, lead, and mercury. Post-off-gas oxidizing units, such as wet scrubbers, often use bulk chemical or sludge additives in conjunction with the scrubbers or pre-clarifier mixing, filter press pre-coat and surge tanks, and may present significant exposure potentials, both when replenishing the chemicals and when performing routine maintenance on the units.

Control. Controls for exposure to toxic materials include:

- Train all workers involved in both the operation and maintenance of the off-gas oxidizer system and in all chemical hazards related to the generation, transport, and treatment of the contaminants, and contaminant byproducts within the system, and the bulk chemical additives used to treat the contaminants.
- Characterize and classify the gaseous waste components prior to and following oxidation.
- Feed only gaseous waste streams compatible with the process into the unit.
- Note design parameters on feed characteristics. Refer to UFGS 02180A, "Remediation of Contaminated Soils and Sludges by Incineration." Select technologies appropriate for the known or anticipated wastes.
- Design engineering controls for the system to prevent or minimize the generation or release of toxic materials/gases into the breathing zone of the workers, both during operation and maintenance. The engineering controls could include real time monitors with alarms and appropriate ventilation controls.
- Install, locate, and maintain emergency eyewash and shower units at critical points throughout the system (see ANSI Z 358.1 – 1998).
- Use PPE appropriate to the work task, to the contaminants to be treated, and to the gaseous oxidation byproducts such as thermal protective gear, acid protective gear, chemical safety goggles, safety glasses, face shields, air-supplied respirators etc. Train workers in the use of the PPE.

CONTROL POINT: Design, Operations

(3) *Transfer Equipment Design*.

Description. Highly chlorinated feed streams may generate corrosive conditions, resulting from HCL gas within the off-gas oxidation exhaust stream, causing leaks in the system. The leaks may result in worker exposure via the inhalation/ingestion/dermal exposure routes.

Control. Controls for transfer systems include:

- Use transfer equipment fabricated from materials that are chemically resistent to the chemical being transferred.
- Consult EM 11101-14008, "Liquid Process Piping," and UFGS 15200A, "Liquid Process Piping," for appropriate materials for pumping various fluids.
- Train workers in potential acid exposure hazards and associated hazard controls.

- Implement preventive maintenance program and complete periodic inspections.

CONTROL POINT: Design, Construction, Maintenance

(4) *Toxic Discharge (Catalytic Oxidation Inefficiency).*
Description. Poisoning/blinding of the catalyst with high metal or particulate loadings in the gas stream may decrease the catalytic oxidation efficiency of the system and increase the discharge of toxic wastes into the work and surrounding areas.

Control. Controls for toxic discharge include:
- Monitor and control ash content of the waste feed to prevent excessive particulates from that source.
- Pre-treat air streams adequately to remove particulates using filtration, quiescent zone separation, or washing to prevent excessive particulates.
- Consider the metals content of the air stream in the design to avoid heavy metal poisoning of the catalyst.

CONTROL POINT: Design, Operations, Maintenance

c. Radiological Hazards.

Radioactive Devices.
Description. Fire ands smoke detection devices and other process monitors and switches may contain radioactive devices potentially exposing workers through lack of identification or mishandling.

Control. Controls for inadvertent handling or exposure to radioactive devices include:
- Workers should be prevented from and warned against tampering with the devices.
- The locations of the devices should be recorded so as to safely retrieve and dispose of them in case of a system failure and equipment replacement.

CONTROL POINT: Design, Operations and Maintenance

d. Biological Hazards.

Opportunistic Insects and Animals.
Description. For all sites but especially in cooler climates, opportunistic insects or animals can nest in and around warm process equipment. Vermin, insect, and arthropod control measures should be considered in any design.

Control. Control of opportunistic insect and animals include:
- Electrical cabinets and other infrequently opened enclosures should be opened carefully and checked for black widow and brown recluse spiders, and evidence

of rodents. As rodents can cause damage to electrical cables, all wiring should be inspected regularly.

- Ensure all storage is off the ground, palleted, and kept dry. Damp areas attract scorpions, rodents and the snakes that eat them.
- Design ceiling corners and other high areas to discourage nesting by swallows, pigeons, and other birds. Birds are carriers of diseases, especially in their droppings, which can foul cranes and process equipment.

CONTROL POINT: Design, Operations and Maintenance