# Chapter 1
# Landfill Covers and Liners

## 1-1. General

The technology of landfill liners and covers is discussed briefly in the chapter's first section. The second portion of the chapter contains a hazard analysis with controls and control points listed.

## 1-2. Technology Description

Landfills are constructed to contain newly generated wastes or to convert existing waste management units to a permanent disposal facility. Landfills are constructed using liners and covers to minimize exposure of the landfill contents to the environment. Liners and covers are described in this section.

*a. Liners.*

Types of liners, components of a liner system, and installation methods are described below.

Landfills are lined on the bottom and sides with natural and synthetic barriers to prevent liquids and waste from escaping into underlying soils. An example of a natural liner material is compacted clay; synthetic liners include high-density polyethylene (HDPE), geosynthetic clay (GCL), and polyvinyl chloride (PVC). The synthetic and natural liners are components of an integrated system to contain and collect liquids (leachate) that leach from the landfilled materials.

An example of a typical Resource Conservation and Recovery Act (RCRA) landfill liner includes two liners and a leachate recovery/detection system at the bottom of the waste management unit. A double liner system consists of the following components from top to bottom:

- Leachate collection system (sand or gravel, or both).
- Geomembrane.
- Secondary leachate collection/leak detection layer constructed of sand/gravel.
- Secondary synthetic liner.
- Low permeability compacted clay liner.

Monitoring the drainage layer between the liners confirms the integrity of the upper liner.

Clay liners are installed as lifts of a low permeability clay at the appropriate moisture content and density to give the strength and permeability needed for the liner. The lifts are placed until the correct total thickness of the liner is achieved. Nuclear density gauges (with radioactive sources) are often used to estimate the moisture content and density of the clay lifts.

Synthetic liners, such as HDPE, are unrolled from spools and installed as long sheets. They are usually thermal-fusion welded together at the seams. PVC, which can also be used as a liner material, is installed as sheets and is typically seamed by chemical or thermal fusion methods.

As the liner system is installed, leachate collection systems are installed to collect and treat leachate generated by the landfill waste. Leachate is often treated in simple biological or other treatment processes at the site, or is trucked or piped to a local POTW (Publicly Owned Treatment Works) or industrial treatment plant.

*b. Covers.*

Cover purpose, system components, and installation steps are discussed in this section.

Once the lined landfill is full, an engineered cover is installed. The purpose of the cover is to keep water from infiltrating into the waste materials and generating leachate that could be released from the landfill, while maintaining a protective vegetative cover on top of the landfill to secure the landfilled materials in place. An engineered cover can consist of natural or synthetic materials, or a combination of the two.

The cover system consists of the following components from bottom to top:

- Low permeability liner to prevent water infiltration.
- Sand or geonet to provide a drainage layer.
- Protective soil cover.
- Top soil.
- Vegetative cover.

Typical cover installation steps include the following:

- Prior to installing an engineered cover, the surface of the landfill is contoured to enhance water runoff. This may involve regrading refuse in the landfill to minimize waste volumes and to ensure positive drainage.
- The low permeability liner is installed on top of the waste materials.
- A layer of coarse sand or a geonet drainage layer is then placed over the liner to collect and transport the water off the surface of the landfill cover.
- A protective soil layer is added to protect the underlying cover components and support vegetative growth.
- As the landfill cover is installed, gas collection and venting systems are installed to manage the gas (methane, hydrogen sulfide, etc.) often produced in landfills. Figure 1-1 illustrates the landfill cover and liner structure.

If the gas is not collected, it can cause heaving and damage the cover, change drainage patterns, or it can escape the landfill and migrate to basements and buildings where it may be toxic, explosive, or asphyxiating. Gas migration is controlled by providing migration pathways and cover vents.

Off-gases can be treated in several ways. If permitted, the most common treatment is simple venting, either passive (by gas pressure generated in the landfill) or active (by vacuum blower assistance to pull gas from the landfill). If simple venting is not acceptable, the gas may be passively or actively vented to a flare. In some cases, the gas is burned in engines or turbines, which may (in turn) drive generators for local power use or feed into the local electrical utility grids.

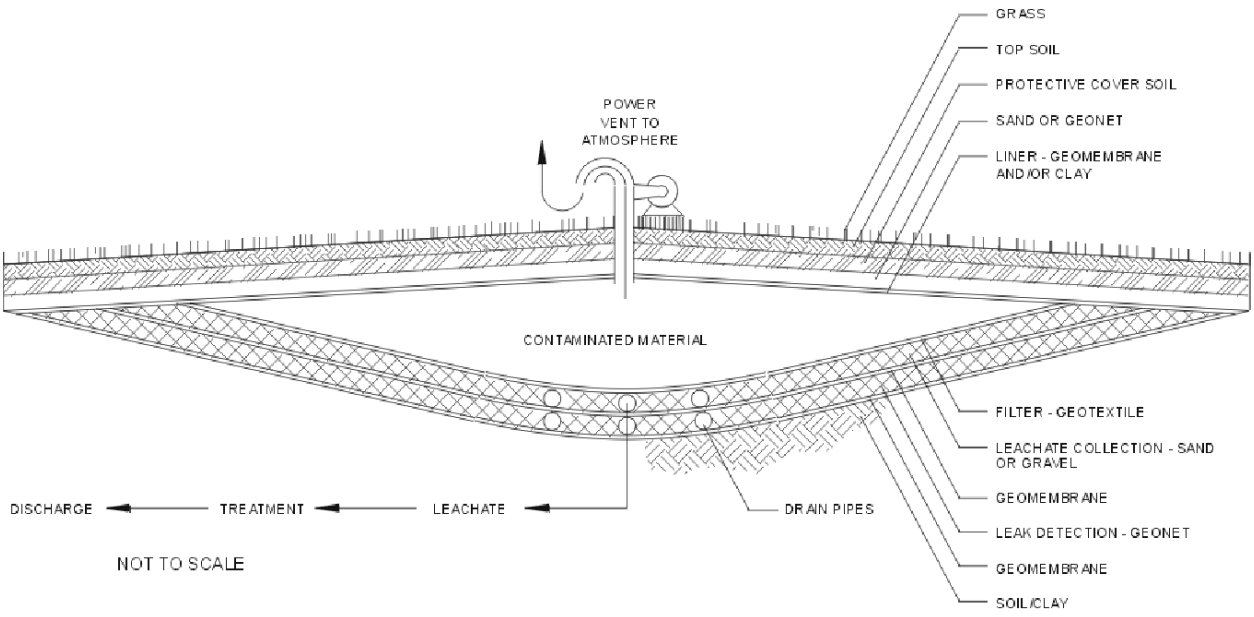


**FIGURE 1-1. LANDFILL COVERS/LINERS**

## 1-3. Hazard Analysis

Principal unique hazards associated with landfill covers and liners, methods for control, and control points are described below.

*a. Physical Hazards.*

(1) *Wind/Liner Handling.*
*Description.* Landfill covers/liners must be handled using heavy equipment to control the roll to prevent crushing workers on the down hill side of the rollout, and must not be installed during periods of high winds, which may pose trip hazards or throw or knock down workers holding or standing on or near unsecured liners.

*Control*. Controls for wind hazards include:

- Select an appropriate liner material.
- Control the rollout of the liners using heavy equipment operated by trained and authorized workers only. Never place workers on the downhill side of the rollout operation.
- Install liners on calm days.
- Place soil or sand bags onto the unrolled portion of the liner. The liner installer should determine the temporary anchoring needs at the time of installation and ensure that anchoring specifications are met or exceeded.

**CONTROL POINT**: Design, Construction, Operations, Maintenance

(2) *Slip Hazards*.
*Description*. Geomembrane and wet clay liners can be very slippery, especially when placed on the slopes or used for footing while a worker carries equipment or materials.

*Control*. Controls for slip hazards include:

- Consider controls for slip hazards during design (see EM 385-1-1, Section 21.A).
- Use rope ladders for ascending/descending lined slopes.
- Select appropriate shoe soles for maximum traction.
- Lay high-traction walkways over the liners.
- Carry light loads or use more workers to carry larger single loads.

**CONTROL POINT**: Design, Construction, Operations, Maintenance

(3) *Sharp Liner Edges*.
*Description*. Synthetic liners are made in varying thicknesses and rigidities. Some liner edges are sharp and stiff after being cut to shape and can inflict cuts and abrasions.

*Control*. Controls for sharp liners include:

- Wear long-sleeved shirts, full-length pants, and appropriate work gloves (e.g., leather or leather-palmed) for better grip and protection.
- Wear safety glasses or goggles to help prevent eye injuries and cut resistant glove liners.

**CONTROL POINT**: Construction, Operations, Maintenance

(4) *Heat Stress*.
*Description*. Heat stress may affect workers during operations. Because most synthetic cover/liner materials are dark or black to enhance ultraviolet (UV) resistance, they absorb radiant energy and emit considerable heat. The surfaces of cover/liner materials can also reflect considerable angled radiant energy, amplifying the energy absorbed by the worker even when wearing a hat. Hot and humid conditions, combined with such operations as liner welding or other heat-

producing activities, may also increase the potential for a heat-related illness, including heat exhaustion and heat stroke.

*Control*. Controls for heat stress include:

- Minimize direct sun exposure by wearing sun hats, long-sleeved shirts, full-length pants, and by applying UV barrier sunscreen. Loose clothing and sun hats should not be worn around moving parts or close to operating equipment that may snag the worker and draw him or her into a danger zone. All UV skin barrier creams should be pre-approved.
- Shade work and break areas if possible.
- Minimize exposure to heat stress by taking frequent breaks, drinking adequate fluids, and working during the early morning and late afternoon hours.
- Use the Buddy System.
- Additional measures include working nights, working early and late in the day, and scheduling jobs for cooler times of the year.
- 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**: Design, Construction, Operations

(5) *Muscle Injuries*.
*Description*. Manual lifting and moving heavy materials used for anchoring may expose workers to muscle strain/sprain to the lower back or shoulder.

*Control*. Controls for muscle strain include:

- Use mechanical lifting equipment, such as cranes, backhoes with cables, and spreaders to lift and move liner material.
- Train workers in proper material handling procedures.

**CONTROL POINT**: Construction, Operations

(6) *Burn Hazards*.
*Description*. Equipment, including hot-shoe welders and extrusion welders, can expose workers to burn hazards. Flare systems for the discharge of off-gas from the landfill and generators may also pose burn hazards.

*Control*. Controls for burn hazards include:

- Make sure all personnel using welding equipment are trained and experienced in the proper use of hot-shoe welding equipment.
- Inform those using or exposed to hot operating equipment about equipment hazards at the start of the project and during daily health and safety meetings.
- Guard all exposed, heated surfaces when practical to prevent accidental contact.
- Use insulated gloves with gauntlets, coveralls, and face protection.

- Request manufacturer's and installer's procedures for the safe operation, repair, and maintenance of this equipment and include it in health and safety and installation work plans.

**CONTROL POINT**: Construction, Operations

(7) *Fire and Explosion Hazards*.
*Description*. Fire and explosion hazards may exist if the off-gas flare systems are improperly designed, installed, or maintained. Also, volatile organic compounds (VOCs) may be generated as off-gas products from wastes in the landfill and accumulate. These gases are explosive and may be ignited as off-gas products by sparks, open flame, or heated surfaces.

*Control*. Controls for fire and explosion hazards include:
- Train workers in the hazards of working in the vicinity of the off-gas flare systems and in the nature of the explosive landfill gases being collected by the systems.
- Train the operators in emergency procedures in case of a catastrophic event; in life saving first aid procedures for burns, and extinguishing flames, extracting, extinguishing and stabilizing victims, and in emergency off-gas flare isolation procedures.
- Design and install an off-gas management system using the guidance provided in EPA/625/4-89/022, "Requirements of Hazardous Waste Landfill Design, Construction and Closure."
- Install gas collection and vent systems in the cover. Unless properly vented, the lateral migration of gas should be anticipated.

**CONTROL POINT**: Design, Construction, Operations, Maintenance

(8) *Elevated Gas Levels*.
*Description*. Off-gas drive engines may generate carbon monoxide and carbon dioxide during operation. Also, VOCs generated as off-gas products by landfill wastes may accumulate. If the gases are not properly vented, they may accumulate to hazardous levels in areas such as buildings and sheds. Exposure to elevated levels of these gases may cause headaches, dizziness, nausea, or possibly even death.

*Control*. Controls for elevated gas levels include:
- Specify (landfill designer) the ventilation/flaring requirements necessary to ensure adequate venting of off-gases from beneath landfill covers and prevent the potential migration of accumulating gases into nearby buildings or other structures on or off site.
- Ventilate buildings or other enclosed-space and test to prevent accumulations of carbon monoxide, carbon dioxide, methane, hydrogen sulfide, and other dangerous gases.

**CONTROL POINT**: Design, Construction, Operations, Maintenance

(9) *Electric Shock Hazards*.
*Description*. Electric shock hazards may exist from on-site generators and infrastructure. Generators may be present during construction, operations (off-gas dependent generation), or maintenance.

*Control*. Controls for electric shock hazards include:

- Verify that the hazardous area classifications, as defined in National Fire Protection Association (NFPA) 70 Chapter 5, sections 500.1 through 500.10, are indicated on the drawings.
- Perform all electrical work according to code and under the supervision of a state licensed master electrician.
- Verify that all controls, wiring, and equipment, including the on-site generators/infrastructure, conform to the requirements of EM 385-1-1, Section 11, and NFPA 70 for the identified hazard areas.
- Make sure that equipment is grounded or provided with ground fault circuit interrupter (GFCI) protection if required by EM 385-1-1, Section 11, or NFPA 70.
- Permit only trained and experienced workers to work on the systems.
- Include appropriate lock-out/tag-out procedures in the construction and O&M of the system.
- Make fire extinguishers rated for energized electrical systems readily available where electrical equipment is installed and operated.

**CONTROL POINT**: Design, Construction, Operations, Maintenance

(10) *Noise Hazards*.
*Description*. Heavy equipment and portable electric generators may create noise hazards to operators or workers in the immediate vicinity.

*Control*. Controls for noise hazards include:

- Implement a noise protection program (see 29 CGR1926.52).
- Wear hearing protection if exposed to noise at or above 85 decibels (steady-state) or to impulse noise of 140 decibels such as that generated by heavy construction equipment or generators.

**CONTROL POINT**: Construction, Operations, Maintenance

(11) *Equipment Hazards*.
*Description*. Any equipment (small and large) used to move soil and liner materials on steep slopes may roll over, crushing the operator.

*Control*. Controls for equipment hazards include:

- Design the angle of the slope to minimize the potential for roll-over.
- Maintain safe slopes during construction (construction contractor).
- Use equipment with roll-over protective devices (ROPS).
- Do not operate equipment on excessively steep slopes.

- Wear seat belts during operation.
- Train workers in the potential operational hazards associated with and the safety features of the heavy equipment.

**CONTROL POINT**: Design, Construction, Operations

(12) *Traffic Hazards—Worker*.
*Description*. During construction, heavy vehicular traffic may also pose a danger to site workers. The movement of heavy equipment in high traffic areas or on public roads may further pose a danger to site workers or to the public.

*Control*. Controls for traffic hazards include:
- Address haul road considerations in the design stage (see EM 385-1-1, Section 21, for control measures).
- Use warning devices where equipment must cross over active roads according to the criteria of the "Department of Transportation Manual on Uniform Traffic Devices for Streets and Highways."

**CONTROL POINT**: Design, Construction, Operations, Maintenance

(13) *Trench Hazards*.
*Description*. During installation of the liner, trenches may be excavated to secure the liner edges. Open excavations may pose a trip hazard to workers crossing the excavation or a collapse hazard to workers working near trench edges.

*Control*. Controls for trench hazards include:
- Provide protection to prevent personnel, vehicles, and equipment from falling into excavations.
- Inform all workers of on-site hazards and allowable access to the landfill.
- See EM 385-1-1, Section 25, for additional control measures and requirements.

**CONTROL POINT**: Construction, Operations, Maintenance

(14) *Heavy Equipment Hazards*.
*Description*. Workers may be seriously injured or killed by the operation of heavy equipment moving liners and other materials. As liners are unrolled, workers may be injured if the liner is allowed to unroll down a working slope of a landfill.

*Control*. Controls for heavy equipment include:
- Use earth-moving equipment and trucks equipped with a backup alarm that alerts workers.
- Approach operating equipment from the front and always within view of the operator.

- Develop an alarm communication system to warn workers during liner unrolling activities, as necessary.
- Train workers in the potential operational hazards and safety features of the heavy equipment.

**CONTROL POINT**: Construction, Operations, Maintenance

(15) *Steam Pressure Washing Hazards*.
*Description*. Steam pressure washing of equipment may expose workers to thermal, burn or injection hazards, eye hazards from flying projectiles dislodged during washing, slip hazards from wet surfaces, and noise hazards.

*Control*. Controls for steam pressure washing include:
- Use insulated gloves (e.g., silica fabric gloves) and keep body parts away from steam pressure ejection nozzle.
- Use safety goggles and hearing protection.
- Wear slip-resistant boots.
- Drain water away from decontamination operations into a tank or pit. Drain walking surfaces and keep free of standing liquids or mud.
- Allow only trained and authorized workers to operate the steam pressure equipment.

**CONTROL POINT**: Construction, Operations, Maintenance

(16) *Respirable Quartz Hazard*.
*Description*. Depending on soil types, exposure to respirable quartz may be a hazard. Consult geology staff to confirm the presence of a respirable quartz hazard (e.g., to determine if soil types are likely to be rich in respirable quartz). As an aid in determining respirable quartz exposure potential, sample and analyze site soils for fines content by ASTM D422 (R2002): "Standard Test Method for Particle Size Analysis of Soils" followed by analysis of the fines by X-ray diffraction to determine crystalline silica quartz content.

*Control*. Controls for respirable quartz include:
- Wet soil periodically with water to minimize worker exposure. Wetting of soil may require additional controls to deal with resulting water, ice, mud, etc. Consult 29 CFR 1910.1000, Table Z-3, to calculate acceptable respirable dust concentrations based on percent silica in the quartz.
- Use respiratory protection, such as an air purifying respirator equipped with N, R or P100 particulate air filters.
- Train workers in the potential inhalation hazards of crystalline silica dust exposures.

**CONTROL POINT**: Design, Construction, Operations, Maintenance

(17) *Ultraviolet (UV) Radiation.*
*Description*. During site activities, workers may be exposed to direct and indirect sunlight and the corresponding UV radiation. Even short-term exposure to sunlight can cause burns and dermal damage.

*Control*. Controls for UV radiation include:
- Minimize direct sun exposure by wearing sun hats, long-sleeved shirts, full-length pants, and by applying UV barrier sunscreen.
- Shade work and break areas if possible.

**CONTROL POINT**: Construction, Operations

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

*Control*. Controls 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

(19) *Traffic Hazards*.
*Description*. The general public may be exposed to traffic hazards and the potential for accidents during loading and transporting soil from borrow pits to the landfill.

*Control*. A control for traffic hazards to the general public includes:
- Develop a traffic management plan before excavation commences to help prevent accidents involving dump trucks and automobiles. EM 385-1-1, Section 21, provides plan details.

**CONTROL POINT**: Design, Construction, Operations

(20) *Utility Contact Hazards*.
*Description*. Workers may be exposed to electrocution hazards when working around electrical utilities such as overhead power lines.

*Control*. Controls for utility contact hazards include:
- Locate overhead power lines, either existing or proposed, in the pre-design phase.

- Keep all lifting equipment, such as cranes, forklifts, and drilling rigs at least 10 feet from a power line according to Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1926.550 and EM 385-1-1, Section 11.

**CONTROL POINT**: Design, Construction, Operations

(21) *Explosion Hazards*.
*Description*. During excavation activities, workers may be exposed to explosion hazards associated with unexploded ordnance or buried flammable materials at military bases.

*Control*. Controls for explosion hazards include:
- Do a thorough pre-design records search of the landfill to identify the possible presence of unexploded ordnance in the areas to be excavated.
- Train the operators in the hazards of excavating in areas with potential ordnance.
- Train the operators in emergency procedures in case of a catastrophic event, in life saving first aid procedures for severe trauma that would be expected in the event of an explosion, in burns, and extracting, extinguishing, and stabilizing victims, and in emergency excavation isolation procedures.
- Use metal detectors or ground-penetrating radar prior to excavation to clear the excavation area of such hazards. Hand probes may also be used.
- Excavate soil suspected of containing an underground hazard slowly and with caution.

**CONTROL POINT**: Design, Construction, Operations

*b. Chemical Hazards.*

(1) *Solvents*.
*Description*. The heating or solvent welding of the cover/liner materials may generate vapors from adhesives, thermal decomposition, or outgassing of liner material components such as plasticizers (e.g., phthalate esters, adipate esters), or from any solvents contained in the adhesive (e.g., methyl ethyl ketone, methylene chloride). A dermal hazard may also exist from skin contact with the cementing chemicals or waste materials generated during installation.

*Control*. Controls for solvents include:
- Ventilate the area or use appropriate respirators to control exposures during installation. Select respirator cartridges based on consultations with the liner manufacturer and the potential compounds that may be emitted.
- Use personal protective equipment (PPE) such as chemically resistant gloves (e.g., nitrile) to help control dermal exposure.

- Perform an analysis of possible chemical exposures prior to issuing gloves and other PPE. The analysis should include obtaining specific chemical hazard information on the liner constituents.

**CONTROL POINT**: Construction, Operations, Maintenance

(2) *Waste Chemicals*.
*Description*. Workers may be exposed to waste chemicals such as airborne dusts and particulates and VOC emissions resulting from redistribution of wastes associated with liner installation, landfill off-gassing, or leachate collected by leachate collection and treatment systems. Leachate may contain both organic and inorganic constituents.

*Control*. Controls for waste chemicals include:
- Apply water or an amended water solution to control airborne dust, particulate, and VOCs generation.
- Use respiratory protection including air-purifying respirators equipped with approved filters/cartridges such as N, R or P100 or N, R or P95 particulate air filters, OV cartridges for vapors, or combination filter/cartridges for dual protection.
- Use PPE to control leachate exposure.
- Conduct an analysis of work tasks and potential chemical exposure, including a chemical waste profile, to determine correct PPE and respirator cartridges if necessary.

**CONTROL POINT**: Construction, Operations, Maintenance

(3) *Hazardous Landfill Gases*.
*Description*. Methane generated by existing landfills is highly flammable and is an asphyxiant. The off-gas generated from an existing landfill may also contain concentrations of vinyl chloride and hydrogen sulfide. Vinyl chloride is a human carcinogen, and hydrogen sulfide damages lungs and circulation. The hazards from exposure to landfill gas must be considered during pre-design, design, construction, operations, and maintenance.

*Control*. Controls for landfill gases include:
- Perform soil gas surveys during pre-design to determine the levels of methane, hydrogen sulfide, and vinyl chloride in soil. The methods for collecting landfill off-gas samples (barhole probe, permanent gas monitoring, and gas extraction wells) are discussed in EPA-450/3-90-011a, “Air Emissions From Municipal Solid Waste Landfills.”
- Periodically monitor landfill off-gas during construction, especially in enclosed areas such as excavations and other low, undisturbed areas.
- Ventilate an area if methane levels reach 10 percent of the Lower Explosive Limit (LEL).
- Train workers in the potential hazards of landfill off-gassing.

**CONTROL POINT**: Design, Construction, Operations

*c. Radiological Hazards.*

(1) *Nuclear Gauge Hazards.*
*Description*. Use of a nuclear gauge to determine the moisture content and density of the clay liner and cover may pose a radiation hazard.

*Control*. Controls for nuclear gauges include:

- Use personnel with the proper training and experience in the use and maintenance of the neutron density gauge.
- Comply with Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation (10 CFR 20), NRC Rules of General Applicability to Domestic Licensing of Byproduct Material (10 CFR 30), licensing requirements for the particular source (10 CFR 31, 32, or 39), all license conditions, and OSHA 29 CFR 1910.1096 or 29 CFR 1926.53.

**CONTROL POINT**: Construction, Maintenance

(2) *Radioactive Materials.*
*Description*. Although an uncommon hazard, radioactive materials may pose a hazard by exposure to radiation or inhalation/ingestion of radioactive particles during the installation of covers/liners. A variety of radiation sources may have ended up in landfills, including Naturally Occurring Radioactive Materials (NORM) from oil and gas exploration and production, medical wastes, low-level research wastes, and disposed of instruments and their sources.

Some radioactive materials are pyrophoric. Machine filings or turnings of uranium or thorium may spontaneously ignite, and pose fire and airborne radioactivity hazards. Turnings or filings buried in existing landfills may combust upon excavation when the material is exposed to air. Other radioactive materials may present an external exposure hazard.

*Control*. Controls for radioactive materials include:

- Test the contents of the landfill prior to construction or maintenance operations.
- Consult a qualified health physicist to determine the exposure potential, the nature and extent of the radiation or radioactive materials, necessary controls, and the appropriate PPE to prevent exposure.
- Provide decontamination facilities if required, using guidance such as *The Health Physics and Radiological Health Handbook* (Bernard, Schleien, Scinta, Inc. 1992).

**CONTROL POINT**: Design, Construction, Operations, Maintenance

*d. Biological Hazards.*

(1) *Biological Contaminants.*
*Description*. At those sites having medical wastes or sewage sludge, biological hazards may result through inhalation/ingestion and dermal contact with microbes in the waste and pathogens, such as *Coccidioides sp., Histoplasma sp.,* and *Mycobacterium sp*. Exposure to biological hazards may result in eye and skin bacterial and fungal infections.

*Control*. Controls for biological contaminants include:

- Test the contents of the landfill to assess the potential risk and prevent exposure to dangerous biological materials during construction. If such materials are present, follow the next step.
- Determine the nature and extent of biological hazards and the appropriate PPE to prevent exposure such as respiratory protection equipped with N, R, or P100 or N, R, or P95 particulate air filters approved for microbial inhalation hazards and provide decontamination.
- Prevent inhalation/ingestion of biological materials through dust suppression techniques using water or amended water treatments. Use dust suppression techniques only when adequate runoff controls are in place and a slip hazard is not generated from the wetting of the material.
- Control eye infections by using portable eyewashes to remove dust or other objects from the eyes.
- Use germicidal soap prior to eating or drinking.

**CONTROL POINT**: Design, Construction

(2) *Pests*.
*Description*. Workers may be exposed to a wide array of biological hazards, including snakes, bees, wasps, ticks, hornets, and rodents during any phase of remediation. The symptoms of exposure vary from mild irritation to anaphylactic shock and death. Deer ticks may cause Lyme disease. Rodents can transmit Hanta virus. Mosquitoes can transmit West Nile Virus.

*Control*. Controls for pests include:

- Periodically inspect the site to identify bee hives and wasp nests and to check for snakes and rodents.
- Use professional exterminating companies if necessary.
- Use tick and insect repellents containing N,N-diethyl-m-toluamide (DEET) 25% as an active ingredient, for exposure control. Workers should check their skin and clothing for ticks periodically throughout the workday. Clothing may be treated with permethrin clothing repellent BEFORE donning it, for added protection.

**CONTROL POINT**: Construction, Operations, Maintenance