2.0 SUBPART X UNITS

This chapter provides basic descriptions of the more typical units permitted as Subpart X units. The chapter also discusses circumstances when it may be appropriate to permit proposed miscellaneous units as conventional hazardous waste management units. Examples of patented or trademark technologies are discussed throughout this chapter. However, the Agency does not endorse the technology available from any specific company.

2.1 TYPES OF UNITS INCLUDED UNDER SUBPART X

2.1.1 Open Burning and Open Detonation Units

Many waste propellants, explosives, and pyrotechnics (PEP), and munitions items are unsafe to treat by conventional methods of hazardous waste management. Open burning and open detonation (OB/OD) remain the primary methods of treatment for these wastes. Currently, research is being conducted to develop alternative methods of treatment for PEP wastes. New technologies, such as enclosed detonation chambers, are likely to become more widely available in the next several years. Some of these new technologies may qualify for permitting under Subpart X.

View of burning pans on a secondary containment pad. Note that the pads do not appear to have berms around them.

The unit descriptions provided here focus on military OB/OD units, because the majority of the units are operated by the military. The design configurations and operational standards discussed in this section will, however, also be used at non-military facilities.

2.1.1.1 Open Burning: Physical and Process Description

Open burning (OB) is used primarily to destroy propellants, and is generally conducted on engineered structures such as concrete pads, or metal pans to avoid contact with the soil surface. Such structures may range in size from 3 to 5 feet wide by 5 to 20 feet long, and are 1 to 2 feet deep. OB pans should be made of a material sufficient to withstand the burning process, and should be of sufficient depth and size to contain treatment residues. The pans may be elevated slightly above the ground to enhance cooling and to allow inspections for leaks. The pans should be covered when they are not in use to prevent precipitation from entering them. Pans may be equipped with ports for draining collected precipitation or cleaning solutions. Collected precipitation should not be discharged onto the ground unless the pan was decontaminated after its last use, or unless the precipitation is sampled and analyzed and determined not to contain hazardous constituents. A metal cage placed over the burn unit during treatment may be helpful to minimize the ejection of residues from the unit.

Closeup view of burning pans on concrete slab. Note the white covers in the background which can be rolled over the pans to prevent precipitation from entering them.

The ground beneath the trays or pans may be surrounded by berms to prevent runon and runoff from the area; however, a well-designed and operated burn pan may not require berms. Ground cover around and beneath the pans should be prepared for ease of recovery of ejected treatment residues and for prevention of fire hazards that such residues may pose. Maintenance of a packed soil surface is the minimum preparation sufficient to accomplish those goals.

To prevent propagation of an accidental detonation from one device to another, DoD regulations require containment devices, trenches, and individual ground treatment units be spaced at least 150 feet apart. Detailed design specifications for containment devices, whether trenches, pans or other types of containment, should be included in the permit application.

To view a video of an open burning operation, double click on the image above.

Waste propellant to be treated is often contained in bags, which are placed directly into the unit. The waste may be primed (that is, an initiating device is placed in the waste material) either electrically or non-electrically with black powder squibs. The waste is then ignited and the established wait time is observed. If explosives are treated, a wait time of at least 12 hours typically is observed before site workers inspect the unit. A 24-hour wait time typically is observed between OB events to allow the surface to cool. After the OB treatment, containment devices are cleaned of any residues. OB operations generally are restricted to daylight hours, and usually are not conducted during inclement weather.

2.1.1.2 Open Detonation Unit: Physical and Process Description

Open detonation (OD) is used primarily to treat munition items. OD typically is conducted in pits or trenches below ground to minimize the ejection of treatment residue, although surface detonations are performed under certain circumstances. Trenches vary in size depending on the quantity of material to be treated, and are usually 4 feet deep or greater, and can vary in size from 4 to 8 feet wide by 6 to 15 feet long.

View of open detonation.

The maximum quantities to be treated are measured by net explosive weight (NEW), which is the total weight of explosives in the munition. The NEW does not include the weight of the explosive charge used to initiate the detonation (donor charge). Military units often use Composition (C-4) (90 percent RDX and 10 percent plasticizer, such as polyisobutylene) as a donor charge for OD operations. The quantity of donor charge used is usually equal to the NEW of the munitions to be treated.

Open detonation is usally conducted in an excavated pit to minimize the ejection of treatment residues, although surface detonations may be performed. Not the rain cover in the background which can be rolled over the area.

Open detonation involves placement of wastes at the bottom of the pit, along with the donor charge. The waste and charge are then covered with soil to the top of the pit. After detonation, any treatment residues should be removed to minimize the potential for releases of hazardous waste or hazardous constituents to the environment. Surrounding soils should be maintained in a manner that minimizes the potential for fire posed by dry vegetation or other hazards.

2.1.2 Enclosed Treatment Units

In recent years, DoD has encouraged the use of controlled thermal treatment units for the destruction of pyrotechnics, small arms ammunition and fireworks. Examples of enclosed thermal treatment units include the Donovan Blast Chamber, the Blast Containment Structure and the Hurd Burn Units.

2.1.2.1 Donovan Blast Chamber

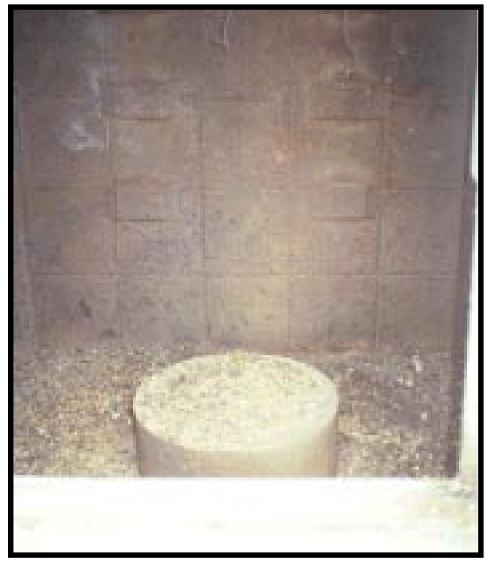
The Donovan Blast Chamber is used to perform controlled thermal treatment of PEP in a room-size blast chamber. The explosion chamber consists of an elongated double-walled steel explosion chamber anchored by bolts to a reinforced concrete foundation. In the preferred design, the inside dimensions of the chamber are eight feet high, six feet wide and fifty feet long. The reinforced concrete foundation is preferably at least four feet thick. The chamber is equipped with a double-walled access door for charging batches of explosives and a double-walled vent door for discharging the products of detonation. The double-walls of the chamber, access door and vent door are filled with a granular shock-damping material such as silica sand and the floor of the chamber is covered with a shock-damping bed such as pea gravel. Within the chamber, plastic polymer film bags containing water are suspended from steel wires over the explosive material. Detailed drawings and design specifications for the unit are available in United States Patent No. 5,613,453. Additional information can also be found at http://www.demil.net

To view a video of an open detonation operation, double click on the image above.

Materials to be treated are placed in the unit through the access door and onto the granular bed. The suspended plastic bags contain an amount of water that approximates the weight of the explosive. An electrical blasting cap is attached to the igniter lead wires. The access and vent doors are interlocked with the electrical igniter to block ignition unless both doors are positively shut. When the doors are opened after a detonation, a vent fan is activated and the gaseous products of detonation are drawn through the vent door opening and discharged to a scrubber system or baghouse. The Donovan Chamber can be utilized to safely detonate explosive charges in a wide variety of sizes, ranging from two to fifteen pounds NEW. A smaller transportable version of the chamber called the T-10 can be used

Exterior view of the Donovan Blast Chamber.

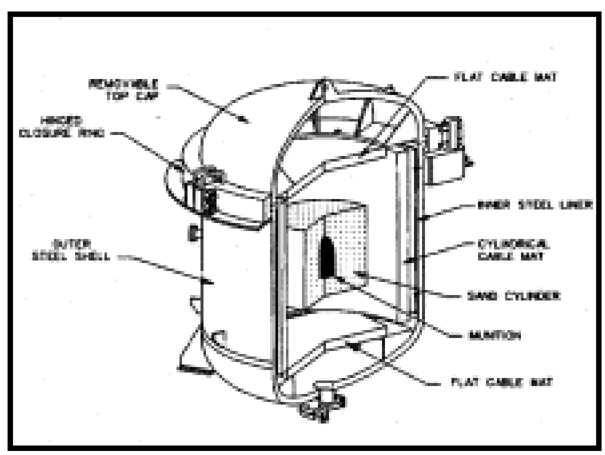
to treat up to 10 pounds NEW per shot. Stack tests have been conducted at units located at the Massachusetts Military Reservation and Blue Grass Army Depot. Performance data from these tests were outlined in *Pollutant Emission Factors for a Transportable Detonation System for Destroying UXO*.



Interior view of the floor of a Donovan Blast Chamber.

2.1.2.2 Blast Containment Structure

The Army Corps of Engineers, Engineering and Support Center in Huntsville, Alabama has developed a blast containment structure which is designed to capture all significant blast pressures for a total NEW of up to six pounds of TNT. The unit is also designed to capture all fragments from cased munitions including 57-mm and 75-mm recoilless rifle shells, 75-mm howitzer and 60-mm and 81-mm mortars. The container consists of a steel cylinder, six feet tall and three and one-half feet in diameter, with elliptical top and bottom caps. The top cap is removable and is held in place by a hinged steel ring. The bottom cap is permanently welded to the cylinder but it features a four-inch diameter drain port for cleanout and several one-inch diameter vent holes. The entire container is mounted on a steel framed skid. The skid includes a working platform, made of fiberglass grating, and a hoist for removing the top cap. All steel parts are cabled together in an electrically continuous fashion and are grounded.



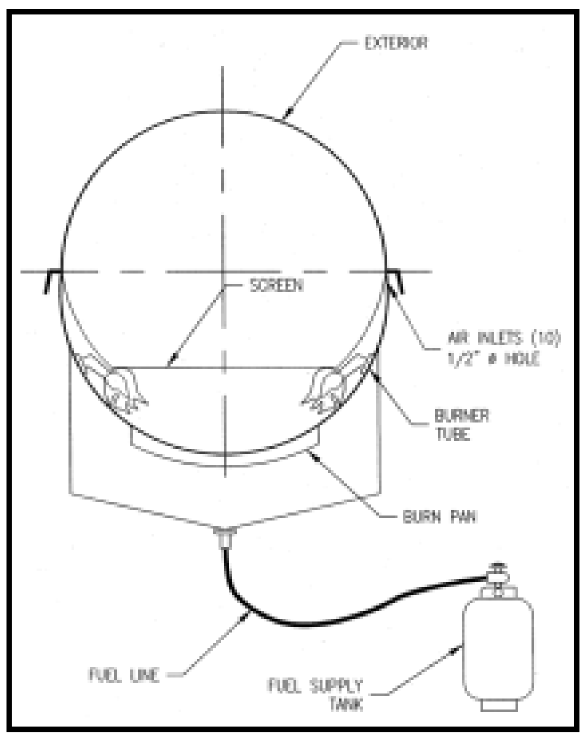
Schematic of Blast Containment Chamber.

The container utilizes a multi-layer fragment capture system to capture debris. Ordnance and a booster charge are placed in a sand-filled plastic cylinder. Just outside the sand layer, plastic bags filled with water are used to absorb much of the heat of the explosion and to reduce the blast pressures. Outside the sand layer is a steel cable mat shaped in the form of the cylinder, with a top and bottom mat to protect the end caps. The mat is similiar to blasting mats used at construction sites. A steel plate liner is located between the cable mat and the outer steel shell. The liner is made in easily removable segments. The sand and water are replaced after each detonation. The cable mats are expected to last for up to ten detonations before being replaced. The liner plate may survive as many as 50 to 75 detonations before requiring replacement. Additional information regarding this treatment device is available at http://www.hnd.usace.army.mil/oew/tech/techindx.html

2.1.2.3 Hurd Burn Units

The unit consists of a quarter-inch thick steel, enclosed cylindrical box equipped with a hinged door on one end. The cylinder or barrel is mounted on a movable trailer which may be positioned on a concrete pad when in operation. The fuel source for the unit is a pair of propane tanks. Waste military munitions are placed onto screens in the barrel of the units. The door to the unit is closed and the propane fuel source is turned on and adjusted through a regulator. The application of a flame ignites the unit. Air holes located on both sides of the unit provide oxygen for the burn. Air emissions escape through the vent at the top of the unit, the air holes on the side of the unit, and through cracks in the doorway. A maximum of 25 pounds NEW may be placed into a single burn unit at any time. The maximum treatment time is 20 minutes. Situating the unit on a steel reinforced concrete slab will provide additional containment in the event of spillage of ash or kickout. However, the unit has no air pollution control features associated with it.

View of Hurd Burn Unit. This is a moble unit which can be used for treating small quantities of PEP.



Schematic Diagram of Hurd's Burn Unit.

2.1.2.4 Confined Burn Facility

The U.S. Navy at Indian Head has designed a Confined Burn Facility (CBF) that uses a batch-feed chamber. Upon ignition of the wastes in the chamber, the hot gases that are generated are quenched with water and stored in a containment reservoir for subsequent scrubbing and treatment at a slow continuous rate before discharge. The five burn chambers of the CBF are connected via ducts, equipped with scrubbing and quenching sprays, to a central exhaust gas storage vessel. Each burn chamber can hold up to 1,200 pounds of explosive hazardous waste. All chambers are loaded at the beginning of the shift. Each chamber is ignited one at a time with 40 to 80 minutes between each ignition to allow processing of all gases. The design requires no additional pre-treatment, and it can burn up to 6,000 pounds of energetics per shift. It includes redundant burn chambers of composite wall construction (inner wall is ablated during mass detonation to absorb shock waves, and it minimizes damage to the chamber should a mass detonation occur). It uses standard exhaust gas treatment technology, and it uses burn pans similar to present OB site operations.

Overview information regarding the Confined Burn Facility is available at http://www.ih.navy.mil/environm.htm

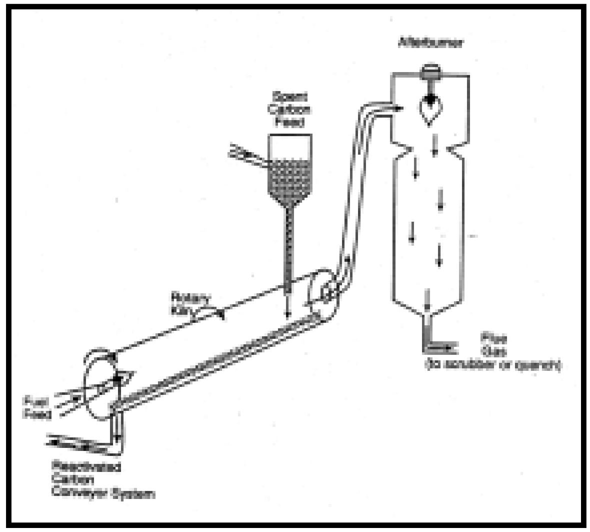
2.1.3 Carbon and Catalyst Regeneration Units

Carbon and catalyst regeneration units include both controlled-flame and non-flame devices. Since 1991, EPA has considered the regeneration or reactivation of spent carbon from a carbon absorption system, used in the treatment of a listed hazardous waste or used to capture emissions from a listed hazardous waste, to be thermal treatment under the interim status provisions of RCRA. The carbon, which contains absorbed organics, is classified as a hazardous waste under the "derived – from rule" (40 CFR §261.3 (c)(2)(i)). In that process, organic contaminants are desorbed from activated carbon at temperatures as high as 1,800 degrees (°) Fahrenheit (F). Carbon regeneration units that use thermal treatment include rotary kilns, fluidized-bed regenerators, infrared furnaces or multiple-hearth furnaces, all of which transfer heat to the contaminated carbon. The most prevalent furnace type is the multiple hearth furnace, followed closely by rotary kilns. As an alternative, steam may be used to desorb contaminants from the media in devices similar to tanks.

Refer to August 8, 1991 Policy Memo and January 5, 1998 Policy Memo regarding the regulatory status of Carbon Regeneration Units.

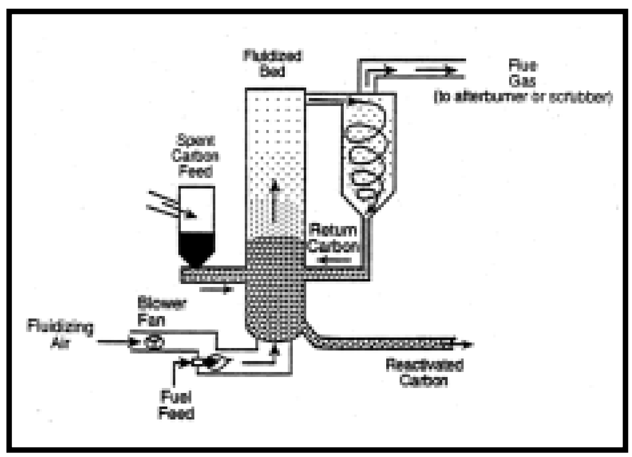
Catalyst regeneration processes can be similar to those used for carbon regeneration. However, the types of catalyst to be regenerated, the types and concentrations of contaminants to be desorbed, and the conditions under which the desorption takes place may alter the combustion chemistry significantly from that which is seen in carbon regeneration units.

Controlled-flame devices used for carbon regeneration are similar to those used for incineration or for boilers and industrial furnaces (BIF). However, strict compliance with incinerator or BIF regulations may not be appropriate. Use of EPA's incinerator and BIF destruction and removal efficiency (DRE) standard and carbon monoxide and total hydrocarbon monitoring in the off gases may be appropriate for such units. Following are brief descriptions of some of the more common types of regeneration units.



Schematic of Rotary Kiln.

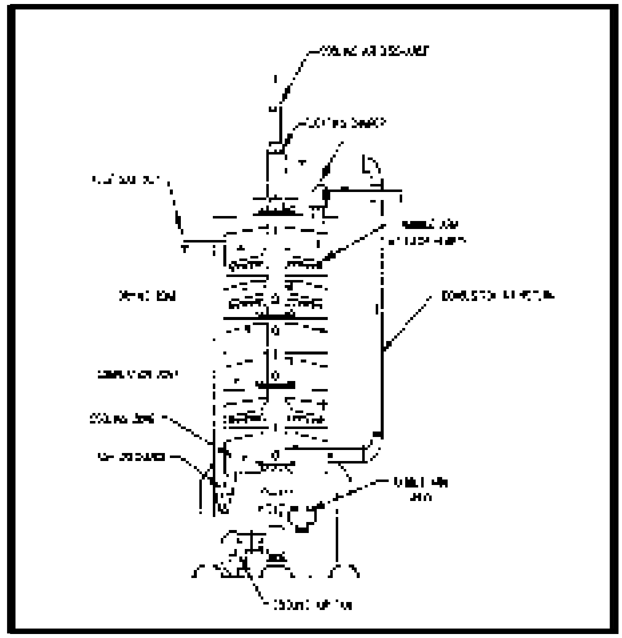
A rotary kiln is an inclined rotating cylinder, lined with refractory brick and internally fired. The spent carbon is fed at the higher end of the kiln and moves, driven by gravity, down the length of the kiln as the kiln rotates. A heated air stream passes countercurrent with the waste, volatilizing the contaminants in the carbon. The exiting air stream contains desorbed contaminants and any combustion products that may have formed within the kiln. The rotational speed of the kiln can be varied. Peripheral speeds of 0.5 meters/minute (m/min) to 2 m/min are typical.



Schematic of Fluidized-bed Furnace.

A fluidized-bed furnace is a cylindrical vertical vessel with an air feed at the bottom of the unit. In fluidized-bed units, the granular material (the bed) is fluidized by directing air upward through the bed. Fuel is charged directly into the fluidized-bed or into the window box beneath the bed. The temperature in the freeboard area above the bed can be higher than that within the bed. Because of the airflow required to fluidize the carbon particles, fluidized-bed furnaces have a larger exhaust volume than other types of regeneration furnaces with the same carbon throughput rate.

A multiple hearth furnace typically consists of a refractory-lined vertical steel shell. Inside is a series of flat hearths that are supported by the walls of the shell. A rotating shaft runs vertically through the center of the hearth. Rabble arms attached to the rotating shaft move the waste across each hearth. The hearths have holes, either in the center near the shaft or near the outside edge through which the waste drops to the hearth below. Combustion air travels countercurrent to the waste flow.

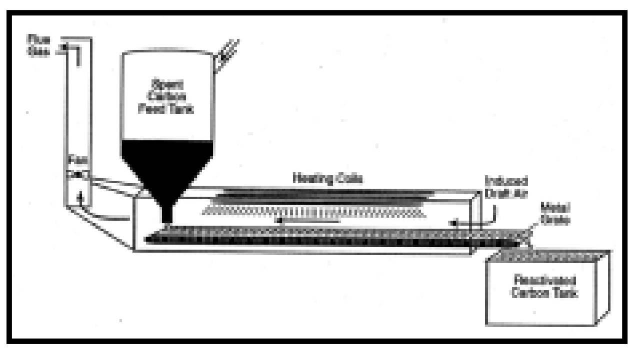


Schematic of Multiple Hearth Carbon Regeneration Unit.

In an infrared furnace spent carbon is transported through the horizontal furnace via a metal grate. A series of heating elements above the metal grate are electrically heated to incandescence. The infrared radiation heats the carbon and a draft fan is used to draw air through the furnace and remove desorbed gases as they are released from the carbon.

These types of units may use a backflush of steam to desorb contaminants. The contaminated steam then is condensed and transferred to a decanter. In the decanter, a concentrated organic solvent phase is separated from the water phase. The water phase contains measurable concentrations of organic contaminants and must be treated as hazardous wastes.

Some carbon regeneration tanks also may meet the definition of wastewater treatment unit under 40 CFR §260.10. Such units are used to adsorb contaminants from wastewaters. These units are exempt from permitting standards under RCRA when they are used to treat wastewater for discharge under National Pollutant Discharge Elimination System (NPDES) or publicly owned treatment works (POTW) standards.



Schematic of Infrared furnace.

2.1.4 Thermal Desorption Units

As outlined in a June 12, 1998 Policy Memo, the EPA regulations do not define "thermal desorber", but the term generally applies to a unit which treats wastes thermally to extract contaminants (i.e., volatile organics) from a matrix. A thermal desorber utilizing controlled flame combustion (e.g., equipped with a directly fired desorption chamber and/or a fired afterburner to destroy organics) would meet the regulatory definition of an incinerator. Alternatively, a thermal desorber that did not use controlled flame combustion (e.g., equipped with an indirectly heated desorption chamber and the desorbed organics were not "controlled"/destroyed with an afterburner) would be classified as a "miscellaneous unit". Thermal desorption may oxidize organics but in some cases merely volatilizes organic compounds from the contaminated media and concentrates them in the desorber exhaust gas stream. Thermal desorption reduces the volume of the contaminated media, but the desorber exhaust gas stream typically still requires some form of treatment.

Additional Policy Memos regarding the applicability of the Subpart X regulations to Thermal Desorbers were issued on July 30, 1997, February 23, 1994, October 29, 1993 and *May 18, 1988.*

A typical thermal desorption unit includes feed processing equipment, such as hoppers, sieves, or shredders. The feed material then is transferred into the thermal treatment unit by such equipment as conveyor belts. The feed storage, preparation, and transfer system may be unenclosed, posing risks of releases during those steps. Emission controls for the ancillary equipment may be necessary to address significant risks.

The thermal treatment unit itself may consist of a rotary kiln, a fluidized-bed system, or a multiple-hearth system, as described above for regeneration units. Typically, the waste feed travels countercurrent to an air stream inside the desorber, where temperatures typically are between 400 and 1,000°F. The contaminated air stream is directed through air pollution control devices, such as afterburners, venturi scrubbers, electrostatic precipitators, or baghouses, before it is released into the atmosphere.

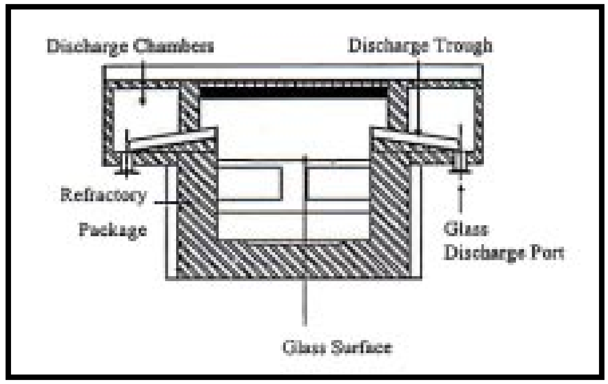
2.1.5 Vitrification Units

The development of vitrification technology has been promoted by the large volume of low-level and high level radioactive waste requiring treatment at U.S. Department of Energy (DOE) sites. Much of this waste includes RCRA hazardous constituents and is regulated as mixed waste.

There are two general categories of vitrification processes: those applied to site remediation (e.g., contaminated soils) and those applicable to treatment of waste streams from uranium/plutonium processing (e.g., tank wastes). Vitrification processes used in the treatment of wastes are typically conducted as ex-situ vitrification whereas treatment of contaminated soils is generally conducted in-situ. A description of both ex-situ and in-situ vitrification processes follows.

2.1.5.1 Ex-Situ Vitrification

The ex-situ vitrification process is a thermal treatment process that both oxidizes and vitrifies wastes. It can treat wastes in the form of solids or as slurries. Typically waste and fuel are mixed in a pre-combustor before being transferred to a combustion chamber. Oxidation will take place in the combustion chamber. After the waste has been oxidized the ash is transferred to a vitrification chamber where it is mixed with glass making ingredients to create glass materials. In some systems, wastes treated this way are reportedly capable of passing the toxicity characteristic leaching procedure (TCLP).



Schematic of high level waste melter used for ex-situ vitrification.

2.1.5.2 In-Situ Vitrification

In-situ vitrification earth-melting technology was developed by Battelle Memorial Institute during the 1980s for DOE and is now commercially available as Geosafe Corporation's GeoMelt™ technology. In-situ vitrification treats contaminated materials where they presently exist. This method is preferred when it is necessary to avoid the risks associated with excavation of the waste. The vitrification process can simultaneously treat wastes with high concentrations of both organic and inorganic (e.g., heavy metal) contaminants. Organic constituents are thermally desorbed and then destroyed by thermal decomposition (pyrolysis) within the oxygen-depleted media being treated. Nonvolatile inorganics (metals) are typically incorporated into the melt and the resulting vitrified product. Such incorporation occurs within the framework of the glassy product itself, as opposed to simple encapsulation (being surrounded) by the glass. A large volume reduction (25-50% for soils) occurs due to elimination of void volume and vaporizable materials during processing. This process works best with treatment zones that are >10 feet in thickness.

In-situ vitrification hoods.

Off-gas hoods are used to cover an area of contaminated soil. The process works by melting soil in place using electricity applied between pairs of graphite electrodes. The process employs joule heating and typically operates in the range of 1,600 to 2,000° Celsius (C) for most earthen materials. A highly conductive starter path is placed between the electrodes to allow initiation of melting. As electricity flows through the starter path, the path heats up and causes the surrounding media to melt. Once the media is molten, it too becomes electrically conductive. Continued application of electricity results in joule heating within the molten media between the electrodes. After the melt is fully established, the melt zone grows steadily downward and outward through the contaminated volume. Successful melting is contingent upon the use of adequate electrical conductivity. Additives including lime, soda, ash, or pre-manufactured glass frit may be used to improve performance.

A low vacuum can be pulled on the hood in operation to capture emissions from the melt and send them to the off-gas treatment system, which may include a quencher, scrubber, demister, heater, particulate filter, blower, and optional activated carbon or thermal oxidation units. The entire ISV system can be monitored from a process control room.

2.1.6 Rotary Metal Parts Treatment Unit

Rotary metal parts treatment (RMPT) is used in the decontamination of empty projectile and mortar shells. The RMPT consists of a cylindrical structure rotating at a prescribed speed inside a cylindrical furnace. The dimensions of the RMPT are 4 feet, 8-inches inner diameter by 15 feet, 7-inches in length with design conditions of 15 psig/full vacuum at 1,500 °F. The inside cylinder contains 15 cages which are evenly distributed around a 36-inch outside diameter inner pipe, supported and strengthened by baffles. Each cage is constructed with three ½-inch diameter stainless steel rods, positioned at a 120-degree angle and parallel in the axial direction. The size of the cages is dependant on the different munitions and mortars to be treated.

The RMPT is heated by using external electric induction coils and superheated steam as the carrier gas.

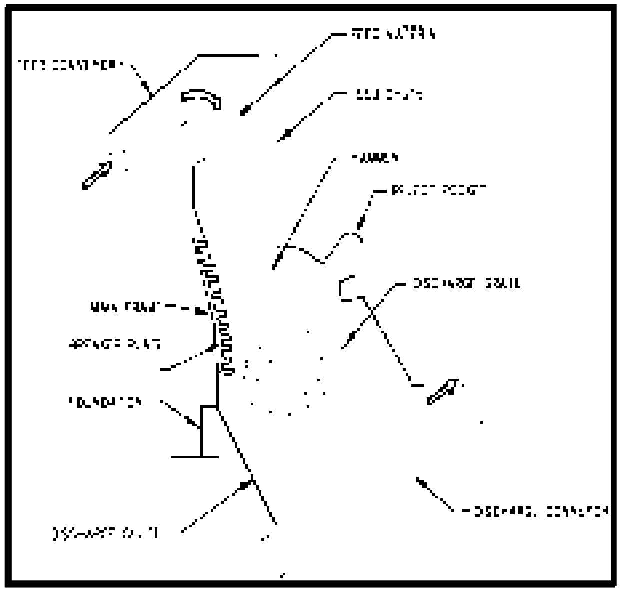
Munitions that have been washed and drained are transported by a conveyor system and loaded into the cages on a unit feed basis. The furnace is heated by induction power supplied from a radio frequency generator. The entire furnace wall area must be heated and maintained at a temperature of 1,250° F. The furnace shell must have a high emittance in order to optimize performance. In addition, the shell must also have good chemical resistance to corrosion, in order to resist the acid gases that are generated during operation. The total residence time for each munition ranges from 75 minutes for 105-mm projectiles and 4.2-inch mortars to 105 minutes for 155-mm projectiles. At the same time as a munition is loaded on the front end of the unit, a treated munition is discharged at the opposite end of the furnace. A vent gas reheater is installed downstream of the RMPT to complete destruction of the agent. Downstream of the reheater, the vent stream is cooled and condensed in a quench condenser which is in contact with a recirculated brine stream. Noncondensable gases will be sent to a dedicated CATOX® offgas treatment system.

Detailed process flow diagrams and design specifications for the RMPT, the BMPT and the associated ancillary equipment are in provided in following document: Rotary Metals Parts Treatment.

Internal parts removed from the 105-mm, 155-mm munitions and 4.2-inch mortars are processed in a smaller Batch Metal Parts Treatment (BMPT) unit. The internal parts consist of burster wells, burster tubes, fuzes, nose cones, lifting lugs and plugs. Similiar to the RMPT, the BMPT consists of a cylindrical furnace which uses external induction coils as the primary heat source and superheated steam as the carrier. The BMPT measures 4 feet, 8-inches in diameter by 11 feet in length with design conditions of 15-psig/full vacuum at 1,500 ° F. The internal parts are removed from the main bodies of the projectiles or mortars and collected into rectangular boxes. These boxes are placed on a rolling plane and fed into the furnace on a batch basis.

2.1.7 Shredder Units

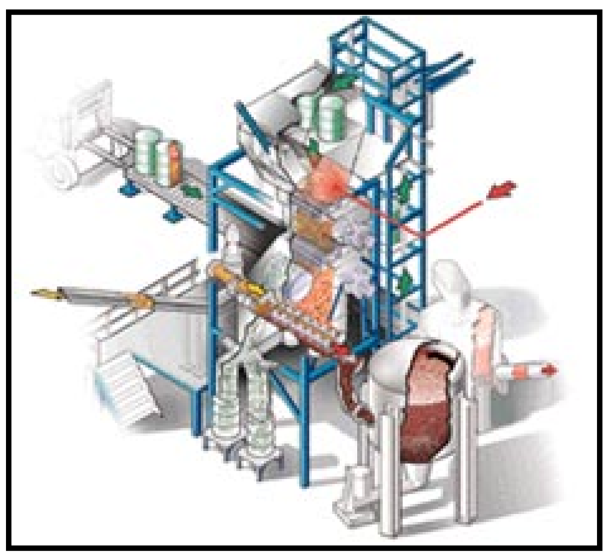
Shredders typically are used to make waste more amenable to subsequent treatment in other units, such as thermal desorbers, regeneration units, or incinerators, through reduction in size, and blending. Shredders may be regulated under Subpart X based on the material managed. Refer to June 24, 1988 Policy Memo. Drum shredders are found at a number of facilities. If the unit is managing "RCRA empty" containers, then the unit is exempt from RCRA Subtitle C regulations. (Refer to 40 CFR §261.7 for the definition of RCRA empty). Several types of shredders are used, the major examples of which are hammer mills, shear shredders, and auger shredders.



Schematic of HammerMill Shredder.

A hammer mill is a type of shredder that reduces the size of the waste by impaction and that works best with friable materials. The mill can handle a wide range of solids but must be matched well with the waste to prevent problems related to excessive equipment wear and jamming. Stringy or sticky materials also can jam the mechanism. Shear and auger shredders use low-speed knives or counter-rotating augers to shred solid materials, such as drums.

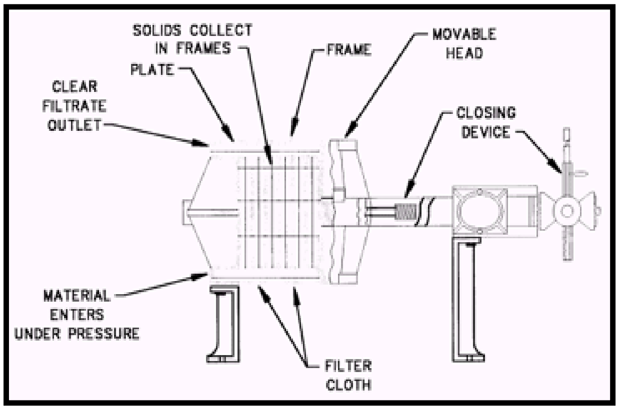
A mechanical feed system, typically consisting of a feed hopper and some type of conveyance system, should be available to avoid the need for plant personnel to be near the opening of the hopper during operation. To prevent flying debris and to minimize emissions, the feed system should be enclosed. The shredder also must be designed to contain dusts and mists of toxic materials, as well as, in the case of hammer mills, particulate matter escaping the unit at high velocity. Dust and fumes can be controlled by drawing them into an air pollution control device associated with the shredder. In some cases, flame-suppression devices may be necessary to prevent explosion and fire in the feed hopper and the shredder.



Schematic of Shear Shredder.

2.1.8 Filter Press Units

Filter presses are used to separate solids from fluids under pressure. The most basic type of filter press is the plate-and-frame press. As shown in the schematic to the right, the unit consists of alternating solid plates and hollow frames that are situated on parallel support bars. The filter medium is placed against each side of the solid plates, the surfaces of which are slotted or grooved. The entire collection of plates and frames is pressed together using a screw or hydraulic ram assembly, which should achieve essentially a fluid-tight closure. The filter medium between the plates and frames acts as a gasket. This schematic also shows the flow path within a plate-and-frame press. Although the figure shows filtrate exiting through a closed system, other designs discharge filtrate through cocks located at the base of each plate into open collection trays. A closed discharge system is essential to prevent toxic or volatile air emissions.



Schematic of Filter Press.

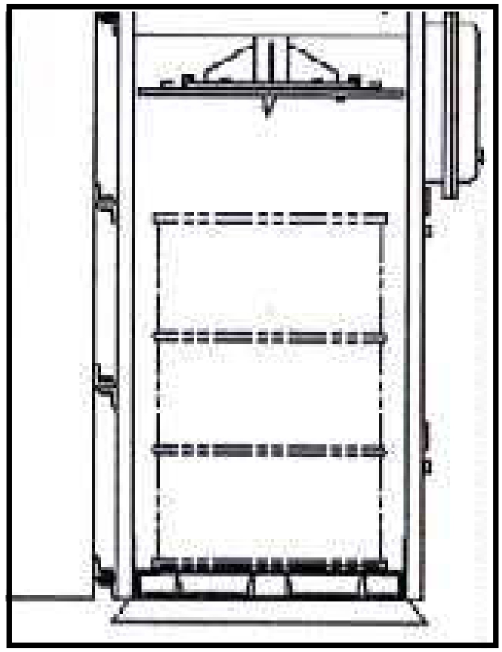
Filter presses often drip and leak. Emptying and cleaning of a filter press may include disassembly of the press and scraping of the filter cloth by hand. For such units, secondary containment (e.g., as required for tanks under 40 CFR §264.193) may be appropriate to minimize the potential for harm posed by releases that may occur during operation and maintenance of the units.

2.1.9 Drum Crushers

Drum crusher units that are eligible to be permitted under Subpart X, handle containers of hazardous wastes. Typically, a can or drum crusher handles one container at a time. The container's lid may be removed before it is placed in the crusher, or the lid can be left in place if an opening, such as a bunghole, is present. Some units are designed to cut off the top of the drum to allow easier access to the interior. After the container is conveyed into the unit and opened, the interior of the container may be sprayed with an appropriate solvent to mobilize hazardous waste residues.

A Policy Memo concerning the applicability of Subpart X to Drum Crushers was issued on May 21, 1991.

Within the unit, a perforated plate is clamped on the top of the container, and then the container is flipped over and crushed with a hydraulic ram. The hydraulic ram may be electric or pneumatic powered. The rinse solvent and residues are forced out of the container and down through the perforations. The solvent and rinsate drain from the bottom of the can crusher unit into a collection tank. The crushed container, which typically is approximately one-inch thick, is then conveyed out of the unit. The hazardous waste that drains into the collection tank may be thick and difficult to mobilize. The collection tank may have ancillary equipment for such processes as agitation, grinding, or addition of fluid to enhance removal of the hazardous waste.

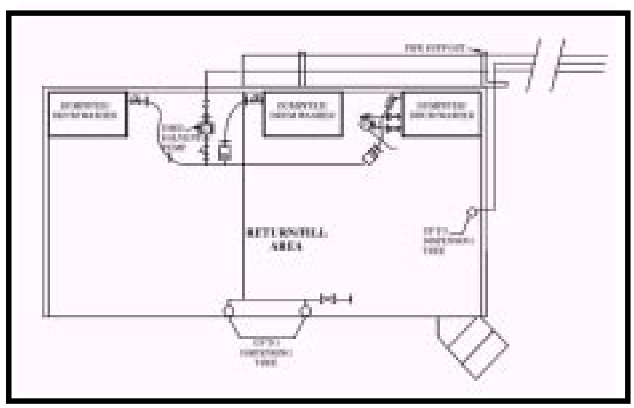


Schematic of Drum Crusher.

The drum crusher unit should be enclosed, so that a nitrogen or carbon dioxide blanket can be applied during crushing to minimize the risk of explosion. The unit also should be equipped with a flame-arrester vent that is connected to appropriate emission control equipment. Secondary containment may be necessary for the entire unit.

2.1.10 Drum Washer

Commercial drum washing systems are available from several manufacturers. These units are regulated as Subpart X units if the units are handling non-RCRA empty drums. The definition of RCRA-empty container is provided in 40 CFR §261.7. Drum washers may be fully automated with several stations to flush, rinse, purge, and siphon both poly and steel drums. In general, a drum washing system provides enclosed containment to capture the liquid solvent used to clean the interior and exterior of a drum. The solvent may be applied by a high-pressure spray wand or automated rotating brushes. The cleaning solvent may be as simple as high-pressure water, although it is common to use a commercial chemical solvent. Recovered solvent carries drum bottoms and may be recycled through a closed-loop solvent recovery system associated with the drum washer. The drum washer may also include an exhaust fan and air pollution control equipment (e.g., fume scrubber) to capture volatile organics and particulates evolved during drum



Schematic of Drum Washer.

cleaning. In addition to drum washers, systems are also available to clean smaller containers such as totes and pails. Examples of drum washing units are shown in the column to the right.

View of interior Drum Washer.

2.1.11 Mercury Bulb Crushers

Fluorescent lamps are widely used in businesses, as they provide an energy-efficient source of lighting. The commercial and industrial sectors dominate usage of fluorescent lamps, accounting for over 90 percent of total usage. Fluorescent lights are designed so that approximately half of them will operate after 20,000 hours of operation. Where these lamps are being used on a small scale, they are generally replaced as they burn out, one at a time. However, in large companies and industries, this method is not practicable, and, therefore, group relamping is done on a regular basis. Typically, group relamping is performed at 15,000 hours, or 75 percent of the lamp's rated life. This translates to replacement every two years for continuous operations, and every three to five years for noncontinuous operations, which are much more common. Approximately 20 percent of all lamps are currently replaced annually. Group relamping operations generate large quantities of lamps to be disposed of at a single time.

A typical fluorescent lamp is composed of a sealed glass tube filled with argon gas at a low pressure (2.5 Torr), as well as a low partial pressure of mercury vapor, thus the tube is a partial vacuum. The inside of the tube is coated with a powder composed of various phosphor compounds. Tungsten coils, coated with an electron emitting substance, form electrodes at either end of the tube. When a voltage is applied, electrons pass from one electrode to the other. These electrons pass through the tube, striking argon atoms, which in turn emit more electrons. The electrons strike mercury vapor atoms and energize the mercury vapor, causing it to emit ultraviolet radiation. As this ultraviolet light strikes the phosphor coating on the tube, it causes the phosphor to fluoresce, thereby producing visible light. The most commonly used fluorescent lamp is the 40-watt, 4-foot long tube, although smaller, larger and differently shaped lamps are also used. The amount of mercury in fluorescent lamps varies considerably with manufacturer, and typically ranges from 27 to 41 mg of mercury per lamp. Many fluorescent, high-pressure sodium, mercury vapor and metal halide lamps exhibit the toxicity characteristic for mercury. In addition, some high-density discharge (HID) and incandescent lamps may contain lead solder at levels which exceed the toxicity characteristic regulatory level for lead. Fluorescent light fixtures may also contain hazardous constituents in their ballasts (i.e., polychlorinated biphenyls (PCBs) and diethylhexyl phthalate (DEPH)).

Historically, spent hazardous waste lamps were placed in landfills. On July 6, 1999 EPA added spent hazardous waste lamps to the list of federal universal wastes (64 FR 36466) in order to encourage recycling of these wastes. The Universal Waste Rule is codified in 40 CFR §273. The Universal Waste Rule for spent lamps became effective at the federal level on January 6, 2000. However, the rule is not effective in states that are authorized for the base RCRA program until the state chooses to adopt it. Some states may choose to not adopt the universal waste regulations but rather to regulate units which treat hazardous waste lamps under a Subpart X permit.

View of a barrel-mounted crusher utilizing a negative air exhaust system.

The simplest of crushers is essentially a single unit, with a crusher mounted on top of a barrel, usually a 55-gallon drum. This system is used in many industrial facilities to crush their fluorescent lamps as a means to reduce the solid waste volume before disposing the material in a landfill. In this version, light lamps are hand-fed to a feeder chute of variable length and diameter. This chute is not necessarily longer than the lamps being fed into it. The lamps pass to the crushing unit, typically consisting of motor-driven blades, which implode and crush the lamps. From here, the crushed powder drops into the barrel below the crusher. There are no air pollution controls on the device. The crushed lamps are collected in drums until they are full, and then the full drums are transported to one of several facilities. The crushed material may then be separated into glass, metal, and powder components. Typically, the untreated powder is then deposited in a landfill. This is currently the most common method of disposing these lamps. Alternatively, the barrels may be transported to a mercury recovery facility, which will separate the mercury-containing phosphor powder from the crushed glass and aluminum endcaps, and recycle all the materials.

A more sophisticated version of this barrel-mounted crusher utilizes a negative air exhaust system to draw the crushed debris and prevent it from reemerging through the feeder tube. The drawn air is then passed through a High Efficiency Particulate Air (HEPA) filter to remove particulate matter from the exhausted airflow. The crushed material is then disposed in one of the manners discussed above.

Another model design consists of a hand fed apparatus with two feeder chutes. One chute is 5 feet long, to accommodate 4 foot lamps, and the other tube is 9 feet, in order to accommodate 6 to 8 foot lamps. Each chute is placed at an angle, and has a 9-inch by 12 inch opening, which can accommodate several lamps at a time. The lamps are delivered down this angled tube onto a motor driven blade made of heavy gauge hardened steel rotating at 2700 rotations per minute. The rotating blades implode and crush the lamps as they arrive. The crushing unit has an operating capacity of 62.5 lamps per minute. A vacuum system collects air from beneath the crusher, preventing mercury-laden air from exiting through the feed tube. Material collected in the vacuum system first passes through a cyclone separator. This removes glass particles, which drop into the drum. Air from the cyclone separator contains phosphor powder and some mercury vapor. After passing through the cyclone, the air is pulled through to a baghouse, where fabric filters trap particulate matter in the air stream. Every 45 seconds, these fabric filters are cleaned with a reverse pulse of air. The air leaving the baghouse is typically composed only of air and mercury vapor. This air and mercury vapor mixture continues through several more particulate matter and HEPA filters, to ensure that all particulates have been removed. From here, the exhaust is delivered to two 250-pound activated carbon beds, which trap the mercury vapor.

The entire process is vacuum-sealed and monitored continuously for leaks and to ensure that air in the containment area is in compliance with OSHA regulations. Effectively, the only time where levels of mercury in the workplace may approach the OSHA limit of 0.05 mg/m^3, is when lamps have been dropped and broken.

A third design is a completely enclosed system that feeds fluorescent lamps in one end to a crusher, passes the exhaust through an extensive filtering system, and delivers the powder to a thermal reduction unit (TRU), which recovers the mercury from the phosphor powder. Thus, this system carries out the entire mercury recycling process, from the crushing of fluorescent light lamps to the retorting and reclamation of mercury from phosphor powder.

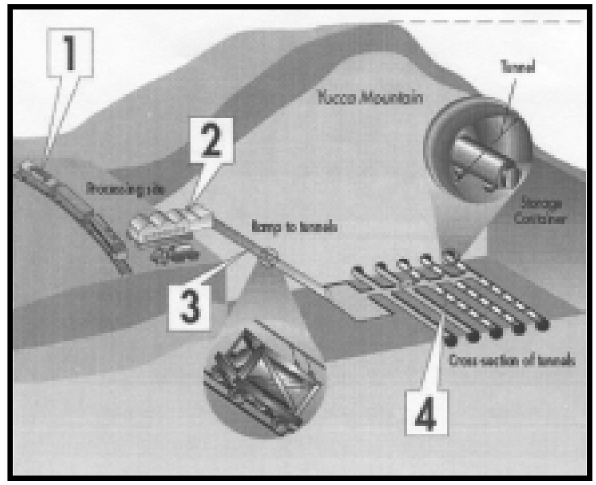
Lamps are hand-fed into feeder tubes of different lengths, depending upon the size of the lamps being processed. The lamps are fed to the crusher, which implodes and crushes the lamps into small fragments. The operating capacity of the unit is 60 lamps crushed per minute. As with the second design, the entire process is conducted under negative airflow. The crushed debris is exhausted first to a cyclone, where the larger particles, such as crushed glass and aluminum endcaps, are separated out. At this point, much of the phosphor powder drops out into a cyclone hopper. From this collection hopper, the phosphor powder, containing mercury, is transferred to the TRU via an enclosed auger conveyer. After the cyclone, the airflow proceeds to a baghouse, where fabric filters continue to remove particulate matter from the airstream. The fabric filters are cleaned with a reverse pulse mechanism, and the powder that drops out here is also routed to the cyclone hopper. The air stream leaving the baghouse proceeds to a HEPA filter, and then to a potassium iodide-impregnated carbon filter. This removes the mercury vapor, by precipitating it in the form of mercuric iodide.

2.1.12 Underground Mines, Caves, and Geologic Repositories

Placement of hazardous waste in subterranean features, such as mines, caves, and salt domes, is regulated under 40 CFR Part 264 Subpart X and constitutes land disposal. Hazardous waste placed in these units must be treated before disposal, in compliance with treatment standards promulgated under the land disposal restrictions (LDR), 40 CFR §268, unless the owner or operator demonstrates that there will be no migration of hazardous constituents from the unit, in accordance with 40 CFR §268.6.

The design considerations for these units are similar to those for landfills. Because of the depth of geologic repositories, it may be extremely difficult to implement groundwater monitoring. The stability of the underground formation also is an important consideration.

At cave and mining sites, infiltration of water should be evaluated carefully. The presence of caves in geologic formations indicates the presence of water within the formation at some time. The permit applicant must demonstrate that ground water is not expected to discharge into the unit for at least the time period of operation of the unit. That requirement can be met by demonstrating that there are no nearby aquifers above the level of the unit, or that aquitards exist above the repository level. Should the applicant be unable to demonstrate that condition, some form of infiltration control must be provided (a requirement similar in concept to that for leachate control for landfills).



Schematic of geologic repository at Yucca Mountain.

1. *Canisters of waste, sealed in special casks, are shipped to the site by truck.*
2. *Shipping casks are removed, and the inner tube with the waste is placed in multilayered storage container.*
3. *An automated system sends storage containers underground to the tunnels.*
4. *Containers are stored along the tunnels, on their side.*

2.1.13 Biological and Chemical Treatment Units

A permit writer may receive a permit application for a biological or chemical treatment unit that the applicant is attempting to permit under Subpart X. Many of these types of units may be more appropriately permitted under either the tank or land treatment unit regulations, or should incorporate such standards as part of the Subpart X permit.

2.1.14 References

Additional information regarding these units described above can be found in the following documents:

EPA. 1992. *Alternative Control Document. Carbon Reactivation Processes. EPA 453/R-92-019.* December.

U.S. Patent Office. 1997. *Patent No. 5613,453. Donovan Chamber.*

EPA. 1994. *Evaluation of Mercury Emissions from Fluorescent Lamp Crushing. EPA 453/R-94-018.* U.S. EPA Control Technology Center. February.