Hazardous Waste
Treatment, Storage, and Disposal Facility

Fire Code Gap Analysis

Final Report

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The objective of this project was to examine the TSDF fire problem, the regulatory framework of hazardous waste, identify gaps contributing to the fire problem and make recommendations to address the gaps. This report could be used to support the logic of developing new text in NFPA 400 Hazardous Materials Code, in the form of a new chapter or annex material, where clarification is needed or specific guidance is lacking.

This paper applies to hazardous waste used, handled, and stored at permitted hazardous waste TSDFs; however, recognition and implementation of the fire codes, NFPA 1 Fire Code and the International Fire Code (IFC) and documents referenced therein, apply also to waste that is determined to be hazardous where generated, stored, or handled in quantities at or exceeding the maximum allowable quantity (MAQ) per control area before reaching a TSDF.

Not all waste is hazardous; this paper applies to waste that has one or more waste characteristics and/or physical hazards that may result in a fire, flash fire, vapor cloud or condensed phase explosion or that can contribute to increased burning rates and/or flame spread.

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The content, opinions and conclusions contained in this report are solely those of the authors.

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NFPA is a worldwide leader in fire, electrical, building, and life safety. The mission of the international nonprofit organization founded in 1896 is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. NFPA develops more than 300 codes and standards to minimize the possibility and effects of fire and other hazards. All NFPA codes and standards can be viewed at no cost at www.nfpa.org/freeaccess.

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Hazardous Waste
Treatment, Storage, and Disposal Facility
Fire Code Gap Analysis

A Fire Protection Research Foundation Code Fund Project

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EXECUTIVE SUMMARY

There have been numerous losses involving hazardous waste at treatment, storage and disposal facilities (TSDFs) ranging from small to large fires to vapor cloud explosions. Some losses are localized to a drum, its contents and one or more workers to spreading throughout buildings and the plant and, in some cases, prompting community evacuations. The fire problem spans from small storage facilities to larger TSDF processing plants and has involved a cross section of hazardous materials. Numerous TSDFs have had repeat occurrences. TSDFs are unique in many respects. TSDFs may use, handle and store the entire cross section of physical and health hazard materials in widely fluctuating quantities. TSDFs rely on the generator to properly classify the waste; some waste is brokered by a third-party. A hazardous waste may have multiple hazards and TSDFs may have mixed hazardous materials stored together.

This project examined the TSDF fire problem, hazardous waste regulations and the fire codes which apply to these facilities. Numerous gaps were identified: two gaps were National Fire Protection Association (NFPA)-related while nine additional gaps were found to relate more to TSDF stakeholders. The first major gap was recognition and proper implementation of the fire codes by the U.S. Environmental Protection Association (EPA), authorities having jurisdiction (AHJs) and TSDF stakeholders. Prior to the first edition of NFPA 400 Hazardous Materials Code in 2010, it was likely less clear that the NFPA codes and standards covered hazardous waste. NFPA 400 better clarifies that hazardous materials codes includes hazardous waste. Once properly classified, NFPA 1 Fire Code, NFPA 400 and other hazardous materials codes and standards give guidance on the fundamental safeguards for the use, handling and storage of hazardous waste based on the physical hazard class. NFPA 484 Standard for Combustible Metals has a new chapter on recycling and waste management facilities that handle combustible metal scrap and waste. As an industry, TSDFs are likely aware of other TSDF losses and of NFPA codes and standards as industry standards in fire prevention and protection. Where fire codes are locally adopted, the AHJ has to understand the TSDFs have to comply. Proper implementation of the fire code should occur and/or be verified during the permitting process. Where not locally adopted, the AHJs could require compliance with the building and fire codes using their ‘omnibus authority provision’ granted by federal regulations. Implementation of building and fire codes at TSDFs would reduce the risk of most emergency events involving hazardous materials.

A second gap identified was the classification of hazardous waste. Improperly EPA-classified waste and highly hazardous materials were identified as root causes and/or responsible for fatalities and rapid spread of fire of some TSDF losses. The classification of waste by NFPA in light of EPA characteristics and regulations is not clear. Mixtures; the lack or inconsistency of test methods; that dilution is not always the solution; and lack of Material Safety Data Sheet (MSDS)-type chemical hazard information are some of the issues related to classification. Some waste streams may be fairly constant and well-characterized; others can vary or be unique like site clean-up waste after train derailments, tank ruptures, process upsets, spills, etc. The well-characterized have established hazards; their risk increases with quantity and proximity to other hazardous materials, tanks, structures, the neighboring communities, etc. High-hazard chemicals can be defined, identified and listed in a NFPA 400 annex. Identification of unwanted reactions is more challenging. Expert assistance may be required to perform a hazard determination of some waste. If required, a subsequent project could explore a strawman classification for hazardous waste. One recent loss involved pyrotechnic waste. The special case of how best to classify and handle pyrotechnic waste as hazardous waste is addressed.

Other, sometimes inter-related, gaps identified not attributed to the NFPA but to the TSDF owners and operators were chemical hazard awareness including recognizing high hazard chemicals; need to establish a procedure for off-spec or unique waste; emergency response training; and, lack of or not properly performed process safety management and/or hazard and operability studies. Once fire protection strategies are established per the building and fire codes including NFPA 400 and other hazardous materials codes and standards, vigilance would be required to maintain the inventory that can be protected by the fire protection system as designed, if present or per specified separation. Recommendations are made to the hazardous chemicals technical committee including consideration of a chapter similar to NFPA 484 Standard for Combustible Metals Chapter 19 addressing Recycling and Waste Management Facilities and also annex material specific to hazardous waste. NFPA 400 and this report should address and resolve previous and recent U.S. Chemical Safety Board (CSB) recommendations stemming from TSDF losses to develop a standard for TSDFs.
Project Objective

The objective of this project was to examine the TSDF fire problem, the regulatory framework of hazardous waste, identify gaps contributing to the fire problem and make recommendations to address the gaps. This report could be used to support the logic of developing new text in NFPA 400 *Hazardous Materials Code*, in the form of a new chapter or annex material, where clarification is needed or specific guidance is lacking.

Scope

This paper applies to hazardous waste used, handled, and stored at permitted hazardous waste TSDFs; however, recognition and implementation of the fire codes, NFPA 1 *Fire Code* and the International Fire Code (IFC) and documents referenced therein, apply also to waste that is determined to be hazardous where generated, stored, or handled in quantities at or exceeding the maximum allowable quantity (MAQ) per control area before reaching a TSDF.

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Introduction

Following a series of TSDF losses, starting in 2005 at Environmental Quality (EQ) in Romulus, Michigan to a more recent fatality and serious burn injury at Heritage WTI in East Liverpool, Ohio in December 2011, the CSB has recommended the NFPA “develop a fire protection standard for TSDFs addressing fire prevention, detection, control, and suppression requirements.” The applicability of NFPA codes and standards to hazardous wastes and TSDFs was not clear.

In 2013, the NFPA Hazardous Chemicals Technical Committee created a task group to further investigate the TSDF fire problem in the context of the NFPA 400 *Hazardous Materials Code*. The task group identified the need for additional research regarding TSDF incidents in the form of a gap analysis. This code fund project, through the Fire Protection Research Foundation (FPRF), was created to gather information on TSDF losses including causes and contributing factors; to identify trends and challenges unique to TSDFs; to review the fire codes in the context of TSDFs; to identify gaps, both real and perceived, by Chemical Safety Board (CSB) and others; and propose a strategy for implementing code language with the existing MAQ per control area approach to fundamental requirements, fire prevention and fire protection for TSDFs containing a cross section of hazardous materials.

TSDFs have a history of releases, fires and explosions occurring during the use, handling and storage of hazardous waste ranging from oxidizers to flammable liquids and combustible metals and reactive chemicals. A review of literature, CSB reports and EPA reports was performed and show that the TSDF industry has a persistent fire problem and a high probability of potential recurrence causing worker and first responder injuries; worker deaths; community evacuations; significant property damage and environmental impact issues.

In April 2011, five workers at Donaldson Enterprise, Inc. (DEI) were killed when a fire occurred during the process of disassembling fireworks determined to be waste. The fire was accelerated by an accumulation of pyrotechnic material stored in the area where the fire occurred. In their report of the DEI incident, the CSB made similar recommendations to NFPA regarding firework waste as TSDF losses.
TSDF Fire Problem

a. Recent TSDF Losses (2002-2014)

The TSDF fire problem is illustrated with a number of TSDF losses presented below. The losses have occurred at permitted TSDFs in compliance with EPA regulations. Not all losses are reported in media or otherwise; some losses have only basic information. Some loss history information was found in EPA permit applications available on the internet. Large losses, investigated by the CSB, Occupational Safety and Health Administration (OSHA), Department of Environmental Quality (DEQ), and/or EPA, are the best documented.

The case studies illustrate the scope of the problem and challenges with a varied cross section of highly hazardous materials that ignite readily, have high energy release rates, and that spread fire rapidly coupled with some form of non-existent or inadequate fire protection or without redundant safety features.

Safety-Kleen Lithium Battery Fire

A fire and explosion occurred at the permitted Safety-Kleen Corporation in Clarence, New York. A press release\(^1\) explained the fire’s area of origin was the lithium treatment process area. The fire occurred when employees opened a 55-gallon drum of lithium batteries. The fire spread and destroyed the 12,000 square foot building as well other buildings on site. There were no injuries.

Von Roll WTI Drum Explosion

Von Roll WTI was a permitted TSDF in East Liverpool, Ohio. A newspaper reported that on August 11, 2005 a single, 55-gallon drum containing a chemical ‘used in the manufacturing of plastics’ exploded as it was being introduced into the incinerator. The blast caused overpressure damage to the building. Debris struck and injured an employee outside.

Teris LLC Contaminated Sodium Chlorate Waste

A large fire occurred at Teris, LLC in El Dorado, Arkansas on January 2, 2005 resulting in complete loss of a warehouse and prompted the evacuation of approximately 2,500 people from the surrounding community including a detention center. An Arkansas DEQ report provided facts regarding the fire.\(^2\) The report stated a reaction involving contaminated sodium chlorate was the most likely cause. On December 31, 2004, Teris received cubic yard boxes of soil, debris, and sodium chlorate from a sodium chlorate train derailment clean-up operation. The waste was listed as an oxidizer and D001 hazardous waste. When the fire was discovered at 8:05AM, employees in the warehouse tried to extinguish the fire with a two-wheeled fire extinguisher but the fire was too large and grew too quickly compromising the alarm system. The security guard at the main gate called 911 at 8:15AM. Two on-site fire trucks and a stationary water monitor were used to keep the fire from spreading while the warehouse burned. The El Dorado Fire Department provided back up for Teris’ on-site brigade. After the fire, remaining 30-gallon containers and one cubic yard box of the same profile were segregated in a trailer. On January 12, 2005, the trailer burned to the ground in less than 30 minutes. There were no injuries.

Environmental Quality (EQ), Romulus, MI Mixing Incompatibles

EQ Romulus received and blended various organic waste streams for use as fuels for cement kilns. The facility received waste in tanker trucks, vacuum trucks, and containerized in drums. There were a

\(^1\) http://www.sec.gov/Archives/edgar/data/701856/000070185602000039/body8-21.txt
\(^2\) http://www.adeq.state.ar.us/ftproot/pub/webdatabases/Legal/CAO/LIS_Files/06-067.pdf
number of storage tanks and a drum warehouse on site. The facility had received and blended without incident, three waste streams. On August 9, 2005, the three waste streams were introduced into a large, vertical blending tank. A runaway exothermic reaction occurred inside the tank while blending. At 9:15 PM, the tank ruptured and caused a fire which spread to the drum storage and processing areas (Fig. 1). Nine hundred homes were evacuated. The EPA performed air monitoring and provided facts regarding the fire and explosion in a report.\(^3\)

![Figure 1 Photographs during and after the 2005 EQ Romulus fuel blending fire](image)

**Environmental Quality-North Carolina (EQNC), Apex, NC Waste Storage Fire**

EQ had another fire at its facility in Apex, North Carolina. On October 5, 2006, this after-hour fire originated in a partially open metal structure or building used to store and handle various hazardous wastes. The CSB investigated the loss.\(^4\) The fire likely originated in an oxidizer bay where sodium chlorate based oxygen generators were stored with pool chemicals. A cloud and chlorine odor prompted the 911 call. The fire spread from the oxidizer bay to involve stored 55-gallon drums of flammable and combustible liquids and other waste. The fire department took defensive action and focused on community evacuation.

**WRR Environmental Plant Fire**

At or around 5:40 AM on June 22, 2007, employees discovered a small fire at WRR Environmental in Eau Claire, Wisconsin.\(^5\) The employees called the fire department and attempted to extinguish the fire but could not suppress it. The workers fled and the fire spread. The fire department focused on protecting nearby buildings at the plant then decided to pull back at 7:15 AM. Power was cut to the plant rendering a water tank for suppression purposes useless. By 8:00 AM, a number of explosions occurred that ‘shot fire more than 400 feet into the air.’ One-half mile around the plant was evacuated. According to one report, the exact cause of the fire was undetermined; however, it was most likely an electrical or mechanical failure in a utility room. The fuel blending process, numerous buildings, and 15 tanks were involved and destroyed.

**Veolia ES Technical Solutions LLC Ignition of Uncontrolled Released Flammable Vapor**

At 12:07 AM on May 4, 2009, an uncontrolled release of heavier-than-air flammable tetrahydrofuran (THF) vapors from a solvent recovery system ignited. The violent explosion and subsequent fire loss at Veolia ES Technical Solutions LLC, a state-permitted TSDF in West Carrollton,  

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\(^3\) [http://www.epa.gov/Region5/cleanup/eqfire/pdfs/romulus-fire-report20050907c.pdf](http://www.epa.gov/Region5/cleanup/eqfire/pdfs/romulus-fire-report20050907c.pdf)

\(^4\) [http://www.csb.gov/assets/1/19/EQFinalReport.pdf](http://www.csb.gov/assets/1/19/EQFinalReport.pdf)

\(^5\) Dowd, A. (2008, June 21) WRR fire from year ago remembered. Leader-Telegram, The (Eau Claire, WI)
Ohio, was investigated by the CSB.\(^6\) The release occurred after the recovery process and during normal post-process operations including a nitrogen purge. The ignition source, though not positively identified, was likely one of many un-rated electrical devices and/or natural gas fired boilers in a laboratory/operations building only 30 feet from the process area and release location. A fireball engulfed the control room. Four workers were injured; two severely. There were multiple explosions that damaged buildings and tanks on site, to at least 20 residences and five businesses off site. The explosions damaged and rendered a 500,000 gallon water tank for fire suppression useless and caused numerous pool fires that compromised tanks that failed releasing solvents further fueling the fire. According to the CSB investigation, the cause of the vapor release was either a chemical reaction involving active peroxides from accumulated THF residue or ‘a line…was inadvertently mis-manifolded prior to the nitrogen blowback, resulting in the pressurization of a nearby dirty tank containing unprocessed, flammable, or peroxide-containing liquid.’

**WRR Environmental Waste Solvent Tank Fire**

WRR Environmental in Eau Claire, Wisconsin experienced another explosion and fire on June 29, 2010.\(^7\) The fire involved two, 10,000 gallon capacity waste solvent tanks. There were no injuries. The company’s president reported the plant and fire department were better prepared and the damage was limited due to improved metal and masonry construction and a foam and water fire protection system since the 2007 fire. It was reported that “a block wall kept the blaze from spreading to other areas of the plant.”

OSHA still issued 14 willful and one serious citation to the company with proposed penalties of $787,000 for failing to fully develop and implement a process safety management program at the facility.\(^8\) According to the OSHA news release, “…the June 29 explosion and fire was likely caused when an ignition source within a solvent sludge feed tank ignited flammable solvent vapors, blowing the roof off of the tank and igniting its contents. A neighboring tank also exploded. Employees had been working in the area of the solvent sludge feed tank immediately prior to the explosion.”

**Heritage WTI Combustible Metal Explosion**

On December 17, 2011, two employees at Heritage WTI in East Liverpool, Ohio were in the process of manually splitting a 55-gallon drum containing combustible metal fines when the drum contents exploded causing fatal burn injuries to one employee and serious burn injuries to the second employee. The explosion and fire activated the fire protection system in the area. OSHA citations referenced NFPA 484 Standard for Combustible Metals.

**ERG Environmental Services Warehouse Fire**

A fire broke out at ERG Environmental Services’ 45,000 square foot warehouse in Livonia, Michigan on January 15, 2014. According to the Livonia Fire Department National Fire Incident Reporting System (NFIRS) report, the fire was reported at 7:24AM; first responding firefighters arrived at 7:29AM. The fire was under control at 9:11AM; however, there were reports of product exploding as crews were hitting hot spots. The area of origin was the shipping/receiving area, loading area, dock, or bay. Fire suppression factors listed flammable and combustible liquid hazard, roof collapse, and significant/ unusual fuel load from contents. There were no sprinklers operating. There were no injuries or deaths. The building was a complete loss (Fig. 2).

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\(^6\) [http://www.csb.gov/assets/1/19/Veolia_Case_Study.pdf](http://www.csb.gov/assets/1/19/Veolia_Case_Study.pdf)
\(^7\) [http://www.weau.com/home/headlines/97447439.html](http://www.weau.com/home/headlines/97447439.html)
\(^8\) [http://www.dol.gov/opa/media/press/osha/OSHA20101737.htm](http://www.dol.gov/opa/media/press/osha/OSHA20101737.htm)
Safety Kleen Solvent Storage Fire

On January 30, 2014, a fire originated in a used solvent and oil storage building at Safety-Kleen in Erie, Pennsylvania (Fig. 3).9 One worker was badly burned. The storage building was described as a shed containing 55-gallon drums of solvent. The newspaper reported OSHA’s investigation revealed an employee was in the storage building warming a frozen pipe with a heater prior to the fire. The burning storage shed was adjacent to above ground storage tanks of oil.

The following trends were identified from the TSDF case studies:

1) EPA permitted facilities had multiple or recurring fire and explosion incidents
2) Releases, fires, and explosions occurred at both large, national TSDFs as well as smaller, more local operations
3) Incidents have occurred during storage, handling, and treatment of solid and liquid waste
4) Damage ranged from localized and limited to the drum or process involved, up to catastrophic resulting in substantial destruction to the plant and community evacuations
5) Fire and explosions involving hazardous waste have caused serious injury and death to workers
6) Improved fire protection has reduced the severity of a solvent tank fire
7) The classification of materials involved in the initiating event have included oxidizers, flammable liquids, combustible metals, and incompatible mixtures

b) US EPA Report on Emergency Incidents at Hazardous Waste Combustion Facilities and TSDFs

In 1999, the EPA published a report on emergency incidents from 1977 to 1998 at hazardous waste combustion facilities and other TSDFs, by region, from coast to coast. The report’s incident data were entered into a spreadsheet for use to identify trends and illustrate the type, range, and scale of incidents, specific equipment involved, and specific processes involved. Data entered into the spreadsheet from the description of the losses included the date, facility city and state, where the incident occurred, the act performed when the incident occurred (e.g., handling, open use, closed use, or storage); the chemical(s) involved, if identified; whether the reported event was a fire, explosion, and/or release; the number of resulting deaths and injuries; whether the facility was Resource Conservation Recovery Act (RCRA) permitted or not; and causes and contributing factors leading to the incident. There was a range in the level of detail regarding the various incidents.

A total of 108 incidents were reported that included releases of acid gases, vapors, liquid, and solid hazardous materials; fires; flash fires and explosions. Of the data provided, there were 28 (26%) explosions; 40 (37%) fires; 37 (34%) releases; and 3 (3%) other. The majority of incidents occurred during handling (45 incidents or 41%), followed by storage (30 incidents or 28%), and use (14 incidents or 13%). The incidents resulted in at least 17 deaths and 179 injuries. In some cases, the cause was identified. In thirty-six (36) cases, equipment failure contributed to the incidents. In 28 cases, the waste was not identified or not properly identified. Other causes included: construction failure, electrical outage, disgruntled employee, mixing incompatibles, and operator error. The damages ranged from minor, requiring clean-up, to complete destruction of the facility.

Causes and chemicals or materials involved in the various emergency incidents are summarized in Tables 1 through 4. Tables 1 and 2 list the causes of the fires/explosions and releases, respectively. Tables 3 and 4 list the chemical(s) or materials identified as involved in fires and explosions, respectively. The chemicals included oxidizer solids, flammable solids, flammable solvents, explosive precursors, and reactive chemicals. Seventeen (17) events were attributed to improper identification of chemicals and lack of chemical hazard awareness.

<table>
<thead>
<tr>
<th>Table 1 Causes Identified in TSDF Fires and Explosions (Number of Incidents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment failure (13)</td>
</tr>
<tr>
<td>Incorrect combination of chemicals (7)</td>
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<tr>
<td>Operator error (5)</td>
</tr>
<tr>
<td>Processing failure (5)</td>
</tr>
<tr>
<td>Incorrect identification of chemical (4)</td>
</tr>
<tr>
<td>Mixed incompatible reactive and/or ignitable waste (3)</td>
</tr>
<tr>
<td>Incorrect identification of chemical properties (3)</td>
</tr>
<tr>
<td>Welding sparks ignited vapors (3)</td>
</tr>
<tr>
<td>Electrical outage</td>
</tr>
<tr>
<td>Pressure transient</td>
</tr>
<tr>
<td>Welding on out-of-service tank</td>
</tr>
<tr>
<td>Faulty equipment</td>
</tr>
</tbody>
</table>

Table 2: Causes Identified in TSDF Emergency Incidents Resulting in Releases (Number of Incidents)

- Equipment failure (15)
- Lack of control of vapor emission (2)
- Spill from bulk container (2)
- Cooling water system rupture
- Failure to attach screw auger
- Incorrect storage
- Poor maintenance of tank trucks
- Aluminum waste not identified on manifest
- Fugitive emissions from process
- Rail car transfer
- Disgruntled employee(s)
- Improper release of contaminated water
- Incorrect identification of chemical
- Incorrect identification of chemical properties
- Improper identification of chemical combinations
- Inadequate system

Table 3: Chemicals Resulting in Fires at TSDFs (1977-1998)

<table>
<thead>
<tr>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unburned propane</td>
</tr>
<tr>
<td>Acid residue</td>
</tr>
<tr>
<td>Molybdenum paste mixed with wood flour</td>
</tr>
<tr>
<td>Lithium manganese batteries</td>
</tr>
<tr>
<td>Alkaline batteries</td>
</tr>
<tr>
<td>Oil, grease, caustic manure with aluminum turnings</td>
</tr>
<tr>
<td>Oil dry, epichlorohydrin</td>
</tr>
<tr>
<td>Landfill</td>
</tr>
<tr>
<td>Reagent sulfur, waste</td>
</tr>
<tr>
<td>D004/D018 Hazardous waste-Portland cement mixture</td>
</tr>
<tr>
<td>Nitrocellulose</td>
</tr>
<tr>
<td>Non-RCRA aerosol containers</td>
</tr>
<tr>
<td>Elemental phosphorous, combustible packaging</td>
</tr>
<tr>
<td>Natural gas</td>
</tr>
<tr>
<td>Hot gases</td>
</tr>
<tr>
<td>Corrective sulfonation acid sludge, sulfuric acid mixture</td>
</tr>
<tr>
<td>Wood debris, heat-generating waste streams</td>
</tr>
<tr>
<td>Farm waste oil</td>
</tr>
<tr>
<td>Combustible gases, air</td>
</tr>
<tr>
<td>Dirt, debris and oxidizer mixture</td>
</tr>
<tr>
<td>Bromine, chlorine, air</td>
</tr>
</tbody>
</table>
Table 4 Chemicals Resulting in Explosions Incidents at TSDF (1977-1998)

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Process-Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Nitroglycerine, 90% lactose</td>
<td>Molten slag, ash</td>
</tr>
<tr>
<td>Nitrocellulose</td>
<td>Hot slag, ash quench water</td>
</tr>
<tr>
<td>Acetone</td>
<td>Molten metal, ash quench</td>
</tr>
<tr>
<td>NitrobidI</td>
<td>Natural gas (3 incidents)</td>
</tr>
<tr>
<td>Tetrazole</td>
<td></td>
</tr>
<tr>
<td>Acid sludge, water based coating, paper</td>
<td></td>
</tr>
<tr>
<td>Spent oxygen breathing apparatus</td>
<td>Ammonium nitrate in ammunition</td>
</tr>
<tr>
<td>PCB-Contaminated paint waste</td>
<td>Detonator components</td>
</tr>
<tr>
<td>Solvent (not specified)</td>
<td>Live rounds of ammunition</td>
</tr>
<tr>
<td>Sodium azide</td>
<td></td>
</tr>
</tbody>
</table>

Chemicals resulting in explosions, fires, and releases represent the cross-section of NFPA 400 hazardous materials categories (e.g., corrosive, flammable solid, organic peroxide, oxidizer solids and liquids, etc.) as well as other NFPA code specific hazardous materials including flammable and combustible liquids (NFPA 30), combustible metals (NFPA 484), and explosives (NFPA 495).

The EPA’s report did not include nor mention the applicable building and fire codes, hazardous materials codes and standards, code compliance or code violations. There was no analysis of the incidents to determine if compliance with the fire codes would have prevented their occurrence or reduced the magnitude of destruction.

c) Chemical Safety Board (CSB) Survey

Over the years, the CSB has investigated and reported on a number of large, toxic releases, fires, and explosions at TSDFs. During the EQ Apex, NC fire investigation, the CSB’s report described a survey or review of other TSDF incidents from 2002-2007. The spreadsheet was reviewed. The spreadsheet data included the date, site, type of incident, report source(s), number of fatalities, number of injured, number of medical evaluation, evacuations, contingency plan violations, and other violations. The spreadsheet listed 23 incidents: 8 hazardous materials releases only; 12 explosions with and without fire; and 3 fire only. The incidents resulted in 2 fatalities (same event), and injuries to 26 employees and six first responders. Released chemicals included hydrogen sulfide, chlorine, nitrogen dioxide, sulfuric acid, and nitric acid. The CSB’s survey, like the EPA report and the losses described above, also highlighted repeat occurrences at TSDFs. For example, Von Roll WTI had explosions in 2005, 2006, and 2007; at least two employees were injured. Heritage Environmental Services, Environmental Quality, Environmental Enterprises, Inc., and Clean Harbors each had two events. The CSB’s review included the presence or absence of fire protection and found a ‘range in fire protection’ from active suppression systems, fire barriers and portable fire extinguishers. There were no details as to the type and/or quantity of hazardous materials being protected.

d) DOT PHMSA Hazardous Materials Statistics

In order to better understand potential root causes of and chemicals involved in accidents, the 2014 Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA)
hazardous materials data and statistics were reviewed. As of August 16, 2014, there were 7,797 hazardous materials incidents: 47% occurred during unloading; 23% during loading; 26% in transit; and 4% in transit storage. Of the reported incidents, the vast majority were spills. There were 30 fires and 5 explosions. The top five known causes for all incidents were: 1) loose closure, component, or device; 2) human error; 3) dropped; 4) forklift accident; and 5) improper preparation for transportation.

By hazard class, a majority of the incidents involved flammable and combustible liquids (Division 3; 4,409 incidents), followed by corrosive material (Division 8; 1,923 incidents), miscellaneous hazardous material (Division 9; 371 incidents), oxidizer (Division 5.1; 346 incidents), and flammable gas (Division 2.1; 238 incidents).

e) Other Literature

Cozzani et al identified that the process operations during which ‘unwanted reaction’ accidents took place were predominately fluid/solid handling/transfer followed by storage, ‘unknown’, chemical reaction, transport, and mixing. Certain handling and processes can and have resulted in ignition sources; some process equipment were not adequately sized. Cozzani identified ‘unwanted reaction’ accidents usually involved ‘substances of quite simple structure and of low molecular weight’. A table of substances involved in 300 unwanted reactions were mostly corrosives and toxics but listed seven oxidizers, seven flammable, and two metals (aluminum and zinc). Three oxidizers (nitric acid, sodium hypochlorite and calcium hypochlorite) made the top five most unwanted reaction involved substances; the other two were hydrochloric acid and sulfuric acid.

Other literature calls attention to losses involving the handling of hazardous waste where there is inadvertent heating. In other cases, operations resulting in ignition; examples include hot work, equipment failure, and process upsets. Clearly, hazardous waste is subject to mischaracterization and to other un-realized hazards such as incompatibility and reactivity.

TSDF Regulatory Framework

In general, the EPA regulates how to identify waste based on hazard characteristics and how to handle it; the DOT regulates how to ship it as a hazardous material; OSHA regulations protect employees who have to handle waste; and the fire codes provide guidance required to protect hazardous waste that may result in or spread fire, or explode. Hazardous wastes are subject to numerous regulations and are not exempted from the adopted fire prevention code in jurisdictions that use either NFPA or the International Fire Code (IFC) as the model fire prevention codes.

Hazardous waste TSDFs are regulated by the US EPA under the 1976 Resource Conservation and Recovery Act (RCRA) and by state regulations typically via departments of environmental quality. “The Resource Conservation and Recovery Act (RCRA), an amendment to the Solid Waste Disposal Act of 1965, was enacted as law in 1976 to address a problem of enormous magnitude - how to safely manage and dispose of the huge volumes of municipal and industrial waste generated nationwide.” RCRA covers

nonhazardous solid waste (subtitle D), underground storage tanks (subtitle I), and hazardous waste (subtitle C). The RCRA subtitle C is a federal program to manage hazardous waste with regulations and requirements for generators, transportation, and TSD facilities.\(^\text{17}\) TSDFs are subject to technical standards regarding their design and safe operation with the goal to minimize releases. Periodic permits are used as a method to comply.

Within the hazardous waste industry, TSDF’s receive and accept or reject waste; handle the waste based on what it is and how it is received (e.g., drums, trucks and tankers); and determine how to recover, re-use, or dispose of the material. Each facility will have some on-site storage of various hazardous materials waste streams and the concentration and inventory may change over time and for up to one year in residence.

All owners or operators of TSDFs are required to meet general facility standards as well as specific standards for the type of treatment or disposal methods used.\(^\text{18}\) The general standards (Title 40 Code of Federal Regulations Part 264, Subpart A) include:

- Obtaining a permit (40 CFR 270);
- Developing and implementing a waste analysis plan (WAP) to ensure that the waste is treated, stored or disposed of in a manner that will not pose a threat to human health and the environment;
- Install security measures to prevent the unknowing entry of people or animals;
- Develop and follow a written inspection schedule to assess the status of the facility and detect potential problem areas;
- Conduct training of employees to reduce the potential for mistakes that could threaten human health and the environment;
- Properly manage ignitable, reactive or incompatible wastes;
- Comply with local standards;
- Develop emergency preparedness plans;
- Return the manifest to the generator with a certification of destruction or disposal and maintain records on releases, ground water monitoring, and closure;
- Develop a ground water monitoring system if the method uses surface impoundments, landfills, or land treatment facilities; and
- Develop closure and post-closure plans and financial assurances.

Typically, individual states may have more stringent requirements than the federal rules and may have state-specific waste codes. The federal and state regulations do not specify how to implement fire protection for the foreseeable cross section of hazardous wastes at TSDFs.

**Hazardous Waste Identification and Treatment Processes**

There are large TSDFs with locations in multiple states and there are smaller permitted facilities operating in the local community. Some TSDFs specialize in one or more treatment processes (e.g., solvent recovery), while others may offer a range of treatment services. Many TSDFs offer environmental services such as site remediation, hazardous materials spill response, and chemical transportation. There are reports of off-site TSDF service-related incidents. For example, a TSDF providing remediation or recovery of asphalt binder released from a storage tank into a containment area caused a fire during remediation. The

\(^\text{17}\) http://www.epa.gov/osw/hazard/tsd/fac_reqs.htm

fire spread rapidly over the combustible liquid and caused an oil heater to explode due to a boiling liquid expanding vapor explosion (BLEVE).19

Two logic flow diagrams were created to illustrate the number of potential steps in the handling, storage and use, treatment or processing of waste, determined to be hazardous, each of which is susceptible to causing spills, fires and/or explosions. The first logic flow diagram shows the generation, characterization, and acceptance of waste by a TSDF (Fig. 4). The second flow diagram shows the various actions by a TSDF in identifying and processing the accepted waste stream to final disposal (Fig. 5). The diagrams show, overall, the number of opportunities for initiating events in the hazardous waste treatment process.

![Flow chart Key](image)

**Figure 4. Logic flow diagram from generator to TSDF**

Figure 5 Flow diagram of waste once received at TSDF.
a.) Waste Identification

The US EPA defines **hazardous waste** as *waste that is dangerous or potentially harmful to our health or the environment*. Per RCRA, wastes are identified as hazardous if listed (40 CFR 261.30) or determined to have one or more characteristics defined in 40CFR261 Subpart C: ignitability (D001), corrosivity (D002), reactivity (D003), and/or toxicity (D004-D043) per the following definitions:

- **Ignitability**
  
  (40 CFR §261.21)
  
  Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 °C (140 °F).\(^{20}\)

- **Reactivity**
  
  (40 CFR §261.23)
  
  Reactive wastes are unstable under "normal" conditions. They can cause explosions, undergo violent reactions, generate toxic fumes, gases, or vapors or explosive mixtures when heated, compressed, or mixed with water.

- **Corrosivity**
  
  (40 CFR §261.22)
  
  Corrosive wastes are acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) and/or are capable of corroding metal containers, such as storage tanks, drums, and barrels.

- **Toxicity**
  
  (40 CFR §261.24)
  
  Toxic wastes are harmful or fatal when ingested or absorbed (e.g., containing mercury, lead, etc.). When toxic wastes are land disposed, contaminated liquid may leach from the waste and pollute ground water.

The hazards of ignitable wastes and reactive wastes are obvious. Corrosion can result in releases; some corrosion reactions can evolve hydrogen gas. Waste is identified by testing to include the pH, flash point of liquids, burning rate of solids, and subjective assessment of reactivity or the generator’s knowledge of the waste. There are numerous books and peer-reviewed papers with methods to identify hazardous wastes.\(^{21,22}\) For instance and attached as Appendix 1 is the EPA’s 2009 *Hazardous Waste Characteristics- A User-Friendly Reference Document* with definitions and links to various rulings that address specific waste streams that will be useful background information to readers of this report.\(^{23}\)

Next, 40 CFR 264 contains requirements for owners and operators of hazardous waste TSDFs. Identification is the first step. Per 264. 13 (a)(1) the chemical and physical analysis of waste ‘must contain all information which must be known to treat, store, or dispose of the waste’ using standard analytical methods and/or published data. The regulations further state ‘if the generator does not supply the information and the owner or operator chooses to accept the hazardous waste, the owner or operator is responsible for obtaining the information required to comply’. The waste analysis plan does not take fire protection into consideration nor reference applicable fire codes or hazardous materials codes and standards referenced therein. A waste analysis plan per 40CFR 264.13 includes pre-acceptance analysis, analytical verification of accepted wastes, and periodic re-analysis/re-evaluation of waste streams. Methods for characterizing waste streams include various American Society of Testing and Materials (ASTM) standard test methods and EPA SW 846.\(^{24}\)

A waste profile sheet (WPS) or waste identification profile (WIP) is required prior to shipment of any new waste and prior to shipment whenever there is a change in the approved waste stream. A TSDF requires the

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\(^{20}\) Note, building and fire codes classify flammable liquids as having flash points less than 100°F.


generator to re-certify the process generating the waste or that the waste has not changed. The signed WPS is considered a certified document of the waste composition, how the generator determined the RCRA regulated waste, and what regulatory requirements apply. An internal review of the completed WPS is performed to assess whether the waste is logically described and classified by RCRA and DOT and if the waste is permitted to be received. Once accepted, the generator of the hazardous waste is required to: 1) maintain the accuracy of the waste profile sheets; 2) identify a change and request evaluation and re-approval; 3) provide analytical data including MSDS. Bar codes are typically used to track accepted waste.

There is no mention of fire codes, fire protection or prevention in the regulations under general waste analysis, waste analysis plans and waste profile sheets in the federal or state regulations.

a.) Waste Storage, Use, Handling and Treatment Processes

The flow diagrams in Figures 4 and 5 show hazardous waste is subject to storage, handling and use, processing or treatment. Waste treatment processes may be divided into physical, chemical, biological, and/or thermal. The NFPA’s Fire Protection Handbook, Section 11, Chapter 1, addresses Waste Handling and Control with a detailed description of hazardous waste management systems, treatment and disposal systems, and ultimate disposal. The various waste treatment processes offered by TSDF are:

- Recycle/reclamation for re-use or resale
- Solvent recovery
- Fuel blending
- Waste consolidation/separation
- Waste material transfer to an off-site EPA approved TSD for treatment or disposal
- Combustion
- Incineration
- Neutralization
- Shredding to reduce size
- Compaction
- Deactivation or treatment of waste to eliminate characteristic
- Stabilization
- Encapsulation
- Solidification
- Chemical Oxidation
- Thermal Desorption
- Beneficial Re-use
- Waste Water Treatment
- Pre-blending

Some of these processes were identified in the losses or case studies described above including solvent recovery, fuel blending, waste separation, combustion, incineration, and chemical oxidation and therefore require some passive and/or active fire protection. Clearly, the various processes themselves may have inherent hazards not related to waste. For example, incinerator explosions have occurred from released natural gas used as fuel; hot gases have escaped from the incineration chamber; and steam explosions have occurred when hot slag contacts water.


NFPA 86 *Standard for Ovens and Furnaces* and NFPA 801 *Standard for Fire Protection for Facilities Handling Radioactive Materials*. There is no clear description of how to apply these standards to TSDFs.

In addition to a variety and complexity of methods to process hazardous waste, TSDFs also have containerized and bulk warehouse storage of these materials (Fig. 6). Waste may be received in bulk-form including trucks, vacuum trucks, semi-trailers, rail cars, cubic meter corrugated board boxes, intermediate bulk containers or totes, and supersacks. Other forms of packaging include metal and poly drums of various sizes, lab packs and pails. Most likely, TSDFs storage will contain a variety of hazardous materials; some or all exceeding the MAQ per control area thereby requiring additional safeguards. For example, a warehouse may contain Class1, Class 2 and Class 3 oxidizers as well as flammable and combustible liquids which would require separation in most instances as well as other safeguards. Water reactives may be stored in facilities with water based suppression systems. The inventory of waste at most TSDFs will likely vary and, potentially, any one hazardous material could exceed the MAQ limits per control area; more than likely, multiple Group H (hazardous) occupancy classifications are warranted triggering occupancy separations between these occupancies as well as numerous other safeguards A process upset or equipment failure could foreseeably result in increased storage. A single event, like a train derailment and clean-up, could result in the increase in a single stored hazardous material. A fire protection specialist is likely required to address multiple hazardous materials processes and storage conditions.

![Figure 6. Image of rack storage of wastes (Veolia ES Website)](image)

**CSB Recommendations Regarding TSDF Fires and Explosions**

Following a series of losses, the CSB issued recommendations to address the TSDF fire problem. The CSB directed one recommendation to the EPA regarding deficiencies in the preparedness and prevention requirements for RCRA TSDFs; and two to the Environmental Technology Council (ETC)\(^\text{27}\) regarding a fire protection standard and guidance for handling and storage of hazardous wastes to reduce likelihood of releases and fires at TSDFs.

The US EPA responded to the CSB recommendation regarding the communication gap between TSDFs and local authorities in a March 5, 2010 letter with guidance to Region 1-10 RCRA Directors\(^\text{28}\). The letter cited existing detailed guidance in 40 CFR 264 and 265 as part of the preparedness and prevention and contingency plan. The US EPA specified the information on the type, quantity and location of hazardous chemicals be communicated as an electronic/written document for faster retrieval and updated by the TSDF whenever there were significant changes in processes, type and quantity of hazardous material treated. The

\(^\text{27}\) The ETC is largely a members-only website; there is no information on fire protection or NFPA.

\(^\text{28}\) [http://www.epa.gov/osw/hazard/tsd/permit/reports/prepare.pdf](http://www.epa.gov/osw/hazard/tsd/permit/reports/prepare.pdf)
letter further highlighted the RCRA omnibus authority (40 CFR 270.32(b)(2)) that can require more measures such as monitoring if not attended 24-hour, contract with security, and what information TSDFs must share, how the information is to be conveyed and when updates were required for local emergency authorities. The preparedness and prevention and contingency plan are analogous to the NFPA 400 Hazardous Materials Management Plan and Hazardous Materials Inventory Statement requirements.

The recommendation to the ETC was for the ETC to petition the NFPA to develop a fire protection standard specific to hazardous waste TSDF to include fire prevention, detection, control and suppression requirements. Following the Veolia vapor cloud explosion, the CSB again recommended the industry improve safety standards and the NFPA to develop a standard for hazardous waste TSDFs to include hazard identification, chemical fire and release protection and prevention, facility and systems design, employee training and procedures, inspection and maintenance as the following section will show. NFPA 1 Fire Code, NFPA 5000 Building Construction and Safety Code, NFPA 400 Hazardous Materials Code’s Chapter 6, the individual hazardous materials chapters and annex material meet this recommendation and already provide guidance on chemical data; facility and systems design; fire and release protection and prevention, employee training and procedures, inspection and maintenance. Some of the CSB requested safety standards are TSDF specific.

**TSDF Fire Problem Gaps Identified**

TSDFs have a fire problem which can be linked to gaps in the application of and/or adherence to fire codes. Two gaps identified were NFPA-related. Additional gaps were identified but ascribed to TSDF owners and operators. The first gap identified was recognition and implementation of the fire codes to TSDFs; the second gap was related to classification of waste and identification of hazards. Before NFPA 400, it was likely less clear the fire codes applied to hazardous waste and to TSDFs. AHJs, enforcers and others less familiar with the fire codes probably thought waste was regulated only by the EPA, and not NFPA. Further, the EPA does not specifically call out NFPA or IFC. The first gap can be addressed with text in NFPA 400 where clarification is required and possible annex material for AHJs. Annex material listing highly hazardous chemicals and addressing waste hazard identification could in part address the second gap. Additional research may be required to develop a harmonized strawman classification system for waste.

**GAP #1: RECOGNITION AND IMPLEMENTATION OF FIRE CODES TO TSDFs**

The first gap is recognition and implementation of the fire codes at TSDFs. The CSB did not recognize the NFPA hazardous materials codes included waste. *Waste* was defined and identified in reference to *hazardous materials* in the first edition of NFPA 400 Hazardous Materials Code in 2010. The IFC also includes waste in the definition of hazardous material. Applicable NFPA and IFC code language regarding waste are reviewed below. NFPA 1 Fire Code and NFPA 400 Hazardous Materials Code are the principal applicable codes and pointer documents to other NFPA standards. For example, some waste is or contains combustible metals, explosives and flammable and combustible liquids; therefore, NFPA 484 Standard for Combustible Metals, NFPA 495 Explosives Code and NFPA 30 Flammable and Combustible Liquid Code, respectively, and possibly other codes are applicable.

*Waste* is defined in NFPA 400 (3.3.91) as

hazardous materials that have been determined by the user to be beyond their useful life and that are awaiting disposal or processing by either public or private means.

Waste is also included in the definition of *hazardous material* in NPFA 400 and IFC:
Hazardous material (NFPA 400 3.3.61.4; IFC) ‘a chemical or substance that is classified as a physical hazard material or a health hazard material, whether the chemical or substance is in usable or waste condition’.

Health and physical hazard materials are defined as:

3.3.61.3.1 Health Hazard Material. A chemical or substance classified as a toxic, highly toxic, or corrosive material in accordance with definitions set forth in this code.

3.3.61.3.2 Physical Hazard Material. A chemical or substance classified as a combustible liquid, explosive, flammable cryogen, flammable gas, flammable liquid, flammable solid, organic peroxide, oxidizer, oxidizing cryogen, pyrophoric, unstable (reactive), or water-reactive material.

The IFC uses the same definitions.

There are clearly more physical hazards than health hazards and the physical hazards materials can cause, provide fuel for fire and explosions, and promote the spread of fire. Health hazard materials, like corrosives, may result in a release of ignitable or reactive materials. The sludge and products of combustion from a fire involving physical hazard materials may be health hazard materials.

The NFPA 400 definition for ‘storage’ also includes foreseeable storage of hazardous wastes at TSDFs:

3.3.81* Storage (Hazardous Material). Hazardous material in the act of being stored as a supply reserved for future use or disposal including, but not limited to, any of the following: (1) hazardous material packaged in individual containers, without active connections, that can be handled, stacked, arranged or transported on site; (2) unconnected mobile equipment or over-the-road transport vehicles containing hazardous materials awaiting transportation; (3) mobile equipment including over-the-road transport vehicles containing hazardous materials when connected and serving as a source of supply; (4) stationary tanks containing hazardous materials, including tanks connected and serving as a source of supply.

TSDFs that accept waste that have or contain a physical and/or health hazard material(s) therefore fall under the scope and applicability of NFPA 400:

1.1.1* Applicability. This code shall apply to the storage, use, and handling of the following hazardous materials in all occupancies and facilities:

(1) Ammonium nitrate solids and liquids
(2) Corrosive solids and liquids
(3) Flammable solids
(4) Organic peroxide formulations
(5) Oxidizer — solids and liquids
(6) Pyrophoric solids and liquids
(7) Toxic and highly toxic solids and liquids
(8) Unstable (reactive) solids and liquids
(9) Water-reactive solids and liquids
(10)* Compressed gases and cryogenic fluids as included within the context of NFPA 55, Compressed Gases and Cryogenic Fluids Code

NFPA 400 expanded the scope of the previous hazardous materials standards for storage (e.g., NFPA 430 Standard for the Storage of Solid and Liquid Oxidizers) to include use and handling. The IFC’s Chapter 50 on Hazardous Materials also apply to TSDFs as well as the applicable Chapters 51 – 67 depending on the range of hazardous materials at each TSDF. Chapter 1 of the IFC describes how the operational permits
should be issued for these facilities which would include annual inspections by the AHJ for continued compliance.

NFPA 400 does not include all hazardous materials and therefore is a pointer document to NFPA 484 Standard for Combustible Metals if the waste was or contained a combustible metal; to NFPA 30 Flammable and Combustible Liquids Code if a flammable or combustible liquid; and NFPA 495 if it contains or is an explosive. The latest edition of NFPA 484 includes Chapter 19 for Recycling and Waste Management Facilities, attached here as Appendix 2. NFPA 484 does not define ‘waste’ or ‘scrap’ but recognizes metals and metal containing mixtures may be recycled or submitted for ultimate disposal. NFPA 30 does not define waste. NFPA 30’s definition of hazardous material is ‘a material presenting dangers beyond the fire problems relating to flash point and boiling point’. Fire and explosion prevention and risk control outlined in NFPA 30’s Chapter 6 is applicable to flammable and combustible solvents recovered or blended for fuel. The definition of waste could be extracted from NFPA 400 into NFPA 484 and NFPA 30. An annex note could be proposed during the next revision cycle of NFPA 30 identifying the TSDF fire problem especially with respect to solvent recovery scenarios and storage.

The EQ Apex, North Carolina fire occurred in 2008 before NFPA 400. Had EQ applied applicable building and fire codes, specifically NFPA 5000, NFPA 430 (2004) Code for the Storage of Liquid and Solid Oxidizers Chapters 4 and 7 and NFPA 30 (2008) Flammable and Combustible Liquids Code Chapters 1, 6 and 7, to the waste storage building, the fire would most likely have been prevented or the spread of fire limited so as not to involve all of the stored chemicals. The oxidizer waste would have been separated from the flammable and combustible liquid by space and/or fire-rated barriers where only curb height containments were used to separate them. The building would most likely have had an approved fire protection system and/or supervised alarms and detection devices. Emergency response planning, HMMP and HMIS would have provided the local emergency responders with an understanding of the types, quantities and location of chemicals stored. The Class 3 solid sodium chlorate in oxygen generators, which promotes the spread of fire from intense burning, is one of the chemicals causing or contributing to multiple large losses; EQ should have isolated the oxygen generators. The EQ Apex, NC fire illustrated the unpredictability of some chemicals (e.g., the exact cause was undetermined), what happens when there are high hazard chemicals present and the likely predictable outcome where there are no active or passive protection systems in place especially after hours.

It is worth noting that the North Carolina’s Governors Hazardous Materials Task Force report to the governor’s office as part of an investigation of the EQ facility fire, recommended reviewing the fire codes to ‘clarify NC Fire Code provisions concerning hazardous waste, hazardous chemicals and hazardous materials.’ A separate Fire Code Recommendation for consideration by the Governors Hazardous Materials Task Force stated develop a committee to review the current fire codes governing TSDFs…to determine if they ‘adequately address the needs and safety of nearby communities’. Confusion in the fire code was identified with respect to the fire marshals ability to properly identify mixed wastes and to apply the control area concept with various hazard chemicals present. In other words, the local fire marshal AHJ may not have the skill set or experience to deal with the complex cross section of hazardous materials at TSDFs. Environmental auditors, Departments of Natural Resource (DNR), EPA-personnel and insurance carriers are more TSDF sophisticated AHJs.

GAP #2: CLASSIFICATION OF WASTE

EPA waste characteristics are clearly broader in comparison to the physical and health hazard classifications used by the model fire prevention codes. Table 5 compares the EPA hazardous waste characteristics with NFPA hazardous materials categories and the applicable NFPA 400 chapters or other codes. Multiple
hazardous materials categories have the characteristic of ignitability, for example, flammable solids, flammable liquids, organic peroxides, oxidizer solids and liquids; and combustible metals.

<table>
<thead>
<tr>
<th>EPA Hazardous Waste Characteristic</th>
<th>NFPA Hazardous Materials Categories</th>
<th>NFPA 400 Chapter or other NFPA Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignitability (D001)</td>
<td>Flammable solid</td>
<td>Chp 1-6, 13</td>
</tr>
<tr>
<td></td>
<td>Flammable liquid</td>
<td>NFPA 30 Chp 1, 6</td>
</tr>
<tr>
<td></td>
<td>Combustible liquid</td>
<td>NFPA 30 Chp 1,6</td>
</tr>
<tr>
<td></td>
<td>Oxidizer</td>
<td>Chp 1-6, 15, Annex G</td>
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<tr>
<td></td>
<td>Oxidizing cryogen</td>
<td>Chp 1-6, 21, Annex H</td>
</tr>
<tr>
<td></td>
<td>Organic peroxide</td>
<td>Chp 1-6, 14, Annex F</td>
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<tr>
<td></td>
<td>Pyrophoric</td>
<td>Chp 1-6, 17</td>
</tr>
<tr>
<td></td>
<td>Flammable gas</td>
<td>NFPA 30B</td>
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<td></td>
<td>Combustible Metals</td>
<td>NFPA 484</td>
</tr>
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<td>Reactivity (D003)</td>
<td>Water reactive</td>
<td>Chp 1-6, 20</td>
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<td></td>
<td>Unstable reactive</td>
<td>Chp 1-6, 19</td>
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<td></td>
<td>Explosives</td>
<td>NFPA 495</td>
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<td>Corrosivity (D002)</td>
<td>Health hazard</td>
<td>Chp 1-6, 12</td>
</tr>
<tr>
<td>Toxicity (D004-43)</td>
<td>Health hazard</td>
<td>Chp 1-6, 18</td>
</tr>
</tbody>
</table>

Some hazardous waste and waste mixtures may have multiple characteristics. From NFPA 400,

1.1.1.2 Multiple Hazards. Hazardous materials that are classified in more than one hazard category shall conform to the code requirements for each hazard category.

How would a user classify a mixture? Take pyrotechnic waste for example. Pyrotechnic waste may exhibit the EPA ignitability hazard category while it may be classed as an oxidizer solid, a combustible metal, oxidizer-combustible metal mixture or explosive waste.

The same list of hazardous material categories in NFPA 400 1.1.1., less the flammable and combustible liquids, combustible metals and explosives, are repeated in NFPA 400’s Chapter 4 Classification of Materials, Wastes, and Hazard of Contents:

4.1* Hazardous Material Classification. Materials shall be classified into one or more of the following categories of hazardous materials, based on the definitions found in Chapter 3:

(1) Corrosive solids, liquids, or gases
(2) Flammable solids
(3) Flammable gases
(4) Flammable cryogenic fluids
(5) Inert cryogenic fluids
(6) Inert gases
(7) Organic peroxide formulations
(8) Oxidizer solids or liquids
(9) Oxidizing gases
(10) Oxidizing cryogenic fluids
(11) Pyrophoric solids, liquids, or gases
(12) Toxic or highly toxic solids, liquids, or gases
(13) Unstable (reactive) solids, liquids, or gases
(14) Water-reactive solids or liquids
NFPA 400 explains in A.4.1:

the categorization and classification of hazardous materials enables the code user to determine the applicability of requirements based on hazard category and class related to the physical and health hazards of materials. The current definitions found in Chapter 3 have been developed using a compilation of criteria found in NFPA codes and standards, requirements of the U.S. Department of Transportation, and in some cases definitions established by OSHA in 29 CFR.

There is no mention of EPA definitions or waste characteristics in A.4.1. In NFPA 400, Chapter 2 Referenced Documents, the Resource, Conservation and Recovery Act (RCRA) is listed. 40 CFR Parts 260-299 for waste are listed in Annex K Information References under US Government Publications but are ‘not part of the requirements of the document’. Similarly, a search of the www.epa.gov website for NFPA 400 does not return hits.

Some hazardous materials ‘criteria’ are subjective. There are burning rate tests and criteria for solid oxidizers and organic peroxide formulations and flash point criteria for flammable and combustible liquids. The EPA 1030 test for oxidizing waste is different from the NFPA 400 Annex G test method. Currently, there are no tests for reactivity or unstable reactive chemicals. The classification of waste is notably more challenging than pure materials or manufactured chemical formulations especially since waste streams may change and are not subject to hazard determination required for hazard communication and MSDS.

In NFPA 400:

4.5* Classification of Waste. Waste comprised of or containing hazardous materials shall be classified in accordance with Sections 4.1 through 4.4 as applicable.

NFPA 400 explains classification of waste is the responsibility of the ‘user’ and may not coincide with the EPA and DOTs classification of waste. A waste containing a combustible metal, for example, will likely meet the requirements of EPA for ignitability (D001); the DOT will assign it a Division 4.1 flammable solid, PG I; NFPA 400 would send a user to NFPA 484 for combustible metals. Per EPA, classification is responsibility of the generator; NFPA expands the responsibility to the ‘user’. Classifier may be interpreted as equivalent to ‘generator’.

A.4.5 The safe handling, collection, and disposal of hazardous waste can be accomplished only if the physical, chemical, and hazardous properties of its components are known and that information is properly applied (emphasis added). The categorization of a material as waste is normally under the purview of the user. In some cases the waste might be contaminated or “off spec” material, or material where the concentration of the hazardous components has been diluted. In other cases the waste might consist of cleaning materials that have become contaminated with a hazardous material.

The classifiers of waste are cautioned that the classification of hazardous waste under the requirements of the Environmental Protection Agency (EPA) or Department of Transportation (DOT) for labeling required for shipping purposes might not correspond to the system of classification incorporated into Section 4.1. In addition, some judgment is needed to apply the code in circumstances where the waste material is not in a form that is normally encountered when the hazardous material employed is in its virgin state….In many cases the waste material could be a mixture of materials that must be classified in accordance with the requirements of Section 4.3.
A.4.5. does not provide a solution. Most chemical hazard awareness and identification are realized from MSDS; however, MSDS are not required for waste. NFPA 400 requires MSDS for hazardous materials (including waste):

3.3.62 Material Safety Data Sheet (MSDS). The document that describes composition of a material, hazardous properties and hazard mitigation, and disposal information prepared in accordance with the Occupational Safety and Health Administration (OSHA) hazard communication standard (29 CFR, 1910.1200, “Hazard Communication”).

However, the OSHA hazard communication standard excludes waste. 29 CFR 1910.1200 (b)(6) states:

this section does not apply to: (i) any hazardous waste as such term is defined by the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended when subject to regulations issued under that Act by the Environmental Protection Agency (ii) any hazardous substance as such term is defined by the Comprehensive Environmental Response, Compensation and Liability Act when the hazardous substance is the focus of remedial or removal action being conducted under CERCLA in accordance with EPA regulations.

Then, from NFPA 400:

4.5.1* Waste classified in accordance with Sections 4.1 through 4.4 shall comply with the requirements of Chapters 1 through 9 and the material-specific requirements of Chapters 11 through 21 as applicable.

The Annex note A.4.5.1 clarifies:

Just because a decision has been made that a material no longer has a useful life does not exempt the material from compliance with the applicable provisions of the code. Materials that have been classified as hazardous based on the system of classification used in Section 4.1 are required to comply with applicable sections of the code in the same manner as may be required for non-waste material.

Therefore, the person, user or generator charged with identifying a waste based on an EPA hazard characteristic has to then assign the waste to an NFPA hazardous materials class (see Table 5). The narrowing down of a wasted or mixtures or hazardous materials physical hazard, in the context of the existing codes, should increase the knowledge of hazards and appropriate protection criteria for the quantities and packaging.

However, not all EPA hazard characteristics are covered by NFPA. For example, EPA’s hazard characteristic spontaneously combustible is not an NFPA 400 physical hazard. Combustible dusts are not included in NFPA 400. The EPA ignitability hazard characteristic has some test methods: flash point, ignition and propagation of flaming combustion by solids and oxidizers and propensity to self-heat. The EPA’s test method for waste containing oxidizers is different than the DOTs test method (Test O.1, O.3) and NFPA 400 Annex G. With respect to the DOT, the DOT packing group assignments are inverse the NFPA oxidizer Class. There are no EPA test methods for reactivity. Reactivity is more challenging. Failure to properly package and a reaction between incompatible or potentially incompatible materials were blamed for a fire at a U.S. Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) in 2014.29

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Waste in drums and containers in storage is one thing; waste in-process necessitates a potentially different approach. Fluer noted in his FPRF report on the transition of the hazardous materials codes and the emergence of the threshold quantity system to NFPA 1 Uniform Fire Code (UFC, now Fire Code)\(^{30}\):

> …apparent shortcomings in the categorization of other hazards include the need to develop a quantitative method to assign an **in-process hazard classification** to unstable reactive materials, and organic peroxides.

A number of his recommendations were to develop a quantitative methodology for classifying various materials including those ‘in process’—an identified weakness in and root cause of TSDF incidents.

NFPA 400 could therefore clarify the classification of waste exhibiting ignitability and reactivity with an annex note to A.4.5.1 like Table 5 above. From the survey of TSDF losses, a number of root causes were improperly classified waste and/or highly hazardous chemicals. Additional guidance could include listing or identifying high hazard chemicals and/or the attributes that make them highly hazardous including ease of ignition and intense and/or rapid flame spread.

Expert assistance may identify ways to render some hazardous chemicals inert. For example, one safe way to ‘neutralize’ sodium chlorate-based oxygen generators is to pull the firing pin to activate the sodium chlorate candle burning and immediately place it in a 5 gallon pail of water until fully reacted. Once spent, the oxygen generator should be non-hazardous.

The special case of pyrotechnic waste was reviewed. Pyrotechnics are an intentional mixture of hazardous chemicals combined with a fuel and a means to ignite the formulation for a specific effect(s)—color, report, etc. In *Safety of Reactive Chemicals and Pyrotechnics*, various reactive and pyrotechnic materials and the variety of test methods to characterize energy release during combustion which depends strongly on composition are described; there is no mention of pyrotechnic waste\(^{31}\). As a solid, pyrotechnics contain an oxidizer, combustible metal and combustible fuel.\(^{32}\) This combination can exhibit explosion properties especially where larger quantities are not adequately separated and/or can become involved in an exposure fire. There has been numerous research on pyrotechnics, their fire hazard and fire control. FTIR studies of gaseous products evolved from ‘potassium nitrate based pyrotechnics found the combustion of KNO\(_3\)-pyrotechnic mixtures proceed through the formation of nitrogen or nitrogen oxides, whereas in a KClO\(_4\) derived mixture, atomic or molecular oxygen takes part in the combustion reactions’\(^{33}\). Marlair *et al* studied the toxicity issues of burning pyrotechnics and compared typical fires and burning pyrotechnics.\(^{34}\)

The cross section of oxidizer-combustible metal mixtures to produce variations in burning intensity and heat release are described in Reference 34 where pyrotechnics are classified, or broken down, into five

\(^{30}\) Fluer, L., FPRF Report: The transition of the hazardous materials codes and the emergence of the threshold quantity system to NFPA 1 UFC, December 23, 2008.


\(^{32}\) A random pyrotechnic was disassembled in the laboratory. The pyrotechnic solids mixture was 29% total mass; the solids contained potassium chlorate and a barium compound as principal constituents. It burned readily (flashed) evolving large quantities of white smoke. The solids included small balls of compressed fine, powder. The booster was 27wt% the firework assembly—it contained fine, black powder with a tan colored inert at the bottom of a plastic cylinder where the fuse entered the bottom. The balance was combustible materials—the label, paper, wood stick, plastic fuse cover. Therefore, up to 50 wt% of pyrotechnic waste is hazardous in and of itself.


groups based on their burning behavior (Table 6, below): Group 1 burns very violently; Group 2 burns violently, Group 3 burns fast, Group 4 exhibits low/medium speed burning and Group 5 burns slowly. Listed typical oxidizers included nitrates, perchlorates and chlorates. Zirconium, already recognized as highly hazardous, is listed as a constituent of Group 1. As a general trend, overall hazard generally decreased with lower oxidizer content: >65% chlorates were listed under Group 2; 35-65% chlorate under Group 3; and <35% chlorate as Group 4. The intimately mixed components and packaging of fireworks are difficult and dangerous to separate. The contractors at DEI were attempting to desensitize or stabilize the burning behavior of the pyrotechnics with diesel fuel. One contributing factor to the fatalities was the amount of separated material present readily ignited by a fire.

Table 6 Classification of Pyrotechnics from Ref 35.

<table>
<thead>
<tr>
<th>GROUP 1</th>
<th>GROUP 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compositions (burn very violently):</strong></td>
<td><strong>Compositions (low/medium speed burning):</strong></td>
</tr>
<tr>
<td>Chlorate and metal perchlorate report or whistling compositions.</td>
<td>Coloured smoke compositions.</td>
</tr>
<tr>
<td>Dry non-gelatinised cellulose nitrates.</td>
<td>White smoke compositions (except those in Group 5).</td>
</tr>
<tr>
<td>Barium peroxide/zirconium compositions.</td>
<td>Thermite compositions.</td>
</tr>
<tr>
<td>Articles (mass explosion risk):</td>
<td>Aluminium/phosphorous pesticide compositions.</td>
</tr>
<tr>
<td>Flash shells (maroons).</td>
<td>Articles (single-item ignitions/explosions):</td>
</tr>
<tr>
<td>Casings containing flash compositions.</td>
<td>Large firework shells without flash compositions in transport packagings.</td>
</tr>
<tr>
<td>Sealed ball preventing rockets.</td>
<td>Signal ammunition without flash compositions, up to 40 g of composition.</td>
</tr>
<tr>
<td><strong>Articles (accelerating single-item explosions):</strong></td>
<td>Small fireworks, fuse protected (except volcanoes and silver wheels).</td>
</tr>
<tr>
<td>Large firework shells.</td>
<td><strong>GROUP 5</strong></td>
</tr>
<tr>
<td>Fuse unprotected signal flares.</td>
<td>Compositions (burn slowly):</td>
</tr>
<tr>
<td>Non-pressed report bullets (bird scarers).</td>
<td>Slow burning heating compositions.</td>
</tr>
<tr>
<td>Report cartridges, unpacked.</td>
<td>White smoke compositions based on hexachloroethane with zinc, zinc oxide and &lt;5% of aluminium, or &lt;10% of calcium silicon.</td>
</tr>
<tr>
<td>Black matches, uncovered.</td>
<td>Articles (slow single-item ignitions/explosions):</td>
</tr>
<tr>
<td><strong>GROUP 3</strong></td>
<td>Small fireworks in primary packagings.</td>
</tr>
<tr>
<td>Compositions (burn fast):</td>
<td>Signal ammunition in transport packaging.</td>
</tr>
<tr>
<td>Nitrate/Metal compositions without sulphur.</td>
<td>Delays without black powder.</td>
</tr>
<tr>
<td>Compositions with up to 35–65% chlorate.</td>
<td>Coloured smoke devices.</td>
</tr>
<tr>
<td>Compositions with black powder.</td>
<td>Sealed table bombs.</td>
</tr>
<tr>
<td>Lead oxide/silicon with &gt;60% lead oxides.</td>
<td>White smoke devices unpacked (see Group 5 composition).</td>
</tr>
<tr>
<td>Perchlorate/metal compositions other than report.</td>
<td><strong>GROUP 5</strong></td>
</tr>
<tr>
<td>Articles (burn very violently with single-item explosions):</td>
<td>Compositions (burn slowly):</td>
</tr>
<tr>
<td>Large firework shells.</td>
<td>Slow burning heating compositions.</td>
</tr>
<tr>
<td>Fuse protected signal flares.</td>
<td>White smoke compositions based on hexachloroethane with zinc, zinc oxide and &lt;5% of aluminium, or &lt;10% of calcium silicon.</td>
</tr>
<tr>
<td>Pressed report cartridges in primary packagings.</td>
<td>Articles (slow single-item ignitions/explosions):</td>
</tr>
<tr>
<td>Quickmatches in transport packagings.</td>
<td>Small fireworks in primary packagings.</td>
</tr>
<tr>
<td>Waterfalls; Silver wheels; Volcanoes.</td>
<td>Signal ammunition in transport packaging.</td>
</tr>
<tr>
<td>Black powder delays.</td>
<td>Delays without black powder.</td>
</tr>
<tr>
<td><strong>GROUP 5</strong></td>
<td>Coloured smoke devices.</td>
</tr>
</tbody>
</table>

Pyrotechnic waste is clearly a hazardous waste which, under certain conditions, can exhibit explosion hazards. Pyrotechnic waste includes confiscated, illegal fireworks and unspent fireworks or duds. Pyrotechnic waste is dangerous to handle because of the potential ease of ignition, rapid flame spread, and toxic combustion gases which increase with the quantities present. Like other hazardous wastes, the occurrence and quantity of pyrotechnic waste would not be constant but fall under the unique-waste category (e.g., seized load) and with truck-load quantities foreseeable.

Consumer fireworks are shipped as 1.3G and 1.4G explosives. Pyrotechnics are often referred to in the same class as with explosives and propellants. The IFC lists fireworks under hazardous materials. Fireworks including their disposal are addressed by in Chapter 56 of the IFC with reference to NFPA 495 and NFPA 1124. NFPA 400 defers to NFPA 495 for explosives, to NFPA 1124 for 1.3G fireworks and NFPA 1123 for 1.4G fireworks. There is no guidance in NFPA 1123 or NFPA 1124 for pyrotechnic waste; neither document defines ‘waste’ or ‘disposal’. In their report on the Donaldson Enterprises Inc. incident, the CSB recommended the NFPA develop a standard for addressing firework waste storage, use and handling including disposal operations. The CSBs recommendations were analogous to recommendations to the ETC to petition NFPA for standards regarding hazardous waste treatment facilities. The NFPA Pyrotechnics Technical Committee (PYR-AAA) reviewed the CSBs recommendation, their standards and came up with a revisions to CSB recommendation and some potential code language for housekeeping, hazard analyses and expert consultation in recognition of and with all applicable codes, standards and regulations. The PYR-AAA technical committee did not reference NFPA 400, or NFPA 484.

The PYR-AAA committee therefore recognized the need and/or confirmed the gap for requirements where pyrotechnic waste is generated, stored and ultimately handled. Their proposed code language identifies the need for professionals to be involved in all aspects of the material as a waste. There is no mention of how to classify the waste once it is determined to not have pyrotechnic value. According to NFPA 400, if the waste is properly classed, it can be properly stored, and ultimately handled for disposal (whatever the method).

The 2011 Donaldson Enterprises, Inc. incident involved a contractor, not a TSDF. Based on the CSB report, oversight coupled with missed opportunities, lack of hazard analysis and other gaps contributed to the five fatalities. DEI clearly did not recognize or implement the IFC Chapter 56 and/or NFPA 495. The CSB referenced NFPA 495, 1123 and 1124 as applicable standards; not NFPA 400.

Based on the current project’s gap analysis, the classification of pyrotechnic waste is not obvious. Fireworks are currently not addressed in NFPA 400. Firework waste is not identified in NFPA 495, NFPA 1123 and NFPA 1124. Therefore, NFPA 400 could take ownership of pyrotechnic waste, identify the hazard class as oxidizer, combustible metal and/or explosive and direct the user to the respective NFPA 400 chapters and other NFPA documents. For example, using the Group assignments in Table 6, the hazard class of the pyrotechnic waste may be handled within NFPA 400, as opposed to NFPA 495, for Groups 2-5; deferring Group 1 to NFPA 495. Pyrotechnics have been compared with oxidizers as an analogous commodity and hazard class; the provisions of NFPA 400 Chapters 6 and 15 could be reviewed for protection guidance where stored. Reference would have to be made to pyrotechnic waste in NFPA 400 scope, definitions and individual chapters such as Chapter 15. The PYR-AAA recommended language and

36 The CSB report indicated that the fireworks found as part of this explosion had been seized fireworks marked at Consumer Fireworks (Division 1.4 (1.4G Consumer Fireworks – UN0336) but where found to be incorrectly identified and should have been marked as (Division 1.3 (1.3G) Display Fireworks – UN0335)
additional guidance for explosives provided in Table 7 below from reference 35 could be developed into Annex material in NFPA 400 for handling pyrotechnic waste.

Table 7 General considerations for work with explosive chemicals (Ref 35)

- Consult with experts on the hazards and on technical, administrative, and legal requirements.
- The chance of accidental initiation is related to the energy imparted to the substance and the sensitivity of the compound. Hence the sensitivity of compounds should be established (e.g., pages 621–2) prior to devising appropriate control measures. (Many sensitive explosives have ignition energies of 1–45 mJ whilst some very sensitive materials have ignition energies <1 mJ.)
- Consider the advantage of continuous vs batch operations.
- Consider intraline distances to minimise explosion propagation.
- Depending on scale, specially designed facilities may be required remote from other buildings, accessways or populated areas. Remote handling procedures may be required possibly with closed-circuit TV monitoring utilising concrete outbuildings or bunkers. Access to hazardous areas must be rigidly controlled.
- Consider fire protection, detection and suppression requirement, and means of escape, alarms, etc.
- Minimise stocks and segregate from other chemicals and work areas. Where appropriate keep samples dilute, or damp, and avoid formation of large crystals when practicable. Add stabilisers if possible, e.g., to vinyl monomers. Store in specially designed, well-labelled containers in ‘no smoking’ areas, preferably in several small containers rather than one large container. Where relevant store in dark and under chilled conditions, unless this causes pure material to separate from stabiliser (page 508).
- Do not decant in store.
- Consider need for high/low temperature alarms for refrigerated storage; these should be inspected and tested regularly.
- Consider need for mitigatory measures (fire, blast, fragment-resistant barricades/screens), electrical and electrostatic safeguards, personal protection, disposal, etc.
- Stores and work areas should be designated ‘No Smoking’ areas and access controlled.
- Depending upon scale, explosion-proof electrics may be required and static eliminated. Grounded equipment is essential with black powder. Non-sparking rods must be used to open containers. Operators must wear anti-static boots.2
- Ensure cleanliness throughout, remembering that some raw materials or products are also toxic.
- Deal with spillages immediately and make provision for first-aid.
- All staff should be fully trained and written procedures provided.

TSDF Stakeholder Gaps

Additional gaps identified that contribute to the TSDF fire problem are listed below—some of which are inter-related.

1) How to address improperly classified waste
2) Policies and procedures to handle, use and store high hazard chemicals
3) Not following or understanding the building code and fire code permitting process
4) TSDF buildings and processes not protected per the building and fire codes
5) Inadequate and/or improper fire protection
6) Lack of performance-based design
7) How to handle, use and store flammable liquid in totes
8) Multiple hazardous buildings
9) Hazard communication training is not the same as emergency response

Addressing these gaps goes beyond the scope of this project. TSDFs already have to comply with various regulatory agencies. A fire protection specialist would likely be required to assess, design and/or install the appropriate fire protection based on the fire codes. Provided the size of the operation and their client base, chemical hazard awareness of all of the hazardous waste submitted is a daunting task. While daunting, the fire code required HMMP and HMIS would provide a more site specific chemical inventory hazard awareness. The individual hazard class chapters in NFPA 400 or documents referenced therein could be applied.

From NFPA 400:

1.11  Hazardous Materials Management Plan (HMMP) (See also IFC Appendix H, H101)

1.11.1* When required by the AHJ, new or existing facilities that store, use, or handle hazardous materials covered by this code in amounts above the MAQ specified in 5.2.1.2 through 5.2.1.13 and 5.4.1.2 shall submit a hazardous materials management plan (HMMP) to the AHJ.

1.11.2 The HMMP shall be reviewed and updated as follows:

(1) Annually
(2) When the facility is modified
(3) When hazardous materials representing a new hazard category not previously addressed are stored, used, or handled in the facility

1.11.3 The HMMP shall comply with the requirements of Chapter 6.

NFPA 400 1.12* Hazardous Materials Inventory Statement (HMIS) (See also IFC Appendix H, H102)

1.12.1 When required by the AHJ, a hazardous materials inventory statement (HMIS) shall be completed and submitted to the AHJ.

1.12.2 The HMIS shall comply with the requirements in NFPA 1, Fire Code.

A fire prevention and protection strategy is entirely consistent with the required contingency plan and preparedness planning already required in the permit process for TSDFs in the event of a release, fire, or explosion.

TSDFs and AHJs would also benefit from process hazard analyses (PHA) for major process equipment, mechanical integrity programs, more training and hazard communication. PHAs should be performed for initial startup, normal startup, normal operation, start-up after emergency shutdown, normal shut down and emergency operation. Mechanical integrity programs would reduce or eliminate causes attributed to equipment. TSDFs have to be prepared to address off-specification and unique waste streams in the context
of the fire codes by quarantine and subject matter expert assistance. Examples of subject matter expert assistance are Chemtrec and academic professionals.

Discussion

The storage and handling of hazardous wastes are governed by local, city, county, state, federal and international laws and regulations, local fire and building codes and NFPA codes and standards. Anyone that stores or handles hazardous materials/wastes must comply with all applicable laws, regulations, ordinances, fire codes and standards relating to the storage and handling of these materials. The requirements for hazardous wastes in the IFC and NFPA are very similar, and the IFC references NFPA standards. The fire code permitting process ensures the appropriate elements of the fire code and referenced codes and standards are in place to protect life, equipment, facilities, and the environment from a fire, explosion, and/or release of hazardous waste. Noncompliance with local fire codes is a major cause for losses at TSDFs, and most incidents could have been mitigated or prevented if the facility complied with the local fire code and NFPA 400.

According to the IFC and NFPA codes and standards, the permissible arrangement and quantity of hazardous waste depends on a number of factors, including the NFPA hazard class; storage quantity and type; building occupancy/usage; and building fire protection (sprinklered or non-sprinklered). This requires the material is properly classified. The NFPA codes and standards also provide guidance on the storage arrangement, such as the permissible size of the pile (length, width and height), separation distance (to next pile and to walls); the maximum quantity limit; placement on and use of pallets; stacking heights; and recommended storage temperatures. If the hazard Class of the waste requires sprinklers, the sprinkler protection must conform to locally adopted building and fire codes or to applicable NFPA codes and standards if no local codes apply.

Each TSDF must have a RCRA permit. Fire code permits, NFPA 400 1.8 and/or IFC 105.6.20, should be linked to the RCRA permit process with the intent the fire code permit be executed by a person with knowledge of the fire codes that can address the complexity of mixed contents and quantities and hazard ratings.

Storage of hazardous materials in amounts exceeding Groups M or S storage must be in accordance with the appropriate Group (H) hazardous storage requirements, indicated in building and fire codes. Once storage capacities exceed the amounts indicated in the Group M and S storage tables, the Group (H) Hazardous Materials Occupancy Requirements must be met. TSDFs store hazardous waste requiring hazardous storage construction H-1 through H-5 if IFC is the adopted fire code and high hazard level L-1 through L-5 if NFPA 1 is the adopted fire code. These requirements include at a minimum: spill prevention and secondary containment, acceptable storage methods, segregation of incompatible materials, building and construction conditions, quantity limits, sprinkler protection, and storage arrangements/limitations. A fire code specialist will likely be required to address an H occupancy building design.

Recognition and implementation of the fire codes is not limited to one stakeholder. TSDF’s, while having to comply with other various regulations, also must comply with the fire codes, where locally adopted. The federal EPA would likely defer to each region and/or state agencies. Local AHJs therefore have to recognize the fire codes apply to TSDFs. Industry specific AHJs include the insurance company. If locally adopted, the IBC/IFC and/or NFPA building and fire code requirements should be applied to TSDFs. Where not locally adopted, ideally the EPA should require full compliance with the fire codes in the permitting process or the AHJ should utilize the EPA omnibus authority to have TSDFs comply.

Recommendations
NFPA 400 could extract or modify NFPA 484 Chapter 19, provided in Appendix 2, for TSDFs. NFPA 484, Chapter 19, addresses, among other general requirements, receiving criteria, combustible metal specific storage requirements, hazard determination, personal protective equipment (PPE), clothing fires, reactivity, contact with water and thermite reaction hazards not covered in NFPA 400 Chapter 6. The technical committee could consider the special case of pyrotechnic waste.

This project and report may be used in support of a public announcement line the EPA Chemical Safety Alert or equivalent citing model fire codes for fire protection where hazardous waste where used, handled and stored.

This project and report may be used in support of a letter to the CSB identifying NFPA 400 Hazardous Materials Code as the principal and pointer document meeting their recommendation for an NFPA code or standard for TSDFs and hazardous waste.

A new annex could pull existing key information references, most of which are listed in NFPA 400 Annex K, for use in identifying chemical hazards and classifying hazardous wastes. Key references are AIChE publications and Bretherick’s Handbook of Reactive Chemical Hazards. Others not listed are Safe Handling of Chemicals in Industry, FPRF projects on separation distances and aqueous based liquids in totes and the EPA Chemical Safety Alert on Safe Storage and Handling of Swimming Pool Chemicals (attached here as Appendix 3) which addresses specific hazards such as wetting, improper mixing, and hazard control all of which would be useful to TSDFs that handle other oxidizers and other hazardous materials. A list of high hazard chemicals, by name and Class, for waste-related processes could be created. Examples of high hazard chemicals include finely divided zirconium metal, solid sodium chlorate, and chemical reactions liable to evolve hydrogen gas (e.g., alkali metals, hydrides).

Other annex material could provide a working example of fire code implementation at a storage TSDF. For example, a TSDF would perform an HMMP and HMIS inventory; list their inventory of physical hazard materials; compare with MAQ’s per control area for the highest hazard class; apply requirements of NFPA 400 Chapter 6; protect oxidizers per NFPA 400 Chapter 15 and Annex G; isolate and protect flammable and combustible liquids per NFPA 30 Chapter 6; isolate water reactives from water based suppression system, etc.

A regulation-harmonized, straw-man classification for waste is beyond the scope of this project. A user-friendly flow diagram from EPA waste characteristics to NFPA 400 physical hazard materials to other NFPA standards (e.g., pointer document) approach could be considered.

Conclusion

TSDFs have a fire problem. Recognition and implementation of the model building and fire codes addresses one major gap that would effectively reduce the potential for, mitigate and/or prevent explosions and the spread of fire at TSDFs which, without protective measures and, as the case histories have shown, could spread to involve other hazardous materials, the building, on-site tanks, could threaten the well-being of workers and result in an evacuation of surrounding community. The NFPA fire and hazardous materials codes and standards should be associated with the RCRA permitting process for TSDFs. Where fire codes are adopted; the AHJ should recognize they apply to TSDFs. On the other hand where fire codes are not locally adopted, AHJs can employ their RCRA omnibus authority and require compliance. Properly classifying hazardous waste per EPA and NFPA is not clear or straight forward especially without MSDS-like chemical hazard information and where there are mixtures, multiple hazards and unique cases--pyrotechnic waste a case in point.
NFPA 1 defers to NFPA 400 for hazardous materials. NFPA 400 includes waste and therefore TSDFs must comply with NFPA 400. This should address the CSBs recommendations for an NFPA code for TSDFs. Before NFPA 400, it was likely less clear that the fire codes applied to these facilities and the prevailing assumption was that TSDFs had only to comply with EPA which doesn’t tell one how to protect hazardous material. Annex material in NFPA 400 could further clarify the role of the AHJ in requiring compliance of TSDFs with the building and fire codes. Annex material may include a list of highly hazardous chemicals resulting in events at TSDFs, guidance for handling confiscated and/or pyrotechnic waste and a summary of this report.
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Introduction

This document describes the Environmental Protection Agency’s (EPA’s) hazardous waste characteristics regulations under the authority of the Resource Conservation and Recovery Act (RCRA) Subtitle C and includes hyperlinks to information that EPA has generated over the years to explain the characteristics regulations. The objective of this document is to consolidate the information on characteristics regulations to assist Environmental Protection Agency (EPA) staff, state staff, industrial facilities that generate and manage hazardous wastes, and the public to understand the current RCRA hazardous waste characteristics regulations. The criteria for identifying the characteristics of hazardous wastes are located in Title 40 of the Code of Federal Regulations (CFR) at Part 261. Please note that this reference document is designed to be web-based, so the usefulness of the document is maximized when it is viewed on a computer that is connected to the internet.

This document is only a reference document and is not to be used as a substitute for the CFR itself or the requirements contained in the CFR. This document is also not a rulemaking in any way. Additionally, this reference document presents only the federal requirements for hazardous waste characteristics. Most states are authorized to manage their hazardous waste management regulatory program. Therefore, states may have their own set of regulations that apply in lieu of federal regulations, and while most state hazardous waste regulations are based on the federal requirements, some states have developed regulations that are more stringent than the federal program. We direct you to the following website to determine if the state regulatory program is different from the federal program: http://www.epa.gov/epawaste/wyl/stateprograms.htm

This document is organized by hazardous waste characteristic (i.e., ignitable, corrosive, reactive and toxic), in a manner similar to the way the identification of hazardous waste regulations are presented in Title 40 of the Code of Federal Regulations (CFR) at Part 261. Therefore, following an overview of the hazardous waste characteristics regulations, this document will present the definition of hazardous waste, criteria for identifying hazardous waste, and the definitions of each of the four characteristics of hazardous waste. Background information and relevant resources are also provided throughout this document.

To help stakeholders better understand specific requirements, we also have provided, where applicable, hyperlinks to Federal Register notices, frequently asked questions (FAQs), letters, and memoranda issued by EPA, as well as guidance and other relevant documents developed by EPA that provide further clarification of the hazardous waste characteristic regulations. We have attempted to identify the relevant related FAQs, letters, memoranda, etc. on a particular subject (miscellaneous resources can also be found in this document). However, please note that it is possible that EPA could have inadvertently overlooked a relevant document and did not include it in this reference document. Therefore, we cannot guarantee that we captured every relevant document in each and every instance. Additionally, once a user has navigated to the characteristics regulation of interest, we have provided hyperlinks to the e-CFR website when the characteristics regulations cross-reference themselves or other regulations.

1 Subtitle C of RCRA has been codified in the United States Code (U.S.C.) as the Solid Waste Disposal Act (SDWA), Subchapter III (Hazardous Waste Management), 42 U.S.C. §§ 6921 through 6939e
Because regulations are promulgated throughout the year, EPA intends to update this reference document periodically to remain up-to-date with the hazardous waste regulatory requirements. However, as noted previously, this web-based reference document is not a substitute for the CFR itself or the requirements in the CFR. Additionally, the Government Printing Office frequently updates the e-CFR website to which the document is linked. The hyperlinks included in this document for Federal Register notices published prior to October 1994 are from HeinOnline and are only available only by subscription to HeinOnline. By including this material, EPA does not endorse HeinOnline.

This reference document assumes that a solid waste has been generated. Therefore, we have not included the applicable regulatory citations for determining if a solid waste (See 40 CFR 261.2) has been generated. Similarly, we have not included the regulatory citations for specific exclusions from either the definition of solid waste and definition of hazardous waste found in 40 CFR 261.4, or the requirements for recyclable materials found in 40 CFR 261.6. Similar documents have been prepared compiling regulations applicable to generators of hazardous waste, “Hazardous Waste Generator Regulations: A User-Friendly Reference Document, May 2007,” and the hazardous waste listings regulations, “Hazardous Waste Listings: A User-Friendly Reference Document, Draft, March 2008.” Documents for Exclusions from the Definition of Solid Waste have also been developed, “Definition of Solid Waste Compendium - Volume A: Exclusions” and “Identification and Listing of Hazardous Waste 40 CFR § 261.4(b): Exclusions: Solid Wastes Which are not Hazardous Wastes.” A collection of written materials about specific issues related to the definition of solid waste is available, “DSW Compendium.”

This document was developed by the Materials Recovery and Waste Management Division in the Office of Resource Conservation and Recovery (formerly Office of Solid Waste). (Name change effective as per 74 FR 30228, June 25, 2009). Please direct any questions concerning this document to: helms.greg@epa.gov.

How to navigate this document

This document is navigable in several ways. First, generators can use the Summary Table to link directly to the regulatory citation of interest in the Government Printing Office’s Electronic Code of Federal Register website (e-CFR) by left-clicking the mouse on the hyperlinks in the table. Clicking on the hyperlink will open the e-CFR in a new web-browser window, so the original document will also remain open. Secondly, users can take advantage of the Table of Contents (page 2 of the document) or the bookmarks (located on the left-hand side of the screen) to navigate through the body of the document. The Table of Contents and bookmarks are organized by hazardous waste characteristic. Users can navigate the document by clicking the left side of the mouse on the link of interest in the Table of Contents and bookmarks.
Overview of the Hazardous Waste Identification Process

EPA's regulations establish two ways of identifying solid wastes as hazardous under the Resource Conservation and Recovery Act (RCRA). A waste may be considered hazardous if it exhibits certain hazardous properties ("characteristics") or if it is included on a specific list of wastes EPA has determined are hazardous ("listing" a waste as hazardous) because we found them to pose substantial present or potential hazards to human health or the environment. EPA's regulations in the Code of Federal Regulations (40 CFR) define four hazardous waste characteristic properties: ignitability, corrosivity, reactivity, or toxicity (see 40 CFR 261.21-261.24). This document presents the regulations that will assist in identifying the characteristics of hazardous waste in §§ 261.31 through 261.33. Since EPA has developed a separate document for listed wastes, only characteristic wastes will be discussed in this document.

Characteristic Hazardous Wastes

A RCRA characteristic hazardous waste is a solid waste that exhibits at least one of four characteristics defined in 40 CFR Part 261 subpart C—ignitability (D001), corrosivity (D002), reactivity (D003), and toxicity (D004 - D043).

- **Ignitability**—Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 °C (140 °F). Examples include waste oils and used solvents. For more details, see 40 CFR §261.21. Test methods that may be used to determine ignitability include the Pensky-Martens Closed-Cup Method for Determining Ignitability (Method 1010A)(PDF) (1 pg, 19K), the Setaflash Closed-Cup Method for Determining Ignitability (Method 1020B)(PDF) (1 pg, 17K), the Ignitability of Solids (Method 1030) (PDF) (13 pp, 116K), Test Method for Oxidizing Solids (Method 1040)(PDF) (17 pp, 207K), and the Test Method to Determine Substances Likely to Spontaneously Combust (Method 1050) (PDF)(20 pp, 611K).

- **Corrosivity**—Corrosive wastes are acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) and/or are capable of corroding metal containers, such as storage tanks, drums, and barrels. Battery acid is an example. For more details, see 40 CFR §261.22. The test method that may be used to determine the ability of a waste to corrode steel is the Corrosivity Towards Steel (Method 1110A)(PDF) (6 pp, 37K). To measure pH electrometrically, see Method 9040C (PDF) (5 pp, 25K).

- **Reactivity**—Reactive wastes are unstable under "normal" conditions. They can cause explosions, undergo violent reactions, generate toxic fumes, gases, or vapors or explosive mixtures when heated, compressed, or mixed with water. Examples include lithium-sulfur batteries and explosives. For more details, see 40 CFR §261.23. There are currently no test methods available.

- **Toxicity**—Toxic wastes are harmful or fatal when ingested or absorbed (e.g., containing mercury, lead, etc.). When toxic wastes are land disposed, contaminated liquid may leach from the waste and pollute ground water. Toxicity is defined through a laboratory
procedure called the *Toxicity Characteristic Leaching Procedure (TCLP) (Method 1311)(PDF)* (35 pp, 288K). The TCLP helps identify wastes likely to leach concentrations of contaminants that may be harmful to human health or the environment. For more details, see 40 CFR §261.24.
## Summary Chart

Links to specific sections of the CFR Citations for the Characteristics of Hazardous Waste

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General Hazardous Waste Resources

- Electronic Code of Federal Regulations
e-CFR: Title 40-Protection of Environment (Parts 260-265)

- Hazardous waste web page on the EPA website
  http://www.epa.gov/epawaste/hazard/index.htm

- RCRA training modules
  http://www.epa.gov/osw/inforesources/pubs/hotline/rmods.htm

- Training Document on Hazardous Waste Identification
  http://www.epa.gov/waste/inforesources/pubs/training/hwid05.pdf

- General Questions on Hazardous Waste and Characteristics
  What is a RCRA hazardous waste?

- Requirements for Generators of Hazardous Waste
  http://www.epa.gov/epawaste/hazard/generation/index.htm

- Website for RCRA Frequent Questions Database
  http://waste.custhelp.com/cgi-bin/waste.cfg/php/enduser/std_alp.php

- Environmental Justice
  Addressing Environmental Justice Issues In RCRA Programs

- Methods for Determining Characteristics of Hazardous Waste, SW-846, Chapter 8

Important Federal Register Notices for Characteristic Hazardous Waste

- Proposed Rule – Hazardous Waste Guidelines and Regulations
  43 FR 58946, December 18, 1978

- Final Rule and Interim Final Rule - Hazardous Waste Management System: General
  45 FR 33066, May 19, 1980

- Petroleum Refining Process Waste - Notice of Data Availability
  68 FR 59935, October 20, 2003
Regulations for the Identification of Hazardous Waste

This document is organized in a manner similar to the way the definition and identification of hazardous waste regulations are presented in Title 40 of the Code of Federal Regulations (CFR) at Part 261.

Title 40: Protection of Environment

PART 261 – Identification and Listing of Hazardous Waste

Subpart C

§ 261.3 Definition of hazardous waste

A solid waste, as defined in §261.2, is a hazardous waste if:

(i) It exhibits any of the characteristics of hazardous waste identified in subpart C of this part. However, any mixture of a waste from the extraction, beneficiation, and processing of ores and minerals excluded under §261.4(b)(7) and any other solid waste exhibiting a characteristic of hazardous waste under subpart C is a hazardous waste only if it exhibits a characteristic that would not have been exhibited by the excluded waste alone if such mixture had not occurred, or if it continues to exhibit any of the characteristics exhibited by the non-excluded wastes prior to mixture. Further, for the purposes of applying the Toxicity Characteristic to such mixtures, the mixture is also a hazardous waste if it exceeds the maximum concentration for any contaminant listed in Table 1 to §261.24 that would not have been exceeded by the excluded waste alone if the mixture had not occurred or if it continues to exceed the maximum concentration for any contaminant exceeded by the nonexempt waste prior to mixture.

§ 261.3(a)(2)(i)

(a) A solid waste, as defined in §261.2, is a hazardous waste if:

(1) It is not excluded from regulation as a hazardous waste under §261.4(b); and

(2) It meets any of the following criteria:

(i) It exhibits any of the characteristics of hazardous waste identified in subpart C of this part. However, any mixture of a waste from the extraction, beneficiation, and processing of ores and minerals excluded under §261.4(b)(7) and any other solid waste exhibiting a characteristic of hazardous waste under subpart C is a hazardous waste only if it exhibits a characteristic that would not have been exhibited by the excluded waste alone if such mixture had not occurred, or if it continues to exhibit any of the characteristics exhibited by the non-excluded wastes prior to mixture. Further, for the purposes of applying the Toxicity Characteristic to such mixtures, the mixture is also a hazardous waste if it exceeds the maximum concentration for any contaminant listed in table 1 to §261.24 that would not have been exceeded by the excluded waste alone if the
mixture had not occurred or if it continues to exceed the maximum concentration for any contaminant exceeded by the nonexempt waste prior to mixture.

§ 261.3(b)(3)

(b) A solid waste which is not excluded from regulation under paragraph (a)(1) of this section becomes a hazardous waste when any of the following events occur:

(1) In the case of a waste listed in subpart D of this part, when the waste first meets the listing description set forth in subpart D of this part.

(2) In the case of a mixture of solid waste and one or more listed hazardous wastes, when a hazardous waste listed in subpart D is first added to the solid waste.

(3) In the case of any other waste (including a waste mixture), when the waste exhibits any of the characteristics identified in subpart C of this part.

§ 261.3(c)(1)

(c) Unless and until it meets the criteria of paragraph (d) of this section:

(1) A hazardous waste will remain a hazardous waste.

§ 261.3(d)(1)

(d) Any solid waste described in paragraph (c) of this section is not a hazardous waste if it meets the following criteria:

(1) In the case of any solid waste, it does not exhibit any of the characteristics of hazardous waste identified in subpart C of this part. (However, wastes that exhibit a characteristic at the point of generation may still be subject to the requirements of part 268, even if they no longer exhibit a characteristic at the point of land disposal.)


§ 261.10 Criteria for identifying the characteristics of hazardous waste

(a) The Administrator shall identify and define a characteristic of hazardous waste in subpart C only upon determining that:

(1) A solid waste that exhibits the characteristic may:
(i) Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

(ii) Pose a substantial present or potential hazard to human health or the environment when it is improperly treated, stored, transported, disposed of or otherwise managed; and

(2) The characteristic can be:

(i) Measured by an available standardized test method which is reasonably within the capability of generators of solid waste or private sector laboratories that are available to serve generators of solid waste; or

(ii) Reasonably detected by generators of solid waste through their knowledge of their waste.

(b) [Reserved]

PART 262 – Standards Applicable to Generators of Hazardous Waste

Subpart

§ 262.11 Hazardous waste determination

A person who generates a solid waste, as defined in 40 CFR 261.2, must determine if that waste is a hazardous waste using the following method:

(a) He should first determine if the waste is excluded from regulation under 40 CFR 261.4.

(b) He must then determine if the waste is listed as a hazardous waste in subpart D of 40 CFR part 261.

Note: Even if the waste is listed, the generator still has an opportunity under 40 CFR 260.22 to demonstrate to the Administrator that the waste from his particular facility or operation is not a hazardous waste.

(c) For purposes of compliance with 40 CFR part 268, or if the waste is not listed in subpart D of 40 CFR part 261, the generator must then determine whether the waste is identified in subpart C of 40 CFR part 261 by either:

(1) Testing the waste according to the methods set forth in subpart C of 40 CFR part 261, or according to an equivalent method approved by the Administrator under 40 CFR 260.21; or

(2) Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used.
(d) If the waste is determined to be hazardous, the generator must refer to parts 261, 264, 265, 266, 268, and 273 of this chapter for possible exclusions or restrictions pertaining to management of the specific waste.


**General Resources for Hazardous Waste Characteristics**

**Representative Sampling**

Appendix I to Part 261—Representative Sampling Methods

The methods and equipment used for sampling waste materials will vary with the form and consistency of the waste materials to be sampled. Samples collected using the sampling protocols listed below, for sampling waste with properties similar to the indicated materials, will be considered by the Agency to be representative of the waste.

[45 FR 33119, May 19, 1980, as amended at 70 FR 34562, June 14, 2005]

**Sampling Plan**

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846) - Sampling Plan

**Federal Register Notices**

- Final Rule and Interim Final Rule - Hazardous Waste Management System: General
  45 FR 33066, May 19, 1980

- Petroleum Refining Process Wastes - Notice of Data Availability
  68 FR 59935, October 20, 2003

**Letters/Memoranda**

- REGULATORY STATUS OF USED NICKEL CATALYST

- STATUS OF SPENT SILVER-BEARING PHOTOFIXER THAT IS RECLAIMED

- BIOSOLIDS

**Ignitability**

The regulations for the hazardous characteristic of ignitability can be found at 40 CFR 261.21.
Regulations for Ignitable Liquids

§ 261.21
(a) A solid waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:

(1) It is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume and has flash point less than 60 °C (140 °F), as determined by a Pensky-Martens Closed Cup Tester (incorporated by reference, see §260.11), or a Setalash Closed Cup Tester, using the test method specified in ASTM Standard D 3278–78 (incorporated by reference, see §260.11).

Letters/Memoranda

- DETERMINATION OF THE IGNITABILITY CHARACTERISTIC
- USE OF PAINT FILTER LIQUIDS TEST TO DETERMINE FREE LIQUIDS IN A WASTE
- MIXTURES OF USED OIL AND CHARACTERISTIC HAZARDOUS WASTE
- USE OF ASTM METHOD D-56 IN IGNITABILITY DETERMINATIONS
- POSITION PAPER ON SPENT ABSORBENT MATERIALS
- DEFINING IGNITABLE LIQUIDS METHOD
- RESPONSE TO SPECIFIC QUESTIONS REGARDING HAZARDOUS WASTE IDENTIFICATION AND GENERATOR REGULATIONS
- ALCOHOL-CONTENT EXCLUSION FOR THE IGNITABILITY CHARACTERISTIC
- CLARIFICATION ON: MANIFEST DOCUMENT NUMBER; F003, F005, D001; WASTE DESTINED FOR RECYCLING; AND TREATMENT STANDARDS FOR CFC
- PRETREATMENT OF CHARACTERISTIC WASTES SUBJECT TO LAND DISPOSAL RESTRICTIONS
- AQUEOUS SOLUTION, IGNITABILITY DEFINED
- AQUEOUS WASTE AS IGNITABLE
- LIQUID WASTE, DEFINITION OF
- CLARIFICATION OF THE RECYCLED USED OIL MANAGEMENT STANDARDS AS THEY PERTAIN TO IGNITABLE USED OIL
- CLARIFICATION OF THE USED OIL REGULATIONS APPLICABLE TO MIXTURES OF USED OIL AND CHARACTERISTIC WASTE
- DEFINITION OF A LIQUID AS IT APPLIES TO IGNITABLE AND CORROSIVE WASTES; LIQUID AS IT APPLIES TO IGNITABLE OR CORROSIVE WASTES
Regulations for Ignitable Solids

§ 261.21(a)
(2) It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that it creates a hazard.

Letters/Memoranda

• FLASH POINT TESTING OF A WASTE FIBROUS FILTER MATERIAL
• INDUSTRIAL WIPERS AND THE HAZARDOUS WASTE IDENTIFICATION RULE
• HOW IGNITABLE SOLIDS AND SOLVENT CONTAMINATED RAGS OR SHOP TOWELS FIT INTO D001 CHARACTERISTIC OF IGNITABILITY
• INTERPRETATION OF THE RCRA IGNITABILITY CHARACTERISTIC WITH REGARD TO ACETONE WIPES
• CHARACTERIZATION OF NITROCELLULOSE FILTER FABRIC WASTE
• REGULATORY STATUS OF METAL CASINGS CONTAINING SPENT POWDERED METALLIC OXIDE CATALYST
• DETERMINATION OF THE IGNITABILITY CHARACTERISTIC
• IGNITABLE SOLID DEFINITION APPLIED TO TITANIUM SWARF
• IGNITABILITY CHARACTERISTIC TESTING FOR SOLIDS
• CLARIFICATION OF THE CHARACTERISTIC OF IGNITABILITY AS IT PERTAINS TO SOLIDS VS. LIQUIDS
• IGNITABILITY CHARACTERISTIC, DEFINITION OF UNDER STANDARD TEMPERATURE AND PRESSURE

Regulations for Ignitable Compressed Gas

§ 261.21(a)
(3) It is an ignitable compressed gas.
(i) The term “compressed gas” shall designate any material or mixture having in the container an absolute pressure exceeding 40 p.s.i. at 70 °F or, regardless of the pressure at 70 °F, having an absolute pressure exceeding 104 p.s.i. at 130 °F; or any liquid flammable material having a vapor pressure exceeding 40 p.s.i. absolute at 100 °F as determined by ASTM Test D–323.

(ii) A compressed gas shall be characterized as ignitable if any one of the following occurs:

(A) Either a mixture of 13 percent or less (by volume) with air forms a flammable mixture or the flammable range with air is wider than 12 percent regardless of the lower limit. These limits shall be determined at atmospheric temperature and pressure. The method of sampling and test procedure shall be acceptable to the Bureau of Explosives and approved by the director, Pipeline and Hazardous Materials Technology, U.S. Department of Transportation (see Note 2).

(B) Using the Bureau of Explosives' Flame Projection Apparatus (see Note 1), the flame projects more than 18 inches beyond the ignition source with valve opened fully, or, the flame flashes back and burns at the valve with any degree of valve opening.

(C) Using the Bureau of Explosives' Open Drum Apparatus (see Note 1), there is any significant propagation of flame away from the ignition source.

(D) Using the Bureau of Explosives' Closed Drum Apparatus (see Note 1), there is any explosion of the vapor-air mixture in the drum.

Letters/Memoranda

- INCINERATORS THAT RECEIVE GASEOUS EMISSIONS, RCRA EXCLUSION, CAA APPLIES

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**Regulations for Oxidizers**

§ 261.21(a)

(4) It is an oxidizer. An oxidizer for the purpose of this subchapter is a substance such as a chlorate, permanganate, inorganic peroxide, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter (see Note 4).

(i) An organic compound containing the bivalent \(-\text{O-O}-\) structure and which may be considered a derivative of hydrogen peroxide where one or more of the hydrogen atoms have been replaced by organic radicals must be classed as an organic peroxide unless:

(A) The material meets the definition of a Class A explosive or a Class B explosive, as defined in §261.23(a)(8), in which case it must be classed as an explosive,

(B) The material is forbidden to be offered for transportation according to 49 CFR 172.101 and 49 CFR 173.21.
(C) It is determined that the predominant hazard of the material containing an organic peroxide is other than that of an organic peroxide, or

(D) According to data on file with the Pipeline and Hazardous Materials Safety Administration in the U.S. Department of Transportation (see Note 3), it has been determined that the material does not present a hazard in transportation.

Letters/Memoranda

- APPLICABILITY OF HAZARDOUS WASTE CODES TO A CHEMICAL POLISHING SYSTEM
- RCRA APPLICABILITY TO POTASSIUM PERMANGANATE AND MANGANESE DISPOSAL
- NITRIC ACID WASTE CHARACTERIZATION
- REGULATORY STATUS OF METAL CASINGS CONTAINING SPENT POWDERED METALLIC OXIDE CATALYST

Regulations for the Hazardous Waste Number for Ignitability

§ 261.21
(b) A solid waste that exhibits the characteristic of ignitability has the EPA Hazardous Waste Number of D001.

Note 1: A description of the Bureau of Explosives' Flame Projection Apparatus, Open Drum Apparatus, Closed Drum Apparatus, and method of tests may be procured from the Bureau of Explosives.

Note 2: As part of a U.S. Department of Transportation (DOT) reorganization, the Office of Hazardous Materials Technology (OHMT), which was the office listed in the 1980 publication of 49 CFR 173.300 for the purposes of approving sampling and test procedures for a flammable gas, ceased operations on February 20, 2005. OHMT programs have moved to the Pipeline and Hazardous Materials Safety Administration (PHMSA) in the DOT.

Note 3: As part of a U.S. Department of Transportation (DOT) reorganization, the Research and Special Programs Administration (RSPA), which was the office listed in the 1980 publication of 49 CFR 173.151a for the purposes of determining that a material does not present a hazard in transport, ceased operations on February 20, 2005. RSPA programs have moved to the Pipeline and Hazardous Materials Safety Administration (PHMSA) in the DOT.

Note 4: The DOT regulatory definition of an oxidizer was contained in §173.151 of 49 CFR, and the definition of an organic peroxide was contained in paragraph 173.151a. An organic peroxide is a type of oxidizer.
Letters/Memoranda

- PRETREATMENT OF CHARACTERISTIC WASTES SUBJECT TO LAND DISPOSAL RESTRICTIONS
- REGULATORY REQUIREMENTS APPLICABLE TO TWO WASTE STREAMS THAT WOULD BE BILAYERED THROUGH PHASE SEPARATION AT A LICENSED TSDF
- SOLVENT-CONTAMINATED WASTEWATER FROM FRAGRANCE MANUFACTURE
- END-USERS OF CHLORDIMEFORM EXEMPTION
- MIXTURE OF METHANOL AND SOLID WASTE WHICH DOES NOT EXHIBIT ANY CHARACTERISTICS

General Resources for the Ignitability Characteristic

- Background document for the Ignitability characteristic

Test Methods

Test methods are not required by the Federal regulations to determine if a waste passes or fails the characteristic of ignitability according to the RCRA regulatory definition at 40 CFR 261.21. To clarify, the test results of these methods cannot be used to directly classify a waste as a D001 hazardous waste, nor can the results be used by themselves to definitively classify a waste as non-hazardous. No specific test for defining ignitable solids or oxidizers is required by the RCRA regulations, and only a waste meeting the narrative regulatory definitions at 40 CFR 261.21(a)(2) and/or 261.21(a)(4) is an ignitable hazardous waste because it is an ignitable solid and/or an oxidizer. However, these test methods were developed to specifically illustrate the ignitable and oxidizer properties of materials, including wastes, and their results provide relevant and useful information that may be applied to knowledge of a waste in determining whether a waste meets the 40 CFR 261.21(a) criteria.

- SW-846 Test Method for Ignitability of Solids – Test Method 1030
- SW-846 Test Method to Determine Substances Likely to Spontaneously Combust - Test Method 1050
- Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846) – Sampling Plan
Federal Register Notices

- Final Rule - Land Disposal Restrictions for Third Third Scheduled Wastes 55 FR 22520, June 1, 1990

Corrosivity

The regulations for the hazardous characteristic of corrosivity can be found at 40 CFR 261.22.

Regulations for Aqueous Solutions

§ 261.21
(a) A solid waste exhibits the characteristic of corrosivity if a representative sample of the waste has either of the following properties:

(1) It is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using Method 9040C in “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,” EPA Publication SW–846, as incorporated by reference in §260.11 of this chapter.

Federal Register Notice


Letters/Memoranda

- INTERPRETATION OF "AQUEOUS" AS APPLIED TO THE CORROSIVITY CHARACTERISTIC
- “AQUEOUS” AS APPLIED TO THE CORROSIVITY CHARACTERISTIC
Regulations for Steel Corrosivity

§ 261.22(a)  
(2) It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55 °C (130 °F) as determined by Method 1010A in “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,” EPA Publication SW–846, and as incorporated by reference in §260.11 of this chapter.

Letters/Memoranda

- SW-846 TEST METHODS
- AGITATE SAMPLES EVALUATED USING METHOD 1110
- SPENT PICKLE LIQUOR CORROSIVITY

Regulations for the Hazardous Waste Number for Corrosivity

§ 261.22  
(b) A solid waste that exhibits the characteristic of corrosivity has the EPA Hazardous Waste Number of D002.


Letters/Memoranda

- CORROSIVITY CHARACTERISTIC AS IT APPLIES TO SOLIDS
- LAND DISPOSAL RESTRICTION INTERIM FINAL RULE
- PRECIPITATION WHICH IS CORROSIVE DUE TO CONTACT WITH EXEMPT WASTES (COAL GASIFICATION ASH)
• NITRIC ACID WASTE CHARACTERIZATION
• ELEMENTARY NEUTRALIZATION UNITS GENERATING AND STORING NON-CORROSIVE HAZARDOUS WASTES
• POLLUTION CONTROL SLUDGE FROM TREATMENT OF MINING WASTE - EXCLUSION
• CEMENT KILN DUST WASTE
• BATTERIES, WASTE ELECTROLYTE FROM RECHARGEABLE NICKEL-CADMIUM
• BATTERIES, SCRAP METAL, AND PRECIOUS METALS
• FOOD PROCESSORS, IMPACT OF HAZARDOUS WASTE REGULATIONS ON
• LIQUID, FREE LIQUID, RELEASABLE LIQUID DEFINITIONS
• REGULATORY STATUS OF LABORATORY WASTEWATER

General Resources for the Corrosivity Characteristic

• Background document for the Corrosivity Characteristic
• "Determination of Water in Waste Materials by Karl Fisher Titration." – Method 9000
• Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846) - Sampling Plan
• Determination of Water in Waste Materials by Quantitative Calcium Hydride Reaction; Method 9001
• Corrosivity Definition of Aqueous

Reactivity

The regulations for the hazardous characteristic of reactivity can be found at 40 CFR 261.23.

Regulations for Reactivity

§ 261.23
(a) A solid waste exhibits the characteristic of reactivity if a representative sample of the waste has any of the following properties:
It is normally unstable and readily undergoes violent change without detonating.

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**Regulations for Reactivity with Water**

§ 261.23(a)

(2) It reacts violently with water.

(3) It forms potentially explosive mixtures with water.

(4) When mixed with water, it generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.

**Letters/Memoranda**

- CHEMICAL AGENTS GB, VX, AND HD AT MUNITIONS DISPOSAL FACILITY
- REGULATION AND DISPOSAL REQUIREMENTS FOR SODIUM AZIDE

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**Regulations for Cyanide/Sulfide Reactivity**

§ 261.23(a)

(5) It is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.

**Letters/Memoranda**

- WITHDRAWAL OF CYANIDE AND SULFIDE GUIDANCE
- HAZARDOUS WASTE TESTING ISSUES

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**Regulations for Explosives**

§ 261.23(a)

(6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.

(7) It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.
(8) It is a forbidden explosive as defined in 49 CFR 173.51, or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.

Letters/Memoranda

- TRANSPORTATION AND DISPOSAL OF SHOCK SENSITIVE OR EXPLOSIVE MATERIALS
- DOT REGULATIONS REFERENCED IN THE RCRA REGULATIONS
- REGULATORY ISSUES PERTAINING TO WASTES CONTAMINATED WITH EXPLOSIVE RESIDUES
- REACTIVE WASTE - EXPLOSIVITY

Regulations for the Hazardous Waste Number for Reactivity

§ 261.23
(b) A solid waste that exhibits the characteristic of reactivity has the EPA Hazardous Waste Number of D003.

[45 FR 33119, May 19, 1980, as amended at 55 FR 22684, June 1, 1990]

Letters/Memoranda

Aerosols

- BUBBLER CANISTERS CONTAINING PHOSPHOROUS OXYCHLORIDE ARE NOT WASTE WHEN RETURNED TO THE UNITED STATES FROM JAPAN FOR REGENERATION
- REGULATORY STATUS OF WASTE AEROSOL CANS
- CLARIFICATION OF REACTIVITY CHARACTERISTIC AS IT PERTAINS TO AEROSOL CANS
- REGULATORY STATUS OF USED RESIDENTIAL AND COMMERCIAL/INDUSTRIAL AEROSOL CANS

Ammunition

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- SMALL ARMS AMMUNITION REACTIVITY, OFF SPECIFICATION
- CLARIFICATION OF DISCARDED AMMUNITION OF 0.50 CALIBER

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• REGULATORY STATUS OF SPENT/DISCARDED LITHIUM-SULFUR DIOXIDE BATTERIES
• WASTE CHARACTERIZATION: LITHIUM BATTERIES
• REGULATORY STATUS OF BATTERIES

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• CLASSIFICATION AND DISPOSAL OF UNUSED FLAMELESS RATION HEATERS
• APPLICABILITY OF RCRA TO DISPOSAL OF UNIFIED GROUP RATION - EXPRESS (UGR-E)
• STATUS OF WASTE HYDROGEN FREE RATION HEATERS (HRHs)

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• BLASTING CAPS AS REACTIVE WASTES
• DETONATING EXPLOSIVE WASTES
• DISCARDED CLASS C EXPLOSIVES

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• LEAKS, SPILLS, AND ILLEGAL DISCHARGES OF LISTED WASTES TO SURFACE WATERS, MIXTURE RULE APPLIED TO
• REGULATORY STATUS OF UNIT AND WASTE IF NONHAZARDOUS WASTE BECOMES REACTIVE WHEN DEWATERED
• RCRA HAZARDOUS WASTE DETERMINATION OF SPENT NUCLEAR REACTOR FUELS
• APPLICABILITY OF 40 CFR 261.5 TO K047
• DREDGE SEDIMENTS  (See Note 5)

Note 5:

§261.4(g) Exclusions

(g) Dredged material that is not a hazardous waste. Dredged material that is subject to the requirements of a permit that has been issued under 404 of the Federal Water Pollution Control Act (33 U.S.C.1344) or section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 U.S.C. 1413) is not a hazardous waste. For this paragraph (g), the following definitions apply:

(1) The term dredged material has the same meaning as defined in 40 CFR 232.2;

[45 FR 33119, May 19, 1980]
Federal Register Notice

- Military Munitions Rule
  62 FR 6622, February 12, 1997

General Resources for the Reactivity Characteristic

- Background document for the Reactivity characteristic

Toxicity

The regulations for the hazardous characteristic of toxicity can be found at 40 CFR 261.24.

Regulations for Toxicity

§261.24
(a) A solid waste (except manufactured gas plant waste) exhibits the characteristic of toxicity if, using the Toxicity Characteristic Leaching Procedure, test Method 1311 in “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,” EPA Publication SW–846, as incorporated by reference in §260.11 of this chapter, the extract from a representative sample of the waste contains any of the contaminants listed in table 1 at the concentration equal to or greater than the respective value given in that table. Where the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering using the methodology outlined in Method 1311, is considered to be the extract for the purpose of this section.

(b) A solid waste that exhibits the characteristic of toxicity has the EPA Hazardous Waste Number specified in Table 1 which corresponds to the toxic contaminant causing it to be hazardous.

Table 1 —Maximum Concentration of Contaminants for the Toxicity Characteristic

<table>
<thead>
<tr>
<th>EPA HW No.</th>
<th>Contaminant</th>
<th>CAS No.</th>
<th>Regulatory Level (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D004</td>
<td>Arsenic</td>
<td>7440–38–2</td>
<td>5.0</td>
</tr>
<tr>
<td>D005</td>
<td>Barium</td>
<td>7440–39–3</td>
<td>100.0</td>
</tr>
<tr>
<td>D018</td>
<td>Benzene</td>
<td>71–43–2</td>
<td>0.5</td>
</tr>
<tr>
<td>D006</td>
<td>Cadmium</td>
<td>7440–43–9</td>
<td>1.0</td>
</tr>
<tr>
<td>D019</td>
<td>Carbon tetrachloride</td>
<td>56–23–5</td>
<td>0.5</td>
</tr>
<tr>
<td>D020</td>
<td>Chlordane</td>
<td>57–74–9</td>
<td>0.03</td>
</tr>
<tr>
<td>D021</td>
<td>Chlorobenzene</td>
<td>108–90–7</td>
<td>100.0</td>
</tr>
<tr>
<td>D022</td>
<td>Chloroform</td>
<td>67–66–3</td>
<td>6.0</td>
</tr>
<tr>
<td>Code</td>
<td>Chemical</td>
<td>CAS Number</td>
<td>PPB</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>------------</td>
<td>-----</td>
</tr>
<tr>
<td>D007</td>
<td>Chromium</td>
<td>7440–47–3</td>
<td>5.0</td>
</tr>
<tr>
<td>D023</td>
<td>o-Cresol</td>
<td>95–48–7</td>
<td>1200.0</td>
</tr>
<tr>
<td>D024</td>
<td>m-Cresol</td>
<td>108–39–4</td>
<td>1200.0</td>
</tr>
<tr>
<td>D025</td>
<td>p-Cresol</td>
<td>106–44–5</td>
<td>1200.0</td>
</tr>
<tr>
<td>D026</td>
<td>Cresol</td>
<td></td>
<td>1200.0</td>
</tr>
<tr>
<td>D016</td>
<td>2,4-D</td>
<td>94–75–7</td>
<td>10.0</td>
</tr>
<tr>
<td>D027</td>
<td>1,4-Dichlorobenzene</td>
<td>106–46–7</td>
<td>7.5</td>
</tr>
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<td>D028</td>
<td>1,2-Dichloroethane</td>
<td>107–06–2</td>
<td>0.5</td>
</tr>
<tr>
<td>D029</td>
<td>1,1-Dichloroethylene</td>
<td>75–35–4</td>
<td>0.7</td>
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<td>D030</td>
<td>2,4-Dinitrotoluene</td>
<td>121–14–2</td>
<td>0.13</td>
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<tr>
<td>D012</td>
<td>Endrin</td>
<td>72–20–8</td>
<td>0.02</td>
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<tr>
<td>D031</td>
<td>Heptachlor (and its epoxide)</td>
<td>76–44–8</td>
<td>0.008</td>
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<tr>
<td>D032</td>
<td>Hexachlorobenzene</td>
<td>118–74–1</td>
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<td>D033</td>
<td>Hexachlorobutadiene</td>
<td>87–68–3</td>
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<tr>
<td>D034</td>
<td>Hexachloroethane</td>
<td>67–72–1</td>
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<td>D008</td>
<td>Lead</td>
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<td>D013</td>
<td>Lindane</td>
<td>58–89–9</td>
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<td>D009</td>
<td>Mercury</td>
<td>7439–97–6</td>
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<td>D014</td>
<td>Methoxychlor</td>
<td>72–43–5</td>
<td>10.0</td>
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<tr>
<td>D035</td>
<td>Methyl ethyl ketone</td>
<td>78–93–3</td>
<td>200.0</td>
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<td>D036</td>
<td>Nitrobenzene</td>
<td>98–95–3</td>
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<td>D037</td>
<td>Pentachlorophenol</td>
<td>87–86–5</td>
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<td>D038</td>
<td>Pyridine</td>
<td>110–86–1</td>
<td>5.0</td>
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<tr>
<td>D010</td>
<td>Selenium</td>
<td>7782–49–2</td>
<td>1.0</td>
</tr>
<tr>
<td>D011</td>
<td>Silver</td>
<td>7440–22–4</td>
<td>5.0</td>
</tr>
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<td>D039</td>
<td>Tetrachloroethylene</td>
<td>127–18–4</td>
<td>0.7</td>
</tr>
<tr>
<td>D015</td>
<td>Toxaphene</td>
<td>8001–35–2</td>
<td>0.5</td>
</tr>
<tr>
<td>D040</td>
<td>Trichloroethylene</td>
<td>79–01–6</td>
<td>0.5</td>
</tr>
<tr>
<td>D041</td>
<td>2,4,5-Trichlorophenol</td>
<td>95–95–4</td>
<td>400.0</td>
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<td>D042</td>
<td>2,4,6-Trichlorophenol</td>
<td>88–06–2</td>
<td>2.0</td>
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<tr>
<td>Hazardous waste number.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical abstracts service number.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If o-, m-, and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/l.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
• RULEMAKING PETITION FOR TRIVALENT CHROMIUM EXCLUSION
• PETITION PROCESS FOR THE TRIVALENT CHROMIUM EXCLUSION
• TOTAL CHROMIUM ANALYSIS

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• CCA TREATED WOOD WHEN DISPOSED
• WOOD MULCH DERIVED FROM WASTE LUMBER PRESERVED WITH CHROMATED COPPER ARSENATE (CCA)
• RECOMMENDATION ON THE DISPOSAL OF WASTE LUMBER PRESERVED WITH CHROMATED COPPER ARSENATE (CCA)
• CURRENT STATUS OF CCA-TREATED WOOD UNDER RCRA

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• TCLP PARTICLE SIZE REDUCTION EXEMPTION FOR MUNITIONS
• COMBUSTION PROHIBITION AND EXPLOSIVE WASTES

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• TCLP AND LEAD PAINT REMOVAL DEBRIS
• LEAD PAINT REMOVAL DEBRIS AND THE TCLP PROCEDURE
• RCRA APPLICABILITY TO PAINT REMOVAL WASTES
• INCORPORATION OF PRETOX 2000 INTO LEADED PAINT STRIPPER
• RECYCLING OF MOLDING AND CASTING SANDS
• LEACH TESTING PROCEDURE TO REMOVE LEAD-CONTAMINATED SOILS FROM RESIDENTIAL AREAS
• MANAGEMENT AND DISPOSAL OF WASTE VINYL MINI BLINDS
• PROPOSED TSCA 403 SOIL LEAD HAZARD AND OSWER'S LEAD-IN-SOILS POLICY

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- STATUS OF FLUORESCENT LAMPS UNDER RCRA
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- WASTE IDENTIFICATION OF DISCARDED THERMOMETERS

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- SAMPLING AND ANALYSIS OF MUNICIPAL REFUSE INCINERATOR ASH; Draft 05/15/1994
- GUIDANCE FOR THE SAMPLING AND ANALYSIS OF MUNICIPAL WASTE COMBUSTION ASH FOR THE TOXICITY CHARACTERISTIC; June 1995
- STATUS OF MUNICIPAL WASTE COMBUSTION ASH
- RESIDUES FROM MUNICIPAL WASTE RESOURCE RECOVERY FACILITIES; MUNICIPAL WASTE COMBUSTION RESIDUES-ASH AND SLUDGE
- MUNICIPAL WASTE COMBUSTION, DISPOSAL OF RESIDUAL ASH

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- TC RULE RELATIONSHIP TO USED OIL FILTER DISPOSAL
- APPLICABILITY OF THE TOXICITY CHARACTERISTIC TO USED OIL FILTERS
- TC RULE DELAY OF IMPOSITION ON OIL FILTERS
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- TCLP EXTRACTIONS AS THEY APPLY TO OILY WASTE
- QUESTIONS ON FINAL USED OIL RULE
- DILUTION OF TEST SAMPLING
- USED OIL USED FOR DUST SUPPRESSION OR ROAD TREATMENT
- CLARIFICATION OF THE USED OIL REGULATIONS APPLICABLE TO MIXTURES OF USED OIL AND CHARACTERISTIC WASTE
• REGULATORY REQUIREMENTS PERTAINING TO THE MANAGEMENT OF WASTE SOLVENTS AND USED OIL

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• DILUTION OF TEST SAMPLING
• EXEMPTION FROM PARTICLE SIZE REDUCTION STEP IN TCLP
• MATRIX SPIKE IN TCLP PROCEDURE
• ANALYSIS OF FLUFF MATERIALS
• GENERATOR HAZARDOUS WASTE DETERMINATION AND THE TCLP
• APPLICABILITY OF THE TCLP
• APPLICABILITY OF THE TOXICITY CHARACTERISTIC AND THE TCLP
• BIAS CORRECTION APPLIED TO THE TCLP
• TC RULE HAZARDOUS WASTE DETERMINATION
• SEMI-VOLATILE CONSTITUENT ANALYSIS AND ANALYTICAL LEVEL OF DETECTION LIMITATIONS OF THE TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)
• INTERPRETATION OF THE PHRASE "WHICH CAN BE REASONABLY EXPECTED TO BE PRESENT" FOR SOIL THAT EXHIBITS THE TOXICITY CHARACTERISTIC
• INAPPROPRIATE USE OF METHOD 1311 (TCLP) AS AN ALTERNATIVE EXTRACTION PROCEDURE
• REVISIONS TO THE TCLP
• SEMI-VOLATILE CONSTITUENT ANALYSIS AND ANALYTICAL LEVEL OF DETECTION LIMITATIONS OF THE TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)
• ENVIRONMENTAL FACT SHEET: EPA REVISES QUALITY ASSURANCE MEASURES FOR THE TOXICITY CHARACTERISTIC LEACHING PROCEDURE

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• CALCULATION OF TCLP CONCENTRATIONS FROM TOTAL CONCENTRATIONS
• BIOSOLIDS
• TOTAL CONCENTRATION USED TO DEMONSTRATE A WASTE DOES NOT EXHIBIT THE CHARACTERISTIC OF EP TOXICITY
• GENERATOR USE OF TOTAL CONSTITUENT ANALYSIS IN LIEU OF THE EP OR TCLP TESTS
• TOTAL CONSTITUENT ANALYSIS TO DETERMINE HAZARDOUS CHARACTERISTICS OF WASTE SAMPLE

• TOTAL WASTE ANALYSIS ON POTW BIOSOLIDS AND CERCLA LIABILITY

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• RESPONSE TO REQUEST FOR OPINION ON SECTION 21 PETITION ON BATTERY DEPOSITS

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• QC REVIEW OF PERMIT DATA

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• DESIGNATION OF AMERICIUM BERYLLIUM SOURCES UNDER RCRA

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• REGULATORY STATUS OF BRASS PARTICLES GENERATED IN THE BELTING AND BUFFING OF BRASS CASTINGS

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• PETROLEUM-CONTAMINATED MEDIA AND DEBRIS DEFERRAL FROM THE TOXICITY CHARACTERISTIC

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• SQG COMPLIANCE WITH TC RULE

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Appendix 2
19.1 General Provisions

A.19.1 Metal recycling facilities receive and process metals for the purposes of re-use or sale. Not all recycling facilities receive, process or handle combustible metals. Some recycling facilities receive, process and handle all combustible metals or metal only mixtures. Waste management facilities receive metal waste for the purpose of final disposal by incineration or other methods. Waste management facilities receive metal in all forms and concentrations including metal only mixtures and mixtures containing combustible metals as well as non combustible metals. Because recycling and waste management facilities vary in scope and scale, the combustible metal hazards vary due to differing process steps. Combustible metals may be delivered for disposal or recycling submerged in water or other fluids and still retain their hazardous properties. Recycling facilities handle and process metals in many forms, the vast majority of which are not reactive.

19.1.1 Retroactivity. The requirements of this chapter shall apply to new and existing recycling and waste management facilities that handle metals in combustible forms including metal only mixtures and mixtures containing metals.

19.1.2 A combustible metal or metal dust hazard shall be identified by testing in accordance with Chapters 4 and 5 prior to application of any of the provisions of this chapter.

19.1.3 For facilities recycling or providing treatment or disposal services, the requirements of Chapters 6 through 10 shall also apply.

19.2 Recycling and Waste Management of Combustible Metal - Collection, Storage, and Handling of fines generated during scrap receiving, storage, recycling and waste treatment.

19.2.1 Receiving Criteria. Incoming combustible material shall be inspected for acceptance criteria.

19.2.1.2 Acceptance criteria for combustible metals being recycled shall be established by the recycler. The acceptance criteria for recycled combustible metals shall include the following as a minimum:
   (1) Acceptable packaging
   (2) Forms
   (3) Identification/manifest (DOT shipping papers)
   (4) Required protection against foreign material
   (5) Identification and segregation of any radiation/contamination of materials
   (6) MSDS
   (7) Certificate of insurance
   (8) Authorized signature of acceptance of material
   (9) Internal quality control procedures
   (10) Incoming material analysis plan
   (11) Non-conforming material plan

19.2.1.3 Acceptance criteria for combustible metals offered for waste disposal shall be established by communication between the generator and waste disposal facility and shall include the following as a minimum:
   (1) Acceptable packaging
   (2) Waste profile specifying the form of the material and any changes in form or concentration from previous shipments
   (3) Waste Analysis Plan
   (4) Identification and concentration range of constituents
   (5) Required protection against physical hazards including combustibility, pyrophoric and water reactivity
   (6) Identification and segregation from incompatible materials if stored
   (7) MSDS
   (8) Non-confirming material plan

19.1.2.1.4 The acceptance criteria shall be documented and available for review by the AHJ.

19.2.2 Rejected Material

19.2.2.1 Combustible metal only and mixtures containing combustible metals that cannot be stored, handled, or processed by the receiving facility shall be rejected.
19.2.2.2 Rejected material shall be returned to the supplier or generator within 5 working days or engineering controls or alternate methods for the safe disposal of the rejected material shall be implemented in accordance with local, state, and federal regulations.

19.2.2.3 Rejected material shall be labeled and segregated in an area identified for storage of rejected or non-conforming material, in accordance with the non-conforming materials plan.

19.3 Storage of Combustible Metals for Recycling and Waste Management

19.3.1 Combustible metal only mixtures, mixtures containing combustible metals and materials that can potentially produce combustible metal or metal dust as a result of normal handling shall include provisions for the handling of any possible resulting metals as defined in this section.

19.3.2* Containers and areas where combustible metals are stored shall be labeled or identified as to the type of metal stored, form of metal, and date of receipt.

A.19.3.2 Storage in waste management facilities are typically short term depending on the disposal process. Depending on the process capacity of the recycling facility, storage may be short or long term.

19.3.3 A tracking system shall be implemented for inventory control and shall include the following:
1. Type and form of combustible metal
2. Storage location
3. Date of receipt
4. Other hazards including but not limited to reactivity with water, pyrophoric and compatibility

19.3.4 The tracking records shall be available for inspection by the authority having jurisdiction.

19.3.5 Area and container labels or identification shall reference the appropriate material safety data sheets (MSDSs) on file.

19.3.6 Buildings used for the indoor storage of combustible metal shall be of noncombustible construction and shall meet the requirements of 18.2.1. (Other Metals Chapter)

19.3.7 Solid combustible metals, such as clippings and castings, shall be stored in noncombustible bins or containers.

19.3.8 Combustible metals shall be separated from other combustible materials that would provide additional fuel in the event of a fire such as wood pallets and corrugated cardboard.

19.3.9 The storage of oily rags, packing materials, and similar combustibles shall be prohibited in storage bins or areas that store solid recycled combustible metal.

19.3.10* Combustible metals delivered for recycling or waste disposal that are stored on-site shall be identified as wet or dry.

A.19.3.10 Some combustible metals completely submerged in water are difficult to ignite but may burn more intensely if ignition occurs.

19.3.2 Dry Combustible Metals Storage. Combustible metals in a dry condition shall be kept in covered steel or other noncombustible containers and shall be kept in such manner or locations that they will not become wet.

19.3.2.1 Buildings used for storage of dry combustible metal shall be well ventilated to avoid the accumulation of hydrogen in the event that the combustible metal becomes wet.

19.3.2.2 When the recyclable or waste material has the potential for water reactivity because of the specific combustible metal content, provisions shall be made to keep it dry.

19.3.2.3 Outside storage of dry combustible metals shall be permitted if such storage is separated from buildings or personnel.

19.3.2.4 Storage of dry combustible metals in quantities greater than 1.4m^3 (50ft^3) [six 208 L drums (six 55 gal drums)] shall be kept separate from other occupancies by fire-resistant construction or by an open space of at least 15m (50ft).

19.3.2.5 Quantity Separation Distance (reserved)

19.3.3 Wet Combustible Metals Storage.
19.3.3.1 Wet combustible metals shall be stored at an outside location identified for that use.

19.3.3.2 Open flames and sparks shall be kept 15 m (50 ft) away from the container unless a hot-work permit allows an open flame within 15 m (50 ft).

19.3.3.3 * Combustible metals that are received wet shall be kept under water in a covered and vented container.

19.3.3.4 Containers of wet combustible metals shall not be stacked.

19.3.3.5 **Quantity Separation Distance (reserved)**

19.4 Container Limits.

19.4.1 Where drums or other containers are used for storage of dry combustible metals, storage shall be limited to a height that would require no more than three movements using available equipment to remove a stack, and no stack shall exceed 3.1 m (10 ft) in height.

19.4.2 The maximum weight of any material container and/or pallet shall be capable of being moved by the available equipment.

19.4.3 Stacked storage shall be arranged to ensure stability.

19.4.3.1 Aisles shall be provided for maneuverability of material handling equipment, for accessibility, and to facilitate firefighting operations.

19.5 Sample Identification and Collection for Metals in a Combustible Form

19.5.1 When the combustibility of a metal or mixture is not known or reported on the waste manifest sheet, the metal shall be tested as specified in Chapter 4 to determine whether it is a combustible metal.

19.5.2 For waste disposal, the waste manifest shall disclose the type of metal(s) by name and if they are in a combustible form.

19.5.3* In recycling facilities where combustible metals are processed, samples shall be collected that represent a “worst case” scenario.

A.19.5.3 Recycling involves open handling and processing of material. Dust generating processes include but are not limited to re-melt and casting; alloying molten metal; washing; scrap chopping, conveyance, shredding, handling and sawing; etc. Sampling strategies should consider collection of samples from different heights within the plant where dust is generated because lighter, small particle size dust tends to collect higher in the structure.

19.5.4 Each site shall develop a sampling strategy and protocol to ensure that samples are collected in all areas where combustible metals and metal dust can reasonably be assumed to be present. The following shall be considered in developing the sampling strategy:

19.5.5 Samples collected shall be promptly submitted for testing as dust tends to oxidize over time.

19.6* Personal Protective Equipment (PPE).

A.19.6 The use of eye, head, and respiratory protection (e.g., face shields, safety glasses, and hard hats) is recommended and should be determined by a PPE hazard assessment, as required by the Occupational Safety and Health Administration (OSHA).

19.6.1 Outer clothing shall be clean and flame-retardant where combustible metals and metal dust have been determined to be present.

19.6.2 All personnel in an identified combustible dust environment shall wear long sleeve shirts, long pants and gloves made of flame-retardant material.

19.6.3 The flame-retardant garments shall be in accordance with NFPA 2112 – “Flame-Resistant Garments for Protection of Industrial Personnel against Flash Fire”, or equivalent standard.
19.6.4 PPE intended for use in explosive atmospheres must be so designed and manufactured that it cannot be the source of an electric, electrostatic or impact-induced arc or spark likely to cause an explosive mixture to ignite.

19.6.5 Tightly woven, smooth fabrics treated with a flame-retardant chemical and from which dust can readily be brushed shall be used if necessary.

19.6.6 Non-Flame Retardant disposable coveralls and other non-flame retardant disposable garments shall not be worn by personnel engaged in cleaning of combustible dust.

19.6.7 Where molten metal hazards exist, garments shall be protective for molten metal splash.

19.7* Clothing Fires

A.19.7.1 Fire blankets have been found to be effective for extinguishing clothing fires. They should be distributed in areas where water is excluded from the plant area.

19.7.1 Emergency procedures for handling clothing shall be established.

19.8 Reactivity.

19.8.1 It shall be the responsibility of the recycling and waste management facilities to evaluate processes and materials for potentially dangerous reactions that could occur in the course of their operations.

19.8.2 Contact with Water.

19.8.2.1* Water leakage inside or into any building where the water can contact metal-reactive materials shall be prevented to avoid possible spontaneous heating.

A.19.8.2.1 The reaction of water and aluminum powder produces hydrogen. Hydrogen is extremely flammable and very easy to ignite. It should not be trapped in nonventilated areas of buildings, equipment, or enclosures.

19.9.3 Thermite Reaction.

A.19.9.3.1* Caution shall be exercised in the mixing of metal fines and metal oxides [e.g., iron oxide (rust)].

A.19.9.3.1 Thermite reactions are extremely exothermic [e.g., temperatures in excess of 2204°C (4000°F)]. A thermite reaction typically occurs between one metal oxide and another metal that reduces that oxide. The main concern is for iron oxide and fine aluminum particulate, especially powder, although there are documented instances of aluminum grinding fines initiating such a reaction. The thermite reaction is not necessarily limited to aluminum and iron oxide. There have been recorded incidents where copper oxide and/or lead oxide in contact with aluminum have created the conditions for a thermite reaction. Once initiated via a heat source, a thermite reaction is vigorous and should be treated as a metal fire.

19.10* Management of Change.

A.19.10.1 It is essential to have thorough documentation, as the slightest changes to procedures, processes, and/or equipment, including those from suppliers, can have a dramatic impact on the overall hazard analysis. Change includes something as benign as process materials replacements-in-kind from a different manufacturer, same manufacturer using new methods to produce the product, or changes in formulation. These changes from a supplier’s end can impact the characteristics of the processes and/or materials.

19.10.1 The requirements of 19.10.2 through 19.10.5 shall apply to new and existing facilities and processes.

19.10.2 Written procedures shall be established and implemented to manage a proposed change to process materials, technology, equipment, procedures, and facilities.

19.10.3 The procedures shall ensure that the following are addressed prior to any change:
(1) The technical basis for the proposed change
(2) Safety and health implications, including hazard analysis
(3) Whether the change is permanent or temporary
(4) Modifications to operating and maintenance procedures
(5) Employee training requirements
(6) Authorization requirements for the proposed change
(7) Results of characterization tests used to assess the hazard, if conducted

19.10.4 Implementation of the management of change procedure shall not be required for replacements-in-kind.

19.10.5 Design documentation shall be updated to incorporate the change.

19.11 Facility Design Requirements

19.11.1 Building Construction

19.11.1.1 Location of Recycling and Waste Management Facilities.

19.11.1.1.1 A hazards analysis shall be conducted to determine the minimum separation distance for individual buildings and operations within recycling and waste management plants.

19.11.1.1.2 All buildings used for the processing, packing, or loading for shipment of recyclable materials shall be constructed of noncombustible materials throughout and shall have non-load-bearing walls.

19.11.1.1.3 Where dust is present, the buildings specified in 19.11.1.2 shall be designed so that all internal surfaces are readily accessible, to facilitate cleaning.

19.11.1.1.4 Where dust is present, all walls of areas where fugitive dust can be produced shall have a smooth finish and shall be sealed so as to leave no interior or exterior voids where combustible metal dust can infiltrate and accumulate.

19.11.1.1.5 The annuli of all pipe, conduit, and ventilation penetrations shall be sealed.

19.11.1.1.6 Floors shall be hard surfaced and shall be installed with a minimum number of joints in which metal dust can collect.

19.11.1.1.7 The requirements of 19.11.1.4 shall also apply to elevated platforms, balconies, floors, and gratings.

19.11.1.1.8 Roofs of buildings that house combustible metal dust–producing operations shall be supported on girders or structural members designed to minimize surfaces on which dust can collect.

19.11.1.1.9* Interior surfaces where combustible metal dust accumulations can occur shall be designed and constructed to facilitate cleaning and to minimize combustible dust accumulations.

A.19.11.1.9 Where surfaces on which dust can collect are unavoidably present, they can be covered by a smooth concrete, plaster or noncombustible mastic fillet having a slope sufficient to prevent accumulation. An angle greater than the angle of repose is recommended.

19.11.1.1.10 Where surfaces on which combustible metal dust can collect are unavoidably present, they shall be covered by a smooth concrete, plaster, or noncombustible mastic fillet having a minimum slope of 55 degrees to the horizontal.

19.11.1.1.11 Roof decks and basements shall be watertight.

19.11.1.1.12 Explosion venting in accordance with NFPA 68, Standard on Explosion Protection by Deflagration Venting, shall be provided for buildings where metal powders are processed.

19.11.1.1.13 Deflagration venting shall not be required for areas where combustible metals are stored or moved only in covered or sealed containers.

19.11.1.1.14 Door and Window Construction.

19.11.1.1.14.1 All doors in interior fire-rated partitions shall be listed self-closing fire doors, installed in accordance with NFPA 80, Standard for Fire Doors and Other Opening Protectives.


19.11.1.15 Enclosed Passageways.

19.11.1.1.15.1 Where buildings or process areas are interconnected by enclosed passageways, the passageways shall be designed to prevent propagation of an explosion or fire from one unit to another in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

19.11.1.1.15.2 All enclosed passageways that connect with one or more processing areas shall be provided with means of egress in accordance with NFPA 101, *Life Safety Code*.

19.11.1.1.16 Grounding and Lightning Protection.

19.11.1.1.16.1* All process equipment and all building steel shall be bonded and grounded in accordance with NFPA 70, *National Electrical Code*.

*A.19.11.1.16.1 For information on static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

19.11.1.1.16.2 All buildings shall be provided with a lightning protection system in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems*.

19.11.1.1.16.3 Lightning protection systems shall not be required for office buildings and buildings that are used for storage and handling of closed containers.

19.11.1.1.17 Heating and Cooling of Production Buildings.

19.11.1.1.17.1 Buildings shall be permitted to be heated by indirect hot-air heating systems or by bare-pipe heating systems using steam or hot water as the heat transfer medium, or by listed electric heaters.

19.11.1.1.17.2 Indirect hot air shall be permitted if the heating unit is located in an adjacent room or area that is free of combustible dust.

19.11.1.1.17.3 Fans or blowers used to convey heated or cooled air shall be located in an area that is free of combustible dust.

19.11.1.1.17.4 The air supply shall be taken from outside or from a location that is free of combustible dust.

19.11.1.1.17.5 Makeup air for building heating or cooling shall have a dew point low enough to ensure that no free moisture can condense at any point where the air is in contact with combustible metal dust or powder.

19.11.1.1.17.6 The requirements of 19.2.1.1.17.1 through 19.2.1.1.17.5 shall not apply to areas where combustible metal is melted.

19.11.2 Fire Protection.

19.11.2.1 Fire protection shall be in accordance with Chapter 6 (Fire Protection and Prevention).

19.11.3 Electrical Classification.

19.11.3.1 For electrical classification shall be in accordance with Chapter 8 (Electrical).

19.11.3 Hazard Analysis.

19.11.3.1* The design of the fire and explosion safety provisions shall be based on a hazard analysis of the facility, the process, and the associated fire or explosion hazards.

*A.19.11.3.1 One method by which this requirement can be satisfied is with a hazard analysis conducted in accordance with the methods outlined by the AIChE Center for Chemical Process Safety in “Guidelines for Hazard Evaluation Procedures.”

19.11.3.2 The results of the hazard analysis shall be documented and maintained for the life of the process.

19.11.3.3 The hazard analysis shall be reviewed and updated at least every 5 years.

19.11.3.4 New and/or altered operations, equipment, and/or facilities shall be reviewed prior to operation for potential hazards.
19.11.3.5 Written records shall be maintained of all hazard analyses.

19.11.3.6 Hazard analyses shall be signed off on, prior to operation, by a knowledgeable authority at the facility.

19.11.3.7 Appropriate safeguards shall be put in place with regard to findings of the hazard analysis.

19.11.3.8 Corrective actions as a result of the hazard analysis shall be tracked and completed to ensure that all identified hazards have been abated or the level of risk has been reduced to an acceptable level by a knowledgeable authority.


19.12.1 Procedures.

19.12.1.1 Emergency procedures shall be established to address fire and explosion events in accordance with 7.4 and 7.5.

19.12.1.2 The emergency procedures shall be documented.

19.12.1.3 In cases were a process hazard analysis indicates that application of low velocity water may be beneficial for the preservation of life and/or property, the provisions of 6.3.3.5 shall be superseded. If the determination is made to apply low velocity water to a fire, the following guidelines shall be observed:
(A) Care should be taken to prevent the formation of a dust cloud
(B) Area should be determined to be well ventilated, and/or ventilation should be maximized prior to water application, in order to prevent the accumulation of hydrogen gas.
(C) After extinguishment, the area should be cleaned of all wetted powder, paste or slurry, and ventilation should be continued throughout this process.


A.19.12.2 See Chapter 6 (Fire Protection) for detailed requirements.

19.12.2.1 All employees shall be trained in the emergency procedures and the hazards of combustible metals.

19.12.2.2 Training shall be documented and available for inspection by the authority having jurisdiction.

19.13 Processing.

19.13.1 Control of ignition sources shall be in accordance with the requirements of 6.2.3.

19.13.1.1 Recyclers and waste generators or waste brokers shall determine the combustibility/ explosivity characteristics of any waste, by-product, intermediate or final material generated as a result of on-site processing.

19.13.1.1* Documentation of the determination in 19.13.1.1 shall be maintained and available for review by the authority having jurisdiction.

A.19.13.1.1 The same metal can be combustible or not combustible, depending on the size or form of the material. During recycling operations, a metal can be converted into a combustible metal through size reduction, separation, or other processes. Processing can include the following:
(1) Size reduction
(2) Melting
(3) Compacting
(4) Briquetting
(5) Washing
(6) Grinding

19.13.1.2 For all processing of recycled combustible metals for which there are specific chapters, the requirements of those chapters shall apply in addition to the requirements of Chapter 19 (Recycling and Waste Management).
19.13.1.3 For all other recycled combustible metal and alloy processing, the requirements of Chapter 14 shall also apply.
19.13.1.4 Combustible or flammable liquids resulting from recycling of combustible metals shall be handled and stored in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

19.13.1.5 Hazardous materials resulting from recycling of combustible metals shall be handled and stored in accordance with local, state, and federal regulations and NFPA 1, *Fire Code*.

19.13.1.6 Sumps and trenches in manufacturing and process areas should be cleaned at the end of the work shift to prevent accumulation of fines and incompatible materials.

19.13.2 Machining and Operations.

19.13.2.1 Requirements for Machinery.

19.13.2.2 All combustible metal dust–producing machines and conveyors shall be designed, constructed, and operated so that fugitive dust is minimized.

19.13.2.3 All machinery and equipment shall be installed in accordance with NFPA 70, *National Electrical Code*.

19.13.2.4* All machinery shall be bonded and grounded to minimize accumulation of static electric charge.

*For information on static electricity, see NFPA 77, *Recommended Practice on Static Electricity.*

19.13.2.5 Bearings.

19.13.2.5.1* Ball or roller bearings shall be sealed against dust.

*Journal bearings should not be used because of the difficulty of maintaining proper lubrication to prevent overheating. Outboard bearings are used where practicable because it is easier to check for overheating. In those instances where dust tends to penetrate bearings, a continuous flow of inert gas (1 ½ percent to 5 percent oxygen) can be employed to pressurize the bearings and seals.*

19.13.2.5.2 Where exposed bearings are used, the bearings shall be protected to prevent ingress of combustible metal and metal dust and shall have a lubrication program.

19.13.2.5.3 Clearances between moving surfaces that are exposed to paste, powder, or dust shall be maintained to prevent rubbing or jamming.

19.13.2.5.4 Permanent magnetic separators, pneumatic separators, or screens shall be installed ahead of mills, stamps, or pulverizers where there is any possibility that tramp metal or other foreign objects can be introduced into processing related operations.

19.13.2.5.5 Startup Operations. All areas of processing machinery that will be in contact with combustible metal materials shall be free of foreign objects, foreign material and water before being placed in operation.

19.13.3 Transfer Operations.

19.13.3.1* Operations involving the transfer of combustible metals or metal dusts or powders from one container to another shall be designed and operated to protect personnel, equipment, and buildings from the fire or dust explosion hazard produced by airborne suspensions of metals in a combustible form.

*See Figure A.8.6.4.1(a) and Figure A.8.6.4.1(b) for examples of dust collection at bag dump stations. Figure A.8.6.4.1(a) Example of Unacceptable Manual Bag Dump Station in Which Operator Is Exposed to Potential Fire or Explosion.*

19.13.3.2 The container shall be grounded and bonded and non sparking tools shall be used.

19.13.3.2 Equipment producing metal in a combustible form shall be permitted to be used for other materials only when the system is thoroughly cleaned of all incompatible materials prior to and after its use.

19.13.5 Electrical Equipment.

19.13.5.1 All electrical wiring and equipment shall be in accordance with Chapter 8.
19.13.6 Chip Processing. (Reserved)

19.13.7 Machining and Sawing Operations.

19.13.7.1* Cutting tools shall be of proper design and shall be kept sharp for satisfactory work with the metal being processed.

A.19.13.7.1 If a sufficient coolant flow is not used, improperly designed or dull tools can produce high temperatures at the tool–workpiece interface, potentially causing ignition of the turnings.

19.13.7.2* Sawing, grinding, and cutting equipment shall be grounded.

A.19.13.7.2 For information on bonding and grounding, see NFPA 77, Recommended Practice on Static Electricity.

19.13.8 Coolant.

19.13.8.1 Nonflammable coolants shall be used for wet grinding, cutting, or sawing operations.

19.13.8.2 The coolant shall be filtered on a continuous basis, and the collected solids shall not be allowed to accumulate in quantities greater than 19 L (5 gal) and shall be removed to a safe storage or disposal area.

19.13.9 Dust Collection.

19.13.9.1 Dust Collection shall be in accordance with Chapter 9.

19.14 Fire and Explosion Prevention.

19.14.1 The requirements of Chapter 6 shall apply.


19.14.2.1. The requirements of Chapter 7 (Housekeeping) shall apply.

19.15 Control of Metals in a Combustible from Finishing Operations.

19.15.1. It shall be permissible to use an open top container to collect metal chips, lathe turnings and swarf if the container is grounded and has shelter to prevent water entrainment.

19.15.2 If the containers collecting metal chips, lathe turnings and swarf are to be sent for disposal, the specific metal and form of the waste shall be documented.

19.16 Inspection, Maintenance, and Training.

19.16.1 Regular inspections shall be conducted to detect the accumulation of excessive metals in a combustible form on any portions of buildings or machinery not regularly cleaned in daily operations.

19.16.2 Records shall be kept of the inspections conducted in 19.16.1.
Appendix 3
Safe Storage and Handling of Swimming Pool Chemicals

The Environmental Protection Agency (EPA) is issuing this Alert as part of its ongoing effort to protect human health and the environment by preventing chemical accidents. We are striving to learn the causes and contributing factors associated with chemical accidents and to prevent their recurrence. Major chemical accidents cannot be prevented solely through regulatory requirements. Rather, understanding the fundamental root causes, widely disseminating the lessons learned, and integrating these lessons learned into safe operations are also required. EPA publishes Alerts to increase awareness of possible hazards. It is important that facilities, State Emergency Response Commissions (SERCs), Local Emergency Planning Committees (LEPCs), emergency responders, and others review this information and take appropriate steps to minimize risk. This document does not substitute for EPA's regulations, nor is it a regulation itself. It cannot and does not impose legally binding requirements on EPA, states, or the regulated community, and the measures it describes may not apply to a particular situation based upon the circumstances. This guidance does not represent final agency action and may change in the future, as appropriate.

Problem

Pool chemicals may become a hazard when they become wetted by a small quantity of water or when they are improperly mixed, such as with other chemicals or reactive materials. Although the potential hazards of swimming pool water treatment and maintenance chemicals, also referred to as "pool chemicals," have been recognized for some time, news media reports over the last five years still show a significant number of fires, toxic vapor releases, and personnel injuries in which pool chemicals were a factor (See Table 1).

A number of the pool chemicals, especially those exhibiting oxidation properties, can potentially be highly reactive and capable of generating high temperatures, as well as releasing toxic vapors if improperly handled or stored. Reactivity may be triggered by water wetting the chemical, or by the inadvertent mixing of a pool chemical with an incompatible material. Some pool chemicals are self-reactive over time, even without moisture addition or mixing with other materials. The products of this decomposition may include chlorine gas which may cause the corrosion of piping and other metal equipment in poorly ventilated areas. These chemicals are packaged in "breathable" containers to avoid pressure buildup while in storage.

A partial listing of pool chemicals includes chlorinated isocyanurates, lithium hypochlorite, sodium bicarbonate, potassium monopersulfate, hydrogen peroxide, sodium hypochlorite, calcium hypochlorite, and certain ammonium, brominated, copper and silver compounds, and muriatic acid. Pool chemicals involved in fire or toxic vapor release are likely to include those that add chlorine or a chlorine ion to the pool water for bacterial control. Chemicals that release chlorine are among the group of chemicals that are classified as oxidizers. These pool oxidizer chemicals include calcium hypochlorite, sodium hypochlorite, and chlorinated isocyanurates. Other pool chemicals are used to control the growth of algae or fungus, to adjust the acidity or alkalinity (pH control), and to clarify pool water.

Large, nonresidential pools may use chlorine stored as a liquid under pressure in metal containers. The Chlorine Institute, Inc. and the Occupational Safety and Health Administration (OSHA) provide guidance on the operation of pressurized chlorine systems (see Information Resources section of this Alert).
Hazard Triggers

The purpose of this Alert is to provide guidance associated with normal operating conditions and routine tasks for storage and handling of pool chemicals. It does not address the precautions to be taken by first responders in case of a fire, a large spill, or the release of toxic vapors.

Wetting: Under normal circumstances, pool chemicals are intended to be added to large quantities of water. If, instead, a limited volume (amount) of water is added to a chemical, an unwanted reaction may occur, resulting in an increase in temperature and the release of toxic gas. Even a small amount of water splashed on the chemical may in some cases trigger a strong reaction. The main exception to this rule concerning water addition is when very large quantities of water are needed for fire fighting, as discussed below. Although the chemicals are usually packaged in plastic bags that are stored in sturdy cartons or drums, accidents have occurred when water leaked into damaged or open containers.

Possible sources of water entry have been traced to:
- Rain water from a roof leak or from an open or broken window;
- Wet floor when the stored chemicals were not elevated off the floor;
- Leakage from fire suppression sprinkler system; or
- Hose-down water generated during area cleanup.

There are other sources of water that may come in contact with pool chemical packages, including high humidity in summer weather. However, the effects of humidity are more likely to be slow-acting, with the rate of temperature buildup and chlorine gas release being less severe.

Chlorine is corrosive to metals such as steel and copper. Instances have been reported where exposed water piping has become corroded causing leaks, and also where metal storage shelves have corroded and collapsed, leading to chemical spillage.

Improper Mixing: The most common pool chemicals are inherently incompatible with each other. Intentional or accidental mixing of incompatible chemicals is likely to lead to a chemical reaction that may generate temperatures high enough to ignite nearby combustible materials. Mixing can also lead to the release of highly toxic and corrosive chlorine gas. Reactions have also been traced to the mixing of old (partially decomposed) and new chemicals of the same type. The mixing of pool chemicals with completely unrelated materials such as swept material from the floor, oily rags, and other miscellaneous materials have been known to cause strong reactions with the potential for a resulting fire.

Improper chemical mixing incidents have occurred when:
- Tools and equipment used to handle one chemical were used with a different chemical before being cleaned;
- Spilled substances (e.g., from damaged containers or from sloppy handling) and other miscellaneous substances on floors were swept up together and mixed; and
- Containers, residues, or wastes are disposed resulting in inadvertent mixing in disposal containers or at waste disposal sites.

Liquid chemicals, such as sodium hypochlorite (bleach), if spilled, can leak into other containers or seep into cracks in the floor. Liquids, because of their properties, can create hazards not associated with solid or granular products and must be carefully handled.

Hazard Control

Facility management is responsible for knowing and understanding the hazards associated with these chemicals and ensuring that pool chemicals are safely stored and handled. Hazardous substances are capable of being safely handled day-after-day through a management system that ensures that good, written procedures are prepared, posted, and followed by trained employees. Also, the facility needs to be properly designed and maintained.

Finally, facility management should very carefully plan for emergencies and work with first responders to mitigate incidents that occur.

Recommendations for addressing the major hazards associated with pool chemicals are described below.

Keep Pool Chemicals Dry. Facility management should design and maintain designated areas for pool chemical storage so that water does not come in contact with containers or packaging.

Any evidence of potential water entry from the following possible sources should receive prompt corrective attention:
• Roof, windows, and doors;
• Wall and floor joints;
• Water pipes or hoses and sprinkler systems; and
• Drains.

You should look for ways to prevent water contact with stored pool chemicals such as:
• Close containers properly;
• Cover opened or damaged packaging;
• Store chemicals away from doors and windows;
• Ensure that there are no roof leaks, open or broken windows, or leaks from water pipes, hoses, or the sprinkler system;
• Ensure that floors are sloped to keep water drained away;
• Store chemicals on shelves or pallets to keep containers off the floor;
• Use waterproof covers on packaging;
• Exercise particular caution to prevent water contact with stored chemicals any time water is used for cleanup of floor areas near stored packages; and
• Ensure that water will not back up from faulty or clogged floor drains.

Avoid Chemical Mixing. You should conduct a review of chemical storage arrangements and chemical handling tasks to identify situations where chemicals could be intentionally or accidentally mixed:

• Separate incompatible substances; avoid storing containers of liquids above containers of other incompatible substances;
• Do not mix old chemicals with fresh chemical, even if they are the same type;
• Consider separate, designated tools for each chemical. Handle only one chemical at a time and make sure that tools used with one substance are not used with another unless all residues are removed;
• Use separate, designated containers for cleanup of spilled materials to avoid inadvertent mixing of spilled substances. Consult your local hazardous waste disposal facility for more detailed information on proper waste disposal; and
• Make chemical storage area housekeeping a priority. Don’t allow rags, trash, debris, or other materials to clutter hazardous material storage area. Keep combustible and flammable substances away.

For storage and handling of large quantities, see the American Chemistry Council (formerly the Chemical Manufacturers Association) Guidelines in the Safe Transportation, Handling, and Storage of Dry Chlorinated Pool Chemicals - 2001 and the Recommended Reading section of this Alert, for guidance on stack height and separation of different chemical types and separation of oxidizers from combustibles.

Fire Prevention. Facility management should prevent a chemical reaction ignition by avoiding wetting or mixing chemicals as described above.

Avoid having combustible or flammable materials near the chemicals, particularly gasoline, oil, paint solvents, oily rags, etc. Do not allow ignition sources, such as gasoline, diesel, or gas powered equipment such as lawn mowers, motors, or welding machines, in the storage area. Also, do not allow smoking in the storage area. Review bulk storage, including packaging and storage locations, relative to potential for accidental contact with water, including sprinkler systems, rainwater, etc.

Emergency Response and Fire Fighting. Facility management should work with local first responders (fire departments, emergency medical teams) and the LEPC on emergency response and fire fighting. LEPC contact information can be found at the website listed in the Other Useful Websites section. The Recommended Reading section provides sources of information on fire prevention and fire fighting associated with pool chemicals.

Note also that once started, fires involving pool chemicals are difficult to attack. Keep in mind that:
• Do not use dry chemical or halon-type fire extinguishers where chlorine gas may be evolving. These agents react negatively with chlorine.
• In extinguishing a fire, only large volumes (copious flow) of water should be applied and then only by persons trained in chemical fire response. Caution must also be exercised to protect against wildlife damage due to contaminated water runoff.
• Large quantities of water should be applied to the burning combustibles to remove heat and for fire intensity control.
• Once started, the reaction of wetted or mixed chlorinated pool chemicals may continue generating heat, unless the material is cooled below its heat of reaction temperature or until all chlorine is used.
Protective Measures

Pool chemicals can cause injury if they directly contact a person's skin, eyes, or respiratory or digestive system. The chemical will immediately react when wetted by perspiration, tears, mucus, and saliva in the nose, throat, and respiratory and digestive systems. Such injuries may occur from direct chemical contact with the skin or if chemical dust in the air contacts eyes, is inhaled, or settles on food that is consumed.

Protect Employees from Exposure. Consult the chemical manufacturer's safety instructions as well as the Material Safety Data Sheets (MSDSs) for guidance on the appropriate personal protective equipment (PPE) necessary to protect your employees. Also, share MSDSs with local emergency medical responders and practitioners.

The following protective measures address conditions that may arise during normal operations or the execution of routine tasks. If, however, additional information is needed for fire, spill, or release intervention, we suggest that you contact the LEPC (see Other Useful Websites).

See that PPE is kept clean, in proper operating condition, and available for use when needed and that the following practices are observed:

Use basic PPE including, as a minimum, chemical goggles and liquid impervious gloves, and boots for any chemical handling activities.

For frequent or extended chemical handling activities, add a face shield and liquid impervious apron or coveralls to the basic PPE.

As a minimum, use a National Institute for Occupational Health and Safety (NIOSH) approved air-purifying respirator, when airborne chemical dust or mist may be present. 29 CFR 1910.134 Respiratory Protection covers the OSHA requirements for respiratory protection.

For additional information on proper selection and use of PPE, consult the OSHA regulatory standards.

In addition:
- Provide a means of ready access to water (e.g., safety showers, eye wash stations, etc.) for removal of chemicals that may accidentally contact employees;
- Consider appropriate first aid and coordinate with local first responders and medical professionals for treatment of accidental exposure until professional medical treatment can be provided;
- Avoid accidental ingestion by storing and consuming foods and beverages away from chemical storage and handling locations, and ensure that employees wash before eating, drinking, etc.; and post the numbers for the local emergency responders, and medical practitioners that are familiar with the appropriate treatment for the chemical present.

Information Resources

Recommended Reading

The American Chemistry Council has several guidelines:

Guidelines in the Safe Transportation, Handling, and Storage of Dry Chlorinated Pool Chemicals - 2001 combines and supercedes the 1995 editions of the Guidelines for Safe Handling and Storage of Calcium Hypochlorite and Chlorinated Isocyanurate Pool Chemicals and Guidelines for Safe Transportation of Calcium Hypochlorite and Chlorinated Isocyanurate Pool Chemicals. This publication discusses product nomenclature; incompatibilities, hazards, and characteristics; storage; processing guidelines; personal protective equipment; first aid; emergency procedures; handling minor spills; do’s and don’ts and emergency telephone numbers. This very clear and comprehensive publication is also available from a number of Chlorinated Pool Chemical (CPC) Panel member companies. It is strongly recommended reading for those responsible for storage and handling of pool chemicals.

American Chemistry Council
1300 Wilson Boulevard
Arlington, VA 22209
Website: www.americanchemistry.com
The National Fire Protection Association (NFPA) has a bulletin for pool chemicals and a code for safe storage of liquid and solid oxidizers:

NFPA Alert Bulletin – Pool Chemicals – 1998, 4 pages – prepared for the fire services and others in order to raise their awareness of hazards created by pool chemicals stored in retail establishments. This Alert bulletin discusses two major fires where pool chemicals were stored. It also gives details concerning two types of fire suppression equipment that should not be used for fires where pool chemicals are involved.

NFPA 430, Code for the Storage of Liquid and Solid Oxidizers, 2000 edition – 16 pages. The 2000 edition was revised to include a section addressing storage and handling at retail stores. It provides a number of useful definitions including the definition of Class 3 Oxidizers which include most pool water treatment chemicals. NFPA 430 also points out the hazards associated with not only the use but also the presence of dry chemical or halon-type fire extinguishers in an area containing oxidizer-type chemicals. NFPA 430 also points out the ineffectiveness of any extinguishing system that relies upon a smothering effect since the oxidizer chemicals do not require air to maintain reaction.

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02269-9101
Telephone: (617) 770-3000
Website: www.nfpa.org

The Chlorine Institute has several pamphlets of interest, including:

Sodium Hypochlorite Safety and Handling, Pamphlet 96, May 2000

The Chlorine Institute, Inc.
2001 L Street, NW.
Washington, D.C. 20036-4919
Telephone: (202) 775-2790
Website: www.ci2.com

The Canadian Transport Emergency Center, CANUTEC, has written an article in response to the calls received from individuals and fire departments requesting information on pool chemicals.

Swimming Pool Chemicals – revised September 1999 - by Jacques Savard, Ph.D. This paper covers spills, disposal, neutralization, and first aid. The paper is available on CANUTEC’s website and is particularly recommended reading.

CANUTEC
330 Sparks Street, Office 1401
Ottawa, Ontario, Canada K1A 0N5
Website: www.tc.gc.ca/canutec/en/articles/documents/pool.htm

EPA's Chemical Emergency Preparedness and Prevention Office has previously written an advisory targeted at LEPC's concerning chemicals used at swimming pools that may release chlorine:

Advisory: Swimming Pool Chemicals: Chlorine, OSWER 90-008.1, June 1990. This publication is available from the EPA National Service Center for Environmental Publications (NSCEP).

U.S. EPA/NSCEP
P.O. Box 42419
Cincinnati, Ohio 45242-0419
Telephone: (800) 490-9198

Other Useful Websites

LEPC Database This database is a list of the LEPCs in each state, including where appropriate, links to state websites.
http://www.epa.gov/ceppo/lepclist.htm

Statutes and Regulations

In addition to the recommendations for improved hazard control, you may be subject to certain regulations. In particular, you need to determine whether the following regulations related to emergency planning, release reporting, and hazardous materials worker protection are applicable to your facility.

EPA

Emergency Planning & Community Right-to-Know

- Emergency Planning [40 CFR Part 355]- Facilities that have listed substances above a specified threshold quantity must report to their LEPC and SERC and comply with certain requirements for emergency planning.
- Emergency Release Notification [40 CFR Part 355]- Facilities that release listed chemicals over
reportable quantity must immediately report the release to the LEPC and the SERC.

- Hazardous Chemical Reporting [40 CFR Part 370] - Facilities that have listed chemicals at or above threshold quantity must submit MSDSs to their LEPC, SERC, and local fire department and comply with the Tier I Tier II inventory reporting requirements.

- Toxic Chemicals Release Inventory [40 CFR Part 372] - Manufacturing businesses with ten or more employees that manufacture, process, or otherwise use listed chemicals above an applicable threshold must file annually a Toxic Chemical Release form with EPA and the state.

**Comprehensive Environmental Response, Compensation, and Liability Act**

- Hazardous Substance Release Reporting [40 CFR Part 302] - Facilities must report to the National Response Center any environmental release which exceeds reportable quantities. A release may trigger a response by EPA, or by one or more Federal or state emergency response authorities.

**OSHA**


**Process Safety Management Standard** [29 CFR 1910] - Facilities with highly hazardous substances in quantities at or above a threshold quantity are subject to a number of requirements for management of hazards, including performing a process hazards analysis and maintaining mechanical integrity of equipment.

**Hazard Communication** [29 CFR 1910.1200] - Facilities are required to evaluate the potential hazards of toxic and hazardous chemicals. Employers transmit this information to their employees.

For additional information on OSHA standards contact OSHA Public Information at (202) 219-8151. Website: [www.osha.gov](http://www.osha.gov)
<table>
<thead>
<tr>
<th>Month Year</th>
<th>City State</th>
<th>Brief Description of Incident</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 2000</td>
<td>Elizabethtown, Tennessee</td>
<td>Fire and smoke from a storage facility that contained chemicals including swimming pool water treatment chemicals. The fire was in an area isolated from the pool chemicals, however particular precautions were taken to prevent the pool chemicals from becoming involved.</td>
<td>Local school closed early to relieve traffic congestion; local residents advised to remain indoors. No injuries reported.</td>
</tr>
<tr>
<td>October 1999</td>
<td>Avon, Indiana</td>
<td>Fumes released from container of a strong acid that was being used to clean a high school swimming pool.</td>
<td>School evacuated. No injuries reported.</td>
</tr>
<tr>
<td>August 1999</td>
<td>Burlington, New Jersey</td>
<td>A pallet containing 400 lbs of calcium hypochlorite spilled at a warehouse. The spill was caused by the corrosion of steel shelving on which the material was stored. The spilled material mixed with other incompatible materials, resulting in fire and release of products of combustion and decomposition including chlorine gas.</td>
<td>Five warehouse workers were hospitalized from the toxic gas exposure. Twenty-four others were treated and released.</td>
</tr>
<tr>
<td>August 1999</td>
<td>Bergen County, New Jersey</td>
<td>Granular chlorinating material, similar to that used for swimming pool water treatment, spilled while moving a container in a warehouse.</td>
<td>Released vapors sent 28 government workers to area hospitals.</td>
</tr>
<tr>
<td>July 1999</td>
<td>Richmond, Virginia</td>
<td>Chemical exploded as it was prepared for release into apartment complex pool.</td>
<td>One employee injured.</td>
</tr>
<tr>
<td>June 1999</td>
<td>Cleveland, Ohio</td>
<td>Toxic fumes released at local community center swimming pool, when pool water chemicals including muriatic acid were inadvertently mixed.</td>
<td>Two fire fighters and two others injured and area evacuated.</td>
</tr>
<tr>
<td>February 1999</td>
<td>Fort Worth, Texas</td>
<td>Fire, smoke and vapors released from large warehouse containing pool chemicals and other materials. The cause of the fire was not reported.</td>
<td>Warehouse destroyed. No injuries reported; residents told to remain indoors.</td>
</tr>
<tr>
<td>December 1998</td>
<td>Auburn, New Hampshire</td>
<td>Small explosion and vapors were released when about a cup of swimming pool chemical was improperly disposed of at a regional waste treatment station.</td>
<td>Four minor injuries. Waste treatment station shut down.</td>
</tr>
<tr>
<td>July 1998</td>
<td>Dayton, Ohio</td>
<td>Toxic cloud was generated when muriatic acid was inadvertently mixed with a chlorinator product at local community center swimming pool.</td>
<td>Nine people sent to the hospital.</td>
</tr>
<tr>
<td>June 1997</td>
<td>Watervliet, New York</td>
<td>Water leaking from sprinkler system wetted water reactive pool chemicals, starting fire at pool chemical storage, repackaging and distribution building. Smoke and chlorine gas released into building and area.</td>
<td>Nearby residents evacuated as a precautionary measure.</td>
</tr>
<tr>
<td>July 1996</td>
<td>Chatsworth, California</td>
<td>Fire and toxic vapor release at a swimming pool supply facility was attributed to improper mixing of muriatic acid and sodium hypochlorite (bleach).</td>
<td>Three people were injured and an eight-block area was closed to traffic.</td>
</tr>
</tbody>
</table>