California Integrated Waste Management Board Response to Landfill Fires Guidance Document

Internal Technical Bulletin

Version 9/12/02

This document provides guidance and information to California Integrated Waste Management Board (CIWMB) staff, local enforcement agencies (LEA), and local fire departments regarding landfill fires.

Landfill Fires

Landfill fires both surface and subsurface are more common than one might expect. Although no one agency in the United States tracks the number of landfill fires a local search of web engine will indicated landfill fires have occurred from California to Minnesota and through out the northern hemisphere. In California alone over 25 subsurface landfill fires have been reported during the past 15 years. Most of the incidents are small rapid oxidation events and are usually handled by the operating facility and the local or state regulatory agency. Seldom do the subsurface events become large-scale environmental responses.

Type of Landfill Fires

The most common types of fires occur at the surface, where fuel and oxygen are abundant. These fires burn between the surface and one foot below ground. The other type smolders below ground and can extend down to 40 feet.

Surface Landfill Fires

A surface fire can start if the facility accepts hot objects (e.g., barbeque coals or other ashes) or over draws the landfill gas collection system. Also arson, spontaneous combustion, or a discarded cigarette can start fires. To keep fires small and manageable immediate action is necessary. Actions may include using heavy equipment to remove the burning material to a safe area, the application of soil to suffocate the fire, or the use of suppression agent and firefighting activities. If no action is taken, significant amounts of rancid and toxic smoke will be generated from burning surface trash. Toxicity of this smoke depends on the composition of the waste stream.

Subsurface Landfill Fires

A subsurface fire typically starts from overdrawing a gas collection system or spontaneous combustion. These fires are more likely to burn slowly without visible flame or large quantities of smoke and are characterized by rapid oxidation of an organic waste. The waste mass tends to oxidize around the extraction well, in the influence zone of the extraction well, or near a surface feature that allows oxygen to enter the waste mass. Subsurface fires in gas collection systems are detected by elevated temperature at the well head or by the detection of soot in the gas collection system. At times underground combustion/oxidation will go undetected until a sinkhole or smoke appears. Normally you will never see an actual flame during this type of fire unless the subsurface fire is excavated and exposed to the atmosphere.

How Spontaneous Combustion Occurs

Spontaneous combustion is the process where waste material is heated by chemical oxidation via biological decomposition to the point of ignition. This type of rapid oxidation in municipal or construction/wood waste facility is directly related to the amount of moisture present in the fill. The bacteria, both aerobic and anaerobic, present in organic matter require water to biologically breakdown organic matter. As shown in the equation below, as organic material is biodegraded, heat (Δt) is produced along with other constituents.

$$\text{Organic Matter (solid waste)} + H_2O \xrightarrow[\Delta t]{\text{bacteria}} \text{biodegraded organic matter} + CH_4 + CO_2 + \text{other gases}$$

With the correct conditions present, spontaneous combustion can occur in household trash or construction debris facilities. This type of combustion will produce excessive amounts of carbon monoxide (CO) and other trace toxic gases due to incomplete oxidation.

Detecting Subsurface Fires

To determine if a subsurface fire exists, one must have visual confirmation or other conditions present. Generally a subsurface fire can be confirmed by:

- Substantial settlement over a short period of time;
- Smoke or smoldering odor emanating from the gas extraction system or landfill;
- Levels of CO in excess of 1000 ppm;
- Combustion residue in extraction wells and/or headers;
- Increase in gas temperature in the extraction system (above 140° Fahrenheit);or
- Temperatures in excess of 170 ° Fahrenheit.

To confirm a subsurface fire by using CO, the results must be acquired through quantitative laboratory analysis. Most field portable equipment only have qualitative abilities and are susceptible to cross-sensitivity with high temperatures, humidity, and other constituents of landfill gas (e.g., volatile organic compounds, hydrogen sulfide, etc.). As a result, landfill gas containing these conditions and constituents may produce artificially high carbon monoxide readings when using portable monitors.

The CIWMB staff considers levels of CO in excess of 1000 ppm to be a positive indication of an active underground landfill fire. Levels of CO between 100 and 1000 ppm are viewed as suspicious and require further air and temperature monitoring. Levels between 10 and 100 ppm may an indication of a fire but active combustion is not present.

Health and Safety Issues

Subsurface landfill fire can create many types of life threatening conditions. These conditions must be communicated to all site personnel and anyone who is involved in the project. Site hazards will vary from standard slip, trips, and falls, to the potential of confine space issues, carbon monoxide and toxic gas exposures, possible cave ins due to the void spaces, and burn issues from the evaluated temperatures. Unique safety protocols and considerations should be implemented for site workers and equipment.

Past CIWMB subsurface fire sampling results have revealed CO in the range of 2,500 to 28,000 ppm at ground surface. Given that NIOSH's Time Weight Average for CO is 35 ppm and the Immediately Dangerous to Life and Health level is 1,200 ppm, personnel and site air monitoring should be required. The CIWMB staff have also recorded temperatures in excess of 300 degrees Fahrenheit within 1 to 3 feet below ground surface. Although not typical, sinkholes in excess of eight feet in diameter and five feet in depth have occurred during underground fires.

Suppression Methods

As with any fire, once one side of the fire tetrahedron collapses the chemical reaction will stop. Landfill fires can be extinguished by smothering with soil, using heavy equipment and a suppressant agent, or simply temporarily shutting down the gas extraction system. No one method will work for all conditions. Each suppression plan will be unique due to site-specific conditions. At times, only an interim cap will prevent the extension of the fire, while other times the use of heavy equipment and foam is preferable.

Interim Cap Recommendations

Based on past experiences with other landfill fires and the thermal properties of plastics (e.g. geomembrane, geotextile, or geosynthetic-anything), it is not recommended that a geomembrane or geosynthetic clay liner (GCL) be used to cover the landfill unit until the subsurface fire is extinguished. Although some GCLs do have a large clay component, the potential for rapid settlement from subsurface fires can make the repair and maintenance very difficult. It is recommended that the cap be constructed of a soil with the following properties:

a) A clean, low permeability soil capable of obtaining a permeability of $1x10^{-5}$ cm/sec with a maximum particle size of three inches or less;
b) The soil should be classified as SC, ML, CL, or CH according to the Unified Soil Classification System;
c) The soil should be compacted to a minimum of 89 percent of the maximum dry density as determined by ASTM D-1557;
d) The cover should extend a minimum of ten feet beyond the landfill area if feasible;
e) The clay cover should be a minimum of 18 inches, but recommended the clay cover be 24 inches and placed over a graded foundation layer;
f) Each lift of clay should not exceed 9 inches before compaction.

Once the fire is confirmed extinguished, other layers including a geotextile, geomembrane, GCL, vegetative, or asphalt could be installed.

Suppression Agents

Although there are many types of foam and wetting agents, it is best to use a Class A foam or wetting agent. These chemicals include a surfactant that reduces surface tension and improves penetration depth. Class B foams are ineffective because it is impossible to separate the oxygen from the fuel as it is done with flammable liquids. Class B foams are a two dimensional product, while Class A and wetting agents work on three dimensional fires such as landfill and tire fires.

Water

The application of large amounts of water without a suppression agent is not recommend. Large amounts of water may actually acerbate the fire potential by increasing the amount of biodegraded matter and heat. The excess water will also increase contaminated runoff and leachate.

Who Needs to be Contacted?

Typically if the fire is localized and contained to a small area, only the LEA, CIWMB's closure staff, and the local fire department should be notified. If significant smoke is visible or a community is threaten by a release then additional agencies such as the local air quality management district, United States Environmental Protection Agency, community advocacy groups, and local hazmat and office of emergency services must be notified.

Conclusion

The recommendations presented in this document are based on practical working knowledge of past surface and subsurface fires at waste facilities. For more information on monitoring requirements or other protocols please contact Mr. Todd Thalhamer at the CIWMB. He can be reached at tthalham@ciwmb.ca.gov or by calling 916-798-5464.