California Integrated Waste Management Board

Landfill Fires Guidance Document

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 engines will indicate landfill fires have occurred from California to Minnesota and throughout the northern hemisphere. In California alone more than 25 subsurface landfill fires have been reported during the past 15 years. Most of the incidents are small fires or 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.

Types of Landfill Fires

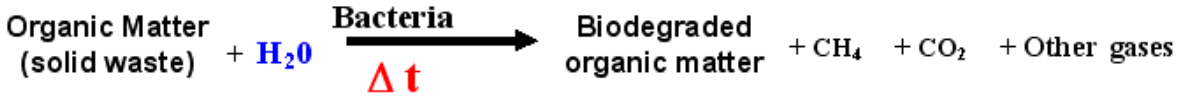
The most common types of fires occur at the surface, where fuel and oxygen are abundant. These fires can burn between the surface and one foot below ground. The other type smolders below ground and can extend down to 40 feet.

Surface Landfill Fires
A surface fire can start if the facility accepts hot objects (for example, barbeque coals or other ashes) or overdraws 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

In spontaneous combustion, waste material is heated by chemical oxidation and biological decomposition. The resulting heat causes the material to reach the point of ignition. This type of rapid oxidation in a 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 is produced along with other constituents.



Equation Text Description: In the presence of bacteria, organic matter (solid waste) and water react to produce increased heat (delta t), methane (CH4) gas and carbon dioxide (CO2) gas as well as other gases and degraded organic material.

With the correct conditions present, spontaneous combustion can occur in household trash or at 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 parts per million (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 (for example, 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 1,000 ppm to be a positive indication of an active underground landfill fire. Levels of CO between 100 and 1,000 ppm are viewed as suspicious and require further air and temperature monitoring. Levels between 10 and 100 ppm may be an indication of a fire but active combustion is not present.

Employee Health and Safety Risks

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 may include slips, trips, and falls; confined space issues; carbon monoxide and toxic gas exposures; possible cave-ins due to the void spaces; and burn issues from the elevated temperatures. Safety protocols and considerations related to subsurface landfill fires should be implemented for site workers.

For example, CIWMB air monitoring data from subsurface landfill fires detected CO levels in the range of 2,500 to 28,000 parts per million (ppm) at ground surface. Given that the immediate danger to life and health (IDLH) level is 1,200 ppm, personnel and site air quality monitoring for CO and other chemical exposures may be necessary. CIWMB staff has also recorded temperatures in excess of 300 degrees Fahrenheit within 1 to 3 feet below ground surface. Although not typical, sinkholes in excess of 8 feet in diameter and 5 feet in depth have occurred during underground fires. For additional information on employee protection, contact Cal/OSHA at 1-800-963-9424 or via e-mail at: InfoCons@dir.ca.gov.

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 10 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 geotextile, geomembrane, GCL, and/or vegetative 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 Notified?

Typically, if the landfill fire is localized and contained in a small area, the LEA, appropriate CIWMB staff, and the local fire department should be notified. Site specific factors, permit conditions, or other mandates may require that the landfill operator or site owner notify other entities including the local air quality management district, the United States Environmental Protection Agency, the California Office of Emergency Services, local hazardous materials program, and neighbors.

Conclusion

The recommendations presented in this document are based on practical working knowledge of past surface and subsurface fires at waste facilities. Each debris or landfill fire will have site-specific issues that must be addressed. For more information on monitoring requirements or other protocols, please contact Todd Thalhamer, P.E., at the CIWMB.

Todd Thalhamer has worked at CIWMB as a waste management engineer since 1992. He has worked on several major waste fires, including the Tracy tire fire and the Fresno debris fire. He is a registered civil engineer and also a Lieutenant with the El Dorado Hills Fire Department.

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