July 23, 2007

<Name>
<Address>
<City, State Zip>

Re: Aluminum Production Waste Advisory, Part II

To Whom It May Concern:

The purpose of this advisory is to share additional information that Ohio EPA has gathered about the characteristics of aluminum production wastes and the potential for subsurface landfill fires. Aluminum production wastes include dross, salt cake, bag house dust, and shredder waste generated from aluminum smelting operations. The information contained in this advisory is based on research documents and data gathered from recent events at Ohio landfills since Ohio EPA issued the first aluminum waste advisory to Ohio landfill owners/operators on November 7, 2006. The November 2006 advisory can be found at:
http://www.epa.state.oh.us/portals/34/document/newsPDFs/aluminum_advisory.pdf

Aluminum Waste Reactions

Aluminum production wastes are chemically active and when exposed to water, can react and emit toxic, flammable, and potentially explosive gases including, but not necessarily limited to ammonia, methane, hydrogen, and acetylene. Abnormally high hydrogen and acetylene readings and positive landfill gas pressures are indicative of aluminum production waste reactions. In addition, changes in concentrations of leachate constituents are likely to result from aluminum production waste reactions. Such changes may include, but are not necessarily limited to, increases in concentrations of ammonia nitrogen, chemical oxygen demand, sodium, potassium, calcium, magnesium, chloride, and some metals.

When aluminum production waste is exposed to water, the water acts as an oxidizer and the resulting combustion reaction is capable of generating heat and abnormally high landfill temperatures. Combustion reactions, in general, are either homogenous or heterogeneous, and the aluminum+water reaction is heterogeneous. Heterogeneous reactions typically occur with metals or with non-metallic elements. Heterogeneous combustion is a simple, single-step rapid oxidation at the surface of the solid material. This reaction does not have any minimum temperature governing the reaction. While

temperature may influence the speed of the reaction, it is the presence of the oxidizer (water in this case) that determines if the reaction will or will not occur.

Municipal Solid Waste Impacts

In the presence of the abnormally high landfill temperatures resulting from the aluminum production waste combustion reaction, the municipal solid waste itself can begin to undergo combustion. The oxidizer for this type of reaction is oxygen, and if it is present, combustion can occur. Again, combustion can be of two types: homogeneous or heterogeneous. Homogeneous combustion is also known as gas-phase combustion, or flaming combustion. It constitutes what is most commonly thought of as “fire.” But flaming combustion is not possible in highly confined situations, due to a phenomenon known as “quenching distance.” Thus, in the underground situation, flaming combustion will be expected only if there arise substantial voids or cavities. In the absence of these, however, heterogeneous combustion is possible. This type of combustion is commonly known as “glowing” or “smoldering.” With glowing or smoldering combustion, flames are not produced, and chemical reactions occur on the surface of the solid material, rather than in the gas phase. Glowing and smoldering combustion are basically similar phenomena, with the only difference being that, by definition, smoldering combustion means the reaction is self-sustained, while the more general concept of glowing combustion can also involve reactions which take place only due to a presence of an external heat source.

There is another factor which is relevant to subsurface combustion. Under most circumstances, flaming combustion will stop if the oxygen level drops below about 12%. However, smoldering or glowing combustion can take place under oxygen conditions barely above zero.

Both types of combustion reactions produce carbon monoxide (CO), although in different amounts. Flaming combustion tends to produce primarily carbon dioxide (CO_2) and CO is generally only a small component. But the reaction when oxidation occurs at a solid surface (heterogeneous combustion) is one that produces CO as the primary combustion product. This can subsequently be oxidized to CO_2, but the process is highly variable. Consequently, if the CO concentration is high and CO_2 concentration is low, it is most likely that heterogeneous combustion is taking place.

Both types of reactions can be extinguished by removing sufficient heat from the system. However, this is easier to accomplish with homogeneous combustion than with heterogeneous combustion. Gas-phase reactions are readily quenched by heat removal and cannot be sustained at low temperatures. But smoldering reactions can persist down to quite low temperatures, since, unlike for gas-phase combustion, a chain-reaction process does not need to be sustained. Thus, smoldering reactions—which are ones that are more likely encountered underground—are harder to extinguish, irrespective of whether this is being accomplished by limiting the oxygen or by the removal of heat.

In the situation of a subsurface landfill fire, the combustion event itself may not generate substantial amounts of smoke. The absence of smoke is not confirmation that a subsurface fire does not exist, as the waste may act as a filter for the visible particulate matter in the smoke. At landfills with thermal heating caused by the rapid oxidation of aluminum production wastes by water, "steam" may be observed at the landfill surface or within the waste mass (e.g., rising from a boring). Steam and smoke are not necessarily distinguishable in the field based solely on visual appearance. What appears to be steam may consist of water vapor from which particulate matter in the smoke has been filtered by the waste, or a combination of water vapor and particulate matter. In any event, if the "steam" contains carbon monoxide in excess of 100 ppm, it is likely indicative of combustion within the waste mass.

Detecting Subsurface Landfill Fires

If a landfill has accepted aluminum production waste, it is important to watch for indications of a subsurface fire. While landfill fires may manifest themselves in different ways, there are several characteristics of subsurface landfill fires that are nearly universal. Generally, subsurface combustion can be identified by any of the following conditions:

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

For more detailed information regarding detecting subsurface landfill fires, please see the Subsurface Landfill Fire Advisory, issued by Ohio EPA on July 23, 2007. This advisory may be found at:
http://www.epa.state.oh.us/portals/34/document/newsPDFs/subsurface_lf_fire_advisory.pdf

The references listed below provide additional information on aluminum waste or landfill fires and may be valuable resources.

Further Reading

Aluminum Dross

Graczyk, D.G., Essling, A.M., Huff, E.A., Smith, F.P., and C.T. Snyder, 1997, *Analytical Chemistry of Aluminum Salt Cake*: Proceedings of the 126th Annual Meeting of the Minerals, Metals, and Materials Society, Symposium on Aluminum Dross and Salt Cake Processing, Orlando, Florida, February 9-13, 1997.

Manfredi, O., Wuth, W., and I. Bohlinger, November 1997, *Characterizing the Physical and Chemical Properties of Aluminum Dross*: JOM, pp. 48-51

Shinzato, M.C., and Hypolito, R., 2005, *Solid waste from aluminum recycling process: characterization and reuse of its economically valuable constituents*: Waste Management, Vol. 25, pp. 37-46

Landfill Fires

California Integrated Waste Management Board Landfill Fires Guidance Document
http://www.ciwmb.ca.gov/LEACentral/Fires/LFFiresGuide/default.htm

FEMA: Landfill Fires, Their Magnitude, Characteristics, and Mitigation
http://www.usfa.dhs.gov/downloads/pdf/publications/fa-225.pdf

For any further questions, please contact the appropriate Ohio EPA District Office solid waste inspector or Gina Gerbasi at (614) 728-5325.

Sincerely,

Pamela S. Allen, Chief
Division of Solid and Infectious Waste Management