Training guidelines for the Fire Debris Analyst

Lesson Plan (Module) 17

Date: November 2012
Instructor: Qualified Instructor

Subject: Self-Heating Processes
Total Time: 12 hrs.

Learning Objectives

➢ Identify materials susceptible to self-heating.
➢ Demonstrate an understanding of the thermodynamics of self-heating.
➢ Understand the relationship between reactivity, time, mass and temperature.
➢ Distinguish between the mechanisms of self-heating.

Suggested Reading

7. Mann DC, Fitz M. “Washing machine Effluent May provide Clues in Dryer Fire Investigations” Fire Findings, 7,4, Fall 1999, 4


Introduction

Self heating processes are sometimes the cause of accidental fires in both structures and vehicles. Because such fires occur without the introduction of an external heat source, it is important that investigators (with the aid of laboratory analysis) carefully consider and eliminate self heating before concluding the fire was started by direct flame application. Self heating can occur in a wide variety of materials in residential, commercial and industrial structures and the laboratory analyst must be aware of the process and materials that can self heat. Because much of the starting material is often destroyed in the fire, the lab must consider analysis of ancillary materials. This module addresses the thermodynamics of self heating processes, analyses of starting materials and chemistry and identification of post-fire residues.

Outline

1. Introduction and Definitions
   a. Self-heating
   b. Spontaneous combustion
   c. Reaction rate
d. Activation energy

e. Auto ignition

f. Pyrophoric

2. Thermodynamics of self-heating
   a. Heat production
      Effects of
      - size
      - mass
      - shape
      - ambient temperature
      - reactivity

   b. Heat loss
      Effects of
      - size
      - mass
      - shape
      - ambient temperature
      - reactivity

3. Mechanisms of self heating
   a. Chemical
      1. Oxidative
         Materials susceptible to self heat
         - Drying oils
         - Hot materials
         - Coal
         - Saw dust
         - Finely ground solids (rubber, plastics)
         - Laundry fires
         - Fish oils (cod liver oil, sardine oil)
         - Metal dusts

      2. Catalytic (Polymerization/Cross linking)
         Materials susceptible to self heat
         - Fiberglass

   b. biological
      Materials susceptible to self heat
      - Hay
      - Wool
      - Some seeds
      - Cotton
4. Recognizing evidence of self heating
   a. more damage to center of mass than damage to exterior of mass
   b. nature of substrate
      ➢ Physical characteristics
      ➢ Capable of forming a rigid porous char
      ➢ Adequate mass
      ➢ Presence of clinkers
   c. chemical characterization
      ➢ identify of reacted and unreacted residues

5. Laboratory Analysis
   a. Identification of substrate
      ➢ Microscope
      ➢ -IR
   b. Identification of unreacted and reacted material
      ➢ -extraction and isolation
      ➢ -IR
      ➢ -GC/MS
      ➢ -LC/MS
      ➢ -Derivatization techniques
      ➢ -XRF (clinkers)
      ➢ -SEM (clinkers)

6. Interpretation and Reconstruction

7. Myths
   a) Spontaneous human combustion
   b) Spontaneous combustion of petroleum products
   c) Use of the term “pyrophoric”

7. Report Writing

Teaching Aids

Hand out
PowerPoint
Demonstration of self-heating processes
Summary

Self heating processes are a delicate balance of mass, heat, time and chemical reactivity, highly dependent on the substrate material. The investigator and the lab must appreciate all the components necessary. The lab can play a critical roll in establishing what was originally present.

Test Questions

1. Self-heating by oxidation processes requires:
   a. Reactive materials
   b. Porous substrate
   c. Adequate time
   d. All of the above

2. The “runaway stage” of self-heating occurs:
   a. When the heat being generated exceeds the heat that can escape
   b. When reactive materials are exposed to air
   c. At the same time for each material
   d. Regardless of external temperature

3. Spontaneous combustion
   a. Is not a scientifically plausible event
   b. Is a rare but occasionally seen phenomenon
   c. Occurs with elderly, overweight females
   d. Involves extremely exothermic cellular malfunctions

4. Self-heating can readily occur in:
   a. Cotton rags with linseed oil
   b. Cotton rags with petroleum motor oil
   c. Dry glass clippings
   d. Clean wool clothing

5. “Pyrophoric” ignition refers to:
   a. Ignition at relatively low temperatures (54degC, 130degF)
   b. Decomposition of solid fuels by the application of heat
   c. Ignition of wood at unusually low temperatures (100degC,212degF)
   d. Ignition using energetic materials

6. “Hay clinkers” contain:
   a. A glassy mass of fused inorganic salts from cellulosic materials
   b. Residues of chemical incendiaries
   c. Organic fermentation products
   d. Residues of chloride salts from cellulosic products
7. Laundry fires due to spontaneous combustion occur:
   a. Most often when the laundry is removed from the dryer while still hot
   b. **when oily rags are laundered**
   c. When wool clothes are left in dryer
   d. When the water temperature is too high

8. Self-heating fires involving wood sanding dust are most likely to occur:
   a. **When recently varnished floors are sanded**
   b. When old, raw wood is sanded
   c. With residues from hand-sanding
   d. Nearly instantaneously when the dust is bagged

9. The mass of reactive material needed to trigger spontaneous ignition:
   a. **Inversely proportional to the chemical reactivity**
   b. Directly related to the chemical reactivity
   c. Independent of reactivity
   d. Independent of time factors

10. A fire starting in a large pile of garden clippings and mulch:
    a. **Is caused by both biological and chemical processes**
    b. Is caused by biological processes only
    c. Is caused by chemical processes only
    d. Cannot be caused by self-heating processes