

URANIUM PYROPHORICITY PHENOMENA AND PREDICTION

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This abstract is approved for public release

We have compiled a topical reference on the phenomena, experiences, experiments, and prediction of uranium pyrophoricity for the Hanford Spent Nuclear Fuel Project (SNFP) with specific applications to SNFP process and situations. The purpose of the compilation is to create a reference to integrate and preserve this knowledge. Decades ago, uranium and zirconium fires were commonplace at atomic energy commission facilities, and good documentation of experiences is surprisingly sparse. Today these phenomena are important to site remediation and analysis of packaging, transportation, and processing of unirradiated metal scrap and spent nuclear fuel. Our document, bearing the same title as this abstract, will soon be available in the Hanford document system. This paper will explain general content of our topical reference and provide examples useful throughout the DOE complex. Moreover, the methods described here can be applied to analysis of potentially pyrophoric plutonium, metal, or metal hydride compounds provided that kinetic data are available.

The phenomenon of pyrophoricity has been studied for chemical process safety and its mathematical formulation, ignition theory, is well-established. We have applied ignition theory to experiments conducted with uranium powders and foils using recently available kinetic rate laws, and found that results can be explained and understood, where before these results were not quantified and were on occasion misinterpreted. Also, documented experience suggests that the rate law for metal oxidation in air is applicable to uranium hydride.

Pyrophoricity incidents were catalogued and classified into four types: Onset of thermal runaway in storage containers of loose or concreted scrap, explosions in such containers when hydrogen was present, ignition of highly corroded or porous material initiated by shock, and ignition of accumulated finely divided material at ambient conditions, including under water. Analysis of explosions considered the minimum ignition energy of uranium metal dust in air and could explain experiences. Unfortunately, convincing explanation could not be made for observations of ignition by impact under water.

A useful result of the study is identification of a simple criterion for screening pyrophoricity potential, with various formulas depending upon the geometry. As an example, we can plot the tradeoff between allowable particle size and metal content, and create a family of curves as other parameters such as the ambient temperature, thermal conductivity, or container size are varied. This allows the safety of storage or transportation to be easily screened.