

**Enclosure 1 to E-53665**

**Response to RSI 1-1  
(Revised February 2019)**

**RSI 1-1**

Identify the content powder specification to ensure that pyrophoric reactions are not credible during all transport conditions.

In document No. DOS-06-0037028-100, Revision 2, the applicant notes that no leak-tightness inspection criterion is specified for use of the packaging. Since the powder environment does not appear to be controlled, it is not clear what materials specification controls would be in place to ensure that pyrophoricity of the contents is not a credible scenario during all transport conditions.

This information is necessary to ensure compliance with the requirements in paragraphs 614 and 644 of the International Atomic Energy Agency (IAEA) Specific Safety Requirements No. 6 (SSR-6), 2012 Edition.

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A pyrophoric material is a liquid or solid that, even in small quantities and without an external ignition source, can ignite within five (5) minutes after coming in contact with air when tested according to the United Nations Manual of Tests and Criteria [1]. Pyrophoric material, even in small quantities and without an external ignition source, can ignite at or below 54.4 °C (130 °F) in contact with air.

Some metals, such as iron and steel, which are not normally thought of as combustible, may ignite and burn when in finely divided form (powders and dusts). Generally, iron and steel are not considered pyrophoric but may be in certain particle ranges and under very specific conditions. For example, clean, fine steel wool may be ignited. Particle size, shape, quantity, and alloy are important factors to be considered when evaluating metal combustibility.

Uranium may form pyrophoric oxides and hydrides that react violently with water and is best stored in oxide form ( $\text{UO}_2$ ) in dry, inert atmospheres. Uranium metal (U) releases hydrogen gas ( $\text{H}_2$ ) when allowed to react with water. The hydrogen may then react with the metal to form uranium hydride ( $\text{UH}_3$ ) which may in turn react with oxygen in the air to form stable uranium oxide ( $\text{UO}_2$ ) and hydrogen gas ( $\text{H}_2$ ) [2].

NRC licensees who generate pyrophoric forms of uranium in their licensed operations are cautioned to carefully consider the requirements to properly "stabilize" such materials prior to offering them for transport [3]. The methods which have been the most satisfactory are:

1. Incineration to a non-pyrophoric oxide; or
2. Mixing and solidifying in a large matrix of concrete.

Furthermore, pyrophoric materials should be stabilized prior to storage [2].

TNF-XI Package Safety Analysis Report (SAR) Chapter 0A, Description of the Content, DOS-06-0037028-006 Revision 7 [4], provides a complete description of the material allowed as Content Number 8 (n°8). Materials other than those described in this chapter are not allowed.

Content n°8 is in the following possible forms:

- (A) Material mainly in the form of lumps or fragments with possibly a very low quantity of powder due to the erosion of the material. The powder is not the main constituent of this type of content, as these residues have not been specifically processed to be reduced in form to powder.
- (B) Piece of material of large size (not powdered material). Traces of powder are not excluded.

Enclosure 2 provides pictures of the above 2 forms.

Form (A) (calcined filter aid silicon dioxide, aluminum oxides, aluminosilicate calcined, with a small amount of iron and gadolinium oxides; calcium and aluminum fluorides; and sodium nitrate and gadolinium (hydr)oxides) are shown in pictures 1 to 3.

Form (B) (aluminum in form of thin sheet, craft paper and composite fibers) (synthetic fibers or glass fibers); polyethylene resin; polyvinyl chloride, glass; glass wool or rock wool; alumina oxide and brick; gypsum; polyethylene resin with carbon black; and concrete) are shown in pictures 4 to 15.

These residues have been stored stably for over 20 years in facilities. Additionally, it should be emphasized that the temperature of the contents remain low with respect to the possibility of the pyrophoricity phenomenon (below 60 °C in normal conditions of transport and below 100 °C in accidental conditions of transport)

Form (A) are precipitations processed from liquid waste before 1999 at the Japan Nuclear Fuel Conversion Company (JCO). These precipitations were calcined at 600 °C, stored in drums for over 15 years, samples taken from the drums, and sent to a laboratory at Springfield Fuels Limited (SFL) in the UK in 2014. A series of tests including the drying test were performed in the SFL laboratory on 2014.

The precipitations in Form (A) that may have had the characteristics of pyrophoric material have been stabilized at JCO by incineration to a non-pyrophoric oxide prior to storage over 20 years ago.

Form (A) are precipitations generated when neutralizing waste liquid from the reversion process or refining process in JCO plant. The precipitations were calcined at about 600 °C, and the precipitations were put in bags after calcining, and these bags were stored in drums. To prepare for the transportation from JCO to SFL and treatment at SFL, JCO has been conducting elemental analysis using X-ray fluorescence (XRF) for each bag in all storage drums.

XRF is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source. Each of the elements present in a sample produces a set of characteristic fluorescent X-rays ("a fingerprint") that is unique for that specific element, which is why XRF spectroscopy is an excellent technology for qualitative and quantitative analysis of material composition.

Based on the XRF data, residues have been sorted into new drums by type of residues. Before transportation, the material from one drum will be transferred into one TNF-XI packaging.

Form (A) materials from the precipitations are stabilized by calcining at 600 °C to form a non-pyrophoric oxide. Pyrophoricity risk does not exist for Form (B) types of material due to the form and composition; therefore, considering these conditions, the pyrophoricity risk is not a concern for Contents n°8.

### References

1. 49 CFR § 173.124 - Class 4, Divisions 4.1, 4.2 and 4.3 - Definitions. (b) Division 4.2 (Spontaneously Combustible Material). (1) A pyrophoric material.
2. DOE-HDBK-1081-2014, Primer on Spontaneous Heating and Pyrophoricity, U.S. Department of Energy, Washington, D.C. 20585.  
<http://www.hss.doe.gov/nuclearsafety/ns/techstds>
3. Information Notice No. 80-25 - Transportation of Pyrophoric Uranium; May 30, 1980.
4. Safety Analysis Report (SAR) Chapter 0A, Description of the Content, DOS-06-0037028-006 Revision 7.

### Impact

No change as a result of this RSI response.