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NUCLEAR REGULATORY COMMISSION  
OFFICE OF INSPECTION AND ENFORCEMENT  
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TRANSPORTATION OF PYROPHORIC URANIUM

Background

From time to time NRC has received reports of transportation incidents involving the shipment of uranium in a pyrophoric form (capable of spontaneous ignition). These forms generally include finely divided metallic saw turnings and chips, sawdust, and abrasive saw sludge. Moisture in the form of water or machining coolants is usually present on the finely divided material, contributing to its reactivity due to the radiolytic decomposition of the water reacting with the base metal to create hydrogen gas. Hydrogen gas generation and reactivity will vary with the particle size (surface area to volume ratio) of the fines, free moisture content, and age of the material. Although the exact reaction kinetics of finely divided pyrophoric metals is not well understood, past industry experience has indicated that extreme care must be exercised in the proper storage and transportation of such pyrophoric forms of uranium so as to preclude spontaneous ignition.

Fires resulting are extremely difficult to extinguish using such conventional fire extinguishing agents as CO<sub>2</sub>, foam, and dry chemical. Water, if used in very large volumes or by total immersion can be effective. Water used as a fine spray, however, can be extremely dangerous, actually causing a more violent reaction due to the radiolytic breakdown of the water from the extremely high temperatures. Further, such fires also create an inhalation hazard due to the dispersion of airborne uranium as particulate matter.

Transportation Regulations

Although the Department of Transportation (DOT) regulations in 49CFR do not provide specific provisions for packaging and shipment of pyrophoric uranium, in 49 CFR 172.101, there does appear a proper shipping name: "Uranium metal, pyrophoric", under the radioactive material hazard class. This indicates that such materials are to be labelled as both a radioactive material and a flammable solid. Under the column "packaging", §172.101 then makes reference to the requirements for low specific activity and fissile radioactive materials. The only other relevant provision of 49CFR, albeit, a very important one is 49 CFR 173.21(b): under "Prohibited packaging", which reads:

"(b) the offering of any package or container of any liquid solid or gaseous material which under conditions incident to transportation may polymerize (combine or react with itself) or decompose so as to cause dangerous evolution of heat or gas is prohibited. Such materials may be offered for transportation when properly stabilized or inhibited. Refrigeration may be used as a means

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of stabilization only when approved by the Bureau of Explosives". However, the DOT regulations require no specific methods of stabilization of pyrophoric uranium prior to shipment.

### Shipping Practices

In the earlier years of the nuclear industry many shippers offered pyrophoric uranium for transportation in steel drums, in which the turnings, chips or sludge was submerged under mineral oil. This method has the distinct safety problem of allowing a pressure buildup of hydrogen gas within the drum. This may cause a personnel hazard upon opening the drum, and a possible explosive release and/or ignition of the hydrogen gas. In some cases, venting devices have been used or holes have been drilled in drum lids to allow continuous venting of hydrogen gas. However, this poses problems also, especially in confined or closed spaces, such as a closed highway van.

Currently, most shippers of pyrophoric uranium have elected not to transport such materials submerged under oil. Instead, one of the following alternatives is used:

1. Conversion of the material to a non-pyrophoric material in an oxide form by incineration prior to shipment.
2. Mixing of the pyrophoric material in a hardened matrix of concrete, with a high concrete to turnings ratio. Such mixing appears to stabilize the material so as to preclude any significant gas generation.
3. Mixing of the pyrophoric material in a solidified plaster-of-paris type matrix. (This method may not eliminate gas generation and may not sufficiently "stabilize" the material. A shipment of such material was involved in a May 14, 1979 incident at the Beatty, Nevada waste burial facility. During this incident fire destroyed a vehicle containing such uranium wastes, along with other wastes containing flammable scintillation fluids. The exact cause of the fire is uncertain, however, the extremely reactive nature of the pyrophoric materials present undoubtedly contributed to the severity of the fire).

### Proposed DOT Regulations

In order to more clearly specify safety provisions for packaging and transport of pyrophoric materials, DOT has recently proposed (Jan 8, 1979 44 F.R. 1852, Part II) new criteria for description, classification and packaging of "pyrophoric radioactive materials". These proposed criteria are quoted in Enclosures 1 & 2.

### Summary

In view of the above, NRC licensees who generate pyrophoric forms of uranium in their licensed operations are cautioned to carefully consider the requirements of 49 CFR 173.21(b) to properly "stabilize" such materials prior to

offering them for transport. The methods which have apparently been the most satisfactory are:

1. Incineration to a non-pyrophoric oxide (will require specific approval pursuant to 10 CFR 20.305); or
2. Mixing and solidifying in a large matrix of concrete.

Questions about this Information Notice can be directed to NRC Headquarters, Office of Inspection and Enforcement, Division of Fuel Facilities and Materials Safety Inspection, Washington, D.C. 20555 (Attn: Sr. Transportation Specialist) 301-492-8188.

ENCLOSURE I

PROPOSED DOT REGULATORY REVISION  
ON PACKAGING OF PYROPHORIC URANIUM

§ 172.119 Authorized packaging—pyrophoric radioactive materials.

(a) Pyrophoric (materials which are capable of spontaneous ignition) radioactive materials, as referenced in § 172.101 of this subchapter, and which are not fissile radioactive materials and not in quantities exceeding A, per package, must be in packages of such a design and constructed of materials that will not react with nor be decomposed by the contents. Contents must be in solid form, and:

(1) Contained in one or more sealed and corrosion resistant innermost receptacles with positive closures (friction or slip-fit covers or stoppers are not authorized);

(2) Dry of water and free of any contaminants which would increase the reactivity of the material; and

(3) Made inert to prevent self-ignition during transport by either:

(i) Mixing with large volumes of inerting materials such as graphite or sand, or other suitable inerting material, or blended into a matrix of hardened concrete; or

(ii) Filling the innermost receptacle with an appropriate inert gas.

(b) In addition to the applicable requirements of § 173.24 of this subchapter—

(1) Each innermost sealed receptacle must contain not more than 4.5 kg (10 lbs.) of materials.

(2) Each innermost receptacle must be further enclosed within an outer wooden or metal packaging with non-combustible cushioning material positioned on all sides between the inner receptacle and outer enclosure.

(3) The maximum net weight of the contents may not exceed 34 kg (75 lbs.), and

(4) The package must be capable of passing the test conditions of § 127.611 without leakage of contents.

als, as referenced in § 172.101 of this subchapter, and which are also not fissile radioactive materials and not in quantities exceeding A, must be packed in suitable inside packagings of earthenware, glass, metal or compatible plastic and suitably cushioned with a material which will not react with the contents. Inner packagings and cushioning must be enclosed within an outside packaging of wood, metal, or plastic. The package must also meet the applicable test requirements of § 127.611 without leakage of contents. For shipment by air, the maximum quantity in any package may not exceed 11.3 kg (25 lbs).

ENCLOSURE II

| (1)<br><br>a/<br>U/<br>A | (2)<br><br>Hazardous materials descriptions<br>and proper shipping names          | (3)<br><br>Hazard<br>class | (4)<br><br>Labels(s)<br>required<br>(if not<br>excepted) | (5)<br>Packaging:  |                                 | Maximum net quantity<br>in one package                |                                  | (7)<br>Water shipments |                                 |  |
|--------------------------|---|----------------------------|--|--------------------|---------------------------------|---|----------------------------------|------------------------|---------------------------------|--|
|                          |   |                            |  | (a)<br>Exception   | (b)<br>Specific<br>requirements | (a)<br>Passenger carry-<br>ing aircraft or<br>railcar | (b)<br>Cargo<br>only<br>aircraft | (a)<br>Cargo<br>vessel | (b)<br>Pas-<br>senger<br>vessel | (c)<br>Other requirement   |
|                          |   |                            |  |                    |                                 |   |                                  |                        |                                 |  |
|                          | Uranium hexafluoride, fissile<br>(containing more than 0.7% U-235)                | Radioactive<br>material    | Radioactive<br>and<br>corrosive                          | 127.203<br>127.503 | 127.117                         |   |                                  | 1, 2                   | 1, 2                            |  |
|                          | Uranium hexafluoride, low specific<br>activity (containing 0.7% or less<br>U-235) | Radioactive<br>material    | Radioactive<br>and<br>corrosive                          | 127.203            | 127.211                         |   |                                  | 1, 2                   | 1, 2                            |  |
|                          | Uranium metal, pyrophoric   | Radioactive<br>material    | Radioactive<br>and flammable<br>solid                    | None               | 127.119                         | Forbidden   | Forbidden                        | 1, 2                   | 1, 2                            |  |
|                          | Uranyl nitrate hexahydrate<br>solution  | Radioactive<br>material    | Radioactive<br>and<br>corrosive                          | 127.203            | 127.111                         |   |                                  | 1, 2                   | 1, 2                            |  |
|                          | Uranyl nitrate, solid   | Radioactive<br>material    | Radioactive<br>and<br>oxidizer                           | None               | 127.121                         | Forbidden   | 25 lbs.                          | 1, 2                   | 1, 2                            | Separate longi-<br>tudinally by<br>an interven-<br>ing hold or<br>compartment<br>from explosive. |

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