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Dr. Steve McGuire
U.S. Nuclear Regulartory Commission
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Dear Steve:

Enclosed is a draft copy of my contribution to 2.3.6.2 Calculation of Potential Airborne Release in 2.3.6 Fabricators of Depleted Uranium Products of the Regulatory Analysis you are preparing. I believe it covers the areas we agreed upon in our discussions. Although the models and data to precisely define the heat to the DU from the fire and the behavior of the DU under the exact conditions of the fire are not available, I believe the experimental data available is valid for reasonable upper bound release calculated here.

One further note, I have taken the liberty of including the dose from this event based upon the ratio of the calculated DU released in this analysis and the calculated DU release in the previous analysis. You may want to have this recalculated by the people who make the original dose calculations. Also, in earlier sections covering other process steps such as the uranium hexafluoride, the analysis points out that the toxicological hazard from compounds such as hydrofluoric acid may be more severe than the radionuclide covered. The toxicological hazard of DU is not covered and you may want to mention tnat fact in this section.

Sincerely

J. Mishima

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JM:cp

Enclosures

A-80

2.3.6 Fabricators of Depleted Uranium (DU) Products

2.3.6.1 Accident History

2.3.6.2 Calculation of Potential Airborne Release

Various operations are performed during the fabrication of depleted uranium metal products. Among the operations are: reduction of "green salt" (uranium tetraflouride) to metal; melting and casting, welding, extrusion, cutting and etching, and machining (ASM 1981). Each type of operation involves various quantities of uranium metal and potential accident situations. The number of operations, facilities, and individuals involved make a wide range of accidents possible. Generally, accidents that can occur frequently result in minor consequences. Accidents that have a moderate frequency of occurence result in moderate but not serious consequences. The serious, infrequent occurence may result in severe consequences. For materials such as uranium where the concern is for an unrestricted airborne release, the consequences can be limited by the amount of material present during the occurence or restricted access to the environment. Since uranium can be a pyrophoric material (Hartman et al. 1951), fires resulting in self-sustained oxidation (ignition) or rapid oxidation are of great concern.

Three potential scenarios during three operations suggest themselves as potentially resulting in large airborne releases of uranium. First, a large quantity of molten uranium is handled during the melting and casting operation. Second, moderate quantities of divided uranium scrap [which can be more readily ignited than bulk pieces (Baker et al. 1966)] can be stored outdoors, under water in containers. Finally, large quantities of uranium in the form of DU munitions are stored by the military.

Up to 682 kg (1,500 pounds) of molten uranium could be poured during a casting operation. If an operational or equipment failure resulted in the release of the molten uranium and the loss of the inert gas cover, the uranium would oxidize rapidly and a fraction would be made airborne. Carter and Stewart (1970) experimentally measured the airborne release from molten uranium and measured fractional airborne release rates ranging from 3 E-3 to 5 E-5 depending upon the conditions - ignition and burning, melting, or partial disruption of liquid into droplets. The potential airborne release from this scenario range from 2041 g to 34 g of uranium. Casting operations occur in enclosed facilities and some of the airborne material will be lost due to natural processes such as gravitational settling or deposition on surfaces during its transport to the release point from the facility. Many such facilities are equipped with particle removal devices such as filters which further reduce the emission.

Scrap metal such as turnings can be stored under water in metal cans. Prezbindowski (1983) analysed such an event postulated to occur outdoors. 190.5 kg (419 pounds) of uranium turnings in a 30 gallon metal drum were assumed to ignite and oxidize to completion. The fractional airborne release was estimated to be 0.001 resulting in 190 g being released to the environment.

The potentially most serious situation would involve a fire in a munitions

storage bunker (igloo) holding a large quantity of various types of munitions (DU, high explosive, etc.). It is postulated that up to 11,850 rounds of a 105 mm DU cartridge could be present. Each cartridge would hold 3.3 kg of uranium resulting in a total of 39,105 kg of uranium. Other types of combustibles such as wooden crates and pallets, paper based packing materials, etc. would also be present. If the material present were ignited, the fire would initially spread slowly until sufficient flammable vapors could be generated and flashover occurs. Once flashover occurs, the entire contents of the enclosure are involved. The fire soon becomes oxygen limited due to the limited accessibility of air. Eventually, the cartridges themselves would be ignited and, if containment is lost, the fire would burn more vigorously due to the greater availability of oxygen.

Igloos are designed to vent in a perferred direction which does not involve adjacent structures. The flammable vapors released may well burn outside the facility due to the high vapor generation rate reducing radiant heat transfer to the materials inside.

There are two types of cartridges cases used for DU munitions - metal and combustible. The DU portion of metal cased cartridges were ejected from and unaffected by the fire in a large-scale, outdoors test (Gilchrist et al. 1978). DU from combustible-cased munitions in similar tests were not ejected from the fire and were almost completely oxidized (83% and 85.2%) (Hooker et al. 1983). Collection and analysis of the residual material did not indicate a loss of uranium and air samples taken during part of the burning and all of the recovery period did not show any significant airborne release (Hooker et al. 1983).

Experimental studies (Elder and Tinkle 1980) measured the rate of oxidation and airborne release during oxidation at elevated temperatures (400 C to 1200 C) of the DU portion of large-caliber munitions in air and a 50%air-50% carbon dioxide mixture. The maximum airborne release rate measured during the outdoor test using combustible materials as the heat source was 2.2 E-6 w%/min. The material was primarily U3O8 and was about 50 w% 10 micrometers Aerodynamic Equivalent Diameter (AED) or less. The three DU specimens oxidized an average of 44% during the three hour test. The velocity of air passing around the samples was 223 cm/s (5 mph). Similar but lower rates were measured in laboratory studies at various temperatures and atmospheres.

Each accident is an unique event and the conditions generated can vary greatly. Thus, it is assumed for the purposes of this analysis that the conditions to which the DU is subjected during the postulated fire are represented by those used in the above references. They may well be less severe.

It is postulated that 39,105 kg of DU are involved in an igloo fire and that it is completely oxidized. It is also assumed that the material is combustible-cased although the limit is for metal-cased. Based upon the experimental studies reported by Elder and Tinkle (1980), the material would be completely oxidized in 406 min. At the rate of 2.2 E-6 w%/min. 8.85 E-4 w% would be made airborne of which 4.5 E-4 w% are particles 10 micrometers AED or less. The total airborne release of DU in the size range of concern is approximately 19.6 kg. Based upon previously calculated doses, the dose at 100 m would be 0.0684 rem. As much as 173,000

rounds, each containing 3.3 kg of DU, could be involved without exceeding the 1.0 rem at 100 m criterion.

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