LICENSEE'S EXHIBIT 6

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judge
Peter B. Bloch

In the Matter of	Docket Nos. 70-00270 30-02278-MLA
THE CURATORS OF THE UNIVERSITY OF MISSOURI	RE: TRUMP-S Project
(Byproduct License No. 24-00513-32; Special Nuclear Materials License No. SNM-247)	ASLBP No. 90-613-02-MLA

AFFIDAVIT OF DR. C. LEON KRUEGER
REGARDING LITERATURE ON FRACTIONAL RELEASE FACTORS

I, C. Leon Krueger, being duly sworn, hereby state as follows:

1. I am a chemist, having earned both a B.S. degree (1964) and a Ph.D. degree (1969). My background and qualifications are summarized in paragraphs 2 - 8 of the Affidavit of Dr. C. Leon Krueger Regarding the Potential for a Fire from the Experiments Being Performed in the Alpha Laboratory. (Licensee's Exhibit 5)

2. I have reviewed in detail Professor James Warf's "A Critique of the TRUMP-S Process" (the "Critique") which is attached to the "Declaration of the TRUMP-S Review Panel" (Intervenors' Exhibit 1).

Response to Intervenors' "A Critique of the TRUMP-S Process"

3. Professor Warf provides a lot of information that is irrelevant to Licensee's amendments. Early in his "Critique", he digresses into a discussion of "INDUSTRIAL-SCALE OPERATIONS" where he speaks of "genuinely frightening hazards" (p. 1), "thousands of tons" (p. 1) of spent fuel and "more than a billion curies" (p. 3) of waste. He follows this by connecting "laboratory-scale and industrial-scale operations" (p. 3) and launching a discussion of accident scenerios and the literature concerning them.

4. Professor Warf's treatment of the literature is not very even-handed. Without claiming to do an extensive search of the

literature, I have read many of the papers referenced by Professor Warf, particularly the ones reporting the findings of Joku Mishima and his co-workers at Battelle Northwest Laboratory. I have selected the Mishima work for four reasons:

a) as shown below, this work has withstood the test of time,

b) it includes a review of and some comments about other literature,

c) Professor Warf relies on it heavily (7 of 13 references used for release fraction data) and describes Mishima as "one of the leading experimentlists in testing the capacity of plutonium to become airborne ..." (p. 10), and

d) examination of other literature convinces me that this body of work serves well as an example as it includes (or is in substantial agreement with) the information most applicable to the experimental TRUMP-S context.

5. As an example of the way the literature is used selectively, in his numbered list of "important papers" and "pertinent data" (beginning on p. 10), seven papers by Mishima and co-workers are referenced (Warf's 8, 10, 11, 12, 13, 15, & 16). Mishima's 1964 review (Warf's reference 8) is used for descriptive information regarding the nature of plutonium combustion but fails to mention several statements that Mishima seems to consider important. For instance, (on page 8) Mishima indents, and flags with a bulls-eye, these statements:

- No significant inhalation hazard would exist at greater than 200 yards from burning several kilograms of plutonium.

- A release value of 0.05% is a satisfactory, safe value for estimating the airborne hazard downwind.

6. These statements are repeated from the conclusions of Stewart (Warf's reference 3) discussing the burning of 200 g plutonium rods suspended over gasoline fires in an outdoor chimney 4 feet square and 11 feet high.

7. On the same page, Mishima mentions an explosive incident at Hanford, saying in part "Although smoke was observed leaking from the stairwell structure and one door was blown open, no significant contamination was detected on the ground beyond 20 yards."

8. Later (in his conclusions, page 16) Mishima states "In the event of fires in the open, even if several kilograms of plutonium were in a fire, no significant inhalation hazard will likely exist beyond several hundred yards downwind."

9. In the last sentence of this paper, Mishima points out the need for additional data. In the following decades, Mishima and his co-workers have addressed that need and have written much

that argues against Warf's position.

10. In a 1968 paper (Warf's reference 10), Schwendiman, Mishima, and Radasch say in their summary:

> "Overheating plutonium metal created less airborne material [than powdered oxalates, CLK1/]. The amount of material entrained during the oxidation of ignited, unalloyed plutonium metal in low air flows, 3.3 to 50 cm per second are small -- 3 x 10^{-4} to 5 x 10^{-3} wt %."
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> [Note that an open glove port accident with Licensee's box will generate a flow of less than 80 cm/s measured in the port oriface. It is also of interest to note that an arc welding unit was used to ignite their metal samples. CLK.]

11. At the end of their paper they draw some general conclusions. Among them:

1.) "Oxidation of metallic plutonium will cause to be airborne from a very small fraction (10^{-4}%) to a few hundredths of 1%.2/ The higher release fractions were measured for massive pieces of plutonium.", and

3.) "Evaporation of plutonium can be achieved with extremely small airborne release if carried out at low evaporation rates. Airborne release accompanying a full rolling boil from a 2-1/2 in. diameter beaker resulted in an airborne release ranging to a few tenths percent."

12. In 1973, Mishima and Schwendiman (Warf's reference 15) considered the inadvertent burning of scrap and waste materials. They used uranium (as a stand-in for plutonium) in cartons of flammable waste containing cardboard, paper, plastic, etc. In their summary, they state: "Measured airborne concentrations [within the 9.5 ft. diameter by 10 ft. tall enclosure, CLK] indicated relatively low fractional releases ranging from 0.05 to

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1/ Comments in square brackets and marked "CLK" are inserted for purposes of clarity by C. Leon Krueger.

2/ The "few hundredths of 1%" used here seems to refer to the data for Test 1 of their TABLE II. This same data was reported earlier by Mishima (Warf's reference 11) and is later quoted both correctly (two places) and incorrectly (in their summary) by Mishima and Schwendiman (Warf's reference 13). This apparent misquotation seems to be the source of the otherwise spurious value that appears in paragraph 73 of the Declaration of the TRUMP-S Review Panel.

0.003 percent of the uranium used as the source." They do point out their previous result (Warf's reference 13) that, not surprisingly, "As much as 40 percent of uranium dioxide powder on [burning, CLK] tissue paper was entrained at a nominal [air, CLK] velocity of 100 cm per sec." Unlike Professor Warf, they do not suggest that this [Mishima and Schwendiman's 'entrained', Warf's 'lofted', CLK.] material should be interpreted as a likely loss to the environment.

13. After more than a decade of study, in a paper not referenced by Professor Warf,1/ Mishima states in Appendix F, p. F.11: "Various incidents have occurred involving plutonium and its compounds ranging from spread of contamination to major fires. In no case have hazardous quantities of plutonium been released into the environment. Three of the incidents were very serious in nature and involved different forms of plutonium."

14. Describing the third incident, he continues (Appendix F, p. F.12): "The most serious and significant incident involving plutonium to date was the fire in a major plutonium fabrication facility at Rocky Flats, Colorado in May 1969. Products of a fire in one area clogged the exhaust filters of one of three exhaust systems. Flammable vapors passed into other areas. Ultimately, a significant portion of the facility was involved. The supply fans operated during the initial phase of the fire and loss in negative pressure allowed back diffusion into office areas. Hundreds of kilograms of plutonium as metal and compounds was involved with a significant quantity in unknown form involved with the equipment (Material Unaccounted For). Only 200 uCi of airborne material (0.003 g) was released through a damaged exhaust system. Based on the authors personal observation and data, a maximum of 0.5% of the plutonium may have been airborne within the facility. This value was derived by making the highly conservative assumption that all contamination measured on the ceiling, walls, and floor of all contaminated areas of the facility and all surfaces outside the enclosure was due to airborne material. The estimate does not include the negligible amounts of plutonium found in the water collected from extinguishment nor the unknown quantities in the exhaust system. The vast majority of the plutonium used to obtain this estimate was measured as floor contamination in the immediate fire area and is probably debris which fell or was washed from the enclosure during extinguishment."

1/ Mishima, J.: Data Useful in the Evaluation of Airborne Plutonium from Postulated Accident Situations. In Appendix F of Considerations in the Assesment of the Consequences of Effluents from Mixed Oxide Fuel Fabrication Plants , J. M. Selby et. al. BNWL-1697 REV1. Pacific Northwest Laboratory, Richland Washington, (1975).

15. Several things should be pointed out explicitly in applying this (and other literature) to the TRUMP-S project. For one thing, most of the available studies use amounts of plutonium (or a stand-in) far in excess of the amounts licensed for the Alpha Laboratory. Secondly, many of the situations described involve fuel loadings far in excess of anything likely (having a greater than negligible probability) in the Alpha Laboratory, and much of the work utilizes intentional mechanical disruption and forced ventilation. Thirdly, the higher release figures reported are applicable to the interior of the structure sustaining the release -- reductions due to settling, adsorbtion on wall and/or duct surfaces, and filtration are not taken into account. Except as an extreme upper limit, it is difficult to apply the available literature to the TRUMP-S context because the situations of practical interest are not only different in degree, but different in kind as well. Both the probabilities of, and the concequences resulting from an accident in a project like the TRUMP-S research very low.

16. Professor Warf suggests on p. 10 of his 'Critique' that it is unscientific and misleading to select low release fraction values to describe possible releases from the TRUMP-S project. In his untitled table on p. 12 of his "Critique", Professor Warf lists values or ranges of values of release fractions for 17 sets of conditions (11 of these from the literature of Mishima and his co-workers). Only two of the 17 exceed 1% (they both involve gasoline fires). Yet, in the Declaration of the TRUMP-S Review Panel, Table III., he recommends the use of 3%, a value[4/] higher than all but those most contrived to maximize the release.

17. It should also be pointed out that the literature of Mishima and his co-workers is still considered to be among the best available. The 1988 document A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees, NUREG-1140, acknowledges (at p. xi, and see also p. 96) Mishima's contributions with regard to release fractions, accident scenerios, and accident analysis, and several of his papers are cited (p. 25, 76, 77, & 98).

18. Although release fraction experiments are subject to much uncertainty, the results reported by Schwendiman, Mishima,

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4/ The 3% release fraction chosen for use in Table III does not seem to come directly from any of the literature quoted by Professor Warf in his "Critique". It is perhaps the 3% mentioned in paragraph 8 (p.A17) of the Declaration of Warf and Hirsch filed June 12, 1990 with the Relpy Memorandum of Petitioners in support of Request for Hearing and Stay Pending Hearing. Releases for over a week from the inferno at Chernobyl are not applicable to the TRUMP-S research licensed at the Alpha Laboratory.

and Radish in 1968 (Warf's reference 10) have held up in subsequent investigation, and provide the best comparison data that exists for the TRUMP-S project at MURR.

Subscribed and sworn
before me in
BOONE County,
Missouri this 13th day of
November 1990

C. Leon Krueger
C. Leon Krueger
Research Scientist

Sharon Wesselman
Notary Public

My Commission Expires

2-21-91

Sharon Wesselman, Notary Public, State of Missouri
My commission expires February 21, 1991
Boone County, Missouri