

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judge  
Peter B. Bloch

In the Matter of  
THE CURATORS OF  
THE UNIVERSITY OF MISSOURI  
(Byproduct License  
No. 24-00513-32;  
Special Nuclear Materials  
License No. SNM-247)

Docket Nos. 70-00270  
30-02278-MLA  
RE: TRUMP-S Project  
ASLBP No. 90-613-02-MLA

AFFIDAVIT OF Dr. SUSAN M. LANGHORST  
REGARDING RELATIVE RADIOLOGICAL RISK ASSOCIATED  
WITH TRACE AMERICIUM-241 IN PLUTONIUM STANDARD

I, Susan M. Langhorst, being duly sworn, hereby state as follows:

1. I am Manager of Reactor Health Physics at the University of Missouri-Columbia Research Reactor Facility ("MURR"), a position I have held since April 16, 1987. My background and experience are described in the Affidavit of Dr. Susan M. Langhorst Regarding NUREG-1140 and Intervenors' Dispersion Concentrations (Licensee's Written Presentation, Exhibit 2 at ¶¶ 2 - 6).

2. As the MURR Health Physics Manager, I am responsible for Licensee's radiological control program at MURR, which includes monitoring receipt and handling of all radioactive materials. As

1 Manager and also Assistant Professor in the University of  
2 Missouri-Columbia Nuclear Engineering Program, I am responsible  
3 for the training and education of students, staff and faculty in  
4 the basic concepts of radioactivity, radiation and dose. Hence,  
5 based on my education, experience, and job responsibilities, I am  
6 qualified to discuss the relative radiological risk associated  
7 with the trace amount of americium-241 present in Licensee's  
8 plutonium standard.

9 3. I have reviewed Intervenors' Motion for Reconsideration  
10 of Memorandum and Order of November 1, 1990 (Licensee's Partial  
11 Response Concerning Temporary Stay) and Emergency Order that  
12 Staff Hold in Abeyance Order of November 1 Part 1 ("Intervenors'  
13 Motion for Reconsideration").

14 4. As I will explain in more detail below, Intervenors'  
15 Motion for Reconsideration greatly exaggerates the minimal  
16 relative radiological risk associated with the trace amount of  
17 americium-241 present in Licensee's plutonium standard. The  
18 statements appear to reflect either a lack of full understanding  
19 of radiation and radiological dose or an attempt to cause  
20 needless concern in individuals who may not have a thorough  
21 scientific background. Accordingly, before responding to  
22 Intervenors' unsupported claims, I will first explain the  
23 governing basic concepts.

1           5. Radioactive materials emit different types of radiation  
2 as they decay. The major types of radiation are alpha, beta and  
3 gamma. Alpha radiation ("alphas") is the least penetrating of  
4 these radiations, i.e., alphas can be stopped (shielded) by a  
5 single sheet of paper. Beta radiation ("betas") can penetrate  
6 further through materials, but as little as a 1/4 inch thick  
7 piece of plastic can stop most betas. Gamma radiation ("gammas")  
8 is the most penetrating of these three types of radiation. The  
9 reduction in the amount (attenuation) of gammas as they pass  
10 through materials is exponential, i.e., if one thickness of  
11 material attenuates gammas to one tenth of their original  
12 strength (dose), then twice that thickness will attenuate gammas  
13 to one one hundredth of their original strength. For instance,  
14 it requires approximately 0.1 inch of stainless steel to reduce  
15 the dose rate from Am-241 by a factor of 10. Adding another 0.1  
16 inch, or 0.2 inches total, reduces the dose rate by 100 -- 0.3  
17 inches reduces it by 1000, and so on. In theory, the complete  
18 attenuation of gammas can never be achieved, but in practice  
19 gammas can be shielded down to levels that are not detectable in  
20 relation to gammas from normal background radiation.

21           6. The relative radiation hazard, or dose, external to the  
22 body is therefore highest for radioactive materials that emit  
23 gammas. 1/ The opposite is true for the case where radioactive

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24           1/ Energy of the gammas also contributes to the level of  
25 relative risk, but I will not go into its description  
26 here so as to keep this explanation simple.

1 materials are internal to the body, i.e., inhaled or ingested.  
2 While alphas do not penetrate far into a material, their  
3 interactions are far more destructive to the material than gamma  
4 interactions. Therefore, the relative radiation hazard, or dose,  
5 internal to the body is highest for alpha-emitting radioactive  
6 materials.

7 7. In light of these basic concepts, I will now respond to  
8 Intervenor's major claims concerning the radiological risk  
9 associated with the trace amount of americium-241 present in  
10 Licensee's plutonium standard.

11 8. In reference to the application for amendment to License  
12 No. SNM-247, Intervenor's maintain that the amendment is  
13 insufficient:

14 "... for failure to realize and acknowledge that some of the  
15 Pu-241 has yielded to americium-241, which requires a thick  
16 metal shield and other equipment and practices appropriate  
17 for gamma emitters..." See Intervenor's Motion for  
18 Reconsideration at 6.

19 That assertion is simply false. Licensee did not fail to realize  
20 the presence of trace amounts of Pu-241 or Am-241. See the  
21 Affidavit of Dr. J. Steven Morris Regarding Plutonium Content  
22 (October 29, 1990) (the "Morris Plutonium Affidavit") at ¶¶ 7 -  
23 16.

24 9. However, Intervenor's fail to appreciate the difference  
25 between Licensee's americium sample, i.e., a distinct sample of

1 Am-241 metal, and the trace amount of Am-241 present in  
2 Licensee's plutonium standard. As I discussed above, gammas  
3 emitted from a radioactive source can be attenuated to reduce the  
4 gamma dose rate by placing shielding material around the source.  
5 The effectiveness of different shielding materials depends mainly  
6 on the material's density and the energy of the gamma. 2/  
7 Americium metal and plutonium metal are both extremely effective  
8 in shielding their own gammas, especially the Am-241 major gamma  
9 at 59.5 keV. This effect is known as self-shielding. A  
10 thickness of less than 0.1 inch of plutonium or americium is all  
11 that is needed to reduce its own dose rate by a factor of 100. A  
12 single cube of the 5 gram plutonium standard would measure 0.25  
13 inches on a side.

14 10. In describing the potential dose rate from the distinct  
15 Am-241 metal sample and the possible shielding requirements,  
16 Licensee states:

17 "A 1/2 cm-thick stainless steel shield will reduce this dose  
18 rate by a factor of ~ 100 and would essentially shield all  
19 the 13.9 keV gammas emitted." (See amendment application  
20 for License No. 24-00513-32 at 18). (Emphasis added). 3/

21 The shielding requirements for the trace amount of Am-241 in  
22 Licensee's five gram plutonium standard are much less than those

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23 2/ In my description, I discuss gamma energies in units of  
24 kiloelectron volts (keV).

25 3/ This is apparently the source of Intervenor's phrase, "a  
26 thick metal shield." Intervenor's Motion for  
27 Reconsideration at 11. It is an example of how  
28 Intervenor utilizes partial quotations to produce a  
29 misleading effect.

1 needed for Licensee's 2.4 gram americium sample. There are two  
2 major reasons for this. First, the americium sample contains  
3 about 8.3 Ci of Am-241 and emits 240 times the number of gammas  
4 than does the 0.035 Ci of Am-241 present in Licensee's plutonium  
5 standard. Second, all of the americium sample will eventually  
6 decay by emitting Am-241 gammas, while the plutonium in  
7 Licensee's plutonium standard is mostly self-shielding the gammas  
8 from decay of its trace amount of Am-241.

9 11. The dose rate from the trace amount of Am-241 present  
10 in Licensee's plutonium standard has been calculated and measured  
11 to be quite low. The dose rate at a one foot distance due to the  
12 59.5 keV gamma from Am-241 is calculated to be 0.14 rem/hour per  
13 one curie. One gram of the CRM 127 plutonium standard has less  
14 than 0.007 Ci of americium. See Morris Plutonium Affidavit at ¶  
15 15. Even if one were to assume that the plutonium standard  
16 offers no self-shielding, then the dose rate at one foot from a  
17 five gram sample of CRM 127 standard material would be less than:

18  $(0.14 \text{ rem/hr-Ci})(0.007 \text{ Ci/g})(5 \text{ g})(10^3 \text{ mrem/rem}) = 5 \text{ mrem/hr.}$

19 However, self-shielding reduces such dose rate even further.

20 12. As per SOP HP-3: "Receiving and Opening Packages of  
21 Radioactive Material," the plutonium standard was monitored for

1 external gamma dose rates <sup>4/</sup> and for evidence of contamination  
2 upon receipt and upon opening the shipping packages. No  
3 contamination was found on any of the outer packaging, and dose  
4 rates due to gamma, beta, alpha, and neutron radiations were  
5 measured on the surface of the inner most container, a glass  
6 vial. The combined gamma plus beta dose rate on contact was  
7 measured at 2.6 mrem/hour. No dose rate due to either alpha or  
8 neutron radiation was observed for the surface measurement of the  
9 plutonium vial. This low gamma dose rate is not surprising due  
10 to self-shielding of the plutonium standard.

11 13. During all handling of the plutonium standard,  
12 radiation monitors, i.e., ring badges, were worn by Dr. Krueger  
13 on each hand and both registered less than 10 mrem. Intervenors  
14 resurrect their claim of dangers to students by stating:

15 "...procedures for handling the plutonium do not include the  
16 procedures necessary to prevent exposing its students to  
17 unacceptable risk of exposure to gamma radiation throughout  
18 the plutonium experiments..." See Intervenors' Motion for  
19 Reconsideration at 12.

20 The extremity dose limit per calendar quarter is 18.75 rem. See §  
21 20.101. At 2.6 mrem/hour, a student holding the plutonium vial  
22 for the total three months could not even reach the dose limit.  
23 Handling the plutonium standard with its trace amount of Am-241  
24 in the TRUMP-S experiments does not present an unacceptable risk

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25 <sup>4/</sup> Licensee routinely monitors all packages received for  
26 gamma dose rate, and for dose rates due to alpha, beta  
27 and/or neutron radiation as is warranted for the  
28 radioactive material.

1 of exposure to gamma radiation. Intervenors' statements are  
2 utterly without merit.

3  
4 14. In regard to the internal radiological risk,  
5 Intervenors use the following phrase:

6 "... americium 241, which is 50 times as toxic as plutonium  
7 241..." See Intervenors' Motion for Reconsideration at 9.

8 In this truncated use, the phrase is true since Am-241 is an  
9 alpha and gamma emitter and Pu-241 is a beta and weak gamma  
10 emitter. What is left unstated is that the Pu-239 and Pu-240  
11 have similar dose conversion factors as does Am-241. 5/ Thus,  
12 Intervenors are improperly presenting a comparison of hazard with  
13 another trace contaminant (Pu-241), rather than with the  
14 principal isotopes involved.

15 15. Intervenors also make a false analogy in claiming:

16 "... this americium is the equivalent of an additional 10%  
17 of the dose-contributing alpha emitter or an additional gram  
18 of the material for which the amendment is sought." Id. at  
19 10.

20 Licensee's authorized 10 grams of plutonium would contain less  
21 than 0.02 grams of Am-241. See Correction to Licensee's  
22 Submittal of October 30, 1990. Intervenors continue to purposely  
23 confuse activity and mass by saying that 0.07 Ci of Am-241 (10%

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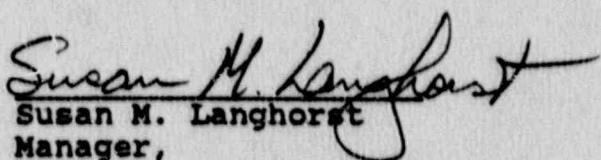
24 5/ NUREG-1140, Table 13 give the following dose conversion  
25 factors:

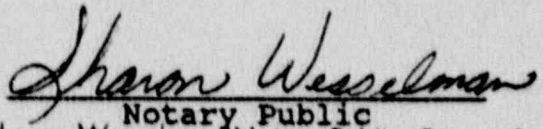
26	Pu-239	510 rem/ $\mu$ Ci inhaled
27	Pu-240	510 rem/ $\mu$ Ci inhaled
28	Pu-241	10 rem/ $\mu$ Ci inhaled
29	Am-241	530 rem/ $\mu$ Ci inhaled



1 of the 0.71 Ci for Pu-239 and Pu-240) implies that there is  
2 another one gram of plutonium. Precautions taken when handling  
3 the plutonium standard to prevent its intake into the body, i.e.,  
4 working in an air-tight, contained glove box, apply equally to  
5 the trace amount of Am-241 which is uniformly distributed in the  
6 plutonium standard. The additional 10% activity due to the trace  
7 amount of Am-241 does not add significantly to the risk  
8 associated with handling the plutonium standard or require any  
9 additional precautions.

10 Subscribed and sworn  
11 before me in  
12  
13 BOONE County,  
14 Missouri this 16<sup>th</sup> day of  
15 November 1990

  
Susan M. Langhorst  
Manager,  
Reactor Health Physics

16   
17 Notary Public

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

18  
19 2-21-91

**DUPLICATE ORIGINAL**

REGISTERED  
USNRC

**UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION**

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**ATOMIC SAFETY AND LICENSING BOARD**

**Before Administrative Judge  
Peter B. Bloch**

OFFICE OF SECRETARY  
DOCKETING & SERVICE  
BRANCH

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

**CERTIFICATE OF SERVICE**

I hereby certify that copies of the letter dated November 21, 1990 to Lewis C. Green from Maurice Axelrad and "Licensee's Response To 'Intervenors' Motion For Reconsideration ... And Emergency Order ... Part I'" were served upon the following persons by deposit in the United States mail, postage prepaid and properly addressed on the date shown below:

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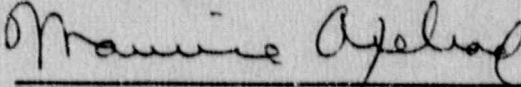
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