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. J. STEVEN MORRIS <u>REGARDING PLUTONIUM CONTENT</u>

I, J. Steven Morris, being duly sworn, hereby state as follows:

1. I am Interim Director of the University of Missouri-Columbia Research Reactor Facility ("MURR"), a position I have held since March 1, 1989.

2. I received a B.S. in Chemistry from Central Missouri State University in 1966 and a Ph.D. in Chemistry from the University of Missouri-Columbia in 1973. I have been employed at the MURR since 1973, in the positions of Radiochemist (1973 to 1975), Research Scientist (1975 to 1978), Sr. Research Scientist (1978 to 1983) and as Group Leader, Nuclear Analysis Program (1983 to present), a position I hold concurrently with that of Interim Director.

3. In the foregoing positions I have had a variety of responsibilities of progressive importance under the NRC licenses relating to the MURR held by the Curators of the University of Missouri ("Licensee"). For three years (1975 to 1978) my job responsibilities at the MURR were principally that of reactor chemist. As such, my group evaluated all experiments involving the use of the reactor. This group was responsible for all chemistry quality assurance measurements as required by Reactor License No. R-103, Material Licenses No. SNM-247 and No. 24-00513-32, and the Technical Operating Specifications. During this period of time, and afterwards, I have conducted, supervised and published research related to the reactor chemistry function. From 1978 to the present, I have continued to have responsibility for the reactor chemistry function in a supervisory capacity. In 1988, I supervised the development of

the quality assurance program for another MURR materials license. Since 1978, I have served as a member of the Safety Subcommittee of the Reactor Advisory Committee at MURR. This Subcommittee, by charter, must review all changes in the operation, maintenance or utilization of the reactor that have any safety significance. Hence, based on my education and experience, I am qualified to evaluate the isotopic composition, quantity and safety significance of the plutonium involved in the TRUMP-S experiments at MURR under the amendment to NRC License No. SNM-247 issued on March 19, 1990.

4. I have reviewed the Written Presentation of Arguments of Intervenors and Individual Intervenors ("Intervenors' Written Presentation") (October 15, 1990) including Exhibit 1 thereof, and other relevant materials, including Intervenors' Renewed Request for Stay Pending Hearing ("Renewed Stay Request") (October 15, 1990). I have also reviewed the Summary of Actions Taken During Conference Call of October 19, 1990 ("Summary of Actions"), which requires that:

> "a. Licensee will respond to Intervenors' allegation that the plutonium possessed by Licensee exceeded 2 curies and that Licensee possessed plutonium in excess of the amount authorized by the subject license amendment; . . ."

Summary of Actions, at 3. Finally, I have reviewed the Memorandum and Order (Grant of Temporary Stay) ("Temporary Stay Order") (issued on October 20, 1990, reissued with editorial changes on October 22, 1990).

5. Intervenors have alleged that the Licensee's application dated February 20, 1990 for amendment of NRC License No. SNM-247 (the "Application") was deficient because it failed to identify accurately the isotopic composition and curie content of the plutonium to be used by Licensee in the TRUMP-S experiments. Intervenors' Written Presentation at 16-19. They also allege that the Licensee possesses unlicensed plutonium. Id. at 19.

6. These allegations are based upon numerous errors by Intervenors and their experts in Intervenors' Written Presentation, including the principal exhibit thereof, Exhibit 1, "Declaration of the Review Panel." Because of the large number of such errors, this response must necessarily be quite comprehensive and will include discussions of the following:

1.) The impurities required to be identified in an NRC license application are any significant contaminants, taking into account their dose contribution.

2.) The Licensee's Application did not exceed the 2 Ci quantity of plutonium specified under 10 CFR § 70.22(i).

3.) The plutonium that the Licensee has received is a single 5 gram lot of New Brunswick Laboratory (NBL) Certified Reference Material (CRM) 127, formally National Bureau of Standards (NBS) Standard Reference Material (SRM) 945.

4.) Laboratory analyses of the five grams of NBL CRM 127 and associated documentation demonstrate that Licensee has correctly identified the isotopic composition of the plutonium on its Application.

5.) The ^{241}Pu and ^{241}Am present in such plutonium are not significant contaminants, in the context of the ^{239}Pu and ^{240}Pu standard material of which they are impurities, and therefore are not required to be identified on a license application.

6.) The total activity of the five grams of NBL CRM 127 that Licensee currently possesses and the ten grams that Licensee could possess under the 10 gram license limit are less than 2 Ci including the ^{241}Pu impurity.

7.) The Intervenors have misrepresented the curie content of plutonium that appears in the Application which in turn potentially misled the Presiding Officer.

8.) The Intervenors' experts (TRUMP-S Review Panel) have misrepresented the availability of plutonium with low isotopic composition of ^{241}Pu.

9.) The Intervenors' experts (TRUMP-S Review Panel) have selectively misused isotopic composition data.

10.) The Intervenors' experts (TRUMP-S Review Panel) have miscalculated ^{241}Pu activity.

11.) The Intervenors' experts (TRUMP-S Review Panel) did not consider obvious sources such as the National Bureau of Standards and New Brunswick Laboratory for obtaining certified plutonium reference standards.

12.) The Intervenors' experts (TRUMP-S Review Panel) only considered activity and ignored the concept of effective dose equivalent.

Background--Plutonium Isotopic Composition

7. In filing its Application for amendment of the SNM-247 license, Licensee followed Regulatory Guide 10.3, "Guide for the Preparation of Applications for Special Nuclear Material Licenses of Less Than Critical Mass Quantities" (RG 10.3). Section 4.3,

"Specifications of Special Nuclear Material", provides the specific guidance pertaining to the description of the isotopic composition. The pertinent part of Section 4.3 states:

> "The special nuclear material requested should be identified by isotope, chemical or physical form, activity in curies, millicuries, or microcuries, and mass in grams. Specification of isotope should include principal isotope and significant contaminants. Major dose-contributing contaminants present or expected to build up are of particular interest." (Emphasis added)

8. Licensee knew that the plutonium to be supplied for the TRUMP-S research project would contain impurities of radioactive isotopes, including ^{241}Pu and its daughter ^{241}Am. However, for the reasons set forth below, such impurities did not have to be identified in the Application. Moreover, even if they had been included, Applicant would not have exceeded the 2 curie level of plutonium requiring the Licensee to address the need or actually submit an emergency plan under 10 CFR § 70.22(i). 1/

9. Licensee's position that it listed the appropriate isotopes in its Application and that ^{241}Pu did not need to be listed is based on RG 10.3. As can be noted from the emphasized language in RG 10.3 quoted above, only "significant contaminants" are to be specified in an application, and significance is based upon the dose contribution of such contaminants in the context of the principal isotopes. The key term is dose-contributing. The applicability of reporting a minor or trace constituent depends on the dose that constituent contributes relative to the dose of the major constituents--in this case ^{239}Pu and ^{240}Pu. To address this further requires first that the record concerning the actual plutonium content be set straight.

Plutonium Certified Reference Material (NBL CRM 127)

10. The plutonium for which the Licensee applied and received authorization under License No. SNM-247 is a high-purity (99.8%) plutonium standard. Originally the material was

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1/ Nevertheless, as discussed in more detail in the Affidavit of Walter A. Meyer Regarding Emergency Plan, the University of Missouri Research Reactor (MURR) Facility Emergency Plan does apply to the TRUMP-S activities. That Plan, along with the NRC correspondence related to its acceptance, is part of the supplement to the hearing file that was provided to the Intervenors and the Presiding Officer by the NRC Staff on August 16, 1990. Moreover, the Plan and associated procedures had been voluntarily made available to Intervenors by the Licensee on June 26, 1990.

available from the National Bureau of Standards (NBS) 2/ as Standard Reference Material (SRM) 945. In 1987, NBS SRM 945 was transferred to the New Brunswick Laboratory (NBL) and became Certified Reference Material (CRM) 127. Copies of the "Certificate of Analysis" for NBL CRM 127 (Attachment 1), the "Certificate of Analysis" for NBS SRM 945--the previous NBS designation for this material (Attachment 1B), DOE/NRC Form 741 (as completed by the NBL when the material was originally shipped to Rockwell International) (Attachment 2), and Form DOE-CH393(10-79) (also completed by NBL) (Attachment 3) are attached. The shipping papers and Form 741 (Attachment 4) for the transfer of the NBL CRM 127 from Rockwell International to the MURR at the University of Missouri-Columbia are also attached.

11. Forms 741 and CH393 (Attachments 2 and 3) were available to the Licensee at the time the Application was prepared. Data from these forms were used by the Licensee in completing that part of the Application regarding isotope composition. These forms include information on both NBL CRM 115 (75 grams of depleted uranium) and NBL CRM 127 (5 grams of plutonium metal) because these two materials were shipped together by the NBL.

12. Form CH393 lists the total activity for both NBL CRM 115 and NBL CRM 127 to be 390 millicuries which essentially can be attributed entirely to the plutonium standard 3/. The plutonium is listed as 4.72 grams ^{239}Pu and 0.279 grams ^{240}Pu. These masses of ^{239}Pu and ^{240}Pu translate to 94.42 and 5.58 weight percent for ^{239}Pu and ^{240}Pu, respectively. These are precisely the numbers used by the Licensee in the Application. See page 1,¶2(d) of Licensee's Application (Attachment 5).

13. On Form 741, NBL did not list ^{241}Pu or ^{241}Am. On Form CH393 it did not list ^{241}Am, and it checked ^{241}Pu as present but left the gram content as blank. The reason that quantities for ^{241}Pu and ^{241}Am were not listed was that they are present only at trace levels. Since Licensee knew that trace levels of these isotopes not listed on the shipping documents could not be significant contaminants in the context of the ^{239}Pu and ^{240}Pu, it did not list them on the Application.

14. The relationship between ^{241}Pu and ^{241}Am is shown in the following equation:

$$^{241}Pu_{94} \rightarrow {}^{241}Am_{95} + {}^{0}\beta_{-1}$$

2/ NBS is now known as the National Institute for Standards and Technology (NIST).

3/ The 75 grams of depleted uranium accounts for only ~30μCi (0.03 mCi) of the total activity for that shipment.

Of particular note is the fact that the decay of ^{241}Pu is almost entirely via beta emission (99+ %) and only a small fraction via alpha emission (0.00245%). The radiological risk due to plutonium is essentially entirely due to the internal dose, and alpha emitting isotopes are of much greater concern than beta emitting isotopes. Therefore, the alpha emitting Pu isotopes are of principal regulatory interest, and the beta-emitting ^{241}Pu does not contribute significantly to the overall potential dose assessment in high-isotopic-purity samples such as NBL CRM 127. The ^{241}Am that builds up from the decay of ^{241}Pu is an alpha emitter; however, it does not contribute significantly to the overall dose because its specific activity (curies/gram) is a factor of 30 less than that of ^{241}Pu which is already at a trace level with respect to mass.

15. The certificate for NBL CRM 127 lists the ^{241}Am content from the beta decay of ^{241}Pu to be approximately 146 μg of ^{241}Am per gram of plutonium as of September 1970. The certificate also states that the build up of ^{241}Am is less than 150 μg per gram of plutonium per year. From these two values and the half-lives of ^{241}Pu and ^{241}Am, reasonable estimates can be computed regarding the present-day levels of these isotopic impurities. The calculations have been summarized and attached (Attachment 6). The isotopic distribution for NBL CRM 127 including the ^{241}Pu and ^{241}Am impurity levels are given in Table 1 below.

Table 1. Total mass and activity for each plutonium isotope in CRM-127 as of September 1990 4/.

		License Limit at MURR is 10 grams	
Isotope	wt. %	grams	curies
^{239}Pu	94.42	9.44	0.586
^{240}Pu	5.58	0.558	0.126
^{241}Pu (β)	< 0.1	< 0.01	< 1
^{242}Pu	< 0.1	< 0.01	$< 4 \times 10^{-5}$
^{241}Am	< 0.2	< 0.02	< 0.07
	total plutonium alpha		0.712 Ci
	total alpha activity (including americium)		0.782 Ci
	total plutonium activity ($\alpha + \beta$)		1.71 Ci

4/ Data are taken or computed from Forms 741, CH:93 and the CRM 127 certificate. Less-than values (<) result from calculations based on less-than values in the certificate. The plutonium was received by Licensee in September 1990.

16. In addition to the data in Table 1 from the NBL CRM 127 certificate and other documents, the isotopic composition was determined in 1975 at Los Alamos National Laboratory (LANL). A copy of a 1982 letter to Dr. Thomas Gills at NBS discussing these analysis results is attached (Attachment 7). The data in the table on page two of that letter, under the "Feb-1975" column heading are given in atom percent. These data converted to weight percent and decay corrected to September 1990 (date CRM 127 standard was received at MURR) are given in Table 2.

Table 2. Isotopic composition (wt%) and curies per 10 grams for NBL CRM 127 (NBS SRM 945) from 1975 LANL analysis decay corrected to September 1990.

Pu Isotope	wt. %	curies per 10 grams
^{238}Pu	0.0081	0.014
^{239}Pu	94.2	0.584
^{240}Pu	5.52	0.126
^{241}Pu	0.116	1.21
^{242}Pu	0.018	$< 1 \times 10^{-6}$
total alpha activity		0.728 5/
total plutonium activity ($\alpha + \beta$)		1.94

These results are in good agreement with those reported in Table 1, especially for the major isotopes, ^{239}Pu and ^{240}Pu. In addition, the atomic weight computed from the atom percent data given in the 1982 letter discussing the 1975 LANL analysis (Attachment 7), and the atomic weight of the plutonium isotopes as given in the Chart of the Nuclides is 239.11. This is in excellent agreement with the value of 239.12 as given in the 1973 NBS certificate (Attachment 1B) and the NBL certificate (Attachment 1) for this plutonium standard.

Intervenors Have Misrepresented Licensee's Application--.07 Ci is not 0.71 Ci

17. Intervenors have argued in their direct case that the Licensee has failed to comply with 10 CFR § 70.22(a)(4). They begin this argument by stating:

> "Regulatory Guide 10.3 is of considerable significance in this respect, and should be read in its entirety." (Emphasis added) Intervenors' Written Presentation at 10.

5/ Does not include ^{241}Am data.

Intervenors continue at pages 10 and 11 to quote a part of Section 4.3 of RG 10.3:

> "The special nuclear material requested should be identified by isotope, chemical or physical form, activity in curies, millicuries, or microcuries, and mass in grams. Specification of isotope should include principal isotope and significant contaminants."

Note that even though Intervenors have instructed that RG 10.3 should be read in its entirety, they conveniently conclude their quotation of Section 4.3 immediately prior to the following sentence:

> "Major dose-contributing contaminants present or expected to build up are of particular interest." (Emphasis added)

This sentence is critical in deciding what impurities should be listed in a materials license application. It establishes that a major factor in the decision is dose-contribution, not merely activity. This omission is relevant and will be further discussed below.

At page 16, Intervenors state:

> "There is realistically no way that the authorized 10 grams of plutonium would contain only .07 curies, as claimed by the University at page 1,¶ 2(d) of the application." (Emphasis added)

At page 17 Intervenors state:

> "...Absent such an affidavit, the University's extraordinary representations that the plutonium represents only .07 curies, obviously based on hearsay, bordering on fantasy, cannot withstand Professor Warf's analysis." (Emphasis added)

At page 18 Intervenors state:

> "The definition of § 70.4(r) excepts research and development activities utilizing 'unsubstantial amounts' of plutonium. Believing that only .07 curies of plutonium were involved, the Staff might reasonably conclude that this is an "unsubstantial amount" and therefore not within the definition." (Emphasis added)

18. In each of these statements, Intervenors state that the Licensee has represented in its application that the curie content of the 10 grams of plutonium requested is .07 curies. This is not correct. In the Application at page 1,¶ 2(d)

(Attachment 5), Licensee correctly listed the total activity of the ^{239}Pu and ^{240}Pu as 710 mCi, 10 times the number stated by Intervenors.

19. Licensee notes that Intervenors filed Intervenors' Correction on this point on October 25, 1990. Licensee does not agree that the substance of the points is not affected by the error--especially given the sarcastic rhetoric used by the Intervenors. The misstated curie content could well have influenced the Presiding Officer's decision to temporarily stay the experiments. The curie content is correctly stated in Intervenors' Exhibit 1, however there is no indication in the Temporary Stay Order that the Presiding Officer had observed the discrepancy and was acting on the correct version. At any rate, the error reflects on the competence of the Intervenors, not the Licensee. Unfortunately, it was not perceived that way by the Presiding Officer or the local and national media, which have characterized the Licensee as incompetent based on language used by the Presiding Officer in the Temporary Stay Order that was put in place prior to allowing Licensee to respond.

<u>Intervenors Have Misrepresented the Availability of Plutonium With Low Isotopic Composition of Pu-241</u>

20. Intervenors argue that all plutonium must contain at least 5.3 Ci of ^{241}Pu per 10 grams of total plutonium, and perhaps as much as 120 Ci. Intervenors' Written Presentation at 16 and Exhibit 1 at page 9, ¶27 and ¶29. They then contrast this with the .07 Ci of total plutonium that they contend the Licensee used in its Amendment application. As Licensee has now shown, the quantitative aspects of the Intervenors' argument are entirely incorrect. The .07 Ci figure for plutonium alpha activity should be 0.71 Ci and the 5.3 to 120 Ci range for ^{241}Pu beta activity should be ≈ 1 Ci in the case of 10 grams of the NBL CRM 127 plutonium standard.

21. Intervenors at page 17, citing Dr. Warf and the "TRUMP-S Review Panel" 6/, 7/ have argued that Licensee should demonstrate the actual isotopic composition of the plutonium that it possesses. Licensee has shown by Certificate of Analysis, issued first by the United States National Bureau of Standards (Attachment 1B), that CRM 127 has a different isotopic

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6/ At Exhibit 1,¶3, the Intervenors TRUMP-S Review Panel is defined to consist of: James C. Warf, Daniel Hirsch, Sheldon C. Plotkin, Miguel Pulido and Lowell Wayne.

7/ The Exhibit 1, Declaration of the Review Panel, paragraphs relevant to this discussion include but may not be limited to: ¶15 through ¶36 inclusive (pages 6-11), ¶54[a] (page 15), and Appendix I (no page number).

composition than those materials cited by Warf 8/, et.al, at Exhibit 1,¶17 and ¶18 and in Appendix I of Exhibit 1.

22. Dr. Warf, *et al*., have stated at Exhibit 1, page 7,¶18: "The lowest figure we have seen reported for ^{241}Pu is 0.44 wt% for twenty-year-old plutonium, which would result in about 0.53 Ci/gram WG-Pu 9/, or ten grams representing about 5.3 curies total." In point of fact, 0.44 wt% is:

$$0.0044 \times 103\ Ci/g\ \underline{10}/ = 0.45\ Ci/g$$

Therefore 10 grams would be 4.5 Ci not the 5.3 Ci reported by the TRUMP-S Review Panel.

23. The fact that the lowest percentage of ^{241}Pu found by Dr. Warf and the Review Panel in the literature was 0.44 wt% is irrelevant. Licensee has shown that a certified reference material exists that is considerably lower. This reference material was once available from the National Bureau of Standards (NBS) and now from the New Brunswick Laboratory (NBL) and is listed in catalogues from both of these agencies.

24. It is astounding that a scientist concerned with the development of chemical or physical methods would not consult the

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8/ As a separate point Intervenors have been critical of Licensee (specifically Dr. Morris) in his citations of release factors, accusing him of citing only low values rather than representative values (*i.e.*, Intervenors' Written Presentation at p. 39 and Exhibit 1, p. 21, ¶ 73). Justification for these citations will be given in Licensee's response to be filed as part of its direct case.

The following is of interest: Warf, et.al.,at ¶17 of Exhibit 1, has listed data "adapted from J.C. Warf, *All Things Nuclear*, page 117". A copy of that page is attached (Attachment 8). The entries for ^{239}Pu and ^{241}Pu are of particular interest because in his book, Dr. Warf cites ^{239}Pu to be 92.0-92.4% and selects 92.0 to enter in Table I of ¶17, Exhibit 1. On the other hand, for ^{241}Pu, Dr. Warf cites the range to be 1.7-2.0% and selects 2.0% to enter in Table I. Licensee would be interested in receiving Dr. Warf's technical rationale for selecting the low end of the ^{239}Pu range and the high end of the ^{241}Pu range.

9/ Licensee believes that WG-Pu stands for weapons-grade plutonium.

10/ The 103 Ci/g factor for ^{241}Pu is taken directly from Exhibit 1, Appendix I. Licensee has checked this factor and agrees that it is correct.

National Bureau of Standards (formally NBS, now NIST) prior to concluding that a desired material or method was not available. The NBS has both a national and international reputation in the development, characterization and distribution of standard reference materials. In fact, the NBS was established as a methods and materials resource by an act of Congress on March 3, 1901. They have catalogued their materials and services since 1906 (Attachment 9)11/.

25. Had Dr. Warf, or others on the Intervenors' TRUMP-S Review Panel checked any recent NBS catalog, up to 1987 (Attachment 10)12/, they would have found:

1.) The catalogs (up to 1987) contain plutonium standards, even some technical information concerning isotopic composition for some of the standards.

2.) Addresses and telephone numbers to obtain more information specific to special nuclear materials.

3.) An open letter of invitation to users from S.D. Rasberry (Chief of the Office of Standard Reference Materials) beginning with the words: "Please do not hesitate to call us if you have any questions about the SRMs (Standard Reference Materials) described, their availability, or if you cannot find what you need."

26. In the most recent NBS SRM Catalog (1990-91) (Attachment 11)13/, information is included directing inquiries concerning special nuclear material standards to the New Brunswick Laboratory (NBL) even though the NBS had transferred responsibility for distribution of SNM materials to NBL on October 1, 1987.

27. Had Dr. Warf or other members of the TRUMP-S Review Panel pursued their interests in plutonium to the New Brunswick Laboratory, they would have discovered a number of plutonium

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11/ Attachment 9 is a copy of the cover, and inside cover page, of the 1982-83 Edition of the NBS Standard Reference Materials Catalog recognizing their 75th anniversary.

12/ Attachment 10 consists of a copy of the cover of the 1986-87 Edition of the NBS SRM Standard Reference Material Catalog, an open letter to users from Chief Rasberry, and page 78 illustrating information on plutonium standards.

13/ Attachment 11 consists of the 1990-91 Edition NBS SRM Catalog cover page and page 10 directing inquiries on special nuclear materials standards to the New Brunswick Laboratory.

standards (Attachment 12)14/ are available. For some of these--for example, CRM 138 listed on catalog page 5, see Attachment 12--there are data in the catalog showing isotopic compositions of ^{241}Pu less than the 0.44 wt.% that Warf, et.al., state is "the lowest figure we have seen reported for ^{241}Pu in weapons-grade plutonium...."(Intervenors Exhibit 1, page 7, ¶18). Whether or not the material is weapons grade plutonium is irrelevant. For any of these materials, including the CRM 127 standard being used in the actinide experiments at the MURR, information can be readily obtained by calling the New Brunswick Laboratory.

28. These steps just outlined are not difficult nor innovative. They are ones taken every day by working scientists and engineers around the world. The question remains as to why the TRUMP-S Review Panel did not check with such an obvious possibility as the National Bureau of Standards for information on the availability of a standard before they took this litigation down such a non-productive pathway that departs so greatly from any legitimate concern regarding public safety.

Relative Radiological Hazards of the Plutonium Isotopes

29. Although the activity of ^{241}Pu is greater than the activity of ^{239}Pu and ^{240}Pu, the radiological hazard associated with ^{241}Pu, a beta emitter, is much less than that associated with ^{239}Pu and ^{240}Pu, both of which are alpha emitters. This difference in radiological risk is reflected in the Nuclear Regulatory Commission regulations, e.g., 10 CFR Part 20, Appendix B, and 10 CFR Part 71, Table A-2. Part 20, Appendix B, permits concentration in air above background for ^{241}Pu at a level 50 times greater than for the alpha-emitting ^{239}Pu and ^{240}Pu isotopes (soluble). Similarly Part 71, Table A-2 defines the activity limits not to be exceeded for shipping Type A quantities of radioactive materials. The ^{241}Pu activities listed in this table are at least 50 times greater than the corresponding ones for ^{239}Pu.

30. This factor of 50 also appears in NUREG-1140, "A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees - Final Report" (Jan 1988) which was prepared by the NRC in considering whether emergency preparedness requirements should be imposed on certain fuel cycle and radioactive materials licensees. Table 13 of NUREG-1140, "Quantities of Radioactive Materials Requiring Evaluation of the Need for Offsite Emergency Preparedness" (based on 1 rem

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14/ Attachment 12 consists of pages from the most current edition (1988) of the New Brunswick Laboratory catalog of Certified Reference Materials.

effective dose equivalent outside the building), identifies a dose conversion factor (in rem/μCi inhaled) for many radioactive materials and, taking into account solubility class and release fraction, calculates a quantity for each material that would require evaluation for need for emergency preparedness. For ^{239}Pu, ^{240}Pu and ^{241}Pu, these result in action levels of 2, 2 and 100 curies, respectively.

31. These numbers point up the misleading nature of Intervenors' argument. By simply adding their alleged (and incorrectly derived, as shown above) quantities of ^{239}Pu, ^{240}Pu and ^{241}Pu, they have argued that Licensee exceeds the 2 curie level for plutonium set forth in 10 CFR § 70.22(i). As demonstrated above, even if beta activity is blindly added to alpha activity, Licensee does not exceed the 2 curie level.

32. But, if any attempt is made to calculate rationally the dose contribution of the ^{241}Pu, it is shown to be negligible in the context of ^{239}Pu and ^{240}Pu. This could be done by calculating the potential impact of the additional isotopes based upon their effective dose equivalent. 15/ A common mechanism for such calculation is computing a sum of the ratios. 16/

33. Table 1 of my affidavit above shows the quantities of ^{239}Pu and ^{240}Pu for a 10 gram CRM 127 sample. For those two isotopes the curie quantities listed in Table 13 of NUREG-1140 (as upper limits based on 1 rem effective dose equivalents) are 2 curies and 2 curies, respectively. Thus, considering only those two isotopes, the following sum of the ratios is computed:

$$\text{sum of ratios} = [(Ci_{Pu\text{-}239}/2) + (Ci_{Pu\text{-}240}/2)$$

$$\text{sum of ratios} = [(0.586/2) + (0.126/2)] = \underline{0.356}$$

If the ^{241}Pu is added (considering its 100 curies level in Table 13 of NUREG-1140), the trace quantity shown in my Table 1 adds a value of (1 curie/100) = 0.01, which brings the foregoing

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15/ Even if Licensee requested authorization for more than 2 curies of plutonium, an alternative under 10 CFR § 70.22(i)(1)(i) would be to provide: "An evaluation showing that the maximum dose to a member of the public offsite due to a release of radioactive materials would not exceed 1 rem effective dose equivalent . . . ."

16/ See for example the Note appended to Part 20, Appendix B.

sum of the ratios to a total of <u>0.366</u>. This is an insignificant addition. 17/

<u>Summary</u>:

34. The Intervenors and their experts (TRUMP-S Review Panel) have made false accusations based on their failure to take simple steps to ascertain the possibility that Licensee had properly represented the isotopic and curie content of the plutonium in the Application. Moreover, they have chosen to make simplistic arguments based on the activity of ^{241}Pu rather than its effective dose equivalent. In so doing they have diverted the attention of this proceeding away from public safety and hence the public's interests. In making their arguments, the Intervenors have altered the record concerning Licensee's Application, misled the Presiding Officer regarding isotopic composition of plutonium, mistakenly accused the Licensee of being in violation of regulations, miscalculated ^{241}Pu activity, inappropriately based arguments on activity rather than dose, and, in general, totally misrepresented the magnitude of the activity of the plutonium being used in the TRUMP-S experiments being done at the MURR. In summary, there is no merit to the allegations made by Intervenors that Licensee has improperly applied for a license for plutonium or is in violation of the license it received.

J. Steven Morris
Interim Director

Subscribed and sworn
before me in
Boone County,
Missouri this 29th day of
October 1990

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

My Commission Expires

2-21-91

<u>17/</u> Even if the trace quantity of ^{241}Am is included from Table 1, the addition of a fourth term [$Ci_{Am\text{-}241}/2$] having a value of ($0.07/2 \approx 0.04$) brings the sum of the ratios to a total of only <u>0.406</u>. This addition is still not significant, and the sum of the ratios is still well less than one.

ATTACHMENT 1

U. S. Department of Energy
New Brunswick Laboratory

New Brunswick Laboratory Certified Reference Materials Certificate of Analysis

CRM 127

Plutonium Metal – Matrix Standard

This Certified Reference Material (CRM) is for use as a source material for the preparation of emission spectroscopy PuO_2 matrix standards. Each unit of CRM 127 consists of several pieces of metal having a total weight of about 5 grams, sealed in a glass tube under a reduced-pressure argon atmosphere. NOTE: *The tube and its containment should be handled under proper radiologically-controlled conditions at all times.*

This CRM was originally issued in 1973 by the National Bureau of Standards (NBS) as Standard Reference Material (SRM) 945. The material was prepared and analyzed by the Los Alamos National Laboratory (LANL) of the University of California, in collaboration with NBS. In 1987, the technical and administrative transfer of NBS Special Nuclear SRMs into the NBL CRM Program was coordinated by the NBS Office of Standard Reference Materials and N. M. Trahey, NBL.

The metal is known to be of a high-purity (>99.8%), as it was prepared from a single lot of material selected because of its low metallic impurity content. The major fixed (nonradioactive) impurities in CRM 127 are: tungsten – 80 μg/g, silicon – 11 μg/g, gallium – 6 μg/g, and iron – 3 μg/g. Total detected fixed metallic impurities are estimated to be 105 μg/g. The americium-241 content, resulting from the decay of plutonium-241, is approximately 146 μg/g as of September 1970, and should increase less than 150 μg/g per year. All values given are not certified and are provided for informational purposes only. Impurity determinations indicate that the material is quite homogeneous.

The atomic weight of the plutonium is 239.12.

RECOMMENDED PROCEDURE FOR USING CRM 127

Each unit (tube) of CRM 127 is provided with a serial number and unique weight. Weighings are accurate to the nearest 1.0 milligram. Very small pieces of metal may be separated from the larger pieces in the tube. The contents of the tube should be washed thoroughly with dilute HCl to insure quantitative removal of the metal pieces.

October 1, 1987
Argonne, Illinois
(Revision of NBS Certificate dated January 29, 1973)

Carleton D. Bingham
Director

(Over)

The matrix material should be prepared to closely approximate the chemical composition of the sample under study, since best results are obtained when the standards have the same chemical matrix as the samples. Also, the matrix material should be prepared under controlled conditions that parallel the ignition of the sample prior to its analysis.

A recommended procedure[1] for determining metallic impurities in plutonium metal is as follows: The entire 5 grams of CRM 127 should be ignited as one batch. Impurity elements are then added in the form of oxides and blend into the matrix using a mixer-mill. Care should be taken to guard against impurity contamination. The material should then be ignited at 800°C for 30 minutes using a Pt-10% Rh crucible, precleaned with hot concentrated HNO_3, and a Pt-lined electric furnace. Addition of 4% Ga_2O_3 as a carrier is performed prior to excitation of the material in a dc arc. Plastic ware is recommended for the blending operation and for storage of the standards.

REFERENCE

1. Unpublished Method, LANL.

U. S. Department of Commerce
Frederick B. Dent
Secretary
National Bureau of Standards
Richard W. Roberts, Director

National Bureau of Standards

Certificate of Analysis

Standard Reference Material 945

Plutonium Metal – Standard Matrix Material

This plutonium metal is issued to provide a source material for the preparation of PuO_2 to be used as matrix material for the preparation of emission spectroscopy standards. Although it is known to be of high purity, it is not intended to replace SRM 949, as a primary chemical standard. The Assay and Atomic Weight values are supplied primarily as information in the use of this standard as a matrix material.

Assay 99.9 ± 0.1

Atomic Wt 239.12

This plutonium metal has been prepared from a single lot of material selected because of its low metallic impurity content. The main impurities detected, exclusive of americium, are: tungsten, 80 ppm; silicon, 11 ppm; gallium, 6 ppm; and iron, 3 ppm--with a total detected metallic impurity content of about 105 ppm. The americium resulting from the decay of plutonium-241 is approximately 146 ppm as of September 1970, and should increase less than 150 ppm per year. Impurity determinations indicate that the material is quite homogeneous.

Each of these SRM's consists of several pieces of metal having a total weight of about 5 grams sealed in a glass tube under a reduced-pressure argon atmosphere. The serial number of the SRM and its weight are given on each tube. Weighings are accurate to the nearest 1.0 milligram. Because of the method used to fabricate the material, very small pieces of metal may be separated from the larger pieces in the tube. These small pieces may be left behind unless the tube is carefully washed out, preferably with dilute hydrochloric acid.

This material was prepared and analyzed by the Los Alamos Scientific Laboratory of the University of California, Los Alamos, New Mexico, in collaboration with the National Bureau of Standards.

Washington, D. C. 20234
April 6, 1971
(Reissued January 29, 1973)

J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

DIRECTIONS FOR USE

For the emission spectrographic analysis of either Pu metal, U metal, or alloys of these two, best results are obtained when standards are prepared having the same matrix, chemically, as the samples. This is because the chemical matrix significantly influences the response of impurity elements to dc arc excitation. Further, the physical properties, particularly the state of subdivision and density, also significantly affect the response of impurity elements to dc excitation. For these reasons, it is recommended that the matrix material should not only closely approximate the chemical composition of the samples, but should also be prepared in a closely controlled manner that parallels the ignition of the sample prior to its analysis.

A recommended method(1) for determining metallic impurities in plutonium metal involves ignition of the metal under controlled conditions (800 °C for 30 minutes), addition of 4% Ga_2O_3 as a carrier, and excitation of the material in a dc arc.

To prepare matrix material for standards for this analysis, the PuO_2 should be produced by ignition of high-purity metal under similar conditions of temperature and time. It is recommended that 5 grams of metal be ignitied as one batch. Impurity elements are then added in the form of oxides and carefully blended into the matrix using a mixer-mill. The usual precautions must be taken to guard against impurity contamination in each preparation step. Use of a Pt-10% Rh crucible precleaned with hot concentrated HNO_3, and a Pt-lined electric furnace is recommended for the ignition step. Plastic ware is recommended for the blending operation and for storage of the standards.

(1) Unpublished Method, Los Alamos Scientific Laboratory.

DOE/NRC FORM 741
(7-80) Previous editions are obsolete.
MANDATORY DATA COLLECTION
AUTHORIZED BY 10 CFR 30, 40, 50, 70, 76, 150, Public Laws 83-703, 93-438, 95-91

U.S. DEPARTMENT OF ENERGY AND U.S. NUCLEAR REGULATORY COMMISSION
NUCLEAR MATERIAL TRANSACTION REPORT

1. Shipper's RIS	2. Receiver's RIS	3. Transaction No.	4. Correction No.	5. Processing Code	7. Action Code	Documentation
CBJ	LAE	1		Shipper A, Receiver A	Shipper A, Receiver B	Page 1 of 1 pages, copy 7 of 7 copies

9. Name and address of shipper:
U.S. DOE/NEW BRUNSWICK LABORATORY
9800 SOUTH CASS AVENUE
ARGONNE, ILLINOIS 60439
Attention: John Sickels
Telephone: FTS 972 - 8402

10. Name and address of receiver:
ROCKWELL INTERNATIONAL
ROCKETDYNE DIVISION
SANTA SUSANA TEST SITE
CHATSWORTH CA 91311
Telephone: V.J. Schaubert FTS 929-4444

11. No. of data lines: 02

Distribution of copies: LAE - CBJ; LAE; LAE - CAA; CAA; LAE - LAA; LAA; CBJ

17. Material type and description: DEPLETED URANIUM & PLUTONIUM - CERTIFIED REFERENCE MATERIAL

18. Transportation profile: Carrier identification: CFWY
19. Package identification: Model ID: SM type B
20. Action date: A. Shipment: 05 12 89; C. Receipt: 05 18 89

21. A. Miscellaneous: [redacted]
89-043

22. Total gross weight: 56 lb

Line No.	Identification (Batch Name)	No. of Items	Project Number		Composition/Facility Code		Country Control Number	Gross Weight	Net Weight	Element Weight	Weight % Isotope	Isotope Weight
01	CRM 115	1	CGD050200A	10	771	G	USUSO000		75.0	*	0.0290	*kg
02	CRM 127	1	CGD050200A	50	771	G	USUSUS00		5.0	5.0	5.58	5 g

Shipper's data — Signature of authorized official: John Sickels [signature]

Receiver's data — Signature: [signature] 7/17/89

SHIPPERS VALUES ACCEPTED---741 received 7/14/89--Reference 741 series CBJ-ZAZ-03 & 03cd1

POSTED AS JUNE RECEIPT, REF TELECON @ McINTOSH, DOE-SAN, 6/14/89 REGARDING RECEIPT, DOCUMENTATION, ETC.....

18 U.S.C., SECTION 1001; ACT OF JUNE 25, 1948, 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

ATTACHMENT 2

ATTACHMENT 3

NBL SHIPPING FORM
NBL RECORD COPY
(RECORD CLERK/CENTRAL FILE)

No. 3233

DATE: / /
CARRIER NO.:
VEHICLE NO.:

NEW BRUNSWICK LABORATORY
Building 350
9800 South Cass Avenue
Argonne, Illinois 60439
(312) 972-2442

SHIP TO:
Rockwell International
Rocketdyne Div., Bldg. 064
Santa Susana Test Site
Top of Woolsey Canyon
Chatsworth, CA 91311

ATTENTION: V. J. Schaubert

DATE REQUIRED AT DESTINATION: Mo. / Day / Yr. / /

NBL REF. NO.: 89-043

SHIPMENT AUTHORIZED BY: Nancy M. Craney — DATE: 5/11/89
HEALTH PHYSICS APPROVAL: M. L. Marks/R. A. Mason, Jr. — DATE: 5/11/89
CONSIGNEE SIGN & RETURN COPY 04 — DATE:

COMPLETE ROUTING INSTRUCTIONS: RVNX $.40 per lb

RADIOACTIVITY PRESENT?: ☒ YES ☐ NO
TYPE: ☒ ALPHA ☒ BETA ☒ GAMMA ☐ NEUTRON
CONTAINER RETURN REQ'D?: ☐ YES ☒ NO
CONSIGNEE REF. NO.: R94PNF89240804

ITEM #	# OF PKGS.	HM	DESCRIPTION	TOTAL QUANTITY	WEIGHT	RATE	CHARGES
1	1	X	Radioactive Material, N.O.S., UN2982;	80.0 g	56 lb		
			Plutonium and Uranium (Depleted) as				
			Solid, Metal; 390.0290 mCi Fissile Exempt				
			U.S.A. DOT Type B Package				
			Two Radioactive White I Labels Applied				
			(one unit each NBL CRM#s 127 & 115)				

FISSILE CLASS: ☒ EXEMPT ☐ I ☐ II ☐ III ☐ N.A.
TRANSPORT GROUP: ☐ I ☐ II ☐ III ☐ IV ☐ V ☐ VI ☐ VII ☐ SPECIAL FORM — N/A

RADIOACTIVE LABEL: ☐ NOT REQUIRED ☒ WHITE I ☐ YELLOW II ☐ YELLOW III
ACTIVITY: 390.0290 mCi
OTHER LABELS: N/A ☐ OXIDIZER ☐ POISON ☐ CORROSIVE ☐ FLAMMABLE ☐ OTHER

RADIATION SURVEYS: ☒ SURFACE α ≤ 200 dpm/100 cm² ☒ SURFACE βγ 0.12 mr/hr
AT 1 METER (βγ) 0.02 mr/hr
TRANSPORT INDEX ☒ N.A.
TRANSFERABLE ACTIVITY: ≤ BKGD; α ≤ 20 dpm/100 cm² βγ ≤ 80 dpm/100 cm²

D.O.T. CERTIFICATION: This is to certify that the above listed items are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to applicable regulations of the U.S. Department of Transportation.
D.O.T. CERTIFICATION BY: Frank P. Orlowicz — DATE: 5/11/89

MAY 12 1989

CARRIER NAME:
CARRIER SIGNATURE: — DATE:

Transportation hereunder is for the U.S. Government and actual transportation costs paid to carrier(s) by the shipper or receiver is to be reimbursed by the government.

MODE OF SHIPMENT: ☐ PREPAID ☒ COLLECT ☐ AIR FREIGHT ☒ MOTOR FREIGHT ☐ U.P.S. ☐ PARCEL POST ☐ PROTECT. SERV. ☐ OTHER ☐ EXCLUSIVE USE

REASON FOR SHIPMENT: ☐ GAE ☒ REF. MAT'L ☐ LOAN/RETURN ☐ OTHER: ☐ SALE ☐ REPAIR ☐ WASTE, DISPOSAL/RECOVERY

FORM OF MATERIAL: ☒ SOLID ☐ LIQUID ☐ GAS ☒ METAL ☐ ALLOY ☐ OXIDE ☐ CARBIDE ☐ SULFATE ☐ NITRATE ☐ ENCAPSULATED ☐ OTHER

D.O.T. # 6M/Type B — SEAL #: 05691
TYPE: Rockwell Drums/n: 0259 ☒ B ☐ LARGE QUANTITY ☐ EXEMPT
DOE/NRC-741 CODE: CBJ-ZAZ-3

NUCLIDES: ☐ 233U ___ g ☒ 235U 0.151 g ☒ 238U 74.832 g ☐ 238Pu ___ g ☒ 239Pu 4.72 g ☒ 241Pu ___ g ☒ OTHER Pu-240 0.279 g

TOTAL ELEMENTS: ☒ U 74.983 g ☒ Pu 4.999 g ☐ Th ___ g ☐ OTHER

FINAL INSPECTION INNER CONTAINER: ☒ PACKING/SHIELDING SECURE ☒ GASKET SEATED SECURELY ☒ NO SIGNIFICANT RUST, DENTS, ETC. ☒ CLOSURE DEVICES SECURE ☒ VALVES/VENTS SECURE — F.O.

FINAL INSPECTION OUTER CONTAINER: ☐ ADDRESS LABELS ☒ GASKETS SEATED SECURELY ☒ PACKING/SHIELDING SECURE ☒ OTHER REQ'D. LABELS ☐ COVER LETTER/INSTRUCTIONS ☒ CLOSURE DEVICES SECURE ☐ VALVES/VENTS SECURE ☒ CONTAINER CONDITION — F.O.

FORM NO. DOE CH-703 (10-79)

NBL RECORD COPY

DOE/NRC FORM 741

U.S. DEPARTMENT OF ENERGY
AND
U.S. NUCLEAR REGULATORY COMMISSION

NUCLEAR MATERIAL TRANSACTION REPORT

LAE	ZNK	002		A	A	B	1 2

Shipper: SNM-21
Rockwell International
Rocketdyne Division
6633 Canoga Ave, Canoga Park, CA
P. D. Rutherford 91303
(818) 710-3413

Receiver: SNM-247
University of Missouri, Columbia
Research Reactor Facility
Research Park, Columbia, MO
Roland Hultsch 65211
(314) 882-4211

P.O. ROA PN/90561327

U. of Mo Letter 2/20/90 & Mo License Amend #12

PU metal for TRUMP-S program

Ref. original receipts CBJ-LAE-01.
Deliver to Dr. Roland Hultsch

1 LM
U.S. Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, CA 94612

DWA
U. S. Department of Energy
Richland Operations Office
P.O. Box 550
Richland, WA 99352

ZNK-LAE
ZNK
ZNK-LM
ZNK-QFA
LAE
LM
QFA
HWA
INTERNAL

9	5	90
9	7	90

135 lbs

Shipper's Data

01		OVL 127	1	LVF2020201	50	771	15	USUS0000			5.0	5.0	5.58	5g

Shipper's data — P. Rutherford [signature] 7/1/90

Receiver's data — [signature] 7/20/90

G

PIECE COUNT VERIFIED
RECEIVER ACCEPTS SHIPPERS
WEIGHTS AND ANALYSIS

WARNING: FALSE STATEMENTS IN THIS CERTIFICATE MAY BE SUBJECT TO CIVIL AND/OR CRIMINAL PENALTIES. NRC REGULATIONS REQUIRE THAT SUBMISSIONS TO THE NRC BE COMPLETE AND ACCURATE IN ALL MATERIAL RESPECTS. 18 U.S.C. SECTION 1001 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

ATTACHMENT 4

THIS MEMORANDUM [illegible]

Tri-State Motor Transit
(Name of Carrier)

RECEIVED, [illegible] ROCKWELL INTERNATIONAL CORPORATION [illegible]

At Santa Susana Field Lab, near Chatsworth, CA 9/5 19 90 Shipper's No. 555

CONSIGNED TO (Mail or street address of consignee—For purposes of notification only)
UNIVERSITY OF MISSOURI RESEARCH REACTOR FACILITY RESEARCH PARK

DESTINATION COLUMBIA STATE OF MISSOURI 65211 COUNTY OF

Delivery Address * (*To be filled only when shipper desires and governing tariffs provide for delivery thereat)

ROUTE
Consignee's phone: 314-882-5204

DELIVERING CARRIER CAR INITIALS CAR NUMBER

No. Pkgs.	Description of Articles, Special Marks and Exceptions	*Weight (Subject to Corr.)	Class or rate	Ck. Col.
1-DM	RQ, Radioactive Material, Fissile, N.O.S.	132 lbs		
	Radioactive Material, UN2918			
	0.39 curies			
	Pu-239 (95%), Pu-240 (5%), Trace amounts of -			
	Pu-241 and Am-241			
	solid form, metal			
	Activity: 0.39 curies			
	Radioactive White I labels applied			
	Fissile Exempt per 173.453(a)			
	DOT 6M Container, Type B			
	Exclusive Use of Vehicle/Driver's Instructions provided			
	Seal No. [illegible]			
	Reference: Z90-3336			

ROCKETDYNE DIVISION, Shipper
ROCKWELL INTERNATIONAL CORPORATION

Per [illegible]

AGENT [signature]
T.S.M.T.
2582

Subject to Section 7 of conditions, [illegible]

ROCKWELL INTERNATIONAL CORPORATION

(Signature of Consignor.)

If charges are to be prepaid, [illegible] "To be Prepaid" [illegible]

PREPAID

Received $ [illegible] to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per [illegible]

Charges Advanced:

$ [illegible]

This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

"If this shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."

NOTE—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.

The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding [illegible]

Per [illegible]

[illegible]
[illegible]
FORM [illegible]

TS-T **THIS MEMORANDUM** is an acknowledgment that a Bill of Lading has been issued and is not the Original Bill of Lading nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record

PAGE 2 of 2

(Name of Carrier)

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading, from ROCKWELL INTERNATIONAL CORPORATION the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Official, Southern, Western and Illinois Freight Classifications in effect on the date hereof, if this is a rail or a rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment.

Shipper hereby certifies that he is familiar with all the terms and conditions of the said Bill of Lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

At ______ 19 ____ Shipper's No. — 555 B36

CONSIGNED TO	(Mail or street address of consignee — For purposes of notification only)
DESTINATION	STATE OF / COUNTY OF
Delivery Address *	(* To be filled only when shipper desires and governing tariffs provide for delivery thereof)
ROUTE	
DELIVERING CARRIER	CAR INITIALS / CAR NUMBER

No. Pkgs	Description of Articles, Special Marks and Exceptions	*Weight (Subject to Corr.)	Class or rate	Ck. Col.
	Dual Driver Requested			
	No Placards required			
	In the event of an emergency, contact			
	Rockwell International 818-700-5124.			
	If arrival is anticipated after noon Friday, contact			
	Charlie McKibben at 314-882-5204 for delivery instructions.			

Subject to Section 7 of conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

ROCKWELL INTERNATIONAL CORPORATION

(Signature of Consignor)

If charges are to be prepaid or collect, write or stamp here "To be Prepaid" or "Collect"

Received $ ______ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per ______
(The signature here acknowledges only the amount prepaid)

Charges Advanced

$ ______

This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

______ Shipper

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "Carrier's or shipper's weight."

NOTE — Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ______

Per ______

ROCKETDYNE DIVISION, Shipper
ROCKWELL INTERNATIONAL CORPORATION,

PER ______
[illegible]
[illegible] Canoga Ave., Canoga Park, CA [illegible]
[illegible]

AGENT [signature] PER

T.S.[illegible] 2582

Rockwell International

COMMERCIAL SHIPPING DOCUMENT

1. Prime Contract/Purchase Order: R04PNZ90561327

2. Invoice No: | Date:

3. Page 1 of 1

4. Acceptance Point:

5. Shipment No: LAE-ZNK-002

6. Date Shipped: 09-05-90

7. B/L: 555

TCN: TSMT PPD

8. Order No:

9. Contractor:

Rockwell International
Rocketdyne Division
6633 Canoga Avenue
Canoga Park, CA 91303

10. Sold To:

11. Shipped From:

Rockwell International, Rocketdyne Division
Santa Susana Field Laboratory
Top of Woolsey Canyon Road
near Chatsworth, CA 91311

12. Date ________ Company Representative ________

The required PQA of listed items has been performed

Typed Name and Office ________ Date ________ Signature of Authorized Govt. Rep. ________

13. Shipped To:

University of Missouri
Research Reactor Facility
Research Park
Columbia, MO 65211

14. Marked For:

Dr. Roland Hultsch

Item No.	Part Number	Description	Quantity Shipped	Unit	Unit Price	Amount
1		Metal, Plutonium Activity: 0.39 curies 95% Pu-239 5% Pu-240 TRACE Pu-241 & Am-241	5	gm		

A. G.O.	B. Sub-Acct.	C. Ledger	D.
70830	50090		

E. Control Number:

U. Other Information: P. Horton, D/635 T020

F.	G. Gross Wt.	H. Cube
	135	

I. Length	J. Width	K. Height
18	18	26

Approval Signature: J. A. Kucinskas (signature)

M. Printed/Typed Name	N. Dept.	O. Mail Code	P. Phone Ext.
J. A. Kucinskas	014	EA35	5159(c)

Q. Date ________ Customer Representative ________

R. Packaging Information	S. Prep. Date	T. Packing List No.
DOT 6M - Type B Container	9/4/90	Z90-3336

Form No. R 49-L-1 REV 4-80

AMENDMENT TO SNM-247

February 20, 1990

RADIOACTIVE MATERIAL (RE: RG 10.3, SUBSECTION 4.3)

1. a. Uranium (Depleted)
   b. any
   c. 500 grams
   d. 0.2 mCi

2. a. Plutonium (94.42 wt% Pu-239, 5.58 wt% Pu-240)
   b. any
   c. 10 grams
   d. 710 mCi

PURPOSES FOR WHICH LICENSED MATERIAL WILL BE USED (RE: RG 10.3, SUBSECTION 4.2)

A research project has been funded at the University of Missouri, the objective of which is to make basic scientific measurements using small amounts (one gram or less) of depleted uranium or a transuranic (TRU) to obtain thermochemical properties data. The data are needed for design of a process to separate actinide and rare-earth metals in nearly pure form from PUREX wastes, which requires computing the separation efficiencies and the purity of the actinide and rare-earth metals that are recovered. Utilizing such a process, uranium and transuranic materials can be recovered from spent reactor fuel material without generation of liquid wastes. The uranium and TRU can then be recycled for use as fuel or transformed to shorter-lived isotopes by use of "actinide burner" reactors or disposed of in much smaller monoliths. As a result, the mass of extremely long-lived, high-level radioactive waste from fuel reprocessing that requires disposal is greatly reduced, thus reducing the time needed for isolation of this waste material by more than a factor of 10,000--a major reduction in the potential environmental impact. Therefore, use of the actinide material for this experiment constitutes "research and development" as defined in 10 CFR 30.4.

The proposed process is based on the electrolytic separation of lanthanide rare earth from transuranic metals. Actinide and rare-earth fission products are dissolved in molten cadmium. The cadmium acts as an anode at the bottom of a crucible in a furnace. Above the cadmium is a liquid salt electrolyte composed of the chloride salts into which the cathode is suspended. When an electric potential is applied, the heavy metal ions flow from the cadmium anode through the salt and are collected in nearly pure form at the metal cathode.

Estimation of Pu-241 and Am-241

Contaminants in CRM 127 as of September 1990[1]

The amount of Pu-241 and Am-241 contaminants in CRM 127 can be calculated for any point in time knowing the decay scheme, and the Am-241 concentration and production rate at a given point in time. Pu-241 decays to Am-241 as shown:

99.99755%[2]

Pu-241	$\Rightarrow$	β^- +	Am-241	$\Rightarrow$	α +	Np-237	$\Rightarrow$
$(T_{1/2}=14.4y)$[2]			$(T_{1/2}=432.2y)$[2]			$(T_{1/2}=2.14\times10^6y)$[2]	

As stated in CRM 127 Certificate:

"The americium-241 content, resulting from the decay of plutonium-241, is approximately 146 μg/g as of September 1970, and should increase less than 150 μg/g per year."

Pu-241 Calculation

The production rate of Am-241 is equivalent to 99.99755% of the decay rate for Pu-241. Therefore, if Am-241 production rate equaled 150μg/year for one gram of CRM 127 material in September 1970, then the decay of Pu-241 would have been:

$$(\lambda_{Pu\text{-}241})(N_{Pu\text{-}241}) = \frac{(150\mu g/y)(6.023\times10^{23} atoms)(10^{-6}g/\mu g)}{(241g)}$$

$$= 3.7\times10^{17} atoms/y \text{ per g of CRM 127 material}$$

Since the Pu-241 decay constant is:

$$\lambda_{Pu\text{-}241} = (\ln 2)/(14.4y) = 0.0481y^{-1}$$

---

1 Receipt of plutonium material at MURR.

2 KOCHER, D.C., Radioactive Decay Data Tables: A Handbook of Decay Data for Application to Radiation Dosimetry and Radiological Assessments, DOE/TIC-11026 (1981), p.211.

then the number of Pu-241 atoms would have been:

$$N_{Pu\text{-}241} = (3.7x10^{17}\text{atoms/y})/(0.0481y^{-1})$$

$$= 7.7x10^{18}\text{atoms per g of CRM 127 material}$$

This would correspond to a Pu-241 mass of:

$$Mass_{Pu\text{-}241} = \frac{(7.7x10^{18}\text{atoms})(241g)}{(6.023x10^{23}\text{atoms})}$$

$$= 0.0031g \text{ per g of CRM 127 material}$$

Therefore, the mass of Pu-241 in September 1990 (20 year decay time) would be:

$$Mass_{Pu\text{-}241} = (0.0031g)e^{-(0.0481y^{-1})(20y)}$$

$$= 0.0012g \text{ per g of CRM 127 material}$$

and the corresponding Pu-241 activity in September 1990 would be:

$$Act_{Pu\text{-}241} = \frac{(0.0012g)(6.023x10^{23}\text{atoms})(0.0481y^{-1})(1Ci)}{(241g)(3.16x10^{7}\text{sec/y})(3.7x10^{10}\text{dps})}$$

$$= 0.12Ci \text{ per g of CRM 127 material}$$

Since the actual production rate of Am-241 in September 1970 was less than 150μg/g per year, then the values estimated to one significant figure for Pu-241 in September 1990 are:

$$Mass_{Pu\text{-}241}(\text{Sep 90}) < 0.001g \text{ Pu-241/g of CRM 127 material}$$

and

$$Act_{Pu\text{-}241}(\text{Sep 90}) < 0.1Ci \text{ Pu-241/g of CRM 127 material}$$

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

20 January 1982

Dr. Thomas E. Gills
Standards Coordinator
Office of Standard Reference Materials
U. S. Department of Commerce
National Bureau of Standards
Washington, D.C. 20234

Dear Tom:

In accordance with your recent telephone request, fourteen units of SRM 945 were sent to New Brunswick Laboratory, Attention: Nancy Trahey. This is one less than the quantity stated in your letter of January 12, but the fourteen had been selected, packaged, and shipped prior to receipt of your letter.

This reference material was reanalyzed during February, 1975, for americium-241, uranium, and plutonium isotopic composition. Based upon the original analyses and the reanalyses in 1975, the calculated results for uranium and americium are as follows:

Uranium Total, μg/g

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1981	360.4	363.2	365.9	368.6	371.3	374.1	376.8	379.5	382.3	385.0	387.7	390.4
1982	393.2	395.9	398.6	401.4								

Americium, μg/g

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1981	1343	1350	1358	1365	1374	1380	1387	1394	1402	1409	1416	1423
1982	1431	1438	1445	1452								

Plutonium isotopic distribution, atom percent, was determined April 1970 (probably by ORNL) and February 1975 by our laboratory. The results, including the ORNL data decay-corrected to February 1975 are given below. Half life values, in years, used for the computation are 87.74(238), 24 119(239), 6 540(240), 14.4(241), and 387 000(242).

Isotope	April 1970	April 1970 decay-corrected	Feb. 1975
238	0.0096	0.0092	0.0092
239	94.130	94.194	94.198
240	5.528	5.530	5.530
241	0.314	0.249	0.245
242	0.018	0.018	0.018

Plutonium assay and metal impurities were not redetermined. The values as of April, 1970, were:

Pu Assay, %: 99.97

Metal Impurities, μg/g: W, 59; Fe, 3; Ga, 2: others less than detection limits ($< \Sigma$ = 93 μg/g).

Very truly yours,

J E Rein

James E. Rein
CMB-1 Acting Group Leader
Analytical & Instrumental Chemistry
MS-740

Glenn R Waterbury

G. R. Waterbury

JER:GRW:vmw

cc: C. D. Bingham, NBL
Nancy Trahey, NBL
CRM-4 (2), MS-150
File (2)

ALL THINGS NUCLEAR

BY

JAMES C. WARF

The Southern California
Federation of Scientists

Pu-240 content is high. Thus the plutonium-239, which is the major component of the bomb core, is awash in neutrons, a circumstance which tends to initiate premature chain reaction ("pre-ignition"). This means that the higher the plutonium-240 content in a bomb core, the more below critical size it must be and the more surface its component parts must have in order to permit the escape of the excess neutrons to prevent a chain reaction. It also means that the implosion must be all the more powerful to cause the intended uncontrolled explosive chain reaction on detonation. The presence of plutonium-240 complicates fabrication and degrades reliability. Also, some plutonium-241 is unavoidably present, and this too requires heavier shielding.

Weapons grade plutonium generally contains 6% Pu-240 or less. Since plutonium-240 does not undergo fission by slow neutrons (as do U-235 and Pu-239), it tends to accumulate in the fuel of nuclear reactors. Typically, weapons-grade plutonium has the following isotopic analysis:

Pu-238	0.06%
Pu-239	92.0-92.4
Pu-240	5.8
Pu-241	1.7-2.0
Pu-242	0.1

The question arises whether the plutonium from commercial, power-generating reactors can be employed in bombs. The answer is definitely yes. Such plutonium generally contains 10 to 20% plutonium-240, and while troublesome, it can be made into a weapon. Test bombs using commercial plutonium have been exploded successfully in the Nevada desert as early as 1962. Such bombs require especially powerful implosion. Although plutonium-240 can be fissioned by fast neutrons, much survives in explosions, making them extraordinarily dirty. The word "dirty" here means that the fission product debris contains much plutonium-240, a particularly dangerous substance. All isotopes of plutonium undergo fission under suitable conditions.

Bombs have been made from commercial plutonium

Warheads containing several percent plutonium-240 emit both neutrons and gamma rays, posing a danger to personnel, especially in confined quarters such as submarines. This is one of the motivations for preparing plutonium which contains little or no plutonium-240. One way to lower the content of the unwanted isotope is to blend it with plutonium containing about 3% of the 240 variety (called supergrade, made in the Savannah River reactors) and this is actually done.

A newer, more sophisticated technique is the physical separation of Pu-240 (and Pu-241) from Pu-239. A factory for this purpose has been proposed (Idaho Nuclear Engineering Laboratory). This is by a process called atomic vapor laser isotope separation (AVLIS). The liquid plutonium metal is vaporized by electron

ATTACHMENT 9

U.S. Department
of Commerce

National Bureau
of Standards

NBS Special Publication 260

NBS Standard Reference Materials Catalog 1981-83 Edition

Four 1906 cast irons (right), and nearly 1,000 SRM's of today

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

THE NATIONAL MEASUREMENT LABORATORY provides the national system of physical and chemical and materials measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; conducts materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

Absolute Physical Quantities[2] — Radiation Research — Thermodynamics and Molecular Science — Analytical Chemistry — Materials Science.

THE NATIONAL ENGINEERING LABORATORY provides technology and technical services to the public and private sectors to address national needs and to solve national problems; conducts research in engineering and applied science in support of these efforts; builds and maintains competence in the necessary disciplines required to carry out this research and technical service; develops engineering data and measurement capabilities; provides engineering measurement traceability services; develops test methods and proposes engineering standards and code changes; develops and proposes new engineering practices; and develops and improves mechanisms to transfer results of its research to the ultimate user. The Laboratory consists of the following centers:

Applied Mathematics — Electronics and Electrical Engineering[2] — Mechanical Engineering and Process Technology[2] — Building Technology — Fire Research — Consumer Product Technology — Field Methods.

THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides scientific and technical services to aid Federal agencies in the selection, acquisition, application, and use of computer technology to improve effectiveness and economy in Government operations in accordance with Public Law 89-306 (40 U.S.C. 759), relevant Executive Orders, and other directives; carries out this mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards guidelines, and managing Federal participation in ADP voluntary standardization activities; provides scientific and technological advisory services and assistance to Federal agencies; and provides the technical foundation for computer-related policies of the Federal Government. The Institute consists of the following centers:

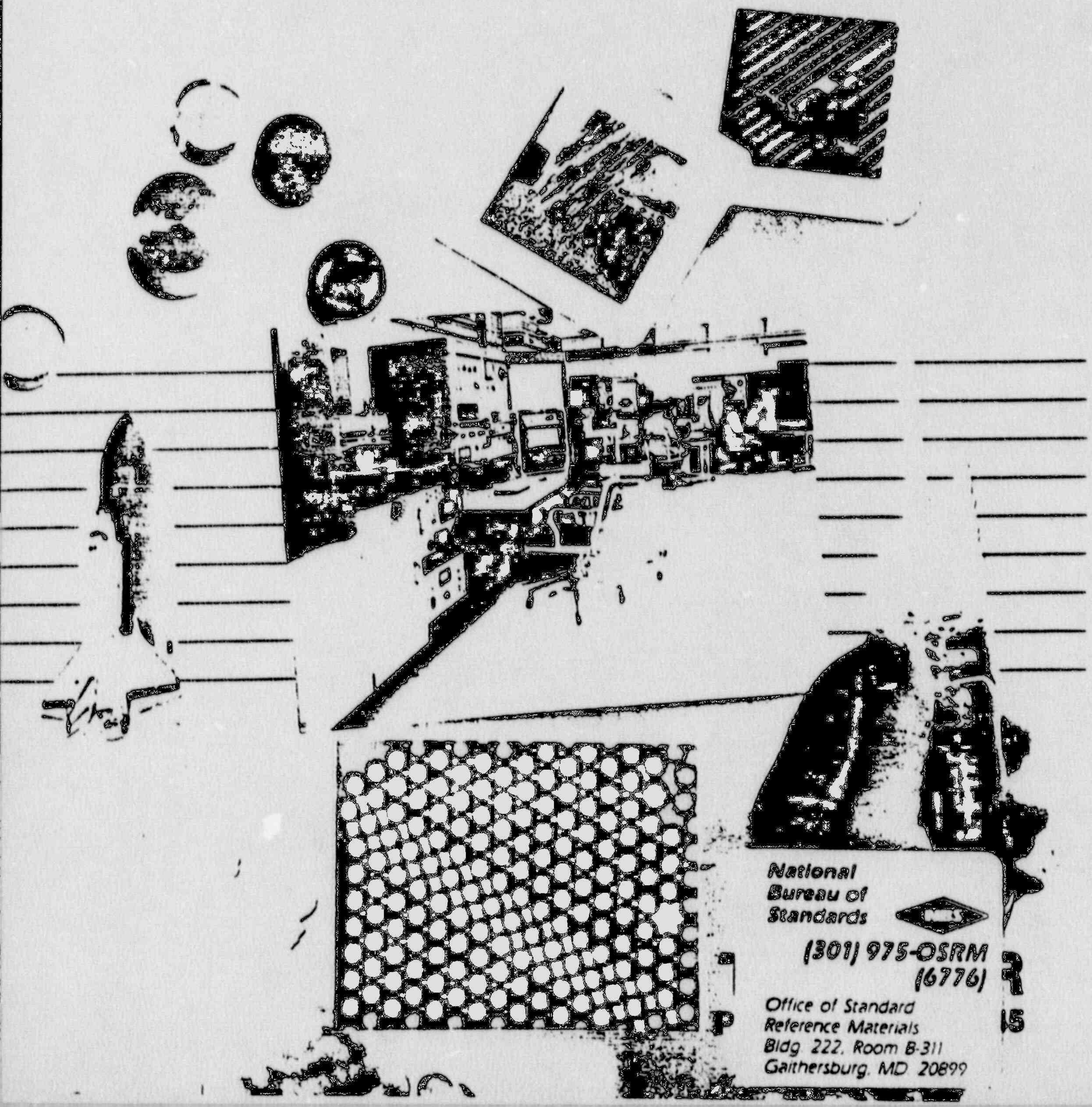
Programming Science and Technology — Computer Systems Engineering.

[1]Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Washington, DC 20234.
[2]Some divisions within the center are located at Boulder, CO 80303.

NBS Special Publication 260

NBS Standard Reference Materials Catalog 1986–87

U.S. Department of Commerce
National Bureau of Standards



UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Gaithersburg, Maryland 20899

Dear Colleague:

I hope that you find this new Standard Reference Materials Catalog to be the best edition we have issued. We have tried to make it user oriented to help you find the materials you need both quickly and easily. We think, and hope you will agree, that the revised alphabetical index is a major improvement over earlier editions.

Because finding the right SRM out of almost 1,000 can be difficult, I would like to suggest the following approach:

1. Start with the Contents,
2. Flip though the Catalog to see its organization,
3. Browse through the Alphabetical Index.

Most of the materials are classified by matrix (such as steel) or by use (such as clinical chemistry). However, with such diverse offerings, the categories are not mutually exclusive, and you may find some materials of interest to you in any part of the Catalog.

The 1984–1985 Catalog went to about 45,000 people. At least 60,000 copies of this one will be distributed. I think this indicates an increasing interest in quality measurements. We are happy to be part of this tradition and welcome you to the growing family of SRM users.

Sincerely,

Stanley D. Rasberry

Stanley D. Rasberry

P.S. Please do not hesitate to call us if you have any questions about the SRM's described, their availability, or if you cannot find what you need. We would be happy to have your suggestions for improved service and new SRM's (see Guide for Requesting the Development of New SRM's).

Nuclear Materials

Special Nuclear Materials

These SRM's are available to Department of Energy contractors, Nuclear Regulatory Commission, or State Licensees, and foreign governments that have entered into an agreement of cooperation with the U.S. Government regarding the use of these materials. Purchase orders and requests for information regarding ordering procedures, availability, and shipment of these SRM's should be directed to:

NBS Special Nuclear Standard Reference Materials
U.S. Department of Energy
New Brunswick Laboratory, D-350
9800 South Cass Avenue
Argonne, IL 60439
(312) 972-2453
FTS: 972-2453

Plutonium Assay

SRM	Identification (Batch Name)	Constituent Certified	Element Weight* (g)	(Weight Percent)
945	Plutonium Metal, standard matrix	Impurities	5	99.9
949f	Plutonium Metal Assay	Plutonium Content	0.5	99.99

*Nominal weight

Plutonium Isotopic

SRM	Identification (Batch Name)	Element Weight (g)	Certified Isotopes (Atom Percent)					
			^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	^{242}Pu	^{244}Pu
946	Plutonium Sulfate Tetrahydrate	0.25	0.232	84.464	12.253	2.477	0.574	
947	Plutonium Sulfate Tetrahydrate	0.25	0.278	77.089	18.610	2.821	1.202	
948	Plutonium Sulfate Tetrahydrate	0.25	0.010	91.736	7.922	0.299	0.0330	
996	Plutonium—Spike	0.001	0.005	0.034	0.677	0.092	1.325	97.867

ATTACHMENT 11

NIST

Standard Reference Materials Catalog 1990-91

NIST Special Publication 260
U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology

TO ORDER
Phone: (301) 975-OSRM (6776)
Fax: (301) 948-3730

GLASCOCK

Certified Reference Materials From Other Sources

Special Nuclear Materials

On October 1, 1987, the New Brunswick Laboratory began issuing special nuclear reference materials as NBL Certified Reference Materials (CRM's). These CRM's include the plutonium and uranium assay and isotopic materials previously issued by the National Institute of Standards and Technology. All orders or inquiries should be addressed to:

U.S. Department of Energy
New Brunswick Laboratory
Attn: Reference Materials Sales
9800 S. Cass Avenue, Bldg. 350
Argonne, IL 60439
708 ~~(312)~~ 972-2767

International CRM's

Certified reference materials (CRM's) are available from many sources. The International Organization for Standardization (ISO), through its Council Committee on Reference Materials (REMCO), has prepared an international Directory of Certified Reference Materials. Inquiries may be directed to:

Dr. M. Parkany
Secretary for REMCO
International Organization for Standardization
1, Rue de Varembe
Case Postale 56
1211 Geneva 20
Switzerland

The International Union of Pure and Applied Chemistry (IUPAC), through its Commission on Physicochemical Measurements and Standards, issues a catalog of CRM's that are useful for the realization of physicochemical properties. It also has prepared a number of related documents. The current IUPAC edition is: "Physicochemical Measurements: Catalogue of Reference Materials from National Laboratories," Revised 1976, Pure & Appl. Chem., 48, 503-515 (1976).

Julie Frum makes the Division Office a pleasant and productive place by her dependability and warm spirit of hospitality.

ATTACHMENT 12

NBL Certified Reference Materials Catalog 1988

United States Department of Energy

Certified Assay and Isotopic Composition CRMs

These NBL CRMs are prepared for use primarily in: 1) analytical method development, calibration, and evaluation; 2) radiometric instrument and method calibration; 3) nuclear materials accountability verification; and 4) field source or working standards preparation. They are available to private companies, academic institutions, DOE contractors, and NRC or state licensees. They are also available to countries authorized to possess radioactive materials and/or to countries which have entered into an agreement for cooperation with the U. S. Government concerning the civil uses of nuclear energy.

AMERICIUM ASSAY AND ISOTOPIC

CRM	Type	Mass/Unit (g)	Weight % Am	Atom %	
				^{241}Am	^{243}Am
•132	Americium-241 Spike, Nitrate	In Preparation		100	–
•133	Americium-243 Spike, Nitrate	In Preparation		–	100
•134	Americium Isotopic, Nitrate	In Preparation		$^{241}Am/^{243}Am = 1$	

PLUTONIUM ASSAY AND ISOTOPIC

CRM	Type	Mass/Unit (g)	Weight % Pu	Atom %					
				^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	^{242}Pu	^{244}Pu
•122	Plutonium Oxide-PuO_2	1	87.79	0.05	87.31	11.54	0.92	0.18	–
•126	Plutonium Metal, chunk	1	99.96	–	97.92	–	–	–	–
•128	Plutonium Isotopic, nitrate, solid	0.002	–	$^{239}Pu/^{242}Pu = 1$					
•130	Plutonium-242 Spike, nitrate, solid	0.002	50	0.004	0.005	0.02	0.02	99.95	0.0004
•131	Plutonium-244 Spike, nitrate, solid	0.002	50	0.005	0.03	0.68	0.09	1.32	97.87
•136	Plutonium Isotopic, sulfate tetrahydrate, solid	0.5	–	0.23	84.46	12.25	2.48	0.57	–
•137	Plutonium Isotopic, sulfate tetrahydrate, solid	0.5	–	0.28	77.09	18.61	2.82	1.20	–
•138	Plutonium Isotopic, sulfate tetrahydrate, solid	0.5	–	0.01	91.74	7.92	0.30	0.03	–

Certified Impurity Element Composition CRMs

These NBL CRMs are designed primarily for impurity element chemical analysis by spectrographic or spectrometric techniques. They can be used for: 1) analytical method calibration; 2) instrument calibration; and 3) nuclear materials accountability verification.

PLUTONIUM

CRM	Type	Mass/Unit (g)	Elements Certified	Weight % Pu
*127	Plutonium Metal, standard matrix material, chunk	5	Fe, Ga, Si, W	99.9

THORIUM

CRM	Type	Mass/Unit (g)	Elements Certified
66(1-7)	Thorium Oxide-ThO_2	7 × 25	Ag, Al, B, Be, Bi, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sn, V, Zn

URANIUM

CRM	Type	Mass/Unit (g)	Elements Certified
17-B*	Uranium (normal) Fluoride-UF_4	200	Fe, Mo, Ni, V
18*	Uranium (normal) Oxide-UO_3	500	Cd, Cr, Cu, Fe, Mo, Ni
114*	Uranium (normal) Oxide-U_3O_8	50	Al, Cr, Fe, Mn, Ni, P, Si
123(1-7)	Uranium (normal) Oxide-U_3O_8	7 × 25	Al, B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, Pb, Si, Sn, V, Zn, Zr
124(1-7)	Uranium (normal) Oxide-U_3O_8	7 × 25	Ag, Al, B, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, Pb, Si, Sn, Ti, V, W, Zn, Zr

*Also certified for assay

This index provides a numerical listing of current NBL CRM Certificates. For each CRM unit ordered a certificate is placed in the shipping container with the material. Additional Certificate copies are available upon request.

Index to Certificates

CRM	Certificate Date
1-A	March 1980
3-B	June 1969
4	September 1950
5	September 1950
17-B	July 1961
18	August 1957
42(1-4)	August 1957
66(1-7)	Undated
101-A	February 1981
102-A	February 1981
103-A	February 1981
104-A	February 1981
105-A	February 1981
106-A	February 1981
107-A	February 1981
108-A	February 1981
109-A	February 1981
110-A	February 1981
111	October 1, 1987 R
112-A	October 1, 1987 R
113	February 15, 1985 R
114	June 1978
115	June 1978
116	June 1978
117	January 1, 1986 R
118	June 1978
119	June 1978
122	May 1, 1985
123(1-7)	September 1, 1983
124(1-7)	September 1, 1983
125	October 1, 1982
126	January 1, 1986

127	October 1, 1987 R
128	October 1, 1985
129	October 1, 1987 R
130	July 1, 1987
131	October 1, 1987 R
132	In preparation
133	In preparation
134	In preparation
135	October 1, 1987 R
136	October 1, 1987 R
137	October 1, 1987 R
138	October 1, 1987 R
969	October 1, 1987 R
U0002	October 1, 1987 R
U005-A	October 1, 1987 R
U010	October 1, 1987 R
U015	October 1, 1987 R
U020-A	October 1, 1987 R
U030-A	October 1, 1987 R
U050	October 1, 1987 R
U100	October 1, 1987 R
U150	October 1, 1987 R
U200	October 1, 1987 R
U350	October 1, 1987 R
U500	October 1, 1987 R
U750	October 1, 1987 R
U800	October 1, 1987 R
U850	October 1, 1987 R
U900	October 1, 1987 R
U930	October 1, 1987 R
U970	October 1, 1987 R

R denotes Certificate revision.