Los Alamos
NATIONAL LABORATORY

memorandum

Risk Reduction & Environmental Stewardship
Environmental Applications
Off-Site Source Recovery (OSR) Project

To/MS: OSR Project Records Management
From/MS: J. Andrew Tompkins, RRES-EA/OSR
Phone/Fax: (770) 517-4320/(770) 517-4317
Symbol: RRES/EA-2003-419
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Re: Review of Documentation on the Special Form Testing of Mound Laboratory ^{239}PuBe Neutron Sources

The purpose of this memo is to establish that stainless steel clad Plutonium-239 beryllium (PuBe) neutron sealed source manufactured by Mound Laboratories qualify as *special form* under 49 CFR 173.469. Although these sources were originally manufactured beginning in 1956, a time that pre-dates the current definition of *special form* as used in 49 CFR, we have been able to document that the sources, with only a few exceptions are compliant with the current regulation. By the discussion below we establish specifically which sealed sources (by serial number) should be considered as *special form* for transportation within the U.S. and which should be considered as *normal form.*

In August 1960, four years after the start of manufacture and distribution, Mound PuBe source serial number M-218 failed, causing a contamination incident and initiating a thorough re-evaluation of the integrity of all Mound produced PuBe sealed sources manufactured to that date and establishing new manufacturing procedures that assured integrity of all subsequently manufactured sources. This reevaluation[1] process eventually led to the development of the engineering documentation that is used here to establish the *special form* qualification.

The Incident: The incident with M-218 involved the removal of an outer source cladding by lathe machining. When the outer cladding was penetrated during this machining operation, the source spontaneously ruptured. An investigation into the failure of M-218 indicated that the fabrication process called for decontamination of the inner source using aqueous liquids, immediately following the welding process that sealed the inner cladding. It was determined that in the case of M-218 this procedure had allowed residual liquid to be drawn into the cladding through a void in a porous weld. The outer cladding had then been installed and welded without this deficiency being detected and setting up the potential for a failure at a later date. As a result of the investigation, a new fabrication process was developed and adopted which improved the welding process, eliminating the use of aqueous liquids during decontamination, and adding a series of inspections and leak tests that improved quality control and assurance. The experience of this incident immediately called into question the integrity of all sources manufactured up to that date and prompted a reevaluation of all of the Mound sources.

[1] Inspection and Recanning program of PuBe Neutron Sources, M.R. Hertz, Mound Laboratory, Report No.: MLM-1188, May 1, 1964.

Reevaluation: By May of 1961, Mound had requested all users of PuBe sources that Mound Laboratory had manufactured and distributed under the Atomic Energy Commission Plutonium Loan/Lease Program to return their sources to Mound for inspection, testing, and recanning (replacement of the outer cladding layer). Prior to August 31, 1960, Mound had manufactured and distributed 743 sources. By January 1, 1964, 668 had been returned as requested for inspection and recanning. Hertz[1] specifically identifies by serial number those sources that were not returned. The sources that were not recanned are listed by serial number in Appendix A.

The recanning process involved the following operations:

a. The outer cladding was machined off.
b. The inner source was helium leaked checked. If a leak was found, the source was heated to remove any possible trapped liquids.
c. The inner container was rewelded and leak checked again.
d. The source was placed into a new outer cladding, rewelded, leak checked, and recalibrated under the revised fabrication procedure developed as the result of the lessons learned from the M-218 source failure. The source was then returned to the user who had it assigned under the Loan/Lease program.

No source, other than M-218, was found to have internal pressure sufficient to cause a violent failure, however 142 sources were found to have leaking inner containers. All of these 142 sources were recanned. As a result of this reevaluation effort each source returned to Mound was effectively re-manufactured to the integrity and Q/A standard in effect after August 1961. About 400 ^{239}PuBe sealed sources were manufactured at Mound after the start of the recanning campaign. These sources were manufactured with revised procedures that included lessons learned from the incident reevaluation and recanning program.

Special Form Testing: In 1971, as a follow-up to the original recall and recanning program, Mound recommended that a new series of nondestructive and destructive tests be performed on a sample of the Pu-239/Be sources in use. Mound initiated a series of destructive tests of Mound fabricated PuBe sources. This testing is documented by Madding and Vallee in MLM-1927[2]. According to Madding and Vallee, "The NDT (nondestructive test) results [on the returned sources] raised a significant question regarding the suitability of having these sources in circulation." Mound decided to test a sample of 16 actual Pu-239 sources (which had been previously in use), using US DOT "special tests" criteria for special form materials per Tariff 25, paragraph 173.398a[3]. The US DOT "special tests" for *special form* materials in 1972 called for the same physical integrity testing methods specified today in 49 CFR 173.469:

Free Drop Test:	The source is dropped a distance of 30 ft onto a flat unyielding surface.
Percussion test:	A 1.4 kg billet 1" OD is dropped onto the source from a height of 1 meter.
Heating Test:	The sources are held at 800° C for 10 minutes.
Immersion Test:	The sources are immersed for 24 hours in low conductivity water.

[2] R. D. Madding Jr. and R. E. Vallee, Plutonium Source Surveillance and Testing, Mound Laboratory, Report No. MLM-1927, Feb. 15, 1973.
[3] Tariff 25, 173.398a, in 1972 was the precursor to the Hazardous Material Transportation Regulations now codified in 49CFR Parts 106 – 180.

Testing to qualify for *special form* is typically done on newly manufactured test specimens that do not contain radioactive material. Mound decided, in a very conservative approach, to test PuBe sources that had been used in the field. Of the 16 sources tested, 14 passed the tests. The distinguishing characteristic of the 14 sources that passed the special form tests was that they bore outer claddings fabricated with 304 stainless steel.

The 2 sources that failed were of a custom design used by Schlumberger Well Services, Inc. One Schlumberger source was found after testing to have a crack in the outer cladding that ran the full length of the source (M-1006). Another Schlumberger source (M-1013) was found to have a leak not detectable by the helium bubble leak method, but detectable by the more sensitive helium leak rate apparatus. Both of the failed sources were found to be a customized design fabricated for Schlumberger. These particular sources had outer claddings of Carpenter Vega Tool steel, not the usual 304 stainless steel. Additionally, in 1970, another source (M-1019) was returned from Schlumberger with swipable activity. That source also had an outer containment made of Carpenter Vega Tool steel. The serial numbers for the sources manufactured to the Schlumberger specification are also listed in Appendix A.

To quote Report MLM-1927 (1972) "Only one source of the 1,226 Mound fabricated sources in the field during the past decade has been involved in a reported detectable release of radioactivity (M-1019/Schlumberger). There exists a striking correlation between the use of Vega steel outer containment and failures, both in the special (*form*) tests and in the field." Report MLM-1927 went even further and explicitly stated as a recommendation that "No sources using Vega steel as an outer container material are (*henceforth*) recommended for use."

Conclusion: Since a reasonable sample (>1% of all sources manufactured) of the Mound ^{239}PuBe sealed sources made with stainless steel cladding successfully passed the “special tests” which are equivalent to 49CFR 173.469, it is justifiable to conclude that all Mound sources manufactured and re-manufactured to the same standard would also meet the integrity requirements of 49 CFR 173.469. Similarly, it is reasonable to conclude that the Schlumberger specification sources clad with the tool steel should not be considered as meeting 49 CFR 173.469. Likewise, Pu-239/Be sources manufactured by Mound, but not returned for inspection and recanning to the improved specifications, should not be considered as meeting 49 CFR 173.469. These two limited groups of sources excluded from *special form* are specifically identified in the Mound documentation and Appendix A of this memo. All other Pu-239/Be sources manufactured by Mound and bearing an M-xxx series serial number should be considered suitable for transport as *special form* Material[4].

J. Andrew Tompkins, CHP
OSR Project Field Engineer

Cc: Records

[4] Copies of the documentation supporting the conclusions of this memo are available from the OSR Project at Los Alamos National Laboratory MSJ552, Los Alamos, NM 87545

APPENDIX

PUBE NEUTRON SOURCES MANUFACTURED BY MOUND LABORATORIES THAT SHOULD NOT BE CONSIDERED SPECIAL FORM

Table 1. PuBe Neutron Sources Not Recanned

M-1	M-353	M-529	M-612	M-675	M-775
M-11	M-354	M-531	M-613	M-676	
M-47	M-355	M-532	M-614	M-677	M-805
M-75	M-356	M-540	M-624	M-678	
	M-357	M-542	M-625	M-679	
M-193	M-361	M-558	M-639	M-692	
M-194	M-396	M-559	M-640	M-693	
		M-560	M-641		
M-203	M-445	M-570	M-642	M-719	
M-205	M-446	M-571	M-643	M-730	
M-206	M-448	M-581	M-644	M-732	
M-235	M-457		M-645	M-733	
M-236	M-465	M-602	M-646	M-744	
M-238		M-603	M-647	M-751	
M-256	M-525	M-604	M-648	M-771	
	M-526	M-611	M-651	M-772	

Table 2. PuBe Neutron Sources Fabricated for Schlumberger Well Services, Inc.

M-509	M-762	M-843	M-855	M-895	M-1009
M-528	M-763	M-844		M-896	M-1010
	M-764	M-845	M-885		M-1011
M-626	M-765	M-846	M-886	M-1000	M-1012
M-627	M-766	M-847	M-887	M-1001	M-1013
	M-767	M-848	M-888	M-1002	M-1014
M-756		M-849	M-889	M-1003	M-1015
M-757	M-838	M-850	M-890	M-1004	M-1016
M-758	M-839	M-851	M-891	M-1005	M-1017
M-759	M-840	M-852	M-892	M-1006	M-1018
M-760	M-841	M-853	M-893	M-1007	M-1019
M-761	M-842	M-854	M-894	M-1008	