AMENDED APPLICATION FOR
TYPE B(U) CERTIFICATION

NEUTRON SOURCE PACKAGING
AND CARRYING SYSTEMS

NLS, H-251810

SCHLUMBERGER WELL SERVICES
HOUSTON, TEXAS

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SCHLUMBERGER WELL SERVICES
NEUTRON SOURCE PACKAGE
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INTRODUCTION

Schlumberger Well Services uses ^{241}AmBe in conjunction with field operations. Many countries in the world require Type B(U) certification for the containment, handling, and shipping system as described by the International Atomic Energy Agency (IAEA) Safety Standards dated 1973 (as amended). Certification must be granted by the country of origin.

On January 24, 1979, Type B(U) certification was granted to Schlumberger by the United States Department of Transportation. This document is presented as an amendment to the original petition. It is nearly identical in format and content, but now includes additional information involving two new models of the packaging system.

Presented are descriptions, calculations, test results and arguments supporting the claim that the models are indeed similar and all fulfill requirements for Type B(U) certification.

BASIC CONFIGURATION

The Neutron Source Packaging Systems presented for Type B(U) certification all consist of three basic assemblies arranged in concentric layers.

Neutron Source, Designated NSR

These are the active sources doubly encapsulated in their welded pressure housings. These components meet special form requirements as recognized by Certificates of Competent Authority granted by the United States Department of Transportation. All certificates are included in Appendix IV.

Neutron Pressure Vessel, Designated NPV

These are additional Pressure Vessels with threaded closures and O-ring seals. The NPV serves to protect the NSR from any environment it will encounter while in use by Schlumberger.

Neutron Carrying Shield, Designated NCS

These are the storage and transportation containers for the NSR-F, L, P, and M assemblies.

The assembly of all three components is designated as a Neutron Logging Source (NLS). The Neutron Source Packaging System presented for type B(U) certification includes three variations of the NLS. These are

NLS-RF (Granted 1/24/79)
NLS-KL (New Submission)
NLS-LM (New Submission)

Three versions are necessary to accommodate the different shap of the three special form certified Neutron Sources used by Schlumberger. Organizati of components and subassemblies making up an NLS are shown in Figure 1.

COMPONENT DETAILS

Neutron Source (NSF)

The three Schlumberger neutron sources which are part of the subject packaging system are based on the following design. The active source material is contained in a doubly encapsulated, welded unit consisting of two parts:

- Inner Capsule
- Outer Case and Closure

The Inner Capsule is constructed of AISI 304 stainless steel and has a welded end cap to contain the source material. The Inner Capsule is then placed into the Outer Case and Closure, made of 18% nickel maraging steel, and is sealed with a welded end plug. A leak test is performed after each welding step and the final assembly is pressure tested at 25,000 psi for one hour.

The active source material is Americium-241 oxide and Beryllium powder. The powders are milled in a single batch and pelletized with a minimum force of 10 tons. The source pellets are then placed in the Inner Capsule and positioned for the correct center of activity.

Schlumberger requires B(U) certification on the packaging required for three different versions of the neutron source (NSR). These sources carry the following model designations:

NSR-F (Granted 1/24/79)
NSR-L (New Submission)
NSR-M (New Submission)

All are manufactured using the previously discussed technique. They differ in their size and in the specified neutron output and, thus, in the nominal amounts of active source material contained. However, the maximum amount of source material contained in any of these sources will not exceed 25 Ci and all packaging is designed to accommodate this amount.

These comp ents have been recognized as meeting requirements for Special Form Material a, evidenced by DOT certificates USA/0113/S for the NSR-F and USA/0135/S for the NSR-L and the NSR-M. Copies of these certificates are included in Appendix IV.

Organization is shown below schematically:

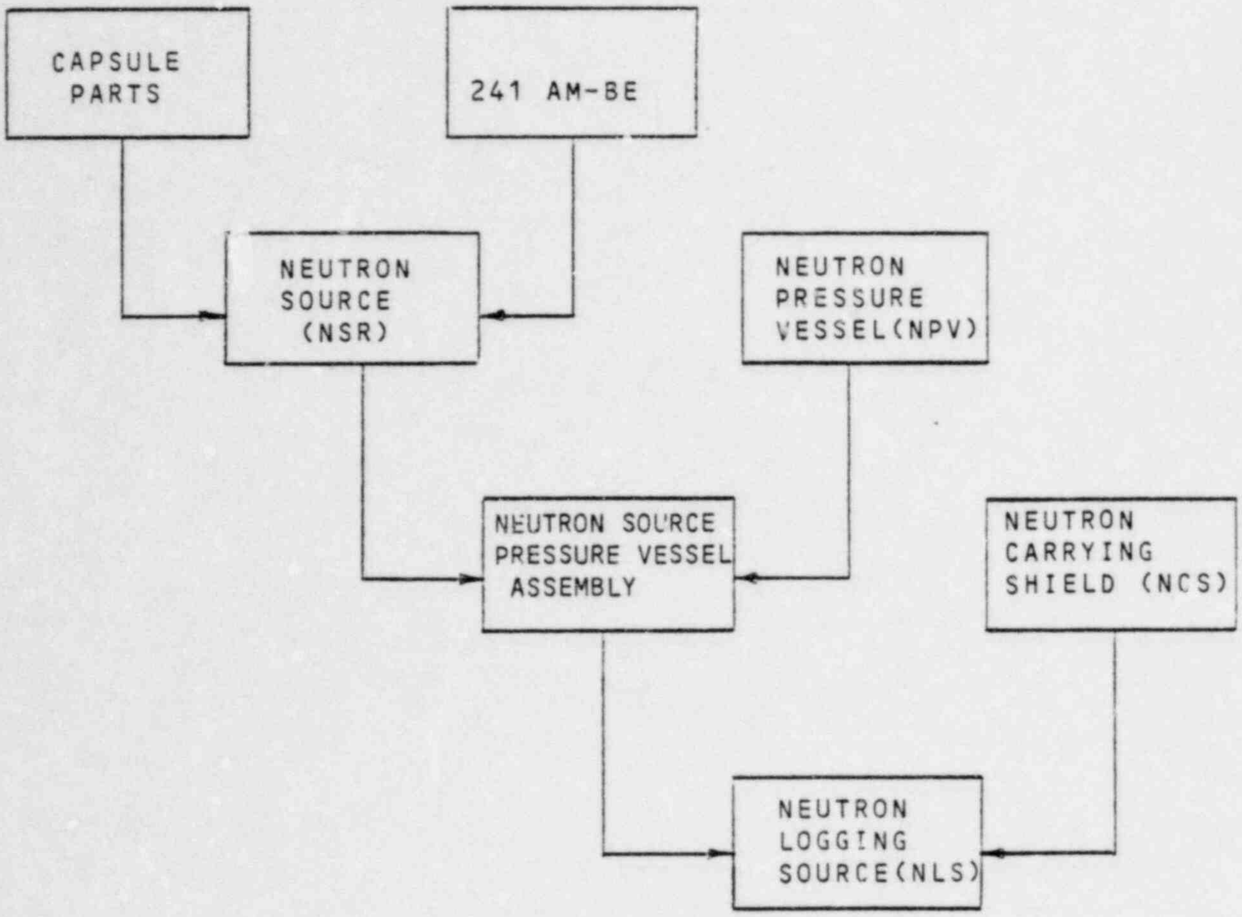


Figure 1

Neutron Pressure Vessel (NPV)

The Neutron Pressure Vessel (NPV) serves as additional protection for the NSR from the hostile environments it will encounter while in use by Schlumberger. To enclose the three sources previously discussed, Schlumberger uses three Pressure Vessels. They are listed below with their corresponding sources.

Pressure Vessel	Neutron Source	Assembly
NPV-C	NSR-F	NPV-CF (Granted 1/24/79)
NPV-K	NSR-L	NPV-KL (New Submission)
NPV-L	NSR-M	NPV-LM (New Submission)

The three Pressure Vessels are described below.

NPV-C. The NPV-C is designed for use in tools rated at maximum conditions of 400°F and 20,000 psi.

The Pressure Vessel Housing is made of 17-4 P.H., condition H-1075 stainless steel and has two double O-ring sealed plugs in one end. The NSR-F Source Capsule is positioned within the vessel housing with ASTM B-36 Brass Washers so that the center line of source activity is controlled. A Type 416 stainless steel Hold-Down Nut is screwed into the housing to contain the source capsule and washers. One of the two plugs (the Bottom Nose) is screwed into the housing and seals with double O-rings. The Bottom Nose also retains a tungsten (Hevimet) cylinder. Finally, the Outer Plug made of 17-4 P.H. stainless steel is screwed into and seals to the Bottom Nose with double O-rings.

The NPV-CF is shown in Appendix II.

NPV-K and NPV-L. The NPV-K is designed to operate in tools rated at maximum conditions of 500°F and 25,000 psi; the NPV-L is designed to operate in tools rated at maximum conditions of 350°F and 20,000 psi. The Pressure Vessel bodies are made from 18% Ni Maraging steel. The Sources are held in place with a stainless steel retainer nuts. Outer Plugs, which have an access hole for wipe testing, seal against the Pressure Vessel bodies. These are plugs made from heat treated 17-4 P.H. stainless steel. Wipe Test Plugs, also made from heat treated 17-4 P.H. stainless steel, seal the wipe test access holes in the Outer Plugs. The Source-Pressure Vessel assemblies for the NPV-K and NPV-L are shown in Appendix II.

Neutron Carrying Shield (NCS)

The Neutron Source-Pressure Vessel assembly, when not in use, is stored and transported in a Neutron Carrying Shield (NCS). The NCS is shown in Appendix III. The shield is a welded steel cylinder 16 3/4" diameter by 17" long. A "Center Tube Assembly" is welded into the center of the cylinder. The Center Tube Assembly consists of the following items:

- Center Tube	(302 or 304 SST)
- Lower Plug	(C-1018 stl, Parkerized)
- Insert	(302 or 304 SST)
- Upper Plug	(302 or 304 SST)
- Source Presssure Vessel Assembly	(when loaded)

The annulus between the Center Tube Assembly and the outer shell of the Shield is filled with a minimum of 5.88" of shielding material. The shielding material consists of polyethylene beads (65% minimum by volume) which are bonded together by vacuum-impregnating with polyurethane resin. The Shield is fitted with two tin Fuse Plugs (Rupture Plugs) for the relief of possible internal overpressure (from outgassing of polymer) in the event of fire.

The Upper Plug Closure is rigidly affixed to the shield body with a scissors-type latch and is locked with a heavy duty lock. This locking mechanism is shown on page 3 of the Package Assembly Drawing H-251810 contained in Appendix III.

Because there are three sizes of Pressure Vessels, the shape of the Insert and Upper Plug Closure differ in each of the three models. The three configurations of Center Tube Assemblies are shown on page 2 of H-251810. This variation in the internal features of the Center Tube Assembly is all that is necessary to accommodate the difference in Pressure Vessels. All other features of the Shield are common to all carrying shields.

The model designations of the three types of Shields are shown in the following Neutron Source-Pressure Vessel-Carrying Shield Summary.

Neutron Source	Neutron Pressure Vessel	Neutron Source Pressure Vessel Assembly	Neutron Carrying Shield	Neutron Logging Source
NSR-F (B(U) Granted 1/24/79)	NPV-C	NPV-CF	NCS-YB	NLS-RF
NSR-L (New Submission)	NPV-K	NPV-KL	NCS-VB	NLS-KL
NSR-M (New Submission)	NPV-L	NPV-LM	NCS-WB	NLS-LM

LABELING

Schlumberger B(U) certified carrying shields will be fixed with the following labels:

- NRC Trefoil Label
- Schlumberger Reward Label
- Two (2) DOT Radioactive Yellow-III Labels
- Three (3) "Caution Radioactive Material Labels"

In addition, B(U) certified carrying shields are fixed with the following labels made from stainless steel and capable of withstanding any standard or accident conditions as described in the IAEA Safety Standards dated 1973 (as amended):

- "Master Label": Indicates carrying shield B(U) certification number, contents special form certification number, maximum contents level, contents description, radioactive trefoil marking, Schlumberger address and phone number, model and serial number of shield, and weight of shield.

- Label indicating carrying shield B(U) certification number.

PRIOR CERTIFICATIONS

- The Source NSR-F was granted Special Form Radioactive Material Encapsulation, USA/0113/S dated March 30, 1977.
- The Assembly NLS-RF was granted IAEA Certification of Competent Authority, Type B Fissile Radioactive Material Package Design, USA/9088/B( ), dated May 18, 1978.
- The Assembly NLS-RF was granted IAEA Certification of Competent Authority, Type B(U) Fissile Radioactive Material Package Design, USA/9088/B(U), dated January 24, 1979.
- The Source NSR-L was granted Special Form Radioactive Material Encapsulation, USA/0135/S dated March 18, 1980.
- The Source NSR-M was granted Special Form Radioactive Material Encapsulation, USA/0135/S dated March 18, 1980.

Copies of the certificates are held in Appendix IV.

QUALITY ASSURANCE

Schlumberger Well Services and its vendors employ rigorous quality control procedures to assure that each device meets the requirements described in this document.

In addition, Schlumberger Well Services and all vendors of these nuclear related items have been granted approval of Quality Assurance Programs satisfying the requirements of Section 71.51, Appendix E, Title 10 Code of Federal Register.

DEMONSTRATION OF TYPE B(U) COMPLIANCE

Following are arguments to demonstrate compliance of the packaging system with the requirements for Type B(U) certification. Excerpts of relevant paragraphs from IAEA 1973 (as amended), Section II, Paragraphs 201-241, are reproduced. Schlumberger Well Services' comments accompany the Paragraphs. Reference is made to IAEA 1973 (as amended), Section VII, Paragraphs 709-721, where applicable.

As previously described, each version of the Neutron Source Packaging System consists of three basic assemblies, the Neutron Source, the Neutron Pressure Vessel, and the Neutron Carrying Shield. All of these combine to form a final assembly for storage and transportation called the Neutron Logging Source. This application includes three versions of the Neutron Logging Source. They are

NLS-RF (NPV-CF in NCS-YB), (B(U) Certification Granted 1/24/79)
NLS-KL (NPV-KL in NCS-VB), (New Submission)
NLS-LM (NPV-LM in NCS-WB), (New Submission)

The NLS-RF has been previously granted B(U) certification. The NLS-KL and NLS-LM use the same basic Carrying Shield to enclose two other Special Form Certified Neutron Sources and their corresponding Pressure Vessels.

When the Source or Pressure Vessel are discussed, arguments refer to each model individually, unless the relevant characteristic is common to all three models.

When the Carrying Shield is discussed, arguments will be directed towards the NCS-YB. Schlumberger feels the NCS-VB and the NCS-WB, which differ only slightly from the NCS-YB (see "Center Tube Assemblies", page 2 of H-251810, Figure 5), would be represented by any test or calculation applying to the NCS-YB. Indeed, of the three model Shields the NCS-YB holds the largest Pressure Vessel and thus has the least massive insert and Upper Plug. Thus, if any difference between the Shields exists, the NCS-YB will represent the worst case.

SECTION II - PACKAGING AND PACKAGE DESIGN REQUIREMENTS

GENERAL DESIGN REQUIREMENTS FOR ALL PACKAGING AND PACKAGES

201. THE PACKAGING SHALL BE SO DESIGNED THAT THE PACKAGE CAN BE EASILY HANDLED AND CAN BE PROPERLY SECURED IN OR ON THE CONVEYANCE DURING TRANSPORT.

The NCS-YB (H-251810) is fitted with a handling ring at top and bottom. These serve for ease for lifting, either by hand or with mechanical assistance. Turned on its side, the shield can be rolled on these rings. Further, the rings serve as a rugged means of securing the shield during transport. See Schlumberger drawing H-251810 in Appendix III to observe this arrangement.

202. A PACKAGE OF GROSS WEIGHT 10 KG OR MORE AND UP TO 50 KG SHALL BE PROVIDED WITH MEANS FOR MANUAL HANDLING.

The minimum weight of the Neutron Source Package in any of its configurations is approximately 70 kg.

203. A PACKAGE OF GROSS WEIGHT IN EXCESS OF 50 KG SHALL BE SO DESIGNED AS TO ENABLE SAFE HANDLING TO BE DONE BY MECHANICAL MEANS.

The handling rings allow attachment for safe handling by mechanical means.

204. THE DESIGN SHALL BE SUCH THAT ANY LIFTING ATTACHMENTS ON THE PACKAGE, WHEN USED IN THE INTENDED MANNER, DO NOT IMPOSE UNSAFE STRESSES ON THE STRUCTURE OF THE PACKAGE; ASSESSMENT SHALL TAKE ACCOUNT OF APPROPRIATE SAFETY FACTORS TO COVER 'SNATCH' LIFTING.

When lifting NCS-YB (H-251810), the weld securing each handling ring is the failure (weakest) point. This ring is attached by at least 55 inches of weld bead with shear base leg section of at least .12 inch or 6.6 square inches. The weld material is ASW E 9018M electrode with a shear strength at least 60,000 psi. In slow (steady-state) lifting, the weld strength calculates 60,000 x 6.6 = 396,000 pounds. In snatch lifting (which is estimated to be about fourfold the stress of steady-state lifting), ability to withstand stress is reduced to 99,000 pounds. This is approximately 600 times the assembly weight.

205. ATTACHMENTS AND ANY OTHER FEATURES ON THE OUTER SURFACE OF THE PACKAGING WHICH COULD BE USED TO LIFT THE PACKAGES SHALL BE REMOVABLE OR OTHERWISE RENDERED INOPERABLE FOR TRANSPORT OR SHALL BE DESIGNED TO SUPPORT THE WEIGHT OF THE PACKAGE IN ACCORDANCE WITH THE REQUIREMENTS OF PARA. 204.

The rings on NCS-YB (H-251810) are able to support the weight of the package. The welds which join the ring support to the body have approximately 600 times safety factor as described in Paragraph 204 above.

206. THE OUTER LAYER OF PACKAGING SHALL BE SO DESIGNED AS TO AVOID, AS FAR AS PRACTICABLE, THE COLLECTION AND RETENTION OF WATER.

The design of NCS-YB (H-251810) is such that when closed it will provide no open cavity or cup-like area which can retain fluid (see drawing H-251810). Further, the external structural materials are all metallic, hence, cannot absorb fluid. The principle label is stainless steel. Other labels are plastic.

The design of the NPV-C, NPV-K, and NPV-L is such to exclude fluid at high pressure. The NPV-C was hydrostatically tested at 21,000 psi successfully. The NPV-K and NPV-L were tested at 26,000 psi successfully.

The Neutron Sources NSR-F, NSR-L, and NSR-M are 100% tested hydrostatically at 25,000 psi during manufacture to insure that no fluid is retained.

207. THE EXTERNAL SURFACES OF PACKAGING SHALL, AS FAR AS PRACTICABLE, BE SO DESIGNED AND FINISHED THAT THEY MAY BE EASILY DECONTAMINATED.

Materials and construction of NCS-YB (H-251810) were selected to provide a minimum receptacle for dirt, grease, water or other foreign materials. The ferrous surfaces are protected from corrosion by plating or paint. Stainless steel is used for the remainder of the parts. The smooth surfaces will allow easy decontamination by wiping with appropriate materials and fluids.

The Neutron Pressure Vessels NPV-C, NPV-K, and NPV-L exteriors have plugs at one end but otherwise smooth. The exteriors are all steel.

The Neutron Sources NSR-F, NSR-L, and NSR-M exteriors are simple cylinders of 18% nickel Maraging steel.

208. ANY FEATURES ADDED TO THE PACKAGE AT THE TIME OF TRANSPORT WHICH ARE NOT PART OF THE PACKAGE SHALL NOT REDUCE THE SAFETY OF THE PACKAGE.

None added during transport, except those selected locally to secure the Carrying Shield to the conveyance. These do not alter the shield configuration, hence, do not reduce the safety features of the shield. The Source in Pressure Vessel Assembly is always transported in the Carrying Shield.

ADDITIONAL REQUIREMENTS FOR STRONG INDUSTRIAL PACKAGES FOR LOW-LEVEL SOLID RADIOACTIVE MATERIALS

209. STRONG INDUSTRIAL PACKAGES SHALL RETAIN THEIR CONTENTS WHEN SUBJECTED TO THE TESTS SPECIFIED IN SECTION VII, PARAS 712 AND 713.

Not applicable.

ADDITIONAL REQUIREMENTS FOR TYPE A PACKAGES

210. THE SMALLEST OVERALL EXTERNAL DIMENSION OF THE PACKAGING SHALL NOT BE LESS THAN 10 CM.

The smallest dimension of NCS-YB (H-251810) exceeds 10 cm and is 17.3" (68.1 cm), the diameter of the Carrying Shield.

211. THE OUTSIDE OF EVERY PACKAGE SHALL INCORPORATE A FEATURE SUCH AS A SEAL, WHICH IS NOT READILY BREAKABLE AND WHICH, WHILE INTACT, WILL BE EVIDENCE THAT THE PACKAGE HAS NOT BEEN OPENED.

The latching mechanism on the Carrying Shield carries a Security Seal. Once applied, the scissors-type latch cannot be opened without destroying the seal.

Further, a high quality padlock controlled by Schlumberger Specification is used to fix the package.

212. AS FAR AS PRACTICABLE, PACKAGING SHALL BE DESIGNED SO THAT THE EXTERNAL SURFACES ARE FREE FROM PROTRUDING FEATURES.

No protrusions on NCS-YB (H-251810) extend past the cylinder define by the shield body and extremes of handling rings. See drawing H-251810.

213. THE DESIGN OF THE PACKAGING SHALL TAKE INTO ACCOUNT THE VARIATIONS IN TEMPERATURE TO WHICH THE PACKAGING MAY BE SUBJECTED DURING TRANSPORT AND STORAGE. IN THIS RESPECT, -40°C and 70°C SHALL BE CONSIDERED AS SATISFACTORY LIMITS TO BE USED IN THE SELECTION OF THE MATERIALS; SPECIAL ATTENTION, HOWEVER, MUST BE GIVEN TO BRITTLE FRACTURE OVER THE TEMPERATURE RANGE.

All materials selected for NCS-YB (H-251810) are considered satisfactory in the -40°C to +70°C range. The materials are:

- AISI 302 or 304 austenitic stainless steel
- Low carbon steel plate, ASTM-A7 or similar
- AISI 1018 carbon steel
- AISI 4130 alloy steel
- Pure tin for Fuse Plugs
- Easy-Flo 45, silver braze, Handy & Harmon
- AWS E 9018M welding electrode.

However, more important in the sense of materials application are the materials used in the Neutron Source (Source in its welded capsule) and Pressure Vessel which combine to make the Source Pressure Vessel assembly.

These materials are:

NSR-F, NSR-L, NSR-M

- AISI 304 austenitic stainless steel
- 18% nickel Maraging steel
- ASTM B-133 copper

NPV-C

- AISI 630 stainless steel

- AISI 304 austenitic stainless steel

- AISI 416 martensitic stainless steel

- ASTM B-36 brass

- 90% tungsten, 10% cobalt alloy.

NPV-K, NPV-L

- AISI 630 stainless steel

- AISI 304 austenitic stainless steel

- 18% Nickel Maraging Steel

None of the above will be unacceptably brittle at -40°C to +70°C. The lowest impact strength will be found in the 18% nickel Maraging steel. This is expected to be about 8 ft.-lbs. Charpy V at -40°C.

Mechanical properties at various temperatures are shown in Appendix VIII.

214. THE DESIGN, FABRICATION AND MANUFACTURING TECHNIQUES FOR WELDED, BRAZED, OR OTHER FUSION JOINTS SHALL BE IN ACCORDANCE WITH NATIONAL OR INTERNATIONAL STANDARDS OR WITH STANDARDS ACCEPTABLE TO THE COMPETENT AUTHORITY.

All joints are described by Schlumberger drawings and specifications. Most notations are in accordance with accepted conventions of the American Welding Society. Further, all welding call-outs and specifications have been approved by a Registered Metallurgical Engineer.

215. THE PACKAGE SHALL BE CAPABLE OF WITHSTANDING THE EFFECTS OF ANY ACCELERATION, VIBRATION OR VIBRATION RESONANCE WHICH MAY ARISE DURING NORMAL TRANSPORT WITHOUT ANY DETERIORATION IN THE EFFECTIVENESS OF THE CLOSING DEVICES ON THE VARIOUS RECEPTACLES OR IN THE INTEGRITY OF THE PACKAGING AS A WHOLE. IN PARTICULAR, NUTS, BOLTS AND OTHER SECURING DEVICES SHALL BE SO DESIGNED AS TO PREVENT THEM FROM BECOMING LOOSE OR BEING RELEASED UNINTENTIONALLY, EVEN AFTER REPEATED USE.

All Pressure Vessels loaded with a Dummy Source were vibration tested. Test was in accordance with Schlumberger Procedure for downhole equipment, which includes multiple sweeps in each of three mutually perpendicular axis, 10 to 60 Hz at 7.5 G. No damage occurred.

Torque required to unseat the Bottom Nose was measured after each sweep. At no time did the plug show any signs of backing out.

Carrying Shield NCS-YB was not vibration tested. The only threaded fastener is the device that secures the scissors-type latch to the body. This is tack-welded after assembly to prevent inadvertent unscrewing.

216. THE DESIGN SHALL INCLUDE A CONTAINMENT SYSTEM SECURELY CLOSED BY A POSITIVE FASTENING DEVICE WHICH CANNOT BE OPENED UNINTENTIONALLY OR BY A PRESSURE WHICH MAY ARISE WITHIN THE PACKAGE.

Scissors-type latch and padlock are described on page 3 of Figure 5, H-251810. NCS-YB scissors-type latch and padlock survived accident conditions testing.

The Neutron Sources NSR-F, NSR-L, and NSR-M are the active source material capsuled in an inner capsule closed by welding plus an outer case closed by welding.

The Neutron Pressure Vessels NPV-C, NPV-K, and NPV-L, when enclosed in their carrying shields, allow access for wipe tests but not removal of the welded source container.

217. SPECIAL FORM RADIOACTIVE MATERIAL MA BE CONSIDERED AS A COMPONENT OF THE CONTAINMENT SYSTEM.

Special Form has been granted on all Neutron Sources. Copies of certification letters are included in Appendix IV.

218. IF A CONTAINMENT SYSTEM FORMS A SEPARATE UNIT OF THE PACKAGING, IT SHALL BE CAPABLE OF BEING SECURELY CLOSED BY A POSITIVE FASTENING DEVICE WHICH IS INDEPENDENT OF ANY OTHER PART OF THE PACKAGING.

The Neutron Carrying Shield is an outer component independent of the Neutron Pressure Vessel. It is secured by the scissors-type latch and the padlock discussed above.

219. THE MATERIALS OF THE PACKAGING AND ANY COMPONENTS OR STRUCTURES SHALL BE PHYSICALLY AND CHEMICALLY COMPATIBLE WITH EACH OTHER AND WITH THE PACKAGE CONTENTS; ACCOUNT SHALL BE TAKEN OF THEIR BEHAVIOUR UNDER IRRADIATION.

Materials are judged to be physically and chemically compatible. In Appendix VIII it is shown that in the worst case a neutron Source-Pressure Vessel assembly will withstand 120 years in flowing sea water before the water reaches the source material.

On NCS-YB, a silver-brazed joint fixes a retention chain to the upper plug. This is subject to corrosion because of silver's noble position in the galvanic series. The chain is for convenience only, so loss of the brazed joint will not disturb structural integrity.

Radiation level at 4×10^7 n/sec is too low to cause structural damage to metal parts in any practical time.

220. THE DESIGN OF ANY COMPONENT OF THE CONTAINMENT SYSTEM SHALL TAKE INTO ACCOUNT, WHERE APPLICABLE, THE RADIOLYTIC DECOMPOSITION OF LIQUIDS AND OTHER VULNERABLE MATERIALS AND THE GENERATION OF GAS BY CHEMICAL REACTION AND RADIOLYSIS.

No liquids are present. Any gas resulting from decomposition of 25 Curie ^{241}AmBe will be contained in the Neutron Source consisting of the Inner Capsule (welded) and the "Outer Case and Closure" (welded). The Neutron Source is certified as meeting Special Form requirements for containment of radioactive matter. Certifications of tests are included in Appendix X. Copies of Special Form certificates are included in Appendix IV.

221. THE CONTAINMENT SYSTEM SHALL RETAIN ITS RADIOACTIVE CONTENTS UNDER THE REDUCTION OF AMBIENT PRESSURE TO 0.25 KG/CM^2.

All Sources NSR-F, NSR-L, and NSR-M were subjected to vacuum of 10^{-6} mmHg during Helium Back Pressurizing test per ANSI N14.5. No leak occurred. See Appendix X.

222. ALL VALVES, OTHER THAN PRESSURE RELIEF VALVES, THROUGH WHICH THE RADIOACTIVE CONTENTS COULD OTHERWISE ESCAPE SHALL BE PROTECTED AGAINST UNAUTHORIZED OPERATION AND SHALL BE PROVIDED WITH AN ENCLOSURE TO RETAIN ANY LEAKAGE FROM THE VALVE.

Not applicable since no valves exist in the configuration.

223. A RADIATION SHIELD WHICH ENCLOSES A COMPONENT OF THE PACKAGING SPECIFIED AS A PART OF THE CONTAINMENT SYSTEM SHALL BE SO DESIGNED AS TO PREVENT THE UNINTENTIONAL RELEASE OF THAT COMPONENT FROM THE SHIELD. WHERE THE RADIATION SHIELD AND SUCH COMPONENT WITHIN IT FORM A SEPARATE UNIT, THE RADIATION SHIELD SHALL BE CAPABLE OF BEING SECURELY CLOSED BY A POSITIVE FASTENING DEVICE WHICH IS INDEPENDENT OF ANY OTHER PACKAGING STRUCTURE.

The NPV-CF Source is assembled by placing the NSR-F Assembly (H-142108) into the outer Pressure Vessel (H-208156), after placing the appropriate shimming material H-128697. When the NSR-F has been shimmed to its required location, more shimming material is placed on top of it and the Hold-Down Nut (H-124467) is threaded into the Bottom Nose Plug. The Bottom Nose Plug is then staked in position and is not removed again unless the source needs to be removed from the housing or the O-rings need to be changed. Both the bottom Nose Plug (H-128692) and the Hold-Down Nut (H-124467) prevent the source from falling out of the housing during a wipe (leak) test since only Plug (H-128696) needs to be removed to perform the test. The Bottom Nose Plug and the Plug that is threaded into it are each sealed with two O-rings. With the plugs torqued into place, the source is securely locked and protected in the Pressure Vessel. The NPV-CF is then placed into its radiation shield for shipping or storage. This shield is provided with a lock that can be opened only with a special Schlumberger key.

The NPV-KL and NPV-LM are the Source-Pressure Vessel assemblies of the source NSR-L and Pressure Vessel NPV-K and the Source NSR-M and Pressure Vessel NPV-L, respectively. The method of securing the source is the same in each case. A source retaining nut holds the source in place in the pressure vessel. An outer plug, which has an access hole for wipe testing, seals against the pressure vessel body. A wipe test plug seals the wipe test access hole in the outer plug. A thread sealant is applied to the threads of the outer plug so that it will not unseat under the torque required to unseat the wipe test plug. When the source-pressure vessel assembly is in its carrying shield, and the carrying shield locking mechanism is engaged, it is impossible to remove the source. It is possible, however, to remove the wipe test plug for regular wipe tests.

The Carrying Shields NCS-YB, NCS-VB, and NCS-WB are welded steel cylinders (drum) 16-3/4" diameter by 17". Both ends are fitted with circular handling rings. A steel tube assembly (typical I.D. = 1.7") is welded in the center of the cylinder (see H-251810, P2). Three assemblies are contained in the tube: Lower Plug made of AISI C-1018 carbon steel, Neutron Source-Pressure Vessel Assembly, Upper Plug cylinder made of AISI 300 series stainless steel. The Upper Plug is rigidly affixed to the shield body with a Scissors-Type Latch and is locked with a heavy-duty Padlock. Only approved Schlumberger personnel are authorized to carry keys to this lock. The shield has been subjected to the Type B (hypothetical accident tests—30-foot drop, puncture, and 1475°F fire) test--in that order. These tests demonstrate that the source assembly will remain within the NCS-YB when subjected to these Type B tests.

224. ANY TIE-DOWN ATTACHMENTS ON THE PACKAGE SHALL BE SO DESIGNED THAT, UNDER BOTH NORMAL AND ACCIDENT CONDITIONS, THE FORCES IN THOSE ATTACHMENTS SHALL NOT IMPAIR THE ABILITY OF THE PACKAGE TO MEET THE REQUIREMENTS OF THE REGULATIONS.

Tie-down is accomplished by attachment to the circular handling rings (see Appendix III, drawing H-251810). These rings have remained in place and maintained struc[illegible] integrity after Type B hypothetical accident tests. Hence, attachmen[illegible] assured.

225. TYPE A PACKAGING SHALL BE SO DESIGNED THAT, IF IT WERE SUBJECTED TO THE TESTS SPECIFIED IN SECTION VII, PARAS 709-714, IT WOULD PREVENT:

(a) LOSS OR DISPERSAL OF THE RADIOACTIVE CONTENTS, AND
(b) ANY INCREASE OF THE MAXIMUM RADIATION LEVEL RECORDED OR CALCULATED AT THE EXTERNAL SURFACE FOR THE CONDITION BEFORE THE TEST.

All Carrying Shields NCS-YB NCS-VB, and NCS-WB meet these requirements as demonstrated by these tests performed on the NCS-Y.

For NLS-RF (NCS-YB loaded with NPV-CF), water spray was not performed, except on Labels H-123122 and H-268213 [illegible]duced of stainless steel with recessed markings by chemical etching. Water spray test is not a damaging test to this specific equipment since it is of all metal construction. Thirty-foot free drop was performed in the following attitudes:

1. Top end drop
2. Side drop
3. Top edge drop
4. Bottom edge drop
5. Bottom end drop

These drops far exceed requirements of IAEA (1973) Paragraph 712. Shield weight is 158.4 lbs. (72.1 kg).

On NCS-YB (which becomes NLS-RF when loaded with its source NPV-CF), compression tests have been made. 1300 kg/m^2 did not damage this structure.

Penetration was made using a procedure similar to IAEA Paragraph 714. In these tests, the shields were dropped from 40" height on a 6" diameter steel cylinder without significant damage.

Appendix IX describes:

Thirty-foot drop tests

Penetration tests

Compression tests

Water spray on stainless steel labels.

All Source-Pressure Vessel assemblies also meet these requirements as discussed below.

NPV-CF

For NPV-CF, work to prove compliance with Normal Conditions of Transport is presented in Appendix VIII. Although not strictly to the format of IAEA (1973) Paragraphs 709-714, it considers:

Heat - at 425^{O}F, all stresses are much lower than yield stress for the materials.

Cold - at -40^{O}F, temperature does not damage any of the package material.

Pressure - subjected to 21,000 psi with no damage.

Vibration - no damage after exposure to 3 sweeps, 10-60 Hz, 7.5 G.

Water Spray - not applicable.

Free drop - survived 30-foot drop tests without damage. The 40-inch drop was neglected.

NPV-KL AND NPV-LM

The tests described in paragraphs 709-714 are the water spray test, the free drop test, the compression test, and the penetration test. These tests were applied to the above Source-Pressure Vessel assemblies as described below:

- Water spray test. This test was not performed as these Source-Pressure Vessel assemblies are designed to exclude fluids at pressures up to 25,000 psi. Samples of each model were tested at 26,000 psi and 518°F and did not leak.

- Free drop test. Samples of NPV-KL and NPV-LM with Dummy Source capsules were dropped from 9 meters and did not suffer any damage. The 1.2 meter test was neglected.

- Compression test. NPV-KL and NPV-LM were tested to [illegible]3,000 psi and did not collapse. This is far in excess of the conditions descibed by paragraph 713.

- Penetration test. Since the Pressure Vessel and Source form an essentially solid unit, and since the special form certified Source passed penetration or percussion tests at least equal in severity to the penetration test specified in paragraph 714, this test was neglected.

The Neutron Sources NSR-F, NSR-L, and NSR-M meet Special Form Requirements and have survived tests more severe than those described in paragraphs 709-714.

226. TYPE A PACKAGING DESIGNED FOR LIQUIDS SHALL, IN ADDITION, BE ADEQUATE TO MEET THE CONDITIONS PRESCRIBED IN PARA. 225 IF THE PACKAGE IS SUBJECTED TO THE TESTS SPECIFIED IN SECTION VII, PARAS 715-717. HOWEVER, THESE TESTS ARE NOT REQUIRED WHEN ENOUGH ABSORBENT MATERIAL TO ABSORB TWICE THE VOLUME OF THE LIQUID CONTENTS IS WITHIN THE CONTAINMENT AND:

(a) THE ABSORBENT MATERIAL IS WITHIN THE RADIATION SHIELD; OR

(b) THE ABSORBENT MATERIAL IS OUTSIDE THE RADIATION SHIELD, PROVIDED THAT IT CAN BE SHOWN THAT IF THE LIQUID CONTENTS WERE TAKEN UP BY THE ABSORBENT MATERIAL THE RESULTANT RADIATION LEVEL AT THE SURFACE OF THE PACKAGE WOULD NOT EXCEED 200 MREM/H.

Not applicable because liquids are not involved.

227. TYPE A PACKAGING DESIGNED FOR COMPRESSED OR UNCOMPRESSED GASES SHALL, IN ADDITION, PREVENT LOSS OR DISPERSAL OF THE RADIOACTIVE CONTENTS IF THE PACKAGING IS SUBJECTED TO THE TESTS SPECIFIED IN SECTION VII, PARAS 715-717. PACKAGES DESIGNED FOR TRITIUM AND ARGON-37, IN GASEOUS FORM AND IN ACTIVITIES UP TO 200 Ci, SHALL BE EXEMPTED FROM THIS REQUIREMENT.

Not applicable because gas is not involved, except that gas resulting from isotope decay which is discussed under Paragraph 220.

BASIC ADDITIONAL REQUIREMENTS FOR TYPE B(U) PACKAGES

228. EXCEPT AS SPECIFIED IN PARA 233, TYPE B(U) PACKAGES SHALL BE DESIGNED TO MEET ALL THE ADDITIONAL REQUIREMENTS SPECIFIED FOR TYPE A PACKAGES. SPECIFIED IN PARAGRAPHS 210 TO 225.

Type A qualifications are discussed above in Paragraphs 210-227. Prior certifications include:

- The Neutron Source, NSR-F, was granted Special Form Radioactive Material Encapsulation, USA/0113/S dated March 30, 1977.

- The Neutron Sources, NSR-L, and NSR-M, were granted Special Form Radioactive Material Encapsulation, USA/0135/S dated March 18, 1980 (revision 2 of original certificate).

- The Assembly, NLS-RF, was granted IAEA Certificate of Competent Authority, Type B Fissile Radioactive Material Package Design, USA/9088/B( ), dated May 18, 1978.

- The Assembly, NLS-RF, was granted IAEA Certificate of Component Authority, Type B(U) Fissile Radioactive Material Package Design, USA/9088/B(U), dated January 24, 1979.

Copies of certificates are reproduced in Appendix IV.

229. THE PACKAGING SHALL BE SO DESIGNED THAT IF IT WERE SUBJECTED TO THE TESTS IN SECTION VII, PARAS 718-721, IT WOULD RETAIN SUFFICIENT RADIATION SHIELDING TO ENSURE THAT THE RADIATION LEVEL AT 1 M FROM THE SURFACE OF THE PACKAGE WOULD NOT EXCEED 1 REM/H HAD THE PACKAGE CONTAINED SUFFICIENT IRIDIUM-192 TO PRODUCE A RADIATION LEVEL OF 10 MREM/H AT 1 M FROM THE SURFACE BEFORE THE TESTS. WHERE THE USE OF PACKAGING IS TO BE RESTRICTED TO A PARTICULAR RADIONUCLIDE, THAT RADIONUCLIDE MAY BE USED AS THE REFERENCE SOURCE IN PLACE OF IRIDIUM-192. IN ADDITION, IF THE PACKAGING IS TO BE USED FOR NEUTRON EMITTERS, AN APPROPRIATE NEUTRON REFERENCE SOURCE SHOULD ALSO BE USED.

NLS-RF with dummy source was subjected to tests which are similar to those required in Section VII, Paragraphs 718-721. The metal parts survived almost intact. See Appendix XI. However, essentially all of the polymer was consumed. To meet conditions of Paragraph 229, it would be required to provide 31 Curie of ^{241}AmBe and measure the radiation level at 1 m for an unshielded source. Our experimental data shows that this is less than 100 mrem/hour at 1 meter which is less than the 1 rem/hour required. Thus, our quantity of ^{241}AmBe cannot exceed the allowed 1 rem/hour at 1 meter, even if unshielded.

The configuration for the shielding material for the NLS-KL and NLS-LM is identical to that of the NLS-RF. The test was not repeated for these assemblies.

230. TYPE B(U) PACKAGES SHALL BE SO DESIGNED, CONSTRUCTED, AND PREPARED FOR SHIPMENT THAT, UNDER THE AMBIENT CONDITIONS SPECIFIED IN PARA. 231, THEY SHALL SATISFY THE CONDITIONS IN (a) AND (b) BELOW.

(a) HEAT GENERATED WITHIN THE PACKAGE BY THE RADIOACTIVE CONTENTS WILL NOT, UNDER NORMAL CONDITIONS ENCOUNTERED IN TRANSPORT (AS DEMONSTRATED BY THE TESTS IN SECTION VII), ADVERSELY AFFECT THE PACKAGE IN SUCH A WAY THAT IT WILL FAIL TO MEET THE APPLICABLE REQUIREMENTS FOR CONTAINMENT AND SHIELDING IF LEFT UNATTENDED FOR A PERIOD OF ONE WEEK. PARTICULAR ATTENTION SHALL BE PAID TO THE EFFECTS OF HEAT WHICH MAY:

(i) ALTER THE ARRANGEMENT, THE GEOMETRICAL FORM OR THE PHYSICAL STATE OF THE RADIOACTIVE CONTENTS OR, IF THE MATERIAL IS ENCLOSED IN A CAN OR RECEPTACLE (FOR EXAMPLE, CLAD FUEL ELEMENTS), CAUSE THE CAN, RECEPTABLE OR MATERIAL TO MELT;
(ii) LESSEN THE EFFICIENCY OF THE PACKAGING THROUGH DIFFERENTIAL THERMAL EXPANSION OR CRACKING OR MELTING OF THE RADIATION SHIELDING MATERIAL;
(iii) IN COMBINATION WITH MOISTURE, ACCELERATE CORROSION.

(b) THE TEMPERATURE OF THE ACCESSIBLE SURFACES OF A TYPE B(U) PACKAGE SHALL NOT EXCEED 50°C IN THE SHADE UNLESS THE PACKAGE IS TRANSPORTED AS A FULL LOAD.

(a) A 25 Curie ^{241}AmBe source will deliver slightly less than 1 watt of power. A test was performed to determine the temperature rise of the NCS-YB (H-251810) Carrying Shield with 1 watt of power being supplied by a resistor that was dissipating the required 1 watt. The temperature of the outside surface of the Carrying Shield and the ambient temperature 1/2" from the surface was measured for a 24-hour period. The temperature of the accessible surfaces did not vary from ambient by more than 0.4°C during the test.

(b) Since in part (a) the accessible surfaces of the package were the same as ambient, the accessible surfaces of the package will not exceed 50°C.

231. IN APPLYING PARA. 230 ABOVE, THE FOLLOWING CONDITIONS SHALL BE ASSUMED:

(a) AMBIENT TEMPERATURE 38°C;
(b) INSOLATION DATA ACCORDING TO TABLE III.

TABLE III. INSOLATION DATA

FORM AND LOCATION OF SURFACE	INSOLATION IN GCAL/CM^2 FOR 12 HOURS PER DAY
FLAT SURFACES TRANSPORTED HORIZONTALLY;	
- BASE	NONE
- OTHER SURFACES	800
FLAT SURFACES NOT TRANSPORTED HORIZONTALLY:	
- EACH SURFACE	200[a]
CURVED SURFACES	400[a]

[a] ALTERNATIVELY, A SINE FUNCTION MAY BE USED, ADOPTING AN ABSORPTION COEFFICIENT AND NEGLECTING THE EFFECTS OF POSSIBLE REFLECTION FROM NEIGHBOURING OBJECTS.

It was learned experimentally that 25 Curie of ^{241}AmBe did not increase the temperature of the NCS-YB Carrying Shield by a discernible amount. Therefore, the insolation factors are not considered relevant.

232. PACKAGING WHICH INCLUDES THERMAL PROTECTION FOR THE PURPOSE OF SATISFYING THE REQUIREMENTS OF THE THERMAL TEST SPECIFIED IN SECTION VII, PARA. 720, SHALL BE SO DESIGNED THAT SUCH PROTECTION WILL REMAIN EFFECTIVE IF THE PACKAGING IS SUBJECTED TO THE TESTS SPECIFIED IN SECTION VII, PARAS 709-714 AND 719. ANY SUCH PROTECTION ON THE EXTERIOR OF THE PACKAGE SHALL NOT BE RENDERED INEFFECTIVE BY CONDITIONS COMMONLY ENCOUNTERED IN NORMAL HANDLING OR IN ACCIDENTS AND NOT SIMULATED IN THE TESTS REFERRED TO ABOVE; E.G., BY RIPPING, CUTTING, SKIDDING, ABRASION OR ROUGH HANDLING.

Thermal insulation for the purpose of satisfying thermal tests is not part of the design. Assembly is all metallic (nonpyrophoric), except for shielding material which is polymeric. The shielding material is fully encased in metal.

SPECIFIC ADDITIONAL REQUIREMENTS FOR TYPE B(U) PACKAGES

233. A TYPE B(U) PACKAGE SHALL BE SO DESIGNED THAT, IF IT WERE SUBJECTED TO THE TESTS REFERRED TO BELOW, IT WOULD:

(a) WITH REGARD TO THE TESTS SPECIFIED IN SECTION VII, PARAS 709-714, RESTRICT THE LOSS OF RADIOACTIVE CONTENTS TO NOT MORE THAN $A_2 \times 10^{-6}$ PER HOUR;

(b) WITH REGARD TO THE TESTS SPECIFIED IN SECTION VII, PARAS 718-721, RESTRICT THE ACCUMULATED LOSS OF RADIOACTIVE CONTENTS TO NOT MORE THAN $A_2 \times 10^{-3}$ IN A PERIOD OF ONE WEEK.

FOR (a) ABOVE, THE EVALUATION SHALL TAKE INTO ACCOUNT THE EXTERNAL CONTAMINATION LIMITATIONS OF SECTION V, PARA. 502, AND, FOR BOTH (a) AND (b) ABOVE, THE A_2 VALUES FOR NOBLE GASES SHALL BE THOSE FOR THE UNCOMPRESSED STATE.

For purposes of this test, the NSR-F (H-142108) was selected. This is the active source material in its welded housings described in Appendix I. It was considered as the appropriate assembly for proof of leak tightness since:

- It is the basic radioactive "package".
- NSR-F cannot be disassembled with ordinary tools.

All testing was conducted for Schlumberger Well Services by Monsanto Research Corporation, Dayton, Ohio. Their report is held in Appendix X.

Procedure was in accordance with IAEA (1973) Paragraphs 708-721, including the requirement of repeated water spray described in Paragraph 709. American National Standard, ANSI N14.5, 1977, Leaktightness by Helium Mass Spectrometer method, was used as a guide for procedure to discriminate the very small leak rate specified by Paragraph 230.

Only minor mechanical damage occurred. The drop tests produced some "denting" and thermal test produced an external surface oxide scale.

After testing, there was no discernible loss of contents when measured by a method more sensitive than that required in (a) or (b) above.

Sources NSR-L (ref. Schlumberger part number H-239681) and NSR-M (ref. Schlumberger part number H-245258) were also tested per requirements listed in Paragraph 233 (Paragraph 230 of unamended version).

After testing, no leakage was found by tests performed according to ANSI N14.5-1977, Appendix A, Paragraph A3.9.

Monsanto's certification of these tests is included in Appendix X.

234. COMPLIANCE WITH THE PERMITTED ACTIVITY RELEASE LIMITS SHALL DEPEND NEITHER UPON FILTERS NOR UPON A MECHANICAL COOLING SYSTEM.

Neither filters nor mechanical cooling are part of this design.

235. A PACKAGE SHALL NOT INCORPORATE A FEATURE WHICH IS INTENDED TO ALLOW CONTINUOUS VENTING DURING TRANSPORT.

Design will not permit venting during transport.

236. THE PACKAGE SHALL NOT INCLUDE A PRESSURE RELIEF SYSTEM FROM THE CONTAINMENT SYSTEM WHICH WOULD ALLOW THE RELEASE OF RADIOACTIVE MATERIAL TO THE ENVIRONMENT UNDER THE CONDITIONS OF THE TESTS SPECIFIED IN SECTION VII, PARAS 709-714 AND 718-721.

No pressure relief system which would allow release of radioactive material exists in this design.

237. WHERE THE MAXIMUM NORMAL OPERATING PRESSURE (SEE SECTION I, PARA. 122) OF THE CONTAINMENT SYSTEM ADDED TO ANY DIFFERENTIAL PRESSURE BELOW MEAN SEA-LEVEL ATMOSPHERIC PRESSURE TO WHICH ANY COMPONENT OF THE PACKAGING SPECIFIED AS PART OF THE CONTAINMENT SYSTEM MAY BE SUBJECTED EXCEEDS 0.35 KG/CM^2, THAT COMPONENT SHALL BE CAPABLE OF WITHSTANDING A PRESSURE OF NOT LESS THAN ONE AND A HALF TIMES THE SUM OF THOSE PRESSURES; THE STRESS AT THIS LATTER PRESSURE SHALL NOT BE MORE THAN 75% OF THE MINIMUM YIELD STRENGTH AND NOT MORE THAN 40% OF THE ULTIMATE STRENGTH OF THAT COMPONENT AT THE MAXIMUM EXPECTED OPERATING TEMPERATURE.

- The NSR-F is the active source material in its welded pressure housings. This assembly is 100% pressure tested to 25,000 psi during manufacture. See Appendix I.

- The NPV-C is the additional Pressure Vessel with threaded closure. Laboratory tests have been successfully made in conditions of 21,000 psi at 425°F. See Appendix VIII for calculation of collapse strength for N?V-CF.

- The NCS-YB is the Carrying Shield. It has not been pressure tested. However, it survived mechanically through "accident conditions in transport" testing and the design is rugged. It must withstand i· service only one atmosphere plus or minus small variations because o. location relative to sea level. Thus, it will remain competent unde. conditions of Paragraph 237.

- The Neutron Sources NSR-L and NSR-M (active source material in welded pressure housings) are 100% pressure tested to 25,000 psi during their manufacture.

- The Neutron Pressure Vessels NPV-K and NPV-L are the additional pressure vessels for the Neutron Source. They have been tested to 26,000 psi and did not leak or deform in any way. A mathematical calculation of collapse strength for these pressure vessels is included in Appendix VIII.

- The Carrying Shields NCS-VB and NCS-WB are subjected to no pressure other th_ atmospheric under normal operating conditions.

238. WHEN THE PACKAGE AT THE MAXIMUM NORMAL OPERATING PRESSURE (SEE SECTION I, PARA. 122) IS SUBJECTED TO THE THERMAL TEST SPECIFIED IN SECTION VII, PARA. 720, THE PRESSURE IN ANY COMPONENT OF THE PACKAGING SPECIFIED AS A PART OF THE CONTAINMENT SYSTEM SHALL BE DEMONSTRATED NOT TO EXCEED THE PRESSURE WHICH CORRESPONDS TO THE MINIMUM YIELD STRENGTH OF THAT COMPONENT AT THE MAXIMUM TEMPERATURE WHICH IT WOULD BE EXPECTED TO REACH IN THE TEST.

For NSR-F (H-142108), a mathematical stress analysis was made as part of the Special Form application contained here in Appendix VII. Monsanto Research Corporation calculated the maximum internal pressure of the source capsule, at the end of 20 years of manufacture, at 450°F (232°C) and 1475°F (802°C), as, respectively,

P (20 yr, 450°F) = 101.1 psia

P (20 yr, 1475°F) = 215.2 psia

The analysis using the cumulative conservatism of the ASME Pressure Vessel Code and numerous worst-case assumptions concludes that each of the source capsules (the inner and intermediate capsules) are independently able to not only withstand an operat g environment of 450°F, but also to be able to pass the Special Form Heating Test at any time within a 20-year period after manufacture.

Additionally, a mathematical stress analysis was made on NPV-CF (H-203295) as shown in Appendix VIII. This studies thermal stress at 1475°F (802°C) during both heating and cooling. The calculations prove that the stresses due to 1475°F are low in comparison to the yield strength of the material.

Neutron Sources NSR-L and NSR-M were granted Special Form Certification and as part of this process were shown to withstand thermal accident conditions as described by Paragraph 720.

Neutron Source-Pressure Vessel Assemblies NPV-KL and NPV-LM are shown to withstand accident conditions specified in Paragraph 720 by calculations included in Appendix VIII.

In addition, a mathematical stress analysis of the inner capsules for Neutron Sources NSR-L and NSR-M was performed and showed stresses far below allowable yield stresses for the conditions described in Paragraph 238. This analysis is included in Appendix VII.

239. THE PACKAGE SHALL NOT HAVE A MAXIMUM NORMAL OPERATING PRESSURE (SEE SECTION I, PARA. 122) IN EXCESS OF 7 KG/CM^2 (GAUGE).

Pressure of 99.54 lbs./sq. in. (7 kg/cm^2) is about the internal pressure to NSR-F caused by heating of air and the formation of gas due to degeneration of the isotope when calculated at 450°F and 20 years after manufacture. Details were presented in the Type B( ) application document and are contained in Appendix VII.

Therefore pressure after one year is less than 99.54 lbs./sq. in. (7 kg/cm^2).

For the NSR-L and NSR-M maximum normal operating pressures were determined to be 32.85 psi and 31.19 psi, respectively. Pressure in these components is considered to be the maximum which would occur in the total package. Thus, maximum normal operating pressure for these packages is below 99.54 psi (7 kg/1 cm^2). Analysis is included in Appendix VII.

240. THE MAXIMUM TEMPERATURE OF ANY SURFACE READILY ACCESSIBLE DURING TRANSPORT OF THE PACKAGE SHALL NOT EXCEED 82°C UNDER NORMAL CONDITIONS OF TRANSPORT (SEE ALSO PARA. 230(b)).

See paragraph 23[illegible]. The thermal rise due to degeneration of the isotope cannot increase the temperature of the package a discernible amount.

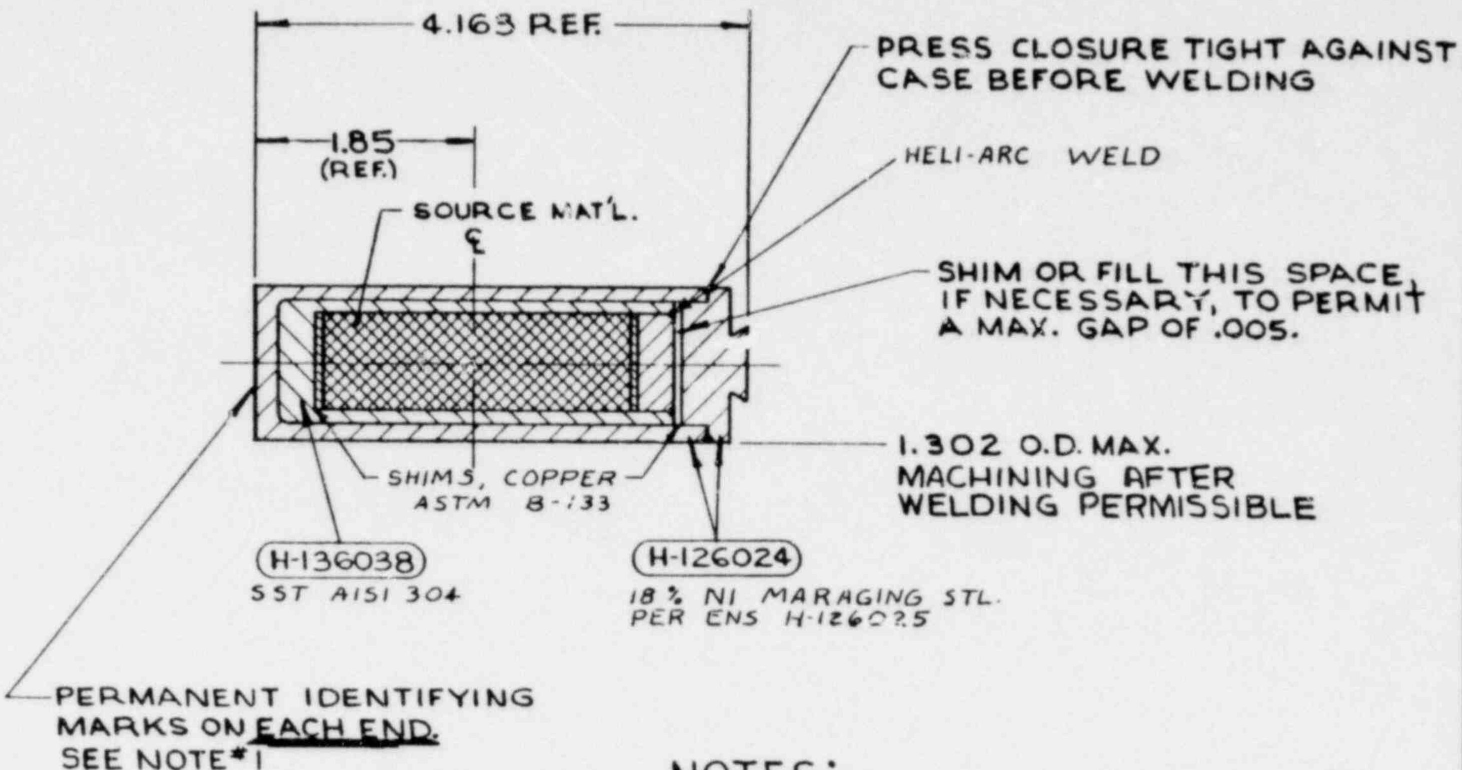
241. THE CONTAINMENT SYSTEM OF A PACKAGE CONTAINING LIQUID SHALL NOT BE IMPAIRED IF THE PACKAGE IS SUBJECTED TO A TEMPERATURE OF -40°C UNDER NORMAL CONDITIONS OF TRANSPORT.

Not applicable because no liquid is involved.

APPENDIX I

SUBJECT: NSR-F, L, M; Active Source Material in its Welded Pressure Housings

NRS-F Assembly Drawing	H-142108
NSR-L Assembly Drawing	H-239681
NSR-M Assembly Drawing	H-245258



NOTES:

1. SERIAL NUMBER & IDENTIFICATION MARKING TO BE DONE BY SUPPLIER. SERIAL NUMBERING SYSTEM TO BE APPROVED BY S.W.S.

TREATED AFTER MACHINING

DIMENSIONS AND TOLERANCES SHOWN APPLY TO FINISHED PART. ALLOWANCE FOR PLATING TO BE MADE BY MANUFACTURER.

SEE ENG. SPECS. ...

H-208295
USED ON

DET	QTY	MATERIAL	APP. SPEC. MAT. COMP. & PROCESSES
		CONSTRUCTION & INSPECTION PER ENS H-209986 (A) ENGINEERING APPROVED SUPPLIER: MONSANTO RESEARCH CO. DAYTON, OHIO OR NUMEC APOLLO, PA.	

SOURCE ACTIVITY: 19.99 CURIE MAX. (A) (B)

SOURCE OUTPUT: $4.0\ ^{+0.6}_{-0.0} \times 10^7$ N/SEC (C)

NO	DATE	BY	DESCRIPTION
C	9/19/79		ECN 52900
B	1-27-76		ECN 42573 FEB 5 1976
A	8-12-75	B.H.	ECN 39819 AUG 2 2 1975

REVISIONS

PROJECTS: NSR-F

TOLERANCES UNLESS OTHERWISE SPECIFIED		
1.0	±.030	CONCENTRICITY .010 T.I.R.
1.00	±.010	125 ✓ ON ALL MACHINED SURFACES
1.000	±.005	
ANG	±½°	BREAK ALL CORNERS .015 MAX. .010 MIN. (R. OR 45°)

DO NOT COPY, DISPLAY, OR USE DRAWING WITHOUT AUTHORIZATION — DO NOT SCALE DRAWING

DATA McCOY	APPROVED FOR RELEASE	
CKD.	DES. ENGR.	PROD. ENGR.
DRN. RLS	DATE 1-26-68	SCALE FULL

SCHLUMBERGER WELL SERVICES
A Division of Schlumberger Technology Corporation
HOUSTON, TEXAS

NEUTRON SOURCE, RADIOACTIVE, (C)
Am-Be ... CURIE

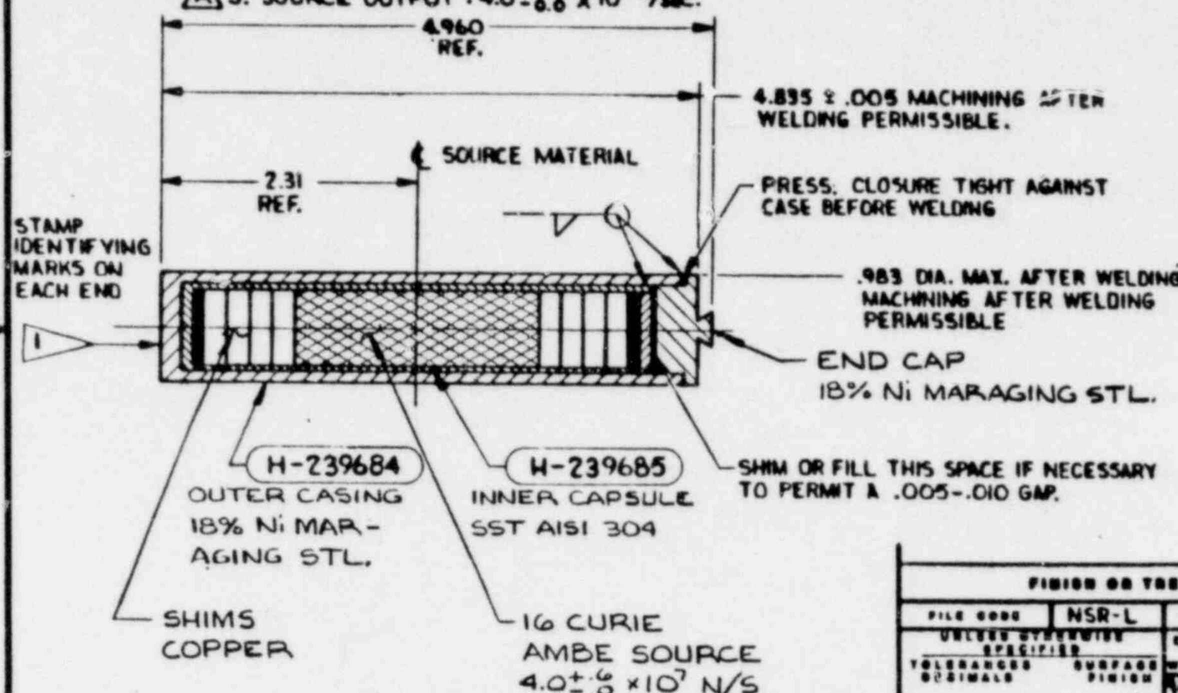
ASSY DWG. H-142108

UNIT-ASSY DWG. H-142108

FEB 2 1971

SHEET SIZE B

NOTES:
1. SERIAL NUMBER & IDENTICATION STAMPING TO BE DONE BY SUPPLIER. SERIAL NUMBERING SYSTEM TO BE APPROVED BY SWS
2. CONSTRUCTION & INSPECTION PER H-209986
3. ENGINEERING APPROVED FABRICATOR: MONSANTO RESEARCH CORP. OR NUMEC, APOLLO P.A.
4. SOURCE ACTIVITY NOT TO EXCEED 19.99 CURIES.
5. (A) SOURCE OUTPUT : $4.0^{+0.6}_{-0.0} \times 10^7$ N/sec.



REVISIONS			
LTR	DCN NO.	DATE	BY
A	52900	9-19-79	LVS

FINISH OR TREATMENT	
FILE CODE	NSR-L
UNLESS OTHERWISE SPECIFIED TOLERANCES DECIMALS	SURFACE FINISH 125
DO NOT COPY, DISPLAY, OR USE DRAWING WITHOUT AUTHORIZATION	
E. MARTINEZ	2-17-76
DES.	
CHK.	
APPR. [signature]	5/20/76
REL/STDS [signature]	5/19/76
ANGLES	
INSIDE CORNERS ... R MAX. DIMENSIONS ARE IN INCHES. REMOVE BURRS, BREAK EDGES .010 MIN-.020 MAX. DIMENSIONS INCLUDE APPLIED FINISH	
H-239690	WHERE USED

DET.	QTY.
MATERIAL	
SCHLUMBERGER WELL SERVICES	A DIVISION OF SCHLUMBERGER TECHNOLOGY CORPORATION
NEUTRON SOURCE RADIOACTIVE AM BE SOURCE, 16 CURIE (A)	
DWG. NO.	H-239681
REV	A
SCALE	1/1
RELEASED	FEB 2 4 1979
SHT	1 OF 1

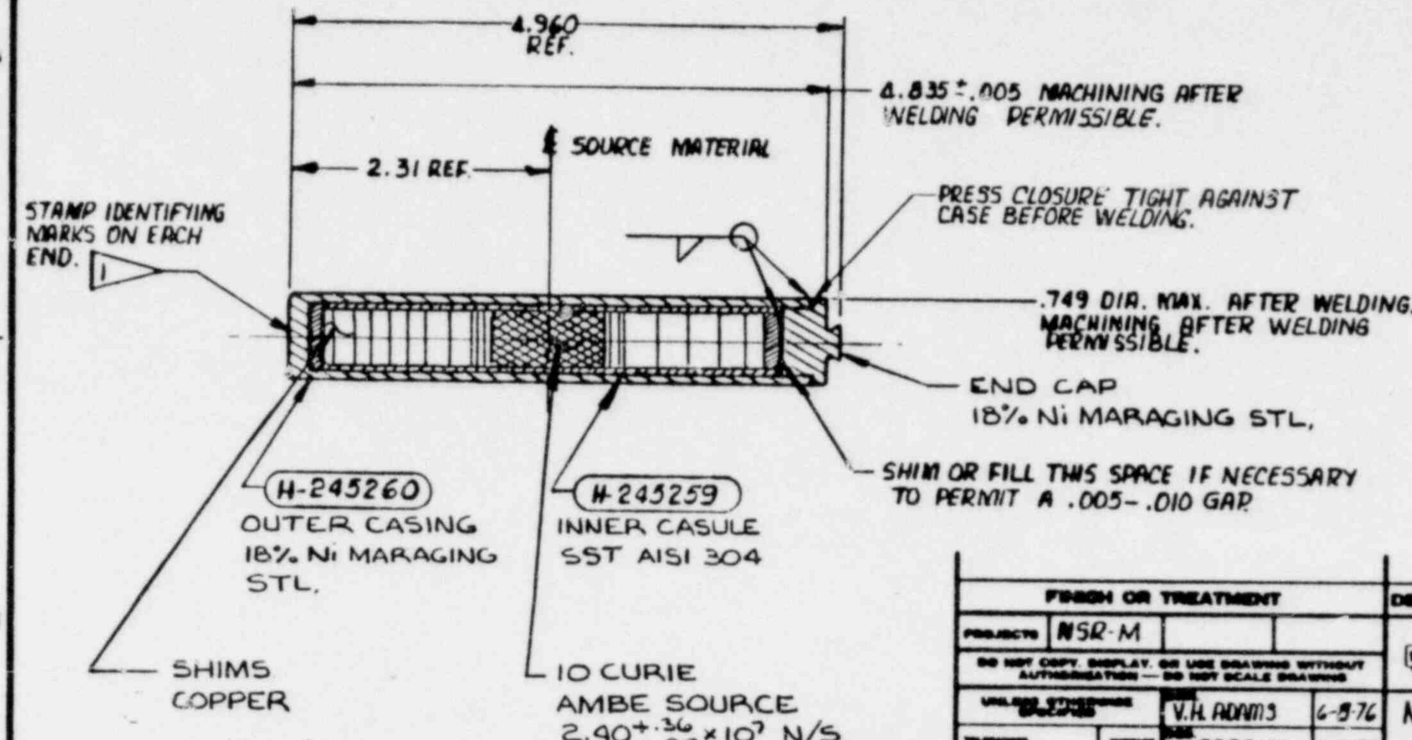
No. 239681

REVISIONS

LTR	DESCRIPTION	DATE	BY
A	ECN 52900	9-1979	LVS
B	ECN 53537	1-16-80	GL

NOTES:

1. SERIAL NUMBER & IDENTIFICATION STAMPING TO BE DONE BY SUPPLIER. SERIAL NUMBERING SYSTEM TO BE APPROVED BY SWS.
2. CONSTRUCTION & INSPECTION PER H-209986.
3. ENGINEERING APPROVED FABRICATOR: MONSANTO RESEARCH CORP. OR NUNEC, APOLLO PA.
4. (B) (A) SOURCE OUTPUT: 2.4 +0.36/-0.00 x 10^7 N/SEC
   MAX ACTIVITY: 19.99 CURIE



H-245267
WHERE USED

FINISH OR TREATMENT | DET. | QTY. | MATERIAL

PROJECTS: NSR-M

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A Division of Schlumberger Technology Corporation
HOUSTON, TEXAS

DRAWN	V.H. ADAMS	6-8-76
CHECKED	GORSKY	6-8-76
	[signature]	7/20/78
	GORSKY	6-8-76
APP	[signature]	7/13/78
	[signature]	7/13/78

NEUTRON SOURCE RADIOACTIVE
Am Be SOURCE
10 CURIE (A)

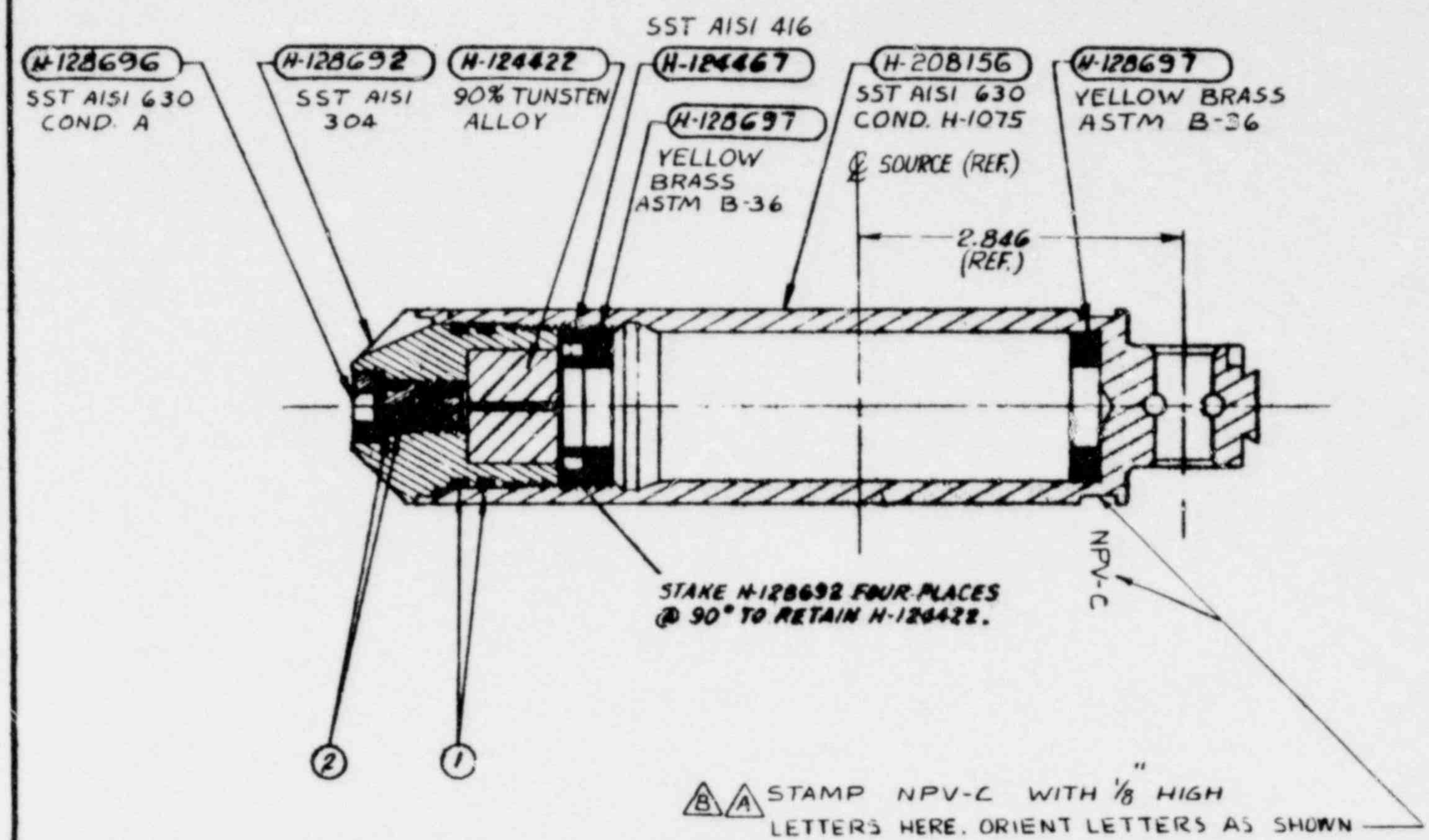
H-245258 REV B

SCALE 1/1 — APR 26 1979 — SHT 1 OF 1

APPENDIX II

SUBJECT: NPV, Neutron Pressure Vessel

NPV-C Assembly Drawing	H-208167
NPV-K Assembly Drawing	H-329044
NPV-L Assembly Drawing	H-329042



MATERIAL | APP. SPEC. MAT. COMP. & PROCESSES

SUB ASSY DWG. H-208167

NO	DATE	BY	DESCRIPTION
B	8-23-73	VR	ECN 34356
A	12-10-71	G	ECN 19676

REVISIONS

PROJECTS: NPV-C

TOLERANCES UNLESS OTHERWISE SPECIFIED

CONCENTRICITY .010 T.I.R.

125 ✓ ON ALL MACHINED SURFACES

BREAK ALL CORNERS .015 MAX. .010 MIN. (R. OR 45°)

DO NOT COPY, DISPLAY OR USE DRAWING WITHOUT AUTHORIZATION — DO NOT SCALE DRAWING

DATA K. H. | APPROVED FOR RELEASE

CKD. W. H. A. | DES. ENGR. | PROD. ENGR.

DRN. [illegible] | DATE 11-26-69 | SCALE FULL

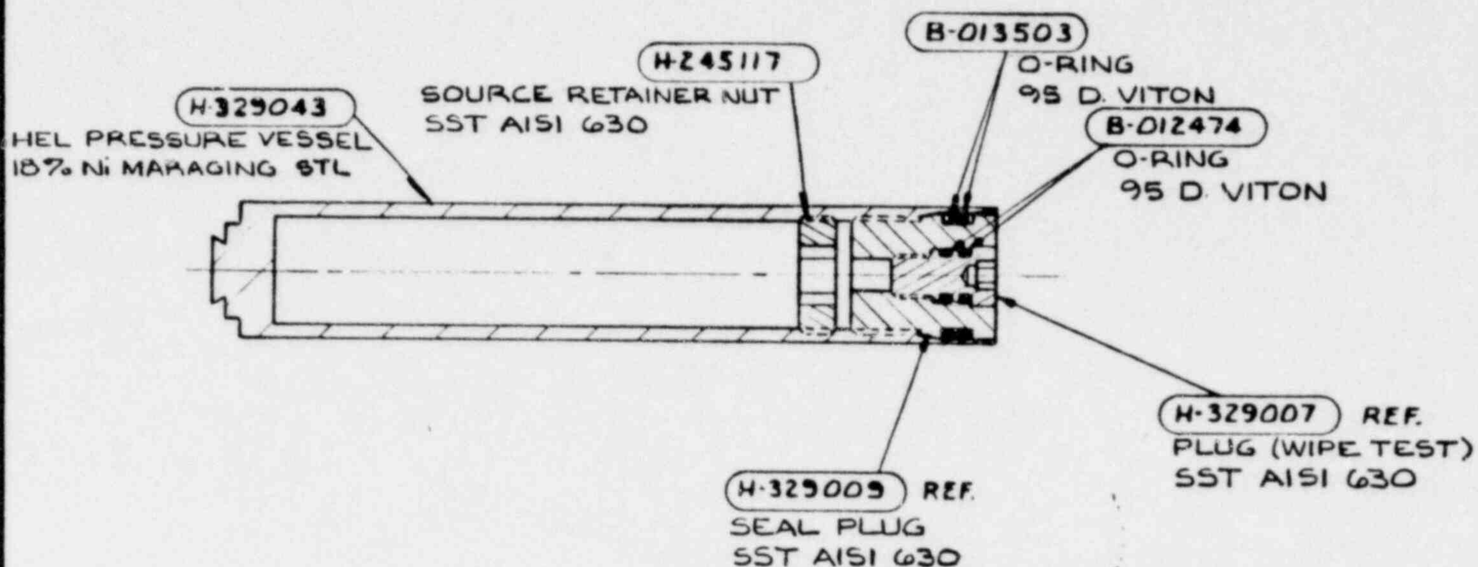
SCHLUMBERGER WELL SURVEYING CORP.
HOUSTON, TEXAS

1 11/16 NEUTRON PRESSURE VESSEL FOR Am-Be 4 × 10⁷ N/SEC. (16 CURIE)

SUB-ASSY. DWG H 208167

H 208295
USED ON

©



H-329044

REVISIONS

FINISH OR TREATMENT

MATERIAL

FILE CODE NPV-K

DO NOT COPY, DISPLAY, OR USE DRAWING WITHOUT AUTHORIZATION

LENDERMON 12/5/79

LENDERMON 12/5/79

12/6/79

12/6/79

SCHLUMBERGER WELL SERVICES

HEL NEUTRON PRESSURE VESSEL ASSEMBLY

H- 329044

SCALE 1/1

JAN 23 1980

SHT 1 OF 1

H-329049

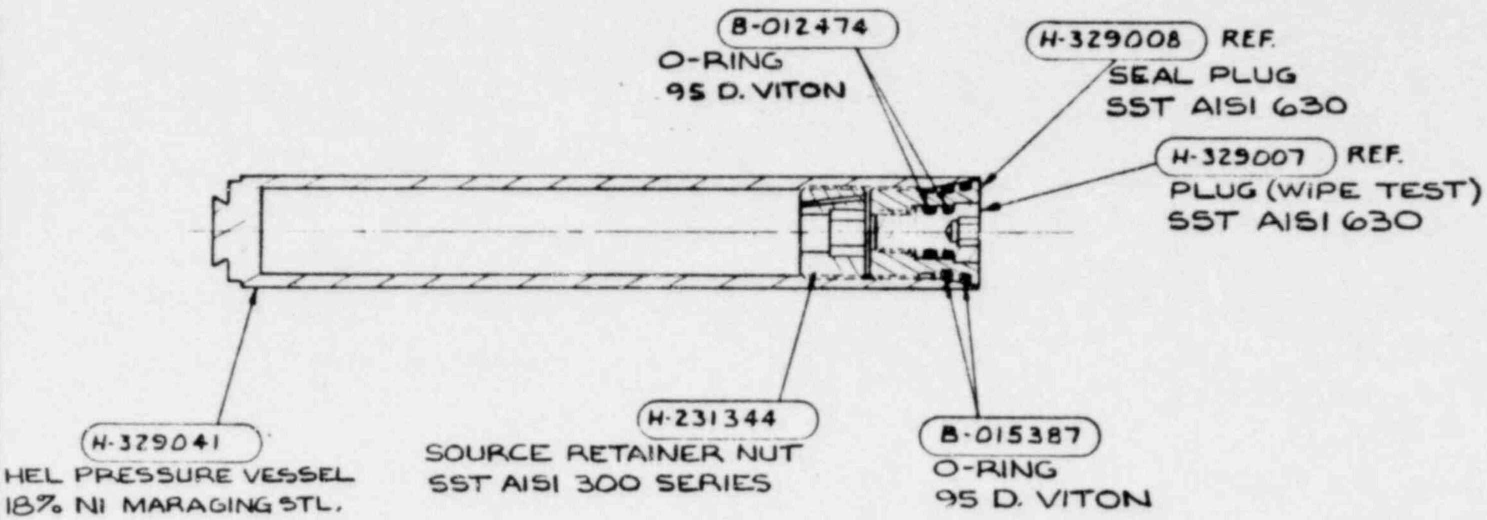
WHERE USED

HOLE SCHEDULE

REVISIONS

LTR	DCN NO.	DATE	BY

H-329042



MK	QTY	SIZE	TOL	TP TOL/REMARKS

HOLE SCHEDULE

H-329050
WHERE USED

FINISH OR TREATMENT | DET. | QTY. | MATERIAL

FILE CODE NPV-L

UNLESS OTHERWISE SPECIFIED
TOLERANCES DECIMALS
SURFACE FINISH 125✓
ANGLES
CONCENTRICITY ______ TIR
INSIDE CORNERS ______ R MAX
DIMENSIONS ARE IN INCHES
REMOVE BURRS, BREAK EDGES .005 MIN-.020 MAX
DIMENSIONS INCLUDE APPLIED FINISH

DO NOT COPY, DISPLAY, OR USE DRAWING WITHOUT AUTHORIZATION

DSN	LENDERMON	12/4/79
DES	—	—
DRN	LENDERMON	12/5/79
CKD		
APP	[signature]	12/6/79
	[signature]	12/6/79

SCHLUMBERGER WELL SERVICES
A DIVISION OF SCHLUMBERGER TECHNOLOGY CORPORATION

HEL NEUTRON PRESSURE VESSEL ASSEMBLY

S/M ✓ | H-329042 | REV

SCALE 1/1 | RELEASED JAN 17 1980 | SHT 1 OF 1

APPENDIX III

SUBJECT: NCS, Neutron Carrying Shield with three center tube versions.

NCS-YB Assembly Drawing H-251810

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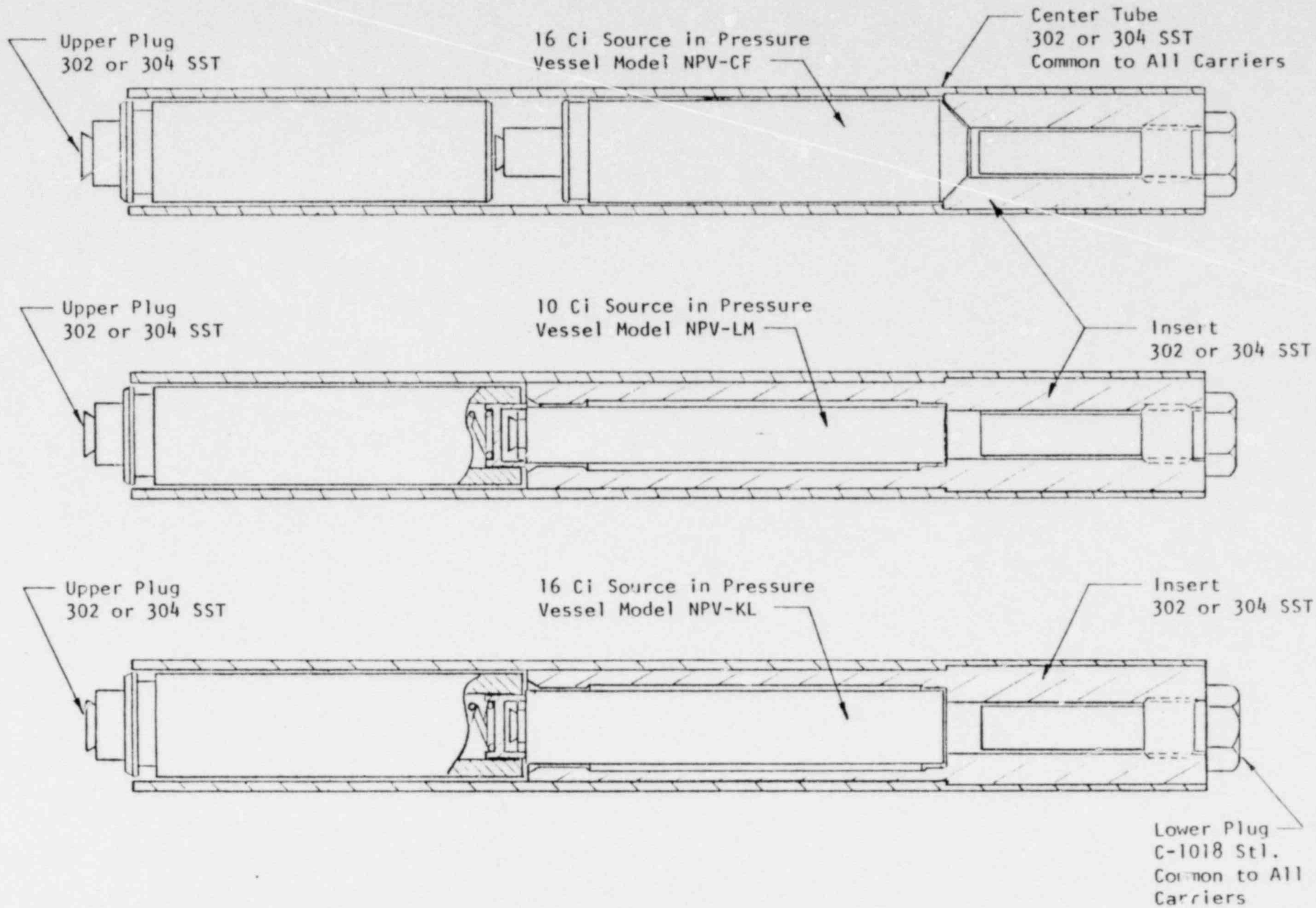

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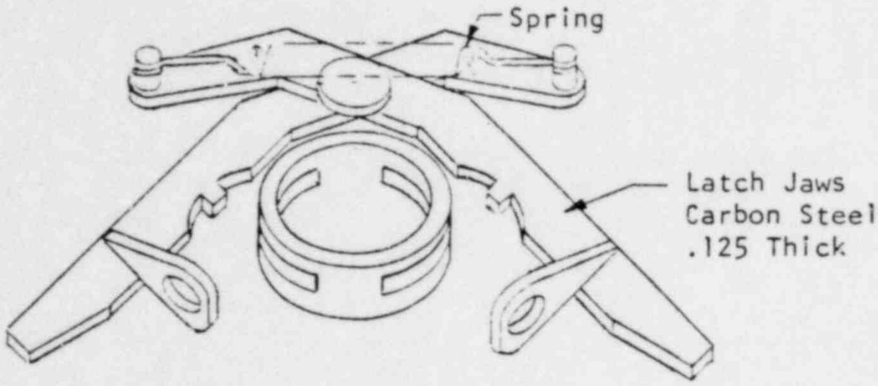
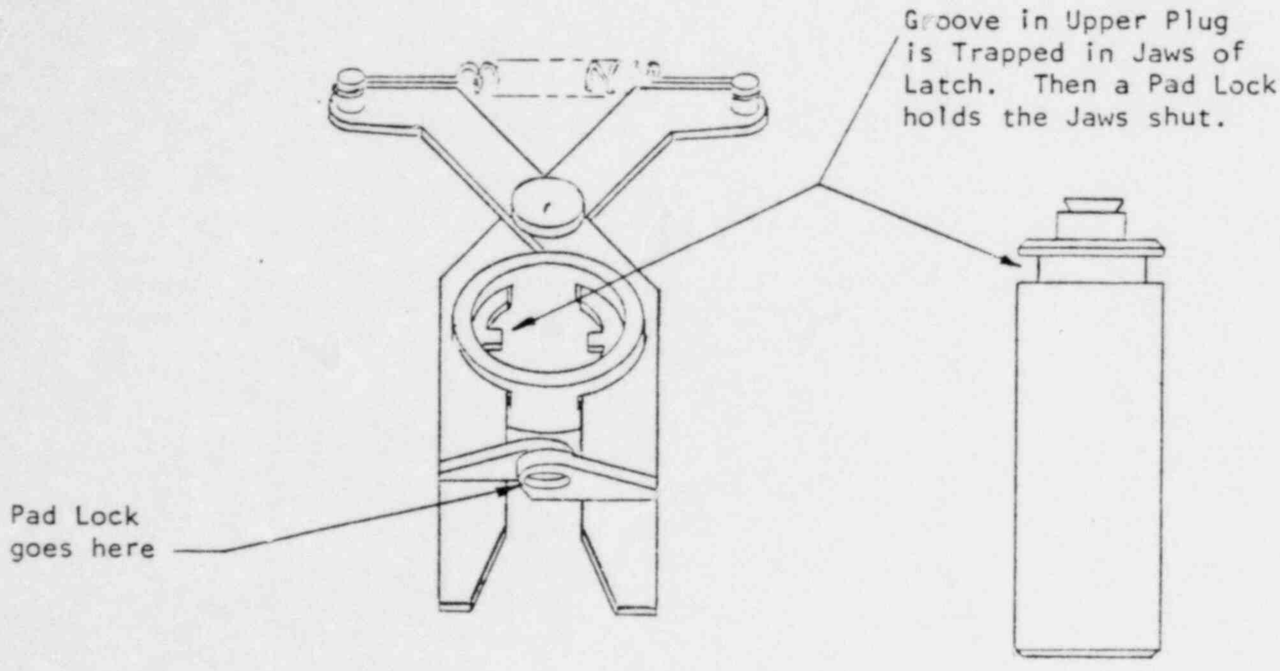
COMMON TO ALL CARRIERS





APPENDIX IV

SUBJECT: Prior Certifications

Special Form Certificate, March 30, 1977	USA/0113/S
Type B Certificate, June 20, 1978	USA/9088/B( )
Type B(U) Certificate, January 24, 1979	USA/9088/B(U)
Special Form Certificate, March 18, 1980	USA/0135/S

DEPARTMENT OF TRANSPORTATION
MATERIALS TRANSPORTATION BUREAU
WASHINGTON, D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Material Encapsulation

Certificate Number USA/0113/S

1.8

This certifies that the encapsulated sources, as described, when loaded with the authorized radioactive contents, have been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in IAEA1/ and USA2/ regulations for the transport of radioactive materials.

I. Source Description - The sources described by this certificate are identified as SWS Model No. H-142108 and H-115686 which are doubly encapsulated in stainless steel and 18% Ni Maraging steel and measure approximately 1.28 inches in in diameter by 4.163 inches long.

II. Radioactive Contents - The authorized radioactive contents of these sources consist of: For Model H-142108, 20.0 Curies, and for model H-115686, 6.3 Curies of Americium-241 as oxide.

III. This certificate, unless renewed, expires March 31, 1980.

This certificate is issued in accordance with Marginal C-6.1 of the IAEA Regulations1/, and in response to the March 23, 1977 petition by Schlumberger Well Services, Houston, Texas and in consideration of the associated information therein.

Certified by:

for R. W. Grella, Chief, Technology Division
U. S. Department of Transportation
Office of Hazardous Materials Operations
Washington, D. C. 20590.

MAR. 30, 1977
(DATE)

1/ "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1967 Edition", published by the International Atomic Energy (IAEA) Vienna, Austria.

2/ Title 49, Code of Federal Regulations, Part 170-178, USA.

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Type B Fissile Radioactive Material Package Design REFER TO:

Certificate Number USA/9088/B()

This establishes that the packaging design described herein, when loaded with the authorized radioactive contents, has been certified as meeting the regulatory requirements for Type B packaging for radioactive materials as prescribed in IAEA[1] Regulations and in accordance with §§ 49 CFR 173.393b, and 173.394(b)(3) of the USA[2] Regulations for the transportation of radioactive materials.

I. Package Identification - Model No. NLS-RF.

II. Packaging Description - Packaging authorized by this certificate consists of a welded, mild steel cylindrical outer shell measuring 17.3 inches in diameter by 20.5 inches in length with a full length inner stainless steel tube measuring 2 inches OD by 1.73 inches ID with the void between the two filled with polyethlene. The bottom closure is a solid plug while the top closure is a plug engaged by a scissor mechanism. The package gross weight is 155 pounds.

III. Authorized Radioactive Contents - The authorized contents consist of special form Americium-241 meeting the requirements of 49 CFR 173.398(a) with a maximum activity of 25 curies.

IV. General Conditions -

a. Each user of this certificate must have in his possession a copy of this certificate.

b. Each user of this certificate, other than Schlumberger Well Services, Houston, Texas, shall register his identity in writting to the Office of Hazardous Materials Regulations Materials Transportation Bureau, U. S. Department of Transportation, Washington, D. C. 20590.

c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.

VI. Marking and Labeling - The package must also bear the marking USA/9088/B() as well as the other marking and labels prescribed by the USA Regulations.

VI. Expiration Date - This certificate, unless renewed, expires on June 30, 1981.

This certificate is issued in accordance with the requirements of the IAEA and USA Regulations and in response to the May 24, 1978 petiton by Schlumberger Well Services, Houston, Texas and in consideration of the associated information provided in U. S. Nuclear Regulatory Commission Certificate of Compliance No. 9088.

Certfied by:

for [signature] 6/20/78
(DATE)

A. W. Grella
Chief, R & D Management
Office of Program Support
Materials Transportation Bureau
Washington, D. C. 20590

1 "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1967 Edition" published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

2 Title 49, Code of Federal Regulations, Parts 100-199, USA.

NRC-618
(12-73)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE

For Radioactive Materials Packages

1.(a) Certificate Number	1.(b) Revision No.	1.(c) Package Identification No.	1.(d) Pages No.	1.(e) Total No. Pages
9088	0	USA/9088/B( )	1	2

PREAMBLE

2.(a) This certificate is issued to satisfy Sections 173.393a, 173.394, 173.395, and 173.396 of the Department of Transportation Hazardous Materials Regulations (49 CFR 170-189 and 14 CFR 103) and Sections 146–19–10a and 146–19–100 of the Department of Transportation Dangerous Cargoes Regulations (46 CFR 146–149), as amended.

2.(b) The packaging and contents described in item 5 below, meets the safety standards set forth in Subpart C of Title 10, Code of Federal Regulations, Part 71, "Packaging of Radioactive Materials for Transport and Transportation of Radioactive Material Under Certain Conditions."

2.(c) This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

This certificate is issued on the basis of a safety analysis report of the package design or application—

3.(a) Prepared by (Name and address):

Schlumberger Well Services
P. O. Box 2175
Houston, Texas 77001

3.(b) Title and identification of report or application:

Schlumberger Well Services Application dated March 25, 1977, as supplemented.

3.(c) Docket No. 71-9088

CONDITIONS

This certificate is conditional upon the fulfilling of the requirements of Subpart D of 10 CFR 71, as applicable, and the conditions specified in item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Fissile Class, Other Conditions, and References:

(a) Packaging

(1) Model No.: NLS-RF

(2) Description

The container is a mild steel, welded, cylindrical shell with a full length stainless steel center tube containing a special form capsule. The 20.5-inch long by 17.3-inch diameter outer cylinder has a 0.075-inch thick shell and 1/8-inch thick end plates. The annulus between the outer cylinder and the 2-inch OD by 1.73-inch ID center tube is filled with polyethylene for shielding. The center tube bottom closure is a welded, solid plug drilled for a bolt closure. The upper closure is a removable steel plug engaged by a scissor mechanism pad-locked closed. Handling rings are welded onto both ends. The gross weight of the container is 155 pounds.

(3) Drawings

The packaging is constructed according to Schlumberger Well Services Drawings Nos. H-251810, Rev. 0, and H-251507, Rev. 0.

. (b) Contents

(1) Type and form

Americium-241 as a sealed source that meets the requirements of special form as defined in 10 CFR §71.4(o).

(2) Maximum quantity of material per package

25 curies

. Name plates shall be fabricated of materials capable of resisting the fire test of 10 CFR Part 71 and maintaining their legibility.

. The packaging authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12(b).

. Expiration date: May 31, 1983.

REFERENCES

chlumberger Well Services application dated March 25, 1977.

upplement dated: April 7, 1978.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Branch
Division of Fuel Cycle and
Material Safety

Date: MAY 18 1978

U.S. NUCLEAR REGULATORY COMMISSION
SAFETY EVALUATION BY THE TRANSPORTATION BRANCH
OF THE MODEL NO. NLS-RF
USA/9088/B( ) PACKAGE

Encl to ltr dtd: MAY 18 1978

SUMMARY

By application dated March 25, 1977, as supplemented, Schlumberger Well Services requested approval of the Model No. NLS-RF shipping package to be used for shipment of radiographic sources containing americium-241 in special form. Based on the statements and representations presented in the application, as supplemented, we have concluded that the packaging and contents meet the requirements of 10 CFR Part 71, for the proposed contents, subject to the conditions contained herein.

REFERENCES

1. Schlumberger Well Services application dated March 25, 1977.
2. Supplement dated April 7, 1978.

DRAWINGS

The packaging is fabricated according to Schlumberger Well Services Drawings Nos. H-251810, Rev. 0, and H-251507, Rev. 0.

DESCRIPTION

The container is a mild steel, welded, cylindrical shell with a full length stainless steel center tube containing a special form capsule. The 20.5-inch long by 17.3-inch diameter outer cylinder has a 0.075-inch thick shell and 1/8-inch thick end plates. The annulus between the outer cylinder and the 2-inch OD by 1.73-inch ID center tube is filled with polyethylene for shielding. The center tube bottom closure is a welded, solid plug drilled for a bolt closure. The upper closure is a removable steel plug engaged by a scissor mechanism pad-locked closed. Handling rings are welded onto both ends. The gross weight of the container is 155 pounds.

CONTENTS

The contents consist of americium-241 as sealed sources that meet the requirements of special form as defined in 10 CFR §71.4(o). The contents are limited to 25 curies of americium-241.

STRUCTURAL/THERMAL

The applicant has provided the results of a series of 30 foot free drop and puncture tests on packagings with both the machined polyethylene shielding and the polyethylene bead-polyurethane foam shielding. The results indicate that although various minor damage is done to the packaging the special foam capsule is not released from the center tube of the packaging. Also the testing indicates that overloading of the handling rings would fail the ring support welds prior to significantly damaging the container, thereby demonstrating compliance with 10 CFR §71.31(c)(4) and §71.31(d)(3).

The polyethylene bead/urethane resin shielded package, considered to be representative, was tested for the thermal accident environment following the series of impact tests. No significant failure was noted.

SHIELDING

No significant loss of shielding as a result of normal conditions of transport and shielding is not required to meet accident conditions of transport (10 CFR §71.36(a)(1)).

Charles E. MacDonald

Charles E. MacDonald, Chief
Transportation Branch
Division of Fuel Cycle and
Material Safety

Date: MAY 18 1978

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

REFER TO:

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Type B Radioactive Material Package Design

Certificate Number USA/9088/B(U)

(Revision 1)

This establishes that the packaging design described herein, when loaded with the authorized radioactive contents, has been certified by the Competent Authority of the United States as meeting the regulatory requirements for Type B packaging for radioactive materials as prescribed in IAEA[1] Regulations and in accordance with §§ 49 CFR 173.393b and 173.394(b)(3) of the USA[2] Regulations for the transportation of radioactive materials.

I. Package Identification - Model No. NLS-RF.

II. Packaging Description - Packaging authorized by this certificate consists of a welded, mild steel cylindrical outer shell measuring 17.3 inches in diameter by 20.5 inches in length with a full length inner stainless steel tube measuring 2 inches OD by 1.73 inches ID with the void between the two filled with polyethylene. The bottom closure is a solid plug while the top closure is a plug engaged by a scissor mechanism. The package gross weight is 155 pounds.

III. Authorized Radioactive Contents - The authorized contents consist of special form Americium-241 meeting the requirements of 49 CFR 173.389(g) with a maximum activity of 25 curies.

IV. General Conditions -

a. Each user of this certificate must have in his possession a copy of this certificate.

b. Each user of this certificate, other than Schlumberger Well Services, Houston, Texas, shall register his identity in writing to the Office of Hazardous Materials Regulation, Materials Transportation Bureau, U. S. Department of Transportation, Washington, D. C. 20590.

c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.

VI. Marking and Labeling - The package must bear the marking USA/9088/B(U) as well as the other marking and labels prescribed by the USA Regulations.

VII. Expiration Date - This certificate, unless renewed, expires on January 31, 1982.

This certificate is issued in accordance with the requirements of the IAEA and USA Regulations and in response to the May 24, 1978, petition by Schlumberger Well Services, Houston, Texas, and in consideration of the associated information provided in U. S. Nuclear Regulatory Commission Certificate of Compliance No. 9088.

Certified by:

R. R. Rawl, Health Physicist
Office of Hazardous Materials Regulation
Materials Transportation Bureau
U. S. Department of Transportation
Washington, D. C. 20590

January 24, 1979
(Date)

[1]"Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition" published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

[2]Title 49, Code of Federal Regulations, Parts 100-199, USA.

Revision 1 issued in accordance with the 1973 Revised Edition of the IAEA Regulations and to extend expiration date in response to the January 5, 1979, petition of Schlumberger Well Services, Houston, Texas.

NRC-618
1̶-73)
CFR 71

U ..JCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE

For Radioactive Materials Packages

) Certific) Number	1.(b) Revision No.	1.(c) Package Identification No.	1.(d) Pages No.	1.(e) Total No. Pages
9088	0	USA/9088/B( )	1	2

PREAMBLE

2.(a) This certificate is issued to satisfy Sections 173.393a, 173.394, 173.395, and 173.396 of the Department of Transportation Hazardou Materials Regulations (49 CFR 170-189 and 14 CFR 103) and Sections 146—19—10a and 146—19—100 of the Department of Transportation Dangerous Cargoes Regulations (46 CFR 146—149), as amended.

2.(b) The packaging and contents described in item 5 below, meets the safety standards set forth in Subpart C of Title 10, Code of Federal Regulations, Part 71, "Packaging of Radioactive Materials for Transport and Transportation of Radioactive Material Under Certain Conditions."

2.(c) This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or intr· ·hich the package will be transported.

This certificate is issued on the basis of a safety analysis report of the package design or application—

3.(a) Prepared by *(Name and address)*:

;chlumberger Well Services
?. O. Box 2175
Iouston, Texas 77001

3.(b) Title and identification of report or application:

Schlumberger Well Services Application dated March 25, 1977, as supplemented.

3.(c) Docket No. 71-9088

CC NDITIONS

This certificate is conditional upon the fulfilling of the requirements of Subpart D of 10 CFR 71, as applicable, and the conditions specified in item 5 below.

Description of Packaging and Authorized Contents, Model Number, Fissile Class, Other Conditions, and References:

(a) Packaging

(1) Model No.: NLS-RF

(2) Description

The container is a mild steel, welded, cylindrical shell with a full length stainless steel center tube containing a special form capsule. The 20.5-inch long by 17.3-inch diameter outer cylinder has a 0.075-inch thick shell and 1/8-inch thick end plates. The annulus between the outer cylinder and the 2-inch OD by 1.73-inch ID center tube is filled with polyethylene for shielding. The center tube bottom closure is a welded, solid plug drilled for a bolt closure. The upper closure is a removable steel plug engaged by a scissor mechanism pad-locked closed. Handling rings are welded onto both ends. The gross weight of the container is 155 pounds.

(3) Drawings

The packaging is constructed according to Schlumberger Well Services Drawings Nos. H-251810, Rev. 0, and H-251507, Rev. 0.

. (b) Contents

(1) Type and form

Americium-241 as a sealed source that meets the requirements of special form as defined in 10 CFR §71.4(o).

(2) Maximum quantity of material per package

25 curies

. Name plates shall be fabricated of materials capable of resisting the fire test of 10 CFR Part 71 and maintaining their legibility.

. The packaging authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12(b).

. Expiration date: May 31, 1983.

REFERENCES

chlumberger Well Services application dated March 25, 1977.

upplement dated: April 7, 1978.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Branch
Division of Fuel Cycle and
Material Safety

Date: MAY 18 1978

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

REFER TO:

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Material Encapsulation

Certificate Number USA/0113/S

(Revision 1)

This certifies that the encapsulated sources, as described, when loaded with the authorized radioactive contents, have been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in IAEA[1] and USA[2] regulations for the transport of radioactive materials.

I. Source Description - The sources described by this certificate are identified as SWS Model No. H-142108 and H-115686 which are doubly encapsulated in stainless steel and 18% Ni Maraging steel and measure approximately 1.3 inches in diameter by 4.2 inches long.

II. Radioactive Contents - The authorized radioactive contents of these sources consist of: For Model H-142108, 20.0 Curies, and for Model H-115686, 6.3 Curies of Americium-241 as oxide.

III. This certificate, unless renewed, expires January 31, 1982.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations[1], and in response to the March 23, 1977, petition by Schlumberger Well Services, Houston, Texas and in consideration of the associated information therein.

Certified by:

R. R. Rawl, Health Physicist
Office of Hazardous Materials Regulation
Materials Transportation Bureau
U. S. Department of Transportation
Washington, D.C. 20590.

January 25, 1979
(Date)

[1] "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Edition", published by the International

Atomic Energy (IAEA) Vienna, Austria.

[2]Title 49, Code of Federal Regulations, Part 170-178, USA.

Revision 1 issued in accordance with the 1973 Revised Edition of the IAEA Regulations and to extend expiration date in response to the January 5, 1979, petition by Schlumberger Well Services, Houston, Texas.

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

JAN. - - 1979 REFER TO:

Mr. C. E. Racster
Schlumberger Well Services
P. O. Box 2175
Houston, Texas 77001

Dear Mr. Racster:

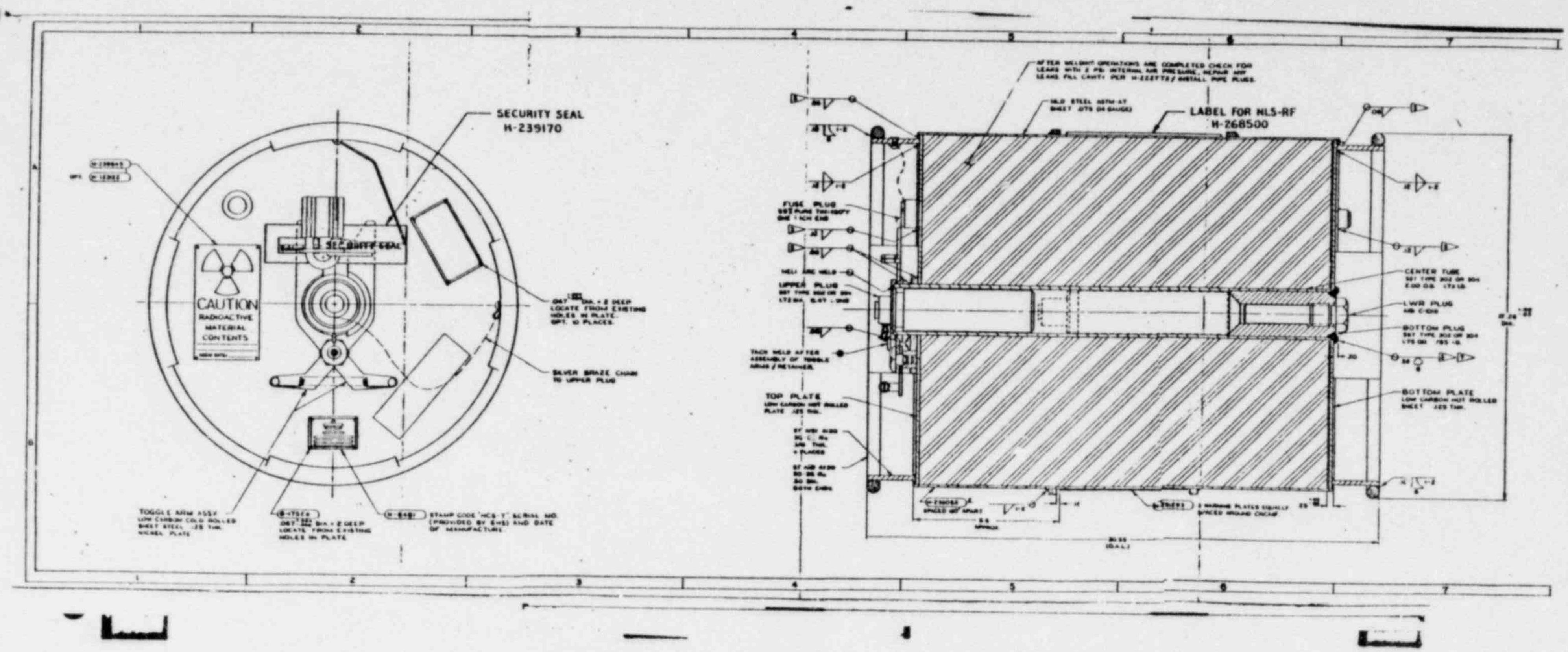
Enclosed please find a line drawing to be attached to IAEA Certificate of Competent Authority Certificate Number USA/9088/B(U) before Appendix A.

Sincerely,

Nora Walls

for R. R. Rawl
Health Physicist
Office of Hazardous
Materials Regulation
Materials Transportation Bureau

Enclosure


SECURITY SEAL
H-239170
CAUTION
RADIOACTIVE
MATERIAL
CONTENTS
LABEL FOR NLS-RF
H-268500
FUSE PLUG
UPPER PLUG
TOP PLATE
CENTER TUBE
LWR PLUG
BOTTOM PLUG
BOTTOM PLATE

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Materials Encapsulation REFER TO:

Certificate Number USA/0135/S
(Revision 2)

This certifies that the encapsulated sources, as described, when loaded with the authorized radioactive contents, have been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in IAEA[1] and USA[2] Regulations for the transport of radioactive materials.

I. Source Description - The sources described by this certificate are identified as SWS Model H-245258 (NSR-M) and SWS Model H-239681 (NSR-L) which are doubly encapsulated in stainless steel and 18% Ni Maraging steel and measure 0.749" in diameter by 4.72" in length and 0.983" in diameter by 4.835" in length, respectively.

II. Radioactive Contents - The authorized radioactive contents consist of: For Model H-245258, 10 Curies, and for Model H-239681, 20 Curies of Americium-241 as an Americium/Berrylium mixture.

III. This certificate, unless renewed, expires September 1, 1983.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations, and in response to the February 14, 1980, petition by Schlumberger Well Services and in consideration of the associated information therein.

Certified by:

R. R. Rawl
Designated U.S. Competent Authority for the
International Transportation of Radioactive Materials
Office of Hazardous Materials Regulation
U.S. Department of Transportation
Washington, D.C. 20590

March 18, 1980
(Date)

[1] "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition", published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

[2] Title 49, Code of Federal Regulations, Parts 170-178, USA.

Original issued in response to the August 9, 1977, petition by Schlumberger Well Services, Houston, Texas.

Revision 1 issued to reflect conformity with the IAEA 1973 Revised Edition of Safety Series No. 6, and to change authorized contents.

Revision 2 issued to extend expiration date.

APPENDIX V

SUBJECT: Paint Specifications*

*See original application for B(U) Certification dated January 5, 1979.

APPENDIX VI

SUBJECT: Safety Closure for NLS-RF*

*See original application for B(U) Certification dated January 5, 1979.

APPENDIX VII

SUBJECT: Documentation involved with NSR-F (H-142108) submitted for Special Form Certificate*

	ITEM
Internal Pressure Analysis NSR-L	5
Internal Pressure Analysis NSR-M	6

* For Items 1 through 4 see original application for B(U) Certification dated January 5, 1979.

INTERNAL PRESSURE ANALYSIS
NSR-L

The following is an analysis supporting arguments demonstrating compliance with requirements for B(U) certification listed in paragraphs 238 and 239 of IAEA Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition (as amended). Two values will be calculated:

1. Maximum normal operating pressure as defined in paragraph 122 of the above document.

2. Internal pressure and component stresses resulting from a Special Form heating test conducted when the capsule is at its maximum normal operating pressure.

General relations to determine pressure buildup and allowable capsule pressure have been developed in Item 4 of this appendix using the ASME Pressure Vessel Code, Division I, Section VIII. These relations express the total pressure buildup in a capsule due to the combination of gas entrapped during assembly and heli m buildup. Dimensions are taken from drawings included in Appendex I. The formula, repeated here, is

$$P(L,T) = 3.41\times10^{-3} \times T + 1.59\times10^{-4} \times \frac{S \times L \times T}{V}$$

where

P = total pressure buildup, atm
L = time after assembly and sealing, year
T = temperature, $^{\circ}K$
S = maximum Curie content
V = minimum void volume, cc

The maximum normal operating pressure will be computed based on the following assumptions:

L = 1 year, as defined for maximum normal operating pressure
T = $518^{\circ}F$, $543^{\circ}K$, maximum operating temperature
S = 25 Ci, absolute maximum content allowed in Schlumberger neutron source package under consideration
V = 0.2254 cc/Ci, from manufacturer's data

Using the above equation maximum normal operating pressure is computed as

$$P=(3.41\times10^{-3})(543) + (1.59\times10^{-4})\frac{(25)(1)(543)}{(.2254)(25)}$$

$=2.235$ atm
$P=32.85$ psi

The internal pressure resulting from conducting a Special Form heating test when the capsule is at its maximum normal operating pressure is computed based on the following assumptions:

L = 1 year
T = 1475°F, 1075°K, from heat test description
S = 25 Ci, absolute maximum content allowed in Schlumberger neutron source package under consideration
V = 0.2254 cc/Ci, from manufacturer's data

The pressure is then computed as

$$P=(3.41\times10^{-3})(1075) + (1.59\times10^{-4})\frac{(25)(1)(1075)}{(.2254)(25)}$$

$=4.424$ atm
$P=65.03$ psi

Item 4, section 6.1, in this appendix develops formulas for calculating maximum allowable internal pressures based on limiting stresses in the head, body and weld area of the source capsule. These relations are repeated here.

$$P_H=(t^2/CD^2)S$$

$$P_S=(t_w/2D)S$$

$$P_C=[Et \div (R+0.6t_r)]S$$

$$P_L=[2Et \div (R-0.4t_r)]S$$

where

P_H=maximum pressure due to head stress

P_S=maximum pressure due to weld shear stress

P_C=maximum pressure due to circumferential body stress

P_L=maximum pressure due to longitudinal body stress

t=thickness of head
C=dimensionless factor, =.75, based on ASME code discussion of figure UG-34(q)
D=diameter of head plug
S=maximum allowable material stress in tension
t_w=weld penetration

E=one, since the body is only welded at the head
t_r=mimimum thickness of body wall

R=one half the diameter of the plug

The maximum allowable pressures for the inner capsule of the NSR-M are computed below based on worst case dimensions. The capsule drawing is included in Appendix II.

$P_H=(t^2/CD^2)S$

$=[(.120)^2/(.75)(.696)^2]S$

$=.0768S$

$P_S=(t_w/2D)S$

$=[.050/(2)(.500)]S$
$=.050S$

$P_C=[Et_r \div (R+0.6t_r)]S$

$=[(1)(.045) \div (.348+(0.6)(.045))]S$

$=.120S$

$P_L=[2Et_r \div (R-0.4t_r)]S$

$=[(2)(1)(.045) \div (.348-(.4)(.045))]S$

$=.2727S$

Maximum tensile yield stress values for 304 stainless steel at 500°, which allows essentially no creepage over a long period of time, is 12,100 psi. The maximum yield stress corresponding to 1475°F is 9,900 psi. These values come from the ASME pressure vessel codes as noted in Item 4 of this appendix.

Given these values maximum allowable pressures can be calculated. The critical stress is in the closure weld, so the limiting pressure will be P_S as calculated below. At maximum normal operating conditions,

P_S=(.050)S=(.050)(12,100 psi)

=605.0 psi

Thus compared to the maximum normal operating pressure as calculated for the inner capsule, 32.85 psi, a safety factor of 18.4 results. During a special form heating test P_S allowable is calculated as

P_S=(.050)S=(.050)(9,900 psi)

=495.0 psi

Compared to the pressure at 1475°F as calculated earlier, 65.03 psi, a safety factor of 7.6 results.

Thus it is shown that internal pressures due to helium buildup and expansion of entrapped gasses will not cause the inner capsule to yield.

INTERNAL PRESSURE ANALYSIS
NSR-M

The following is an analysis supporting arguments demonstrating compliance with requirements for B(U) certification listed in paragraphs 238 and 239 of IAEA Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition (as amended). Two values will be calculated:

1. Maximum normal operating pressure as defined in paragraph 122 of the above document.

2. Internal pressure and component stresses resulting from a Special Form heating test conducted when the capsule is at its maximum normal operating pressure.

General relations to determine pressure buildup and allowable capsule pressure have been developed in Item 4 of this appendix using the ASME Pressure Vessel Code, Division I, Section VIII. These relations express the total pressure buildup in a capsule due to the combination of gas entrapped during assembly and helium buildup. Dimensions are taken from drawings included in Appendex I. The formula, repeated here, is

$$P(L,T)=3.41\times10^{-3}\times T + 1.59\times10^{-4}\times\frac{S\times L\times T}{V}$$

where

P = total pressure buildup, atm
L = time after assembly and sealing, year
T = temperature, °K
S = maximum Curie content
V = minimum void volume, cc

The maximum normal operating pressure will be computed based on the following assumptions:

L = 1 year, as defined for maximum normal operating pressure
T = 518°F, 543°K, maximum operating temperature
S = 25 Ci, absolute maximum content allowed in Schlumberger neutron source package under consideration
V = 0.320 cc/Ci, from manufacturer's data

Using the above equation maximum normal operating pressure is computed as

$$P=(3.41\times10^{-3})(543) + (1.59\times10^{-4})\frac{(25)(1)(543)}{(.320)(25)}$$

$=2.121$ atm
$P=31.19$ psi

The internal pressure resulting from conducting a Special Form heating test when the capsule is at its maximum normal operating pressure is computed based on the following assumptions:

L = 1 year
T = 1475°F, 1075°K, from heat test description
S = 25 Ci, absolute maximum content allowed in Schlumberger neutron source package under consideration
V = 0.320 cc/Ci, from manufacturer's data

The pressure is then computed as

$$P=(3.41\times10^{-3})(1075) + (1.59\times10^{-4})\frac{(25)(1)(1075)}{(.32)(25)}$$

$=3.719$ atm
$P=54.67$ psi

Item 4, section 6.1, in this appendix develops formulas for calculating maximum allowable internal pressures based on limiting stresses in the head, body and weld area of the source capsule. These relations are repeated here.

$$P_H=(t^2/CD^2)S$$

$$P_S=(t_w/2D)S$$

$$P_C=[Et \div (R+0.6t_r)]S$$

$$P_L=[2Et \div (R-0.4t_r)]S$$

where

P_H =maximum pressure due to head stress

P_S =maximum pressure due to weld shear stress

P_C =maximum pressure due to circumferential body stress

P_L =maximum pressure due to longitudinal body stress

t=thickness of head
C=dimensionless factor, =.75, based on ASME code discussion of figure UG-34(q)
D=diameter of head plug
S=maximum allowable material stress in tension
t_w=weld penetration

E=one, since the body is only welded at the head
t_r=mimimum thickness of body wall

R=one half the diameter of the plug

The maximum allowable pressures for the inner capsule of the NSR-M are computed below based on worst case dimensions. The capsule drawing is included in Appendix II.

$$P_H=(t^2/CD^2)S$$

$$=[(.120)^2/(.75)(.500)^2]S$$

$$=.0768S$$

$$P_S=(t_w/2D)S$$

$$=[.050/(2)(.500)]S$$
$$=.050S$$

$$P_C=[Et_r \div (R+0.6t_r)]S$$

$$=[(1)(.045)\div(.250+(0.6)(.045))]S$$

$$=.1625S$$

$$P_L=[2ET_r \div (R-0.4t_r)]S$$

$$=[(2)(1)(.045)\div(.250-(.4)(.045))]S$$

$$=.3880S$$

Maximum tensile yield stress values for 304 stainless steel at 500°, which allows essentially no creepage over a long period of time, is 12,100 psi. The maximum yield stress corresponding to 1475°F is 9,900 psi. These values come from the ASME pressure vessel codes as noted in Item 4 of this appendix.

Given these values maximum allowable pressures can be calculated. The critical stress is in the closure weld, so the limiting pressure will be P_S as calculated below. At maximum normal operating conditions,

$$P_S=(.050)S=(.050)(12,100\ \text{psi})$$

$$=605.0\ \text{psi}$$

Thus compared to the maximum normal operating pressure as calculated for the inner capsule, 31.19 psi, a safety factor of 19.4 results. During a special form heating test P_S allowable is calculated as

$$P_S=(.050)S=(.050)(9,900\ \text{psi})$$

$$=495.0\ \text{psi}$$

Compared to the pressure at 1475 °F as calculated earlier, 54.67 psi, a safety factor of 9.0 results.

Thus it is shown that internal pressures due to helium buildup and expansion of entrapped gasses will not cause the inner capsule to yield.

APPENDIX VIII

SUBJECT: NPV, Neutron Source Assembly, consisting of NSR in NPV.*

ITEM

Analysis NPV-KL	12
Analysis NPU-LM	13

* For items 1 though 11, see original application for B(U) Certification dated January 5, 1979.

NPV-KL

Basic Description

The NPV-KL is the assembly of the source capsule, NSR-L, and its protective pressure vessel, NPV-K, as shown in Figure 2. Detail drawings of all components are included in the appendix. The NSR-L has passed all tests and met all requirements for special form material and has received the appropriate Certificate of Compentent Authority. The NSR-L consists of the source material sealed in an "inner capsule," H-239685, which is in turn enclosed in an "outer case and closure," H-239684. The inner capsule is not relied upon as a structural member, but it offers a substantial increase in reliability as a welded containment vessel. The outer case and closure is the primary containment vessel. It is welded shut and cannot be accidentally opened. It is capable of withstanding any environment of pressure and temperature it will be subjected to while in use by Schlumberger. The NPV-K is an additional protective vessel for the NSR-L. It is sealed against pressure by an outer seal plug, H-329009, and a wipe test plug, H-329007, which is threaded into the outer plug. When the source-pressure vessel assembly is in its carrying shield (NCS-VB), the wipe test plug allows access to the NSR-L for a wipe test without allowing removal of the source. Both these plugs incorporate double O-ring seals. The NSR-L remains within the NPV-K throughout its use at Schlumberger.

Description of Materials

The materials used in construction of the NPV-K are indicated on Figure 2. The stated value of 16 Ci of Am-Be powder is a nominal value only. A sufficient quantity of Am-Be is used to produce a neutron output of 4.0 +0.6, -0.0 x 10^7 n/s. The material properties to be used in the analysis to follow are listed in Table 1 for convenience. The properties for 304 stainless steel were taken from the A.S.M. Handbook of Metal Properties, First Edition, page 58. The properties of 18% nickel Maraging steel were taken from the International Nickel Company's specification. This report is included in the appendix to this section.

16 CURIE NEUTRON SOURCE PRESSURE VESSEL ASSEMBLY
NPV-KL H-329049

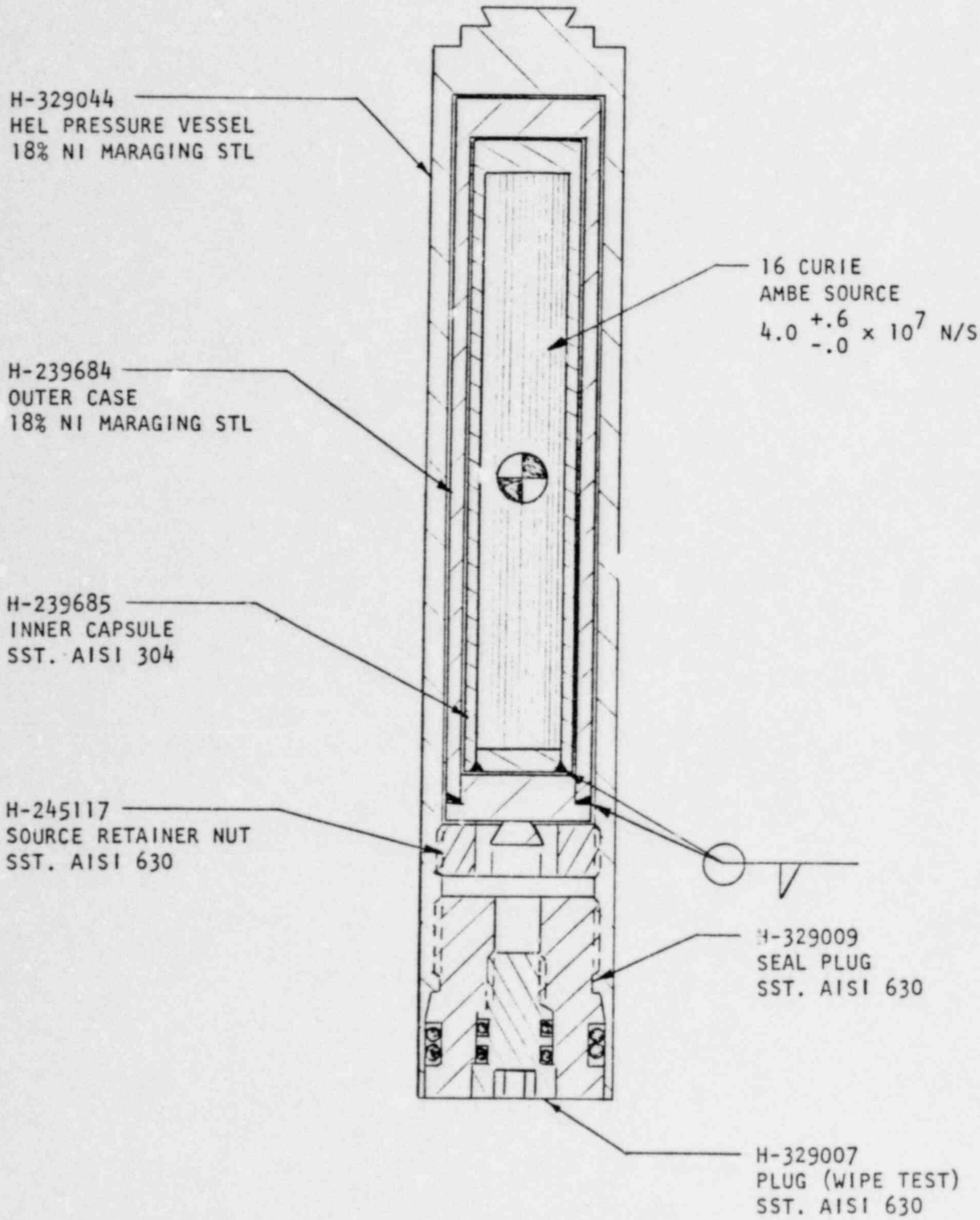


FIGURE 2.

Table 1

Property	304	Maraging Steel
Tensile Strength, psi	85,000 (annealed)	265,000 - 300,000 (aged)
Min. Yield Strength, psi, 70°F	30,000	250,000 (aged)
Min. Yield Strength, psi, 400°F	-	220,00 (aged)
Modulus of Elasticity, psi	28×10^6	27.0×10^6
Elongation, 2 in. %	50	5 - 10
Impact (Charpy V Notch) ft/lb at R.T.	90 (Izod)	12 (minimum)
Rockwell Hardness	80B	50-55C
Coefficient of Thermal Expansion 400°F, $^{in}/_{in}/_{F^o}$	9.9×10^{-6}	5.6×10^{-6}
Coefficient of Thermal Expansion 1400°F, $^{in}/_{in}/_{F}$	10.3×10^{-6}	(not available)
Density, lb/in^3	.29	.289

Construction and Assembly

Details of the construction and quality assurance testing of the NSR-L are given by SWS Engineering specification H-209986 (included in the appendix). Briefly, the source material is placed in the inner capsule and a cap is pressed, and then welded into place. The inner capsule is then placed in the outer case and closure. Again, a cap is pressed and welded into place. A leak test is performed after each of the above procedures. The completed NSR-L is placed in its pressure vessel, the NPV-K. It is held in place by a hold down nut, SWS part number H-245117. The outer seal plug, H-329009, is then threaded into place. Finally, the wipe test plug, H-329007, is threaded into the outer seal plug. A thread sealant is used on the outer seal plug to insure that it does not unseat when subjected to the amount of torque required to remove the wipe test plug. It can, however, be removed when sufficient torque is applied. When both plugs are torqued into place, the source is securely locked and protected in its pressure vessel.

For transportation and storage, the NPV-KL is placed in its carrying shield, the NCS-VB. This shield is secured with a lock that can be opened only with a special Schlumberger key.

Chemical and Galvanic Reactions

The housing of the NPV-K pressure vessel and the outer case and closure of NSR-L are made of 18% nickel maraging. The inner capsule is made from type 304 stainless steel. Since these are electromotively similar metals assembled in an essentially dry atmosphere, no galvanic reactions are possible. 18% nickel Maraging steel has a corrosion rate in flowing sea water of .007 in/yr as reported by the International Nickel Company. Type 304 stainless is listed as having a corrosion rate of .0005 in/yr in flowing sea water in the A.S.M. Metals Handbook, Volume 1, 8th Edition, page 558. At these rates, using minimum material conditions, it would require more than 120 years for salt water to reach the source material.

External Pressure

The design criteria for the outer case and closure, H-239684, and the outer pressure vessel, H-329044, is that they must withstand 26,000 psi and 518^{o}F with a minimum factor of safety of 1.23 based on yield stress. The equation used to compute the maximum safety pressure for closed cylinders is:

$$P/_s = 2.31k\,(1-k)$$

where

D = external allowable pressure

s = yield strength of material

k = t/D

t = wall thickness

D = outside diameter

This equation is a variation of the Lamb equation developed in Schlumberger Engineering Report 41 written by Ed Moser. A copy of the report is included in the appendix.

The minimum yield strength for 18% nickel Maraging steel at room temperature is 250,000 psi. At 518°F, the yield strength degrades approximately 16% to 210,000 psi. The outer pressure vessel can, therefore, withstand the following external pressure:

$$D = 1.228 \text{ in}$$

$$t = \frac{1.228 - .986}{2} = .121 \text{ in}$$

$$k = .009$$

$$P = 2.31\ (.099)\ (1-.099)\ (210,000)$$

$$= 43,270 \text{ psi}$$

The safety factor is therefore:

$$F.S. = \frac{43,270}{26,000} = 1.66$$

The outer case and closure is also made of 18% nickel Maraging steel. It can withstand the following external pressure:

$$D = .982 \text{ in.}$$

$$t = \frac{.982 - .781}{2} = 100 \text{ in.}$$

$$k = .102$$

$$P = 2.31\,(.102)\,(1-.102)\,(210,000)$$

$$= 44,433 \text{ psi}$$

The safety factor is thus:

$$F.S. = \frac{44.433}{26.000} = 1.71$$

The ability of the outer pressure vessel to withstand external pressure was demonstrated experimentally by testing a prototype built per drawing H-329044 at 26,000 psi and 518°F. The vessel aid not collapse nor did the seals leak.

Thermal Stresses, Heating

The following calculations give the stresses due to differential thermal expansion of the three housings at a steady state temperature of 518°F. Stresses that would develop during a cooling cycle from 518°F are analyzed using an assumed temperature distribution.

At assembly, the inner capsule is enclosed in the outer case and closure with a minimum axial gap of .005 in., (see H-239681). The outer case and closure and the pressure vessel are asembled with no clearance. If the inner capsule, H-239685, was allowed to expand freely, its length would change as shown below:

L_{ic} = 4.275 in.

α = 9.9×10^{6} in./in.

ΔT = $518 - 70^{o} = 448^{o}$

ΔL = αTL

L = $(9.0 \times 10^{-6})(448)(4.275)$
= .019 in.

$L_{518^{o}}$ = 4.294 in.

The mating surface of the outer housings will also expand.

$$L = 4.280 \text{ in.}$$

$$\alpha = 5.6 \times 10^{-6} \text{ in./in.}$$

$$\Delta T = 448^{\circ}F$$

$$\Delta L = (5.6 \times 10^{-6})\ (448)\ (4.280)$$
$$= .011 \text{ in.}$$

$$L_{518} = 4.291 \text{ in.}$$

This shows an interference of .003 in. Thus a compressive force will be developed in the inner capsule and a tensile force in the outer housings. Interference will occur at two surfaces: between the inner capsule and outer case and closure, and between the outer case and closure and the pressure vessel. The inner capsule will not contact the inner surface of the outer case and closure until it has expanded through the .005 in. gap left at assembly. Thus, it will expand in two phases, first unrestrained until it fills the .005 in. gap, then restrained as it contacts the inner capsule. The temperature difference through which unrestrained expansion occurs can be determined knowing the initial gap and the relative rates of expansion:

$$.005\ \text{in} = \alpha_{ic} \; L_{ic} \, \Delta T_{ur} - \alpha_{oc} \; L_{oci} \, \Delta T_{ur}$$

$$T_{ur} = \frac{.005}{\alpha_{ic} \quad L_{ic} \quad -\alpha_{oc} \quad L_{oci}}$$

$$= 272.4^{\circ}$$

The temperature difference through which restrained expansion occurs is then:

$$\Delta T_r = \Delta T - \Delta T_{ur}$$

$$= 448^{\circ} - 272.4^{\circ}$$

$$= 175.6^{\circ}$$

Expressions for the change in length of the outer case and closure and the corresponding surfaces of the pressure vessel can be written:

(1)

$$L_{pv} = \frac{(L)}{(EA)_{pv}} P' + \alpha_{pv} \, \Delta T_{pv} \quad P_{pv}$$

(2)

$$L_{oc} = \frac{(L)}{(EA)_{oc}} P + \frac{(L)}{(EA)_{oc}} (-P') + \alpha_{oc} \, \Delta T_{oc} \; L_{oc}$$

where

P = force due to expansion of inner capsule

P' = force due to expansion of outer case and closure

Since there is interference at the mating surface between the outer case and closure and the pressure vessel, the change in length of the components will be equal. Thus,

$$\Delta L_{pv} = \Delta L_{oc}$$

The change in length of the interior of the outer case and closure can be written:

(3)

$$\Delta L_{oci} = \frac{(L)}{(EA)_{oci}} P + \frac{(L)}{(EA)_{oci}} (P') + \alpha_{oc} \Delta T_R L_{oc}$$

The inner capsule will expand .005 in. plus the amount it expands after contracting the outer case and closure.

This is expressed by:

(4)

$$L_{ic} = L_{oci} + .005$$

$$= \frac{(L)}{(EA)_{ic}} (-P) + \alpha_{ic} \Delta T_R L_{ic} + .005$$

Equations (1) and (2) can be used to solve for P in terms of P':

(5)

$$P = \frac{P'\left(\frac{(L)}{(EA)_{pv}} + \frac{(L)}{(EA)_{oc}}\right) - \alpha_{oc}\,\Delta T_{oc}\,L_{oc} + \alpha_{pv}\,\Delta T_{pv}\,L_{pv}}{\frac{(L)}{(EA)_{oc}}}$$

Equations (3) and (4) can also be solved for P.

(6)

$$P = \frac{P'\left(\frac{L}{(EA)}\right)_{pv} + \left(\frac{L}{(EA)}\right)_{oci} - \alpha_{oc}\,\Delta T_{oc}\,L_{oc} + \alpha_{pv}\,T_{pv}\,L_{pv}}{\frac{(L)}{(EA)_{oc}}}$$

Equations (5) and (6) can now be solved for P'.

(7)

$$P' = \frac{\dfrac{\alpha_{oc}\,\Delta T_{oc}\,L_{oc} - \alpha_{pv}\,\Delta T_{pv}\,L_{pv}}{\frac{(L)}{(EA)_{oc}}} + \dfrac{\alpha_{ic}\,\Delta T_{R}\,L_{ic} - \alpha_{oc}\,\Delta T_{R}\,L_{oci}}{\frac{(L)}{(EA)_{oci}} + \frac{(L)}{(EA)_{ic}}}}{\dfrac{\frac{(L)}{(EA)_{pv}} + \frac{(L)}{(EA)_{ov}}}{\frac{(L)}{(EA)_{pc}}} - \dfrac{\frac{(L)}{(EA)_{oci}}}{\frac{(L)}{(EA)_{oci}} + \frac{(L)}{(EA)_{ic}}}}$$

The constants $\frac{(L)}{(EA)}$ can be evaluated:

$$\frac{(L)}{(EA)}_{oci} = \frac{4.280}{(27 \times 10^6)\ (.276)} = 5.743 \times 10^{-7}$$

$$\frac{(L)}{(EA)}_{oc} = \frac{4.835}{(27 \times 10^6)\ (.276)} = 6.488 \times 10^{-7}$$

$$\frac{(L)}{(EA)}_{pv} = \frac{4.835}{(27 \times 10^6)\ (.421)} = 4.254 \times 10^{-7}$$

$$\frac{(L)}{(EA)}_{ic} = \frac{4.275}{(28 \times 10^6)\ (.106)} = 1.440 \times 10^{-6}$$

The constants, when substituted into equations (7) and (6) give a general expression for P' and P:

$$P' = 30.439\ \Delta T_{oc} - 30.439\ \Delta T_{pv} + 15.325\ \Delta T_R - 8.679\ \Delta T_R$$

$$P = P'(.285) + 21.011\ \Delta T_R - 11.899\ \Delta T_R$$

For ΔT uniform = 448°F

$P' = 1167.038$ lbs.

$P = 1932.673$ lbs.

The stress in the individual members can now be calculated:

$$s_{pv} = -\frac{F}{A} \quad \frac{P'}{A} = 2772. \text{ psi}$$

$$s_{oc} = \frac{F}{A} = \frac{P - P'}{A} = 2774. \text{ psi}$$

$$s_{ic} = \frac{F}{A} = \frac{P}{A} = 18{,}233 \text{ psi}$$

Thus, when maximum interference conditions are assumed, all members are well below stress levels necessary to cause yielding when at 518°F.

Thermal Stresses - Cooling

For a worst case cooling cycle, a temperature distribution is assumed in which the temperature of the assembly varies linearly from 518°F at its center line to 70°F at its outer edge. Thus, the temperature of the mean housing radius for each of the three components can be given by:

$$T_r = 518^\circ - \frac{\text{mean housing radius}}{\text{max package radius}}(Tm - Ta)$$

$$T_{ic} = 518^\circ - \frac{367}{.615} \ (518 - 70) = 250^\circ F$$

$$T_{occ} = 518^\circ - \frac{.441}{.615} \ (518 - 70) = 196^\circ F$$

$$T_{pv} = 518^\circ - \frac{.553}{.615} (518 - 70) = 115^\circ F$$

This gives temperature differences of:

$\Delta T_{ic} = 180^{o}$
$\Delta T_{oc} = 162^{o}$
$\Delta T_{pv} = 45^{o}$

When the inner capsule is at 250°F and the outer case is at 196°F, there will be no interference between the two members. Thus, a simplified form of the general equation developed earlier can be used to solve for P'.

$$P' = \frac{\alpha_{oc} \; \Delta T_{oc} \; L_{oc} \; - \alpha_{pv} \; \Delta T_{pv} \; L_{pv}}{\frac{(L)}{(AE)}_{pv} + \frac{(L)}{(AE)}_{oc}}$$

$P' = 2949.1 \text{ lbs.}$

The resulting stresses in the outer case and closure and presure vessel are given by:

$$S_{oc} = \frac{2949.1}{.276} = 10{,}685 \text{ psi}$$

$$S_{pv} = \frac{2949.1}{.421} = 7{,}005 \text{ psi}$$

These forces are well below stress levels necessary to cause yielding on cooling from 518°F to 70°F.

Accident Conditions

The following paragraphs describe ability to withstand accident conditions as described by paragraphs 719 through 720 of the IAEA Regulations for the Safe Transport of Radioactive Material, 1973 Revised Edition. The NSR-L has previously been certified as meeting special form requirements, which meet or exceed the accident conditions mentioned above: the discussion to follow addresses the assembly of the NSR-L and its protective pressure vessel, the NPV-K.

Mechanical Test for Ability to Withstand Accident Conditions

The NPV-KL was tested per paragraph 719 of the IAEA Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition. This describes dropping the assembly from 9 meters onto a specified target followed by a subsequent drop from one meter. The NPV-KL suffered no damage as a result of these tests.

Thermal Stress at Accident Conditions

Thermal test conditions describe an environment of 1475^{O}F. If a steady state temperature of 1475^{O}F is assumed for the NPV-KL assembly, this corresponds to maximum absorption and exposure for a sufficient time to incure maximum thermal damage due to the elevated temperature.

The analysis will use the equations developed earlier, however, the temperature elevation will cause the yield strength of the 18% nickel Maraging steel to degrade to 116,000 psi.

The relations for change in length of the mating surfaces of the intermediate housing and the pressure vessel will be repeated.

$$\Delta L_{pv} = \frac{(L)}{(EA)}_{pv} P' \quad \alpha_{pv} \, \Delta T_{pv} \quad L_{pv}$$

$$\Delta L_{oc} = \frac{(L)}{(EA)}_{oc} P + \frac{(L)}{(EA)}_{oc} (-P') + \alpha_{oc} \, \Delta T_{oc} \, L_{oc}$$

In this case the compressive force experienced by the inner capsule will cause the material to exceed its elastic limit and yield. However, the inner capsule is not relied upon as a structural or containment vessel and the material deformation experienced will not cause the release of radioactive matter. The yield stress of 304 stainless is approximately 30,000 psi. Thus P can be assumed to be a product of the cross sectional area of the inner capsule and the yield stress:

$P = s_{ic} A = 30{,}000\ (.106) = 3180$ lbs.

The force between the pressure vessel and outer case and closure can be found:

$$P' = \frac{P \frac{(L)}{(EA)_{oc}} + \alpha_{oc} \Delta T_{oc} L_{oc} - \alpha_{pv} \Delta T_{pv} L_{pv}}{\frac{(L)}{(EA)_{pv}} + \frac{(L)}{(EA)_{oc}}}$$

= 1921 lbs.

The resulting stresses are:

$$S_{pv} = \frac{1921}{.421} = 4563 \text{ psi}$$

$$S_{oc} = \frac{3180 - 1921}{.276} = 4562 \text{ psi}$$

Thus, we see that exposure to 1475°F will not cause the containment vessels to fail.

Water Immersion, Accident Conditions

The NPV-KL has been designed to exclude fluids under conditions much more severe than those described in paragraph 721. It has been tested to 26,000 psi at 518°F and did not leak or suffer any damage.

NPV-LM

Basic Description

The NPV-LM is the assembly of the source capsule, NSR-M, and its protective pressure vessel, NPV-L, as shown in Figure 2. Detail drawings of all components are included in the appendix. The NSR-M has passed all tests and met all requirements for special form material and has received the appropriate Certificate of Compentent Authority. The NSR-M consists of the source material sealed in an "inner capsule," H-245259, which is in turn enclosed in an "outer case and closure," H-245260. The inner capsule is not relied upon as a structural member, but it offers a substantial increase in reliability as a welded containment vessel. The outer case and closure is the primary containment vessel. It is welded shut and cannot be accidentally opened. It is capable of withstanding any environment of pressure and temperature it will be subjected to while in use by Schlumberger. The NPV-L is an additional protective vessel for the NSR-M. It is sealed against pressure by an outer seal plug, H-329008, and a wipe test plug, H-329007, which is threaded into the outer plug. When the source-pressure vessel assembly is in its carrying shield (NCS-WB), the wipe test plug allows access to the NSR-M for a wipe test without allowing removal of the source. Both these plugs incorporate double O-ring seals. The NSR-M remains within the NPV-L throughout its use at Schlumberger.

Description of Materials

The materials used in construction of the NPV-L are indicated on Figure 2. The stated value of 10 Ci of Am-Be powder is a nominal value only. A sufficient quantity of Am-Be is used to produce a neutron output of 2.4 +0.36, -0.0 x 10^7 n/s. The material properties to be used in the analysis to follow are listed in Table 1 for convenience. The properties for 304 stainless steel were taken from the A.S.M. Handbook of Metal Properties, First Edition, page 58. The properties of 18% nickel Maraging steel were taken from the International Nickel Company's specification. This report is included in the appendix to this section.

10 CURIE NEUTRON SOURCE PRESSURE VESSEL ASSEMBLY
NPV-LM H-329050

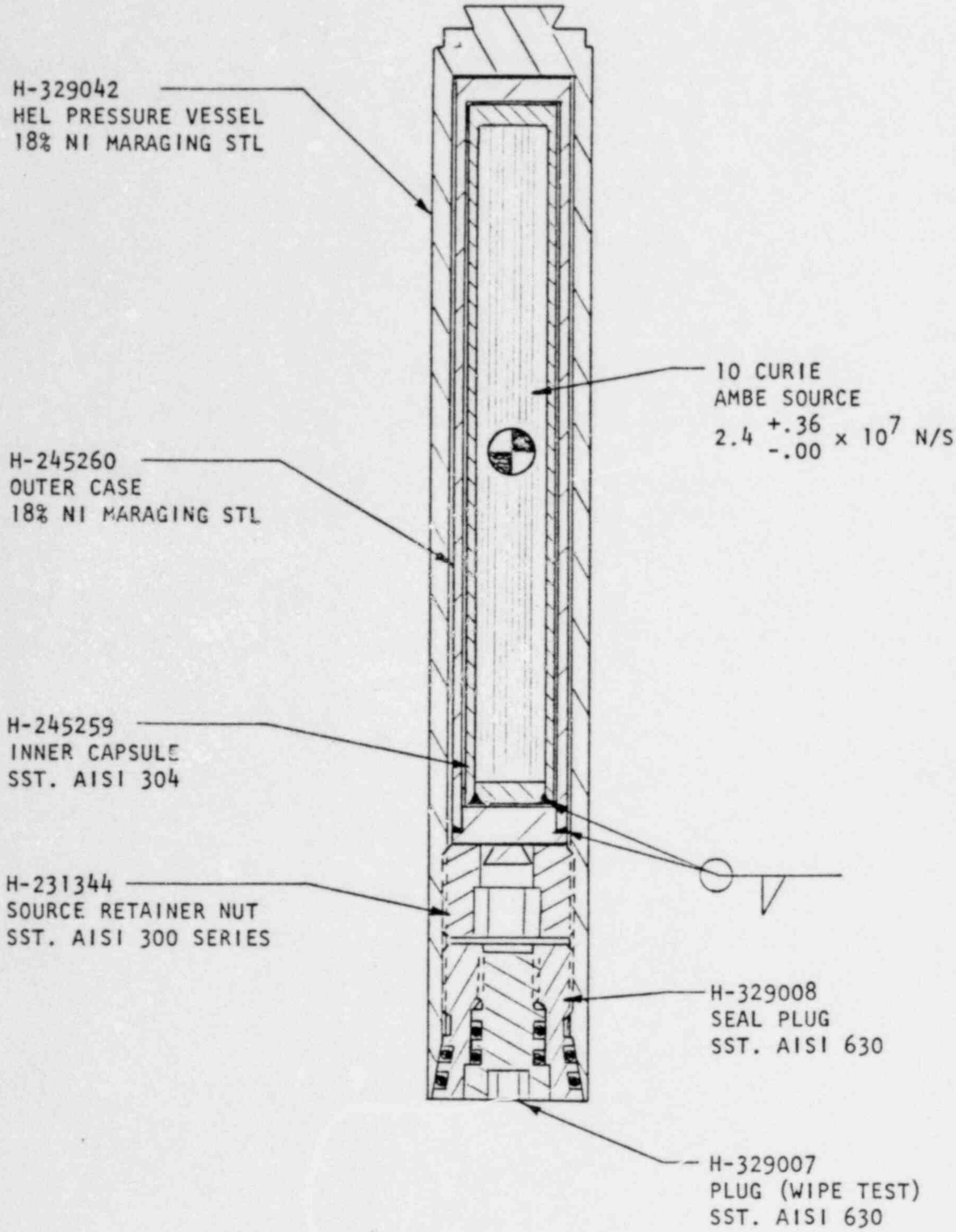


FIGURE 2.

Table 1

Property	304	Maraging Steel
Tensile Strength, psi	85,000 (annealed)	265,000 - 300,000 (aged)
Min. Yield Strength, psi, 70°F	30,000	250,000 (aged)
Min. Yield Strength, psi, 400°F	-	220,00 (aged)
Modulus of Elasticity, psi	28×10^6	27.0×10^6
Elongation, 2 in. %	50	5 - 10
Impact (Charpy V Notch) ft/lb at R.T.	90 (Izod)	12 (minimum)
Rockwell Hardness	80B	50-55C
Coefficient of Thermal Expansion 400°F, in/in/F°	9.9×10^{-6}	5.6×10^{-6}
Coefficient of Thermal Expansion 1400°F, in/in/F°	10.8×10^{-6}	(not available)
Density, lb/in^3	.29	.289

Construction and Assembly

Details of the construction and quality assurance testing of the NSR-M are given by SWS Engineering specification H-209986 (included in the appendix). Briefly, the source material is placed in the inner capsule and a cap is pressed, and then welded into place. The inner capsule is then placed in the outer case and closure. Again, a cap is pressed and welded into place. A leak test is performed after each of the above procedures. The completed NSR-M is placed in its pressure vessel, the NPV-L. It is held in place by a hold down nut, SWS part number H-231344. The outer seal plug, H-329008, is then threaded into place. Finally, the wipe test plug, H-329007, is threaded into the outer seal plug. A thread sealant is used on the outer seal plug to insure that it does not unseat when subjected to the amount of torque required to remove the wipe test plug. It can, however, be removed when sufficient torque is applied. When both plugs are torqued into place, the source is securely locked and protected in its pressure vessel.

For transportation and storage, the NPV-LM is placed in its carrying shield, the NCS-WB. This shield is secured with a lock that can be opened only with a special Schlumberger key.

Chemical and Galvanic Reactions

The housing of the NPV-L pressure vessel and the outer case and closure of the NSR-M are made of 18% nickel maraging. The inner capsule is made from type 304 stainless steel. Since these are electromotively similar metals assembled in an essentially dry atmosphere, no galvanic reactions are possible. 18% nickel Maraging steel has a corrosion rate in flowing sea water of .007 in/yr as reported by the International Nickel Company. Type 304 stainless is listed as having a corrosion rate of .0005 in/yr in flowing sea water in the A.S.M. Metals Handbook, Volume 1, 8th Edition, page 558. At these rates, using minimum material conditions, it would require more than 174 years for salt water to reach the source material.

External Pressure

The design criteria for the outer case and closure, H-245260, and the outer pressure vessel, H-329042, is that they must withstand 26,000 psi and $518^{\circ}F$ with a minimum factor of safety of 1.23 based on yield stress. The equation used to compute the maximum safety pressure for closed cylinders is:

$$P/_{s} = 2.31k\,(1-k)$$

where

P = external allowable pressure

s = yield strength of material

k = t/d

t = wall thickness

D = outside diameter

This equation is a variation of the Lamè equation developed in Schlumberger Engineering Report 41 written by Ed Moser. A copy of the report is included in the appendix.

The minimum yield strength for 18% nickel Maraging steel at room temperature is 250,000 psi. At 518°F, the yield strength degrades approximately 16% to 210,000 psi. The outer pressure vessel can, therefore, withstand the following external pressure:

$$D = .979 \text{ in}$$

$$t = \frac{.979 - .758}{2} = .110 \text{ in}$$

$$k = .112$$

$$P = 2.31\,(.112)\,(1-.112)\,(210{,}000)$$

$$= 48{,}248 \text{ psi}$$

The safety factor is therefore:

$$F.S. = \frac{48,248}{26,000} = 1.86$$

The outer case and closure is also made of 18% nickel Maraging steel. It can withstand the following pressure:

$D = .748$ in.

$$t = \frac{.748 - .596}{2} = .076 \text{ in.}$$

$k = .102$

$P = 2.31\,(.102)\,(1-.102)\,(210,000)$

$= 44,433$ psi

The safety factor is thus:

$$F.S. = \frac{44,433}{26,000} = 1.71$$

The ability of the outer pressure vessel to withstand external pressure was demonstrated experimentally by testing a prototype built per drawing H-329042 at 26,000 psi and 518°F. The vessel did not collapse nor did the seals leak.

Thermal Stresses, Heating

The following calculations give the stresses due to differential thermal expansion of the three housings at a steady state temperature of 518°F. Stresses that would develop during a cooling cycle from 518°F are analyzed using an assumed temperature distribution.

At assembly, the inner capsule is enclosed in the outer case and closure with a minimum axial gap of .005 in., (see H-245258). The outer case and closure and the pressure vessel are asembled with no clearance. If the inner capsule, H-245259, was allowed to expand freely, its length would change as shown below:

L_{ic} = 4.275 in.

α = 9.9×10^{6} in./in.

ΔT = $518^{\circ} - 70^{\circ} = 448^{\circ}$

$\Delta L \approx \alpha L T$

ΔL = $(9.0 \times 10^{-6})\,(448)\,(4.275)$
= .019 in.

$L_{518^{\circ}}$ = 4.294 in.

The mating surface of the outer housings will also expand.

$L = 4.280$ in.

$\alpha = 5.6 \times 10^{-6}$ in./in.

$\Delta T = 448^{\circ}F$

$\Delta L = (5.6 \times 10^{-6})\ (448)\ (4.280)$
$= .011$ in.

$L_{518} = 4.291$ in.

This shows an interference of .003 in. Thus a compressive force will be developed in the inner capsule and a tensile force in the outer housings. Interference will occur at two surfaces: between the inner capsule and outer case and closure, and between the outer case and closure and the pressure vessel. The inner capsule will not contact the inner surface of the outer case and closure until it has expanded through the .005 in. gap left at assembly. Thus, it will expand in two phases, first unrestrained until it fills the .005 in. gap, then restrained as it contacts the inner capsule. The temperature difference through which unrestrained expansion occurs can be determined knowing the initial gap and the relative rates of expansion:

$$.005 \text{ in.} = \alpha_{ic} \; L_{ic} \; \Delta T_{ur} - \alpha_{oc} \; L_{oci} \; \Delta T_{ur}$$

$$\Delta T_{ur} \qquad \frac{.005}{\alpha_{ic} \; L_{ic} - \alpha_{oc} \; L_{oci}}$$

$$= 272.4^{\circ}$$

The temperature difference through which restrained expansion occurs is then:

$$\Delta T_r = \Delta T - \Delta T_{ur}$$

$$= 448^{\circ} - 272.4^{\circ}$$

$$= 175.6^{\circ}$$

Expressions for the change in length of the outer case and closure and the corresponding surfaces of the pressure vessel can be written:

(1)

$$L_{pv} = \frac{(L)}{(EA)_{pv}} \; P' + \alpha_{pv} \; \Delta T_{pv} \; L_{pv}$$

(2)

$$L_{oc} = \frac{(L)}{(EA)_{oc}} \; P + \frac{(L)}{(EA)_{oc}} \; (-P') + \alpha_{ov} \; \Delta T_{oc} \; L_{oc}$$

where

P = force due to expansion of inner capsule

P' = force due to expansion of outer case and closure

Since there is interference at the mating surface between the outer case and closure and the pressure vessel, the change in length of the components will be equal. Thus,

$$L_{pv} = L_{oc}$$

The change in length of the interior of the outer case and closure can be written:

(3)

$$L_{oci} = \frac{(L)}{(EA)_{oci}} P + \frac{(L)}{(EA)_{oci}} (-P') + {}_{oc} T_R L_{oci}$$

The inner capsule will expand .005 in. plus the amount it expands after contracting the outer case and closure.

This is expressed by:

(4)

$$L_{ic} = L_{oci} + .005$$

$$= \frac{(L)}{(EA)_{ic}} (-P) + {}_{ic} T_R L_{ic} + .005$$

Equations (1) and (2) can be used to solve for P in terms of P':

(5)

$$= \frac{P' \frac{(L)}{(EA)_{pv}} + \frac{(L)}{(EA)_{oc}} - \alpha_{oc} \Delta T_{oc} L_{oc} + \alpha_{pv} \Delta T_{pv} L_{pv}}{\frac{(L)}{(EA)_{oc}}}$$

Equations (3) and (4) can also be solved for P.

(6)

$$P = \frac{P' \frac{(L)}{(EA)_{oci}} + \alpha_{ic} \Delta T_{r} L_{ic} - \alpha_{oc} \Delta T_{R} L_{oci}}{\frac{(L)}{(EA)_{oci}} + \frac{(L)}{(EA)_{ic}}}$$

Equations (5) and (6) can now be solved for P'.

(7)

$$P' = \frac{\frac{{}_{oc} \Delta T_{oc} L_{oc} - \alpha_{pv} \Delta T_{pv} L_{pv}}{\frac{(L)}{(EA)_{oc}}} + \frac{\alpha_{ic} \Delta T_{R} L_{ic} \quad \alpha_{oc} \Delta T_{R} L_{ci}}{\frac{(L)}{(EA)_{oci}} + \frac{(L)}{(EA)_{ic}}}}{\frac{\frac{(L)}{(EA)_{pv}} + \frac{(L)}{(EA)_{ov}}}{\frac{(L)}{(EA)_{pc}}} - \frac{\frac{(L)}{(EA)_{oci}}}{\frac{(L)}{(EA)_{oci}} + \frac{(L)}{(EA)_{ic}}}}$$

The constants $\left(\frac{L}{EA}\right)$ can be evaluated:

$$\frac{(L)}{(EA)}_{oci} = \frac{4.280}{(27 \times 10^6)\ (.163)} = 9.275 \times 10^{-7}$$

$$\frac{(L)}{(EA)}_{oc} = \frac{4.835}{(27 \times 10^6)\ (.163)} = 1.099 \times 10^{-6}$$

$$\frac{(L)}{(EA)}_{pv} = \frac{4.835}{(27 \times 10^6)\ (.308)} = 5.814 \times 10^{-7}$$

$$\frac{(L)}{(EA)}_{ic} = \frac{4.275}{(28 \times 10^6)\ (.080)} = 1.908 \times 10^{-6}$$

The constants, when substituted into equations (7) and (6) give a general expression for P' and P:

$$P' = 20.686\ \Delta T_{oc} - 20.686\ \Delta T_{pv} + 12.336\ \Delta T_R - 6.986\ \Delta T_R$$

$$P = P'(.338) + 14.693\ \Delta T_R - 8.321\ \Delta T_R$$

For ΔT uniform = 448°F

P' = 939 46 lbs.

P = 1436.46 lbs.

The stress in the individual members can now be calculated:

$$s_{pv} \frac{F}{A} = \frac{P'}{A} = 3050 \text{ psi}$$

$$s_{pv} = \frac{F}{A} = \frac{P'}{A} = 3050 \text{ psi}$$

$$s_{oc} = \frac{F}{A} = \frac{P - P'}{A} = 3049 \text{ psi}$$

$$s_{ic} = \frac{F}{A} = \frac{P}{A} = 17{,}956 \text{ psi}$$

Thus all members are well below stress levels necessary to cause yielding when at 518°F.

Thermal Stresses - Cooling

For a worst case cooling cycle, a temperature distribution is assumed in which the temperature of the assembly varies linearly from 518°F at its center line to 70°F at its outer edge. Thus, the temperature of the mean housing radius for each of the three components can be giv... .

$$T_r = 518^\circ - \frac{\text{mean housing radius}}{\text{max package radius}} (Tm - Ta)$$

$$T_{ic} = 518^\circ \frac{.273}{.490} (518^\circ - 70^\circ) = 249.6^\circ$$

$$T_{occ} = 518^\circ - \frac{.336}{.490} (518^\circ - 70^\circ) = 210.8^\circ$$

$$T_{pv} = 518^\circ - \frac{.434}{.490} (518^\circ - 70^\circ) = 121.3^\circ$$

This gives temperature differences of:

$\Delta T_{ic} = 179.6^{o}$
$\Delta T_{oc} = 140.8^{o}$
$\Delta T_{pv} = 51.2^{o}$

When the inner capsule is at 250°F and the outer case is at 196°F, there will be no interference between the two members. Thus, a simplified form of the general equation developed earlier can be used to solve for P'.

$$P' = \frac{\alpha_{oc} \; \Delta T_{oc} \; L_{oc} \; - \; {}_{pv} \Delta T_{pv} \; L_{pv}}{\frac{(L)}{(AE)_{pv}} + \frac{(L)}{(AE)_{oc}}}$$

P' = 1443.7 lbs.

The resulting stresses in the outer case and closure and presure vessel are given by:

$$S_{pv} = \frac{1443.7}{.163} = 8{,}857 \text{ psi}$$

$$S_{pv} + \frac{1443.7}{.308} = 4{,}687 \text{ psi}$$

These forces are well below stress levels necessary to cause yielding on cooling from 518°F to 70°F.

Accident Conditions

The following paragraphs describe ability to withstand accident conditions as described by paragraphs 719 through 720 of the IAEA Regulations for the Safe Transport of Radioactive Material, 1973 Revised Edition. The NSR-M has previously been certified as meeting special form requirements, which meet or exceed the accident conditions mentioned above: the discussion to follow addresses the assembly of the NSR-M and its protective pressure vessel, the NPV-M.

Mechanical Test for Ability to Withstand Accident Conditions

The NPV-LM was tested per paragraph 719 of the IAEA Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition. This describes dropping the assembly from 9 meters onto a specified target followed by a subsequent drop from one meter. The NPV-LM suffered no damage as a result of these tests.

Thermal Stress at Accident Conditions

Thermal test conditions describe an environment of 1475^{o}F. If a steady state temperature of 1475^{o}F is assumed for the NPV-LM assembly, this corresponds to maximum absorption and exposure for a sufficient time to incure maximum thermal damage due to the elevated temperature.

The analysis will use the equations developed earlier, however, the temperature elevation will cause the yield strength of the 18% nickel Maraging steel to degrade to 116,000 psi. The relations for change in length of the mating surfaces of the intermediate housing and the pressure vessel will be repeated.

$$L_{PV} = \frac{(L)}{(EA)}_{pv} P' + \alpha_{pv} \Delta T_{pv} L_{pv}$$

$$\Delta L_{oc} = \frac{(L)}{(EA)}_{oc} P + \frac{(L)}{(EA)}_{oc} (-P') + \alpha_{oc} \Delta T_{oc} L_{oc}$$

In this case the compressive force experienced by the inner capsule will cause the material to exceed its elastic limit and yield. However, the inner capsule is not relied upon as a structural or containment vessel and the material deformation experienced will not cause the release of radioactive matter. The yield stress of 304 stainless is approximately 30,000 psi. Thus P can be assumed to be a product of the cross sectional area of the inner capsule and the yield stress:

$$P = s_{ic} A = 30{,}000 \; (.080) = 2400 \text{ lbs.}$$

The force between the pressure vessel and outer case and closure can be found:

$$P' = \frac{P \frac{(L)}{(EA)_{oc}} + \alpha_{oc} \ \Delta T_{oc} \ L_{oc} - \alpha_{pv} \ \Delta T_{pv} \ L_{pv}}{\frac{(L)}{(EA)_{pv}} + \frac{(L)}{(EA)_{oc}}}$$

= 1570 lbs.

The resulting stresses are:

$$S_{pv} = \frac{1570}{.308} = 5097 \text{ psi}$$

$$S_{oc} = \frac{2400 - 1570}{.163} = 5092 \text{ psi}$$

Thus we see that exposure to 1475°F will not cause the containment vessels to fail.

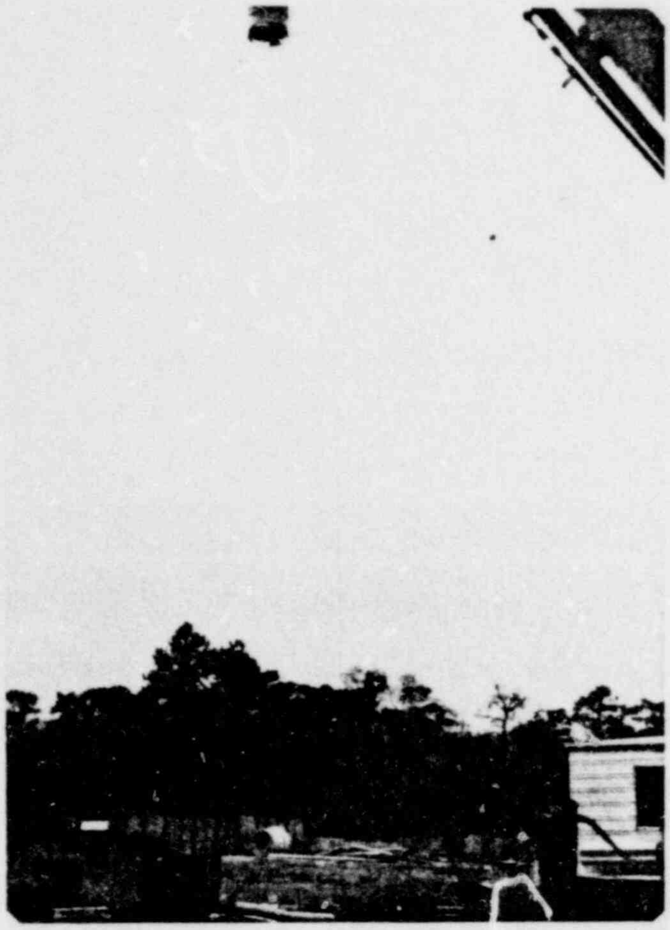
Water Immersion, Accident Conditions

The NPV-LM has been designed to exclude fluids under conditions much more severe than those described in paragraph 721. It has been tested to 26,000 psi at 518°F and did not leak or suffer any damage.

APPENDIX IX

SUBJECT: Additional information describing some of the tests performed on NLS-RF.

	ITEM
Drop Test from 30 feet	1
Puncture Test from 40 inches	2
Compression Test	3
Label Qualification	4



TEST SET UP FOR 30' DROP

30 Ft. Drop Test. The basic test set-up used to perform the 30 ft. drop test involves a crane, quick release hook and 1 in. thick 4 ft. X 8 ft. steel plate. The crane was supplied with operator by Westheimer Construction Company of Houston, Texas. All tests were performed at the Schlumberger Well Service facilities at 5000 Gulf Freeway, Houston, Texas. Figure 4 shows the test site.

Each of the drop tests was performed in the following manner:

1. Arrange harness such that the test item falls in the selected orientation.

2. Raise the test item to a height of no less than 30 ft. above the steel plate. A mark on the rope indicated when the test item reached the prescribed height.

3. Release the test item allowing it to fall to the strike plate.

4. Photograph and record all damage to the test item.

ITEM 1

Test shields No. 1 and 2 before testing.

Test shield No. 1 containing machined polyethylene filler.

Test shield No. 2 containing urethane consolidated polyethylene beads.

The individual drop tests were performed in the following order:

Test Shield No. 1
1. Top end drop
2. Side drop
3. Top edge drop
4. Bottom edge drop
5. Bottom end drop

Test Shield No. 2
1. Side drop
2. Top end drop
3. Top edge drop
4. Bottom edge drop
5. Bottom end drop

30' DROP - TOP END - SHIELD #1

Inspection of the shield after the 30 ft. drop impacting on the top handling ring revealed only damage to the welds retaining the top handling ring to the support plates and a slight deformation of the lower edge of the lock. The damage to the handling ring weld was limited to one of the four support plates where the weld was cracked; all other support plates, although slightly bent, were functionally intact. The lock and scissor mechanism functioned normally after the test. No damage occurred to the bottom plug weld.

30' DROP - TOP END - SHIELD #2

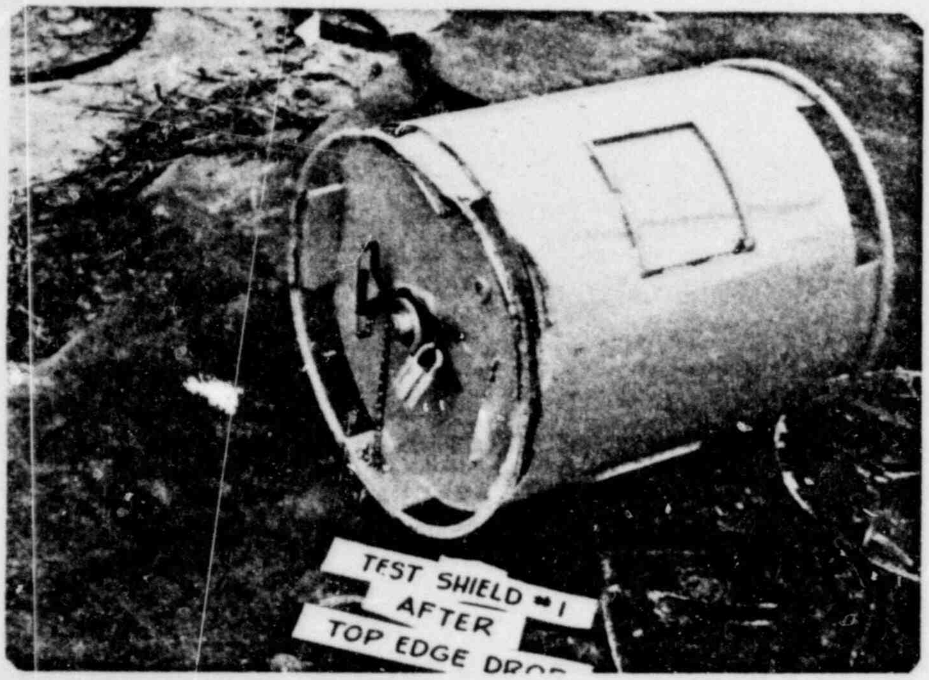
Inspection revealed no damage to any area of the shield except the top handling ring and the weld joining the top end plate to the outer cylinder. The handling ring deformed on impact in an area between two support plates while the welds immediately below the handling rings beat slightly. No damage at all was noted on the bottom plug weld, lock or scissor mechanism.

30' DROP - SIDE - SHIELD #1

The only new damage resulting from the side drop was a local separation of the top end and bottom end plate from the outer cylinder at the point where the side impact occurred. The mottled line in the photograph shows the line of impact.

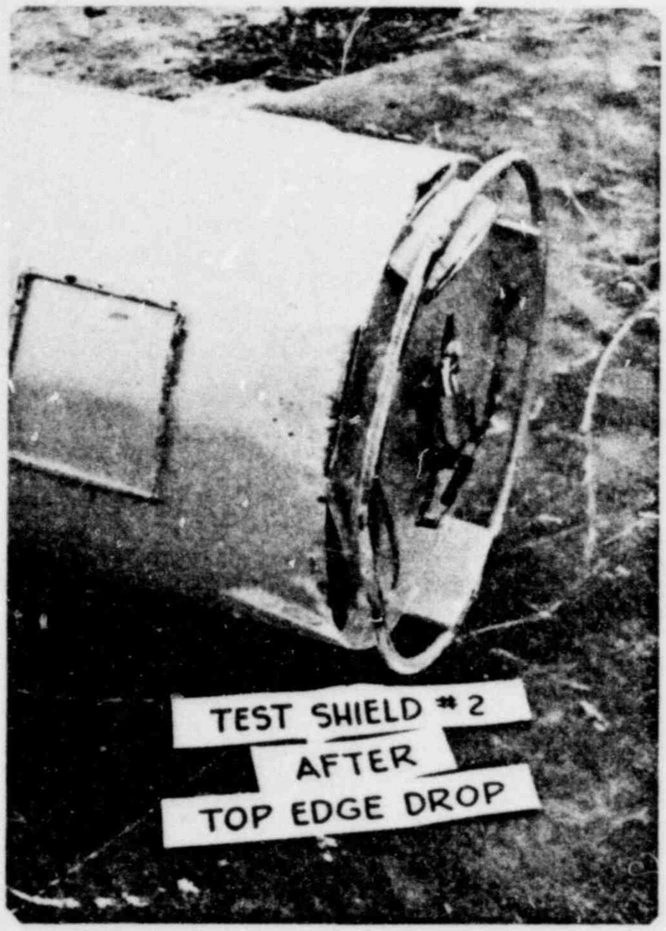
30' DROP - SIDE - SHIELD #2

The resulting additional damage was similar to that described for test shield #1.



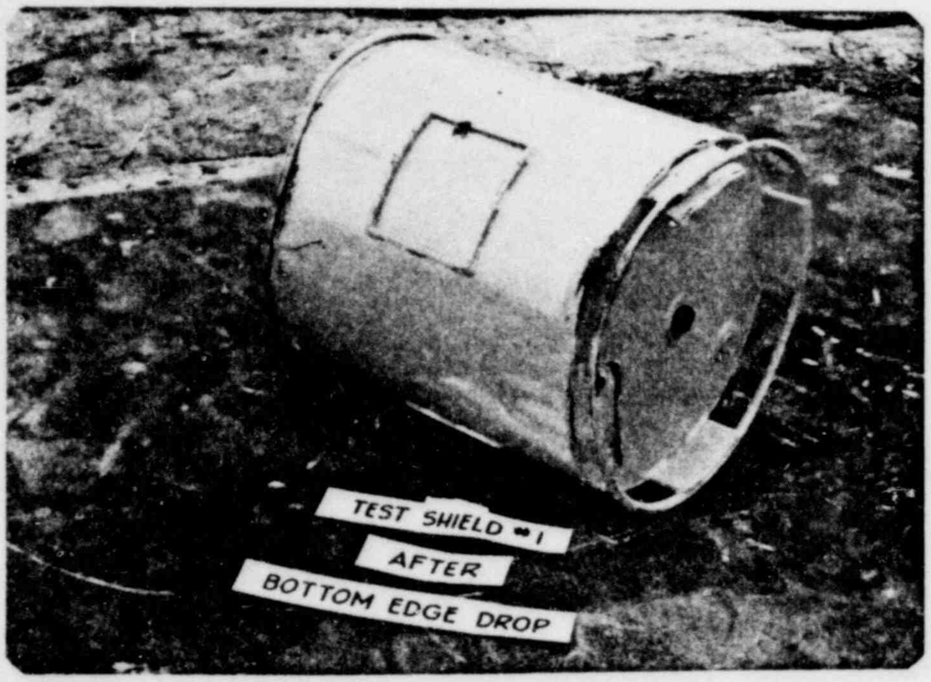
30' DROP - TOP EDGE - SHIELD #1

Again any damage resulting from the drop was confined to the handling rings and support plates. The welds attaching the ring to the support plates in the area adjacent to the point of impact failed. The photos clearly show the point of impact.



30' DROP - TOP EDGE - SHIELD #2

(Same as 30' top edge #1.)



30' DROP - BOTTOM EDGE - SHIELD #1

(Same as 30' top edge #1.)

30' DROP - BOTTOM EDGE - SHIELD #2

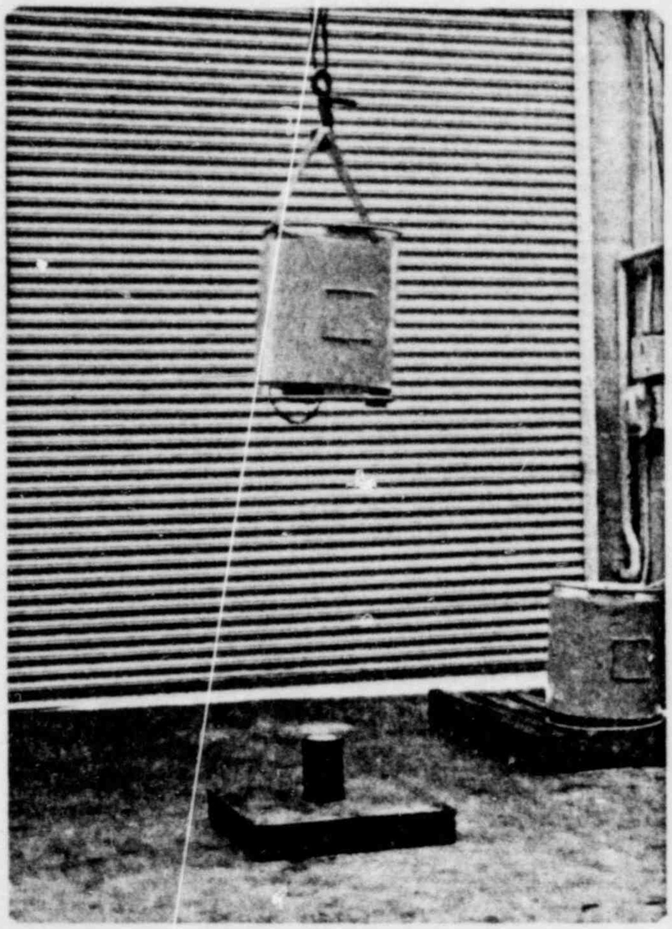
(Same as 30' top edge #1.)

30' DROP - BOTTOM END - SHIELD #1

The bottom end drop was totally absorbed by the handling ring and support plates. Although the welds attaching the ring to the plates and plates to the bottom end plate failed, no further damage was suffered by the shield.

30' DROP - BOTTOM END - SHIELD #2

(Same as 30' bottom end - shield #1)



TEST SET UP FOR 40" PUNCTURE TEST

Following the 30 ft. drop tests, the same shields were subjected to a 40" drop onto a 6" diameter, 8" long steel cylinder. The edges of the cylinder were rounded to a 1/4" R. These test items were positioned directly above the puncture cylinder and then released,. On the top end drop, the initial positioning was such that cylinder struck directly on the locking mechanism; on the bottom end drop, positioning was such that the cylinder impacted on the weld securing the bottom plug to the shield body. Test sequence was as follows:

Test Shield #1:
1. Top penetration drop
2. Bottom penetration drop
3. Side penetration drop

Test Shield #2:
1. Top penetration drop
2. Bottom penetration drop
3. Side penetration drop

ITEM 2

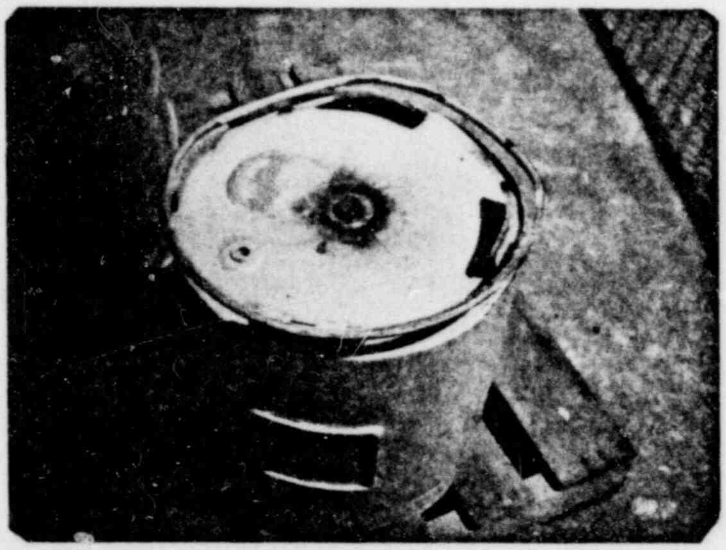
40" PUNCTURE - TOP END - SHIELD #1

Both shields were carefully aligned over the bar such that impact would occur directly on the locking mechanism and source tube assembly. No significant damage occurred to either test item. Test shield #1 did shear a portion of the flange on the upper plug but this minor failure could in no way have allowed the upper plug to come out of the center tube assembly, since this flange is above the locking device.

No damage resulted to the lock or scissor mechanism on either test item.

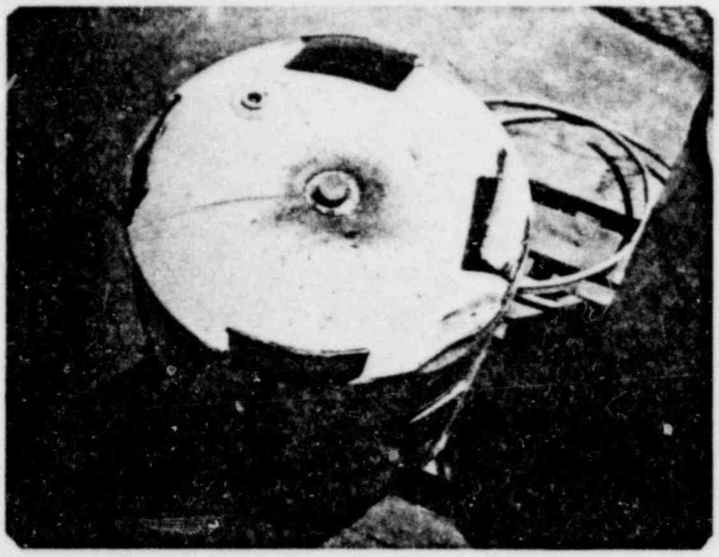
40" PUNCTURE - TOP END- SHIELD #2

(Same as 40" puncture - top end #1.)



40" PUNCTURE - BOTTOM END - SHIELD #1

The shield was dropped such that impact occurred directly on the bottom plug. No damage to welds, some deformation of bottom plate. You will note additional marks where we missed the target on the first two attempts. On the third try we did hit the plug "head on" as evidenced by the concentric ring.



40" PUNCTURE - BOTTOM END - SHIELD #2

The shield was dropped such that impact occurred directly on the bottom plug.

No damage to welds, some deformation of bottom plate.

40" PUNCTURE - SIDE - SHIELD #1

As expected, the 40" puncture - side did little damage. Marring of paint and minor denting was all.

40" PUNCTURE - SIDE - SHIELD #2

As may have been expected, the side drop from 40" did little damage. Test shield #2 was dropped such that impact occurred directly on the side seam weld. No damage to the weld occurred.

REQUISITION

MECHANICAL ENVIRONMENTAL TEST LAB

PRODUCT ENGINEERING - 9241

Requested by R. M. Shapiro Date 12-20-78

Department Product Engineering-9241 Project No. 23-01-02

Description of Article to be Studied Neutron Carrying Shield NCS-Y, H-251810

Description of Tests or Information Desired Compression test per IAEA (1973), Section VII, Paragraph 713. Load with 1044 lbs. (473.6 kg) for 24 hours.

Results of Tests or Disposition After 24 hours, no damage or dimensional change measured on NCS-Y assembly.

Disposition Date 12-21-78

Engineer in Charge William J. Nichols

Tested by Joe Kabosek

ITEM 3

Compression Test of NCS-Y, H-251810

Purpose: To examine ability of NCS-Y to withstand compression testing per IAEA (1973), Section VII, Paragraph 713.

Required Load: a. Wt of pkg. X 5

72.1 kg X 5 = 360.5 kg

b. 1300 kg/m^2 X vertical projected area

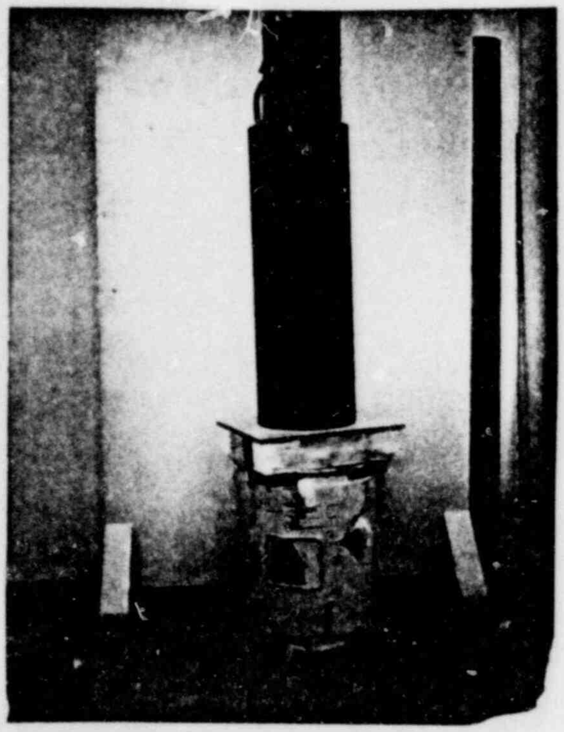
$$A = \pi \left(\frac{D}{2}\right)^2 = \pi \left(\frac{68.1}{2}\right)^2 = 3642.4 \text{ sq cm}$$

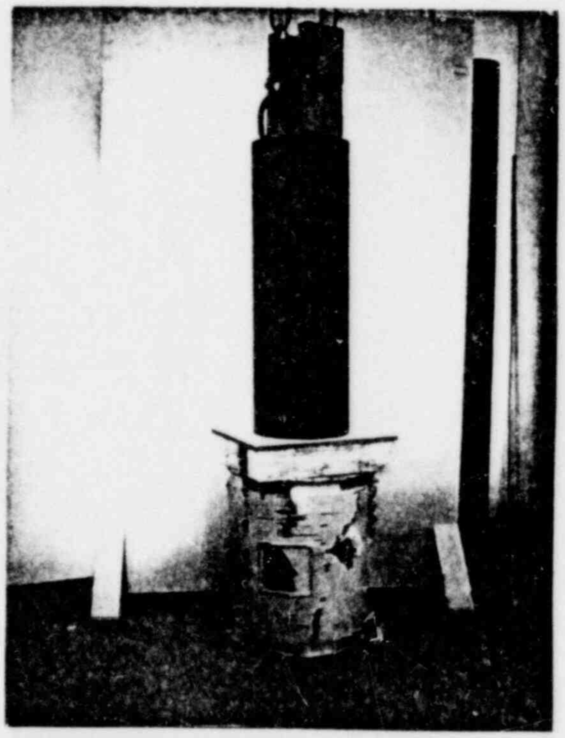
$$\frac{1300 \text{ kg}}{m^2} \Big| \ .3642 \ m^2 = \underline{473.5 \text{ kg}}$$

Use 473.5 kg which is greater than 360.5 kg

$$\frac{473.5 \text{ kg}}{} \Big| \frac{1 \text{ lb.}}{.4536 \text{ kg}} = 1044 \text{ lbs.}$$

Procedure: Place NCS-Y assembly in a vertical position on a flat surface. Load with 950 lb. billet plus 100 lb. additional. Use slings and overhead crane for safety purposes but not to carry weight. After 24 hours, remove weights and examine for damage and dimensional change.





SWS- 18-H

RMS file

SCHLUMBERGER-NAM

Interoffice Correspondence

VIA: A. C. Skellie ACS

Date: October 26, 1978

To: Safety

File No.: 23-01-04

From: Product Engineering-9241

Subject: Durable Labeling for NCS-Y

This letter describes work by Engineering to provide durable labeling for NCS-Y, Carrying Shield for 16 Curie Source, NLS-RF.

Attachment I is a letter dated September 11, 1978 from the Canadian Atomic Energy Control Board to W. R. Henry, RA Safety Officer, Schlumberger of Canada. One of the requests in this letter is for confirmation that the wording "Type B" and the "trefoil symbol" are resistant to the effects of fire and water.

By telphone to Mr. Henry, Engineering learned that the labels involved are H-123122 and H-268213, sketches shown in Attachment II. These labels are currently specified as printed vinyl plastic, adhesive attachment.

Engineering's plan is to provide improved labels made of stainless steel with recessed markings produced by chemical etching. These would be attached by welding or perhaps with drive screws, if the latter are considered acceptable.

For expediency, the first trail was performed using thin (.015") gage metal. Although satisfactory, it was judged better to use a heavier (.035") gage metal and to provide a border for welding.

Test Procedure

1. Produce labels and attach by welding and by drive pins to a metal plate identical in alloy and thickness to the shield of the NCS-Y. See Attachment III, photographs 1 and 2.

2. Thermal test by exposure in a furnace at 800°C for 30 minutes per IAEA Regulations, Section VII, Paragraph 720. See attachment III, photograph 3 for appearance after test.

3. Water spray test under uniformly distributed water spray approximating rainfall rate of 5 cm per hour for at least one hour per IAEA Regulations, Section VII, Paragraph 711. Our test was conducted with the specimens periodically rotated 90° with respect to the hose base. Time in each of the four positions was two hours for a total of eight hours. See Attachment III, photograph 4.

ITEM 4

4. Examine after completion of tests. See Attachment III, photographs 5 and 6.

Results

1. Labels remained legible after exposure to fire and water.
2. Both the welded and pinned labels remained securely fixed to the base.

Conclusions

1. Satisfactory labels can be constructed of alloy 304 stainless steel, .035" thick with recessed markings produced by chemical etching.
2. Such labels may be attached to the NCS-Y by welding or with drive pins.

New examples of each label and the tested samples have been delivered to your office for examination.

Robert M. Shapiro, PE

Robert M. Shapiro
Texas Registration No. 14238

RMS:jas

Attachments

Control Board de l'énergie atomique

OPERATIONS DIRECTORATE
Safeguards & Nuclear
Materials Branch

Your file Votre référence

ATTACHMENT I

Our file Notre référence 30-S7-1

September 11, 1978

Mr. W. R. Henry
RA Safety Officer
Schlumberger of Canada
5029 Coronet Road
Edmonton, Alberta
T6E 4P2

Dear Mr. Henry:

Re: Your request for Cdn. endorsement of USA/9088/B(U)

In reviewing your submission for Canadian endorsement of your Model NLS-RF neutron source package the durability of the labelling is not clear. Please confirm that the wording "Type B" and the "trefoil symbol" are resistant to the effects of fire and water. A summary of the complete labelling in regards to Canadian use would be appreciated. Please note that bilingual placards will probably be required for the truck once the new regulations have been adopted for road.

Also note that under the requirements of USA CFR 49 para. 173.393 Note 2, for special form material shipped out of the USA a Certificate of Competent Authority issued by USDOT must be obtained. Please forward a copy of this certificate.

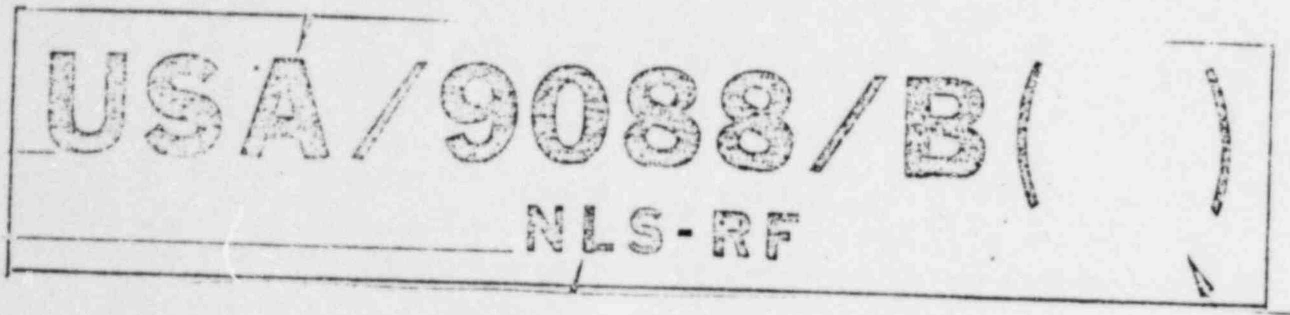
Your cooperation is appreciated.

Yours sincerely,

John J. McLellan, P.Eng.
Associate Scientific Advisor
-Transportation

JJM/pn

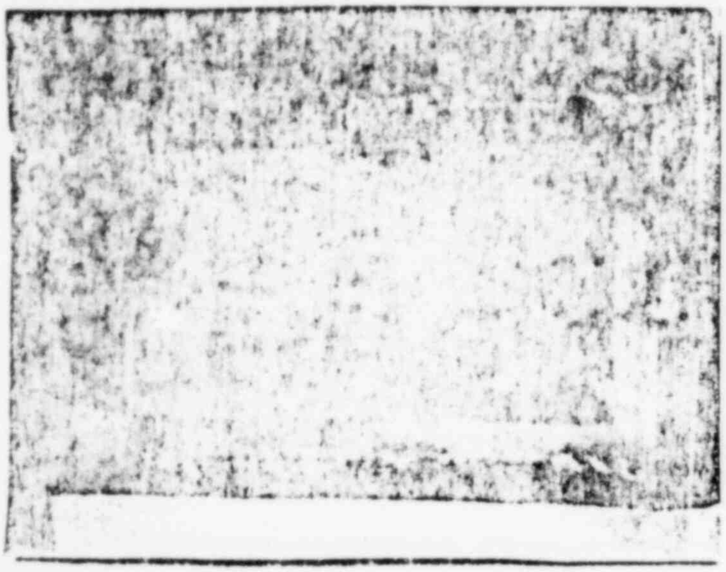
ATTACHMENT II



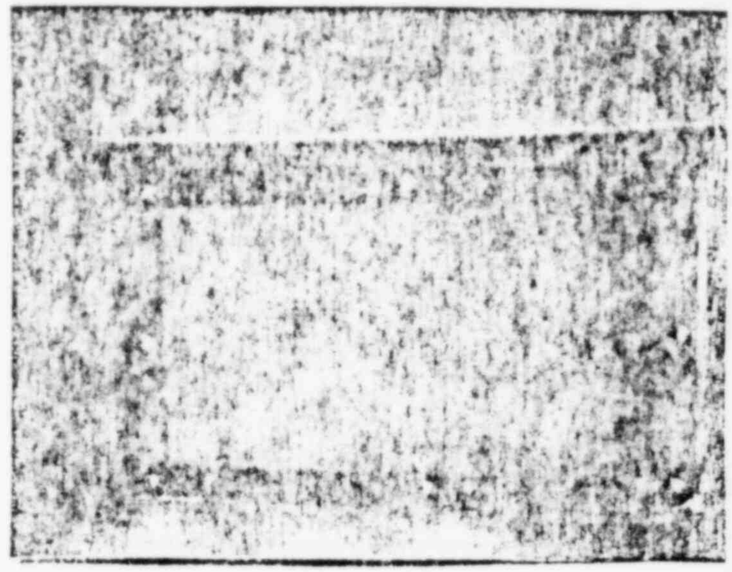
H-268213

H-123122

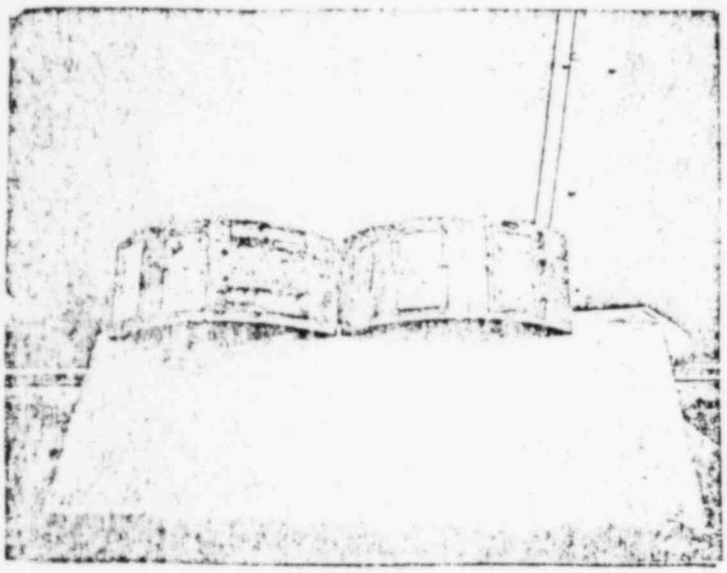
ATTACHMENT II



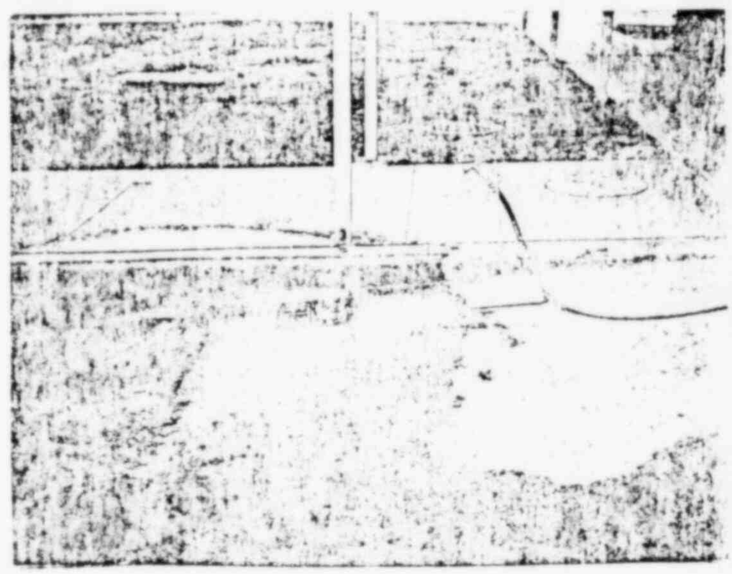
No. 1



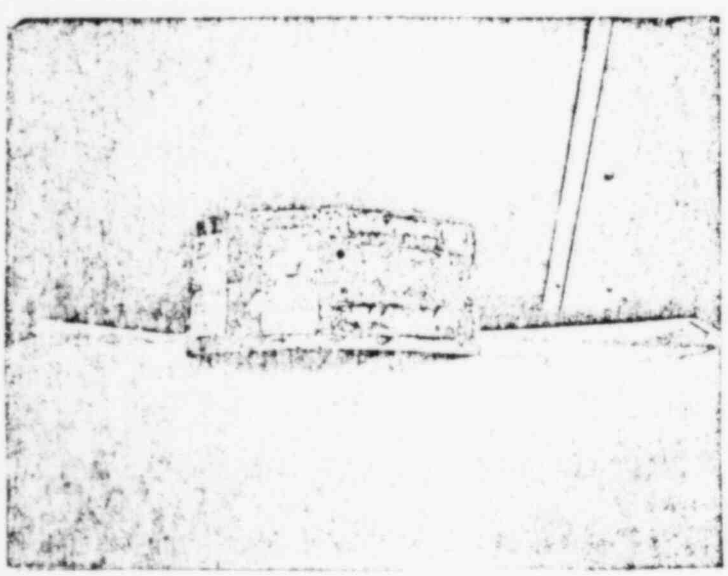
No. 2



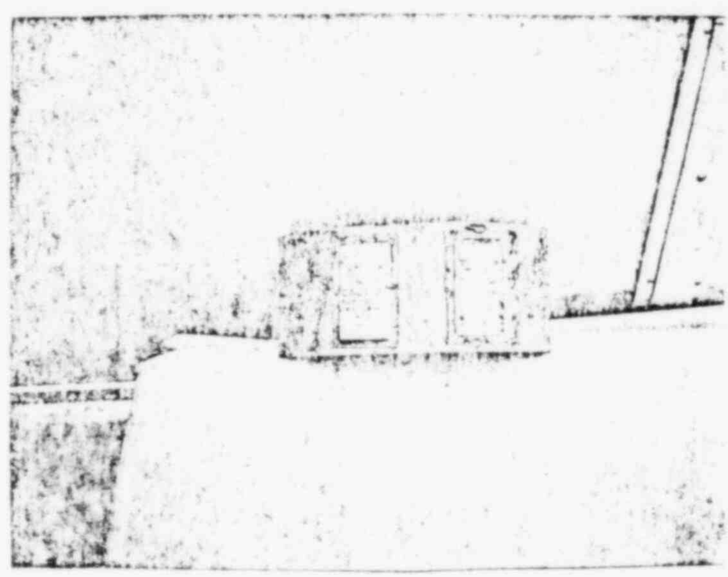
No. 3



No. 4



No. 5



No. 6

APPENDIX X

SUBJECT: Test of NSR against requirements of IAEA, 1973 Edition, Paragraph 230.

	ITEM
Test Certification NSR-F	1
Test Certification NSR-L and NSR-M	2

Monsanto

ENGINEERED PRODUCTS

MONSANTO RESEARCH CORPORATION
Dayton Laboratory
1515 Nicholas Road
P. O. Box 8, Station B
Dayton, Ohio 45407
Phones: (513) 268-6769
(513) 268-3411
Telegraph: TWX 810-459-1681

For: Schlumberger Well Services
P.O. Box 2175
Houston, Texas

Drawing: H-142108

MRC Contract No: 194-8A0

M.O. 821.5100

TEST CERTIFICATION

This certifies that two (2) AmBe neutron source containers, per SWS design H-142108, each consisting of an inner capsule per SWS drawing H-136038 and an outer capsule per SWS drawing H-126024, were subjected to and passed test conditions equal to or exceeding those specified in paragraph 230 of the IAEA Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition.

Passage of the tests were determined by a Helium Mass Spectrometer Leak Test similar to that described in the American National Standard for Leakage Test on Packages for Shipment of Radioactive Materials, ANSI N14.5-1977, appendix A, paragraph A3.9. Leak tests on the capsules prior to and following the specified testing showed the capsules to be "leaktight" as defined by paragraph 3.7 of ANSI N14.5-1977. Actual Helium Leak Test Procedure is on file at Monsanto Research Corporation.

By *Susan J. Mougey*
Susan J. Mougey
QC Technician

Date 1-05-79

By *Robert R. Taylor*
Robert R. Taylor
Manager, Operations

Date 1-05-79

JUL 2 1979

Monsanto

ENGINEERED PRODUCTS

MONSANTO RESEARCH CORPORATION
Dayton Laboratory
1515 Nicholas Road
P. O. Box 8, Station B
Dayton, Ohio 45407
Phones: (513) 268-6769
(513) 268-3411
Telegraph: TWX 810-459-1681

For: Schlumberger Well Services
P.O. Box 2175
Houston, Texas

Source Drawings: H-239681
H-245258

MRC Contract No: 029-9A0

M.O. 824.2320
824.2330

TEST CERTIFICATION

This certifies that two each dummy AmBe neutron source containers, per SWS designs H-239681 and H-245258 were subjected to and passed test conditions equal to or exceeding those specified in paragraph 230 of the IAEA Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition.

Passage of the tests were determined by a Helium Mass Spectrometer Leak Test similar to that described in the American National Standard for Leakage Test on Packages for Shipment of Radioactive Materials, ANSI N14.5-1977, Appendix A, paragraph A3.9. Leak tests on the capsules prior to and following the specified testing showed the capsules to be "leaktight" as defined by paragraph 3.7 of ANSI N14.5-1977. Actual Helium Leak Test Procedure is on file at Monsanto Research Corporation.

By: [signature]
Robert R. Taylor
Manager, Opeations

Date: 28 June 1979

JUL 2 1979

Monsanto

ENGINEERED PRODUCTS

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Dayton Laboratory
1515 Nicholas Road
P. O. Box 8, Station B
Dayton, Ohio 45407
Phones: (513) 268-6769
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For: Schlumberger Well Services
P.O. Box 2175
Houston, Texas

Source Drawings: H-239681
H-245258

MRC Contract No: 029-9A0

M.O. 824.2320
824.2330

TEST CERTIFICATION

This certifies that 2 each dummy capsules per SWS designs H-239681 and H-245258 were subjected to and passed prototype testing according to ANS N542-1977 (NBS Handbook 126), Classification 66542.

Test results are on file at Monsanto Research Corporation.

By: [signature]
Robert R. Taylor
Manager, Operations

Date: 28 June 1979

APPENDIX XI

SUBJECT: Thermal Test of NLS-RF against requirements of IAEA, 1973 Edition, Paragraph 720.

INSTITUTE FOR RESEARCH, INC.
8330 WESTGLEN DR. • HOUSTON, TEXAS 77063 • 713/783-8400

September 23, 1977

Mr. Tony Thyen
Schlumberger Well Ser.ices
Box 2171
Houston, TX 77001

ANALYTICAL REPORT

SUBJECT: Thermal test of radioactive container.

RESULTS: The radioactive container was placed in a temperature programmed furnace and heated to 1620° F.

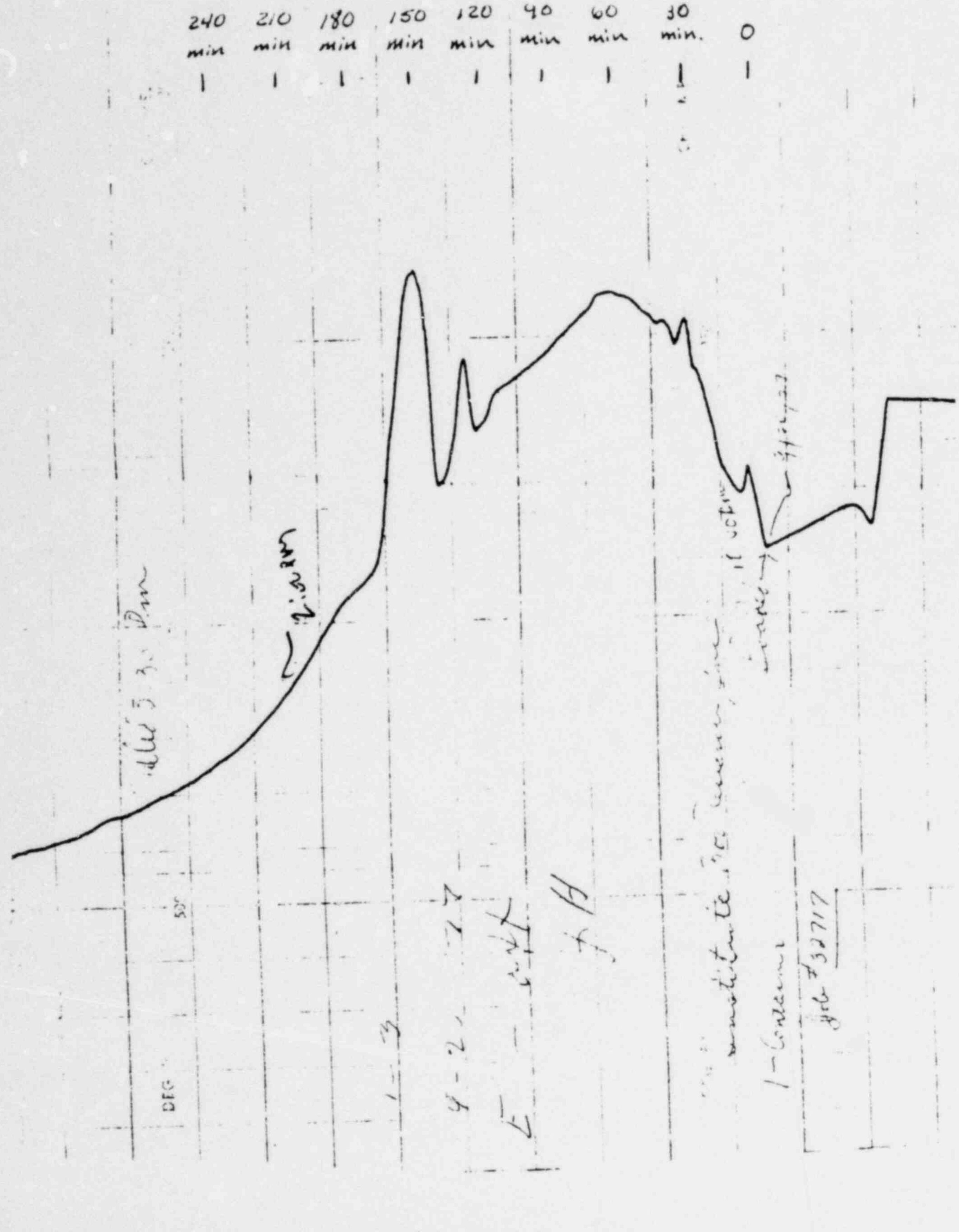
Figure 1 gives the thermogram for the heating cycle.

Respectfully submitted,

Benjamin Mosier

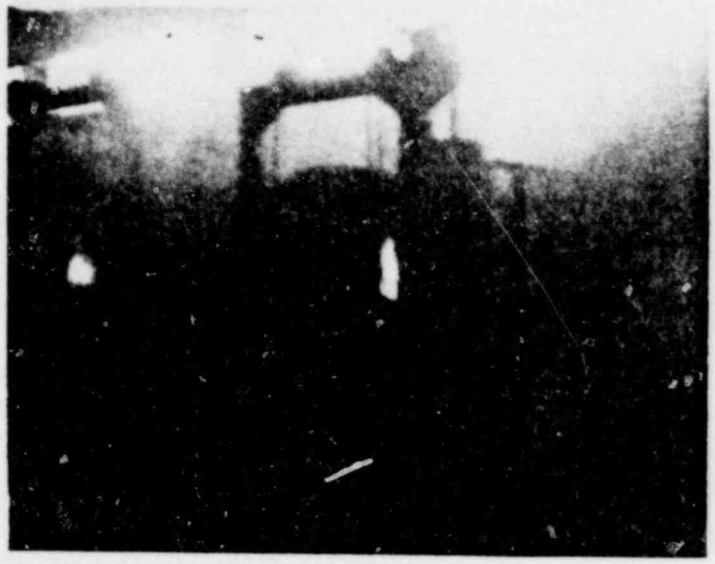
Benjamin Mosier, Ph.D.
President

BM:pq
Enclosures: Figure 1
Photographs (6)
Inv. SW 0923772



240 min
210 min
180 min
150 min
120 min
90 min
60 min
30 min.
0
DEG

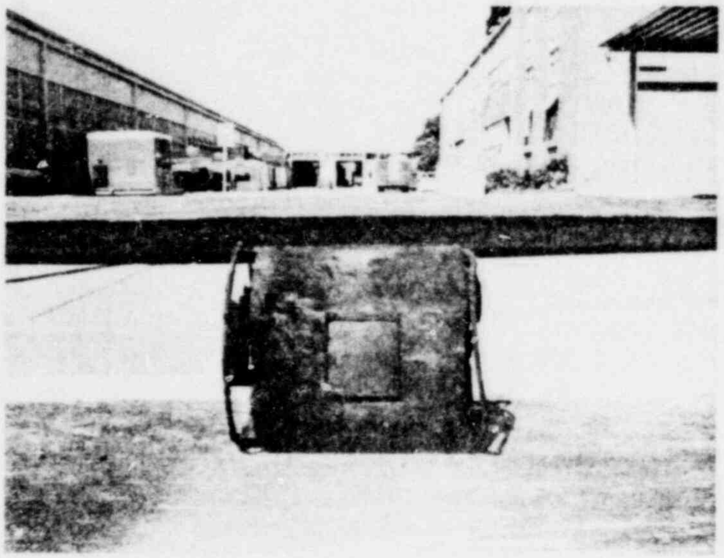
Thermal Test Shield



Shield being burned in heat-treating furnace

Thermal Test Cont'd.

After removal
from furnace.



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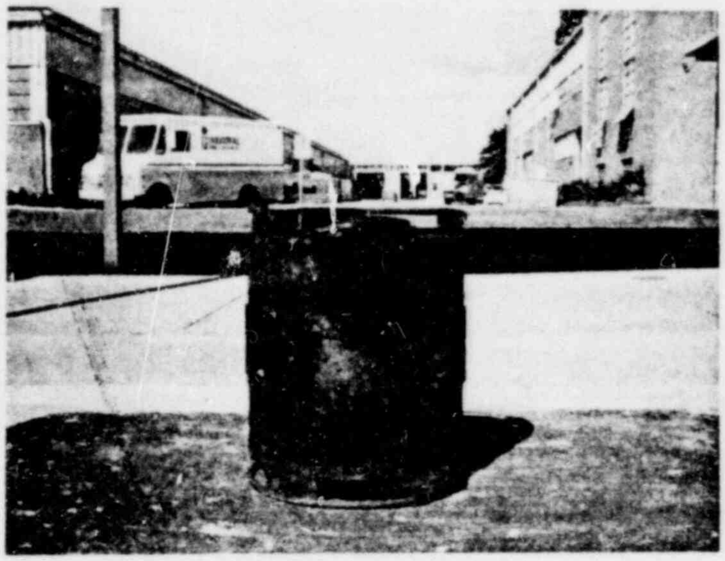
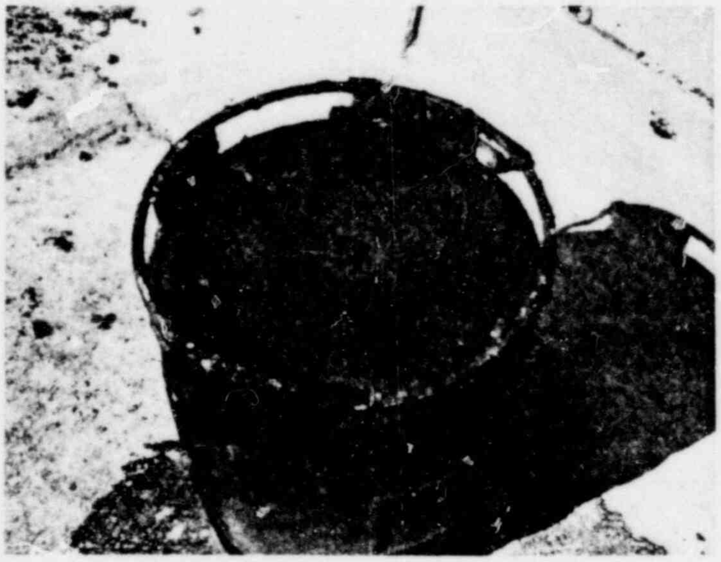


After removal
from furnace.



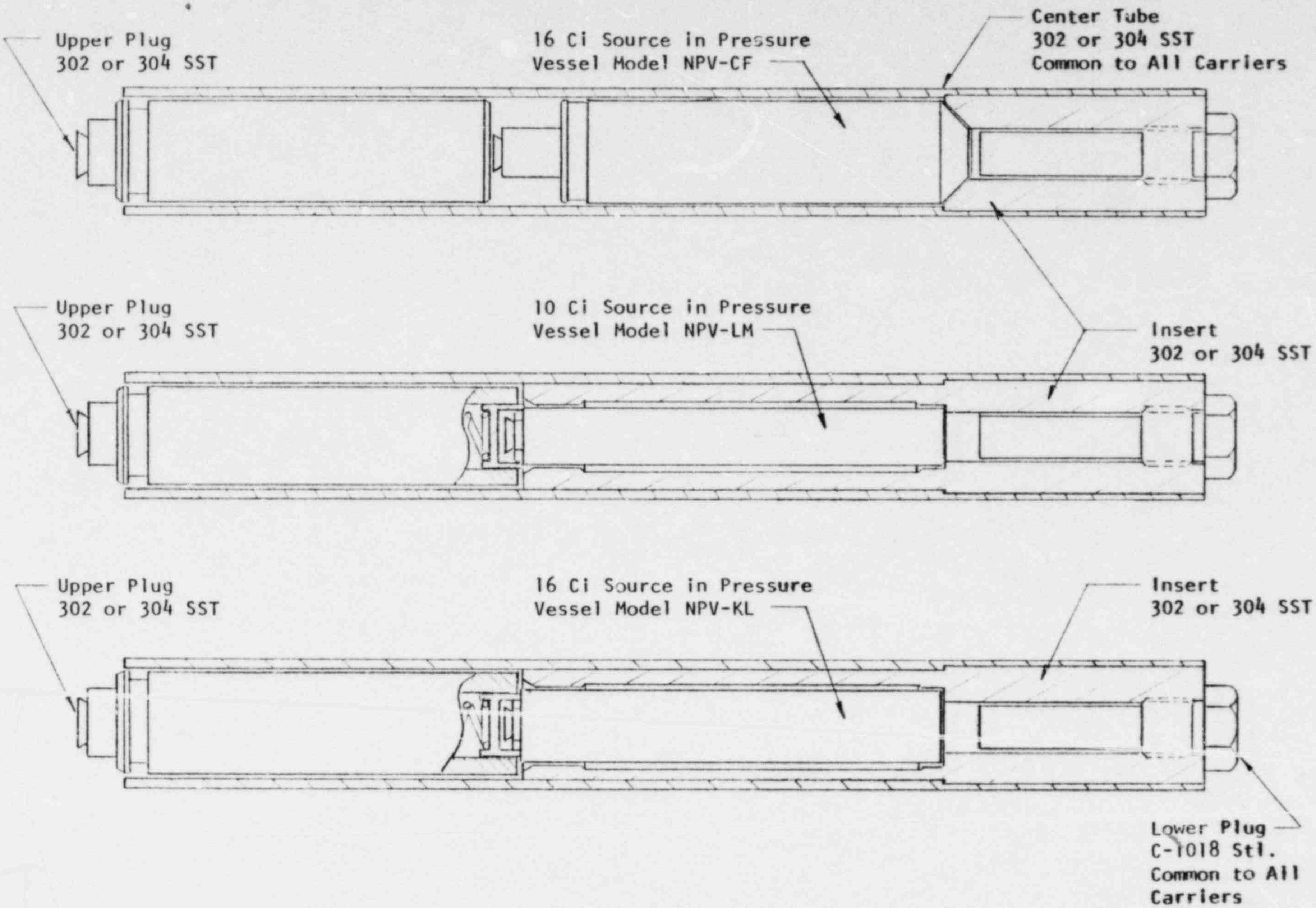
APPENDIX XII

SUBJECT: Typical vendor certifications, test reports, and rules relative to radioactive materials.*

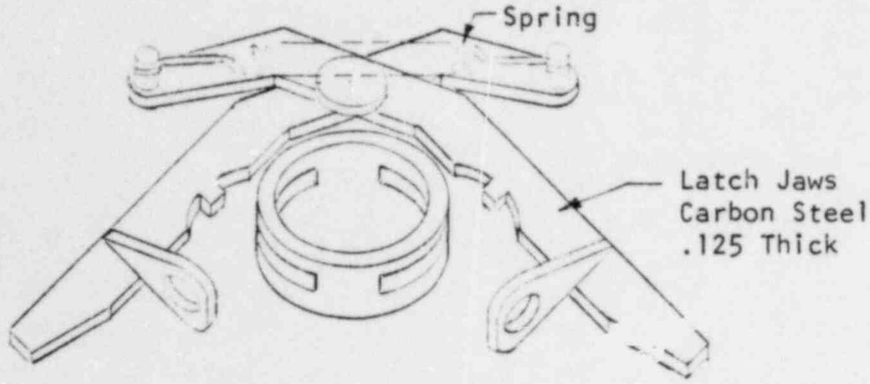
*See original application for B(U) Certification dated January 5, 1979.

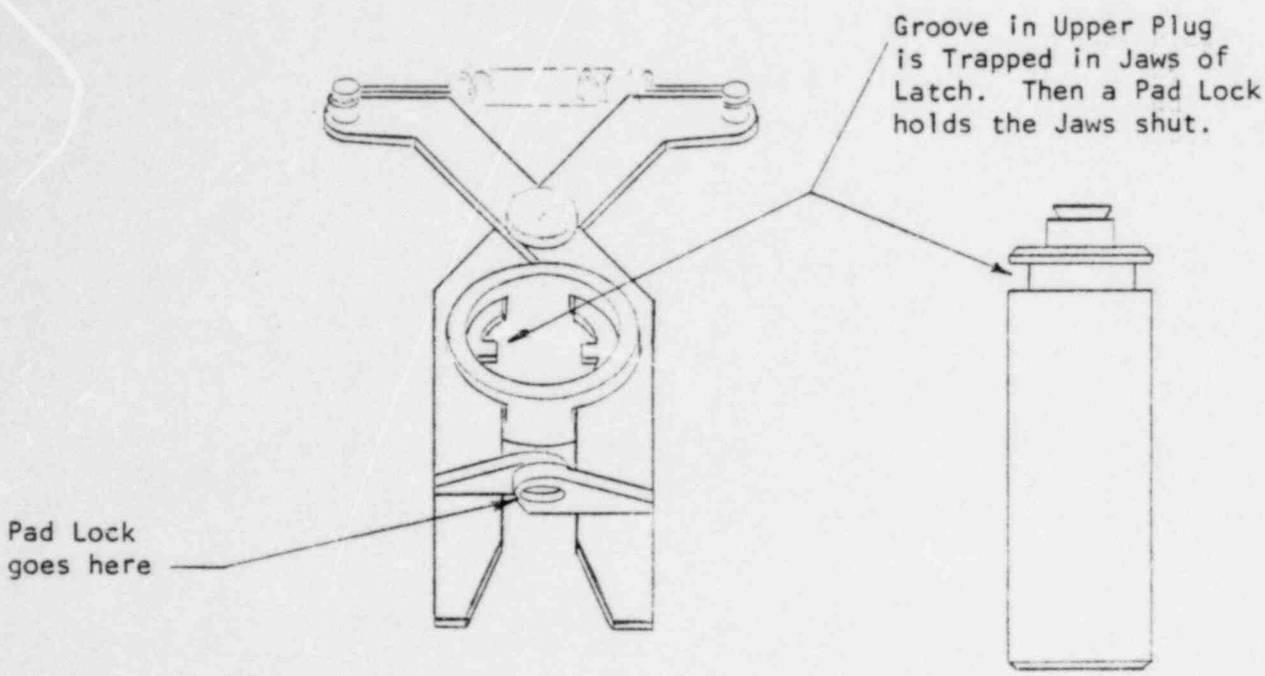
1-1

CENTER TUBE ASSEMBLIES



UPPER SOURCE PLUG LOCKING DETAIL
COMMON TO ALL CARRIERS





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