

# **DEVELOPMENT AND CERTIFICATION OF A SPECIAL FORM CAPSULE (MODEL II) FOR SEALED SOURCES TO FACILITATE TRANSPORTATION AND STORAGE AS SPECIAL FORM MATERIAL**

By

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## **Abstract**

The Off-Site Source Recovery (OSR) Project at Los Alamos National Laboratory (LANL) recovers and manages excess and unwanted radioactive sealed sources and other radioactive materials that present a risk to public health, safety and national security; and for which no disposal options currently exist. Due to their age, a lack of available manufacturer data and unknown origin, or the potential for leakage, some of the radioactive sealed sources targeted for recovery by the OSR Project do not meet US Department of Transportation (US DOT) Type A requirements. Sealed sources that are special form can be shipped using US DOT Type A, 7A packages, which provide increased flexibility in shipping. In 2000, the OSR Project developed a sealed source overpack called the LANL Special Form Capsule (SFC) Model I to provide a method to ensure US DOT special form containment of radioactive sealed sources during transport. A key feature of the SFC was that it could be easily assembled in the field and allowed sealed sources which did not have current special form certification or documentation for domestic transport to be made special form by field encapsulation in a LANL SFC. After successful testing of the Model I, it was decided to fabricate a capsule that could encapsulate the Model I, should ever one of the capsules leak and to allow encapsulation of sources larger than one inch in diameter. The Model II, with an internal diameter of 2.0 inches was then fabricated and tested. This second model of the LANL SFC has been tested and certified to meet all requirements specified in Title 49 Part 173 of the Code of Federal Regulations, Section 469 (49CFR173.469). Its development expands the capabilities of the OSR Project and Department of Energy (DOE) to efficiently transport and store sealed sources.

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## Attachments

- Attachment A. Pacific Testing Laboratories Certificate of Testing
- Attachment B. LANL Drawing 90Y-219998, Revision G, Special Form Capsule

## **I. INTRODUCTION**

The Off-Site Source Recovery (OSR) Project at Los Alamos National Laboratory (LANL) recovers and manages excess and unwanted radioactive sealed sources and other radioactive materials that present a risk to public health, safety and national security. Due to their age, a lack of available manufacturer data and unknown origin, or the potential for leakage, some of the radioactive sealed sources targeted for recovery by the OSR Project do not meet US Department of Transportation (US DOT) Type A requirements. Sealed sources that are special form can be shipped using US DOT Type A, 7A packages, which provide increased flexibility in shipping. In 2000, the OSR Project developed a sealed source overpack called the LANL Special Form Capsule (SFC) Model I to provide a method to ensure US DOT special form containment of radioactive sealed sources during transport. The development and testing of the Model I SFC was documented in LAUR-02-433<sup>1</sup>. A key feature of the SFC was that it could be easily assembled in the field and allowed sealed sources which did not have current special form certification or documentation for domestic transport to be made special form by field encapsulation in a LANL SFC. After successful testing of the Model I, it was decided to fabricate a capsule that could encapsulate the Model I, should ever one of the capsules leak and to allow encapsulation of sources larger than one inch in diameter. The Model II, with an internal diameter of 2.0 inches was then fabricated and tested. This second model of the LANL SFC has been tested and certified to meet all requirements specified in Title 49 Part 173 of the Code of Federal Regulations, Section 469 (49CFR173.469<sup>2</sup>). Its development expands the capabilities of the OSR Project and Department of Energy (DOE) to efficiently transport and store sealed sources.

## **II. SCOPE**

The scope of the project was to develop a larger capacity special form capsule that could encapsulate the Model I, should ever one of the capsules leak and to allow encapsulation of sources larger than one inch in diameter. The special form capsule also had to be easily sealed in the field. The following definitions are applicable:

### **A. SEALED SOURCE**

Radioactive material that is contained in a sealed capsule, sealed between layers of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means. The confining barrier prevents dispersion of the radioactive material under normal and most accidental conditions related to the use of the source (from *Implementing Guide for Occupational Radiation Protection* (GN5400.9/M1) *Sealed Radioactive Source Accountability and Control*<sup>3</sup>).

### **B. SPECIAL FORM**

Class 7 Radioactive material that satisfies the following conditions:

- (1) it is either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule;
- (2) the piece or capsule has at least one dimension not less than 5 millimeters (0.2 inch); and
- (3) it satisfies the test requirements of 49 CFR 173.469.

## **III. DEVELOPMENT**

After successful testing of the Model I, it was decided to fabricate a capsule that could encapsulate the Model I, should ever one of the capsules leak and to allow encapsulation of sources larger than one inch in diameter. The Model II, with an internal diameter of 2.0 inches, was then fabricated and tested based upon the original design of the Model I. Initial testing resulted in a modification to the design to limit the impact of the larger mass of capsule contents that could be accommodated in the Model II capsule. After several internal tests were performed, two new components, a snap ring and an impact plug were designed to ensure the integrity of the seal.

#### IV. GENERAL DESCRIPTION

The LANL SFC Model II has exterior dimensions of 3" OD x 11" long. The container body is fabricated from SS 304 bar stock. The SFC incorporates a tapered plug, made of the same material. A cap, utilizing 2 ½ -10 ACME 2G threads, is used to apply pressure on the tapered plug forming a seal against the inner wall. The impact limiting disk and snap ring are used to ensure the integrity of the seal. The cap incorporates a knob that shears off during assembly as part of the sealing process to a final containment that cannot be opened without machining, which would result in the destruction of the capsule. The capsule components are shown in Figure 1.



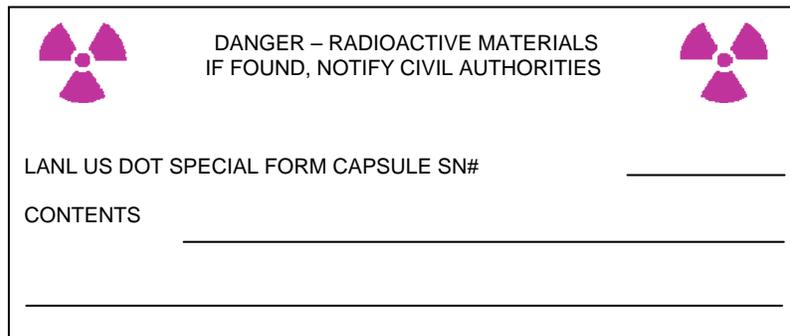
Figure 1. Special form capsule components.

#### V. FEATURES OF THE SFC

The walls of the housing are 0.5" thick or greater. The sealing plug is longer and slightly larger in diameter on the large end than its tapered seat to ensure that, when placed loosely in the seat, at least 0.020" projects above the upper face of the seat. The sealing plug dimensions are controlled because the cap seating depth is the primary indicator of an appropriately sealed capsule. The impact limiting disk and the snap ring are inserted prior to sealing the capsule. If a capsule were accidentally dropped, the source(s) inside the capsule would hit the impact limiting disk first, ensuring the integrity of the seal. To seal the SFC, the sealing plug is placed in the seat. The threaded cap is then advanced into the female thread of the cylinder until the face of the cap is resting on the sealing plug surface.

The relieved stem of the threaded cap is sized 0.350" OD to require a minimum of 75 ft-lb. of torque prior to the shearing of the stem from the cap. Once the stem is sheared, the sealing plug is firmly seated in the capsule. The sealing surfaces provide a metal-to-metal seal. The threaded cap remains in place and serves to protect and retain the sealing plug within the capsule. After the stem is sheared flush with the surface of the cap, the assembly cannot be opened and reused without destroying the capsule.

The SFC serial numbers are unique and intended to identify the individual capsules. The serial numbers have been laser etched on the capsules and include appropriate safety information. A traveler sheet, which includes quality assurance information, is generated for each SFC and is packaged with it in a sealed plastic bag prior to use. A section is reserved on the capsule in order to etch content information. A typical LANL SFC displays the following information:



**Figure 2. Special form capsule laser etching.**

## **VI. SFC COMPONENT SPECIFICATIONS**

The LANL SFC consists of five components: the container body, a sealing plug, an impact limiting disk, a snap ring and the threaded cap. The capsule consists of a 3" OD SS (304) billet 11.75" in length. An internal cavity 2.225" ID is machined into the billet 10.75" deep. A female machine screw thread (2 ½ -10 ACME 2G) is machined into the open end of the billet 0.75" deep. A seat for the sealing plug is machined into the billet below the threaded section.

The sealing plug is tapered 1.909° in 1.25" of length and the seat is given a 32 machine finish. The sealing plug is 0.78" in length and is sized to 2.225" OD where it joins the 2.225" ID bore of the container body.

The impact limiting disk is 2.110" OD and 0.25" thick and the snap ring is a 2" internal ring made of zinc-plated steel.

The threaded cap for the SFC consists of a threaded (2 ½ -10 ACME 2G) disc 0.75" thick, topped by a 0.75" OD x 0.75" long stem. The stem is sized to 0.625" OD and then further relieved to an OD of 0.350" for a distance of 0.25" above where it joins the threaded disc of the cap. Flats are then machined into the remaining portion of the stem to allow a wrench to apply torque.

## **VII. SPECIAL FORM TESTING**

During the development phase of the SFC, a suite of in-house tests was conducted to verify the adequacy of the design. Once the design was validated, capsules were fabricated, assembled, and sent to PTL in Valencia, CA, for independent testing.

## **VIII. TEST CRITERIA**

The capsules were tested to the requirements of "special form radioactive material," as defined in 49 CFR 173.469(b)-(1)-(4). All tests, except the heat and leakage tests, were carried out at ambient temperature and were done using a capsule fabricated according to drawing specifications. A different capsule was used for each of the tests. In order to evaluate the performance of the capsules, the test criteria specified that the leak-tightness be determined following each test. A brief summary of the tests is presented in IX Test Results, and a detailed copy is available upon request.

## **A. IMPACT TEST**

The impact test [49 CFR 173.469 (b) (1)] required that the sealed specimen be dropped onto the target from a minimum height of 9 m. The target was a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage to the specimen. After the test was performed, each capsule was examined visually and subjected to a leakage test.

## **B. PERCUSSION TEST**

The percussion test [49 CFR 173.469 (b) (2)] required that the specimen be placed on a sheet of lead supported by a smooth solid surface and then be struck by the flat face of a steel billet to produce an impact equivalent to that resulting from a free drop of 1.4 kg through 1 m. The flat face of the billet must be 25 mm in diameter with the edges rounded off to a radius of  $(3.0 \pm 0.3)$  mm. The lead, of hardness number 3.5 to 4.5 on the Vickers scale and not more than 25 mm thick, covered an area greater than that covered by the specimen. A fresh surface of lead was used for each impact. The billet struck the specimen so as to cause maximum damage. After the test was performed, each capsule was examined visually and subjected to a leakage test.

## **C. HEAT TEST**

The heat test [49 CFR 173.469 (b) (4)] required that the test specimen be heated in air to a temperature of not less than 800°C, held at that temperature for a period of 10 minutes, and then allowed to cool. After testing was performed, each capsule was examined visually and subjected to a leakage test.

## **D. LEAK-TIGHTNESS DETERMINATION METHOD**

Following each of the above tests, 49 CFR 173.469 specifies that the leak-tightness or indispersibility of the specimen must be determined. For Class 7 (radioactive) materials the method used can be as prescribed in the International Organization for Standardization (ISO) Technical Report 1979-02-15<sup>4</sup>, which was prepared in support of ISO 2919<sup>5</sup>. Analytical reagent-grade ethylene glycol, water, or silicon oil was used as the leak-test fluid in a vacuum chamber. The air content of the fluid was lowered by evacuating the chamber for one minute and then returning it to atmospheric pressure. The capsule was then submerged completely to a depth of 5 cm (2 in) below the fluid level. The pressure in the chamber was reduced to between 15 to 25 kN/m<sup>2</sup> (2 and 3.6 lb/in<sup>2</sup>) absolute. If no bubbles were observed, the sealed capsule was considered to be leak free.

## **IX. TEST RESULTS**

The test results are presented in Table 1. Each test, impact, percussion, and heat, was performed three times using a different capsule every time. Three capsules were used for each of the tests. Each of the capsules was evaluated for leakage as described above before and after each individual test.

**Table 1. Test results**

<b>SFC#</b>	<b>TEST</b>	<b>RESULTS</b>
001	Impact	PASS
002	Impact	PASS
003	Impact	PASS
004	Percussion	PASS
005	Percussion	PASS
006	Percussion	PASS
007	Heat	PASS
008	Heat	PASS
009	Heat	PASS

## **X. FABRICATION**

All capsules are fabricated according to the design specifications in LANL drawing 90Y-219998, Revision C (see Attachment B). Fabrication is conducted in compliance with the quality assurance specifications in 10 CFR 71 subpart H and the additional quality assurance requirements specified in LANL QA Supplement, Form-838c.

## **XI. QUALITY ASSURANCE Inspection Prior to Use**

Critical components, which include the sealing plug and the mating surface of the capsule, are thoroughly examined for any defects upon receipt from the manufacturer. Possible defects include nicks, scratches, and nonconformance with dimensional requirements as specified in the LANL drawing. In addition, quality assurance (QA) measurements of critical components of each individual capsule assembly are made using a QA tool called the Plug Seating Depth Tool (PSDT) and a feeler gauge or dial gauge. The threaded cap is hand tightened on the capsule body with and without the tapered plug in place, and the gap measurements between the PSDT and the top of the capsule are recorded. If the gap measurement following assembly falls between the two QA gap measurements, a leak tight assembly is assured.

## **XII. APPLICATION OF LANL SFC**

The materials intended for encapsulation by the LANL SFC are limited to metal clad sealed sources or leaking sealed sources containing dry solids. In general, use of the SFC by LANL will be for radioactive sources containing the following alpha-emitting isotopes: Pu-238, Pu-239, Am-241, Np-237, Cm-244, and Ra-226 with a total weight of 2400 grams. However, the potential radioactive contents of this capsule are limited only by the potential for pressurization of the capsule and/or the heat generated in the capsule by radioactive decay. Adequate void space should be left to assure that pressure build-up due to an inner container leak would not significantly challenge the integrity of the capsule.

### **A. THERMAL LIMITS FOR THE SFC**

Thermal limits for US DOT Class 7 packages are detailed in 49 CFR: 173.410, 173.442, and 173.448. In summary, the two most restrictive packaging requirements are

1. The temperature of the accessible package surface must not be greater than 50°C (122°F), when the air temperature is 38°C (100°F), which is a net 12°C (21.6°F) temperature increase. For shipments by air, insulation cannot be considered.
2. The average surface heat flux of the package must not exceed 15 watts per square meter without special stowage provision and the immediately surrounding cargo must not be in sacks or bags or another form that would impede air circulation for heat removal.

A simple conductive heat flow model (Fourier) of the SFC demonstrates that 90 watts of heat generated by radioactive decay will increase the SFC surface temperature by about 12°C (21.6°F) in free air. Thus, the SFC in an un-insulated state will increase in temperature only by about 12°C, which would meet the thermal requirements of number 1. However, under most instances of transport, the SFC would not be “the accessible package surface.” The SFC will be shipped inside an external shipping container.

If the standard shipping package is a 55-gallon drum, with surface area of 2.11 m<sup>2</sup>, then the 15W/m<sup>2</sup> limit specified in requirement 2 would allow packaging of radioactive material emitting 31.6W of decay heat. This 31.6W limit is about 1/3 of the limit calculated above (90-W). Clearly the 15W/m<sup>2</sup> without special stowage provision is more restrictive and will be the limitation used by LANL when shipping in a 55-gallon drum. Other packaging geometries should be specifically evaluated to determine the thermal limit for the SFC.

It should be noted that the thermal limits described above are a packaging requirement and not a special form requirement. Neither a 12°C temperature rise nor a 15W/m<sup>2</sup> thermal flux will present any significant physical challenge to 300 series SS at ambient temperature or the elevated (800°C) temperature at which the SFC has been tested. The potential effects of higher thermal loading should be specifically evaluated in conjunction with the specific packaging geometries and materials to be used.

### **XIII. FIELD LOADING PROCEDURE**

A set of tools and accessories has been developed to enable efficient loading and closing of the capsule in the field to reduce external radiation dose to workers while ensuring a quality seal. For encapsulation of neutron sources, polyethylene shielding is included among the accessories to minimize radiation dose and to comply with ALARA (as low as reasonably achievable) policies. The capsules must be assembled in strict accordance with the procedures described in OSR- OP-180, “Assembly Procedure for the Special Form Capsule, Model II”<sup>6</sup>. The procedure provides a quality control process to ensure a compliant seal.

### **XIV. CONCLUSION**

The design of the LANL SFC Model II has been tested and certified to meet all requirements specified by the US DOT in 49 CFR 173.469 (ANSI N43.6 Annex E) for special form material. Note that the LANL SFC Model II can be fabricated in lengths up to 19 inches without additional testing. Pacific Testing Laboratories issued a certificate indicating that the SFC meets US DOT requirements on November 27, 2001 (see Attachment A). The design characteristics of the capsule and the successful testing allow us to state that the capsules meet the requirements of ANSI N43.6 Annex E, ISO 2919, and ISO 1979-02-15.

### **XV. ACKNOWLEDGEMENTS**

The authors acknowledge the many people involved in the design, testing, and fabrication of the LANL Special Form Capsule. We are indebted to Radiation Service Organization, Inc., Laurel, MD, for their original work. The United States Department of Energy funded this work. Special thanks to Robert Campbell (US DOE, NNSA, NA-211) Washington, DC, James Orban (US DOE, EPD) Albuquerque, NM, and Joel Grimm (US DOE, NNSA, NA-211) Washington, DC for their support of this work. The LANL SFC

has been developed and qualified for use as special form containment by LANL with the participation of and contribution from Pacific Testing Laboratories (Valencia, CA), Continental Machining and Standard Machining Co. (Albuquerque, NM).

## **XVI. REFERENCES**

1. Development and Certification of a Special Form Capsule for Sealed Sources to Facilitate Transportation and Storage as Special Form Material, LAUR-02-433, February 22, 2002.
2. Code of Federal Regulations Title 49, Part 173.469.
3. *Implementing Guide for Occupational Radiation Protection (GN5400.9/M1) Sealed Radioactive Source Accountability and Control*
4. Sealed Radioactive Sources – Leak Test Methods, International Organization for Standardization, Technical Report 4826, Published 1979-02-15.
5. Radiation Protection – Sealed Radioactive Sources – General Requirements and Classification, International Organization for Standardization, ISO 2919, Second edition, 1999-02-15.
6. Assembly Procedure for the Special Form Capsule, Model II, OSR-OP-180 Los Alamos National Laboratory, Off-Site Source Recovery Project, N-2, April 2005.



**PACIFIC TESTING LABORATORIES, INC.**

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**CERTIFICATE OF CONFORMANCE**

This certifies that the specimens of Special Form Capsule, manufactured in accordance with Los Alamos National Laboratory (LANL) drawing number 90Y-219998, have been tested to meet the requirements established in 49 CFR 173.469, and have been found to be in compliance with the following specifications:

1. ANSI/HPS N 43.6-1997 Sealed Radioactive Sources, Classification
2. E-WMOSR-002, 3" Special Form Radioactive Material Capsule Specification Testing, August 23, 2001

The following physical tests were performed:

1. Impact
2. Percussion
3. Heat
4. Leakage

The leakage-test performed was a vacuum-bubble test, as identified in Annex A, Method A.2.2.1 of ANSI/HPS N43.6-1997. The tests results were compiled in Test Report #23331, and are held on file for review by authorized individuals, upon request.

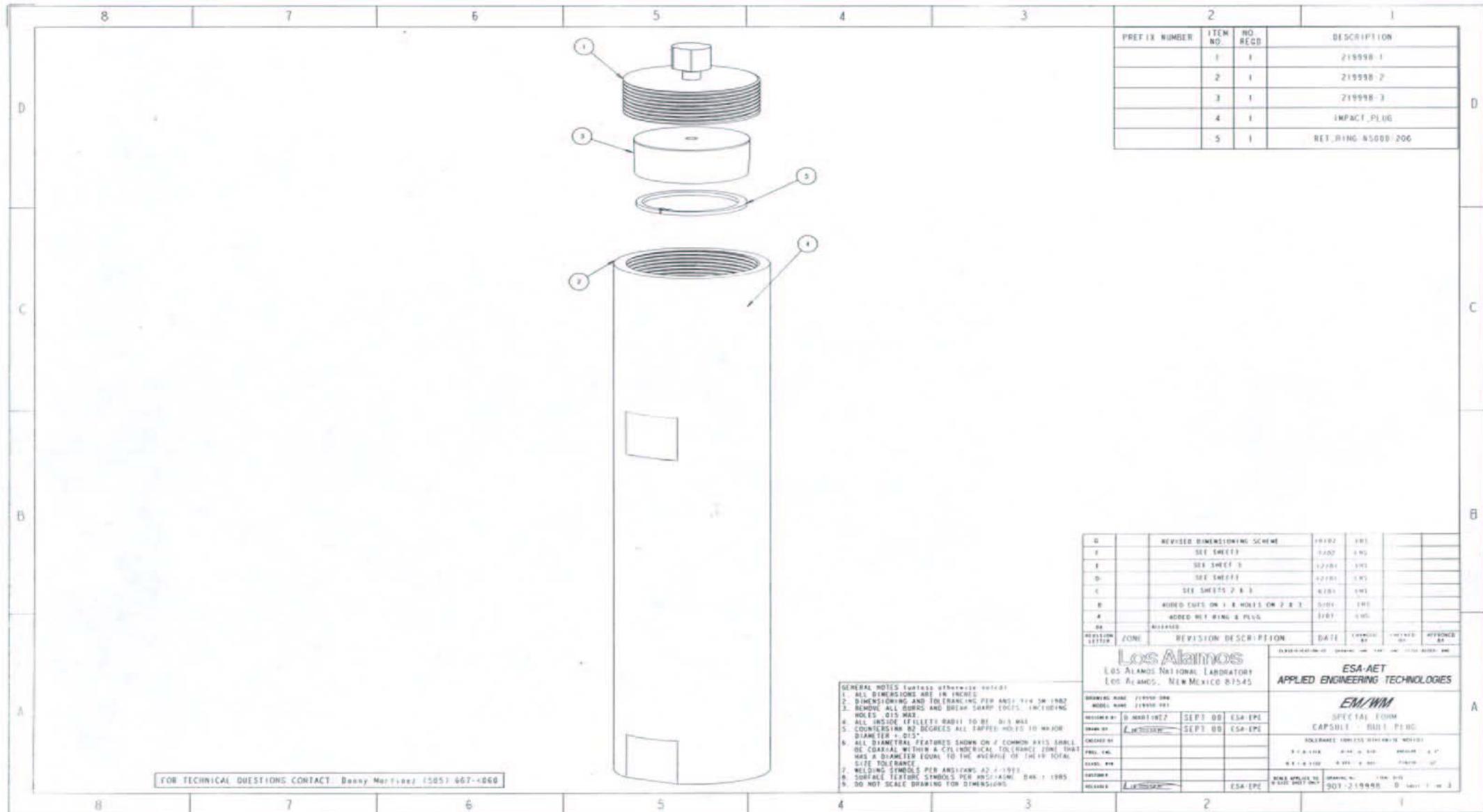
PACIFIC TESTING LABORATORIES, INC.

Signed:

A handwritten signature in black ink, appearing to read 'Frank Barrett', is written over a horizontal line.

Frank Barrett  
Quality Assurance Manager

Date: Nov. 27, 2001



PREFIX NUMBER	ITEM NO.	NO. RECD.	DESCRIPTION
	1	1	219998-1
	2	1	219998-2
	3	1	219998-3
	4	1	IMPACT_PLUG
	5	1	RET_RING_85009_206

REVISION LETTER	ZONE	REVISION DESCRIPTION	DATE	DESIGNED BY	CHECKED BY	APPROVED BY
D		REVISED DIMENSIONING SCHEME	10/02	EPS		
E		SEE SHEET 1	11/02	EPS		
F		SEE SHEET 3	12/01	EPS		
D		SEE SHEET 1	12/01	EPS		
C		SEE SHEETS 2 & 3	8/01	EPS		
B		RODED ENDS ON 1 & 8 HOLES ON 2 & 3	5/01	EPS		
A		ADDED RET RING & PLUG	3/01	EPS		

- GENERAL NOTES (unless otherwise noted):
1. ALL DIMENSIONS ARE IN INCHES
  2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982
  3. REMOVE ALL BURRS AND BREAK SHARP EDGES, INCLUDING HOLES .015 MAX.
  4. ALL INSIDE FILLETS RADIUS TO BE .015 MAX.
  5. COUNTERSINK 82 DEGREES ALL TAPPED HOLES TO MAJOR DIAMETER + .015"
  6. ALL DIAMETRAL FEATURES SHOWN ON Z COMMON AXIS SHALL BE COAXIAL WITHIN A CYLINDRICAL TOLERANCE ZONE THAT HAS A DIAMETER EQUAL TO THE RADIUS OF THE TOTAL SIZE TOLERANCE
  7. WELDING SYMBOLS PER AWS/AAS 42.1-1983
  8. SURFACE TEXTURE SYMBOLS PER ANSI/ASME B46.1-1985
  9. DO NOT SCALE DRAWING FOR DIMENSIONS

FOR TECHNICAL QUESTIONS CONTACT: Danny Martinez (505) 867-0860

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**ESA-AET**  
**APPLIED ENGINEERING TECHNOLOGIES**

**EM/WM**  
SPECIAL FORM  
CAPSULE - BUBBLE PING

TOLERANCE UNLESS OTHERWISE NOTED:  
 .005 - .010    .010 - .030    .030 - .060    .060 - .125  
 .125 - .250    .250 - .500    .500 - 1.000    1.000 - 2.000

DESIGNED BY: D. MARTINEZ    SEPT 08    ESA-EPC  
 DRAWN BY: L. MARTINEZ    SEPT 08    ESA-EPC  
 CHECKED BY: \_\_\_\_\_  
 PROJ. ENG. \_\_\_\_\_  
 DATE: 08/08  
 CUSTOMER: \_\_\_\_\_  
 RELEASE: L. MARTINEZ    ESA-EPC

FORM APPLIES TO: 1984-001  
 DATE: 08/08  
 PART NO: 901-219998-0    REV: 1 OF 1

