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SUMMARY REPORT ON SNAP-19B (IRHS) PROGRAM

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MONSANTO RESEARCH CORPORATION
A Subsidiary of Monsanto Company

MOUND LABORATORY
Miamisburg, Ohio operated for

UNITED STATES ATOMIC ENERGY COMMISSION

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I. SUMMARY

Four fueled SNAP-19B intact-upon-reentry heat sources (IRHS) were fabricated at Mound Laboratory and delivered to Martin Company, the system contractor, for application to the NIMBUS B mission. Two of these sources were for actual flight units whereas the other two were for prototype testing. Each source had a thermal power of 570 ± 17 W and was designed to remain intact under reentry conditions.

The design established for the SNAP-19B (IRHS) comprised a single encapsulation of the fuel within a liner of Haynes alloy No. 25. A filter was incorporated into one end of each capsule to provide continuous venting and to preclude failure due to pressure buildup during reentry or while in operation. Zirconia frit filters were used for the two flight units and Haynes alloy No. 25 frit filters for the prototype models. A refractory metal canister was placed around each capsule and the whole was then incorporated within a graphite heat shield to contain and prevent release of the fuel from the capsule which could possibly become molten under reentry conditions. The refractory canister provided a barrier between the heat shield and the fuel-capsule combination, thereby eliminating the possibility of chemical reactions detrimental to the strength and integrity of the shield.

The prototype and flight heat sources were delivered on schedule to Martin Company in November and December, 1967, respectively.

II. INTRODUCTION

Characteristic of the SNAP-19B Reference (or Dispersal) heat sources, as originally designed for the NIMBUS mission, was the fact that fuel could be released to the atmosphere during reentry. As a result of safety considerations it was considered essential by the Atomic Energy Commission, Space Nuclear Systems Division (AEC/SNS) that a heat source be developed capable of remaining intact upon reentry. Such a source was designated SNAP-19B (IRHS) (later also termed SNAP-19B2), to distinguish it from the earlier design which had been referred to as SNAP-19B (Reference) or SNAP-19B (Dispersal).

The Martin Company was the system contractor, with responsibilities to include furnishing the necessary hardware for fabrication of the SNAP-19B (IRHS) units. Monsanto Research Corporation at Mound Laboratory was contracted by the AEC/SNS to provide the fuel and fabricate the sources. A task force, comprised of representatives from the AEC/SNS, Martin Company, Monsanto Research Corporation (Mound Laboratory), and Sandia Corporation, was created in April, 1967, to establish a suitable design and to oversee development and fabrication of four SNAP-19B (IRHS) units.

In order to be compatible with the SNAP-19B thermoelectric generator and the overall NIMBUS B/SNAP-19B configuration, it was necessary to impose restrictions on the overall dimensions and weight, and still conform to development schedules for the SNAP-19B (IRHS) units. The thermal power of each source was retained at 570 ± 17 W, to be derived from plasma-fired plutonium-238 dioxide microspheres.

The four fueled capsules, two possessing filters of Haynes alloy No. 25 and two of zirconia (zirconium dioxide), were assembled into canisters and heat shields and delivered to the Martin Company in November and December, 1967, respectively. Prior to shipment extensive tests were conducted at Mound Laboratory to establish the compatibility characteristics at anticipated operating temperatures of the various materials in the heat source and the flow characteristics of the filters.

III. SYSTEM DESIGN CONCEPT

A. HEAT SOURCE COMPONENTS

The Intact Reentry Heat Source, shown in the cutaway view of Figure 1 and in the component layout of Figure 2, was a right circular

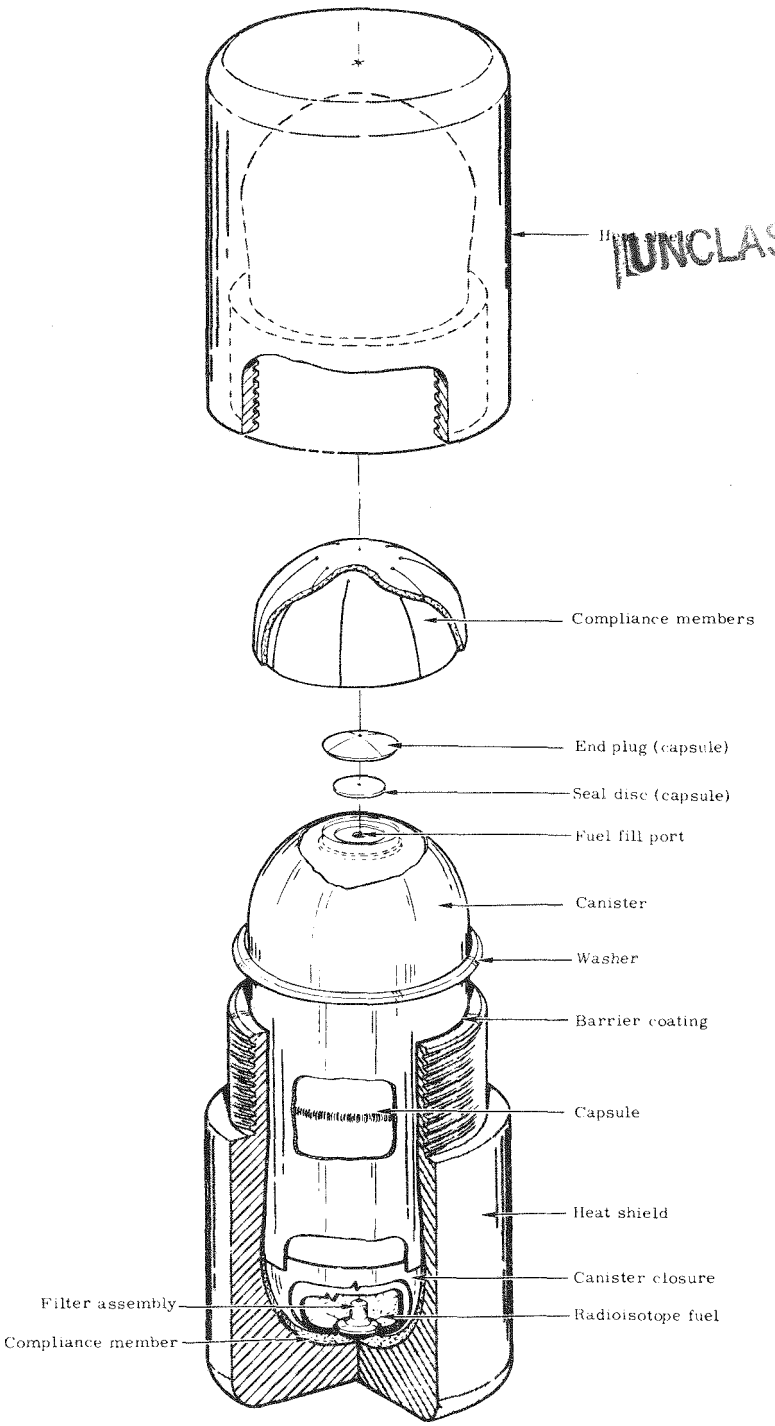


FIGURE 1 - SNAP-19B intact-upon-reentry heat source.

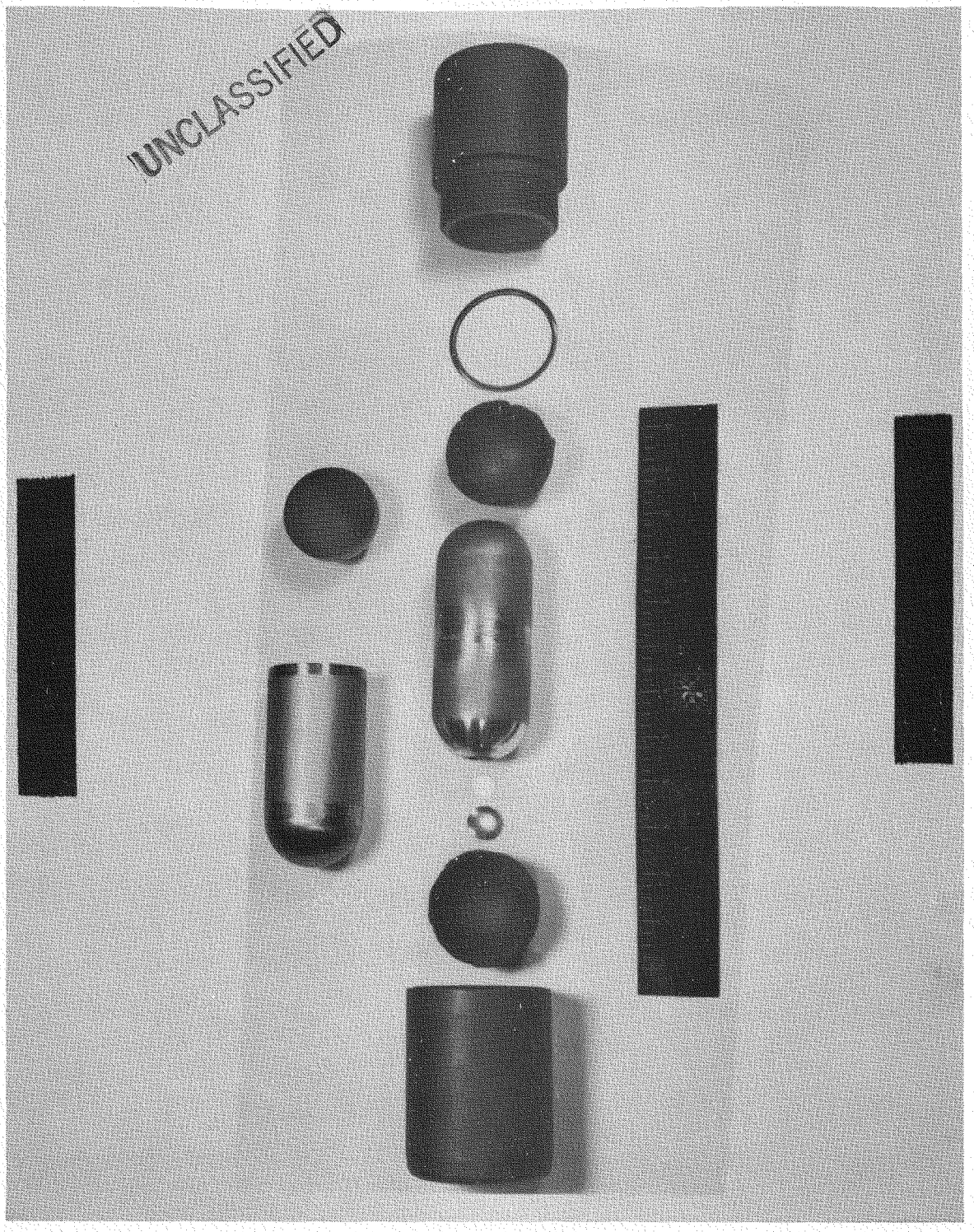


FIGURE 2 - Components for SNAP-19B (IRHS).

cylinder 3.0 in. (7.62 cm) in diameter by 6.5 in. (16.51 cm) long. It was designed to contain plasma-fired plutonium-238 dioxide microsphere fuel, to have a thermal capacity of 570 ± 17 W, and to operate in the same generator cavity as the SNAP-19B (Reference) heat source.

The fuel was sealed in a Haynes alloy No. 25 capsule with no liner. A filter/gas-vent combination was installed in one end of the capsule to allow the helium generated by the decay of the fuel to escape without a pressure increase.

To provide a barrier during reentry for prevention of possible reaction between the Haynes alloy No. 25-fuel mixture and the graphite heat shield into which it was enclosed, two protective measures were provided. A tantalum canister, coated on its inside surface with zirconia, was used as a barrier around the capsule. Also, a multilayer coating was applied to the inside surface of the graphite heat shield adjacent to the outside surface of the canister to provide further protection.

1. Fuel Capsule

The fuel capsule was made from two deep-drawn cups of Haynes alloy No. 25 having a nominal thickness of 0.060 in. (0.152 cm). The two cups were welded together at their open ends, the closed hemispherical ends forming the extremities of the complete capsule. Fueling, sealing of the fuel port, and welding of the closure cap were performed at one end of the capsule. The filter was installed in the other end.

The original filter was made from Haynes alloy No. 25 powder by pressing and sintering the powder in place and placing this frit in a 0.040 in. (0.102 cm) hole in a small filter assembly. This assembly was then welded into the capsule. The filter was designed to retain solid particles greater than 0.1 μm in diameter while passing greater than 0.1 std. cc/min of helium at 50 psi (3.5 atm) pressure differential.

In several flow tests with the Haynes alloy No. 25 filter the helium flow rate decreased after several hours at operating temperatures. This was undesirable since any rise in the capsule internal pressure, which might possibly occur after several months, could cause micro-cracking in the capsule wall. The Martin Company, therefore, investigated new materials that could be used in place of Haynes alloy No. 25 and that would still be compatible with the SNAP-19B (IRHS) system.

As a result of the Martin study a new filter element composed of zirconia was selected. This material, available in rod form from the Norton Company, is known as Rokide Z. A layer of platinum was electroplated onto the surface of this rod and then the surface was polished until the nominal diameter of the filter

element was 0.040 in. (0.102 cm). This element was then pressed into a new filter assembly.

Two SNAP-19B (IRHS) flight capsules, from which Haynes alloy No. 25 filter assemblies had been removed, were fitted with the new zirconia assemblies described above. The new filters were then checked for helium flow rate at room temperature. The design flow rates of 1.0×10^{-3} and 2.0×10^{-1} std. cc/sec were obtained when the pressure differentials over the filters were 1 and 10 psi, respectively. These rates were accepted by Martin Company for the two flight capsules.

2. Tantalum Canister

The canister was composed of two tantalum shells - a sleeve and a closure cap. A deep-drawn tantalum cup, 0.010 in. (0.025 cm) thick, was welded to a tantalum tube of the same thickness to form the sleeve portion, and another deep-drawn cup, 0.010 in. (0.025 cm) thick, formed the closure cap. The inner surface of both shells was flame-sprayed with zirconia to give a coating of 0.050 in. (0.127 cm) thick. A sliding fit was achieved between the outer surface of the closure cap and the inner surface of the sleeve. This mechanically fitted canister, coated on the interior with zirconia, served as a barrier to retard any movement of molten Haynes alloy No. 25-fuel mixture and to prevent it from contacting the graphite heat shield during reentry.

3. Compliance Members

The compliance members provided mechanical support of the canistered fuel capsule within the heat shield and allowed for thermal expansion of the capsule with respect to the surrounding graphite.

Each compliance member was made from two 1/8 in. (0.317 cm) thick layers of tantalum felt which were cut to a flat rosette pattern (Figure 3). A large rosette was put into each end of the graphite heat shield and was fitted so that the adjacent lobes of the rosette did not overlap. A small rosette was then placed over the larger one in each case. The finished compliance member acted as a socket to hold the canistered capsule in fixed longitudinal and lateral positions. During the heat source assembly the compliance members were compressed to about 40% of their original thickness.

It was found during the assembly of the heat sources at Mound Laboratory in August, 1967, that the two halves of the graphite heat shield (see Section III.A4) could not be screwed together and still be within the minimum gap requirement (Appendix D). A solution to this problem was effected by removing the smaller of the two tantalum felt rosettes from the male portion of the graphite heat shield. The final design of the heat source,

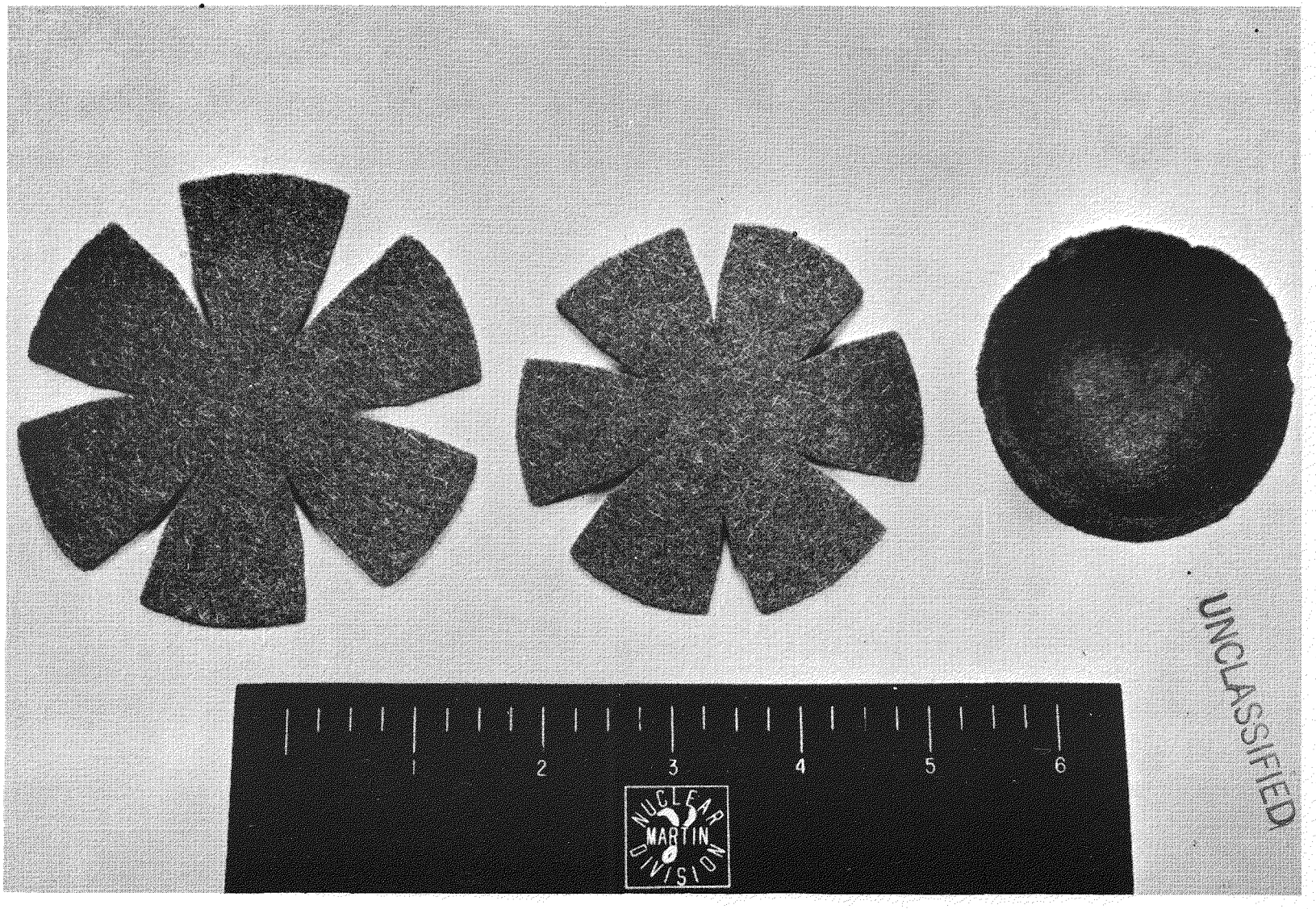


FIGURE 3 - Compliance pads for SNAP-19B (IRHS).

therefore, incorporated one large and one small tantalum rosette as the compliance member in the female half of the graphite heat shield and one large tantalum rosette in the male portion. These rosettes were hand-fitted at the Martin Company and held in position during shipment by a stainless steel dummy capsule having domed ends of the same dimensions as the actual fueled capsule.

4. Graphite Heat Shield

The heat shield was a two-part assembly designed for a threaded connection, and having walls of nominal 0.4 in. (1.016 cm) thickness. It was constructed of POCO AXM-5Q graphite, a material of high temperature strength and mechanical isotrophy. In the original design the diagonally opposite ends were beveled to promote instability during the reentry flight profile. Subsequent investigation by Martin Company and Sandia revealed that the bevels would not accomplish this purpose, hence they were not included in the final design. When threaded together, the male and female portions of the graphite heat shield seated tightly on a 0.010 in. (0.025 cm) thick tantalum washer at the inner joints, but left a gap approximately 0.035 in. (0.089 cm) wide at the outer surface. The heat shield was successively coated on the inside surface by first plasma spraying layers of molybdenum and tantalum, followed by flame spraying of tantalum-zirconia and finally of zirconia alone. This multi-layer coating prevented any molten materials in the fueled capsule from contacting the bare graphite during reentry. The tantalum washer, inserted at the inner joint between the two graphite halves, prevented direct contact and possible damage of the two sprayed ceramic surfaces.

B. FUEL

1. Nature

Plutonium-238 dioxide in the form of plasma-fired microspheres was the heat-producing radioisotope used in the SNAP-19B (IRHS) system. The decay scheme of plutonium-238 is shown in Figure 4. Figure 5 illustrates the physical form of plutonium-238 dioxide in the final stages of production at Mound Laboratory; Figure 6 shows a cross-sectional view of typical microspheres produced.

The fuel form was prepared at Mound Laboratory following established procedures. After the material was processed, it was then characterized to the fuel specifications established for the SNAP-27 program (Appendix A).

Table 1 shows typical properties of the plutonium-238 dioxide microsphere fuel used in the SNAP-19B (IRHS) capsules.

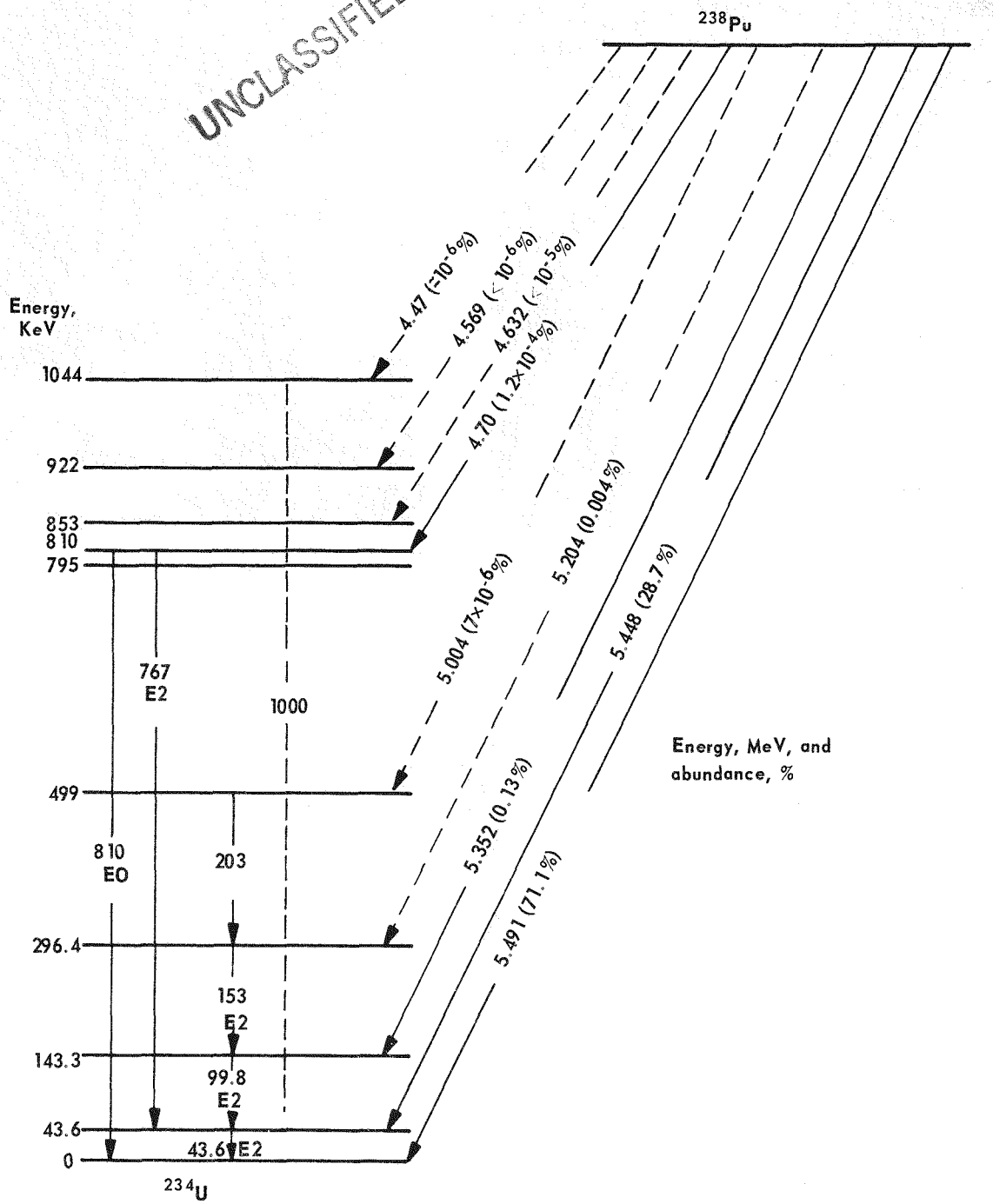
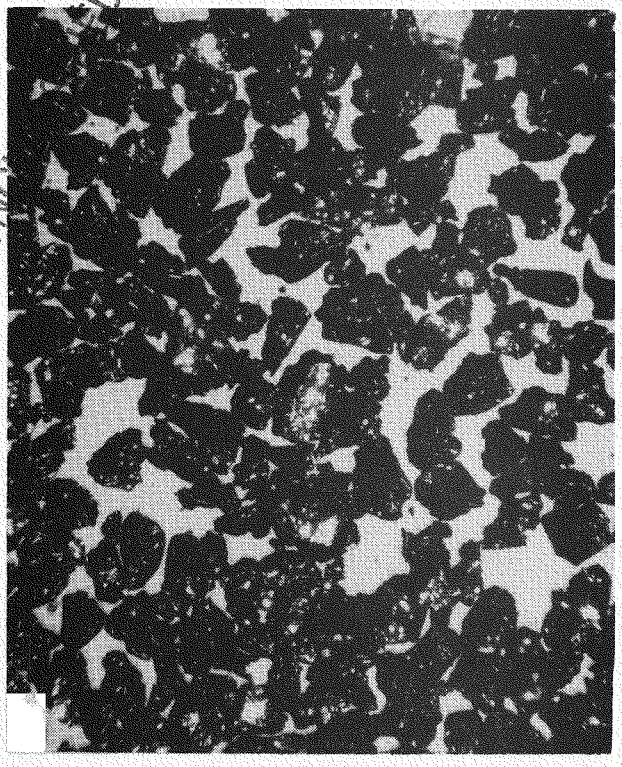
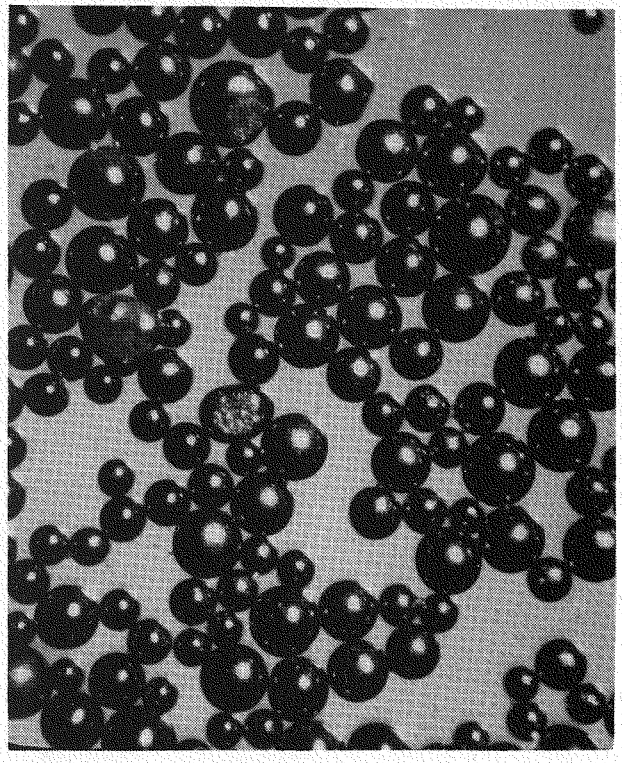


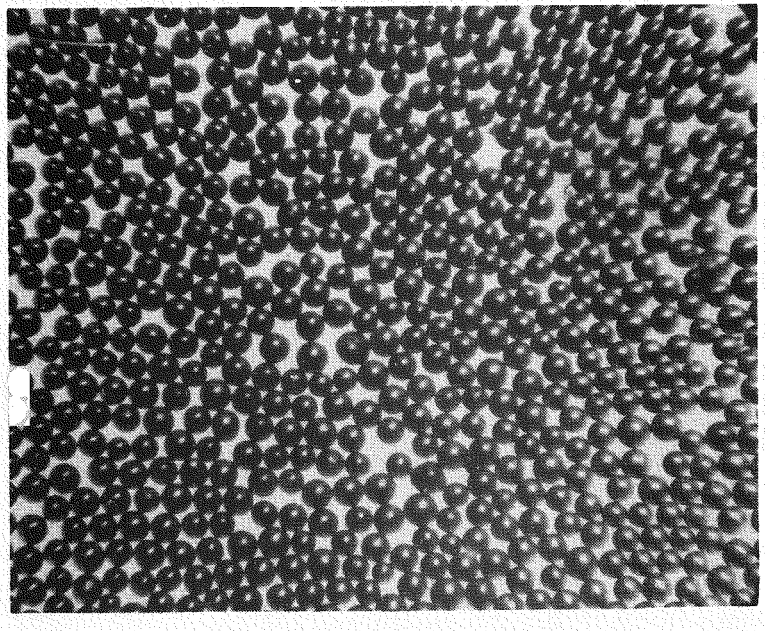
FIGURE 4 - Decay scheme of plutonium-238.



(A) PuO_2 feed material (before going through plasma torch).



(B) PuO_2 microspheres after torching (not segregated).



(C) PuO_2 microspheres (segregated).

FIGURE 5 - Plutonium-238 dioxide in final steps of microsphere production at Mound Laboratory.

TABLE 1

TYPICAL PROPERTIES OF PLUTONIUM-238 DIOXIDE MICROSPHERES

Particle Density (production grade)	9.8 - 10.4 g/cc
Bulk Density	~6.7 g/cc
Power Density	2.5 - 2.8 W/cc
Hardness	~1163 kg/mm^2
Cation Impurities (^{231}Pa, ^{232}Th, ^{233}U, ^{235}U, ^{236}U, ^{236}Pu, and ^{237}Np)	Less than 1 wt % of the fuel
Other Cation Impurities except ^{234}U	Less than 2 wt % of the fuel
^{236}Pu Content	~1.0 - 1.2 ppm
Melting Point	2150°C - 2355°C
Stoichiometry (O/^{238}Pu at. ratio)	1.96 - 2.04
Isotopic Ratio	79.38 - 81.91% ^{238}Pu
Solubility in H_2O	1.26×10^{-3} µg/day/mm^2
Neutron Count	$1.8 - 2.2 \times 10^4$ n/sec/g ^{238}Pu*

*Based on neutron emission data taken on SNAP-19B (IRHS) capsules

2. History

The first four SNAP-19B (IRHS) capsules to be fueled and fabricated contained filters of Haynes alloy No. 25. It was necessary to draw qualified fuel from the SNAP-27 program for these heat sources since there was insufficient time to prepare and qualify new fuel and still meet schedule requirements. It was also necessary to fabricate the four sources before filter flow tests were completed. Data from these tests (Section V.A) showed subsequently that the Haynes alloy No. 25 filters, after several hours at operating conditions, would not pass helium at the designed flow rate.

As described in Section III.A1, Martin Company developed and tested a new filter using zirconia rod plated with platinum. It was, therefore, decided that two additional fueled IRHS capsules should be fabricated with zirconia filters to serve as the flight units for the program. It was also decided that two of the fueled

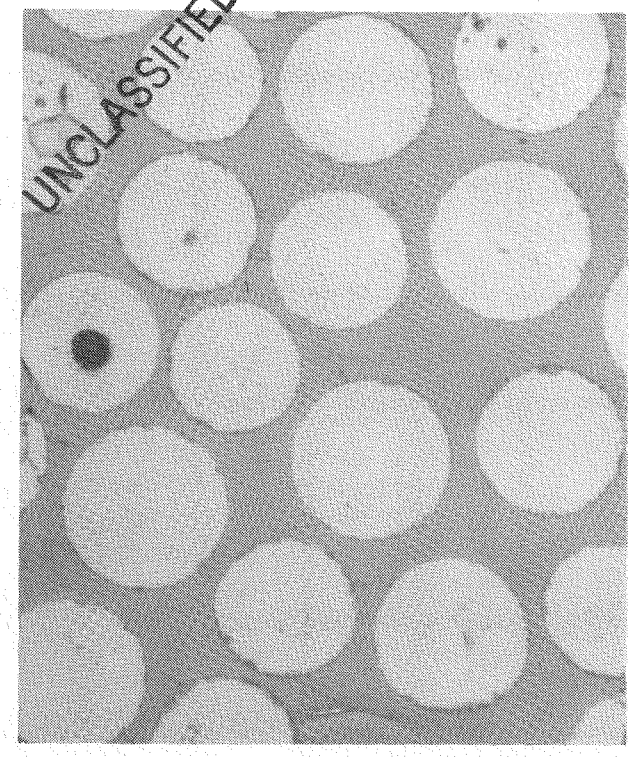


FIGURE 6 - Cross section of typical plasma-fired plutonium-238 dioxide microspheres.

capsules having Haynes alloy No. 25 filters would be used as prototype units for the program, and the two remaining capsules would be cut open to augment the supply of fuel available at the time.

Resolution of the fuel problem for the two flight capsules was accomplished as follows as a result of decisions by the task force and by the AEC/SNS. Fuel from one of the capsules having a Haynes alloy No. 25 filter was directly usable, without need for further processing, and hence was incorporated into one of the flight capsules. The other SNAP-19B (IRHS) capsule was undergoing a filter flow test at the time and this fuel was not available. Accordingly, fuel for the second flight capsule was secured by cutting open a SNAP-19B (Reference) capsule and using its fuel without further qualification.

The historical sequence outlined above is given in Table 2, along with the quantities of fuel involved in the respective capsules.

C. SHIPPING CASK

The SNAP-19B (IRHS) shipping cask (Figure 7) was a modification of the cask used to ship the SNAP-19B (Reference) capsule. The original cask consisted of a finned aluminum body with a cavity large enough to accept the reference capsule. The latter was then held in place with a heavy aluminum plate secured by bolts.

Modification of the cask was required in view of the special handling procedure adapted for the SNAP-19B (IRHS) capsule. After being assembled into its canister and heat shield (see Sections III.A and IV.F), the heat source was sealed in an argon atmosphere into a stainless steel primary shipping container. Valves were provided on each end of the container to allow a flow of inert gas through the container for contamination checks prior to opening the seal. To assure that the heat source would not be damaged during shipment, Min-K 2002 support pads were provided at each end of the container. This primary container was sealed by inserting a metal O-ring between the two halves and then tightening three bolts to a torque of 180-190 in.-lb (208-219 cm-kg).

TABLE 2

FABRICATION SEQUENCE FOR SNAP-19B (IRHS) UNITS

Capsule Serial No.	Type of Filter	Origin of Fuel Used	Total Wt. of Pu-238 Isotope(g)	Fueling Date	Date Shipped to MMC[c]	Date Returned to MRC[c]	Final Disposition
342/360	Haynes alloy No. 25	SNAP-27 Qualified Fuel	1012.3	8-08-67	9-04-67	12-03-67	Cut open on 12-20-67
370/376[a]	"	"	1004.0	8-10-67	9-04-67	11-29-67	Returned to MMC on 11-30-67 after disassembly and assembly of new canister and graphite heat shield. Returned to MRC on 1-12-68 and cut open on 2-08-68.
341/358[a]	"	"	1005.5	8-15-67	11-27-67	1-12-68	Subjected to filter flow tests prior to shipping to MMC on 11-27-67. Cut open on 2-01-68.
373/380	"	"	1006.5	8-17-67	--	--	Cut open on 11-27-67 and the fuel used in SN-361/368.
369/375[b]	ZrO_2	SNAP-19B (Reference) Capsule 309	1010.2	11-20-67	12-06-67	--	On board aborted NIMBUS B flight 5-18-68.
361/368[b]	"	SNAP-19B (IRHS) Capsule 373/380	1006.2	11-28-67	12-06-67	--	On board aborted NIMBUS B flight 5-18-68.

[a] Prototype capsule for SNAP-19B (IRHS) qualification test
[b] Flight capsule for SNAP-19B (IRHS) NIMBUS B mission
[c] MMC = Martin-Marietta Corp; MRC = Monsanto Research Corp.

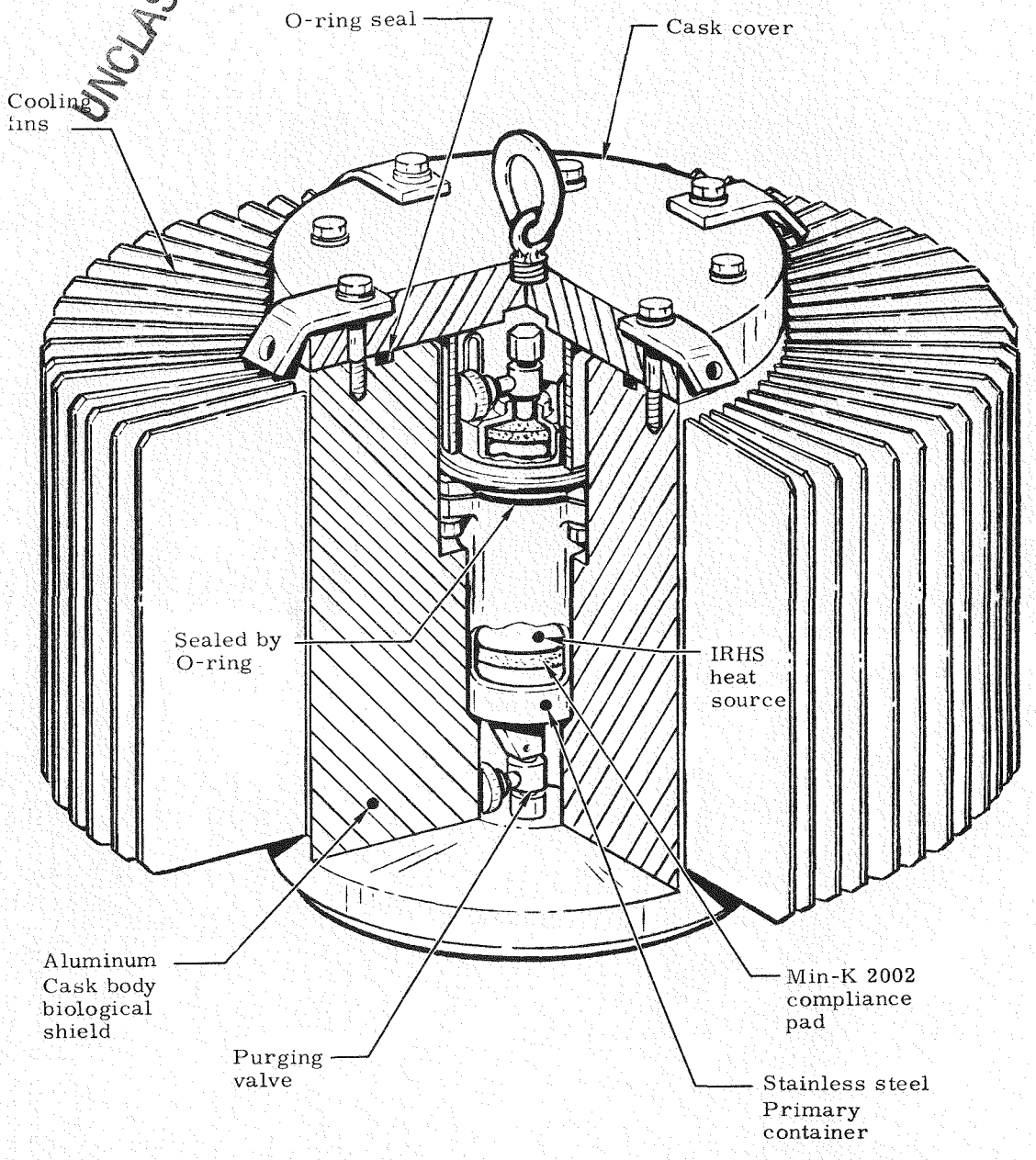


FIGURE 7 - Modified shipping cask for SNAP-19B (IRHS) capsule.

In the light of the above design, the modification of the shipping cask to accommodate the SNAP-19B (IRHS) capsule comprised enlargement of the cavity to accept the primary shipping container and provision for sampling the inert atmosphere surrounding the heat source prior to breaking the seal.

In practice the sealed primary container was removed from an inert atmosphere glove box and placed in the cavity of the finned aluminum shipping cask body. A shim, to eliminate any axial clearance between the primary container and the cask cover, was then placed over the primary. The cask cover was put in place and secured by eight 5/8 in. (1.59 cm) diameter bolts. These bolts were then torqued to about 500 in.-lb (577 cm-kg).

IV. HEAT SOURCE FABRICATION

Fabrication of the SNAP-19B (IRHS) heat sources followed a carefully controlled processing sequence (Figure 8). Details of the various steps are described in the following and also in Appendix B.

A. GAGING

Shipping regulations required a radiation level less than 10 counts/min at the surface of the SNAP-19B (IRHS) capsule. To meet these regulations it was necessary to construct a special welding and cooling fixture for the capsule which would minimize radiation hazard to personnel during fueling and welding and would also reduce the subsequent decontamination to a minimum. This fixture is shown in Figure 9 and is described in Section IV.B. To obtain the best possible fit of the capsule within the fixture and to ensure a uniform closure weld after fueling, accurate gaging of various vital dimensions related to concentricity and sphericity of the capsule and domed ends was imperative. Figure 10 illustrates the areas and dimensions of interest.

In view of the tight program schedule, it was agreed that the following inspections on hardware received from Martin Company would be conducted and recorded at Mound Laboratory:

1. Dimensions of the closure cap. These should match those of the recess in the capsule wall so that the cap would fit in place with a mismatch not exceeding 0.005 in. (0.0127 cm).

2. Outside diameter of the seal disc. The disc should fit into the recess in the capsule to provide 0.003 - 0.005 in. (0.0076 - 0.0127 cm) clearance.

3. Depth of the seal disc recess in the capsule. This dimension should equal the seal disc thickness within ± 0.002 in. (0.0051 cm).

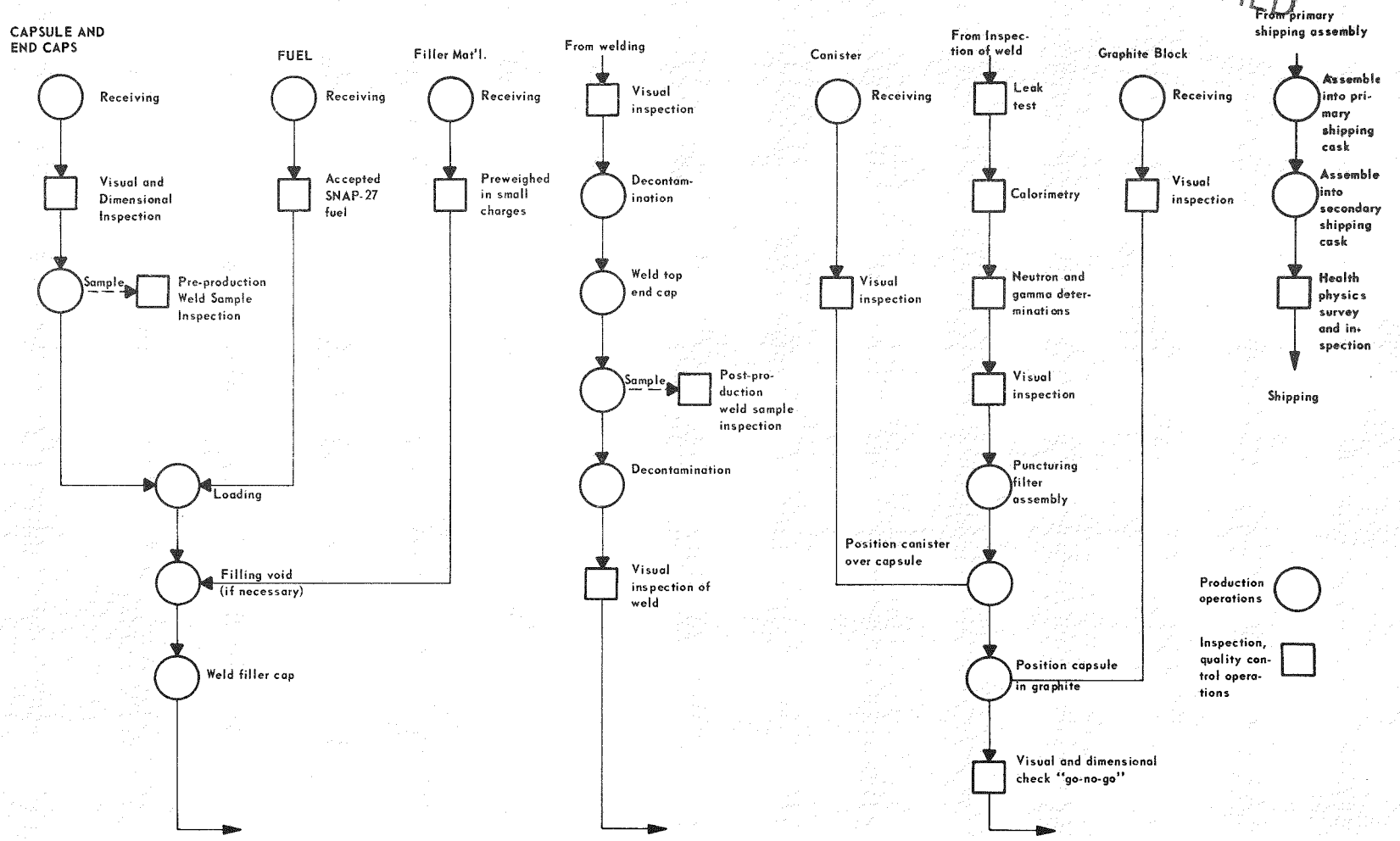


FIGURE 8 - Process flow diagram for SNAP-19B (IRHS).

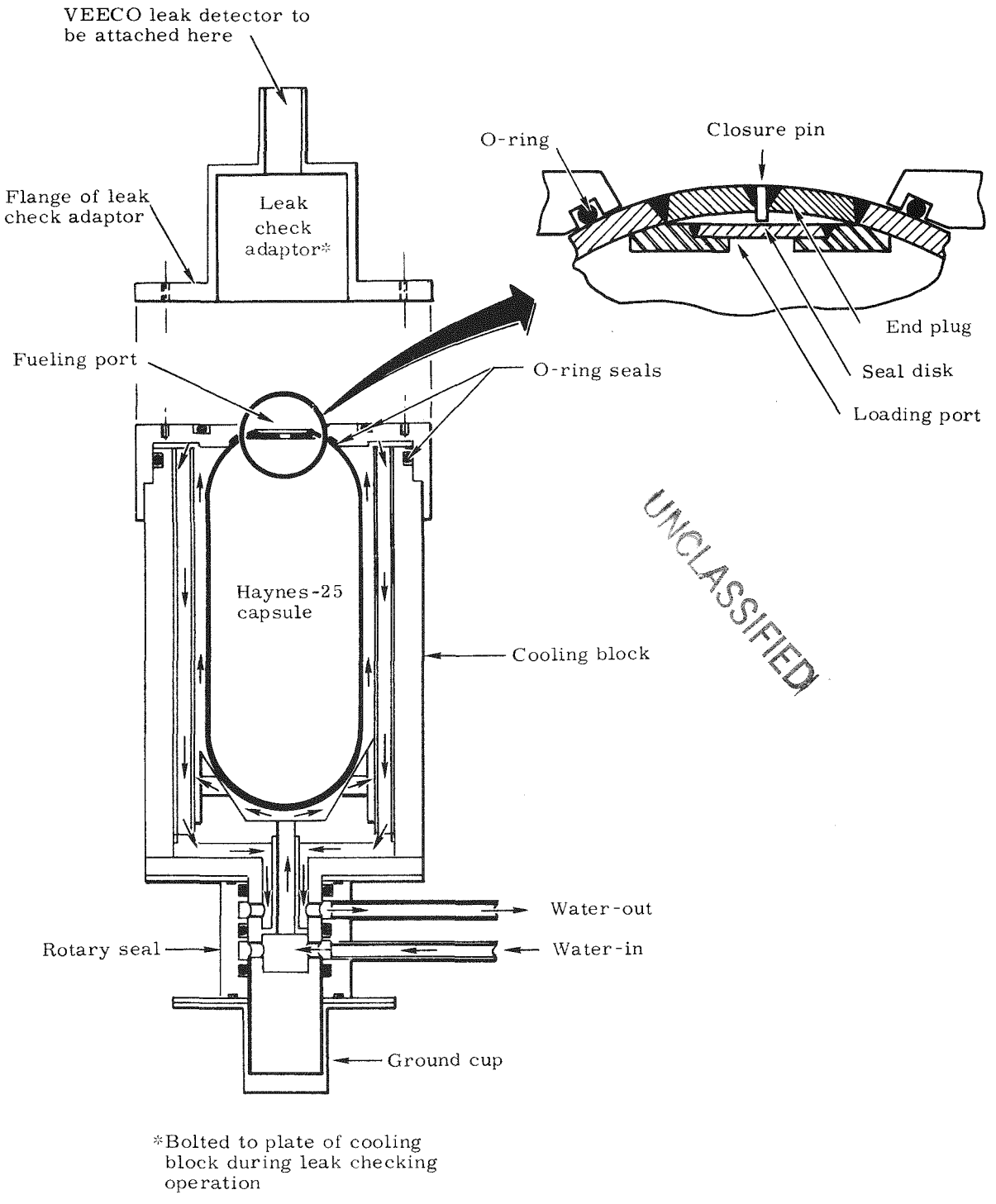


FIGURE 9 - Welding and cooling fixture for SNAP-19B (IRHS) capsule.

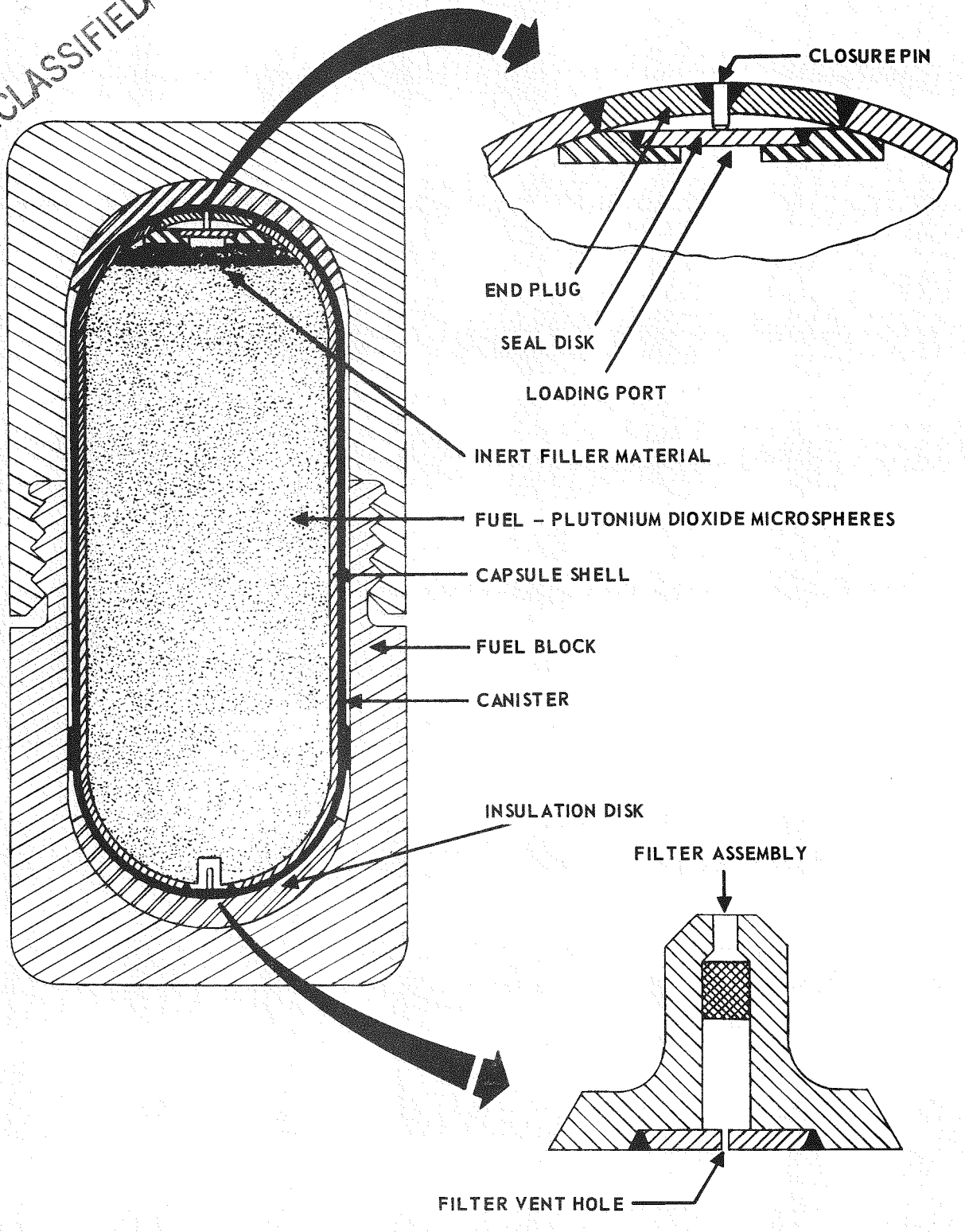


FIGURE 10 - SNAP-19B (IRHS) capsule showing details of end design.

The above inspections at Mound Laboratory pertained to both weld development and flight capsule hardware. Any attributes that were not within the established specifications were noted and a deviation request submitted to the task force and the AEC/SNS for acceptance.

The inspection program at Martin Company on the same hardware, prior to shipment to Mound Laboratory, included gaging as noted above, as well as two additional tests:

1. Smoothness of capsule surface. The surface should have a finish of 32 rms (root mean square) on the spherical fueling end.

2. Concentricity of capsule for welding. By mounting the bottom of the capsule in a jig having a 50° taper (simulating bottom of cooling block shown in Figure 9), Martin would measure the maximum concentricity at the contacted surface. This should not exceed 0.005 in. (0.0127 cm) total indicator reading (TIR).

B. WELD DEVELOPMENT

Since a capsule of the IRHS design had not previously been welded at Mound Laboratory, welding parameters were developed. This development program required approximately one month and was completed on schedule.

A cooling block (Figure 9) was designed to cool the capsule surface and to prevent alpha contamination. Since the capsule had domed ends, a taper was provided in the bottom of the chill block to ensure that the capsule was centered throughout the welding operation. After the capsule was placed into the block, the top was screwed down until a seal was made on a silicone O-ring. The capsule was cooled by passing tap water through the block.

To ensure production of acceptable welds it was essential that the capsule surface in the sealing area be as smooth as possible and that the concentricity of the capsule be within a tolerable range. These requirements were met by adequate gaging (see Section IV.A).

The weld development effort was conducted on the fueling end of half capsule, and then full capsule, units. As shown in Figure 10 an inner weld was required for the seal disc and an outer weld for the closure cap. Further details on these studies are given in the following:

1. Seal Disc Weld

The purpose of the inner weld was not to provide structural strength, but rather to seal the capsule after fueling in order to prevent any foreign matter, such as a constituent from the decontamination operation, from entering the capsule. This

precautionary sealing operation was considered imperative in view of the low level of radiation (<10 counts/min, see Section IV.A) which could be tolerated on the capsule surface.

It was the opinion at Mound Laboratory that the required penetration on this inner weld should be about 10% of the seal disc thickness, i.e., 10% of 0.010 in. (0.0254 cm). Some difficulty was experienced in maintaining the weld zone coincident with the seam; however, this was corrected by first tack-welding the seal disc in several places and mounting the welding electrode slightly outside the seam. A typical metallographic cross section of this weld in shown in Figure 11.

2. Closure Cap Weld

The closure cap weld (outer weld) was a structural weld and required at least 80% penetration of the 0.060 in. (0.1524 cm) cap thickness. Considerable difficulty was encountered during the development of parameters for this weld. It was not possible to control the course of the weld pool for any set position of the electrode, and there was evidence of pressure buildup between the cap and seal disc which could lead to weld blowout. These problems were resolved by changing the taper on the bottom of the cooling block, installing a small cooling block at the center of the closure cap, and providing a 0.030 in. (0.0762 cm) diameter hole through the center of the closure cap to relieve any gas pressure during welding. A typical metallographic cross section of the closure cap weld is shown in Figure 12.

3. Pin Weld

After completion of the closure cap weld, a Haynes alloy No. 25 pin of diameter slightly less than 0.030 in. (0.0762 cm), was placed in the hole and welded to achieve a 10-15% pin weld penetration. A typical metallographic cross section of this weld is shown in Figure 13.

To determine the validity of the welding parameters established for the above welds, two IRHS capsules were loaded with a fuel simulant mixture comprising a 1:1 weight ratio of molybdenum and tungsten powder. A weld control sample was made before and after the loading of these two capsules. The capsules were then shipped to Martin Company for impact testing. The results of these tests indicated clearly that the welding parameters used were satisfactory.

C. PRE-FABRICATION QUALITY CONTROL

A quality control program was implemented at Mound Laboratory to ensure that the SNAP-19B (IRHS) fueled capsules were of the desired high quality. Specifically, this program assured that the product

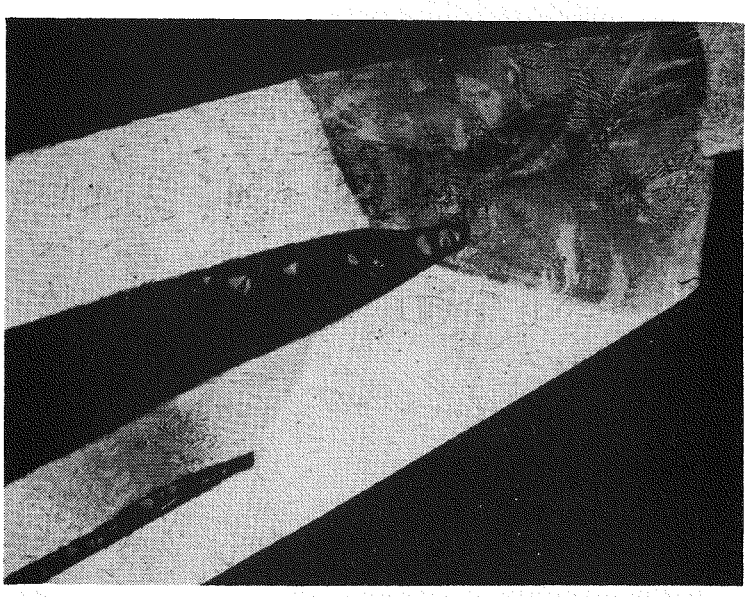


FIGURE 11 - Typical metallographic cross section of seal disc weld. (Magnification 16X)

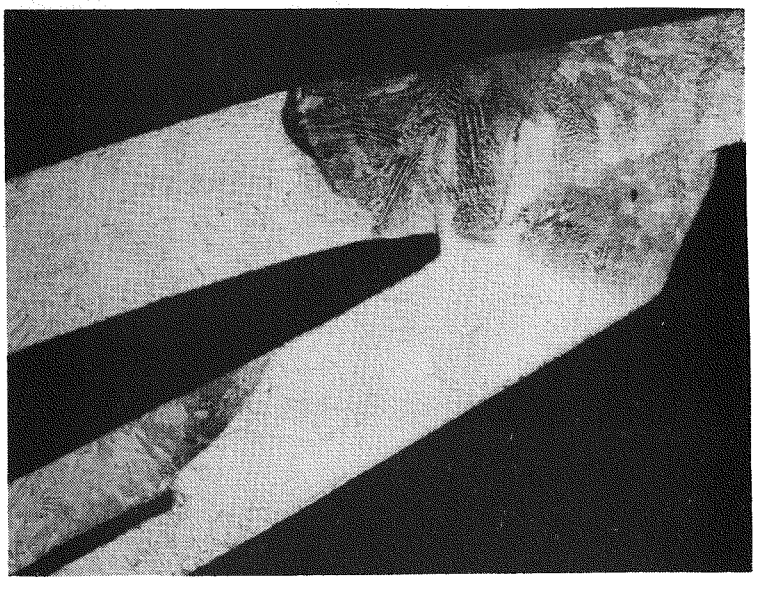


FIGURE 12 - Typical metallographic cross section of closure cap weld. (Magnification 16X)

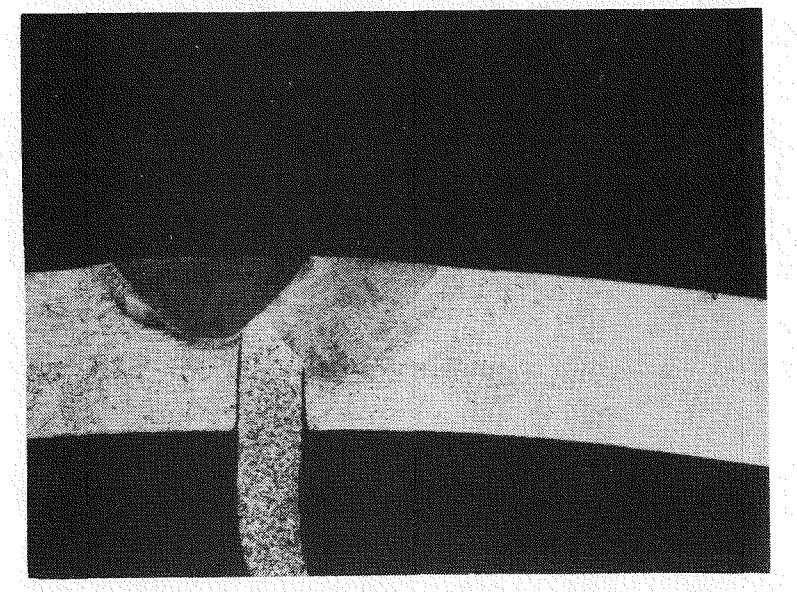


FIGURE 13 - Typical metallographic cross section of pin weld. (Magnification 16X)

was manufactured by a controlled process, that components and assemblies conformed to drawings and specifications, and that non-conformance of components, process, and/or product was appropriately documented. If significant deviations existed, these deviations were reviewed by the task force and submitted to the AEC/SNS for disposition. Also, a data package was prepared, documenting the product quality characteristics of each capsule,and submitted to the Atomic Energy Commission, Dayton Area Office (AEC/DAO) for quality approval.

The following tasks were performed prior to the actual fabrication of the capsules.

1. Gaging

   All capsule components received from Martin Company were gaged at Mound Laboratory, as described in Section IV.A. Any outstanding attributes were noted and, if not detrimental to the fabrication of the sources, were treated as deviations which were in turn reviewed by the task force and the AEC/SNS.

2. Weld Control Samples

   Two different pre-fabrication weld control sampling techniques were used in fabricating the SNAP-19B (IRHS) capsules. This was required because four heat sources were fabricated with filters of Haynes alloy No. 25 and two with zirconia.

For the case of the Haynes alloy No. 25 filters, a weld control sample using qualified hardware was prepared before the fueling of the first two capsules and again before fueling of the last two. After welding of the sample, the closure cap weld was first checked for leaks and then tested with dye penetrant for possible cracks and pores. The weld was also radiographed to check for cracks and inclusions. Finally, the weld was examined metallographically. These quality control operations are described in Section IV.E.

When the two capsules with zirconia filters were fabricated it was necessary to change slightly the weld control sample procedure, because of the limited fabrication time necessitated by an early desired shipping date. A weld control sample was produced before the fueling of each of the first and second capsules. This sample was then tested with dye penetrant to check visually for cracks and pores followed by metallographic cross sectioning to search further for cracks and to determine the weld penetration at 250 magnification. If no cracks or pores were evident and the penetration was within specification (80% of cap wall thickness), the capsule was fueled on the same day. The balance of the metallographic inspection was then performed on the weld areas.

In another pre-fabrication quality control check the volume of each flight capsule was determined by use of denatured alcohol. This was necessary to ensure that there was sufficient space for the required fuel in the selected capsule. It was found that the volumes determined by Mound were within ± 2 cc of those provided by Martin Company.

D. ENCAPSULATION OF FUEL

The SNAP-19B (IRHS) capsules were encapsulated at Mound Laboratory after procedures had been established and accepted and after two capsules had successfully passed impact tests at the Martin Company (see Section IV.B).

The first fueled capsules to be fabricated were the four containing Haynes alloy No. 25 filters; fueling dates and other details of these units are given in Table 2. Each capsule was loaded with sufficient plutonium-238 dioxide microspheres to provide the desired thermal output of 570 ± 17 W. After loading, any void area in the capsule was filled with a known weight of plasma-fired zirconia microspheres. Closure of the loaded capsule was then effected by TIG welding of the seal disc, closure cap, and pin. Details of these various operations, which were conducted in the presence of a representative from the Martin Company, are given in Appendix B. No major problems were encountered. The contamination level on the outside surface of each of the completed capsules was less than 10 counts/min.

Subsequent results from flow tests conducted on the Haynes alloy No. 25 filters revealed that the filters did not permit flow at the design rate (see Section V.A1). Accordingly, as mentioned in Section III.A1, the Haynes alloy No. 25 filter assemblies were removed from two SNAP-19B (IRHS) capsules and two zirconia filters were installed instead. These two units were then encapsulated as the four above (Table 2). Again, no major problems arose and the surface contamination was less than 10 counts/min.

E. POST-FABRICATION QUALITY CONTROL

After fabrication the capsules were subjected to the following post-fabrication quality controls.

1. Helium Leak Checking

A Veeco MS9AB mass spectrometer leak detector, calibrated with a standard leak, was used to measure the leak rate of the closure cap weld. The capsule surface was first cleaned and then a special leak adaptor (Figure 14) was bolted to the top of the welding fixture. A vacuum was applied to the closure cap area which was connected to the detector through the adaptor. All capsules had a leak rate less than the acceptable limit of 1×10^{-6} standard cc of helium/sec.

2. Dye Penetrant Inspection

In this test a special dye (Tracer-tech, manufactured by the Shannon Luminous Materials Company) was applied to the surface of the weld area to be examined. After the dye had completely wetted the surface, it was washed off with a solvent. The part was then sprayed with a developer and inspected under ultraviolet light. Dye that penetrated into surface defects and was not eliminated by the subsequent solvent treatment fluoresced under the ultraviolet light, establishing the location of the defect. The defect was then observed under a high magnification and evaluated. The discovery of a crack or pore could be cause for rejection as defined in the established procedures (Appendix B). Weld control samples in the SNAP-19B (IRHS) program met the required specifications.

3. Radiography

It was not feasible to radiograph the closure and pin welds of the IRHS capsule because, due to the design of the ends of the capsule, radiographs would not show the weld areas. Therefore, the side of each capsule was x-rayed to observe the fuel level. Figure 15 illustrates a typical radiograph. The average void depth in each capsule after encapsulation of the fuel was about 0.250 in. (0.635 cm).

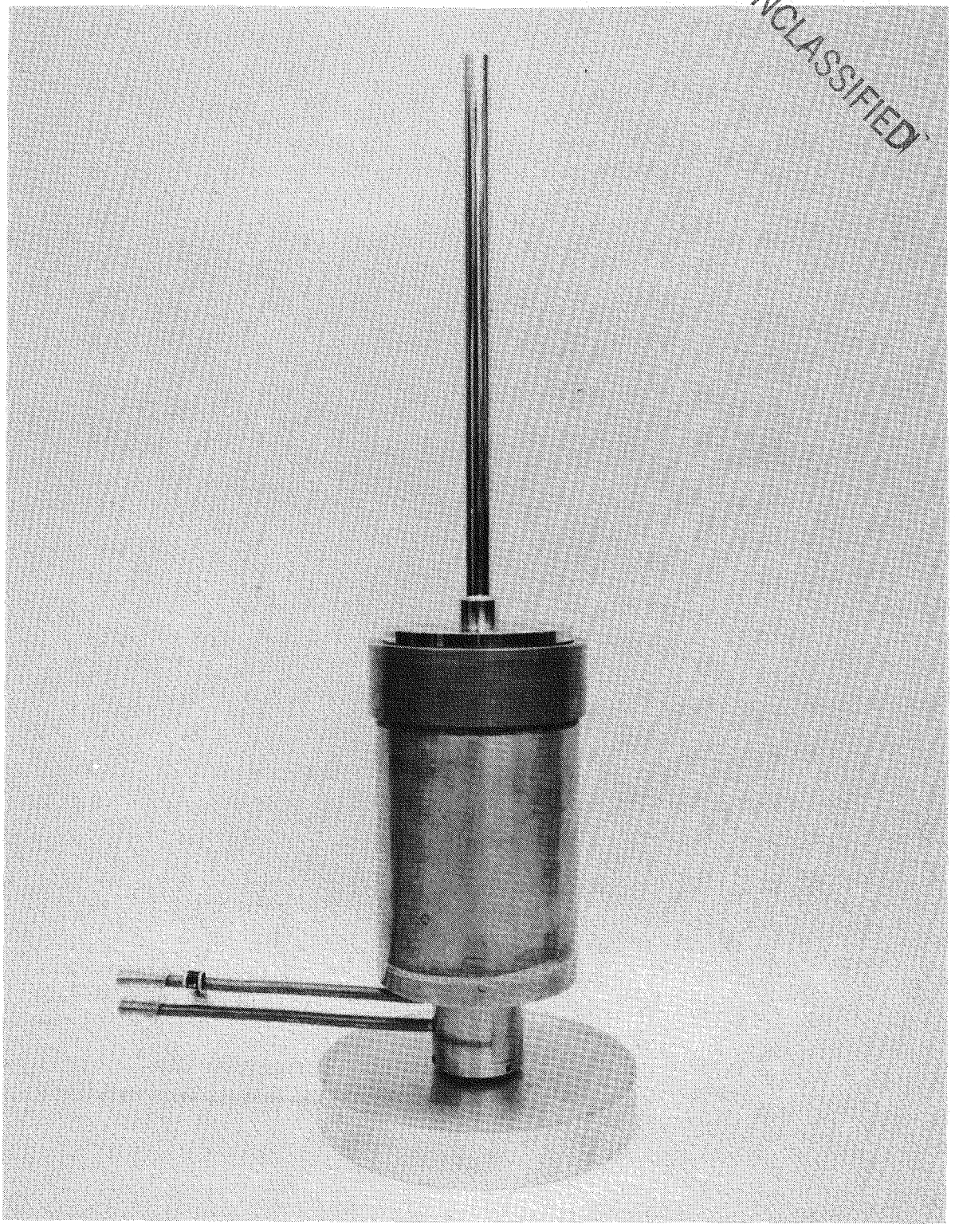


FIGURE 14 - Leak check adaptor for SNAP-19B (IRHS) capsule.

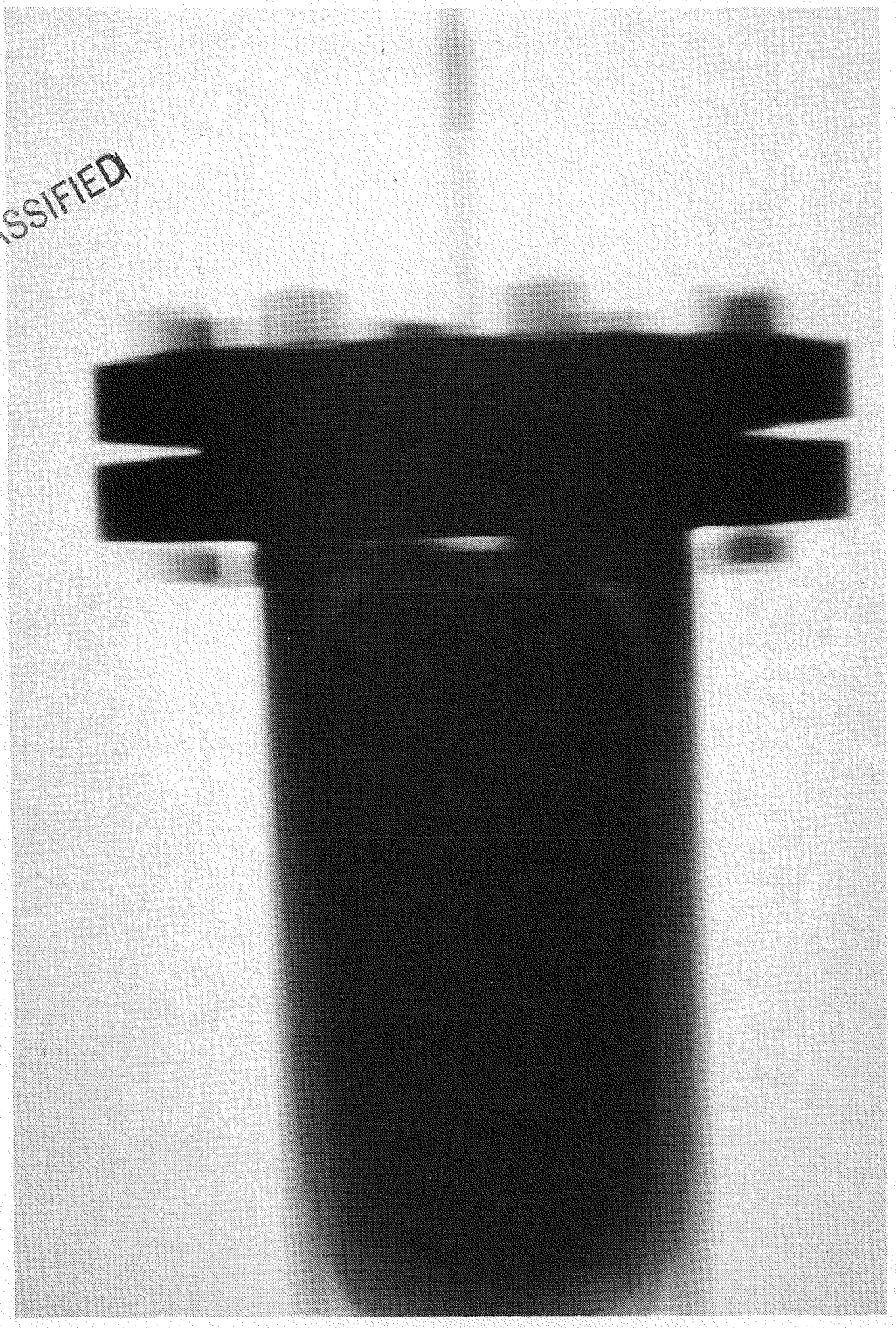


FIGURE 15 - Typical radiograph of capsule showing fuel level.

4. Metallography

To establish the integrity of the closure cap weld, weld control samples were prepared by sectioning at one point through the weld overlap, at another through the manual weld bead, and at a third point through the closure pin weld. The above cross-sections were mounted, polished, and etched to bring out the weld profile. Each section was photographed at 16X and visually inspected at 250X for cracks and penetration. All weld control samples met the specifications.

5. Calorimetry

After each fueled source had been leak checked and radiographed, it was placed in a calorimeter can (Figure 16) and the thermal power determined by standard calorimetric methods. These values are listed in Table 3.

TABLE 3

THERMAL POWER OF SNAP-19B (IRHS) HEAT SOURCES

Heat Source Number	Power[a] [W (th)]	Date Measured
342/360	575.8	August 10, 1967
370/376	571.9	August 14, 1967
341/358	572.7	August 28, 1967
373/380	572.5	August 22, 1967
369/375	574.6	November 28, 1967
361/368	572.3	November 29, 1967

[a] Error ± 1% at 95% confidence level

Each thermal power cited in Table 3 was the average of at least five calorimetric values obtained on each of the six sources. The specified power for each source was 570 ± 17 W including calorimetry error.

6. Neutron Emission

The neutron flux of each source was measured against an N.B.S.-calibrated standard using a DePangher-type precision long counter (Figure 17). The flux values are given in Table 4.

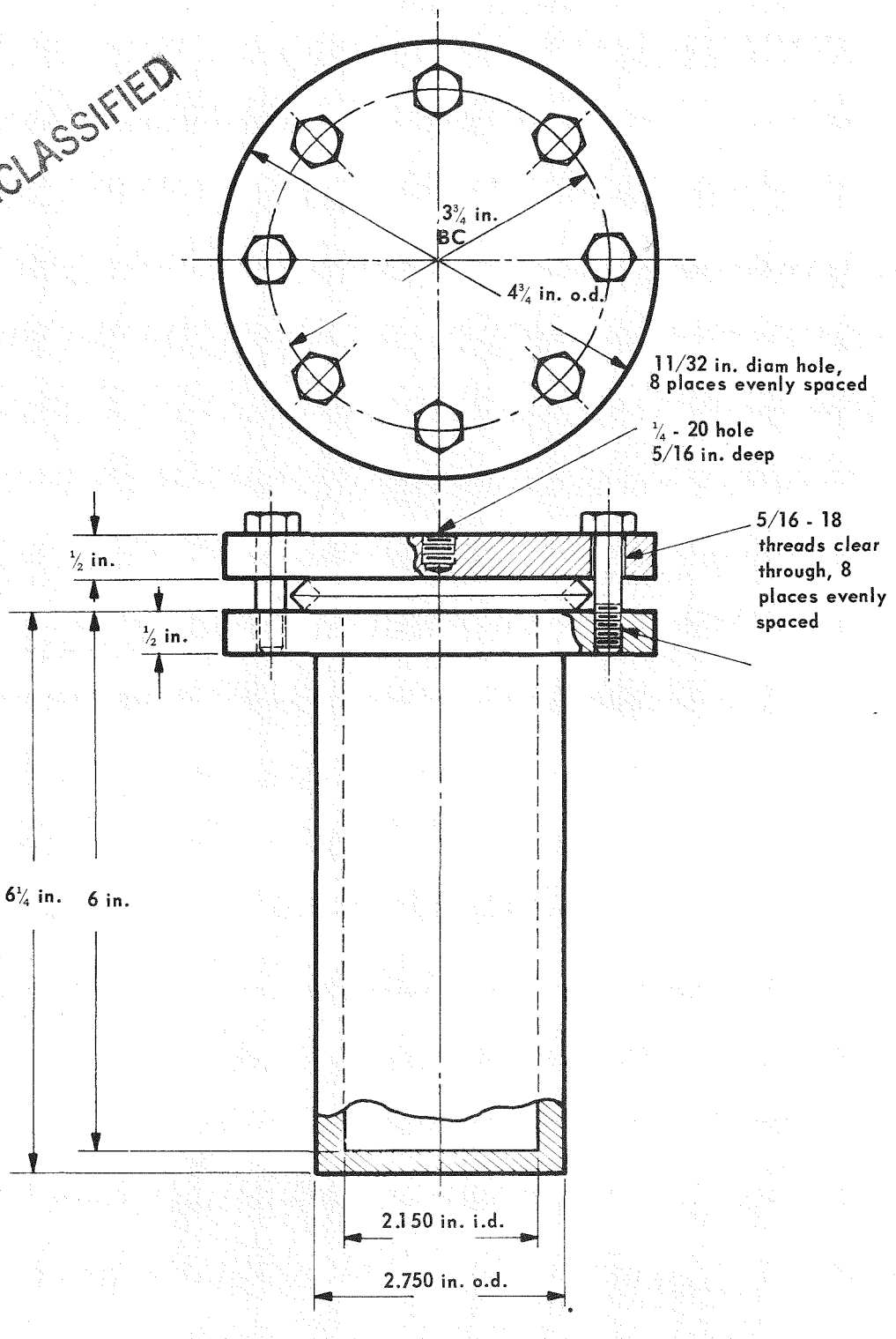


FIGURE 16 - Calorimeter can and transfer container for SNAP-19B (IRHS) capsule.

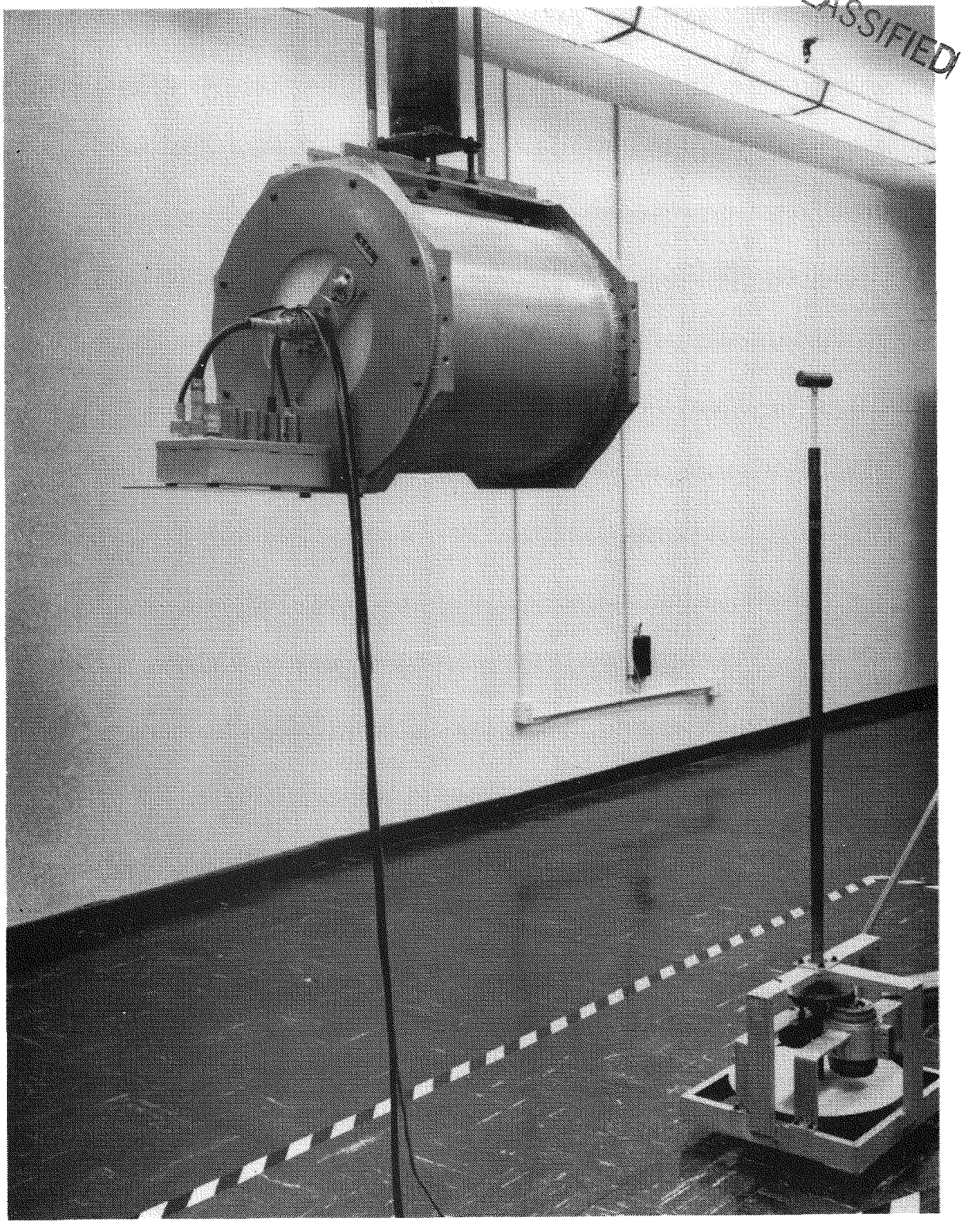


FIGURE 17 - Typical equipment for measurement of neutron emission from fueled capsules.

TABLE 4

TOTAL NEUTRON EMISSION DATA

Source Number (SN)	Neutron Flux (n/sec)[a]	Date Measured
342/360	2.42×10^7	August 11, 1967
370/376	2.33×10^7	August 11, 1967
341/358	2.32×10^7	August 21, 1967
373/380	2.36×10^7	August 21, 1967
369/375	2.54×10^7	November 29, 1967
361/368	2.32×10^7	November 29, 1967

[a] ± 6% absolute uncertainty

7. Gamma-Ray Spectra

Gamma-ray spectra were taken on each of the first four sources using a NaI(Tl) detector, 3 in. (7.62 cm) by 3 in. (7.62 cm). For the last two sources, 369/375 and 361/368, a similar detector, 2 in. (5.08 cm) by 2 in. (5.08 cm) was used. The detectors were protected by a lead shield to reduce scattered radiation. The source was positioned in a bucket of water, approximately 19 ft (5.8 m) from the detector, so that the detector was oriented perpendicular to the axis of the cylinder.

Spectra were measured for each source covering the approximate energy ranges of 30 - 850 keV and 100 keV - 2.8 MeV. These spectra showed no unusual indications and were identical to those normally characteristic of plutonium-238 heat source material.

8. Dose Rates

Neutron and gamma dose rate measurements were taken in air and at various distances from the sides and end of the bare sources. For the side measurements the capsules were positioned with the closure cap facing up and for the end measurements the closure cap faced away from the detector. All distances were measured from the center of the detector to the center of the sources.

The instruments used in this study were:

1. Texas Nuclear Nemo Spherical Neutron Dosimeter Series 9140
2. Victoreen Radector II gamma survey meter.

The calibration of these instruments was checked before and after each set of measurements.

For all sources the combined neutron and gamma dose rates on either the side or end of the capsule did not exceed 41 mrem/hr at a distance of 100 cm. The corresponding maximum allowable total dose rate called for in the specification was 55 mrem/hr. Detailed data are given in Appendix C.

F. FINAL ASSEMBLY OF HEAT SOURCES

After post-fabrication quality control was completed, each of the four fueled capsules containing Haynes alloy No. 25 filters was placed into a tantalum canister and then into a graphite heat shield using procedures outlined in Appendix D.

The assembly operation, which was first applied to capsule SN 342/360, was improved as a result of difficulties encountered. The canister sleeve was put over the capsule using a special tool (Figure 18). The end-cap was then properly aligned and pressed into place (Figures 19, 20, 21). The surface temperature at the center of the canistered capsule was measured making use of the cradle and thermocouple fixture shown in Figure 22. The capsule was then placed into the graphite block (Figure 23), and the two halves joined with the aid of two strap wrenches (Figure 24).

Some difficulty (see Section III.A3) was experienced in this operation, and it was found that the two halves could not be joined beyond the first few threads. The two halves of the heat shield were disassembled; the tantalum felt rosette pads had compacted and prevented tightening of the two halves. When new pads were installed and the assembly operation repeated, the same result was obtained. After review with the Martin Company it was decided that the surface of the domed portion of the canister was not sufficiently smooth and that this factor, along with the high temperature present, caused the tantalum pads to stick to the domed end and then twist as the graphite halves were being assembled. The problem was resolved by removing one of the pads from the end. The graphite halves were then screwed together and the final assembly completed by placing the source in a primary shipping container and then into a shipping cask (Figure 7).

The second source (capsule SN 370/376) was assembled using the same procedures as described. Both sources were shipped to Martin Company on September 4, 1967 (see Table 2).

As noted in Section III.A4 the original design of the heat shield incorporated bevels on diagonally opposite ends. Since the bevels were later found to be unnecessary, capsule SN 370/376 was returned to Mound Laboratory for disassembly, and then re-assembled with a new canister and an unbeveled heat shield. Capsule SN 341/358 was assembled in the same manner. As shown in Table 2, both of these two capsules were subsequently shipped to Martin Company to serve as prototype units for the SNAP-19B (IRHS) program. Both capsules contained filters constructed of Haynes alloy No. 25.

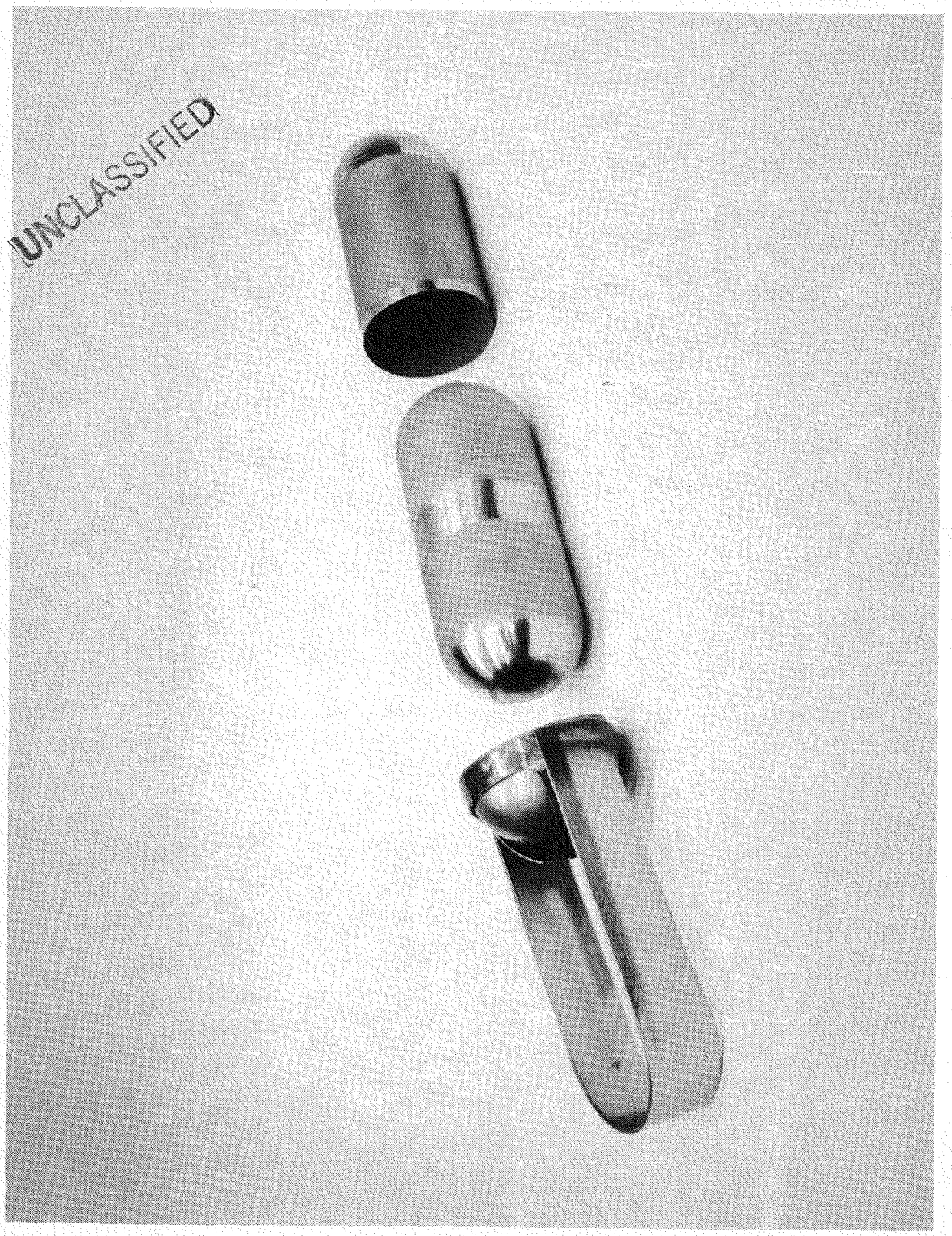


FIGURE 18 - Canister handling tool.

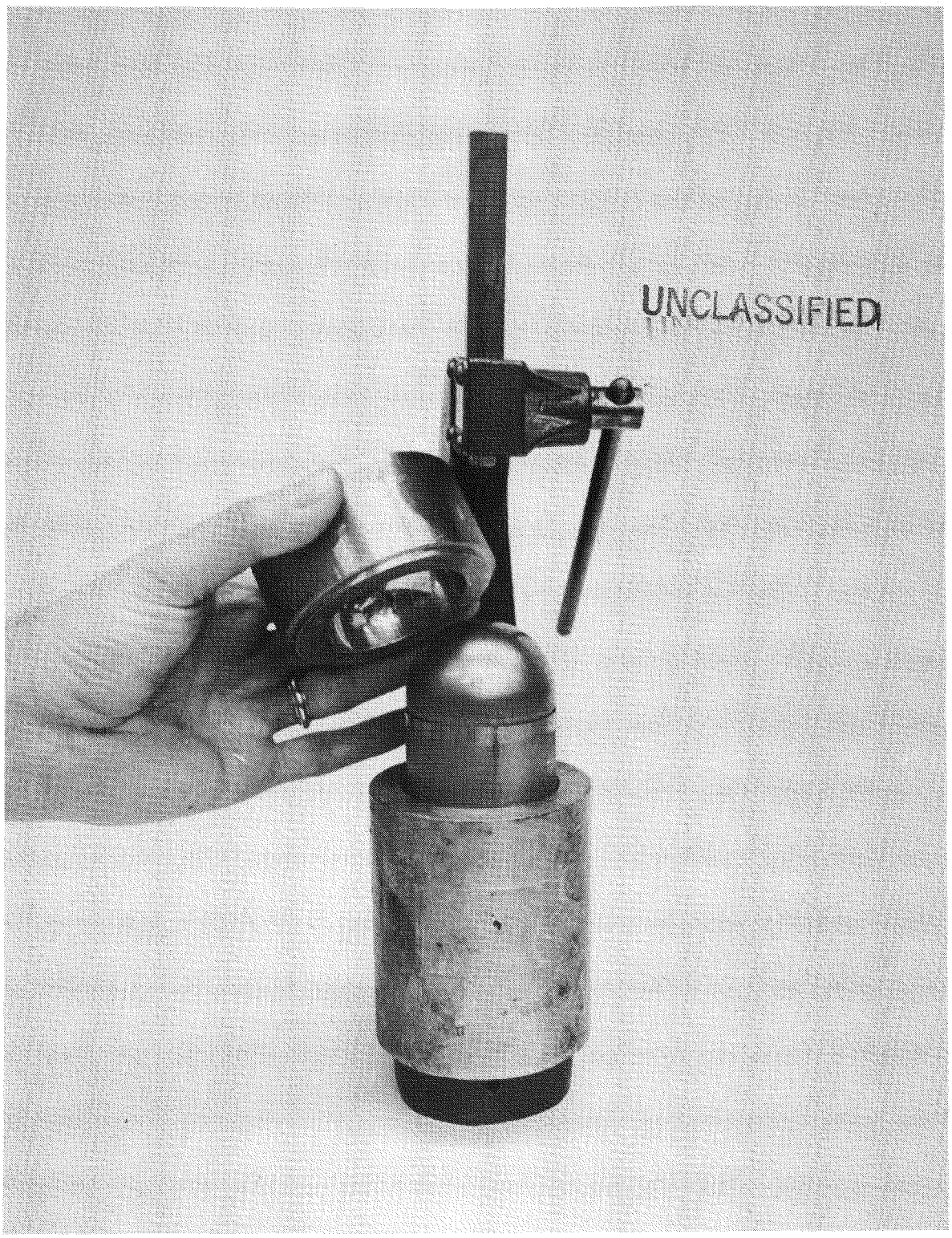


FIGURE 19 - Placement of canister cap on SNAP-19B (IRHS) capsule.

FIGURE 20 - Placement of pressing cap over canistered SNAP-19B (IRHS) capsule.

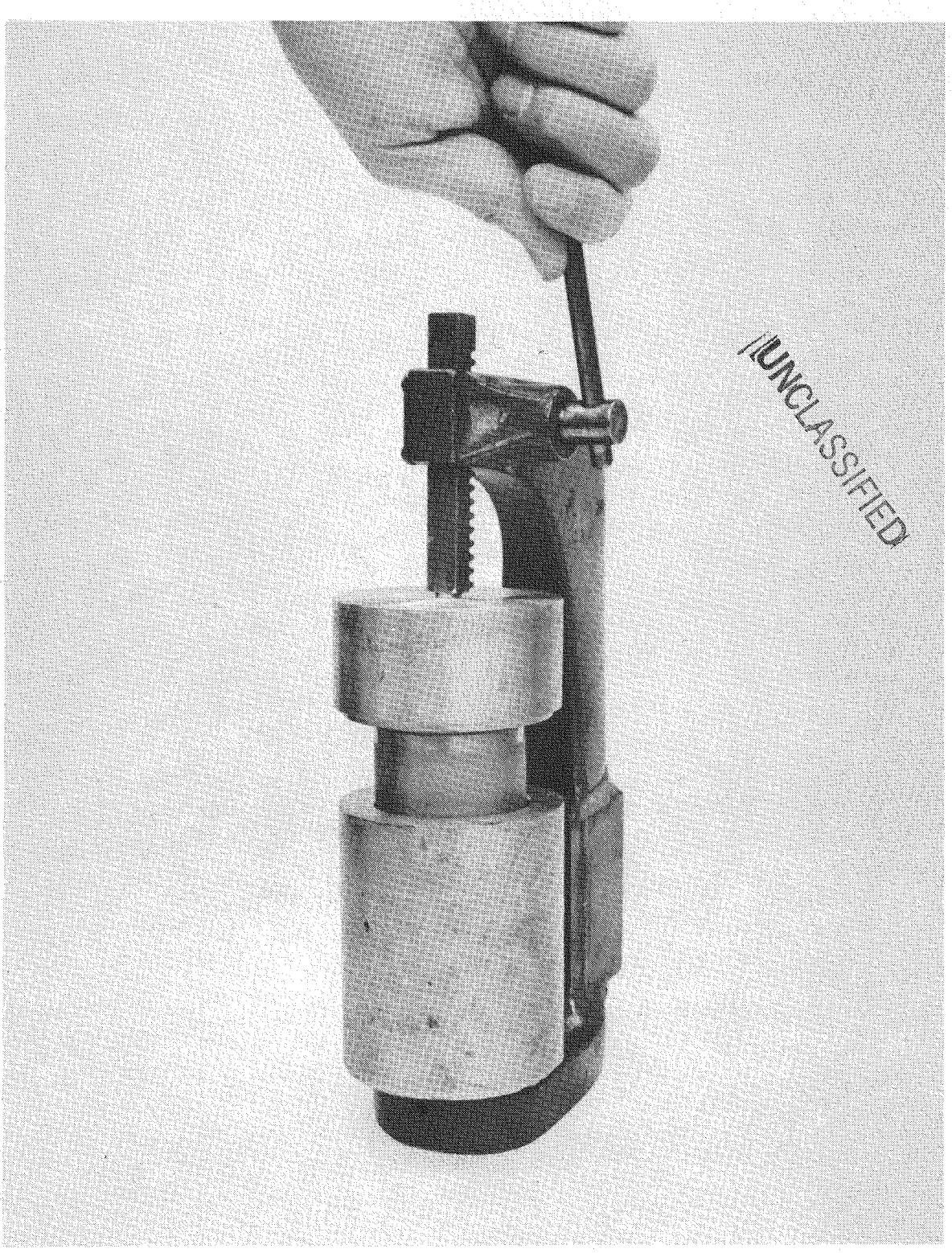


FIGURE 21 - Pressing operation for final placement of canister.

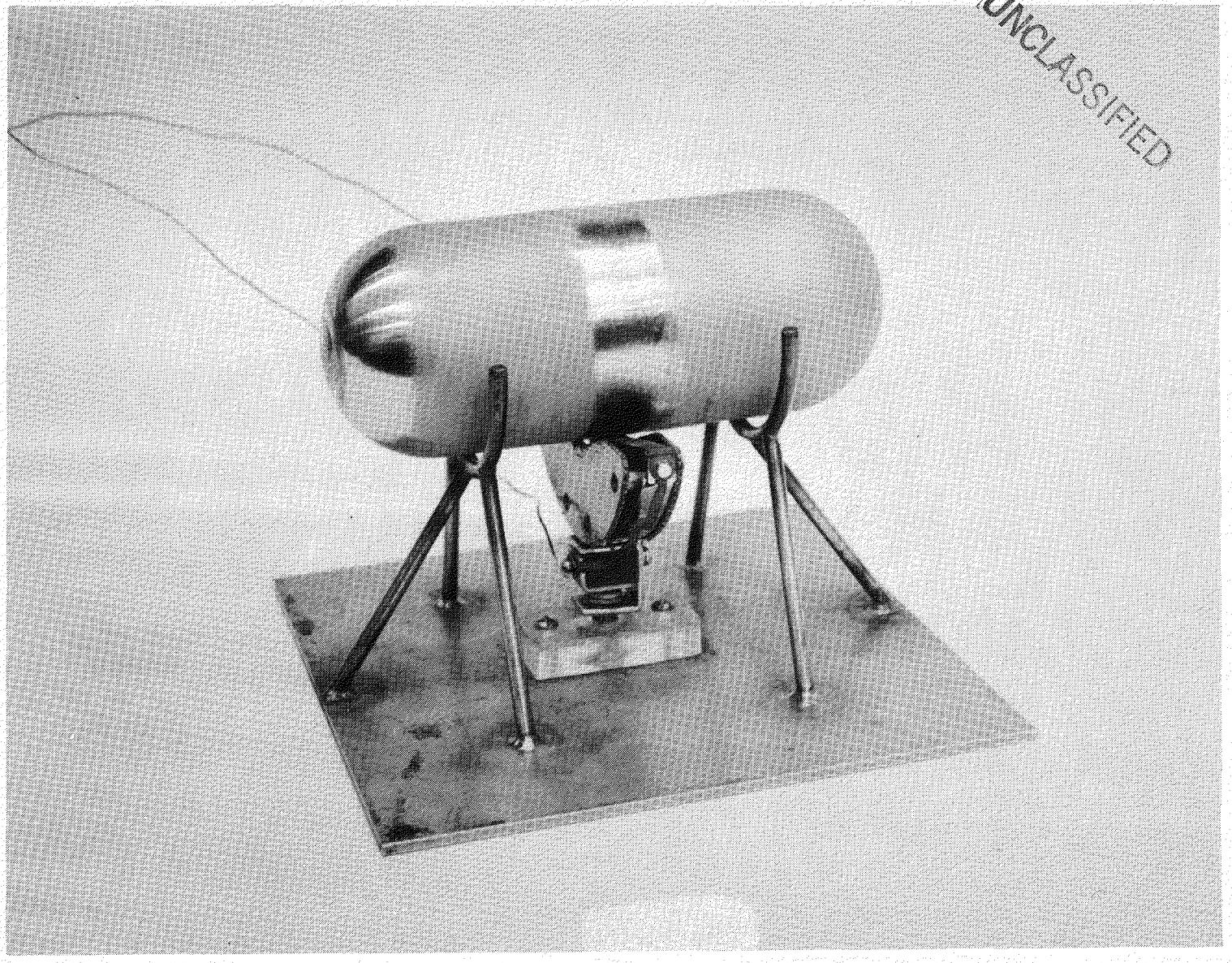


FIGURE 22 - Cradle and surface temperature fixture for SNAP-19B (IRHS) capsule.

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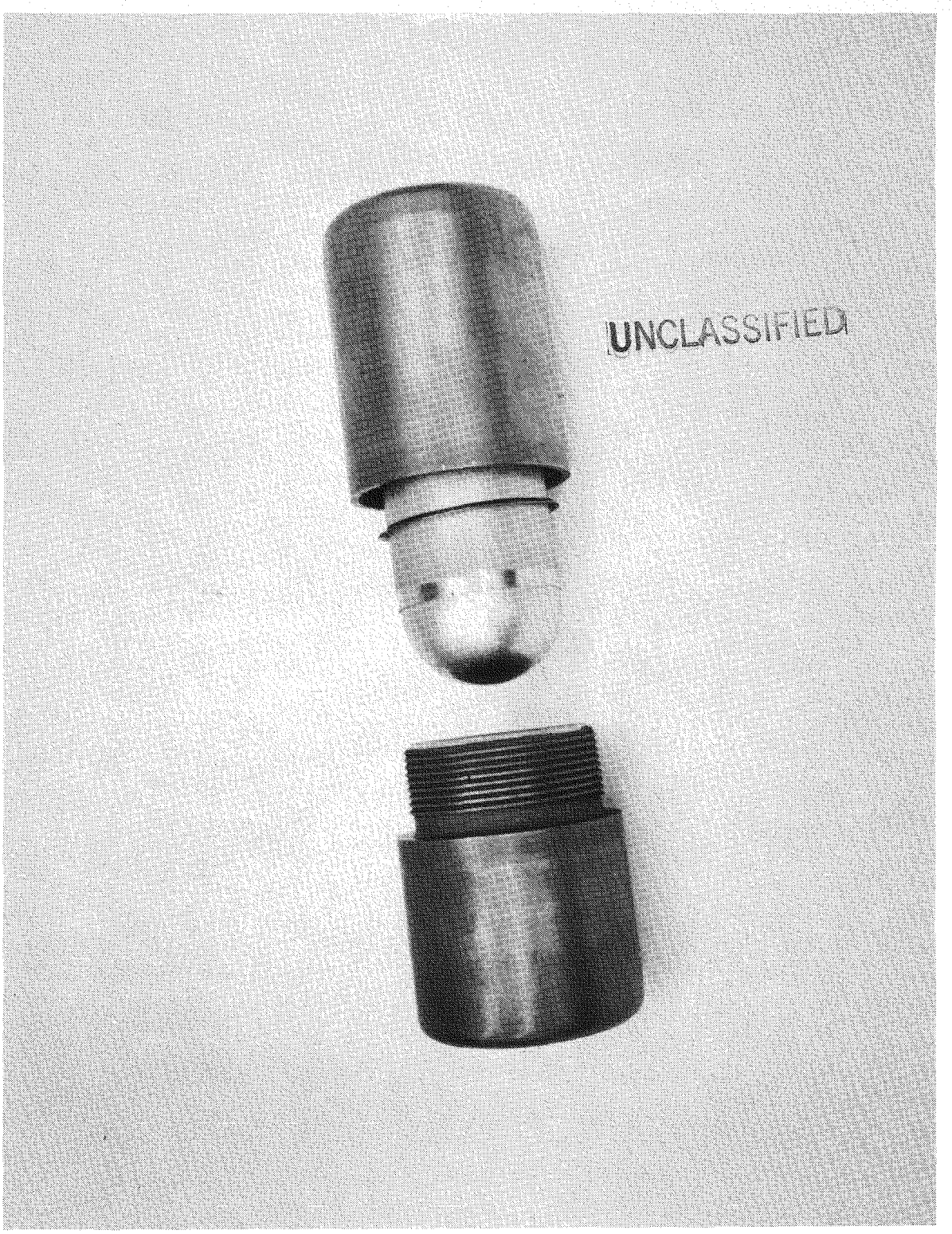


FIGURE 23 - Graphite heat shield showing canistered SNAP-19B (IRHS) capsule in female section.

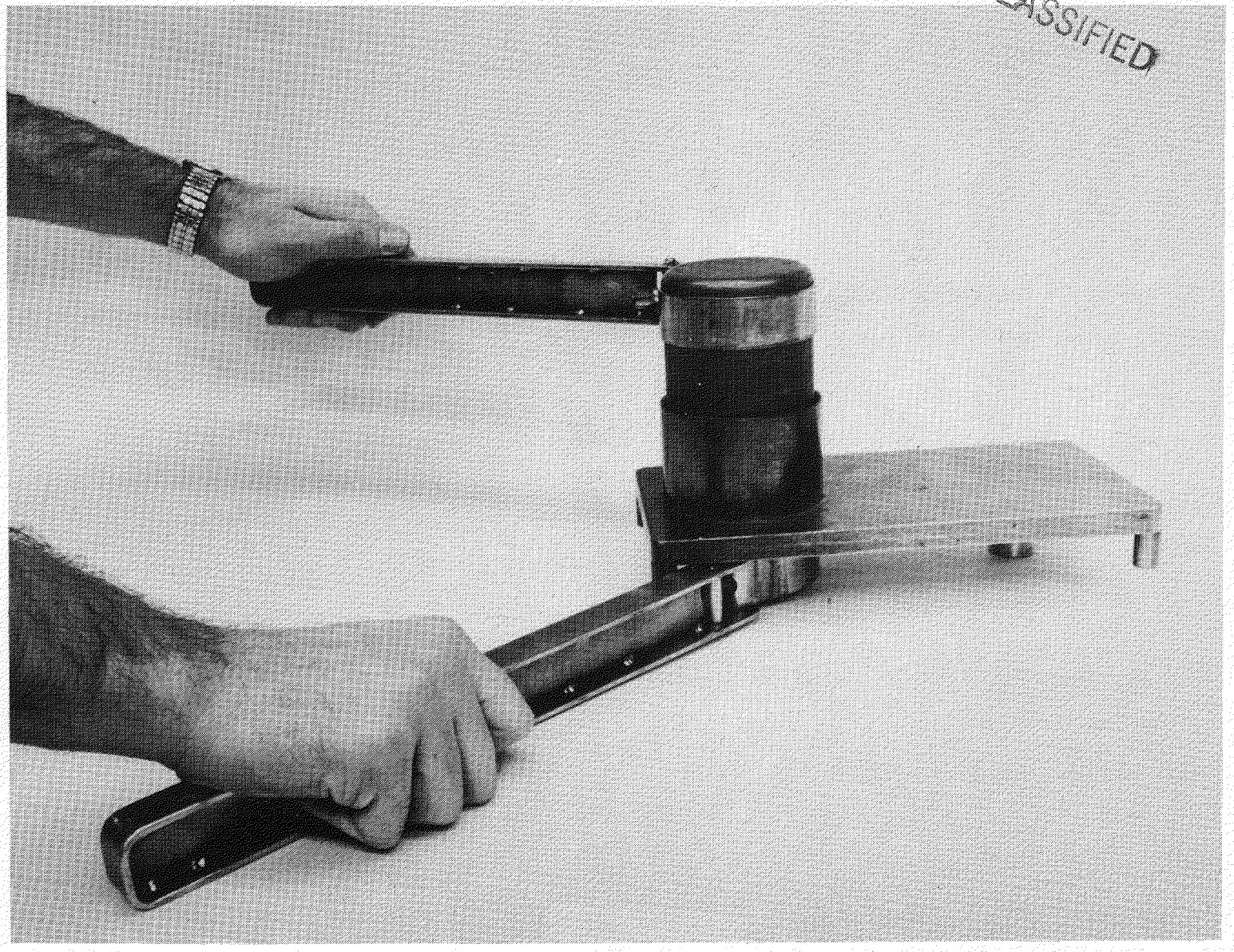


FIGURE 24 - Enclosure of canistered SNAP-19B (IRHS) capsule in graphite heat shield.

Again, as described in Section III.A1, two flight capsules were fabricated with filters of zirconia. These capsules, designated SN 369/375 and SN 361/368 (see Table 2), were assembled as above with unbeveled heat shields and were then shipped to Martin Company.

In addition to the problems described above, only one other was significant. Capsule SN 341/358 had been subjected to filter flow tests, assembled into a canister and a beveled-type of heat shield, and retained at Mound Laboratory until required by Martin Company. Prior to shipment the capsule was disassembled and then re-assembled using an unbeveled-type of heat shield. In this operation it was not possible to screw the two halves of the shield together, apparently due to improper placement of one of tantalum rosettes in the graphite, thereby causing the rosette to roll with the twisting of the graphite. Application of too much torque to the strap wrenches caused fracture of the graphite (Figure 25). When a new graphite heat shield was used, and proper care taken to place the tantalum rosette, the assembly was accomplished without difficulty.

All data pertinent to the various assemblies were collected and recorded, and all operations were conducted in the presence of representatives from the Atomic Energy Commission, Dayton Area Office (Quality Assurance) and from Martin Company.

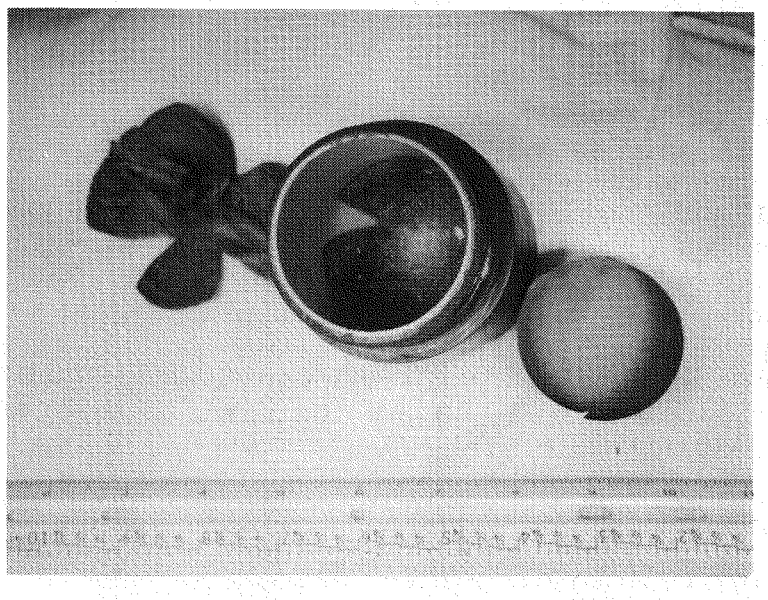
G. DISASSEMBLY OF HEAT SOURCES

Two heat sources containing SNAP-19B (IRHS) capsules SN 370/376 and SN 341/358, that had undergone prototype qualification testing at the Martin Company, were returned to Mound Laboratory for a diagnostic disassembly. The procedures drawn up and approved for this operation are contained in Appendix E.

The primary shipping container (see Section III.C) was first flushed out with argon in a cold TIG welding box, to determine if any radon or alpha contamination could be observed using an Eberline AIM-3 air monitor. None was detected. Following this step, the graphite heat shield, with canistered capsule enclosed, was removed from the primary shipping container and visually inspected. Complete disassembly, that is removal of the graphite heat shield and the tantalum canister, was then performed (see Appendix E).

No problems were encountered during disassembly of either of the two heat sources. The canister on capsule SN 370/376 was noted to be crack-free (Figure 26) but that on capsule SN 341/358 was cracked on the bottom end (Figure 27). Also, in the case of the latter capsule, a portion of the tantalum rosette tore away during disassembly and adhered to the bottom end near the cracked area.

(A)



(B)

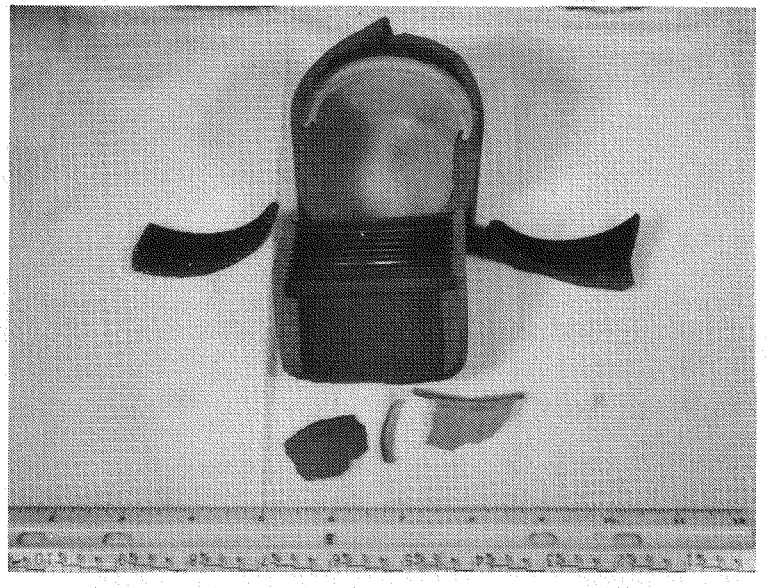
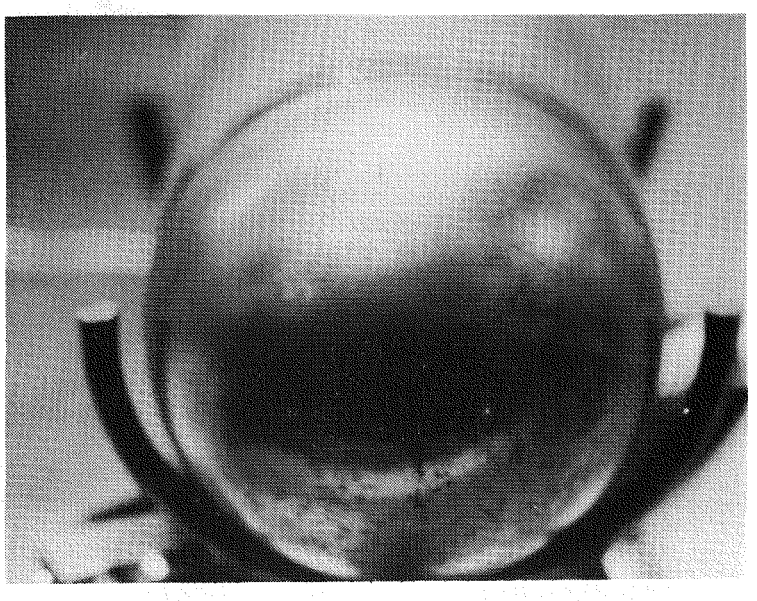
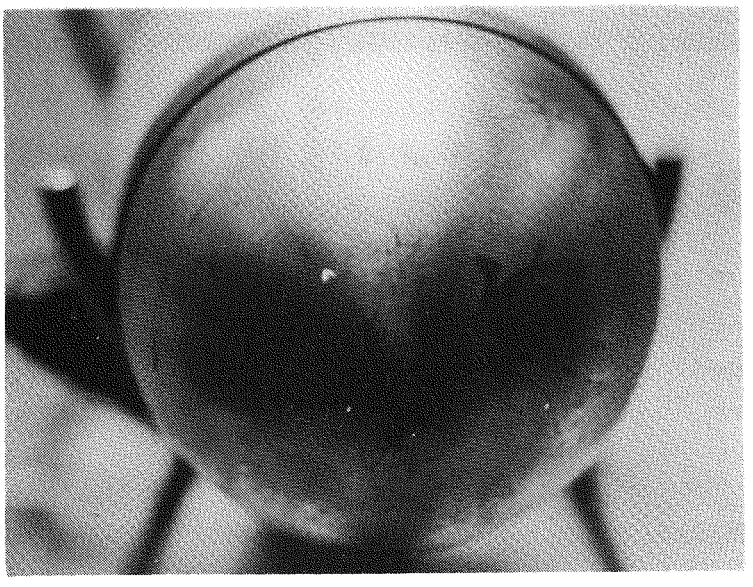


FIGURE 25 - Fractured heat shield resulting from faulty assembly of capsule SN 341/358.



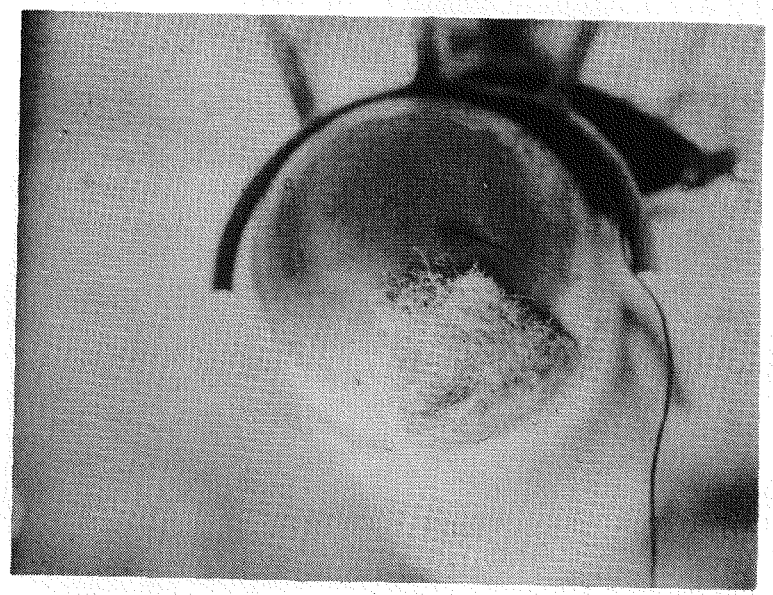
(A)
Bottom End

UNCLASSIFIED

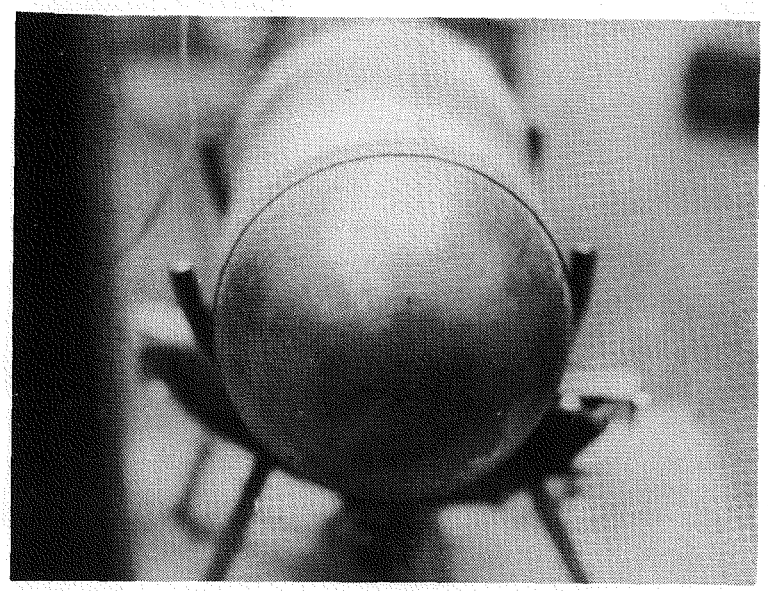


(B)
Vent End

FIGURE 26 - Disassembly of heat source showing bottom and vent ends of canistered capsule SN 370/376.



(A)
Bottom End



(B)
Vent End

FIGURE 27 - Disassembly of heat source showing bottom and vent ends of canistered capsule SN 341/358.

V. SPECIAL TESTING AND EVALUATION

A. FILTER CHARACTERISTICS

Filters composed of Haynes alloy No. 25 and zirconia were investigated to determine the effects of operating temperature, pressure, and time on the flow of helium through filter assemblies installed in SNAP-19B (IRHS) capsules. In addition, the behavior of zirconia filters was studied under conditions of blow out, thermal cycling, and accelerated thermal environments; the ability of such filters to prevent passage of particulate radioactive material was also examined. An analytical study of the performance of the components used for installing zirconia filters in the filter assemblies was included in the test program.

1. Haynes Alloy No. 25 Filter Tests

In three experiments the anticipated actual conditions to which the filter assemblies would be exposed were simulated. In all three tests, the filter assembly (Figure 28) was housed in a cylindrical test fixture (Figure 29). In Test No. 1, this fixture was fabricated from Type 304 stainless steel; in Tests No. 2 and 3 the material was Haynes alloy No. 25. The three filter assemblies, received from Martin Company and quality-certified, were machined from the bottom halves of weld control capsules.

The helium gas used during all three tests was Bureau of Mines Grade A quality (99.996% pure). Helium flow was determined with a Veeco MS9A leak detector. The test fixtures were heated and maintained at temperature by an induction furnace. The pressure was measured with calibrated Wallace-Tiernen gages.

Test No. 1 - Vacuum Thermal Test

The test fixture was installed in the system (Figure 30) and a vacuum was established on the downstream side. Helium was first introduced at 1 atm followed by a reduction to the test pressure of 5.5 torr (with vacuum still on the downstream side). After the first 24 hr of the test run, the system was maintained in helium at 1 atm for 64.5 hr. Then the pressure was reduced to 5.5 torr for the remainder of the test. The fixture temperature was maintained at 718°C for 114 hr, and then raised to 774°C for the balance of the test since this was the approximate capsule operating temperature. The helium flow through the filter constantly decreased during 258 hr from an initial rate of 5.62×10^{-9} standard cc/sec to 4.02×10^{-9} cc/sec. With the temperature held constant, the upstream pressure was then raised from 5.5 torr to 1500 torr. The flow increased to 1.31×10^{-6} cc/sec but 47 hr later it had decreased to 4.67×10^{-9} cc/sec. Flow through the filter appeared to be dependent on time and/or temperature.

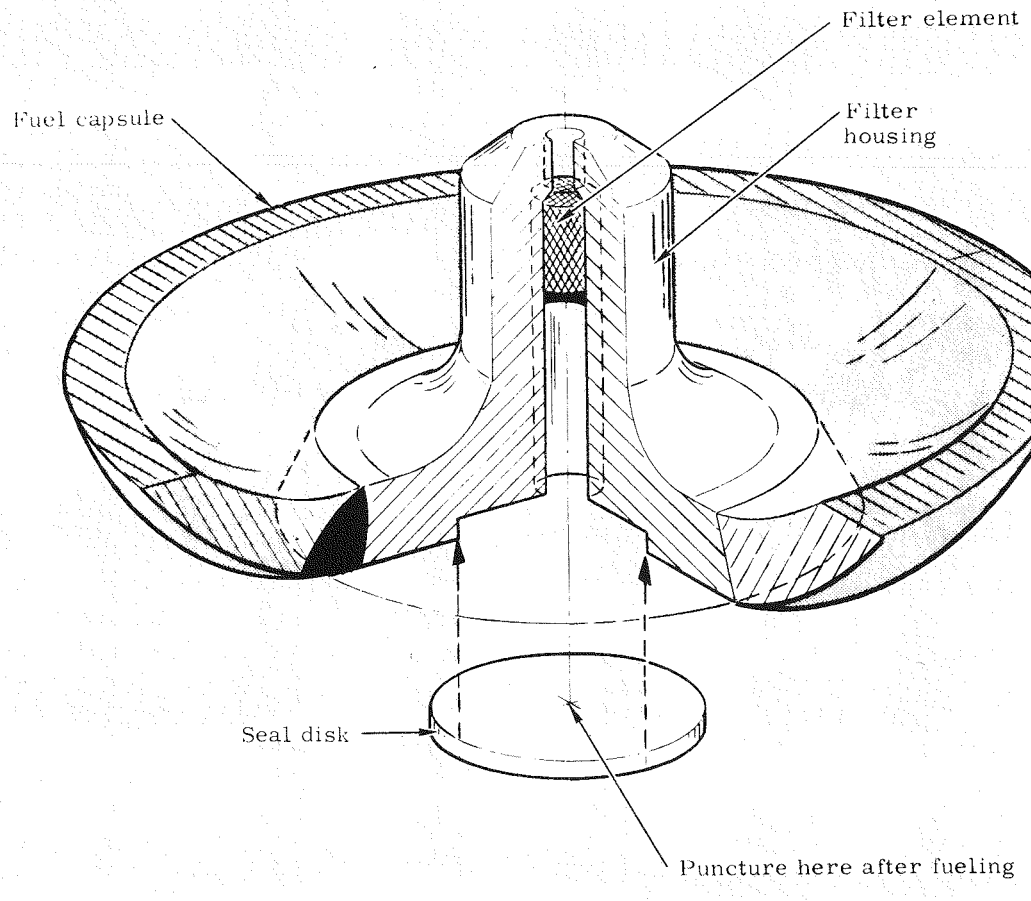


FIGURE 28 - SNAP-19B (IRHS) filter assembly.

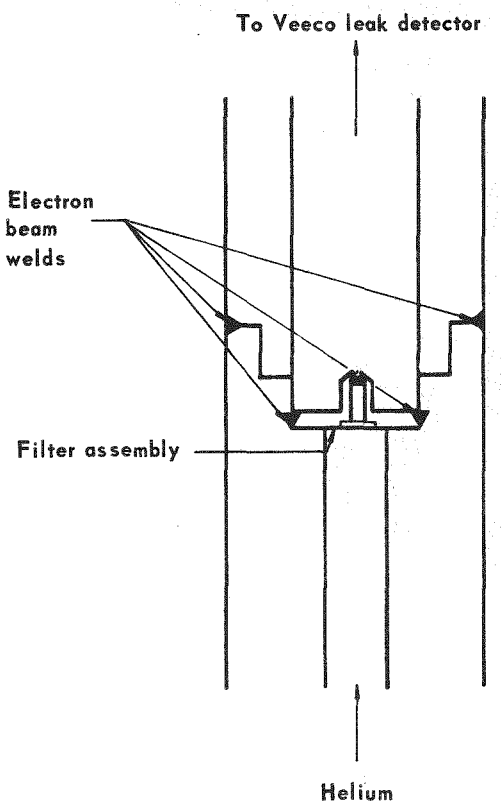


FIGURE 29 - Test fixture for SNAP-19B (IRHS) filter assembly.

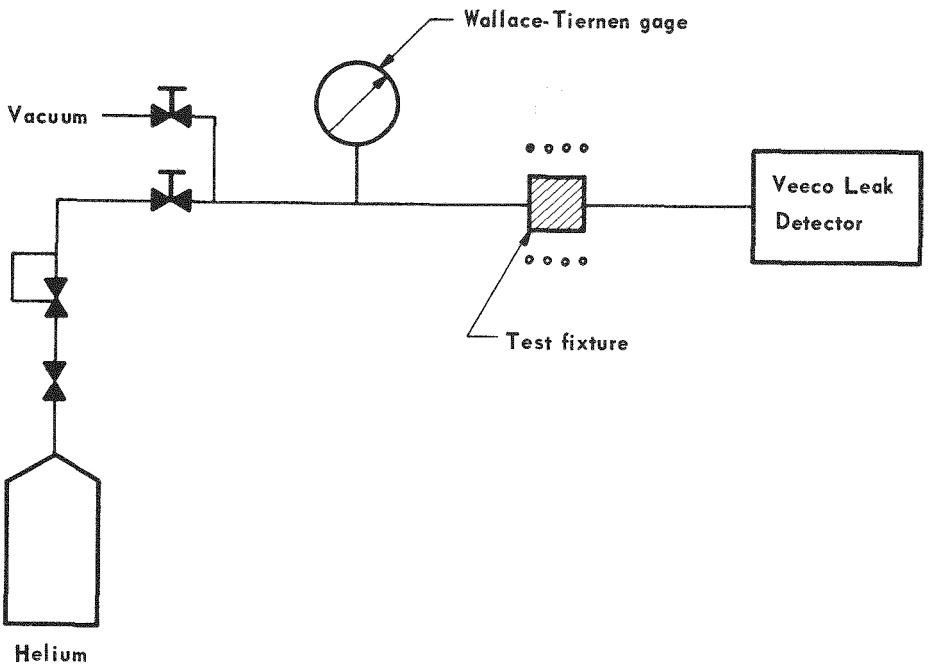


FIGURE 30 - System diagram for filter test No. 1.

At the end of the test (305 hr total) the filter assembly was cut out of the fixture and prepared for metallographic analysis at Mound Laboratory. Results are contained in the conclusions.

Test No. 2 - Variable Pressure-Thermal Test

The test fixture was installed in the test system as shown in Figure 31. The fixture was first evacuated, calibrated with helium (4 torr to give desired flow rate), evacuated again, then soaked in 1 atm of argon at both the inlet and outlet, and re-evacuated. The temperature of the fixture was maintained at 788°C for 501 hr of testing. Helium flow through the filter assembly was measured at 24-hr intervals for upstream pressures of 4, 8, 12, and 15 torr. After 407 hr, the flow rate decreased to 4.72×10^{-8} standard cc of helium/sec from an initial rate of 3.12×10^{-6} cc/sec. The upstream pressures were then increased to 95, 190, 380, and 760 torr. With these pressures the flow rate still decreased. After a total of 501 hr of testing, all with a constant fixture temperature of 788°C, the filter test specimen was cut out of the test fixture, prepared for metallographic analysis, and sent to Oak Ridge for further analysis. The results are included in the conclusions.

Test No. 3 - Simulated Flow Test

The fixture for this test was installed in the test system as illustrated in Figure 32. During the test, the fixture was subjected to a pressure which would result in a helium flow of 3×10^{-5} standard cc/sec through the filter assembly. A pre-calibrated helium leak frit comprised of a tantalum-zirconia matrix material was installed between the helium supply and test fixture. The pressure needed to effect an initial flow of 3×10^{-5} cc/sec through the filter assembly was 6.35 torr. After 407 hr a pressure of 42,500 torr was needed to produce the same flow rate. The temperature of the test fixture was held at 788°C. Upon completion of the test (407 hr) the test fixture was removed and sent to the Metal and Ceramics Division, Oak Ridge National Laboratory, for metallographic analysis.

CONCLUSIONS

The metallographic analyses on the tested filters performed by Mound Laboratory and Oak Ridge showed that:

1. The probable cause of plugging was oxidation of the Haynes alloy No. 25 filter material in quantities sufficient to close all small pores.

2. At least two complex phases or combinations of oxides were present in the pores.

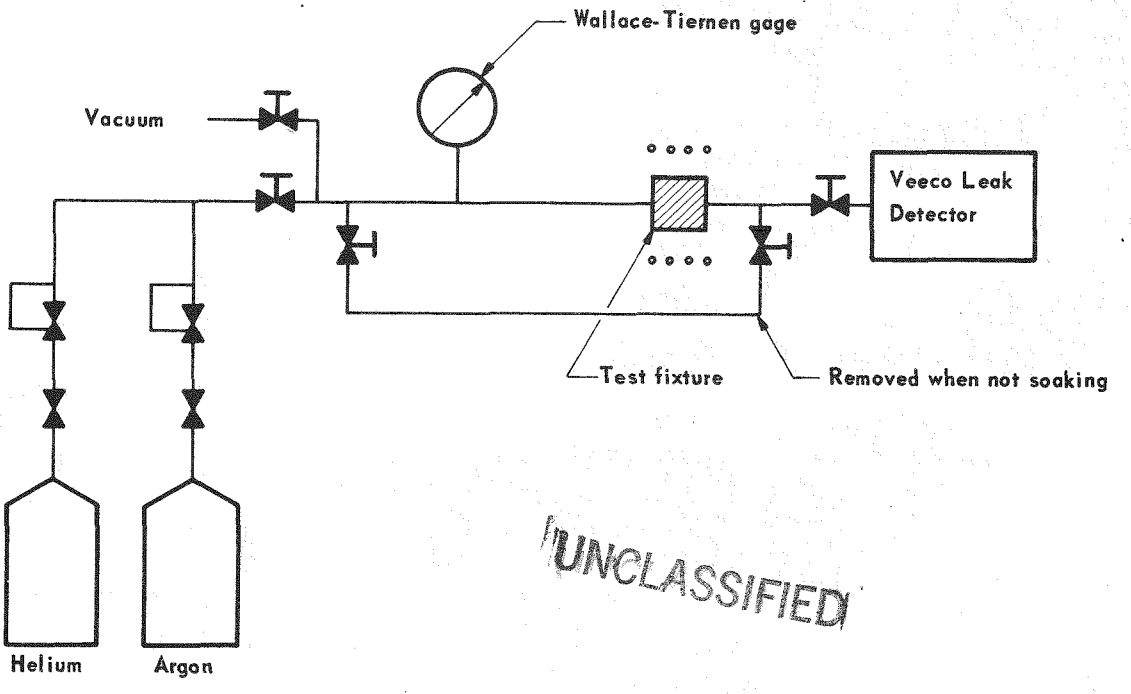


FIGURE 31 - System diagram for filter test No. 2.

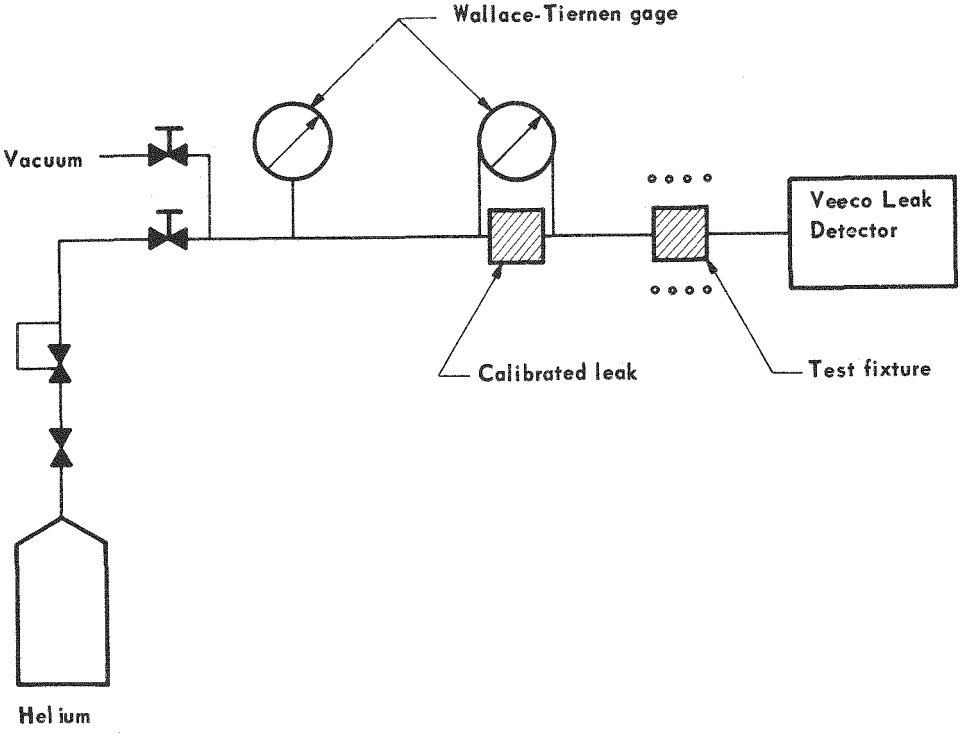


FIGURE 32 - System diagram for filter test No. 3.

3. One major oxide phase was rich in iron and cobalt.

4. A second oxide phase (or combination of oxides) was rich in cobalt, chromium, and tungsten.

The helium used during the testing, 99.996% pure, was apparently not a factor in the oxidation. The calibrated tantalum-zirconia frit installed in the line between the helium supply and the tested filter assembly during Test No. 3 would have been directly affected by any oxygen impurities in the helium. However, after 407 hr, the helium flow rate through this calibrated frit did not change, while that through the test filter assembly showed a marked reduction.

It may be definitely concluded from the results of the three tests that the rate of helium flow through the Haynes alloy No. 25 filters was reduced significantly below design requirements when the filters were maintained at operating temperature for several hundred hours. Oxidation occurring in the small pores of the filters was apparently responsible for the reduction in flow rate.

2. Zirconia Filter Tests

For all the tests with zirconia filters the filter assemblies were received from Martin Company and were quality-certified. The helium gas used in the tests was of Bureau of Mines Grade A quality, 99.996% pure. Helium flow was determined by a Veeco MS9A leak detector. Test fixtures were heated and maintained at temperature by an induction furnace. Pressure measurements were made with calibrated Wallace-Tiernen gages.

Test No. 1 - Thermal Tests with Plutonium-238 Dioxide Microspheres

Three SNAP-19B (IRHS) half-capsules were each loaded with approximately one gram of production-grade plutonium-238 dioxide microspheres. Contamination of the fume hood and handling equipment during the loading of these capsules confirmed that detectable quantities of air-borne activity were associated with the fuel. A swipe survey of the interior of the downstream tubes of the half-capsules revealed that no particulate radioactivity had gone through the filters under gravity.

The half-capsules were assembled in parallel in the test fixture (Figure 33). Helium was passed through them for 2 hr under a differential pressure of 150 mm at ambient temperature. The combined flow rate of the three capsules was measured by water displacement. Individual flow rates were also measured by water displacement and these were maintained between 0.7×10^{-2} and 2.6×10^{-2} standard cc/sec of helium throughout the test period.

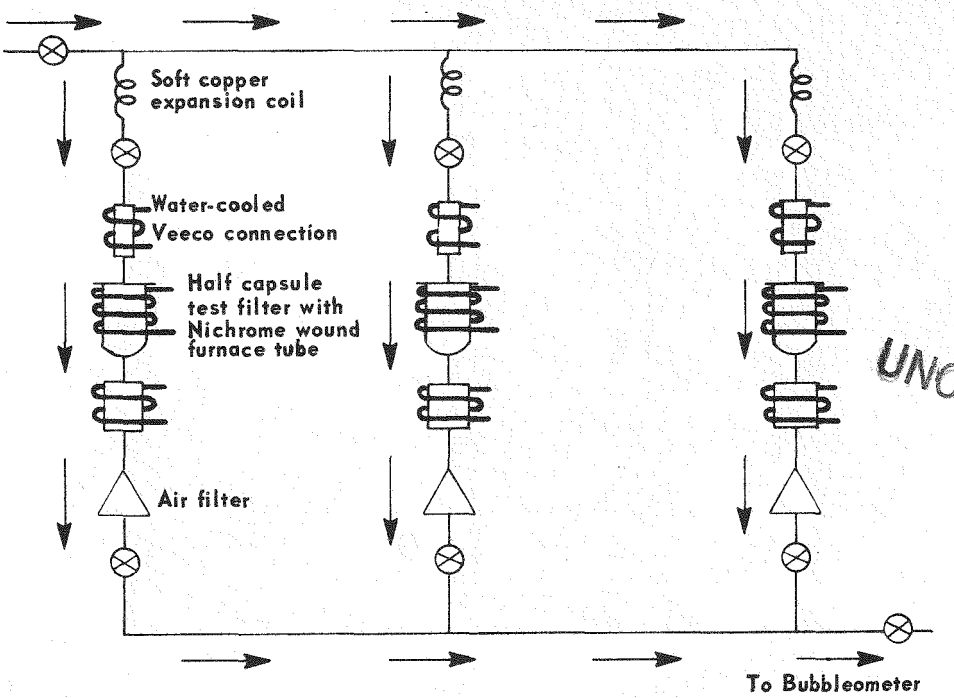


FIGURE 33 - Schematic diagram of SNAP-19B (IRHS) filter test assembly.

At the end of the 2 hr period, the absolute filters downstream from the half-capsules were removed and counted for alpha contamination. No detectable radioactive particulate material was found on the filter paper. New filter papers were installed and the test temperature was raised to 771°C. This temperature was maintained for 24 hr and then reduced to room temperature for 24 hr, after which it was maintained between 704-774°C for the duration of the 9-day test. No radioactive particulate material was detected in the absolute filters in daily surveys during this period.

Test No. 2 - Vacuum Thermal Environment Tests

Two SNAP-19B (IRHS) half-capsules (Figure 34), equipped with filter assemblies, were flow tested with helium at room temperature and again after 220 hr at 774°C. The results are given in Table 5.

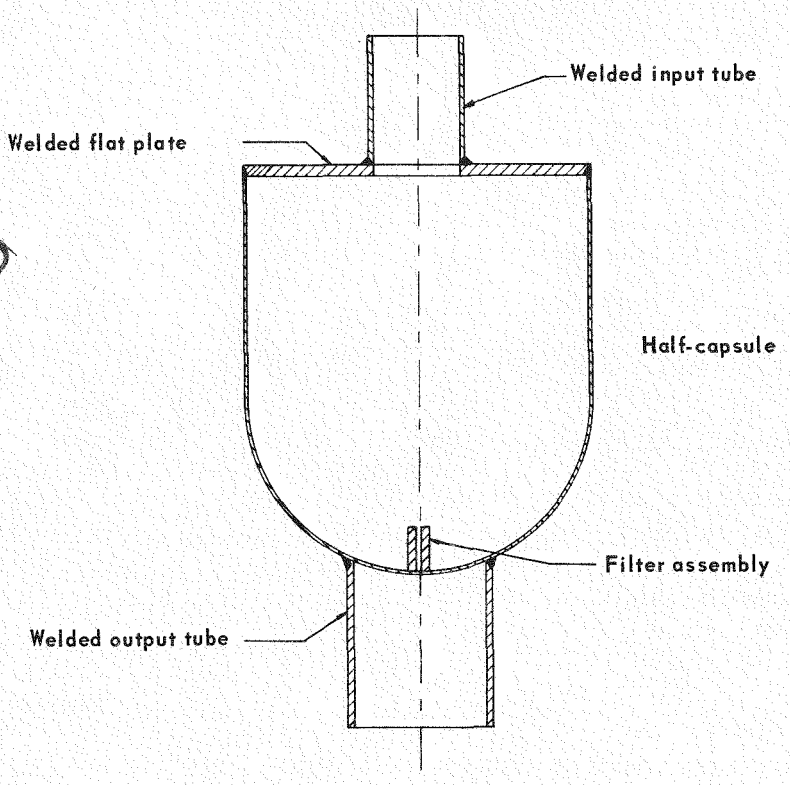


FIGURE 34 - SNAP-19B (IRHS) half capsule.

TABLE 5

RESULTS OF VACUUM THERMAL ENVIRONMENT TESTS ON ZIRCONIA FILTER ASSEMBLIES

Half Capsule (SN)	Initial Flow Rate (std. cc/sec)	Downstream Vacuum (torr)	Upstream Pressure (torr)	Final Flow Rate (std. cc/sec)
384	2.76×10^{-3}	2×10^{-6}	160	9.48×10^{-4}
381	3.41×10^{-3}	5×10^{-6}	160	1.28×10^{-3}

The flow rates through the filters after the test were about one third the rates at the start. Metallographic examination of the tested filters showed a diffusion zone at the Haynes alloy No. 25-platinum interface and a number of holes in the platinum coating. However, nothing was observed that would significantly affect the functional integrity of the filter assembly.

Test No. 3 - Blow-Out Tests

Three filter assemblies were EB-welded into a thick-walled, stainless steel tube having a pressure gage before and after the filter assembly. The operating temperature of the filter was maintained by an induction coil. The system was flushed with helium and then pressure was applied to the filter in the direction of helium flow from the capsule. The pressure gage on the downside of the filter was monitored until a rise was noted. This pressure was recorded as the maximum the filter could withstand before failing. The temperature of the fixture (i.e., of filter) was noted prior to and immediately after the failure occurred. This failure was not due to the filter blowing out, but due to an undetermined pressure release.

One of the assemblies was exposed to three blow-out cycles and the other two were subjected to only two cycles. Results are summarized in Table 6.

TABLE 6

RESULTS OF BLOW-OUT TESTS ON ZIRCONIA FILTER ASSEMBLIES

Half Capsule (SN)	Fixture Temperature during Test: Before Pressure Reduction (°C)	Fixture Temperature during Test: After Pressure Reduction (°C)	Maximum Attainable Pressure (psig)
188	829	784	9200
	829	802	8500
	839	805	8300
189	838	768	8900
	839	762	6500
192	843	805	7500
	843	799	8900

All three filter assemblies were examined metallographically after the tests and similar results were noted: a diffusion zone at the Haynes alloy No. 25-platinum interface, signs of stress on the Haynes alloy side of the interface, and voids in the platinum plate. No drastic compromise of design requirements was deemed necessary as a result of the tests.

Test No. 4 - Thermal Cycling Tests

Filter assemblies contained within three modified test fixtures (Figure 35) were exposed to 15 thermal cycles between 21°C and 774°C. A vacuum furnace, with a pressure of approximately 10^{-6} torr in the furnace chamber, was used for heating. Flow rates through the filters were measured before and after the test. The final flow rates were higher, two filters showing a rate increase of approximately 55% and the other about 14%.

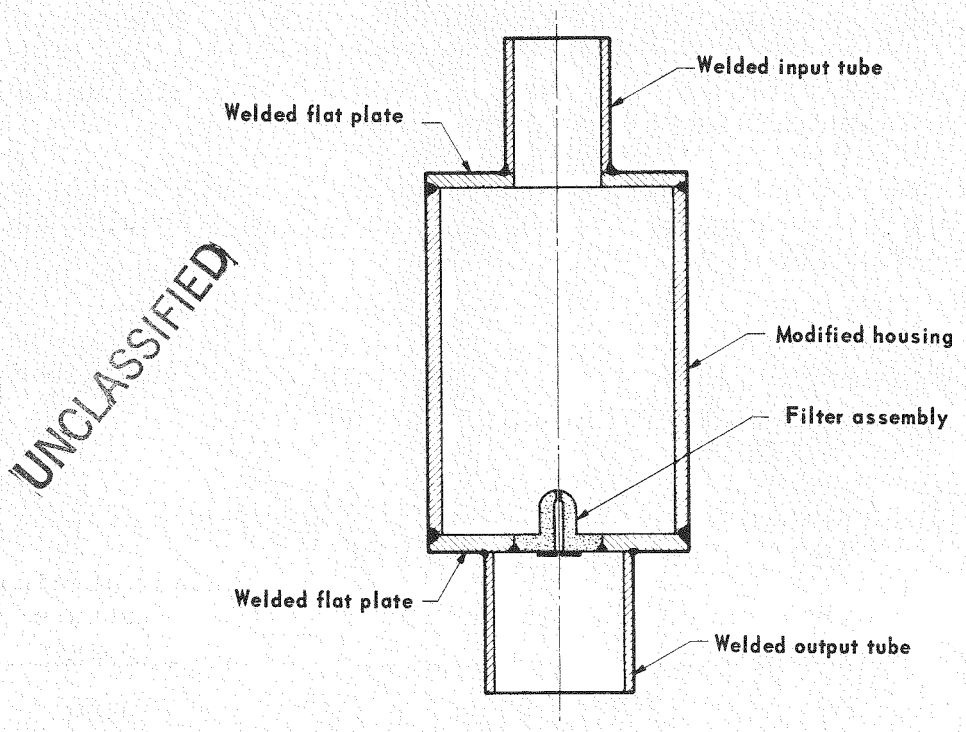


FIGURE 35 - Modified test fixture containing filter assembly.

Metallographic examination of the three tested filter assemblies indicated apparent diffusion zones in the Haynes alloy No. 25-platinum interface, void areas in the platinum plate, and stress signs at the Haynes alloy side of the interface. The filter assembly that showed a 14% flow rate increase was most uniform in structure; it had no extremely large voids in the refractory rod as was the case for the two assemblies that showed a 55% increase in flow rate.

Test No. 5 - Accelerated Thermal Environment Tests

Two filter assemblies were heated in a vacuum furnace to 921°C at 10^{-6} torr for 99.5 hr.

Results from metallographic and qualitative electron microprobe examinations were similar for both specimens. The metallographic

examination showed a diffusion zone greater than that in any other specimen at the Haynes alloy No. 25-platinum interface. Also, there were voids in the platinum plate. A qualitative scan of the diffusion zone with the microprobe indicated that chromium, cobalt, and possibly some nickel may have diffused into this zone.

Test No. 6 - Chemistry Studies

Since the zirconia filter (Rokide Z-Norton Co.) was coated by Martin Company with a layer of substrate (Liquid Brite #7447-Dupont Co.) and then electroplated in a platinum solution (Englehard #209-Englehard Industries), it was necessary to determine whether any of these components might have an effect on the filter under conditions of high operating temperature and pressure. Accordingly, samples of Rokide Z-rod, Rokide Z-rod coated with Liquid Brite, and Rokide Z-rod coated with Liquid Brite and then plated with platinum were heated to 788°C at 2×10^{-6} torr for 1 hr.

Metallographic examination revealed no appreciable change in the tested specimens compared with untested specimens. It was, therefore, concluded that when the filter was exposed to the elevated temperature and relatively high pressure used in these tests, the design criteria of the filter were not compromised by the presence of the coating materials.

B. COMPATIBILITY STUDIES

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Compatibility tests were performed at Mound Laboratory to support the SNAP-19B (IRHS) Program.[3,4] The investigation included "hot" tests using plutonium-238 dioxide microspheres and "cold" tests without the fuel form.

1. "Hot" Tests

The purpose of the "hot" tests was to ascertain whether or not molten Haynes alloy No. 25 and plutonium-238 dioxide microspheres could be contained in a multi-coated graphite crucible at high temperatures; that is, whether there was any evidence of attack on the multi-coated graphite by the molten Haynes alloy No. 25 and the fuel.

The two test specimens consisted of graphite crucibles coated with tantalum, molybdenum, tantalum-zirconia, and zirconia barriers in that order. A tantalum crucible coated with zirconia was placed inside the coated graphite crucible, and within it was placed a Haynes alloy No. 25 cup. The production-grade fuel was weighed and set inside the Haynes alloy No. 25 cup prior to heating.

Each test specimen was then heated by induction, resulting in the time-temperature data given in Table 7. Before heating the test specimens, a reference specimen was heated using no fuel. The atmosphere over the heated samples was approximately 0.1 atm of argon. The temperature of each heated specimen was observed with an optical pyrometer. Each specimen was cooled in an argon atmosphere and then submitted for metallographic analysis.

TABLE 7

HEATING RATES OF "HOT" TEST SPECIMENS

Reference Sample		Sample 1		Sample 2	
Time (Sec)	Temperature (°C)	Time (Sec)	Temperature (°C)	Time (Sec)	Temperature (°C)
0	795.25	0	>30°<825°	0	>30°<825°
400	800.81	330	950	200	885
500	811.93	400	1000	400	1015
600	814.71	500	995	500	1015
700	820.27	600	- -	600	1005
800	823.05	700	1025	700	1020
900	834.17	800	- -	800	1025
1000	839.73	900	1075	900	1010
1100	845.29	1000	1050	1000	1005
1200	867.53	1100	1045	1100	1025
1300	889.77	1200	1035	1200	1025
1400	967.61	1300	1045	1300	1020
1500	1190.01	1400	1075	1400	1020
1560	1345.65	1500	1145	1500	1120
1600	1468.01	1560	1210	1560	1205
1700	1779.37	1600	1235	1600	1355
1755	1883.90	1700	1505	1700	1455
1800	1723.77	1755	1550	1755	1875
1825	1345.69	1800	1850	1800	1795
1900	1301.21	1845	1415	1875	1250
2000	1117.73	1920	1230	1900	1150
2030	1078.81	1945	1000	2000	850
		2045	850	2030	<825

A previously observed reaction between plutonium-238 dioxide microspheres and molten Haynes alloy No. 25 was again observed (Figure 36). No penetration of the zirconia-coated tantalum crucible was noted. Metallographic examination of the multi-coated graphite crucible revealed no contact of the molten Haynes alloy No. 25 with the graphite (Figure 37). Partial separation of the coating(s) from the graphite was noticed, however. While the free fuel present in the two samples after the test was 4.9% and 73.0% (Table 8), there was no apparent reaction of the graphite with either the fuel or molten Haynes alloy No. 25.

TABLE 8

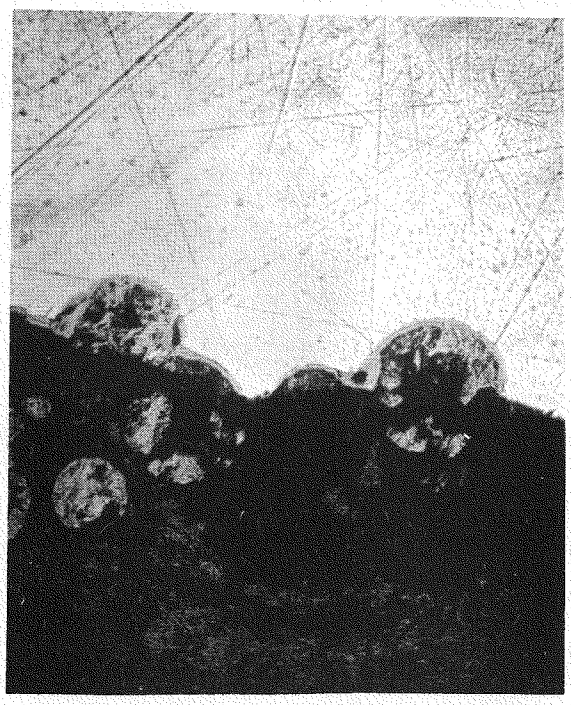
FREE FUEL PRESENT AFTER "HOT" TEST

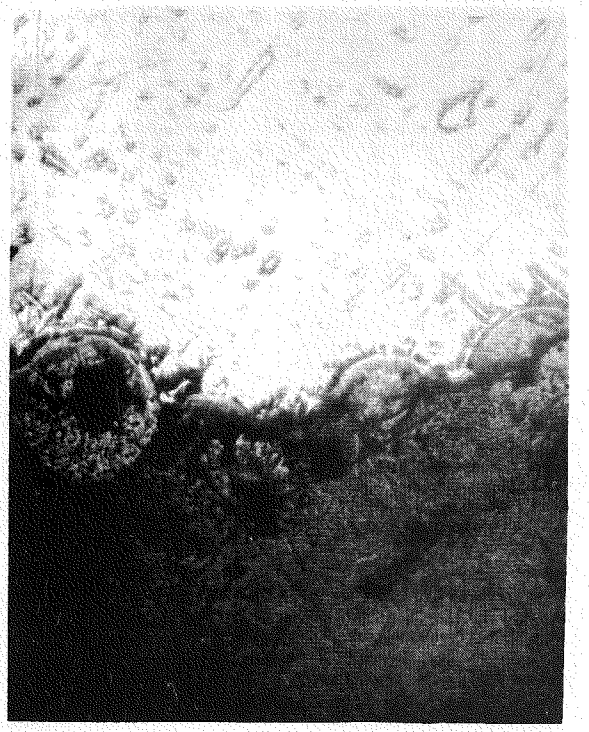
Sample Number	Components Charged		Free Fuel after Heating	
	Haynes Alloy No. 25 (g)	Fuel (g)	(g)	(%)
1	17.3	5.11	0.252	4.9
2	16.8	5.02	3.64	73.0

2. "Cold" Tests

PART 1

A number of tests were performed based on a time-temperature profile curve for the SNAP-19B (Dispersal) System, as determined by the Martin Company and shown in Figure 38; a comparable curve for the SNAP-19B (IRHS) system was not available at the time. The metals chosen for evaluation in this test program were Haynes alloy No. 25, tantalum-10% tungsten alloy, and T-111 alloy. The protective barriers consisted of 0.005 in. (0.0127 cm) of platinum sheet, 0.005 in. (0.0127 cm) of zirconia (plasma sprayed), and 0.005 in. (0.0127 cm) of molybdenum disilicide (plasma sprayed). The zirconia and molybdenum disilicide were plasma sprayed onto graphite discs, whereas the platinum sheet was





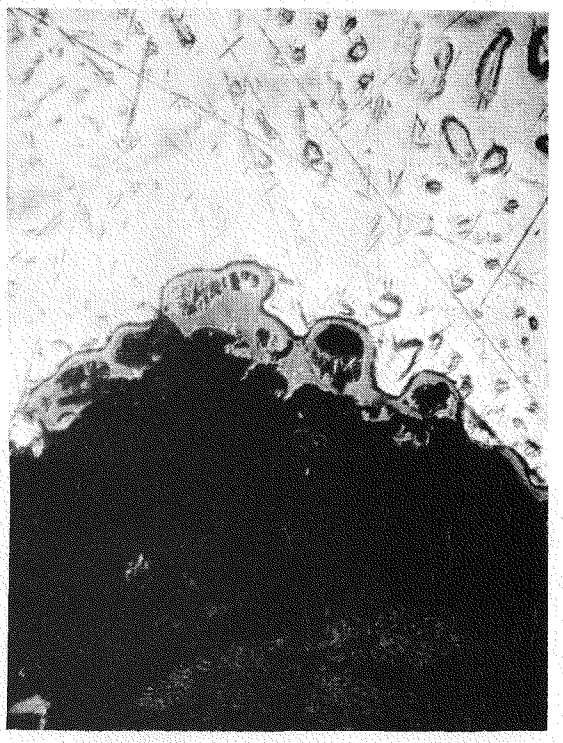


FIGURE 36 - Examples of fuel - Haynes alloy No. 25 reaction at interface. (200X).

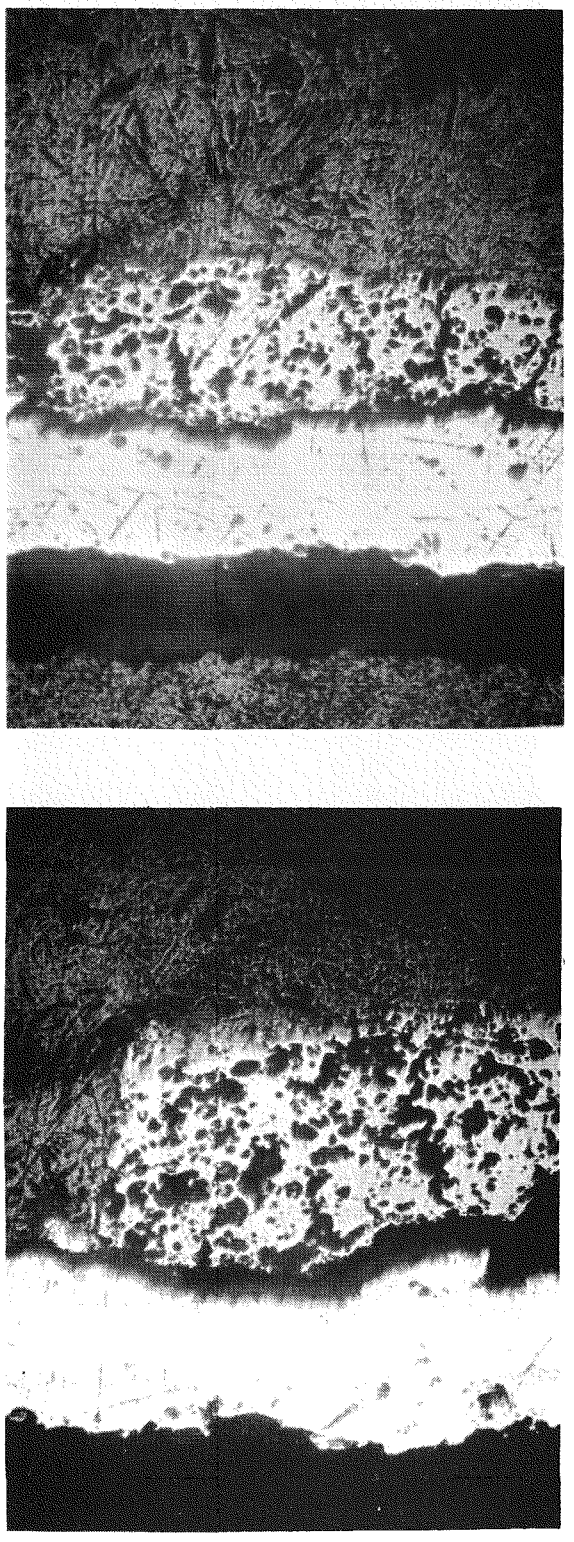


FIGURE 37 - Examples of unbroken capsule coating and no penetration of fuel - Haynes alloy No. 25 to graphite. (200X - graphite at extreme bottom of picture)

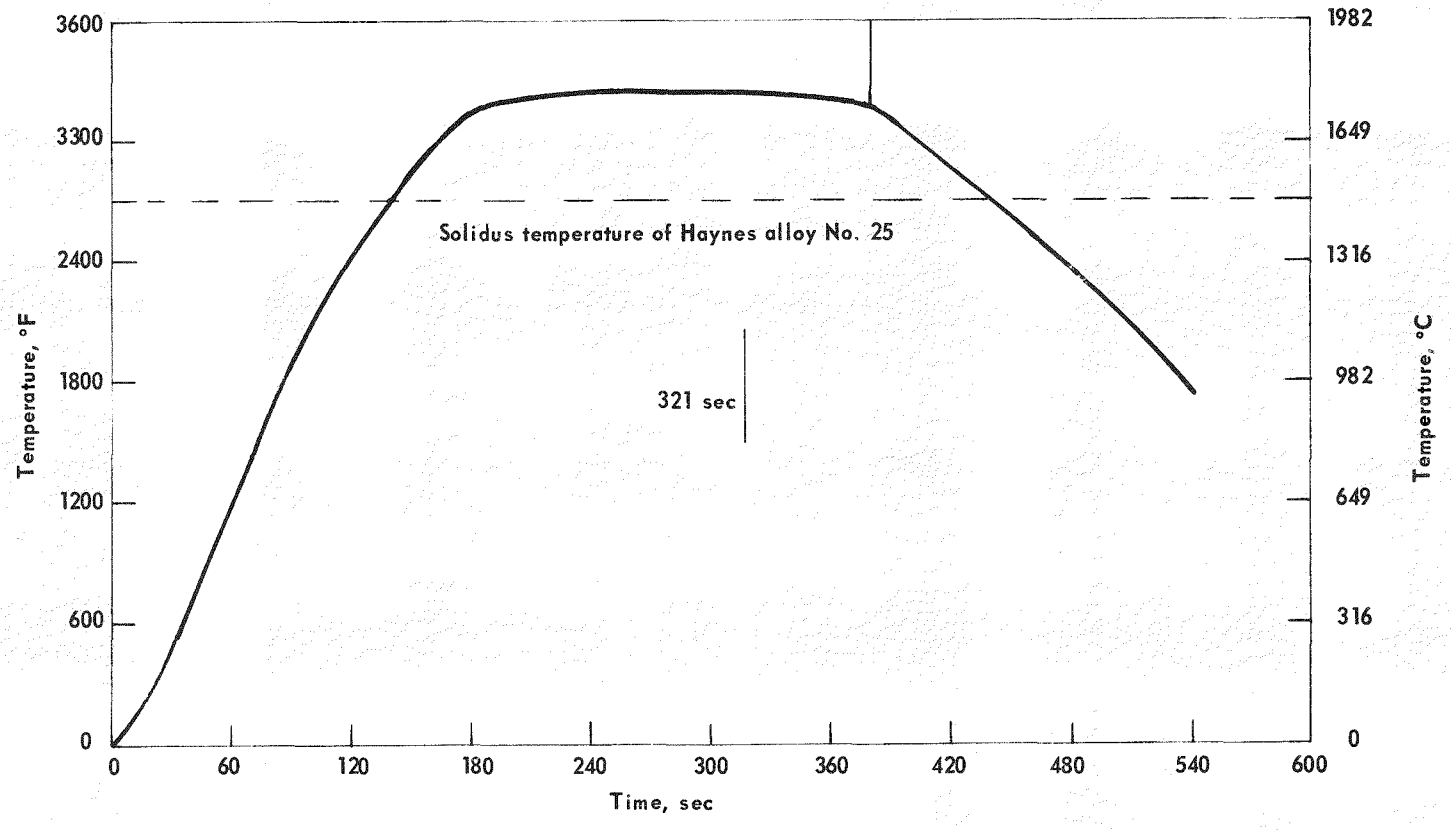


FIGURE 38 - Reentry time-temperature profile of SNAP-19B (Dispersal) system.

placed between the graphite and the metal to be tested. Each specimen consisted, therefore, of a graphite disc [1 in. (2.54 cm) in diameter by 0.25 in. (0.635 cm) thick], the protective barrier, and the metal under investigation.

Each specimen was placed in a 20-kW vacuum resistance furnace. The graphite specimen was thoroughly out-gassed prior to the test run to eliminate impurities. The specimens were quickly heated to a peak temperature of 1732°C at a pressure of approximately 2×10^{-4} torr or less. The time-temperature profile shown in Figure 38 was followed; i.e., the sample temperature was raised to 1732°C in 180 sec, held at 1732°C for 200 sec, and then allowed to cool by radiation.

Temperature measurements for the test runs were made with a calibrated optical pyrometer which was sighted through a quartz window and focused on a black body hole drilled in the graphite sample support cylinder.

After cooling, the samples were examined metallographically. The results are given in detail in Table 9.

PART 2

Three separate categories of tests were considered in this case, varying in sample configuration, but all based on the reentry time-temperature profile for the SNAP-19B (IRHS) System as determined by Martin Company and shown in Figure 39. The metal evaluated was Haynes alloy No. 25; the protective barriers were tantalum-10 wt % tungsten alloy sheet, tantalum sheet, and special coatings prepared by the Martin Company.

Category 1: The test specimen was comprised of a graphite disc [0.25 in. (0.635 cm) in diameter by 0.187 in. (0.476 cm) thick], a barrier (either tantalum-10 wt % tungsten alloy or tantalum sheets), and Haynes alloy No. 25. Each specimen was placed in a 20-kW resistance furnace and the time-temperature profile (Figure 39) was followed. The materials were then examined metallographically and some samples were taken for microprobe analysis. Results are presented in detail in Table 10.

Category 2: At Martin Company, the inside of a test crucible of POCO graphite was plasma and flame-sprayed with tantalum and zirconia coatings. Each coating was approximately 3-5 mils (0.0076-0.0127 cm) thick. A Haynes alloy No. 25 tube was inserted in the crucible and the time-temperature profile of Figure 39 was followed.

It was apparent after completion of the test that the Haynes alloy No. 25 had splattered during the test cycle, causing a short circuit of the furnace heating elements. The Haynes alloy was alloyed in some places with these elements.

TABLE 9

RESULTS OF COMPATIBILITY STUDIES FOR ATJ GRAPHITE AND VARIOUS METALS

Test No.	Metal	Diffusion Barrier	Results and Comments
1	Haynes alloy No. 25	5 mils (0.0127 cm) platinum	Haynes alloy No. 25 reacted with the graphite. Unreacted carbon present in reaction mixture.
2	Haynes alloy No. 25	~5 mils (0.0127 cm) zirconia	Reaction zones indicated where Haynes alloy No. 25 soaked into the graphite. Carburization of areas of the zirconia.
3	Haynes alloy No. 25	~5 mils (0.0127 cm) zirconia	Same as No. 2
4	Haynes alloy No. 25	~5 mils (0.0127 cm) molybdenum disilicide	Breakdown of the molybdenum disilicide barrier. ($MoSi_2$ decomposes completely in the presence of carbon at 3390°F (1865°C) and this reaction apparently begins below that temperature). Haynes alloy No. 25 penetration into the graphite.
5	Ta-10 wt % W	~5 mils (0.0127 cm) molybdenum disilicide	$MoSi_2$ reacted the same as in No. 4. No Ta-10 wt % W penetration into the graphite.
6	Ta-10 wt % W	~5 mils (0.0127 cm) zirconia	Carburization of the zirconia. Cavities in barrier appear to be result of coating operation. No penetration of graphite by Ta-10 wt % W.
7	T-111	~5 mils (0.0127 cm) zirconia	Carburization of zirconia. No penetration of graphite by T-111.

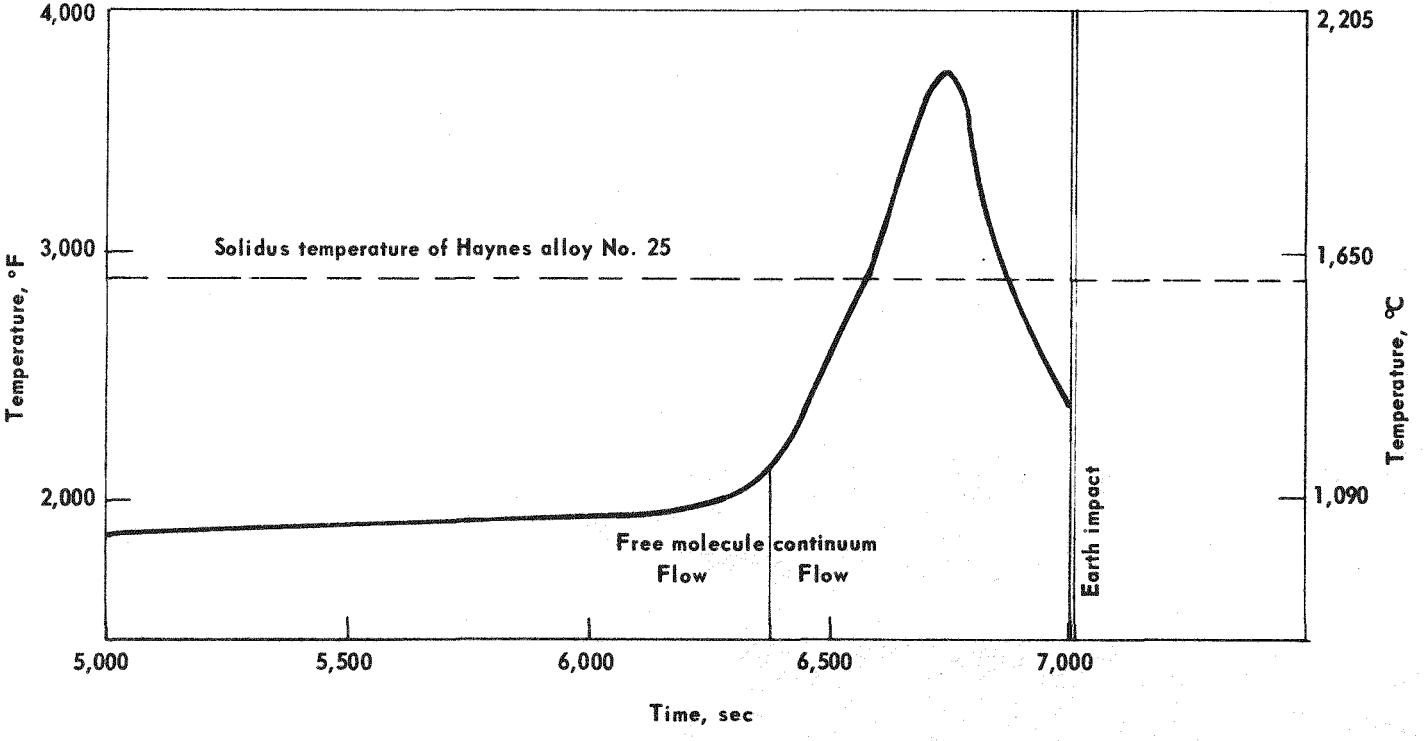


FIGURE 39 - Reentry time-temperature profile of the SNAP-19B (IRHS) system.

TABLE 10

RESULTS OF COMPATIBILITY STUDIES FOR HAYNES ALLOY NO. 25 AND POCO GRAPHITE

Test No.	Thickness of Haynes alloy No. 25	Diffusion Barrier	Results and Comments	
			Metallography	Microprobe Analysis
8	~62 mils ~(0.158 cm)	7.5 mils (0.0191 cm) Ta-10 wt % W	Small amount of carburization. No great penetration of the graphite by the Haynes alloy No. 25. Haynes alloy No. 25 and Ta-10 wt % W reacted to give a very brittle alloy.	No microprobe results.
9	~187 mils ~(0.475 cm)	20 mils (0.0508 cm) Ta-10 wt % W	The Haynes alloy No. 25 and Ta-10 wt % W reacted to give a brittle but very hard alloy. Definite reaction of alloy with the graphite. Tantalum carbide present in the alloy.	Less than 5% carbon was in the sample. Chromium, cobalt, and nickel concentrated in the area closest to the graphite. Apparently, a good and even concentration of tantalum and tungsten was present in the new alloy.
10	~187 mils ~(0.475 cm)	10 mils (0.0254 cm) Ta	Definite reaction of Haynes alloy No. 25 and tantalum. Product had void spaces, had lost key physical properties, and did not appear to be brittle. When lifted off the graphite after cooling, no apparent carburization. A micro-hardness test of the alloy indicated two well-defined phases: a matrix phase having a DPH value of 1500 and a minor phase having a DPH value of 890.	Results indicated an alloy rich in tungsten, tantalum and nickel. Chromium was finely dispersed throughout the alloy. Cobalt was depleted in areas which were rich in tungsten. Areas rich in nickel with low tantalum content were also present.

(Table 10 continued on next page)

TABLE 10 (continued)

RESULTS OF COMPATIBILITY STUDIES FOR HAYNES ALLOY NO. 25 AND POCO GRAPHITE

Test No.	Thickness of Haynes alloy No. 25	Diffusion Barrier	Results and Comments	
			Metallography	Microprobe Analysis
11	~187 mils ~(0.475 cm)	none	Strong reaction of Haynes alloy No. 25 with the graphite. Migration of graphite into the Haynes, and void spaces were present in the Haynes. Approximately 49% of the Haynes had dimpled into the graphite. Structural cracks were evident in the graphite.	Very low concentration of nickel and tungsten dispersed throughout the specimen. Unreacted carbon was evident in the sample. Chromium was enriched in the nickel-depleted areas. Cobalt was dispersed throughout the specimen with noticeable depleted areas which were again enriched with cobalt.
12	~187 mils ~(0.475 cm)	none	Same as No. 11	No microprobe results.

Category 3: The interiors of two POCO graphite, test crucibles were coated by Martin Company with approximately 3 mils (0.0076 cm) of plasma-sprayed tantalum, approximately 1.5 mils (0.0038 cm) of plasma-sprayed molybdenum, about 2 mils (0.0051 cm) of flame-sprayed tantalum-zirconia mixture, and about 6.5 mils (0.0165 cm) of flame-sprayed zirconia in that order. Zirconia B powder was then enclosed in a 20 mil (0.0508 cm) Haynes alloy No. 25 capsule and this was in turn placed in the coated graphite crucibles to simulate a fueled SNAP-19B (IRHS) assembly. The two graphite halves were slip-fitted together and sealed with National C-9 glue.

After out-gassing, the samples were subjected to the time-temperature profile of Figure 39. Further out-gassing of the samples occurred during the test and prevented attainment of the peak temperature.

The "cold" tests reported above in PART 2 indicated that a Haynes alloy No. 25-graphite reaction is very difficult to stop. The coating tested in Category 3 provided the best protection of all the coatings investigated and no detectable Haynes alloy No. 25-graphite reaction areas were apparent. However, high heat flux seemed to cause a uniform shrinking of the coatings. As a result, the coating separated in some areas from the graphite, but still provided a barrier between the graphite and the Haynes alloy No. 25.

It cannot be concluded, however, from these tests that other variables present during reentry would not be conducive to the reaction in question.

VI. REFERENCES

1. R. E. Zielinski, Haynes Alloy No. 25 Filter Test
Special report from Mound Laboratory, January 12, 1968
(Classified CRD-1)

2. B. R. Kokenge, SNAP-19B2 Compatibility Report
Special report from Mound Laboratory, September 11, 1967
(Classified CRD-1)

3. R. E. Zielinski, Materials Compatibility Testing for the SNAP-19B Remake System
Special report from Mound Laboratory, December 11, 1967
(Classified CRD-1)

VII. ACKNOWLEDGMENT

The SNAP-19B (IRHS) Program at Mound Laboratory required extensive team effort and the use of many disciplines. The authors of the present report wish to acknowledge all contributions made to the Program by their associates in the Nuclear Operations Division, and particularly by those in the Production, Technology, Quality & Reliability, and Program Planning & Coordination Departments. Appreciation is likewise extended to the gaging section and various engineering groups at Mound Laboratory - also to the Atomic Energy Commission, Dayton Area Office - for their assistance.

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APPENDIX A

FUEL SPECIFICATIONS FOR SNAP-19B (IRHS) PROGRAM*

*Fuel specifications were identical to those for the SNAP-27 program.

FUEL SPECIFICATIONS

A. FUEL

1. Lot Definition A lot of fuel shall be the amount required to load a half capsule. A lot shall consist of several batches. If the lot of fuel is reclaimed material from the liner, half capsule, or either half of the complete capsule, a sample of the lot shall be taken and shall conform to the requirements of items 3 through 9.

2. Batch Definition A batch of fuel shall be approximately 200 grams of fuel enclosed in a container.

3. Stoichiometry The fuel shall be in the form of plutonium dioxide having a stoichiometry of $PuO_{1.96-2.04}$. This characteristic shall be measured on a sample from a minimum of one batch in every five or on a representative lot sample.

4. Isotope Ratio Not less than 77.5% of the atoms of plutonium shall be of atomic weight 238. This characteristic shall be measured on a sample from a minimum of one batch in every five or on a representative lot sample.

5. Impurities The cation impurities consisting of the isotopes Pa-231, Th-232, U-233, U-235, U-236, Pu-236 and Np-237 shall not exceed 1 w/o of the fuel. The total of all other cation impurities with the exception of U-234 shall constitute not more than 2 w/o of the fuel. The actinide impurities shall be determined on a sample taken from a minimum of one batch in every five batches or on a lot sample made up by proportionate quantities taken from each of the lot batches. All the other cation impurities shall be determined for each batch and individual impurities shall be tabulated. The systems contractor shall be advised if any single impurity exceeds 0.5 w/o on more than three of the batches combined into a lot.

6. Sphericity The plutonium-238 dioxide shall be in the form of plasma-fired microspheroids with a maximum to minimum axis ratio of 2 or less. This characteristic shall be measured on a sample from each batch.

7. Size Range The spheres shall fall in the range from 50-250 micron diameter with no more than 3% of the particles between 250 and 262 micron diameter, no more than 2% between 262 and 280 micron diameter, and no particles greater than 280 micron diameter. No more than 5% of the spheres shall be between 47 and 50 micron diameter. The size range shall be measured on a sample from each batch.

8. Density The average apparent density of the fuel in a lot shall not be less than 9.5 gm/cm^3 as determined by the weighted average of the various batches in the lot. The minimum average apparent density permitted for any batch of fuel shall be 9.1 gm/cm^3.

9. Crush Strength The average particle crush strength shall be greater than 200 grams. This characteristic shall be determined on a sample randomly selected from each batch of fuel.

10. Power Density The fuel as measured by final calorimetry and volume of the fuel annulus assembly shall have a power density of 2.5 to 2.8 $watts/cm^3$.

11. Melting Point The melting point of the fuel exclusive of instrument error shall be greater than 2000°C. The melting point shall be determined on a sample which is representative of the lot of fuel.

12. Fines Determination The quantity of particulate material below 47 microns in diameter removed from a sample of the lot of fuel shall not exceed 1×10^{-3} weight percent. The fines shall be determined on a sample which is representative of the lot of fuel.

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B. INERT FILLER

The inert filler material shall be zirconium dioxide particles. The following characteristics shall be determined by the fueling agency on a sample representative of a batch consisting of approximately 400 grams of the material.

1. Size Range The particles shall fall nominally in the range from 300-590 micron diameter with no more than 5% of the particles between 590 and 710 micron diameter or between 285 and 300 micron diameter. No particles shall be less than 285 micron diameter or greater than 710 micron diameter.

2. Size and Shape The size and shape of the zirconium dioxide filler material shall be determined by photography.

3. Stoichiometric Analysis The zirconium dioxide shall have a stoichiometry of $ZrO_{1.95}$ or greater.

4. Crush Strength The average particle crush strength shall be greater than 200 grams.

5. Impurities Analysis The cation impurities shall constitute less than 2 w/o of the filler material.

6. Inert Filler Compatibility The fueling agency shall provide to the systems contractor such data that are available at the time the heat source is shipped concerning the compatibility of the zirconium dioxide filler material with the fuel and liner material. Such compatibility data which may be developed following the shipment of the source will be made available to the systems contractor upon written request.

APPENDIX B

SNAP-19B (IRHS) FABRICATION PROCEDURES

TABLE OF CONTENTS

I. INTRODUCTION

This document describes the procedures that will be used to fabricate, inspect, and package SNAP-19B (IRHS) heat sources. The SNAP-19B (IRHS) heat source (Figure 1) will deliver 570 ± 17 watts of thermal power and consists of a graphite fuel block, insulation discs, a tantalum canister, and the fuel capsule. The fuel capsule consists of the Haynes alloy-25 shell, plutonium-238 dioxide microsphere fuel, zirconia microsphere filler material, a filter assembly, a seal disc, and an end plug. The fabrication procedures are illustrated in Figure 2.

II. APPLICABLE DOCUMENTS

In case of conflict with any other documents, this document shall have precedence over all other documents.

SNAP-19B (IRHS) Heat Source Fabrication Procedures
Drawing No. 1-11391, Rev. 7, Section 3.3 (Fuel Specifications)
Drawing No. 1-11391, Rev. 7, Section 3.5 (ZrO_2 Filler specifications)
Drawing No. 1-11533, Procedures for Nonconforming Material
Drawing No. 4-7067, Capsule Assembly for IRHS
Technical Manual MD-10032, Health Physics Precautions (MLM-CF-64-7-11)
Technical Manual MD-10038, Nuclear Criticality Precautions
Technical Manual MD-10050, Special Precautions for Handling Radioactive Materials in the Research Department
Technical Manual MD-10058, Quality Control Policy and Program
Technical Manual MD-20619, Fuel Fabrication Procedures
Technical Manual MD-20631, Operating Procedures for Calorimeter #107
Technical Manual MD-20650, SNAP-27 Analytical Procedures (Chapters 3 and 4)
Operation and Maintenance Manual of VEECO Mass Spectrometer Leak Detector Models MS-9A, MS-9AB, MS-9ABC

III. QUALITY CONTROL GUIDELINES

The Quality and Reliability Organization will implement a quality control program, excluding the detailed procedure manuals required under the N-10 concept, that will provide adequate assurance of quality of the 19B (IRHS).

Quality Control Engineering will provide independent assurance that the product was manufactured by a controlled process; that components and assemblies conform to drawings and specifications; that non-conformance of components, process and/or product is appropriately documented. If significant deviations do exist, these

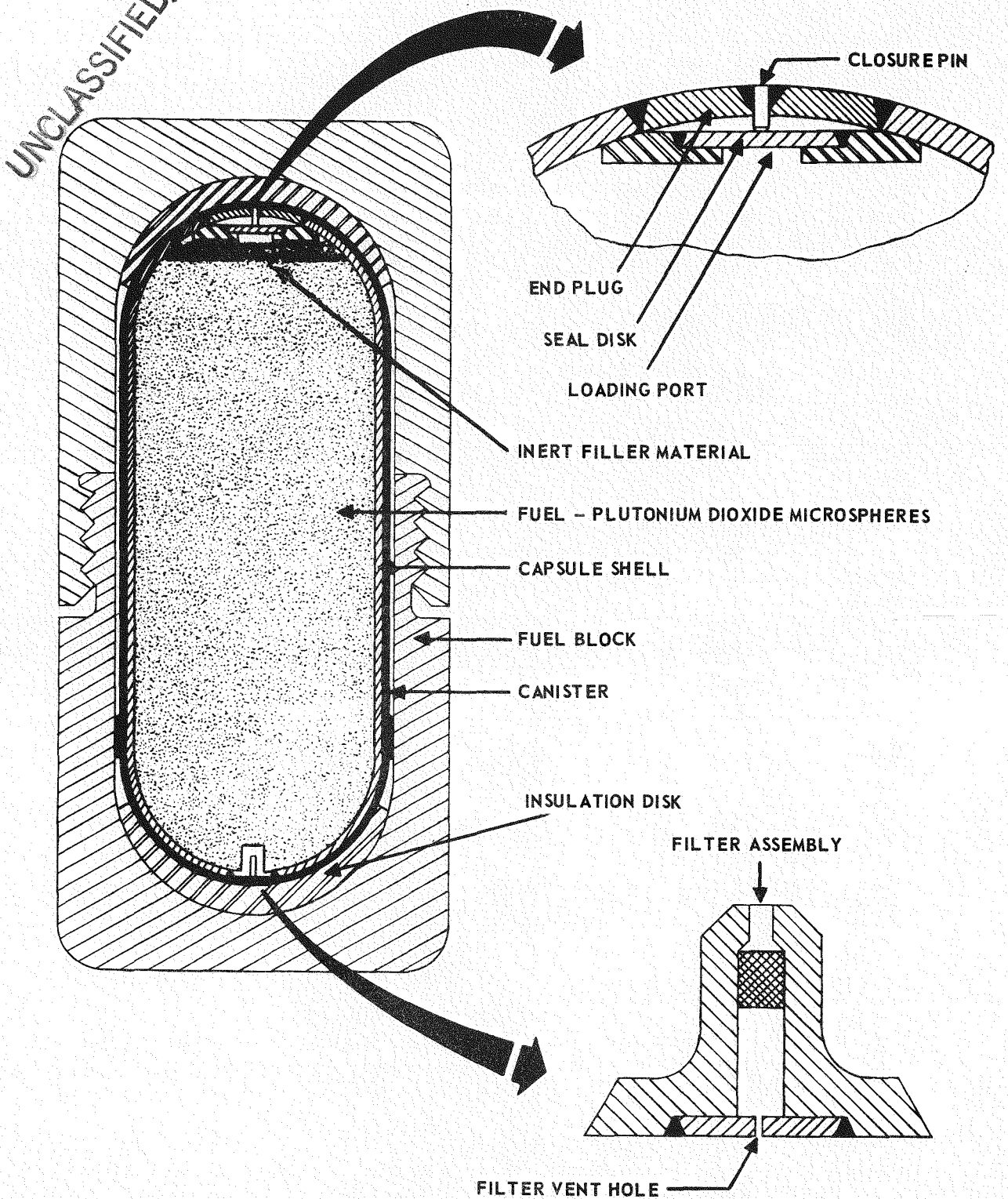

FIGURE 1 - SNAP-19B (IRHS) heat source.

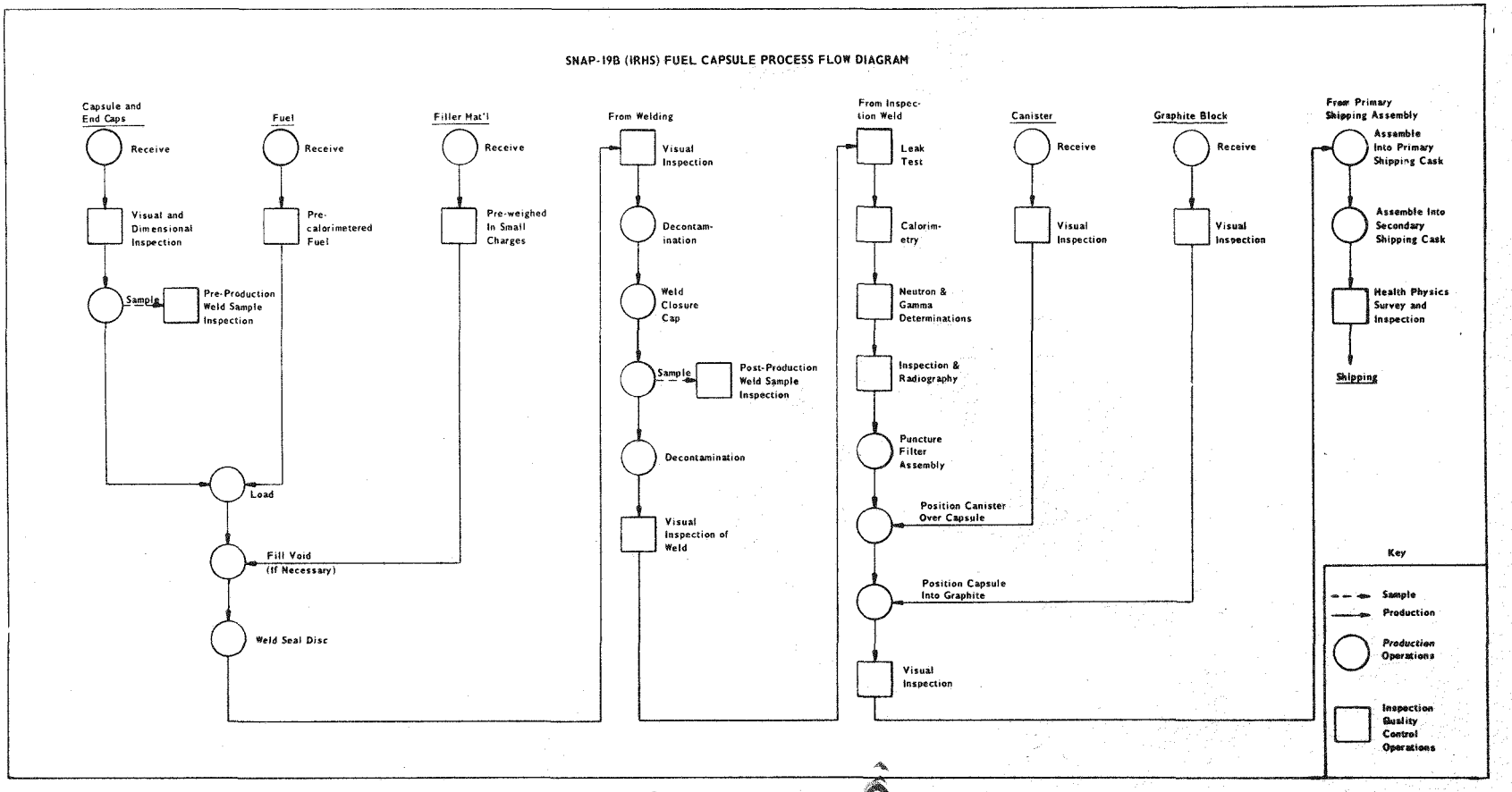

FIGURE 2 - Fabrication procedures.

deviations will be reviewed by the Task Force and accepted by the AEC. An adequate data package will document product quality.

1. AEC-accepted SNAP-27 fuel and filler will be used.

2. The following capsule component dimensions, which are critical to the welding, will be gaged and recorded:

   Capsule

   .Dimensions of end plug to match those in recess of capsule so that end plug will fit in place with a maximum mismatch not greater than 0.005 inch.

   .Outside diameter of seal disc to fit dimension in capsule to provide 0.003-0.005 inch clearance.

   .Depth of seal disc recess in capsule shall equal seal disc thickness within ± 0.002 inch.

3. A record of assembly will be maintained (See Figure 3).

4. Welding parameters will be recorded (See Figures 4 and 5).

5. Sample welds will be prepared before and after fueling capsules. These welds will be leak checked, dye penetrated, radiographed, metallographically examined and photographs will be taken of the metallographic cross sections.

6. The fueled heat source closure weld will be visually inspected for defects and the results will be recorded. This weld will have a minimum penetration of 80% of the closure cap wall thickness.

7. The fueled heat sources will be helium leak-checked and the results recorded and shall be no greater than 1.0×10^{-6} standard cc/sec.

8. The fueled heat sources will be calorimetered and results recorded. A thermal inventory of 570 ± 17 watts including calorimetry error is required.

9. A statement will be included that the fuel capsule diaphragm has been punctured.

10. The neutron and gamma dose rates of the fueled heat sources will be determined and recorded. The total dose rate shall not exceed 55 mr/hr at 1 meter.

LOADING DATA SHEET

Batches of Fuel Loaded

_____

_____

_____

_____

_____

_____

_____

_____

Capsule SN _____

Vibrator Operation

Setting	Time
_____	_____
_____	_____
_____	_____
_____	_____

ZrO_2 Filler

Original Weight ZrO_2 and Container _____ grams

Final Weight ZrO_2 and Container _____ grams

Difference _____ grams loaded

Operator: _____ Date: _____

Remarks:

FIGURE 3 - Loading data sheet.

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SEAL DISC WELD DATA SHEET

Capsule SN _____

Spot Welding

Current: _____ amperes

Arc Gap: _____ inch

Weld Time: _____ second

Flow Gas Setting: _____ cu. ft/hr.

Closure Welding

Current: _____ amperes

Arc Gap: _____ inch

Weld Time: _____ second

Flow Gas Setting: _____ cu. ft/hr.

Speed of Rotation: _____

Flow Gas: _____

Visual Results: _____

_____

_____

Operator: _____ Date: _____

FIGURE 4 - Seal disc weld data sheet.

END PLUG WELD DATA SHEET

Operator_____

Capsule SN_____ Date_____

Spot Welding

Current: _____ amperes

Arc Gap: _____ inch

Weld Time: _____ second

Flow Gas Setting: _____ cu. ft/hr.

Closure Welding

Current: _____ amperes

Arc Gap: _____ inch

Weld Time: _____ second

Flow Gas Setting: _____ cu. ft/hr.

Speed of Rotation: _____

Flow Gas: _____

Pin Closure Welding

Current: _____ amperes

Arc Gap: _____ inch

Weld Time: _____ second

Flow Gas Setting: _____ cu. ft/hr.

Speed of Rotation: _____

Visual Results: _____

_____

FIGURE 5 - End plug weld data sheet.

11. The level of surface contamination on the fueled heat sources will be determined prior to shipment and recorded. The graphite block will be 20 dpm or less for 100 cm^2 alpha survey swipe.

12. All fabrication and inspection data will be reviewed by the QC Engineer before the heat source is submitted to the DAO/QA of the AEC for acceptance.

13. Requests for deviations from specifications will be submitted to the AEC as described in Drawing No. 1-11533.

NOTE: Take extreme precautions at all times to protect the interior of the capsule from intrusion of foreign particles or liquids which might damage the filter. When inspecting or handling the capsule in an ordinary environment the capsule should be kept inverted (open hole down) as much of the time as possible so that airborne particles will not settle into the capsule cavity. A clean plastic, metal or other cover should be placed over the hole or the entire capsule if possible, during operations when the capsule cannot be inverted.

IV. LOADING

The loading, welding, and decontamination procedures will be performed in R-149 (Figure 6). The loading operation is described in this section.

1. Before the capsule is placed in the SNAP line, it will be sealed inside of the water-cooled cooling block (See Figure 7). The cooling block is then pressure tested for water leakage. The entire block, except for the ground cup and the fueling port, will be covered with a strippable coating, over which will be placed a plastic bag, again leaving the ground cup and the fueling port exposed. The inlet and outlet water lines and the rotary fitting will not be covered with plastic because they will be discarded during the decontamination operation.

2. One set of quick-disconnects will be placed in the lines for removal of the block from the pass box on the way out. These quick-disconnects will be covered with plastic to keep them free of contamination. This will help insure that no contamination is introduced into the water lines.

3. A gas sample will be taken from the loading box within one hour prior to fueling. Results will be recorded.

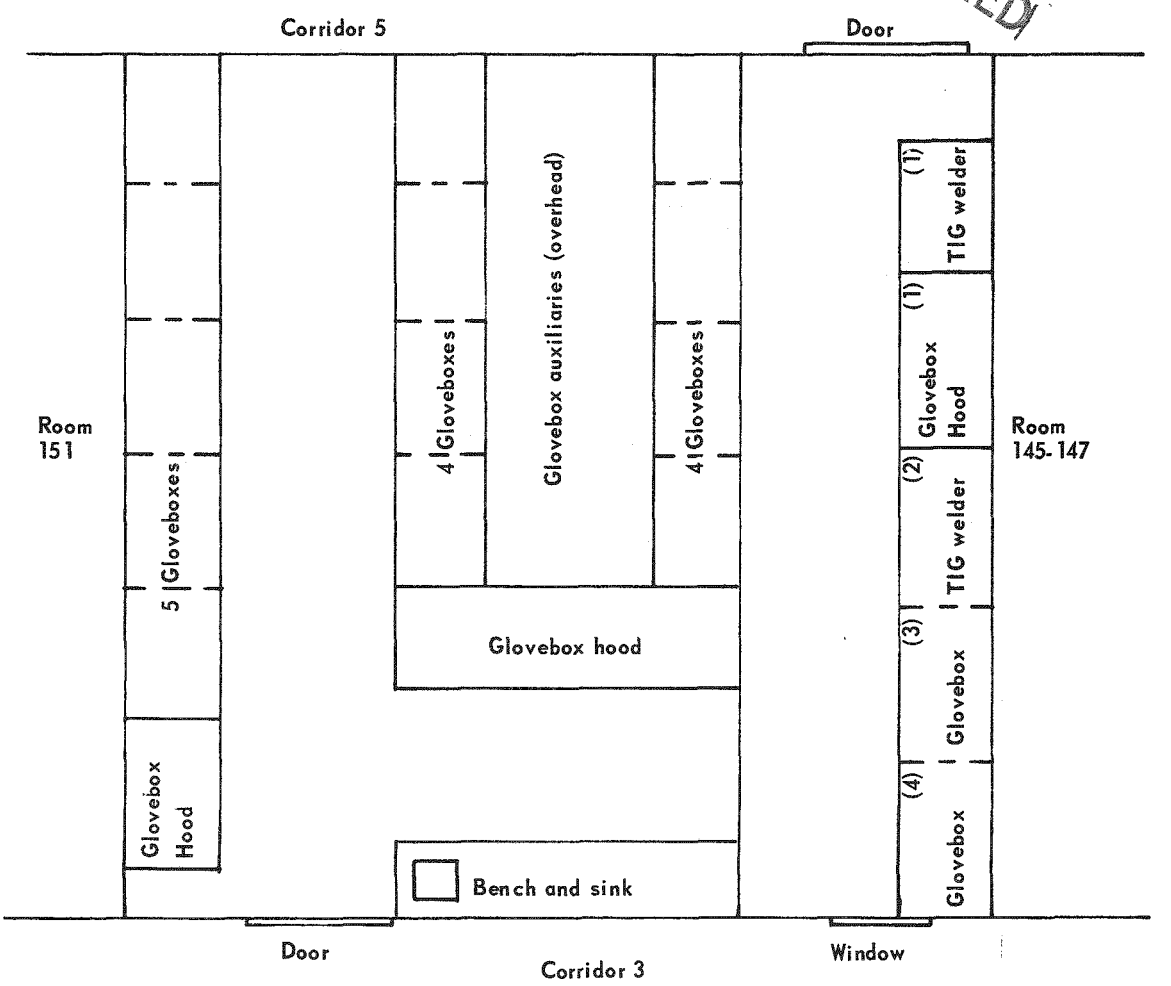
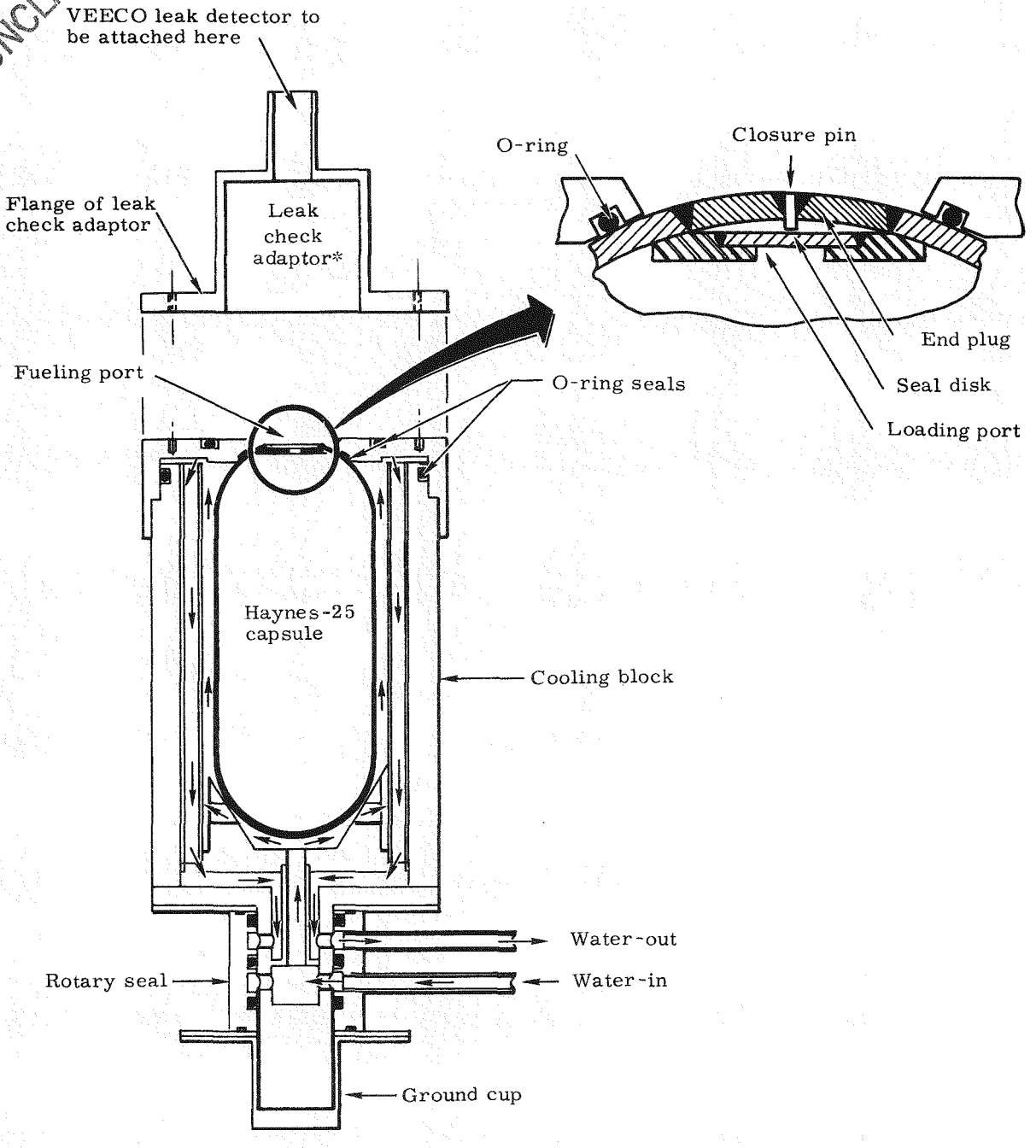


FIGURE 6 - Equipment arrangement - Room 149.



*Bolted to plate of cooling block during leak checking operation

FIGURE 7 - Water-cooled cooling block.

4. With the capsule sealed in the cooling block and the block doubly sealed, the unit will be placed in the fumehood which will be free of contamination. The water lines will be connected to the water lines inside the pass box which again will be free of contamination. These lines are Tygon tubing attached to 1/4 inch O.D. stainless steel tubing with brass hose clamps.

5. After water line hookup, an appropriate water flow rate will be established and the block and hose placed in the pass box. The pass box will be evacuated and refilled with high purity commercial helium three times before the inner door is opened and the unit is passed into the SNAP line. The cooling water will be released in a "hot" drain.

6. Once inside the SNAP line, the inner door of the pass box will be left ajar so that the water lines will remain connected inside the pass box. The gap left by the open door will be sealed with tape to keep the pass box as free of contamination as possible.

7. The cooling block will be placed in the welding fixture and the fixture will be tested to see that it functions properly. A protective collector pan will be placed on top of the cooling block and a fueling funnel placed in the fueling port in the top of the capsule.

8. The acceptable fuel (1-11391, Rev. 7), placed in glove box #3 before the cooling block is passed in, with lids cracked for easy opening, will be poured into the capsule through the funnel. The fueling funnel will be designed so as to eliminate contamination of the primary weld area. If the capsule does not accept the entire pre-calorimetered fuel load, the cooling block will then be placed on a vibratory table. If the fuel does fill the capsule and still leaves a void, the latter will be filled with ZrO_2 spheroids. Handling of the fuel containers and the fueled capsule and cooling block will be done with beaker tongs. These tongs should keep the fuel at least four to six inches from the operator's hands.

V. WELDING

A. GENERAL

1. Welding parameters (TIG) will be established by a weld development program. The final parameters will be recorded.

2. All weld development samples will be metallographically sectioned and evaluated. All samples will be photographed and filed with their respective welding parameters.

3. Weld control samples of the final closure weld and vent weld will consist of one prior to fueling of two capsules and one after. The weld control samples will be evaluated in the following manner:

   a. Leak check (maximum leak rate of 1×10^{-6} std cc/sec).

   b. Dye penetrant

      (1) Any well-defined crack shall be evaluated for acceptance or rejection.

      (2) No surface pore shall exceed 0.005 in. diameter.

   c. Radiography

      (1) Any well-defined crack shall be evaluated for acceptance or rejection.

      (2) The weld area shall not contain any inclusions exceeding those of parent material (except for vent weld).

   d. Metallographic evaluation will consist of

      (1) Sample will be sectioned at one point through weld overlap (minimum penetration of 80% of cap wall thickness will be obtained).

      (2) Sample will be sectioned at one point through the normal weld (minimum penetration of 80% of cap wall thickness will be obtained).

      (3) The specimen will be sampled to include the vent weld (minimum penetration of 0.010 inches shall be obtained).

      (4) The above samples will be visually observed at 250X (any well-defined crack shall be cause for rejection).

      (5) Above samples will be photographed at 16X (photos will be kept at Mound for future reference).

4. One sample weld will be run before and one after the fueling of two fueled capsules. These sample welds will demonstrate the characteristics of welds made using the

same parameters employed for the fueled capsules. Both the sample seal welds and the sample closure welds will be made in the "cold" glove box (TIG welder #1 of Figure 6) because of contamination problems if the seal welds were made in the same glove box as those of the fueled capsules. The same power supply will be used in performing the seal weld in the "hot" box and the closure weld in the "cold" box. During fabrication of the live capsules the box atmosphere will be sampled and recorded before the seal welding operation and before the closure welding operation.

5. The fueled capsule final closure weld and vent weld will be evaluated in the following manner:

   a. Leak check (maximum leak rate of 1×10^{-6} std. cc/sec).

   b. Radiography (side view of capsule for observing fuel level).

   c. Examination will be performed for visual defects of the weld area.

6. Records will be kept of all welding done on capsules by Mound personnel.

B. SEAL WELD PROCEDURES

1. When the capsule has been fully loaded, the funnel and protection pan will be removed and the seal disc placed in its appropriate recess. A holddown clamp will be fixed to the outside of the cooling block to hold the seal disc in place.

2. The TIG torch head will be positioned over the weld area and aligned. With the torch head in position the seal disc will be tack-welded in at least two places.

3. The holddown clamp will then be removed and the seal disc welded all around. The depth of penetration sought will be for a seal only. This seal weld will be examined visually for a complete bead around the seal disc.

4. A gas sample will be taken after the seal weld and recorded.

5. After the seal weld has been made, the cooling block will be placed back into the pass box along with the water lines for passage out into the fumehood for decontamination.

C. DECONTAMINATION

1. Prepare the decontamination fumehood by covering the floor of the fumehood with three layers of wet rags. The minimum front face air velocity for this hood is 125 linear feet/minute.

2. With the fumehood front closed, the shadow shield in place, and the interior lined with wet rags, the pass box door will be opened and the cooling block removed and placed in the bottom of the fumehood on wet rags. The outside of the cooling block will be covered with wet rags, as it is removed from the pass box. The water lines will be opened by means of the quick-disconnect fittings which were covered with plastic. The cooling block will then be reconnected to water lines in the fumehood. With the water lines reconnected, the pass box door will be closed. The block will be placed in a holding device for decontamination. This will prevent unnecessary hand exposure which would result if someone had to hold the block during the subsequent steps.

3. The rags covering the top of the cooling block will be removed and the fueling port and top of the capsule will be decontaminated. This will be done using scouring cleanser, water and a brush. At this point the exposed portion of the capsule will be decontaminated to a few thousand counts per minute or less.

   NOTE: The following procedure will be used to determine the level of surface contamination:

   a. Depending on the temperature of the capsule use glass fiber cloth or standard filter paper to wipe the exposed area.

   b. Count the activity with a PAC-1SA (high level) or an Eberline Alpha Scintillation Counter (low level).

4. Next, the outer plastic bag will be removed from around the block using tongs and scalpel. As the bag is removed from top to bottom the block will be covered with wet rags. Once the bag and contaminated rags have been removed from the fumehood, the capsule and fueling port will be decontaminated with scouring cleanser to the lowest level possible.

5. The strippable coating will be removed from the cooling block. The rotary fitting on the base of the block along with the ground cup will be removed and discarded, and a new fitting applied. The new fitting will be connected

to water lines inside of the pass box leading into a welding box which will be free of contamination (cold). The decontaminated cooling block will be placed in the pass box and the door closed.

D. CLOSURE WELD

1. The cold weld box will have been evacuated and refilled with high purity (U.S. Bureau of Mines, Grade A) commercial helium three times before the cooling block and capsule is passed in. The pass box will be evacuated and refilled with helium three times before the inner door is opened for entrance of the block and capsule. A sample of the gas in the box will be taken prior to welding and recorded.

2. Once inside the cold weld box, the cooling block will be positioned in the welding fixture. The end plug will be placed in position and held by a holddown clamp fastened to the cooling block. The TIG torch will be positioned and aligned and the end plug tacked in at least three places. After tacking, the holddown clamp will be removed and the end plug will be welded in one continuous path.

E. CLOSURE PIN WELD

1. After completing the closure weld, a pin hole (0.025" - 0.030" diameter), which will contain a pin, will be closed by TIG welding to meet Mound's Drawing No. 4-7067.

F. POST WELD OPERATIONS

1. After the final closure weld, the outer pass box door will be opened and a wipe survey taken of the pass box. If there is no indication of activity, the source will be placed in the pass box. The outer door will be opened again and the cooling block wiped to determine the surface contamination level. The cooling block will be placed in the fumehood and the capsule removed. The capsule will then be decontaminated until further decontaminating procedures do not reduce the level of wipeable activity on the capsule.

2. The capsule will then be placed in a clean cooling block for leak testing.

VI. POST FABRICATION INSPECTIONS

A. LEAK CHECK

The leak check adapter (Figure 7) will be connected to the source holder. This in turn will be connected to a VEECO MS 9AB Leak Detector and a leak rate will be determined as described in Operation and Maintenance Manual of VEECO Mass Spectrometer Leak Detector Models MS9A, MS-9AB, MS-9ABC. The maximum leak rate allowable will be 1 x 10^{-6} std cc/sec.

B. RADIATION MEASUREMENTS

1. Room Preparation

   1.1 Survey the room to assure that the room and equipment to be used are free of contamination.

   1.2 The following health physics equipment and supplies must be in location and ready for use:

   - One Texas Nuclear neutron spherical dosimeter, Model #9140
   - One Victoreen Radector II beta-gamma survey meter
   - One Eberline PAC-1SA alpha survey meter
   - One Victoreen Alpha Air Particulate Monitor
   - Tongs for handling the heat source

2. After the capsule is leak tested, it is received in R-199 for measurement of gamma and neutron radiation levels. Up to this point, all dose rate measurements have been taken through shielding water, or hurriedly taken on the bare capsule before it could heat up appreciably. These measurements can now be taken under much better conditions. The instruments used are the Texas Nuclear spherical neutron dosimeter and a Victoreen Radector II beta-gamma survey meter or equivalent.

3. Measure the neutron and gamma radiation levels at 200, 100, 40 and 25 cm (center of the heat source to the center of the detector) both with and without the graphite fuel block.

4. Use the measured intensities to calculate the surface dose rate. These measurements provide the exposure guidelines

during all subsequent steps. (Other measurements will be required to be performed for the AEC under appropriate health physics conditions.)

5. Return the heat source to the transfer container.

C. NEUTRON COUNTING

1. Room Preparation

1.1 Survey the room to assure that the room and equipment to be used are free of contamination.

1.2 The following health physics equipment must be in location, ready for use:

- One Victoreen Alpha Air Particulate Monitor
- One Eberline PAC-1SA alpha survey meter
- Tongs for handling the heat source

2. Remove the heat source from the transfer container and survey it for alpha contamination.

3. Determine the neutron emission rate of the heat source with a precision long counter or similar instrument.

4. Place the heat source in the transfer container.

D. CALORIMETRY

1. Prior to admitting the source to the calorimetry room, the room will be surveyed to assure that room and equipment are free of contamination.

2. Suitable instrumentation as specified by Health Physics should be on hand to monitor the source during calorimetry.

3. After the source is received, enclosed in the calorimeter can (see Figure 8), it is taken from the transfer container and loaded into the calorimeter.

4. Radiation levels around the calorimeter are measured.

5. The capsule is to be calorimetered in Calorimeter 107 as described in Technical Manual 20631, Operating Procedures for Calorimeter 107, to determine its thermal output. During calibration runs, the sample can will be replaced by an empty calorimeter can with the same configuration.

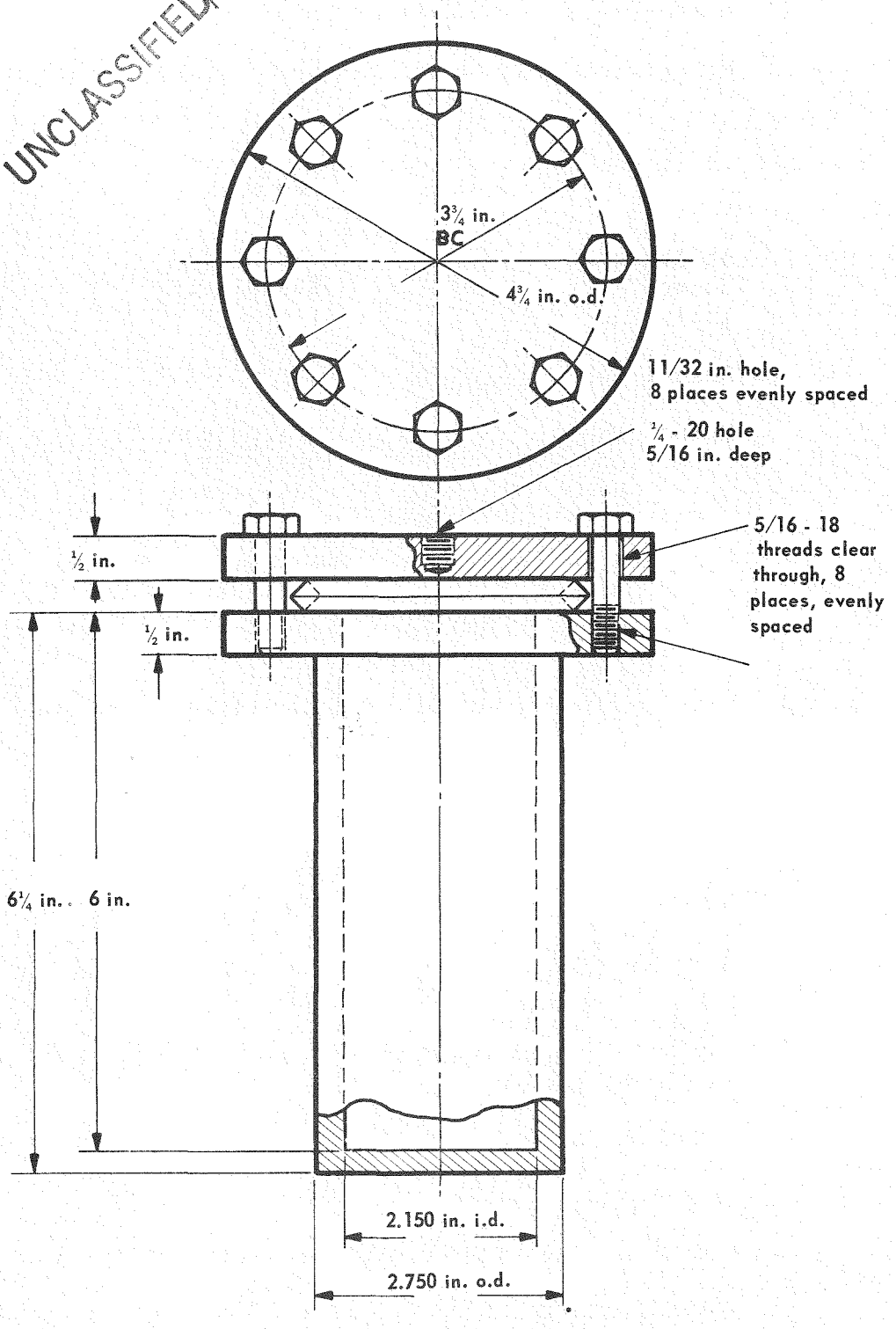


FIGURE 8 - Calorimeter can.

6. At least five calorimeter values will be obtained on the source. The source is to have an output of 570 ± 17 watts including calorimetry error.

7. Results will be reported on Form R-1152.

NOTE: The sequence of operations concerning neutron counting, and calorimetry may not necessarily be done in the order as presented above.

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APPENDIX C

NEUTRON AND GAMMA DOSE RATE MEASUREMENTS FOR SNAP-19B (IRHS) FUELED CAPSULES

TABLE 1

MEASURED NEUTRON AND GAMMA DOSE RATES
FROM
SNAP-19B (IRHS) CAPSULE 342/360[a]

Location on Capsule	Distance (cm)	Distance (in.)	Dose Rate Neutron (mrem/hr)	Dose Rate Gamma (mrem/hr)	Dose Rate Total (mrem/hr)
Side	20	7.9	745	80	825
	25	9.85	451	48	499
	30.5	12.0	298	32	330
	40	15.7	166	16	182
	50	19.7	105	9	114
	61	24.0	71	6	77
	100	39.4	29	2	31
	122	48.0	20	1	21
	183	72.0	9	0.6	9.6
	200	78.8	9	0.5	9.5
End	20	7.9	536	38	574
	25	9.85	319	20	339
	40	15.7	117	6	123
	50	19.7	73	4	77
	100	39.4	20	1	21
	200	78.8	7	0.3	7.3

[a] See Section IV.E.8 in main report for details relating to these measurements.

TABLE 2

MEASURED NEUTRON AND GAMMA DOSE RATES
FROM
SNAP-19B (IRHS) CAPSULE 370/376[a]

Location on Capsule	Distance (cm)	Distance (in.)	Dose Rate Neutron (mrem/hr)	Dose Rate Gamma (mrem/hr)	Dose Rate Total (mrem/hr)
Side	20	7.9	653	78	731
	25	9.85	399	45	444
	30.5	12.0	264	28	292
	40	15.7	152	15	167
	50	19.7	97	8	105
	61	24.0	65	5	70
	100	39.4	26	2	28
	122	48.0	18	1.3	19.3
	183	72.0	10	0.5	10.5
	200	78.8	8	0.5	8.5
End	20	7.9	483	38	521
	25	9.85	295	20	315
	40	15.7	103	6	109
	50	19.7	66	4	70
	100	39.4	18	0.8	18.8
	200	78.8	6	0.3	6.3

[a] See Section IV.E.8 in main report for details relating to these measurements.

TABLE 3

MEASURED NEUTRON AND GAMMA DOSE RATES
FROM
SNAP-19B (IRHS) CAPSULE 341/358[a]

Location on Capsule	Distance (cm)	Distance (in.)	Dose Rate Neutron (mrem/hr)	Dose Rate Gamma (mrem/hr)	Dose Rate Total (mrem/hr)
Side	20	7.9	643	68	711
	25	9.85	398	37	435
	30.5	12.0	261	23	284
	40	15.7	151	12.5	163.5
	50	19.7	98	7.5	105.5
	61	24.0	66	5	71
	100	39.4	26	1.7	27.7
	122	48.0	18	1	19
	183	72.0	10	0.6	10.6
	200	78.8	8	0.4	8.4
End	20	7.9	480	34	514
	25	9.85	280	18	298
	40	15.7	104	5.7	109.7
	50	19.7	62	3.4	65.4
	100	39.4	19	1	20
	200	78.8	5.6	0.3	5.9

[a] See Section IV.E.8 in main report for details relating to these measurements.

TABLE 4

MEASURED NEUTRON AND GAMMA DOSE RATES
FROM
SNAP-19B (IRHS) CAPSULE 373/380[a]

Location on Capsule	Distance (cm)	Distance (in.)	Dose Rate Neutron (mrem/hr)	Dose Rate Gamma (mrem/hr)	Dose Rate Total (mrem/hr)
Side	20	7.9	733	81	814
	25	9.85	443	52	495
	30.5	12.0	288	30	318
	40	15.7	163	16	179
	50	19.7	105	8.8	113.8
	61	24.0	70	5.5	75.5
	100	39.4	28	2	30
	122	48.0	21	1.3	22.3
	183	72.0	10	0.6	10.6
	200	78.8	9	0.5	9.5
End	20	7.9	484	25	509
	25	9.85	295	14	309
	40	15.7	102	4.4	106.4
	50	19.7	65	2.6	67.5
	100	39.4	18	0.6	18.6
	200	78.8	6	0.2	6.2

[a] See Section IV.E.8 in main report for details relating to these measurements.

TABLE 5

MEASURED NEUTRON AND GAMMA DOSE RATES
FROM
SNAP-19B (IRHS) CAPSULE 369/375[a]

Location on Capsule	Distance (cm)	Distance (in.)	Dose Rate Neutron (mrem/hr)	Dose Rate Gamma (mrem/hr)	Dose Rate Total (mrem/hr)
Side	20	7.9	737	105	842
	25	9.85	476	71	547
	30.5	12.0	326	48	374
	40	15.7	194	29	223
	50	19.7	127	18.5	145.5
	61	24.0	89	11.5	100.5
	100	39.4	36	4.2	40.2
	122	48.0	26	2.7	28.7
	183	72.0	13	1.4	14.4
	200	78.8	12	1.2	13.2
End	20	7.9	724	75	799
	25	9.85	439	40	479
	40	15.7	154	13.5	167.5
	50	19.7	96	7.5	103.5
	100	39.4	26	1.9	27.9
	200	78.8	9	0.6	9.6

[a] See Section IV.E.8 in main report for details relating to these measurements.

TABLE 6

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MEASURED NEUTRON AND GAMMA DOSE RATES
FROM
SNAP-19B (IRHS) CAPSULE 361/368[a]

Location on Capsule	Distance (cm)	Distance (in.)	Dose Rate Neutron (mrem/hr)	Dose Rate Gamma (mrem/hr)	Dose Rate Total (mrem/hr)
Side	20	7.9	704	94	798
	25	9.85	457	59	516
	30.5	12.0	312	40	352
	40	15.7	181	22	203
	50	19.7	118	13	131
	61	24.0	81	9.5	90.5
	100	39.4	34.2	3.2	37.4
	122	48.0	23	2.2	25.2
	183	72.0	12	1.0	13
	200	78.8	11	0.9	11.9
End	20	7.9	547	40	587
	25	9.85	326	22	348
	40	15.7	119	7.2	126.2
	50	19.7	77	4.5	81.5
	100	39.4	22	1.3	23.3
	200	78.8	7.5	0.4	7.9

[a] See Section IV.E.8 in main report for details relating to these measurements.

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APPENDIX D

UNCLASSIFIED

ASSEMBLY AND SHIPPING PROCEDURES FOR SNAP-19B (IRHS) CAPSULES

ASSEMBLY AND SHIPPING PROCEDURES

GENERAL

In the helium atmosphere of a Mound glove box, the IRHS fuel capsule will be loaded into its graphite heat block. Upon completion of this operation, this fueled graphite assembly will be placed in a primary container capable of maintaining a helium atmosphere. The primary container will then be placed into a modified SNAP-19B shipping cask. The shipping cask will be sent to MMC from MRC by truck.

Equipment Descriptions:

1. Primary Container

   Dimensions: Major dia. - 6"; length - 9.5"

   Material: Stainless Steel

The primary container is in two sections. They are bolted together with 3/8" bolts that thread into the larger bottom section. The smaller top section is ~3" long. The top section seals to the body by a metal O-ring.

In the center of the top and bottom sections, external purge lines are located. These lines are equipped with bellows valves close to the container surface. This arrangement permits a straight-through flow of gas.

2. SNAP-19B Shipping Cask

   Dimensions: Modification of SNAP-19B Shipping Cask

   Cavity length increases from 10-7/8" to 12"
   Major diameter increases from 3-1/8" to 6"
   Minor diameter increases from 3" to 4"

The lid and bottom of the cask are recessed to provide space for the primary container purge valves. The lid seals to the body by a Viton O-ring.

PROCEDURES

A. Prior Set-Up Inside Box

1. Pass 20 wipes and envelopes into the operation box.

2. Position the cap and sleeve pieces of the zirconia-coated canister on a dummy capsule to observe if they fit functionally.

3. Place the sleeved portion of the zirconia-coated capsule canister in the vertical assembly holder.

4. Record graphite heat shield dimensions on suitable calculation sheet outside the working environment. The required measurement to be supplied by Martin will be the length of the graphite heat shield with the tantalum washer installed and the inside of the primary shipping cask. These measurements will be certified to meet the specification of MD-4-7138.

5. Remove the graphite heat shield components in a helium atmosphere from the heat-sealed polyethylene bags. Assemble graphite heat shield with the tantalum washer and bottom out. Then measure and record the gap between the halves. The female heat shield detail will be placed in the clamping fixture with the open end up. One tantalum support pad (MM 452B1200108-003) is installed in the male detail of the graphite heat shield. Two tantalum support pads are installed in the female detail of the graphite heat shield. The larger pad (MM 452B1200108-001) is installed first, then the smaller pad (MM 452B1200108-003). These are installed by the Martin Company before shipping to Mound Laboratory. Check to see that the top, or smaller pad, overlaps the slits of the bottom, or larger pad, in the female detail.

6. Invert the primary shipping container top section in its stand with the O-ring to receive the finished heat source assembly. Min-K pads will then be positioned in the well of the top section and in the well of the bottom section.

B. Heat Source Assembly

1. Swipe the surface of the capsule for alpha activity and record the measurement.

   NOTE: A swipe is the wiping of 100 cm^2 of the designated surface with a piece of wipe paper.

2. Place fueled capsule in helium atmosphere box.

3. Take a gas sample of the operation box atmosphere and record the results. It should be less than 300 ppm of oxygen.

4. Place the capsule in the measuring boat with tongs. Measure the overall length of the capsule with a vernier caliper. Record the measurement of the length and the surface temperature of the capsule at the time of measurement.

5. With capsule tongs, place the capsule in the sleeved part of the tantalum canister. The filter end of the capsule must protrude from the open canister.

6. Punch the hole into the seal diaphragm with specified punch that is free from alpha contamination.

7. Swipe punch and hole area of the capsule for alpha activity. Record the measurement. If the measurement shows any increase above background from the first swipe of the capsule, the operation will be halted and the task force and AEC will be appraised of the situation.

   NOTE: The wipe paper will be placed in an envelope after the swipe is taken and will be passed out of the box through the pass box. (The helium atmosphere of the box in which the operation is being performed will be maintained.) The wipe will be counted for alpha activity and results recorded.

8. Place the canister cap on the canister, carefully lead closure rim into the canister, and finally seat it by pressing straight down with the installation tool. Check visually to verify the assembly alignment.

9. Remove the canistered capsule from the vertical holder and place it in the horizontal measuring boat. Measure the overall length with a vernier caliper and record the length measurement and the canister surface temperature at the time of measurement.

   NOTE: Overall length of the canistered capsule may be as much as 0.090 inches longer than the base capsule even though the canister wall thickness is 0.015 inches. If the canistered capsule does not immediately meet length specifications, it may be repositioned in the canister compression tool and an attempt made to further compress it until it meets the length specification. If, after several attempts, the length of the canistered capsule does not meet specifications, proceed with item 10, page 111. Only record the final length measurement and canistered capsule surface temperature.

ALTERNATE METHOD

a. Place the capsule in the vertical holder and punch the hole into the seal diaphragm with the specified punch that is free from alpha contamination.

b. Swipe punch and hole area of the capsule for alpha activity. Record the measurement. If the measurement shows any increase above background from the first swipe of the capsule, the operation will be halted and the task force and AEC will be appraised of the situation.

NOTE: The wipe paper will be placed in an envelope after the swipe is taken and will be passed out of the box through the pass box. (The helium atmosphere of the box in which the operation is being performed will be maintained.) The wipe will be counted for alpha activity and results recorded.

c. Place the canister cap on the capsule, seat it by pressing straight down with the top half of the canister compression tool. Check visually to verify that the cap is straight.

d. Remove the capsule from the vertical holder and with the capsule tongs place the capsule in the sleeved portion of the tantalum canister.

e. Mate the canister sleeve and cap with the aid of the canister compression tool.

f. Remove the canister capsule from the canister compression tool and place it in the horizontal measuring boat. Measure the overall length with a vernier caliper and record the length measurement and the canister surface temperature at the time of measurement.

NOTE: Overall length of the canistered capsule may be as much as 0.090 inches longer than the base capsule even though the canister wall thickness is 0.015 inches. If the canistered capsule does not immediately meet length specifications, it may be repositioned in the canister compression tool and an attempt made to further compress it until it meets the length specification. If, after several attempts, the length of the canistered capsule does not meet specifications, proceed with item 10, below. Only record the final length measurement and canistered capsule surface temperature.

10. Insert one tantalum washer into the female section of the graphite with the raised lip facing up.

11. Pick up the canistered capsule with tongs and insert it in the female heat shield detail. The canister cap must protrude from the graphite. (The filter end of the capsule must be up.) Adjust the position of the canister until it is vertical as checked visually.

12. Pick up the male threaded heat shield component, lower the open end over the canistered capsule, and engage the stub acme threads.

13. With the female half of the heat shield positioned in the clamping device, tighten the heat shield components with a strap wrench on the male portion of the heat shield. The assembly shall be tightened until the clearance on the outer surface is ± 0.005 in. of the gap measured in Section A.4 at the same point on the heat shield.

14. Swipe the surface of the graphite and record the reading. If higher than 20 dpm clean until it is <20 dpm.

    NOTE: The wipe paper will be placed in an envelope after the swipe is taken and will be passed out of the box through the pass box. (The helium atmosphere of the box in which the operation is being performed will be maintained.) The wipe will be counted for alpha contamination and results recorded.

15. Place the completed heat source assembly in the primary shipping container top section which has been located in the stand making sure that the male end is inserted. (The male end will be dimpled for easy identification.)

    NOTE: Make sure Min-K pads are in place.

16. Lower the bottom section of the shipping container over the heat source. Assemble the cap screws through the flanges into the tapped holes. Hand tighten, then torque from 170 in.-lb to 190 in.-lb.

    NOTE: Make sure Min-K pads are in place.

17. Flush the shipping cask with argon for two minutes.

18. Take gas sample of box and record results. It should be less than 300 ppm of oxygen.

19. Remove the loaded primary container from the glove box. Swipe the surface of the primary container and record the reading. It should be <20 dpm before being installed into the shipping cask. Position loaded primary container into the shipping cask.

20. With the O-ring in position, place the lid on the shipping cask.

21. Thread the bolts snug, in a diametrically opposite pattern and then torque from 480 to 500 in.-lb in a diametrically opposite pattern.

22. A permanent assembly record noting past serial numbers will be maintained. (See Figure 1).

List of Martin-Furnished Equipment

Quantity	Item
1	Filter Assembly Punch - P/N 45-2B1800101
1	*Vertical Holding Fixture - P/N N0035028
2	*Strap Wrenches Per MM Dwg. 452B1800105
1	*Calibrated Torque Wrench, 0-0250 in.-lbs., with 9/16" Thin Wall Socket - No P/N
1	*Capsule Handling Tongs - No P/N
1	*Vertical Support Stand for the Primary Shipping Container - No P/N
1	*Detachable Handle for the Primary Shipping Container - No P/N
1	*Vertical Lifting Bail for the Primary Shipping Container - No P/N

*To be returned to Martin Company after completion of heat source assembly.

C. Preparation of Cask for Shipment

1. Using a Victoreen Radector II beta-gamma survey meter and a Texas Nuclear neutron spherical dosimeter, Model #9140, measure the gamma and neutron radiation at a distance of three feet from the surface of the shipping container.

2. Using these radiation measurements, calculate the radiation dose rate that exists at the surface of the shipping container.

NOTES: These radiation measurements are taken to assure compliance with D.O.T. regulations. If the levels exceed those permitted by the D.O.T., the Source Development Group, the Health Physics Section, and the Dayton Area Office of the AEC will be notified immediately. If radiation levels are within D.O.T. specifications, mark the shipping container to comply with D.O.T. regulations.

According to standard procedures, the radiation levels are recorded on Form 1245: Radioactive Material Shipping Form. This information becomes a permanent part of the fabrication records for this particular SNAP-19B (IRHS) heat source.

CAPSULE ASSEMBLY DATA SHEET

Assembler_____ Date_____

A. General

Capsule S/N_____ Canister S/N_____

Graphite Heat Shield S/N _____

Length of heat shield plus tantalum washer _____

Amount of gap between graphite halves _____

B. Assembling

Swipe count on capsule surface prior to putting into box _____

Length of capsule _____ Surface temp. _____

Swipe count on punch _____

Swipe count on vent _____

Length of canistered capsule _____ Surface Temp. of canistered capsule _____

Amount gap between halves _____

Swipe count on graphite _____

Swipe count on primary container _____

FIGURE 1

3. When all of the above steps are completed, store the loaded shipping container in a locked security area.

D. Storage - Awaiting Shipment

During the period of time that a shipment is in storage at Mound Laboratory awaiting shipment to the Martin Company, an alpha wipe survey will be taken every seven days. The survey results will become a part of the fabrication records for each SNAP-19B (IRHS) unit so retained in storage.

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APPENDIX E

DIAGNOSTIC DISASSEMBLY PROCEDURES FOR SNAP-19B (IRHS) CAPSULES

DIAGNOSTIC DISASSEMBLY PROCEDURES FOR
SNAP-19B (IRHS) CAPSULES

The following procedures will be followed by Mound Laboratory in the disassembly of SNAP-19B (IRHS) heat sources.

1. Perform the disassembly operation in an argon atmosphere. Monitor the dry box atmosphere with an Airline Analyzer and record the results.

2. Check both valves on the primary shipping container to verify that they are closed after removal from the shipping cask.

*3. Flush primary shipping container with argon and collect and analyze the gas for radioactive gas concentration. Take a control sample of the argon for later chemical analyses.

4. Open the primary container and carefully remove the heat source. Visually inspect the Min-K2002 insulation pads.

5. Visually inspect the graphite heat shield and note any irregularities.

6. Measure and record the gap between heat shield halves at approximately three equally spaced positions.

7. Visually inspect the outside of internally threaded heat shield in thread relief area for indication of cracks.

8. Carefully assemble strap wrenches onto heat shield halves. Note if there is or is not significant "breakaway" torque to separate the two halves. Also, note if there is significant force needed to unscrew the two halves after the breakaway torque is noted.

9. After removal of the graphite heat shield, note the condition of the compliance member taking care not to disturb the pads. Also, inspect the interior coating of the heat shield for discoloration, cracks or chips.

10. Note the condition (color, cracks, oxidation degree and distribution) of the canister.

11. Take photographs of the above components, if at all possible, during the disassembly operation in the glove box. If photographs are not feasible at this time, take them at a later date outside the glove box.

12. Measure and record the overall length of the canistered capsule. Record the canistered capsule temperature within 1-3 minutes of the length measurement.

13. Attempt to remove the canister from the capsule without damaging this component. If destructive removal is necessary, attempt to avoid the cracked areas. Retain the canister pieces for post disassembly examination.

14. Remove the graphite heat shield and canister components from the glove box.

15. Perform health physics survey on all components using care not to disturb the compliance members.

16. Take photographs of all components for historical records.

17. If the activity levels are acceptable, ship the heat shield with dummy capsule inside to MMC for plasma tests.

18. Note and record all results of the disassembly. (Figure 1)

*If Mound feels that this procedure can be performed then it will be done; if it is not feasible, then it will be omitted.

FIGURE 1

Capsule Disassembling Data Sheet

Disassembler_____ Date_____

General

A. Capsule

Capsule SN_____ Subsystem_____

Both valves closed on primary shipping container: Yes____No____

Primary shipping container flushed with argon: Yes____No____

B. Pads

Visually inspect Min-K 2002 pads: Yes____No____

Comments:

C. Graphite

Visually inspect graphite heat shield: Yes____No____

Comments:

Gap between graphite halves: a.____b.____c.____

Visually inspect heat shield in thread relief area: Yes____No____

Comments:

Breakaway Torque: Significant____Medium____None____

FIGURE 1 (continued)

Comments:

Visually inspect the coating on graphite halves: Yes____No____

Comments:

Visually inspect compliance pads: Yes____No____

Comments:

D. Canister

Visually inspect canister for oxidation and cracks:

Comments:

E. Capsule

Visually inspect for cracks:

Comments: