MASTER

**Procedures and Instructions for Fabrication,
Assembly, and Test of PCP III Multisection
Ionization Chamber (Q-2633)
for Reactor Control**

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INSTRUMENTATION AND CONTROLS DIVISION

PROCEDURES AND INSTRUCTIONS FOR FABRICATION,
ASSEMBLY, AND TEST OF PCP III MULTISECTION
IONIZATION CHAMBER (Q-2633)
FOR REACTOR CONTROL

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ABSTRACT

This document is a collection of procedures for fabrication, assembly, and testing of a PCP III multisection ionization chamber (Q-2633) for reactor control.

ACKNOWLEDGMENT

This document reports revised and updated procedures originally prepared by D. P. Roux, formerly of the Oak Ridge National Laboratory Instrumentation and Controls Division.

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SUBJECT: HELIUM LEAK TEST

I. INTRODUCTION

During assembly of a PCP III multisection ionization chamber, several helium leak tests must be performed. This procedure describes how to perform such tests and the maximum acceptable leak rates.

II. PREPARATION FOR HELIUM LEAK TEST

1. Select the jigs, O-rings, or adaptors needed to connect the part to be tested to the vacuum system of the helium leak detector. In some cases, special jigs must be constructed.

2. Carefully clean all parts to be tested.

III. HELIUM LEAK TEST

1. Use a helium leak detector having a minimum sensitivity of 10^{-10} std cc/sec. Check the sensitivity at the time tests are to be made.

2. Connect the inside of the part to be tested to the vacuum system of the leak detector, and pump it down to the required pressure. Flood the exterior of the part with helium gas, using a jet ("probe") to direct the gas onto joints, thin sections, potting compounds, etc. With the detector set to a sensitivity of 10^{-10} std cc/sec minimum, there shall be no indication of a leak.

3. Reclean the parts to remove fingerprints and vacuum grease or sealing compounds that may have been used in leak checking.

SUBJECT: ELECTRODES PUNCHING, ETCHING, AND COATING

I. INTRODUCTION

These instructions describe the punching, etching, cleaning, and coating of the titanium and nickel electrodes (ORNL drawing Q-2633-303). First, the electrodes are punched from flat sheet foils with Danly dye sets. Then, the curls and sharp edges due to punching are removed by chemical polishing (etching) in a specified acid bath. (This polishing reduces the thickness of the electrodes ~0.001 in.) Last, the electrodes used in neutron-sensitive volumes are coated with boron.

It is necessary to follow these instructions in the correct order.

II. PREPARATION FOR PUNCHING

1. The bills of material of drawings in the series Q-2633-1XX-3 list the number and type of electrodes to be used in the sensitive volume of each subassembly type 1XX.

2. In the bill of material, the detail number is a code: the first digit corresponds to the type of electrodes shown on drawing Q-2633-303, and the letters, if any, correspond to the type of coating to be placed on the electrodes (see the coating chart on drawing Q-2633-303).

3. The initial thickness indicated on the bill of material is the thickness of the flat sheet foils from which electrodes are to be punched.

4. The material to be punched must satisfy the following criteria:

a. Initial thickness: within ± 0.0002 in. of the thickness listed in the bill of material.

b. Purity: titanium 99.8% min, nickel 99.97% min.

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c. Flatness: flat within 0.009 in. for a surface area of 2 × 2 in.

d. Surface finishing: no scratches or marks deeper than 0.0002 in.

III. ELECTRODE PUNCHING

1. Punch the electrodes as specified by the bill of material for the sensitive volume subassembly by using Danly die set 0404-DI with appropriate dies.

2. Remove the large burrs and sharp edges by hand with a small, fine-grade honing stone.

3. Place each punched electrode between two plates of hardened tool steel having parallel, ground surfaces. The ground surfaces of the steel plates must have a honed and lapped finish ¹⁶✓. Pound the plates together with a 2-lb plastic mallet to flatten the curls left on the electrodes by the punching operation. Avoid damaging the electrode surfaces by not hitting the steel plates too hard.

4. Degrease the electrodes with Freon at room temperature.

IV. ELECTRODE ETCHING

A. Titanium Electrodes

1. If the initial thickness is 0.006 in., the thickness must be 0.0051 ± 0.0001 in. after etching. Measure the thickness at each of the three 0.064-in.-dia holes in each electrode.

2. Hook a nickel wire through one of the 0.064-in.-dia holes and dip each electrode into the following etching mixture (parts by volume): 25.2 cc of hydrofluoric acid (48%), 42.2 cc of nitric acid (70%), and 210 cc of water.

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3. Experimentally determine the etching time, which can vary from 15 to 60 sec depending on the mixture "age" (the number of electrodes etched in the same batch of the mixture). When the batch becomes too "old," the etching time decreases, and the etched surfaces are dull and spotty.

4. After the electrodes are etched, wash them in three different baths of circulating water. Remove the electrodes from the third bath of water, and while they are still wet, dip them in 190 proof ethyl alcohol, remove them, and hang them to dry.

5. Reject electrodes having dull spots or uneven etching.

B. Nickel Electrodes

1. If the initial thickness is 0.010 in., the thickness must be 0.0090 ± 0.0002 in. after etching. Measure the thickness at each of the three 0.064-in.-dia holes in each electrode. If the initial thickness is 0.006 in., the thickness must be 0.0051 ± 0.0001 in. after etching. Measure the electrode thickness at each of the three 0.064-in.-dia holes in each electrode.

2. Hook a nickel wire through one of the 0.064-in.-dia holes and dip each electrode into the following etching mixture (parts by volume): 90 parts of glacial acetic acid, 60 parts of nitric acid (71%), and 1.0 part of hydrochloric acid (38%).

3. Experimentally determine the etching time, which can vary from 15 to 100 sec depending on the mixture temperature and the hydrochloric acid proportion. Keep the mixture in a container that is immersed in water between 80 and 90°F. The mixture has a tendency to etch the electrodes unevenly and to leave some surface spots unetched or dull. If the electrodes need to be reetched for a short time to remove these spots, dry the electrodes before re-etching.

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4. After the electrodes are etched, wash them first in a sodium hydroxide bath (4 g of NaOH per 100 ml of water) and then in two baths of circulating water. Remove the electrodes from the last bath of water, and while they are still wet, dip them in 190 proof ethyl alcohol, remove them, and hang them to dry.

5. Reject electrodes having dull spots or uneven etching.

6. Place each electrode between the two steel plates with parallel ground surfaces, and strike the plates with a plastic mallet to straighten them.

V. ELECTRODE BORON COATING

A. Preparation of Boron Coating Mixture

1. Use a colloidal suspension of Boron-10 in pure mineral oil, as purchased from the Isotope Sales Department of ORNL (Catalog No. 4647-47-2, Series DAG, Lot 3, or a mixture made at a later date). The mixture must contain 20 wt % boron (^{10}B , 92%) and 80 wt % oil.

2. Filter the ^{10}B colloidal suspension through a 200-mesh, stainless steel sieve which has been cleaned with Freon and blown dry with lint-free dry nitrogen to remove any dust particles.

3. Keep the ^{10}B in suspension by continuous stirring while spraying the electrodes.

B. Preparation of Electrodes

1. The bill of material on drawing Q-2633-IXX-3 lists the number and type of electrodes to coat for the sensitive volume of each subassembly (Sect. II.2).

2. Clean the electrodes with Freon at room temperature, and then remove any remaining dust particles by blowing with dry nitrogen.

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C. Boron Coating, Spraying, and Backing

1. The boron coating thickness to be deposited on the electrodes is given on drawing Q-2633-IXX-3 for the sensitive volume of each subassembly.
2. Weigh each electrode and record its weight in Table 1.
3. Dilute the ^{10}B colloidal suspension (described in V.A.1) with benzene (C_6H_6) to the desired viscosity for spraying. When the mixture is sprayed, the benzene will immediately evaporate, allowing one to weigh the wet deposit of ^{10}B and mineral oil.
4. From the following table, determine the amount of wet coating to be deposited on one side of an electrode:

Electrode wet weight gain, mg			
Desired (Dry) Boron Coating Thickness (mg/cm ²)	Weight Gain for Electrode Types		
	1,2 (mg)	3 (mg)	4 (mg)
0.25	19	16	20
0.30	22	19	24
0.35	26	22	28
0.40	30	25	32
0.50	37	32	40
±0.050	±2	±2	±2

5. Apply the diluted mixture evenly across the electrodes with an air brush, Paasche No. 8654, size 5, type H5. Coat each electrode separately, and then weigh it. If the weight of the wet coating is correct, record it in Table 1 and proceed with the

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Date: _____
Initials: _____

[illegible]

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remaining electrodes of the group. (Caution: Keep wet-coated electrodes under a dust-proof hood until they are ready to be baked in the oven.)

6. Place each group of coated electrodes on an $\sim 1/8$ -in.-thick glass sheet, with the wet coat up. Bake the electrodes in a dust-free vacuum furnace at 650°F for 1 hr. The pressure in the furnace must be less than 10 μ Hg. Remove the electrodes from the furnace and let them cool to room temperature. (Figure 1 is a diagram of a typical oven.)

7. Inspect each coating individually. Reject any uneven, spotty, or dusty coating.

8. Weigh the electrodes and record the weights. Ensure that the weights of the dry coats correspond with the values specified in Table 1.

9. Repeat steps 5, 6, 7, and 8 for electrodes that are to be coated on the other side.

10. Suspend all the coated electrodes from 1/16-in.-dia titanium or stainless steel rods and bake them in a preheated vacuum furnace at 650°F for 2 hr. The pressure in the furnace must be less than 10 μ Hg. Remove the electrodes from the furnace and let them cool to room temperature.

11. Remove all dust particles by blowing dry nitrogen across the electrodes. Place the electrodes between sheets of dust free paper (Dietzgen 374W) inside glass containers and store them in a vacuum.

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Fig. 1. Typical Vacuum Oven System.

PCP III MULTISECTION IONIZATION
CHAMBER (Q-2633) FOR REACTOR CONTROL

PROCEDURE: P-2633-106A-2R1

DATE: December 11, 1977

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SUBJECT: ASSEMBLY AND TESTING OF THE CHAMBER HOUSING ASSEMBLY,
TYPE 106A, SERIAL NO. _____

I. INTRODUCTION

These instructions describe how to assemble and test the PCP III multisection ionization chamber housing assembly type 106A.

For this assembly one must refer to the drawing Q-2633-106A-2 which contains the bill of material, the wiring schematic diagram, details, different views, and other information. It is necessary that these assembly and testing instructions be followed precisely as outlined. Each step shall be performed successfully before proceeding to the next step. The person responsible for this assembly must write the date and his initials in front of each section in the space provided, and, after each step has been successfully performed, he must mark a check (✓) on the line at the right of the step.

For soldering, a solid wire, 60-40, tin-lead soft solder shall be used. A mild acid flux may be applied prior to soldering, but it must be removed after soldering.

This assembly can be made in two separate stages: Sect. III, "Preparation of the Core Assembly"; and Sect. IV, "Connection of the Sensitive Volume Subassembly to the Core Assembly." Any period of time may be allowed between these two stages.

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TYPE 106A, SERIAL NO. _____

II. INSPECTION OF PARTS LISTED IN THE BILL OF MATERIAL

Date _____ Initials _____

Part 1. Casing Subassembly

- a. Subassembly was leak checked according to procedure
P-2633-1 _____
- b. Chamber type 106A and serial No. _____, are
engraved on the assembly _____
- c. The inside diameter and concentricity of the casing
are as specified _____

Part 2. Gamma Shield Can

- a. Its length and its inside and outside diameters and
their concentricities are as specified _____
- b. Part 2 moves freely when inserted into and removed
from part 1 _____

Part 3. Gamma Shield Plate

- a. All holes match the corresponding holes of the core
(part 8) _____
- b. Its outside diameter and its concentricity are as
specified _____

Part 4. Connector Housing

- a. Insert the connector housing into the casing sub-
assembly (part 1) until the housing seats on the
bottom of the counterbore of the subassembly _____
- b. Check the distance from the face of part 4 to the
end of the subassembly. This distance is $1.440 \pm$
 0.020 in. _____

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Part 5. Multihole Insulator

- a. Its length is as specified _____
- b. Holes are straight and parallel to the longitudinal
axis _____
- c. The insulator slides with a slip fit through the
bore of the core (part 8) _____

Part 6. Single-Hole Insulators

- a. Their lengths are as specified _____
- b. The resistance of the conductive coating on each
insulator is less than 20,000 ohms/in. _____
- c. One insulator slides through each of the three
(0.100 in. dia) holes of part 5 with a slip fit _____
- d. The remaining insulator slides through the signal
shield tubing (part 11) _____

Part 7. Insulating Washer

- a. The washer slides over part 5 _____
- b. Insert the washer into the counterbore of the core
(part 8) _____

Part 8. Core

- a. Its length and its outside diameter and concentricity
of the outside diameter are as specified _____
- b. The core moves freely when inserted into and removed
from part 1 _____

Part 9. Insulating Ring

- a. Its inside and outside diameters and their concen-
tricities are as specified _____

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b. Its electrical resistance measured between its inner
surface and outer surface is greater than 10^4
megohms _____

c. The ring fits when slid over the sensitive
volume subassembly (part 5) _____

Part 10. Spacer Rods

a. The spacer rods seat properly when screwed into
part 4 _____

b. The rods can be inserted into and removed from
part 8 freely _____

Part 11. Signal Shield Tube

a. Its length is as specified _____

b. The tubing and part 5 mate with a slip fit when slid
into center hole of part 5 _____

c. The tube bottoms in the threads when screwed into
the multipin header of part 15 _____

Part 12. Spring

a. Its length and number of turns are as specified _____

b. It slides over part 5 and into the counterbore
of part 8 _____

Part 13. Base Support Sleeve

a. The sleeve seats correctly when slid into the
sensitive volume subassembly (part 15) _____

b. It slides over part 5, into the counterbore of
part 8, and through the center hole of part 3 _____

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TYPE 106A, SERIAL NO. _____

Part 14. No Inspection Needed

Part 15. Sensitive Volume Subassembly, Type 106A,
Serial No. _____

Date _____ Initials _____

Refer to the assembly and testing instructions,
procedure P-2633-106A-3, which was used to
assemble this subassembly. The electrical tests
specified in Sect. IX of that procedure were performed
successfully

Parts 16 - 17. No inspection needed

Part 18. Wires, No. 24 (0.020 in. dia) Nickel

Cut seven 3-ft lengths and straighten each length

Parts 19 - 27. No inspection needed

Part 28. Retaining Ring

It fits the groove on part 5

III. PREPARATION OF CORE ASSEMBLY

1. Place the retaining ring (part 28) into the groove in
the multihole insulator (part 5)
2. Slide the end opposite the retaining ring of the
multihole insulator (part 5) into counter-bored end
of the core (part 8) until the ring seats
3. Position the multihole insulator (part 5) as shown in
the wiring schematic diagram of drawing Q-2633-106A-2.
Tighten the screw (part 17) until the insulator (part 5)
is secure

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4. At the counter-bored end, slide the spring (part 12) first and then insulating washer (part 7) over the multihole insulator and into the counter bore _____
- 5a. Slide part 25 into place in the core (part 8) _____
- 5b. Mount the shield plate (part 3) on the counter-bored end of the core (part 8) using screws (part 16). Turn the bevel on part 3 toward the core (part 8), and align the holes in part 3 to match the holes in the core _____
6. Solder a pin jack (part 14) on to one end of six of the 3-ft-long wires (part 18). The solder joints shall be of good quality _____
7. Attach the braids (part 27) to three of the single-hole insulators (part 6) as shown in detail I of drawing Q-2633-106A-2. Check the connections. Measure the electrical continuity between the braids and the conductive coatings of the insulators, which shall be less than 10,000 ohms resistance _____
8. Insert three single-hole insulators (part 6) into the three large outer holes of the multihole insulator from the end opposite the counter bores _____
- 9a. Insert the six wires prepared in step 6 through the insulators from the sensitive volume end. Seat the pin jacks into the holes in the multihole insulator _____
- 9b. Measure the insulation resistance between each center wire and its respective braid of the three single-hole insulators. The resistance should be greater than 10^{13} ohms _____

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- 9c. Measure the insulation resistance between each of the remaining three wires and the aluminum core. The resistance shall be greater than 10^{13} ohms _____
10. Attach a braid (part 27) to the unthreaded end of the signal shield tube (part 11) as shown in detail I of drawing Q-2633-106A-2. All solder joint connections shall be tight. Measure the continuity between the braid and the signal shield tube, which shall be less than 1 ohm _____
11. Clean the signal shield tube inside and out with Freon, and then dry the tube _____
12. Insert the last single-hole insulator (part 6) into the signal shield tube (part 11) _____
13. Insert the signal shield tube (part 11) into the center hole of the multihole insulator (part 5) from the end opposite the counter bores _____
14. Insert the seventh 3-ft-long wire (part 18), with both ends pretinned and cleaned, into the single-hole insulator (part 6), which was installed in step 12. Allow the wire to protrude from both ends of the signal shield tube _____
15. Cut the preirradiated insulation (part 19) to the length specified below for each wire (part 18). As it is cut, slide each piece of insulation onto its respective wire, referring to detail II of drawing Q-2633-106A-2.
 - a. The length of the insulation for the center wire is 3 in. _____
 - b. The length of each insulation for each of the three shielded wires is 2-5/8 in. _____

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- c. The length of each insulation for each of the three unshielded wires is 2-13/16 in.
- 16. Cut two 1-1/2-in.-long pieces from the remaining shielding braid (part 27). Referring to the wiring schematic diagram of drawing Q-2533-106A-2, slide one piece of braid over the insulation on the wire in position 3 and the other piece of braid over the insulation on the wire in position 5
- 17. Slide a crimping sleeve (part 20) over each of the five braids (part 27), except the center braid
- 18. Attach the wires (part 18), except the center wire, to the coaxial contacts as follows:
 - a. Slide a crimp support sleeve (part 21) over the preirradiated insulation (part 19) of each wire
 - b. With the preirradiated insulations flush against the single-hole insulators or the multihole insulator, cut each wire so that $5/32 \pm 1/64$ in. is exposed beyond the preirradiated insulation
 - c. Crimp a male pin (part 22) onto each wire (part 18), using crimping tool AMP 90146-1. The pin shall be flush against the preirradiated insulation
 - d. Slide a grommet (part 23), with its counter-bored end toward the preirradiated insulation, over each pin until it is past the small ridge on the outer diameter of the pin and then over the end of the preirradiated insulation

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- e. Slide the crimp support sleeve (part 21) toward the male pins (part 22) until the grommets (part 23) are seated into the front of part 21. Insert the pins into the rear of the socket outer body (part 24) and tighten part 21 in part 24 _____
- f. Slide each braid (part 27) along each part 19 until the braid fits snugly and in place over the crimp support sleeve (part 21); then trim the braid to the correct length _____
- g. Slide the crimping sleeves (part 20) along the braids until the sleeves seat against the crimp support sleeve shoulders. Crimp them in place with sleeve crimping tool Deutsch 20053 _____
19. Measure the electrical insulation of each coaxial contact between the male center pin (part 22) and the outer body (part 24) with a Keithley, model 500 megohmmeter. Each insulation resistance shall be greater than 2M megohms (2×10^{12} ohms). Record the resistance values in the correct spaces of the following table.

Wire from pin	2	3	4	5	6	7
Insulation resistance						

20. Screw the three spacer rods (part 10) into the threaded holes in the plug housing (part 4) until the rods seat . . . _____

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21. Insert the three spacer rods (part 10) into the three 3/16-in. holes in the rear of the core (part 8), with the exhaust hole in the plug housing 180° from position 7 as shown in the wiring schematic diagram of drawing Q-2633-106A-2 _____
22. Insert each contact into the plug holes of the plug housing (part 4) according to the wiring schematic diagram of drawing Q-2633-106A-2 _____
23. Slide the spacer rods (part 10) into the core (part 8) until the distance between the plug housing (part 4) and the core is 2.532 in. Fasten each spacer rod in the core with a set screw (part 17) _____
24. a. Pretin and clean part 29.
b. Tie together the braids of coaxial contacts 3, 4, 5, and 6 with the wire (part 29). Wrap part 29 one turn around each of the two braids on wires 4 and 6 and around the end of braids 3 and 5. Part 29 shall keep these braids well separated from the braid on the wire in position 1. Cut off the excess length of part 29, and solder part 29 to the four braids using rosin-core solder. Remove the rosin with ethyl alcohol _____
25. With the core grounded, measure the electrical insulation resistance between the outer shells of the coaxial contacts 2, 3, and 7 with a Keithley, model 500 megohm-meter _____

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Each insulation resistance shall be greater than
 10^4 megohms (1×10^{10} ohms). Record the resistance
values in the correct spaces of the following table.

<u>Coaxial</u> <u>contact</u>	<u>Outer</u> <u>Shell 2</u>	<u>Outer</u> <u>Shell 3</u>
<u>Outer shell 7</u>	<u> </u>	<u> </u>
<u>Outer shell 3</u>	<u> </u>	<u> </u>

IV. CONNECTION OF SENSITIVE VOLUME SUBASSEMBLY TO THE CORE ASSEMBLY

Date _____ Initials _____

1. Measure the electrical insulation resistance between each
pin of the multipin header and the base of the sensitive
volume subassembly (part 15) with a Keithley model 500
megohmmeter _____

Each insulation measurement shall be greater than
2M megohms (2×10^{12} ohms). Record the resistance
values in the correct spaces of the following table.

<u>Pin No.</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
<u>Insulation</u> <u>Resistance</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>

2. On the core assembly, push the center wire back into the
signal shield tube and screw the signal shield tube into
the multipin header on the base subassembly (part 15).
With the fill tube on part 15 in line with the quartz tube

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- (part 25) on part 8, plug the pins on part 15 into the pin jacks (part 14) and check the alignment of the pins. All pins should slide freely into the pin jacks
3. Unplug the sensitive volume subassembly (part 15) and unscrew the signal shield tube (part 11)
 4. Place the base support sleeve (part 13) over the front end of the multihole insulator (part 5)
 5. Solder center wire 1 into the multipin header center pin 1, which had previously been tinned. Use no flux. The solder joint shall be of good quality
 6. Screw the signal shield tube (part 11) into the multipin header of part 15 until it seats into bottom of the threads, with the fill tube of the sensitive volume inserted into the quartz tube (part 25)
 7. Using a screw driver, push the base support sleeve (part 13) back into the core until the spring is fully compressed. Slide the sensitive volume forward until the multipin header pins are inserted into the pin jacks firmly, then release the base support sleeve; the sleeve must slip into the counter bore of part 15. Compress the spring (part 12) as much as possible and then release the sensitive volume; the spring tension should push the sensitive volume back about 1/8 in.
 8. Press the insulating ring (part 9) into the gamma shield can (part 2) until it is firmly seated against the bottom of the shield can. Measure the insulation resistance between the insulating ring and the shield can. The insulation resistance shall be greater than 1 megohm

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9. Slide the gamma shield can (part 2) over the sensitive volume subassembly (part 15) and onto the core (part 8). Secure it in place with four screws (part 16). No screw head shall protrude beyond the outside diameter of the shield can _____
10. Slide a crimping sleeve (part 20) over the braid on the signal shield tube (part 11) _____
11. Attach the center wire (part 18) in position 1 to the coaxial contact as follows:
 - a. Slide a crimp support sleeve (part 21) over the preirradiated insulation (part 19) of the center wire _____
 - b. With the preirradiated insulation flush against the single hole insulator (part 6), cut the wire so that $5/32 \pm 1/64$ in. of wire is exposed beyond the preirradiated insulation _____
 - c. Crimp a male pin (part 22) onto the wire (part 18), using crimping tool Deutsch 12500-25-1. The pin shall be flush against the preirradiated insulation _____
 - d. Slide a grommet (part 23), with its counter-bored end toward the preirradiated insulation, over the pin until it is past the small ridge on the outer diameter of the pin and then over the end of the preirradiated insulation _____
 - e. Slide the crimp support sleeve (part 21) toward the male pins (part 22) until the grommet (part 23) is seated into the front of part 21. Insert the pin into the rear of the socket outer shell (part 24) and tighten part 21 in part 24 _____

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- f. Slide the braid (part 27) along part 19 until it fits snugly and into place over the crimp support sleeve (part 21), then trim the braid to the correct length _____
 - g. Slide the crimping sleeve (part 20) along the braid until it seats against the crimp support sleeve shoulder. Crimp it in place with crimping sleeve tool Deutsch 20053 _____
 - h. Measure the electrical insulation resistance between the pin and the outer shell of coaxial contact in position 1. This resistance shall be greater than 2M megohms (2×10^{12} ohms) _____
 - i. Insert the outer shell No. 1 into the plug housing _____
 - 12. Insert the chamber assembly into the casing subassembly (part 1). The plug housing (part 4) shall seat on the bottom of the counter bore of the casing subassembly. Measure the distance from the face of part 4 to the end of the casing subassembly. This distance shall be $1-7/16 \pm 1/64$ in. _____
 - 13. With the core grounded, measure the electrical insulation resistance between the outer shells of the coaxial contacts 1, 2, 3, and 7 with a Keithley, model 500 megohmmeter _____
- Each insulation resistance shall be greater than 10^4 megohms (1×10^{10} ohms). Record the resistance values in the correct spaces of the following table.

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Coaxial Contact No.	Outer Shell 1	Outer Shell 2	Outer Shell 3
Outer Shell 7			
Outer Shell 3			--
Outer Shell 2		--	--

14. Measure the electrical insulation resistance of each coaxial contact between the male center pin and the outer shell with a Keithley, model 500 megohmmeter.

Each insulation resistance shall be greater than 2M megohms (2×10^{12} ohms). Record the resistance values in the correct spaces of the following Table.

Male Pin No.	1	2	3	4	5	6	7
Insulation Resistance							

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I. INTRODUCTION

These instructions describe how to assemble and test the sensitive volume subassembly of the PCP III multisection ionization chamber, type 106A. For this assembly, one must refer to the drawing Q-2633-106A-3, which contains a bill of materials, the electrode sequence, the function of the different connections from the header pins to the tie rods, and other information.

Special procedures for preparation of every part are indicated in detail drawings Q-2633-301A, -302A, -303, -304, and -305.

It is necessary that these assembly and testing instructions be followed precisely as outlined. Each step shall be performed successfully before proceeding to the next step. The person responsible for this assembly must write the date and his initials at the start of each section in the space provided, and after each step has been successfully performed, he must check (✓) the line.

Each visual inspection must be made with the aid of an optical magnification of 5 to 10 power. Each electrical insulation must be measured with a Keithley megohmmeter, model 500 or equal, unless otherwise specified.

Solid wire, 60-40, tin-lead soft solder shall be used for soldering. A mild acid flux shall be applied prior to the soldering, but it must be removed after soldering.

II. INSPECTION OF MATERIAL FOR THE SENSITIVE VOLUME SUBASSEMBLY

Date: _____ Initials: _____

1. Base Subassembly (part 1)

- a. Base subassembly was helium leak checked in accordance
with procedure P-2633-1 _____

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b. The subassembly was degreased with Freon and is dust
free _____

2. Can (part 2)

a. Chamber type 106A and serial number _____ of this
assembly are engraved on this can _____

b. The can was degreased with Freon and is dust free _____

3. Coated Electrodes (parts 3, 4, 6, 7, 8, and 9)

a. The electrode material and the initial thickness are
as specified in the bill of material _____

b. The electrodes were etched and coated according
to procedure P-2633-2 R1 _____

c. Boron-10 was evenly deposited on the electrode
surfaces as shown on drawing Q-2633-106A-3 to a thick-
ness of 0.35 ± 0.05 mg/cm² as specified in procedure
P-2633-2 R1 _____

d. No sharp edges remain on the coated electrodes _____

e. Record the boron-10 batch used. DAG No. _____
Production No. _____ _____

4. Uncoated Electrodes (part 5)

a. The electrode material and the initial thickness are
as specified in the bill of material _____

b. The electrodes were punched and etched according to
procedure P-2633-2 R1 _____

c. No sharp edges remain on the etched electrodes _____

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5. Tabs (part 10)

- a. The material and the initial thickness are as specified in the bill of material _____
- b. The tabs were etched according to procedure P-2633-2 R1 _____
- c. No sharp edges remain on the etched tabs _____

6. Ceramic Insulator Plates, Type 1A and Type 1B
(parts 11 and 12) _____

- a. The electrical resistance measured across the diameter of the evaporated conductive surface on each plate shall measure less than 1000 ohms on each of the two sides _____
- b. Degrease the tab tie rods (part 32) and nuts (part 31) used for mounting. Mount a tab (part 10) on one type 1A plate in the coated hole. Each tab shall extend radially outward on ceramic plates. Mount a tab on plate 1B in the coated hole, which is evenly spaced with masked holes _____
- c. Inspect the tabs to ensure that they are securely mounted _____
- d. Spot weld the nuts on the tie rods with clean welding tweezers _____
- e. Remove all sharp edges and burrs on the tab tie rods and the spot-welded nuts _____
- f. Measure the electrical resistance between the conductive coating on either side of the ceramic plates and their tab; the resistance shall be less than 1000 ohms.

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Plate type 1A, tab to front side _____ ohms,
to back side _____ ohms. Plate type 1B, tab to
front side _____ ohms, to back side _____ ohms.

7. Base Insulating Tubes (part 13)

- a. The lengths are as specified in the bill of material _____
- b. The tubes are clean and dust free _____

8. Signal Insulating Tube (part 14)

- a. The length is as specified in the bill of material _____
- b. The tube is clean and dust free _____

9. Tie Rods (parts 15, 16, 17, and 18) and Nuts (part 31)

- a. The length of each tie rod is as specified in the bill of material within +0.020 and -0.000 in. _____
- b. There are no sharp edges or burrs on the threads or ends of the tie rods _____
- c. Each round titanium nut (part 31) can be threaded smoothly on the threads of its tie rod _____
- d. The tie rods and their nuts were degreased with Freon and are dust free _____

10. Spacers (parts 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, and 29)

- a. The length of each spacer is as specified in the bill of material within ± 0.0005 in. _____
- b. The spacers were degreased with Freon and are dust free _____

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11. Signal Shield Tube (part 30)

- a. The length of the tube is as specified in the bill
of material _____
- b. The tube was degreased with Freon and is dust
free _____

12. Center Signal Terminal (part 33)

- a. The length is as specified in the bill of material . . . _____
- b. The terminal was degreased with Freon and is
dust free _____

13. Screws (part 35) and Wire (parts 36 and 37)

These parts were degreased with Freon and are dust
free _____

III. ELECTRICAL CONNECTIONS ON THE BASE SUBASSEMBLY (Part 1)
BEFORE STACKING

Date: _____ Initials: _____

- 1. Insert the wires (part 36) through the holes in the base subassembly and bend them into a loop around the pins on the header. Section A-A of drawing Q-2633-106A-3 shows the header pins that must be connected. Solder the nickel wires to the header pins. Tin part 37 its full length, and then clean and insert it into the center pin of the base subassembly and solder it in position. Tin the hole in the center pin on the other side of the base subassembly . . . _____
- 2. Clean every connection with ethyl alcohol to remove any flux that might be present. Inspect each connection and remove any sharp edges observed. Check each space in the table below as header pins are inspected to indicate acceptance of each pin connection.

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Pin	1	2	3	4	5	6	7

3. Place the insulating tubes (part 13) over the connection wires (part 36) as shown in Section A-A of drawing Q-2633-106A-3. Inspect to determine that the insulating tubes keep the wires separated from the base, and after the tubes are pushed against the header pins, they shall protrude from the base subassembly, but not more than 1/16 in.
4. Measure the electrical insulation resistance of each connection wire to the base. The resistance shall be greater than 10M megohms (10^{13} ohms)
5. Screw the signal shield tube (part 30) into the threaded shield ring of the header pin (part 1)
6. Place the insulating tube (part 14) over the center wire and into the signal shield tube. The distance from the aluminum header to top of the insulator shall be 1.360 $\pm$ 0.010 in.
7. Measure the electrical continuity between the signal shield tube and base subassembly. The electrical resistance shall be less than 5 ohms
8. Remeasure the insulation resistance from the center wire to the base subassembly. The resistance shall be greater than 10M megohms (10^{13} ohms)
9. Securely mount the first type 1A ceramic insulator plate (part 11) on the base subassembly with aluminum screws (part 35). Slip the can (part 2) over the ceramic plate and the base subassembly. Loosen all screws and retighten them if necessary to align the parts

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10. Measure the continuity of both conductive coatings on the type 1A insulator plate to the base subassembly. The resistance shall be less than 1000 ohms _____

IV. STACKING OF SECTIONS 1 AND 2

Date: _____ Initials: _____

1. General Remarks to be Followed Throughout the Entire Stacking Sequence

- a. The electrode assembly sequence shown on the drawing Q-2633-106A-3 shall be followed _____
- b. The assembly shall be completely assembled in a dust free atmosphere _____
- c. There shall be no direct contact of the bare hands with the individual parts _____

2. Stacking of Section 1 Through the Second Insulator Plate Type 1A (Part 11)

- a. Mount the six tie rods (parts 17 and 18) on first type 1A insulator plate with round nuts (part 31). Leave the nuts loose. See drawing Q-2633-106A-3, section AA, and function table for positioning _____
- b. Assemble the unit as shown in the drawing through the second type 1A insulator plate. Immediately after stacking plate 26, install the three nuts that hold the signal plates _____
- c. Position the second insulator plate as shown by section C-C of drawing Q-2633-106A-3. Tighten the nuts on the tie rods that support this section. (Caution: too much torque will break the ceramic insulator plates.) _____

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- d. Measure the length of this section, being sure that it is perpendicular to the base subassembly (part 1).

See drawing Q-2633-106A-3 _____

- e. Measure the length of the signal insulator tube (drawing Q-2633-106A-3, detail 1), remove the second type 1A insulator (part 11) and electrode 27 (part 6), and then spot weld the nuts to the tie rods that secure the signal plates _____

- f. Replace electrode 27 and the spacers _____

- g. Mount the remaining tie rods (part 15) on first type 1A insulator plate _____

- h. There shall be clearance between the signal shield tube and the electrodes surrounding it in this stack _____

- i. Mount the second type 1A insulator plate, making sure that the insulating tube protrudes into the center hole of plate 1A, but not more than halfway, and tighten the nuts on the tie rods used to support the high voltage stacking of section 1.
(Caution: too much torque will break the ceramic insulator plates.) Make sure that the tab is correctly positioned _____

3. Stacking of Section 2 through Insulator Plate, Type 1B
(Part 12)

- a. Mount the tie rods (part 16) on the second type 1A insulator plate with round nuts (part 31). Leave the nuts loose _____

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b. Stack the first high voltage electrode (part 6) _____

c. Make a connection to the center of the first signal
electrode (part 7) according to detail 1 of drawing
Q-2633-106A-3 and the following steps:

(1) Tin the hole in the center signal terminal
(part 33) with soft solder. Carefully clean away
the excess flux with ethyl alcohol _____

(2) Position the center signal terminal (part 33) in
the center and spot weld it to the first signal
plate as shown by detail 1. Remove any burrs
left by the welding _____

(3) As the first signal plate is stacked, heat the
center signal terminal with a soldering iron
and slide the center wire through the center
signal terminal _____

(4) Measure the insulation resistance between the
signal plate and the base subassembly. It shall
be greater than 10M megohms (10^{13} ohms) _____

(5) Cut away any excess wire, and carefully remove
sharp edges on the end of the center wire _____

d. Stack according to the specified sequence up to, and
including, the type 1B insulator plate _____

e. Tighten the nuts on the tie rods used to support this
section. (Caution: too much torque will break the
ceramic insulator plates.) _____

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V. INSPECTION OF THE COMPLETE ASSEMBLY AFTER STACKING

Date: _____ Initials: _____

1. Recheck the nuts for tightness _____
2. Measure the length of the two stackings and the overall length of the assembly. Compare these measurements with the electrode assembly sequence tolerances _____
3. The electrodes shall be flat and uniformly spaced.
4. Each grounding tab shall be in position to make contact with the can _____
5. The electrical insulation resistance between any set of electrodes and tab 1, tab 2, and base subassembly shall be greater than 2M megohms (2×10^{12} ohms).

Record the resistance values in the following table.

Section	1		2		
	Signal	+HV	Signal	+HV	-HV
Base Subassembly					
Tab 1					
Tab 2					

VI. SPOT WELDING OF NUTS AND CONNECTING WIRES

Date: _____ Initials: _____

1. Spot weld all nuts to their tie rods, except for the six nuts to which nickel wires (part 36) are connected (refer to section A-A of drawing Q-2633-106A-3) _____

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2. Spot weld the nickel wires (part 36) to the six nuts at the base subassembly. Section A-A of drawing Q-2633-106A-3 shows how the wires must be cut and formed around the nuts before spot welding _____

VII. INSPECTION OF SUBASSEMBLY AFTER SPOT WELDING

Date: _____ Initials: _____

1. Visual Inspection

- a. There shall be no sharp edges or burrs on any of the nuts after spot welding _____
- b. There shall be no sharp edges or burrs on any of the wire connections to the tie rod nuts _____
- c. There shall be no dust particles between electrodes _____
- d. The wires (part 36) from the header pins to the tie rod nuts shall not touch the base subassembly. The ceramic insulator tubes (part 13) shall not be cracked or broken. Check the space provided below when each wire has been inspected and meets these requirements _____

Tie Rod 1 3 4 6 8 10

Check

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2. Electrical Tests

- a. Measure the continuity between each set of electrodes and its corresponding pin on the base subassembly header. The resistance between these points shall be less than 5 ohms. Check in the correct spaces provided below after each measurement is completed and the continuity is satisfactory.

SECTION		2		1			
Chamber Function	Signal	+HV	-HV	+HV	Signal	+HV	Signal
Tie Rod	10 2nd Sect.	1	3	4	6	8	10
Header Pin	1	7	2	3	4	5	6

- b. Measure the electrical insulation resistance between any set of electrodes, tabs, and base subassembly. The resistance shall be greater than 2M megohms (2×10^{12} ohms). Record the insulation resistance values in the following table.

Section		1	2		
Chamber Function	Signal	+ HV	Signal	+HV	-HV
Base Subassembly					
Tab 1					
Tab 2					

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VIII. DUST AND MOISTURE REMOVAL

Date: _____ Initials: _____

1. Before the assembly is inserted into the can, each set of electrodes and grounds shall be connected together and to an electrical ground. Blow dry nitrogen or air over, around, and through the assembly to remove all remaining dust and foreign particles _____
2. Blow dry nitrogen or air into the inside of the can to remove dust particles, and then insert the assembly into the can _____

IX. ELECTRICAL TESTS BEFORE WELDING THE CAN TO THE BASE
SUBASSEMBLY

Date: _____ Initials: _____

The following tests are to be performed with the sensitive volume subassembly inserted into the can.

1. Insulation

At the multipin header, measure the electrical insulation resistance from pins to pins and from pins to the base subassembly. The resistance shall be greater than 2M megohms (2×10^{12} ohms). Record the resistance values in the correct spaces below.

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Pin	7	4 or 6	3 or 5	2	1
Base					
1					
2					
3			short		
4		short			
5					
6					

If any resistance is less than 2M megohms, bake the sensitive volume in an oven at 180°F for 15 min and repeat the measurement.

2. Noise and Leakage

Connect RG 179/U coaxial cable to header pins 6 (signal section 1), 1 (signal section 2), 3 (HV section 1), 7 (+HV section 2), and 2 (-HV section 2). The length of the coaxial cables must be such that they can be used in the compensation checks described in Sect X. Connect the signal leads to micro-microammeters, Keithley model 410 or 411 (or equal), and the HV leads to regulated HV supplies, Keithley model 240 (or equal). Every ground and shield must be connected to the instrument ground. Apply HV to each section, simultaneously, at three different values as indicated in the following table. At each voltage setting, after the current transients have decayed, observe the noise and leakage currents of each

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section for 2 min. Record the maximum noise and leakage currents measured during this time. The maximum permissible values are given in amperes in parentheses in the following table. (The word "leakage" describes the DC component plus the slowly varying fluctuations, and "noise" describes the fast fluctuations, or spikes, superimposed on the leakage):

Volts	Section 1		Section 2			
	Leakage (A)	Noise (A)	Volts		Leakage (A)	Noise (A)
			+HV	-HV		
+50	(1×10^{-12})	(1×10^{-12})	+50	-50	(0.5×10^{-12})	(0.5×10^{-12})
+400	(3×10^{-12})	(1×10^{-12})	+400	-400	(0.5×10^{-12})	(0.5×10^{-12})
+900	(5×10^{-12})	(1×10^{-12})	+900	-900	(1.5×10^{-12})	(0.5×10^{-12})

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3. Neutron Sensitivity

- a. Construct a test geometry as shown in drawing Q-2633-502. Place the sensitive volume in the Plexiglas holder and insert both pieces in hole 3. Insert a calibrated Pu-Be neutron source in hole 1.
- b. Measure the currents of sections 1 and 2 and record the values in column A of the following table. Use the same connections and instruments as in step 2, above; apply +50 V to HV section 1, +50 V to +HV section 2, and -50 V to -HV section 2.
- c. Compare, in the following manner, the currents measured with those specified in column D of the following table:
 - (1) When the tests are made with the Pu-Be neutron source of the ORNL Controls Dept., Instrumentation and Controls Division, the currents of column A and D must agree within 15% (write the ratio of currents A to D in column E).
 - (2) If the tests are made by a commercial fabricator (Seller) outside ORNL, a correction factor must be computed to compare the measured currents with those specified in column D. The correction factor will include corrections for differences of atmospheric pressure and neutron-source strength. Write the correction factor in column B, and calculate the corrected neutron currents in column C. Currents in columns C and D must agree within 15% (write the ratio of currents C to D in

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column E). NOTE: When the ionization chambers are fabricated by a Seller, ORNL will assist the Seller in computing or in estimating the correction factor in column B.

A	B	C	D	E
Measured Neutron Currents in Air (A)	Correction Factor	Corrected Neutron Currents (A)	Specified Neutron Currents at ORNL in air (A)	A/d or C/D
Section 1			7.6×10^{-11}	
Section 2			7.0×10^{-11}	

X. MEASUREMENT OF GAMMA COMPENSATION IN SECTION 2 OF THE
IONIZATION CHAMBER

Date: _____ Initials: _____

1. Gamma Facility Description

- a. Measurements of the gamma compensation must be performed with a cobalt-60 source of at least 50 but not more than 2,000 curies (Ci) (600 Ci is recommended) in a hot cell or similar installation . . . _____

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- b. The source and the ionization chamber must be at least 8 in. from the vertical walls to minimize the back-scattered radiation. However, both the chamber and the source can be on the floor during this measurement _____

2. Measurement of the Compensation

- a. Using the same setup as in Sect. IX, step 2, apply +300 V to HV section 1, to +HV section 2, and to -HV section 2 _____
- b. Place the chamber in the gamma facility, with the bottom of the chamber toward the source. Position the cobalt-60 source so that a current of approximately 5.0×10^{-8} A is obtained in section 2. Record this current in the correct space of the following table _____
- c. Apply the voltages as indicated in the second and third steps of the following table, and record in their respective spaces the currents obtained in section 2 _____
- d. Subtract the current in step 2 from the current in step 3 and divide this result by the current in step 1 (see the table). This value is the deviation from total gamma compensation _____
- e. Repeat steps a, b, c, and d, but with a current of approximately 5.0×10^{-9} A _____

PCP III MULTISECTION IONIZATION
CHAMBER (Q-2633) FOR REACTOR CONTROL

PROCEDURE: P-2633-106A-3R1

DATE: December 11, 1977

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Steps	Section 1	Section 2		Section 2	Gamma Uncompensation (%)
	Pin 3 or 5 HV (V)	Pin 7 +HV (V)	Pin 2 -HV (V)	Pin 1 Current (A)	
1	+300	+300	+300	$\times 10^{-8}$	
2	+300	-300	+300		$\frac{3 - 2}{1} = \text{_____} =$
3	+300	+300	-300		_____ or _____ %
1	+300	+300	+300	$\times 10^{-9}$	
2	+300	-300	+300		$\frac{3 - 2}{1} = \text{_____}$
3	+300	+300	-300		_____ or _____ %

f. Write the two gamma uncompensation values obtained in the table (%) in the spaces below, and determine their average. The average uncompensation must be between the limits of -2.5 and +2.0%.

_____ % + _____ %

Average uncompensation = $\frac{\text{_____}}{2} = \text{_____} \%$.

Note: This sensitive volume must be kept in a vacuum until the chamber assembly (parts 1 and 2 on drawing Q-2633-106A-3) has been welded and filled.

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XI. WELDING AND FILLING

1. Heliarc weld the can to the base subassembly as shown by drawing Q-2633-106A-3. While being welded, the header must be cooled by water flowing through a jacket clamped with an O-ring seal to the base around the header. After the welding is complete, the length or diameter shall comply with the tolerances shown for the can on drawing Q-2633-302A.

Date: _____ Initials: _____

2. Helium leak check the sensitive subassembly in accordance with procedure P-2633-1.

Date: _____ Initials: _____

3. Evacuate and degas the sensitive volume subassembly at 150°F until a pressure less than 5×10^{-5} mm of Hg is obtained.

Date: _____ Initials: _____

4. Fill the sensitive volume subassembly with nitrogen gas (purity 99.997%) to 800 ± 20 mm Hg abs at room temperature. To remove any moisture from the nitrogen gas, the gas shall flow through a cooling coil which is near liquid nitrogen temperature.

Date: _____ Initials: _____

5. Crimp off the fill tube 2 in. from where tube enters the base subassembly and weld the crimped end. The fill-tube clamping jig shall be attached to the fill tube while the crimped end is being welded. Leak test the crimped end of the fill tube in water.

Date: _____ Initials: _____

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XII. FINAL ELECTRICAL TESTS OF SENSITIVE VOLUME SUBASSEMBLY

Date: _____ Initials: _____

1. Insulation

At the multipin header, measure the electrical insulation resistance between each pair of pins and from the pins to the base subassembly. The resistance shall be greater than 2M megohms (2×10^{12} ohms). Record the measured resistance values in the following table.

Pin	7	6	5	4	3	2	1
Base							
1							
2							
3			short				
4		short					
5							
6							

If any resistance is less than 2M megohms, bake the sensitive volume in a vacuum oven at 180°F for 15 min and repeat the measurement.

2. Noise and Leakage

Connect RG 179/U coaxial cables to header pins 6 (signal section 1), 1 (signal section 2), 3 (HV section 1), 7 (+HV section 2), and 2 (-HV section 2). The length of

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the coaxial cables must be such that they can be used in the compensation checks described in Sect. XI. Connect the signal leads to micro-microammeters, Keithley model 410 or 411 (or equal), and the HV leads to regulated HV supplies, Keithley model 240 (or equal). Every ground and shield must be connected to the instrument ground. Apply HV on each section, simultaneously, at three different values as indicated in the following table. At each voltage setting and after the current transients have decayed, observe the noise and leakage currents of each section for 2 min. Record the maximum noise and leakage currents observed during this time. The maximum permissible values are given in amperes in parentheses in the following table. (The word "leakage" describes the DC component plus the slowly varying fluctuations, and "noise" describes the fast fluctuations, or spikes, superimposed on the leakage.)

Section 1			Section 2			
Volts (V)	Leakage (A)	Noise (A)	Volts		Leakage (A)	Noise (A)
			+HV (V)	-HV (V)		
+50	(1×10^{-12})	(1×10^{-12})	+50	-50	(0.5×10^{-12})	(0.5×10^{-12})
+400	(3×10^{-12})	(1×10^{-12})	+400	-400	(0.5×10^{-12})	(0.5×10^{-12})
+900	(5×10^{-12})	(1×10^{-12})	+900	-900	(1.5×10^{-12})	(0.5×10^{-12})

SUBJECT: ASSEMBLY AND TESTING OF THE SENSITIVE VOLUME SUBASSEMBLY
TYPE 106A, SERIAL NO. _____

3. Neutron Sensitivity

- a. Construct a test geometry as shown in drawing Q-2633-502. Place the sensitive volume in the Plexiglas holder and insert both pieces in hole 3. Insert a calibrated Pu-Be neutron source in hole 1.
- b. Measure the currents of sections 1 and 2 and record them in column A of the following table. Use the same connections and instruments as in step 2, above; apply +50 V to HV section 1, +50 V to +HV section 2, and -50 V to -HV section 2.
- c. Write in column B the currents measured in Sect. IX, step 3. Calculate the ratio A/B and record it in column C. This ratio shall be within the limits of 1.00 to 1.12. (The current increases are caused by the change of chamber gas filling, i.e., from air at atmospheric pressure to nitrogen at 800 mm Hg abs.) If this measurement is not made at ORNL, the limits of the ratio A/B shall be decreased 1% for each positive increase of 10 mm of Hg in the average atmospheric pressure at the location of measurement and 730 mm of Hg abs (mean atmospheric pressure at ORNL).

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CHAMBER (Q-2633) FOR REACTOR CONTROL

PROCEDURE: P-2633-106A-3R₁

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TYPE 106A, SERIAL NO. _____

A	B	C
Measured Neutron Currents (in nitrogen) (A)	Measured Neutron Currents in Sect. IX, Step 3 (in air) (A)	Ratio A/B
Section 1		
Section 2		

SUBJECT: FABRICATION AND TEST OF CABLE ASSEMBLY AND INSTALLATION
OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

I. INTRODUCTION

These instructions describe how to assemble and test a cable assembly and how to connect an assembly to a PCP III multisection ionization chamber, type 106A. They also describe other operations and tests to be performed before a completed ionization chamber is delivered to the user.

For this assembly, one must refer to drawing Q-2633-106A-4, which contains a color chart for the connections, a bill of material, several detail views, and other information.

It is necessary that these fabrication and testing instructions be followed precisely as outlined. Each step shall be performed successfully before proceeding to the next step. The person responsible for this assembly must write the date and his initials at the start of each section in the space provided; and, after each step has been successfully performed, he must check the box.

Solid wire, 60-40, tin-lead soft solder shall be used for soldering.

II. CONNECTION OF CABLE (PART 6) TO HERMETIC RECEPTACLE (PART 2)

Date: _____ Initials: _____

1. Ensure that the hermetic receptacle (part 2) has been helium leak checked in accordance with procedure P-2633-1 _____
2. Cut the cable (part 6) to the length indicated by the bill of material _____

SUBJECT: FABRICATION AND TEST OF CABLE ASSEMBLY AND INSTALLATION
OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

3. Connect the individual coaxial cables and shielded and unshielded hook-up wires to part 2, as shown by detail I of drawing Q-2633-106A-4.
 - a. Choose the proper end of the cable (part 6) for which the individual cables, without crossing each other, match the pins of part 2 according to the color chart of drawing Q-2633-106A-4 _____
 - b. Remove the outer jacket and outer braid of part 6 back 1-3/8 in. from the end _____
 - c. Begin the connections with the low-noise coaxial cable (black) as shown by detail I of drawing Q-2633-106A-4. Slide a hood (part 7) over the cable. Remove 1/4 in. of the Aquadag coating from the dielectric with ethyl alcohol. Solder the center conductor to pin 1 of part 2, screw the hood into place, and solder the braid to the hood _____
 - d. Continue the connections with the three other coaxial cables and the three shielded hook-up wires as indicated by the color chart. Use hoods (part 7) for the coaxial cables and hoods (part 8) for the shielded hook-up wires _____
 - e. Connect the three unshielded hook-up wires as indicated by the color chart _____

PCP III MULTISECTION IONIZATION
CHAMBER (Q-2633) FOR REACTOR CONTROL

PROCEDURE: P-2633-106A-4R₁

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

Cable color	Receptacle Pin	Continuity Center Conductor	Continuity Braid
Black	1		
Red	2		
Violet	3		
Yellow	4		
Gray	5		
Blue	6		
White	7		
Brown	8		_____
Orange	10		_____
Green	12		_____

III. ELECTRICAL TESTS AFTER COMPLETION OF CONNECTION OF CABLE
(PART 6) TO RECEPTACLE (PART 2)

Date: _____ Initials: _____

1. Electrical Continuity of Individual Connections

Check separately the continuity of each center conductor and braid from the unconnected end of the cable to the front end of the receptacle (part 2). The maximum resistance shall be less than 5 ohms. Check the appropriate box in the preceding table.

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
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2. Electrical Insulation

- a. Measure the electrical insulation resistance between the center conductor and its braid of each coaxial cable. Record the insulation resistance values in the following table. Perform these measurements at the unconnected end of the cable with an insulation tester "Megger," or equal, set at 500 V. The insulation resistance must be greater than 2M megohms (2×10^{12} ohms).

Coaxial Color	Black	Red	Violet	Yellow	Gray	Blue	White
Center Conductor to Braid resistance (ohms)							

- b. Measure the electrical insulation resistance between the following components:
- (1) each pair of the seven coaxial contact shells;
 - (2) pins 8, 19, 12, the receptacle shell, the cable outer braid, and each of the seven coaxial contact shells;
 - (3) the receptacle shell and pins 8, 10, and 12; and

SUBJECT: FABRICATION AND TEST OF CABLE ASSEMBLY AND INSTALLATION
OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO.

(4) the cable outer braid and pins 8, 10, and 12.

Perform these measurements at the receptacle (part 2) end with a Keithley, model 500 megohmmeter (or equal). The insulation resistance must be greater than 1M megohm (10^{12} ohms). Record the values in the following table.

[illegible]

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
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IV. EPOXY POTTING OF REAR END OF RECEPTACLE (PART 2)

Date: _____ Initials: _____

1. Insert the potting ring (part 4) into the receptacle (part 2) as shown by detail II of drawing Q-2633-106A-4. Inspect visually to be sure that the potting ring seats correctly in the receptacle groove. Clamp this assembly in a vertical position as shown in detail II _____
2. Mix 25 g of Epoxy P-430 (manufactured by Carl F. Biggs Co., Santa Monica, California) with 1.5 g of hardner B. Centrifuge the mixture approximately 1 min to remove the air bubbles and use it within 30 min _____
3. Fill the potting ring with the mixture to approximately 1/16 in. below the counterbore. Let the epoxy set 4 hr _____
4. Seat the potting cup (part 3) in the potting ring, with the assembly in a vertical position as in step 1. Check to make sure that cable shield does not contact parts 2, 3, or 4. Prepare more epoxy mixture in accordance with step 2. Add the mixture through the 1/8 in. hole in the potting cup. Let the epoxy set 12 hr _____

V. ASSEMBLY OF RECEPTACLE (PART 2) WITH HOUSING SUBASSEMBLY
(PART 1)

Date: _____ Initials: _____

1. Measure the length of the housing subassembly to ensure that it is correct as indicated by the bill of material _____

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
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2. Check that the housing subassembly has been degreased
and helium leak checked according to procedure
P-2633-1 _____
3. Cover the front end of the receptacle (part 2) with
a metallic cap to protect part 2 during the welding
operation specified in the next step. Any cap that
will fit part 2 and permit the welding operation can
be used _____
4. Insert the receptacle (part 2) and the cable (part 6)
into the receptacle housing of part 1. Inspect to see
that the receptacle seats correctly. Heliarc weld the
two parts as shown by detail III of drawing
Q-2633-106A-4 _____
5. Remove the metallic cap (step 3), and helium leak check
the weld according to procedure P-2633-1. To leak
check, seal the receptacle housing end of the assembly,
and pump through the 1/8-in.-dia, nickel exhaust tube of
the receptacle housing. Allow helium to flow into the
rear end of the cable assembly _____

VI. BURNDY CONTACTS INSTALLATION AND SUBSEQUENT ELECTRICAL TESTS

Date: _____ Initials: _____

1. Slide the moisture-proofing capsule subassembly (part 5)
over the cable (part 6) and onto the capsule connector
end of part 1 as shown by detail IV of drawing
Q-2633-106A-4 _____

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2. Remove the outer jacket of the exposed end of part 6 to 2-3/8 in. Wrap the conductor of the hook-up wire (part 17) one turn over the outer braid of part 6 against the outer jacket as shown by detail V of drawing Q-2633-106A-4. Solder the hook-up wire conductor to the outer braid. Cut off excess outer braid, remove any sharp edges left after this cutting, and insulate the exposed part with Scotch brand, Vinyl plastic electrical tape 33 _____
3. Crimp the Burndy individual contacts on the individual cables of part 6 at its exposed end as shown by detail V. Refer to the color chart for the proper connections. The length from the end of the outer jacket of part 6 to the front end of the shield contacts (part 16) must be 2-3/4 in., as shown by detail V _____
 - a. Use as crimping tool a Burndy Hytool M8ND with die N22RVMT-10 _____
 - b. For the four coaxial cables (black, red, blue, and yellow), slide the hyrings (part 11) over the cables, remove 1/2 in. of Aquadag coating on the dielectric insulation of the black coaxial cable with ethyl alcohol, crimp the pins (part 12) onto the cable center conductors, insert the crimped pins into the shield contacts (part 16), slide the cable braids over rear end of parts 16, slide parts 11 over the cable braids, and crimp _____
 - c. For the three shielded hook-up wires (violet, white, and gray), place the hyrings (part 11) and the wire stiffener (part 14) over the cables, and crimp the

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pins (part 12) onto the cable center conductors.
Insert the crimped pins into the shield contacts
(part 16), slide parts 14 into parts 16, move the
cable braids over the rear end of parts 16, move
parts 11 over the cable braids, and crimp _____

d. For the black hook-up wire, slide a hyring (part 11)
and a wire stiffener (part 15) over the wire, crimp
a pin (part 13) onto the wire conductor, insert the
crimped pin into a shield contact (part 16), slide
part 15 into part 16, slide part 11 onto part 16,
and crimp _____

4. Cut off the brown, orange, and green hook-up wires 1/2 in.
longer than the outer braid end of part 6 _____

5. Slide the heat shrinkable boot (part 18), as shown by
the cable assembly diagram, and the adapter (part 10)
over the individual contacts. Insert the individual
contacts into the plug (part 9) in accordance with the
color chart on drawing Q-2633-106A-4 _____

6. Measure separately the continuity of each center pin and
each shell from the Burndy individual contacts to the
front end of the receptacle (part 2). The electrical
resistance shall be less than 5 ohms. Record the values
in the following table.

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Burndy Contact	Receptacle Pin	Continuity Center Pin	Continuity Shell
A	7		
B	6		
E	5		
H	4		
F	3		
G	2		
J	1		
C	Cable outer braid		

7. Measure the electrical insulation resistance between the center pin and shell of each Burndy contract. Perform these measurements with a Keithley, model 500 megohmmeter (or equal). The insulation resistance must be greater than 2M megohms (2×10^{12} ohms). Record the insulation resistance values in the following table:

Burndy contract	A	B	E	F	G	H	J
Pin to shell insulation							

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

VII. INSERTION OF CABLE ASSEMBLY INTO CHAMBER HOUSING ASSEMBLY
(Q-2633-106A-2) AND SUBSEQUENT ELECTRICAL TESTS

Date: _____ Initials: _____

1. Ensure that the chamber housing assembly Serial
No. _____ to be used has been completed and tested
in accordance with procedure P-2633-106A-2 _____
2. Insert the cable assembly into the chamber housing
assembly as shown by the cable assembly view, drawing
Q-2633-106A-4. The receptacle (part 2) shall mate and
make contact with the plug of the chamber housing
assembly Q-2633-106A-2 _____
3. Perform the following electrical tests:
 - a. Continuity. At the plug (part 9), measure the con-
tinuity from pin H to pin B, and from pin E to
pin F _____
 - b. Insulation Resistance. Measure the following insu-
lation resistances at the plug (part 9) with a
Keithley, model 500 megohmmeter (or equal): _____
 - (1) Between the individual pins and their own shells
and to shell J. The resistance shall be greater
than 1M megohm (10^{12} ohms). Record the values
in the following table:

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

Pin	A	B	E	G	J
Insulation from pin to its own shell					
Insulation to shell J					--

- (2) Between the individual shells and the chamber housing, and also the cable outer braid (pin C). The resistances shall be greater than 10^4 megohms (10^{10} ohms), except that from shell J to the chamber housing it shall be greater than 10^3 megohms. Record the values in the following table:

Shell No.	A	B	G	J	Pin C
Insulation to chamber housing					
Insulation to pin C (cable outer braid)					--

- c. Noise and leakage. By referring to the chamber function table of drawing Q-2633-106A-1, connect the different sections of the ionization chamber as follows: the signal leads to a micro-microammeter, Keithley model 410 or 411 (or equal), and the HV leads to regulated HV supplies, Keithley model 240 (or equal). For this purpose, use the mating connector (Burndy P/n M22T10XS2N) of the plug (part 9

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SERIAL NO. _____

of the cable assembly drawing Q-2633-106A-4), with
the coaxial cables mounted to the individual contacts.
Every ground and shield shall be connected to the
instrument ground

Apply HV to each section simultaneously, at three
different values as indicated in the following
table. At each voltage setting and after the current
transients have decayed, observe the noise and the
leakage currents of each section for 2 min. Record
the maximum noise and leakage currents observed during
this time. The maximum permissible values are given
in amperes in parentheses in the table. (The word
"leakage" describes the DC component plus the slowly
varying fluctuations, and "noise" describes the fast
fluctuations, or spikes, superimposed on the leakage):

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

Section 1			Section 2			
Volts (V)	Leakage (A)	Noise (A)	Volts		Leakage (A)	Noise (A)
			+HV (V)	-HV (V)		
+50	(1×10^{-12})	(1×10^{-12})	+50	-50	(0.5×10^{-12})	(0.5×10^{-12})
+400	(3×10^{-12})	(1×10^{-12})	+400	-400	(0.5×10^{-12})	(0.5×10^{-12})
+900	(5×10^{-12})	(1×10^{-12})	+900	-900	(1.5×10^{-12})	(0.5×10^{-12})

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

- d. Neutron Sensitivity. Measure the chamber sensitivity with the neutron source and the test geometry used in Sect. XII, step 3 of procedure P-2633-106A-3. Use the same connection set up and the same instruments as in step c; apply +50 V to the HV electrodes of section 1, and +50 V to + HV and -50 V to the -HV electrodes of section 2.

Record the measured currents in the column A of the table below. Record in column B the currents measured in Sect. XII, step 3, of procedure P-2633-106A-3 (Caution: use the procedure filled in for the same chamber serial number.) In column C, write the ratio of currents from column A to those from column B. These ratios shall be between 0.842 and 0.994.

A	B	
	Measured Neutron Currents in Sect. XII, Step 3 of Procedure P-2633-106A-3	Ratio of Currents A/B
Measured Neutron Currents		
Section 1		
Section 2		

SUBJECT: FABRICATION AND TEST OF CABLE ASSEMBLY AND INSTALLATION
OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

VIII. CHAMBER WELDING AND FILLING

Date: _____ Initials: _____

1. Heliarc weld the cable assembly to the chamber housing assembly, with the two joints flush as shown by the cable assembly view of drawing Q-2633-106A-4. During welding, excess heat is absorbed by a 1/2-in.-thick-wall, copper clamp (4 in. long) that is clamped to the chamber casing just below the weld joint.
2. Recheck neutron sensitivity after welding.
3. Date: _____ Initials: _____
By pumping through the 1/8 in. exhaust tube, helium leak check the weld according to procedure P-2633-1. After ensuring that the hermetic receptacle (part 2) had not been damaged during the weld operation of step 1, allow helium to flow into the rear end of the cable assembly.
4. Date: _____ Initials: _____
Evacuate and degas the chamber housing volume at 150°F until the following pressure requirements are met:
 - a. 2×10^{-5} mm of Hg abs or lower is obtained.
 - b. Not greater than 10^{-1} mm of Hg abs (100 microns) is maintained after the chamber has outgassed at room temperature for 16 hr. (overnight), with the vacuum system closed.
5. Fill the chamber housing volume with nitrogen gas (purity 99.997%) to 800 ± 20 mm Hg abs at room temperature. To remove any moisture from the nitrogen gas, it must be

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

allowed to flow through a cooling coil that is near liquid-nitrogen temperature.

6. Date: _____ Initials: _____

Crimp off the fill tube 3 in. long, and soft solder the crimped end. Leak check the tube under water. For its protection, carefully bend the tube into the weld relief groove so that it does not extend above the welded joint.

IX. EPOXY POTTING OF MOISTURE-PROOFING CAPSULE SUBASSEMBLY (PART 5)
AND ASSEMBLY OF HEAT SHRINKABLE BOOT (PART 18)

Date: _____ Initials: _____

1. First, the cable should be pushed back into the bellows tubing as much as possible. Starting 1-1/2 in. above the capsule connector end of part 1, peel off the next 2 in. of the cable jacket (see detail IV). Cut the outer shield braid in the middle of its exposed portion. Push the two parts of the braid back over the cable jacket. Wrap three turns of nickel wire (AWG 26) around each part of the braid, 1/4 in. from the jacket edge, to secure the braid ends. Solder the braid to the nickel wire and then cut off the excess braid. Separate the individual cable components of the cable (part 6) to ensure that the epoxy mixture will flow between them. Use a hook-up wire (part 17) to connect the two exposed braid parts. Solder the ends of the hook-up wire to the braids, and remove any sharp edges left after the soldering operation. Insulate the exposed outer shield braids with Scotch brand, Vinyl plastic electrical tape No. 33 _____

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

2. With the protruding end of the cable (part 6) pointing vertically, pour quick-set epoxy inside the tapered portion of part 1 around the cable as shown by detail IV _____
3. Insert the moisture-proofing capsule subassembly into the capsule connector as shown by detail IV. Measure the resistance between the cable braid (pin C) and outside capsule; it shall be 10^{10} ohms or greater. Mix 100 g of epoxy base (Araldite 502) with 10 g of epoxy hardener (Araldite 951), centrifuge the epoxy mixture to remove the air bubbles. Fill the moisture-proofing capsule subassembly with the epoxy mixture through the 1/8 in. hole in the upper end. The level of the epoxy mixture shall remain constant while it cures for 4 hr _____
4. Apply S-1006 Thermofit adhesive over the adapter (part 10) and the rear end of the cable (part 6). With a heat gun, heat shrink the boot (part 18) over parts 10 and 6 according to the instructions in Rayclad Tubes, Inc., Thermofit catalog. The final position of the boot (part 18) must be in accordance with the cable assembly view, drawing Q-2633-106A-4 _____

X. FINAL ELECTRICAL TESTS OF IONIZATION CHAMBER

Date: _____ Initials: _____

1. Continuity (repetition of Sect. VII, step 3a). At the plug (part 9) measure the continuity from pin H to pin B, and from pin E to pin F _____

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

2. Insulation resistance (repetition of Sect. VII, step 3b).
Measure the following insulation resistances at the plug
(part 9) with a Keithley, model 500 megohmmeter (or
equal) _____

- a. Between the individual pins and their own shells and
to shell J. The resistance shall be greater than
1 megohm (10^{12} ohms). Record the values in the
following table:

Pin	A	B	E	G	J
Insulation from pin to its own shell					
Insulation to shell J					--

- b. Between the individual shells and the chamber
housing, and also the cable outer braid (pin C).
The resistances shall be greater than 10^4 megohms
(10^{10} ohms), except that from shell J to the chamber
housing shall be greater than 10^3 megohms. Record
the values in the following table:

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

Shell	A	B	G	J	Pin C
Insulation to chamber housing					
Insulation to pin C (cable outer braid)					--

3. Noise and leakage (repetition of Sect. VII, step 3c).
By referring to the chamber function table of drawing Q-2633-106A-1, connect the different sections of the ionization chamber as follows. The signal leads to micro-microammeters, Keithley model 410 or 411 (or equal), and the HV leads to regulated HV supplies, Keithley model 240 (or equal). For this purpose, use the mating connector (Burndy P/n M22T10XS2N) of the plug (part 9 of the cable assembly drawing Q-2633-106A-4) with the coaxial cables mounted to the individual contacts. Every ground and shield shall be connected to the instrument ground. Apply HV to each section, simultaneously, at the three different values as indicated in the following table. At each voltage setting and after the current transients have decayed, observe the noise and the leakage currents of each section for 2 min. Record the maximum noise and leakage currents observed during this time. The maximum permissible values are given in amperes in parentheses in the table. (The word "leakage" describes the DC component plus the slowly varying fluctuations, and "noise" describes the fast fluctuations, or spikes, superimposed on the leakage):

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OF CABLE ASSEMBLY ON IONIZATION CHAMBER, TYPE 106A,
SERIAL NO. _____

Section 1			Section 2			
Volts (V)	Leakage (A)	Noise (A)	Volts		Leakage (A)	Noise (A)
			+HV (V)	-HV (V)		
+50	(1×10^{-12})	(1×10^{-12})	+50	-50	(0.5×10^{-12})	(0.5×10^{-12})
+400	(3×10^{-12})	(1×10^{-12})	+400	-400	(0.5×10^{-12})	(0.5×10^{-12})
+900	(5×10^{-12})	(1×10^{-12})	+900	-900	(1.5×10^{-12})	(0.5×10^{-12})

SUBJECT: FABRICATION AND TEST OF CABLE ASSEMBLY AND INSTALLATION
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SERIAL NO. _____

4. Neutron sensitivity (repetition of Sect. VII, step 3d). Measure the chamber sensitivity with the neutron source and the test geometry used in Sect. XII, step 3, of procedure P-2633-106A-3. Use the same connection set up and the same instruments as in step 3; apply +50 V to the HV electrodes of section 1, and +50 V to the +HV and -50V to the -HV of section 2.

Record the measured currents in column A of the table below. Record in column B the currents measured in Sect. VII, step 3d. In column C, write the ratios of currents from column A to those from column B. These ratios shall be equal to 1.

A	B	C
Measured Neutron Currents	Measured Neutron Currents in Sect. VII, Step 3d of this procedure	Ratio of Currents A/B
Section 1		
Section 2		

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