REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF DEVICE

CORRECTED PAGES 1, 4 and 7 – Change of Ownership, Update Source info, May 15, 2006

NO. **GA-1077-D-101-S** **DATE: September 23, 1999**

DEVICE TYPE: Continuous Neutron Analyzer

MODEL: POLAB CNA

MANUFACTURER/DISTRIBUTOR (previously Krupp-Polysius)
EADS SODERN North America, Inc.
180 Interstate North Parkway, NW
Suite **300**
Atlanta, Georgia 30339-2194

SOURCE MANUFACTURER:
SODERN
20 Avenue Descartes - B.P 23
94451 Limeil-Brevannes Cedex
FRANCE

SEALED SOURCE MODEL DESIGNATION:

SODERN SODITRON neutron tube **SS&D Registry CO-1230-D-101-S**

ISOTOPE: Hydrogen 3

MAXIMUM ACTIVITY: 3.63 Curies (134 GBq), 3.3 Curies (122 GBq) nominal

LEAK TEST FREQUENCY: Not Required

PRINCIPAL USE: H -- General Neutron Source Applications

CUSTOM DEVICE: ___ YES _X_ NO

NMSS12

DEVICE TYPE: Continuous Neutron Analyzer

DESCRIPTION:

The POLAB Continuous Neutron Analyzer (CNA) is a device that measures the elemental composition of raw materials used in the manufacture of cement and other building materials in an on-line and continuous fashion. The material passes through the analyzer on a conveyor belt and undergoes Prompt Gamma Neutron Activation Analysis (PGNAA), where the material is irradiated by a neutron source beneath the belt, and its characteristic gamma emission spectrum is recorded and analyzed by detectors above the belt.

The device consists of three main design components: (1) the measuring unit, consisting of the radiation source, the detector units, and moderation and reflecting material; (2) radiation shielding around the measuring unit; and (3) electronic control and evaluation unit in a separate control cabinet. The bulk of this review will focus on the first two components, which comprise the radiation protection enclosure.

The POLAB CNA is a large device consisting predominantly of borated concrete. Other materials of construction include lead for interior shielding, and polyethylene and graphite, for reflection and moderation of the neutrons. The dimensions of the radiation protection enclosure plus the tunnels added over the conveyor belts are 3000 mm (9.8 ft) in length, 4542 mm (14.9 ft) in width, and 2310 mm (7.6 ft) in height, with a total weight of 26000 kg (57460 lbs). This weight does not include the material on the conveyor belt. An exploded view of the device can be found in Attachment 1.

The neutrons required for the PGNAA are created within the SODITRON neutron tube. The tube is a sealed, metal-ceramic vacuum tube, 155 mm (6.1 in) long and 25 mm (1.0 in) in diameter. It consists of a cold cathode ion source (Penning type); a deuterium-tritium (D-T) gas reservoir, ionized via an internal permanent magnet; and a 5 μm (0.0002 in) thick target consisting of titanium hydride loaded with a mixture of deuterium and tritium. The beta radiation from the tritium remains contained within the vacuum tube. When a high voltage (90 - 100 kV) is applied across the tube, the deuterium and tritium ions are accelerated across the reservoir, where they undergo fusion reactions with the target to produce 14 MeV neutrons. A picture and cross section of the SODITRON neutron tube can be found in Attachment 2.

For additional safety and to make handling easier, the SODITRON neutron tube is contained in a component called the MEN 16G (from the French Module Emission Neutronique -- neutron emitting module). This is a 0.2 mm (0.008 in) thick steel tube, 740 mm (29.1 in) long and 100 mm (3.9 in) in diameter. The total weight of the MEN 16G is 6 kg (13.3 lbs). In addition to containing the SODITRON neutron tube, the MEN 16G contains the necessary wiring and circuitry to connect the tube to the high-voltage power supply. A picture of the MEN 16G can be found in Attachment 3.

The measuring unit consists of a lower assembly and an upper assembly. The lower assembly is a rectangular solid designed to support the conveyor belt and its related equipment, and to house the MEN 16G in a recess beneath the conveyor belt. The upper assembly is designed to house the detection units.

DESCRIPTION: (continued)

Surrounding the measuring unit are the multiple pieces of radiation shielding. The shield pieces are modular prefabricated sections made of borated concrete shaped into tongue-and-groove joints to minimize the likelihood of radiation "streaming" out of the analyzer. The overall shielding wall thickness varies from 30 to 54 cm (11.8 to 21.3 in), with the thickest shielding being located directly above the detectors. Additional shielding where required is provided by high-density polyethylene plates located inside the concrete. All external surfaces of the radiation shield are made of borated concrete.

The MEN 16G and the detectors are securely located within the POLAB CNA. Access to the MEN 16G neutron tube is via a large shield plug through a secured hatch. The hatch is configured with safety switches that will shut off the high voltage power supply if the hatch is opened more than 5 mm (0.2 in). Access to the detectors is via a maintenance opening closure plug located on top of the device. The plug cannot be removed manually since it weighs in excess of 250 kg (550 lbs).

The POLAB CNA is equipped with a flashing lamp to indicate that the neutron generator is ON. The lamp is located either on top of, or in the near vicinity, of the device. There is a one minute delay between initiation of a beam START command and actual neutron emission. During this time, the lamp will flash, indicating that the device will start producing neutrons.

An electronics cabinet is located at a distance from the POLAB CNA. Contained within this cabinet are all necessary equipment needed to run the neutron generator, control the detectors, and perform the data acquisition using high-speed data processing. Also included are safety loops to stop the analyzer in case of an accident. Emergency stop buttons are located at the outside of the electronics cabinet, and at additional locations around the CNA unit, as dictated by the installation location of device. Initiation of an emergency stop cuts power to the neutron generator, ceasing production of neutrons within the device. After an emergency stop has been initiated, the CNA can only be restarted by local acknowledgment via a key-operated switch.

The operator also has the option of shutting off the CNA's power supply or interrupting radiation generation from a remote operator's console. The CNA is equipped with a safety circuit that monitors the neutron flux created by the neutron generator. If neutron flux does not remain within a specified control range, neutron generation is interrupted. Additionally, the CNA contains a control circuit that will interrupt neutron generation if the conveyor belt has been stopped for a user-defined amount of time. In order to prevent material blockages entering the CNA's tunnel, the user installs level indicators along the conveyor belt, upstream of the CNA. The presence of material at a height above the level indicator will cause the conveyor belt to stop.

DEVICE TYPE: Continuous Neutron Analyzer

LABELING:

The POLAB CNA is labeled in accordance with Georgia Rules and Regulations for Radioactive Material, Chapter 391-3-17-.03(11)(d), which is comparable to 10 CFR 20.1904. The labels contain the radiation symbol, isotope, activity, model number, serial number, name of the distributor, and the words "CAUTION-RADIOACTIVE MATERIAL".

The labels are made of stainless steel or aluminum, rectangular in shape, and are permanently attached by rivets or screws to the device.

Since the analyzer can be installed and operated in conditions ranging from indoor conditions within a building to nearly outdoor conditions in a sampling tower or on a conveyor structure, the final placement of radiation signs, labels, and warning signals such as the flashing lamps will depend upon the local conditions. The labels are supplied by **EADS SODERN North America, Inc.** The user is responsible for affixing the signs, labels, and signals such that they are clearly visible by personnel approaching the POLAB CNA.

DIAGRAMS:

Attachment 1 -- POLAB CNA device, exploded view
Attachment 2 -- SODITRON neutron tube
Attachment 3 -- MEN 16G (neutron emitting module)
Attachment 4 -- Dose rate measurement locations around POLAB CNA

CONDITIONS OF NORMAL USE:

The POLAB Continuous Neutron Analyzer (CNA) is a device that measures the elemental composition of raw materials used in the manufacture of cement and other building materials in an on-line and continuous fashion.

The POLAB CNA will normally be used in ambient temperatures ranging from -40°C to +50°C. The device is usually installed in areas with light to medium conditions of vibration, but because of its size and weight is designed to withstand more severe conditions. The system is normally located along a process line carrying the raw materials. The most typical environmental operating conditions range from indoor operation within a plant building, to semi-outdoor operations located in a sampling tower or a conveyor structure. The POLAB CNA is expected to last a minimum of 10 years even in the harshest environments; if properly maintained, the device can last much longer than that.

The recommended working life of the SODITRON neutron tube is approximately 5000 hours of use, or, if used for 10 hours a day, 5 days a week, approximately 2 years. However, tube lifetime will vary according to numerous operational factors, such as neutron flux output, high voltage level setting, and temperature. At the end of working life, or at the latest 10 years after receipt, the neutron tube must either be returned to the manufacturer, SODERN, or transferred to another person licensed to receive the source.

CONDITIONS OF NORMAL USE: (continued)

When handling the MEN 16G, polyethylene gloves should be worn to ensure that the high-voltage connectors are kept clean. Additionally, ensure that the MEN 16G is not subjected to unnecessary shocks, stresses, or pressures greater than 5 bar (500 kPa, or 72.5 psi).

PROTOTYPE TESTING:

No prototype testing criteria for this type of source application has been established. ANSI N540-1975, "Classification of Radioactive Self-Luminous Light Sources" does not apply since this source-device combination is not luminous. ANSI/HPS N43.6-1997, "Sealed Radioactive Sources -- Classification" (equivalent to ISO 2919) has a usage application for "General neutron source application," but the SODITRON neutron tube contains only tritium; it only produces neutrons when a high voltage is applied across it. Thus, the description that follows contains a listing of prototype testing that the source has passed, and comparisons with existing sealed sources that contain tritium. Analysis will concentrate on the test results from other tritium sources; and comparison of the SODITRON neutron tube, contained within the MEN 16G, to the other tritium sources; and a justification that the SODITRON neutron tube, contained within the MEN 16G will perform at least as well in those testing environments.

The SODITRON neutron tube, contained within the MEN 16G unit, has been subjected to the prototype tests identified below. No malfunction occurred nor was there any loss of shielding or containment integrity.

- Temperature — 400°C (752°F) for a period of one hour, followed by a thermal shock into room-temperature water
- Drop test — Dropped multiple times from a height of 60 cm (2 ft)

These tests are consistent with expected operating and emergency conditions. Under most conditions, the SODITRON neutron tube, contained within the MEN 16G unit, will be installed in the POLAB CNA. The exceptions would include source installation and exchange, and during transport to/from the manufacturer. During installation and exchange, the MEN 16G is moved between the device housing and the transport container, which meets applicable IAEA requirements.

For comparison, the SODITRON neutron tube, contained within the MEN 16G unit, is compared to Safety Light Corporation's Model 880-12-6-XX (NR-579-D-110-G), a commercial exit sign. An exit sign is used because of similar use (drop) conditions during handling when performing source installation and exchange. The exit sign has been subjected to testing criteria under ANSI N540-1975 and achieved a classification of T6GC1333444.

DEVICE TYPE: Continuous Neutron Analyzer

PROTOTYPE TESTING: (continued)

The end result of putting the SODITRON neutron tube within the MEN 16G unit is that two barriers must fail for there to be a release of radioactive material. The majority of the tritium contained within the SODITRON tube is in solid form (titanium hydride), with a smaller amount in gaseous form, as opposed to being entirely in gaseous form; therefore, there is less likelihood of leakage and spread of contamination in the event of tube rupture. The MEN 16G unit has passed more stringent temperature and thermal shock tests than the exit sign. Because the materials used in the MEN 16G are solid, there is no concern for operating at a reduced pressure. Even though the MEN 16G weighs much more than the exit sign, it would still be expected to pass the impact tests as defined in ANSI N540-1975. The combination of the steel outer case and the polyurethane resin will provide sufficient strength and shock absorption to prevent the release of tritium. The MEN 16G is expected to survive the vibration testing because there is minimal void space within the unit: the polyurethane resin fills in around the SODITRON neutron tube and associated circuitry, preventing motion. Thus, under the expected handling conditions, the MEN 16G will prevent leakage of tritium.

During most accident scenarios, it is assumed that power is lost to the POLAB CNA. Upon loss of power, the device ceases to produce neutrons. Thus, as long as the SODITRON neutron tube remains contained within the device, the integrity of the radiation source is maintained.

The POLAB CNA, as an entire device, has not been subjected to specific prototype testing. However, considering that the device weighs in excess of 25,000 kg (50,000 lbs), there is little chance of damage as a result of an impact, penetration, or vibration identified in postulated accident scenarios. Since the device, including the entire exterior, is composed predominantly of borated concrete, the device will withstand postulated fires, sprays, and corrosive environments. In summary, the size and construction of the device ensures that the SODITRON neutron tube will remain in a securely within the device.

EXTERNAL RADIATION LEVELS:

The dose rates reported by the manufacturer for the POLAB CNA containing 3.3 curies (120 GBq) of tritium in the form of a SODITRON neutron tube were submitted with the device application. A map showing location of each point in relation to the device is provided in Attachment 4. Dose rates were only taken with the neutron tube energized, since there is no neutron production when the tube is de-energized, and the beta radiation from the tritium cannot be detected outside the neutron tube itself.

Dose rates were taken at numerous positions around the POLAB CNA with the device operating in its most unfavorable conditions: generator ON, no material on conveyor belt, and the maximum belt gap height opening of 320 mm (12.6 in). Neutron and gamma dose rates were measured at a distance of 5 cm from the device. The total dose rate (both neutron and gamma) at most measuring points was less than 5 μSv/hr (0.5 mR/hr). The only locations that exceeded a total dose rate of 10 μSv/hr (1.0 mR/hr) were points on the belt, at the tunnel openings.

DEVICE TYPE: Continuous Neutron Analyzer

QUALITY ASSURANCE AND CONTROL:

Both the device manufacturer and the source manufacturer have quality assurance programs that meet ISO 9001 certification criteria. The source manufacturer ensures that sub-components are procured from quality vendors, equipment can be identified and traced throughout the manufacturing process, defects are reported and investigated as they occur, and that finished products are subject to a final technical assessment prior to delivery to the device manufacturer. The device manufacturer uses an extensive series of checks on the radiation protection housing, numerous mechanical components, and the analysis system itself prior to device delivery to customer sites.

The device distributor and the device manufacturer are part of the same company. The device distributor confirmed that they are part of the design change process and will ensure that any changes that affect the radiation source and shielding parameters will be reviewed and incorporated into this device registration document prior to installation in the field.

LIMITATIONS AND/OR OTHER CONSIDERATIONS OF USE:

- The device shall be distributed to persons specifically licensed by the State of Georgia, the NRC or an Agreement State.
- The SODERN model SODITRON neutron tube, for use in the MEN 16G, ~~is approved by the State of Georgia for use in the Krupp Polysius POLAB CNA. The source is not registered on a separate certificate.~~ **is Identified on SS&D Registry Certificate CO-1230-D-101-S.**
- Handling, storage, use, transfer, and disposal:
  - Persons handling the neutron tube should be qualified in both radiation protection and high voltage installation safety.
  - Polyethylene gloves should be worn when handling the neutron tube to ensure that the high-voltage connectors are kept clean.
  - The neutron tube should not be subjected to unnecessary shocks, stresses, or pressures greater than 5 bar (500 kPa, or 72.5 psi).
  - At the end of working life, or at the latest 10 years after receipt, the neutron tube must either be returned to the manufacturer, SODERN, or transferred to another person licensed to receive the source.
- The POLAB CNA will be installed/assembled at user sites under the supervision of **EADS SODERN North America, Inc.**
- Training of users in the proper operation, safety, and accident procedures will be performed by **EADS SODERN North America, Inc.**

DEVICE TYPE: Continuous Neutron Analyzer

LIMITATIONS AND/OR OTHER CONSIDERATIONS OF USE: (continued)

- Emergency stop buttons should be located at the outside of the electronics cabinet, and at additional locations around the CNA unit, as dictated by the installation location of device. These buttons should be checked for proper operation at intervals not to exceed 6 months.
- Since the conveyor belt and the POLAB CNA have different power supplies, the user should develop lock-out/tag-out procedures such that, if the conveyor belt has stopped, the POLAB CNA is put in the "stand-by" mode prior to working in close proximity of the device.
- The user should have at least one operator trained in emergency shutdown procedures available whenever the POLAB CNA is producing neutrons (beam ON, "measuring" mode).
- This registration sheet and the information contained within the references shall not be changed without the written consent of the Georgia Department of Natural Resources, Radioactive Materials Program.

SAFETY ANALYSIS SUMMARY:

The POLAB CNA contains tritium in the form of titanium hydride, and an ionized gas reservoir. Both are enclosed within a metal-ceramic vacuum tube. The vacuum tube (SODITRON) is then enclosed within a steel tube (MEN 16G). A prototype of this arrangement has been subjected to a battery of tests and meets the definition of a sealed source. Under normal conditions of use and reasonable expected accident conditions, this source design will contain the enclosed tritium. Additionally, the beta radiation emitted by the tritium does not penetrate the exterior of the MEN 16G.

The steel tube (MEN 16G) is located in the device surrounded by many kilograms of borated concrete. When a high voltage is applied to the MEN 16G, neutrons are produced. As evidenced in the submitted documentation, the concrete serves as adequate radiation shielding to reduce the radiation levels to less than 50 μSv/hr (5.0 mR/hr) at a distance of 5 cm. When there is material on the conveyor belt, the radiation levels will be lower, and access to analyzing area is greatly reduced. The shielding also serves to protect the neutron tube from fire, corrosive environments, spray, and missiles/impacts.

The main radiation hazard is the neutrons produced when high voltage is supplied to the neutron tube. When the voltage is removed, either via planned shutdown or via accident, neutrons are no longer produced, and the radiation hazard is removed.

Based on review of the POLAB CNA, and the information and test data cited below, we conclude that the device is acceptable for licensing purposes.

Furthermore, we conclude that the device would be expected to maintain its containment integrity for normal conditions of use and accidental conditions which might occur during uses specified in this certificate.

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF DEVICE

DEVICE TYPE: Continuous Neutron Analyzer

REFERENCES:

The following supporting documents for the POLAB CNA, containing the SODERN model SODITRON neutron tube, are hereby incorporated by reference and are made a part of this registry document.

- Krupp Polysius Corporation's application dated June 3, 1999, with enclosures thereto.
- Krupp Polysius facsimile received July 8, 1999.
- Krupp Polysius letter dated July 26, 1999, with enclosures thereto.
- Krupp Polysius documentation received August 17, 1999.
- Krupp Polysius electronic mail, dated September 13, 1999.
- American National Standard N540-1975, "Classification of Radioactive Self-Luminous Light Sources," issued January 1976.
- Registry of Radioactive Sealed Sources and Devices, Safety Evaluation of Device, number NR-579-D-110-G, dated March 28, 1991

ISSUING AGENCY: Georgia Department of Natural Resources
Radioactive Materials Program

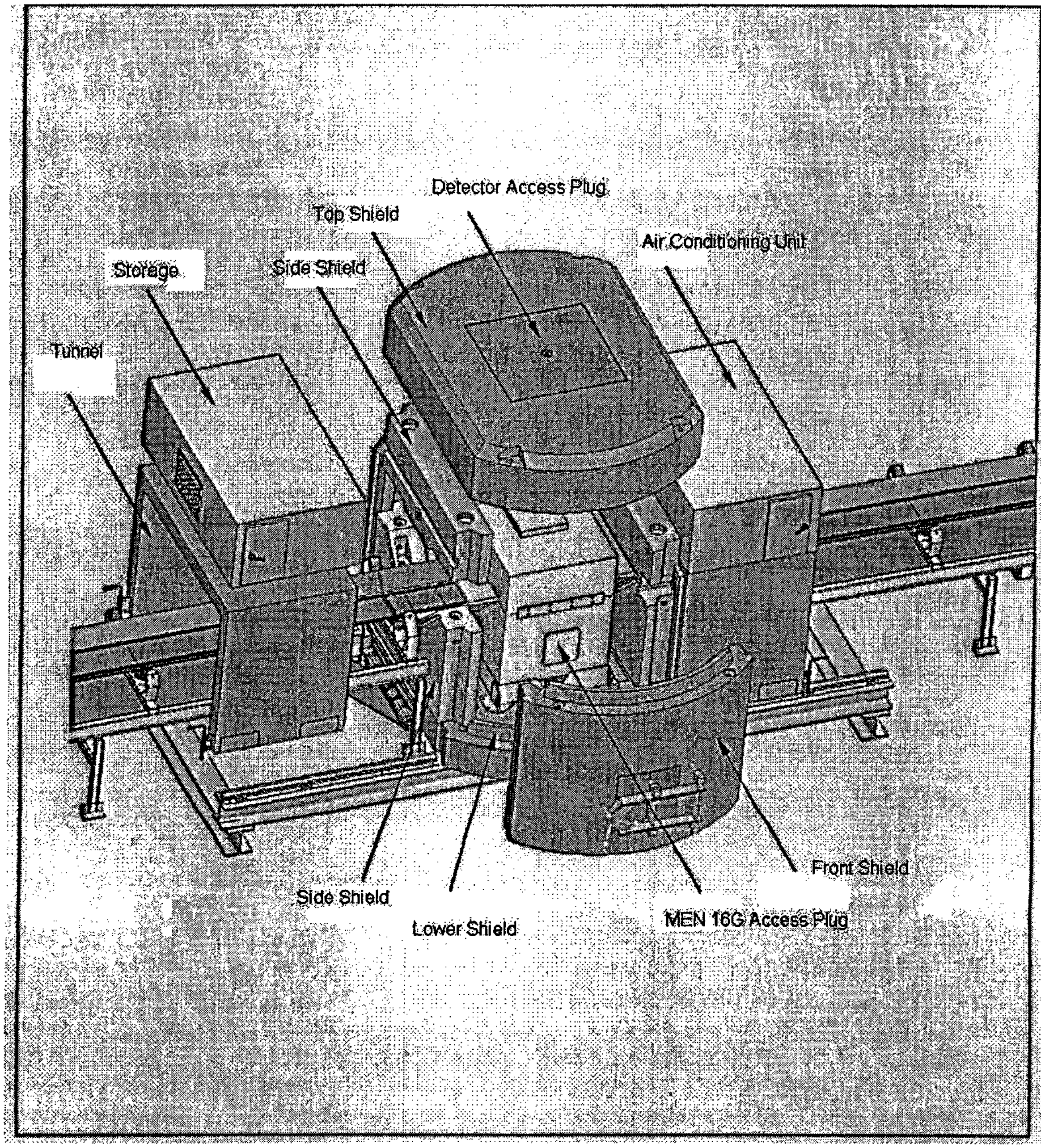
This document is not a license to receive, possess or distribute radioactive material. Receipt, possession and distribution of radioactive material, sources and devices containing radioactive material, are subject to the terms and conditions of applicable regulations and licenses issued by NRC or Agreement States.

Date: September 23, 1999 Reviewer: Eric T. Jameson

Date: September 23, 1999 Concurrence: Elizabeth L. Drinnon

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF DEVICE

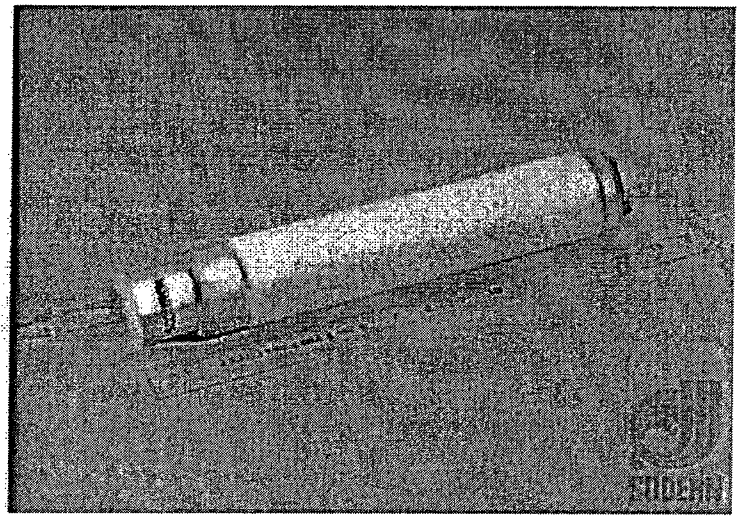
NO. **GA-1077-D-101-S** **DATE: September 23, 1999** **Attachment 1**



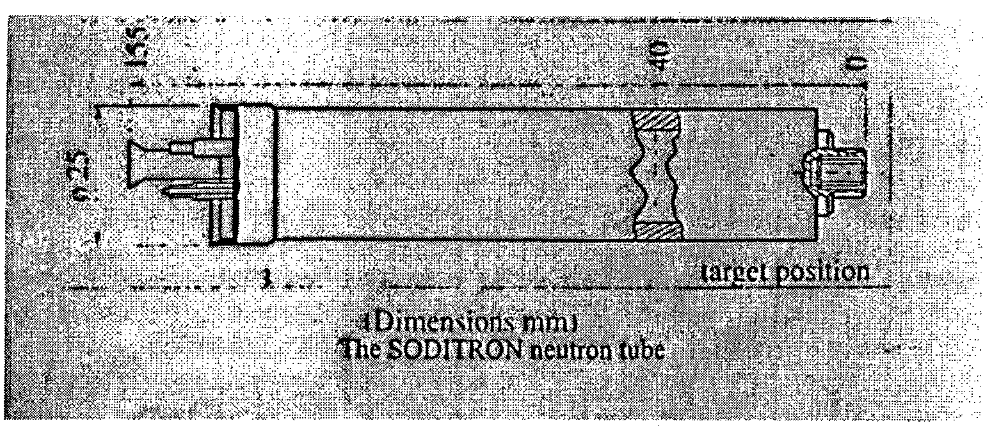
POLAB CNA, exploded view

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF DEVICE

NO. GA-1077-D-101-S **DATE:** September 23, 1999 **Attachment 2**



SODITRON Neutron Tube



SODITRON Neutron Tube, Cross Section

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
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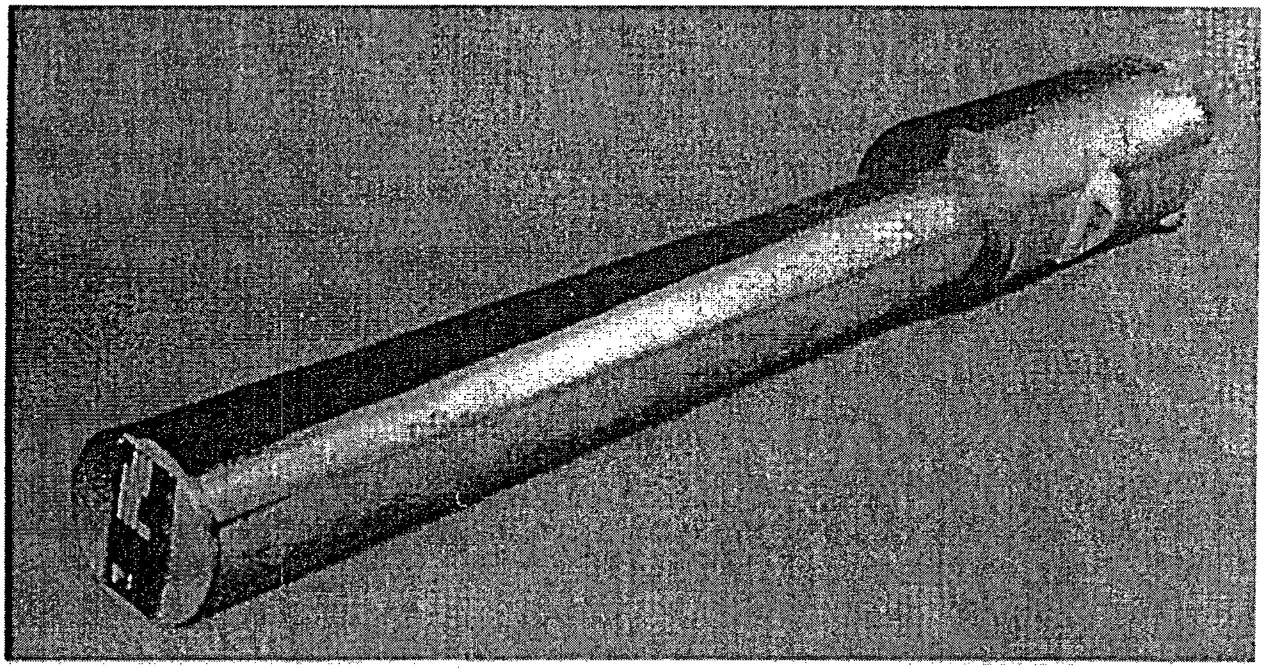
NO. GA-1077-D-101-S **DATE:** September 23, 1999 **Attachment 3**



MEN 16G neutron emitting module

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
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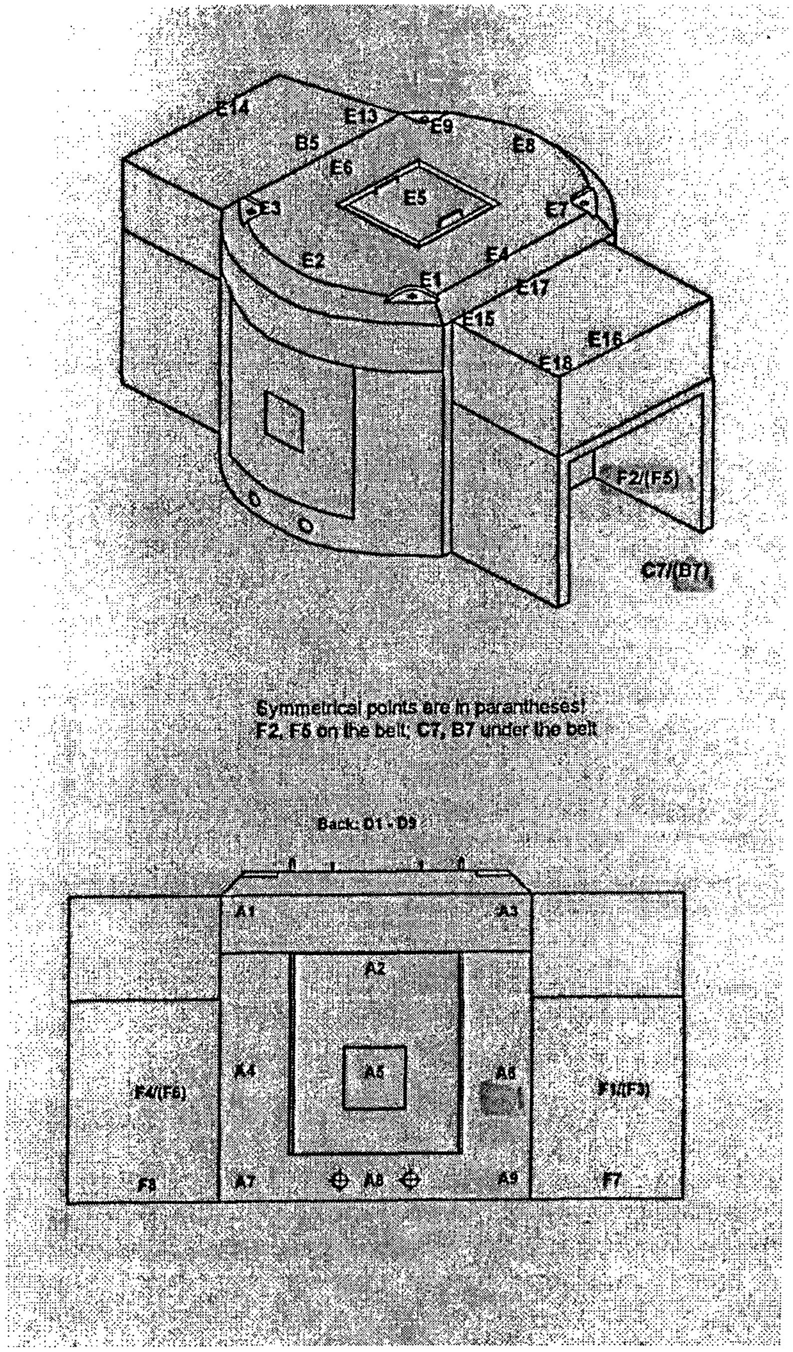
NO. **GA-1077-D-101-S** **DATE:** **September 23, 1999** **Attachment 4**



Dose rate measurement locations around the POLAB CAN