

**REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES  
SAFETY EVALUATION OF DEVICE**

**NO.:** NC-646-D-830-S                      **DATE:** April 03, 2007                      **PAGE:** 1 of 8

**SUPERSEDES**      NC-646-D-119-S & NC-646-D-121-S

**DEVICE TYPE:**      Portable Surface Moisture and Density Gauges

**MODEL No.:**      3401, 3401-B, 3411, 3411-B

**MANUFACTURER/DISTRIBUTOR:**      Troxler Electronic Laboratories  
3008 Cornwallis Road, P.O. Box 12057  
Research Triangle Park, NC 27709  
(919) 549-8661

**SEALED SOURCE MODEL DESIGNATION:**                      **ISOTOPE:**                      **MAXIMUM ACTIVITY:**

<u>Troxler Drawing No. A-102112 which covers:</u> AEA Technology/QSA, Inc. Model No. CDCW556 Capsule Type XN.30 Special Form Certificate No. USA/0673/S	Cs-137	9 millicuries (333 MBq)
AEA Technology/QSA, Inc. Model No. CDCW556 Capsule Type X1218 Special Form Certificate No. USA/0614/S	Cs-137	9 millicuries (333 MBq)
Isotope Product Laboratories Model # HEG-137 Capsule type: 3024 Special Form Certificate # USA/0356/S	Cs-137	9 millicuries (333 MBq)
<u>Troxler Drawing No. A-102451 which covers:</u> AEA Technology/QSA, Inc. Model # AMNV.997 Capsule type: X.1 Special Form Certificate # USA/0632/S	Am-241:Be	44 millicuries (1.63 GBq)
Isotope Product Laboratories Model # Am1.NO2 Special Form Certificate # CZ/1009/S-85	Am-241:Be	44 millicuries (1.63 GBq)
<u>Troxler Drawing No. C-106580 which covers:</u> Isotope Product Laboratories Model Nos. 3021 or 3027 Special Form Certificate No. USA/0462/S	Am-241:Be	44 millicuries (1.63 GBq)
<u>Troxler Drawing No. A-105779 which covers:</u> Isotope Product Laboratories Model HEG-252 Capsule Type 3024 Special Form Certificate No. USA/356/S	Cf-252	66 microcuries (2.44 MBq)
AEA Technologies Capsule Type X.1 Special Form Certificate No. USA/0632/S	Cf-252	66 microcuries (2.44 MBq)

**LEAK TEST FREQUENCY:**                      12 months

**PRINCIPAL USE:**                      (G) Portable Moisture/Density Gauges

**CUSTOM DEVICE:**                      \_\_\_\_\_ YES                      \_\_\_\_\_ X NO

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**SUPERSEDES** NC-646-D-119-S & NC-646-D-121-S

**DEVICE TYPE:** Portable Surface Moisture and Density Gauges

**DESCRIPTION:**

The models 3401, 3401-B, 3411, 3411-B gauges are portable gauges designed to measure the moisture content and density of soils, soil-stone aggregates, cement and asphalt treated bases and asphalt surfacing. The basic differences between these gauges are their electronics packages.

The moisture measurement is based on the principle of neutron thermalization by hydrogen in the test material and incorporates a neutron emitting doubly or triply encapsulated radioactive source (40 millicuries +/- 10% Am-241:Be or 60 microcuries +/- 10% Cf-252) and a helium-3 proportional counter tube. The neutron source is held stationary in the base of the gauge in a threaded cavity by a threaded plug made of stainless steel and surrounded by lead. A "Caution-Radioactive Material" label indicating the radioisotope, quantity, serial number and assay date covers the threaded plug. The base of the gauge is placed on the material being tested. Fast neutrons emitted by the source traverse the material and are thermalized by hydrogen atoms in the sample. The thermal neutrons are then detected by the helium-3 proportional counter and counted over a specified time period. Because of the insensitivity of these detectors to fast neutrons, the number of thermalized neutrons detected is directly proportional to the number of water molecules present in the material. The instrument electronics convert the count data to a moisture content based on an internally stored calibration.

The density measurement is based on Compton scattering and photoelectric absorption of photons by the test material. Measurements can be made in a "direct transmission mode" or a "backscatter" mode. The gamma source is located near the end of the extendable source rod. Proper use of the gauge in the direct transmission mode consists of first making a hole in the test material with the drill rod provided as an accessory. The gauge is then placed over the hole and the operator pulls a trigger on the source rod handle and inserts the source rod into the test material. The source rod can be inserted to depths from 2" to 12" in increments of either 1" or 2". An "index rod" on the gauge allows the trigger mechanism to be latched at the desired measurement depth. Geiger detectors located in the base of the gauge detect photons that have traversed the test material. The photons are counted over a specified time period and the number of counts detected is converted to a density value based on an internally stored calibration. A backscatter measurement is made by lowering the source rod so that its tip is essentially flush with the surface of the test material. The gauge is designed so that if the operator attempts to pick it up without first returning the source rod to the shielded position, the trigger in the handle releases and the rod retracts to the shielded position. A padlock is provided with the gauge so that the source rod can be locked in the shielded position when the gauge is not in use.

The density measurement uses a sealed source composed of 8 millicuries (+/- 10%) of Cs-137 in special form. The Cs-137 source is placed in the end of the source rod in a source cup and secured by welding. When retracted into the shielded position, the source is surrounded by tungsten. When the operator engages the trigger and lowers the source rod, the spring-loaded tungsten sliding block is moved back allowing the source rod to be inserted into the test material.

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**DEVICE TYPE:** Portable Surface Moisture and Density Gauges

**DESCRIPTION (Continued):**

The gauge housing consists of two primary components: the aluminum base casting and the top-shell. The base casting holds the detectors, batteries, sources and shielding. The base is covered with a top-shell made of either aluminum or plastic. The electronic circuit boards for the device are attached to both the base casting and top-shell.

**DETAILS OF CONSTRUCTION:**

All gauges in the 3400 series use similar materials in their construction. The primary materials used are aluminum, lead, tungsten, and stainless steel. When the handle-source assembly is in the safe position, *i.e.*, at the highest vertical setting, the Cs-137 source is contained in the approximate center of a cylindrical tungsten shield 1.75" in diameter and 3.00" high with a 0.640" diameter center hole through which the source rod passes. The thickness of the tungsten in a radial direction is 0.455".

At the safe position, the source is shielded on the bottom of the gauge by a spring-loaded tungsten sliding block 2.00" high by 0.750" wide. The minimum thickness of tungsten provided by the sliding block on the bottom of the gauge is 0.702". The entire tungsten shielding is mounted in a cast aluminum base. The Cs-137 source has additional shielding in the form of cast lead approximately 0.450" thick to the rear of the gauge tower. This lead shielding protects the user who comes into contact with the rear of the gauge. There is also approximately 0.37" of cast lead shielding surrounding the aluminum boss housing the neutron source. This lead shielding also serves to protect the user.

The following subsections describe the major components of the original design and the revisions to those components which have occurred since the 3440 gauge's original release in January 1986:

**Original Design:**

Extendable Source Rod (Serial Nos. < 25266): The Cs-137 source, 0.238" diameter, was housed inside of a 0.625" diameter x 1.750" long stainless steel source cup. Atop the Cs-137 source, within the source cup, was a 0.450" diameter x 0.250" long tungsten spacer, followed by a stainless steel spring. The source cup was then screwed onto a stainless steel source rod and welded.

**Revisions to the Original Design:**

Extendable Source Rod (Serial Nos. > 25265): In November 1995, the Agency authorized a change from the source cup design to a threaded plug design. The Cs-137 source is housed within a 0.625" diameter x 0.725" long stainless steel source plug. The source plug is screwed into the lower end of a stainless steel rod with a similar diameter, which is machined out to hold a 0.448" x 0.250" thick tungsten disk (abuts the source) and a stainless steel spring. The source rod with source plug is then welded.

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**DEVICE TYPE:** Portable Surface Moisture and Density Gauges

**LABELING:**

The 3401, 3401-B, 3411, 3411-B gauges are labeled in accordance with 15A NCAC 11 .1626. The labels contain the radiation symbol, isotope, activity, model number, serial number, name of distributor, and the words "CAUTION-RADIOACTIVE MATERIAL."

**DIAGRAM:**

See Attachments A through C for a three dimensional view of the 3401, 3401-B, 3411, 3411-B gauges, including locations of the sources and labels.

**CONDITIONS OF NORMAL USE:**

The 3401, 3401-B, 3411, 3411-B gauges are designed to be used by trained personnel to measure moisture and density of soils, aggregates and paving materials, typically at temporary job sites. The user will normally be near the device only for the time period necessary to set up the gauge and perform the measurement. The gauge has a recommended working life of 30 or more years under normal use conditions and with proper maintenance. However, the gauge should be returned to Troxler Electronics Laboratories, Inc. (hereafter Troxler) every five years for a thorough manufacturer's inspection, to include an extensive inspection of the extendable source rod and its welds.

The device is designed for the following environments:

Operating temperature      -10°C to 70°C ambient

Pressure                              Atmospheric

Vibration                              Ranges from zero to mild (tested @ a displacement of 0.1" @ 12.5 Hz)

Corrosion                              Ranges from zero to corrosive

Fire                                      +327°C (to melt the lead shielding used in the base casting around the Am-241:Be source)

**PROTOTYPE TESTING:**

The 3401, 3401-B, 3411, 3411-B gauges underwent prototype testing for mechanical, structural, and radiological integrity using measurement methodologies and testing procedures found in ANSI Standard N538-1979. This prototype testing included stray radiation measurements of gamma dose rates at 5 cm, 30 cm, and 100 cm for the gauges in both the "on" and "off" configurations; testing of the gauges' safety features at room temperature and at an elevated use temperature of 105°C, and at a decreased use temperature of -40°C; a leak test of the radioactive source after the safety feature/temperature testing; and an engineering evaluation of the likelihood of source retention in the source housing following a severe

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accident involving fire. The results of the testing showed: (1) no safety feature failure or stray radiation increase over the range of temperatures tested; (2) no loss of radioactive material from the sealed source; and (3) no loss of the shielding integrity of the device at temperatures below 327°C. Although a 327°C temperature would not, based on the ANSI classification of the source capsule, result in leakage of radioactive material, such a temperature would melt the lead shielding used in the base of the gauge. At this temperature, there would be a loss of some degree of shielding around the Am-241:Be capsule although the capsule would remain captive in the base of the gauge. The results of the prototype testing support the assignment of an ANSI standard rating of ANSI-54-164-154-R1.

**EXTERNAL RADIATION LEVELS:**

See Attachments D – H for external radiation levels for the various models of gauge.

**QUALITY ASSURANCE AND CONTROL:**

Troxler Electronic Laboratories maintains a quality assurance and control program which has been deemed acceptable for licensing purposes by the North Carolina Radiation Protection Section. A copy of the program is on file with the Radiation Protection Section.

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**DEVICE TYPE:** Portable Surface Moisture and Density Gauges

**LIMITATIONS AND/OR OTHER CONSIDERATIONS OF USE:**

**Distribution:** This device will be distributed as a specifically licensed device in accordance with the requirements of section .0300 of 15A NCAC 11 and/or applicable regulations of the NRC or an Agreement State. This shall not preclude the exportation of this device to a foreign entity following the applicable regulations.

**Leak Testing:** The device shall be leak tested by the user following the instructions in the "Manual of Operation and Instruction" at intervals not to exceed twelve months using techniques capable of detecting the presence of 0.005 microcurie of removable contamination. If the level of contamination exceeds this limit, the device shall be returned to Troxler for repair/disposal. Please note, Troxler maintains a customer leak test service using the Troxler Model 3880 Leak Test Kit.

**Servicing:** The 3401, 3401-B, 3411, 3411-B gauges require periodic maintenance of two specific gauge components by the gauge user. The scraper ring/sliding block require periodic cleaning and lubrication, and the source rod bearings require lubrication. The maintenance should be performed according to the manufacturer's instruction located in the operation and instruction manual. In addition, the gauge should be returned every five years for a thorough manufacturer's inspection of the gauge, to include an extensive inspection of the extendable source rod and its pertinent welds. Servicing of the source rod, including but not limited to source replacement, general servicing, repair, and/or disposal, shall be done by the manufacturer.

**Dosimetry:** All authorized users of these gauges should wear personnel dosimetry (film badges or TLD) in accordance with NRC or Agreement State regulations.

**Operating and Safety Instructions:** The device shall be operated in accordance with the written operating and safety instructions given in the device manual. The source rod **shall not** be driven or forced into the material to be tested; rather, a hole **must** be formed in the test material with the "drill rod" accessory provided with the gauge. The licensee should not attempt to remove the source rod from the gauge unless specifically authorized by his specific license.

**Training:** Use of these gauges is limited to individuals who have completed an approved training class in the basic principles of radiation safety and the proper use of these gauges. Please note, Troxler provides a training program for gauge users.

**Use:** Any time the gauge is not being used to make a measurement or is not under the physical surveillance of the operator, the source rod should be locked in the safe position. The operator should periodically inspect the source rod release mechanism and the gauge for loose and worn components. If any damaged components are found, the gauge should be returned immediately to the manufacturer for servicing.

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

**Reviewer Notes:**

1. This registration sheet and the information contained within the references shall not be changed without the written consent of the North Carolina Radiation Protection Section, Radioactive Materials Branch.
- 2) The manufacturer reports the following data concerning distribution of these devices:

Model	No. Manufactured	No. Possibly still in field
3401/3401-B	2,247	1,484
3411/3411-B	10,205	7,635
- 3) Troxler Electronic Laboratories no longer manufactures these devices, but will accept the devices for service, repair, and disposal.

**DOCUMENTATION:**

The documentation enclosed with the device upon shipment to the user shall include the following:

1. manual of operation and instruction,
2. special form certificate,
3. type "A" package testing results,
4. a copy of the final leak test results made prior to packaging,
5. bill of lading,
6. an emergency response information sheet,
7. Troxler gauge certificate,
8. Troxler transportation guide.

**SAFETY ANALYSIS SUMMARY:**

The design of the 3401, 3401-B, 3411, 3411-B gauges makes the devices safe to operate by personnel trained in radiological safety. The inherent safety features of the device include: (1) a sealed source, doubly or triply encapsulated, and secured into the device; (2) the use of shielding to attenuate the radiation to lower exposure levels; (3) a positive retraction feature to assure that the extended source rod retracts into the shielded position before the gauge is picked up off the surface being tested. The radiation profile for the device both in and out of the transport case show relatively low radiation levels that are acceptable per federal regulations for exposure. Therefore, based on the information cited above and technical information provided in the application attachments, and with the condition that the licensee (*i.e.*, user) maintain the gauge(s) in accordance with the manufacturer's recommendations and the requirements of this registry sheet, we conclude that the Troxler Models 3401, 3401-B, 3411, 3411-B

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gauges meet and exceed the requirements to be manufactured and distributed as specifically licensed devices pursuant to applicable regulations listed in 15A NCAC 11.

**REFERENCES:**

The following supporting documents are hereby incorporated by reference into this SS&D registry document:

1. All information from NC-646-D-130-S pertaining to the 3401/3411 models, Registry of Radioactive Sealed Sources and Devices registration certificates NC-646-D-119-S and NC-646-D-121-S, and electronic messages dated August 01, 2006 and February 21, 2007 from Stephen A. Browne, Corporate RSO

**ISSUING AGENCY:**

North Carolina Radiation Protection Section, Radioactive Materials Branch.

**Principal Reviewer**

  
\_\_\_\_\_  
J. Marion Eaddy III, Health Physicist

Date: April 03, 2007

**Concurrence Reviewer:**

  
\_\_\_\_\_  
Sharn M. Jeffries, Health Physicist

Date: April 03, 2007



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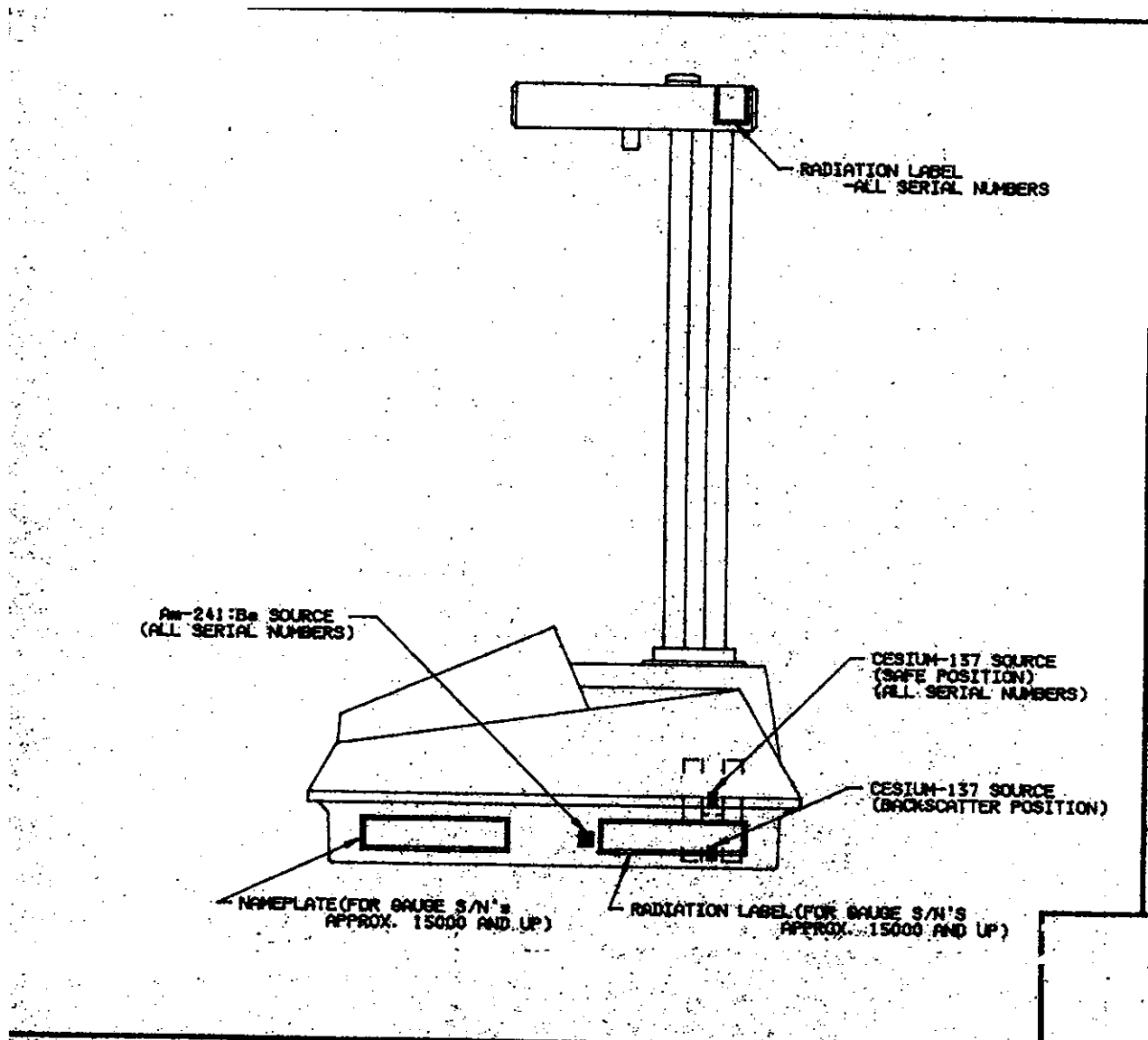
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**ATTACHMENT:** 1 of 3

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**Attachment A: View of the 3400 Series Label and Source Locations**



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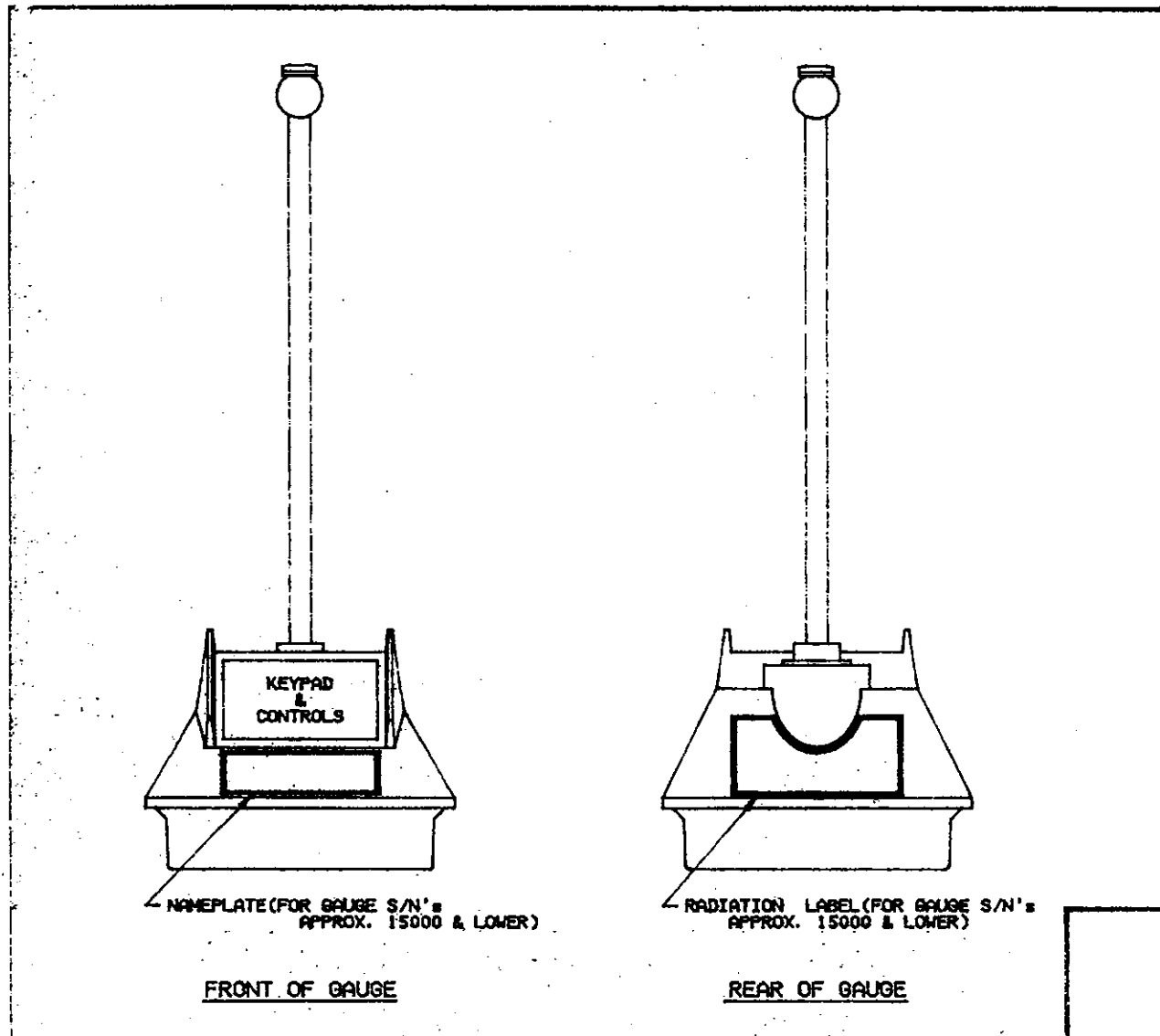
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**Attachment B: 3400 Series Gauge Label Locations**



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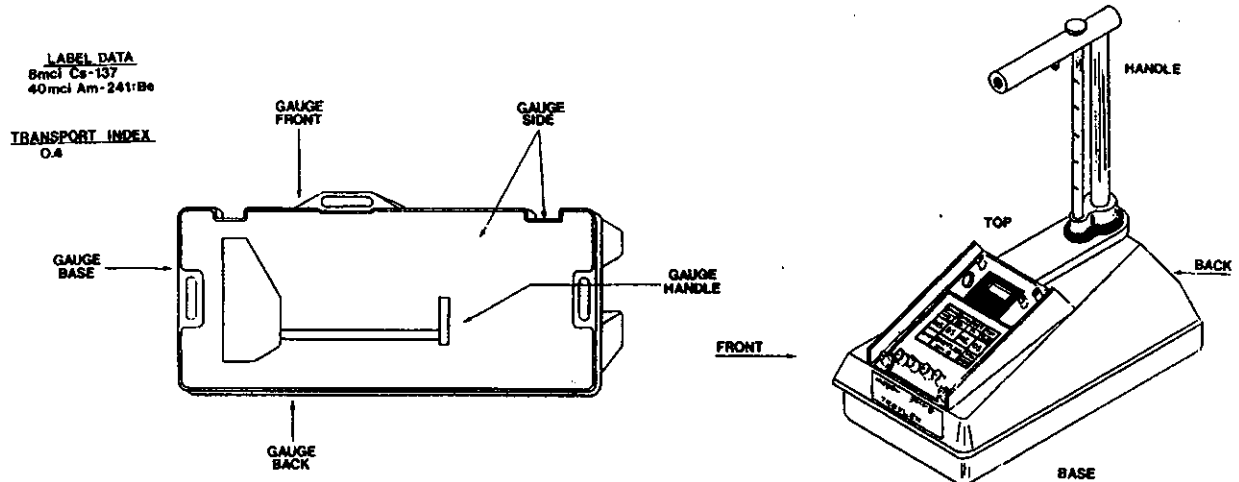
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### Attachment C: 3401/3411 Radiation Profiles for Gauge and Gauge in Transport Case



3400 SERIES RADIATION DOSE RATES (mrem/HR.)

GAUGE	SURFACE			10 cm.			30 cm.			100 cm.		
	GAMMA	NEUTRON	TOTAL	GAMMA	NEUTRON	TOTAL	GAMMA	NEUTRON	TOTAL	GAMMA	NEUTRON	TOTAL
FRONT	4.0	1.0	5.0	0.4	0.5	0.9	0.16	0.1	0.26	0.06	0.01	0.07
BACK	14.0	1.0	15.0	1.5	0.5	2.0	0.18	0.1	0.28	0.02	0.01	0.03
SIDES	13.0	1.0	14.0	2.5	0.5	3.0	0.6	0.1	0.7	0.1	0.01	0.11
TOP	6.0	0.5	6.5	0.52	0.2	0.7	0.2	0.05	0.25	0.06	0.01	0.09
BOTTOM	8.0	3.0	12.0	0.7	1.0	1.7	0.15	0.1	0.25	0.05	0.01	0.06
HANDLE	0.2	0.32	0.52	0.06	0.21	0.3	0.01	0.05	0.06	*	*	*
<b>TRANSPORT CASE</b>												
GAUGE HANDLE	0.2	0.1	0.3	0.1	*	0.1	0.1	*	0.1	*	*	*
GAUGE BASE	4.0	1.0	5.0	1.0	0.7	1.7	0.3	0.4	0.7	0.2	*	0.2
GAUGE FRONT	5.0	0.4	5.4	2.5	0.3	2.8	1.1	0.1	1.2	0.4	*	0.4
GAUGE BACK	2.0	0.2	2.2	1.0	0.1	1.1	0.2	*	0.2	0.1	*	0.1
GAUGE SIDES	6.0	0.4	6.4	2.4	0.3	2.7	0.7	0.1	0.8	0.3	*	0.3

1. GAMMA MEASUREMENTS MADE WITH A VICTORIZED MODEL 3015 SOLVENT METER (CALIBRATED - SEP. 14, 1961).  
 2. NEUTRON MEASUREMENTS MADE WITH NEUTRON RESEARCH COOP. MODEL NP-2 SOLVENT METER, CALIBRATED - FEB. 28, 1962.  
 3. MNSA RATES ARE FOR PURE Cs-137/GAMMA SOURCE AND 40 mCi Am-241 MIXTURE SOURCE.  
 \* - INDICATES A READING LESS THAN 0.1 mrem/hr.