REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF DEVICE
(AMENDS IN ITS ENTIRETY)

NO. : NC-356-D-101-S **DATE:** April 21, 2008 **PAGE:** 1 of 9

DEVICE TYPE: Portable Moisture and Density Gauge

MODEL No.: 5001

MANUFACTURER/DISTRIBUTOR: Humboldt Scientific, Inc.
551-D Pylon Drive
Raleigh, NC 27606
(919) 833-3190

SEALED SOURCE MODEL DESIGNATION:	ISOTOPE:	MAXIMUM ACTIVITY:
Humboldt Drawing No. 2200064-1 which covers:		
AEA Technology/QSA, Inc. Model No. CDC.805 Capsule Type X8	Cs-137	11 millicuries (407 MBq)
Isotope Product Laboratories Model HEG-137 Capsule Type A3015	Cs-137	11 millicuries (407 MBq)
Humboldt Drawing No. 2200067-1 which covers:		
AEA Technology/QSA, Inc. Model No. AMN.V997 Capsule Type X1	Am-241:Be	44 millicuries (1.63 GBq)
Isotope Product Laboratories Model Am1.NO2 Capsule Type NO2	Am-241:Be	44 millicuries (1.63 GBq)

LEAK TEST FREQUENCY: 12 months

PRINCIPAL USE: (G) Portable Moisture Density Gauge

CUSTOM DEVICE: _____ YES __X__ NO

DEVICE TYPE: Portable Moisture and Density Gauge

DESCRIPTION:

The Humboldt Scientific, Inc. Model 5001 Moisture and Density gauge is a portable nuclear gauge designed to measure the bulk density and moisture content of *in-situ* soil, cement concrete and asphalt concrete.

This device contains two separate radionuclides, one for moisture determination and one for density. For the moisture determination, a doubly encapsulated fast neutron source of Americium-241:Beryllium (Am-241:Be) is deployed along with a single Helium-3 (He-3) thermal neutron detector. The fast neutrons from the source penetrate the test material and are subsequently thermalized by interactions with hydrogen atoms in the water of the test material. The thermal neutrons which are scattered towards the He-3 tube are detected and counted over a specified period of time. The counts are converted into a moisture content measurement based on an internally stored algorithm.

Density measurements are accomplished by use of a Cesium-137 (Cs-137) doubly-encapsulated sealed gamma photon source and are based on the principal of Compton scattering. The measurement can be made either in the "backscatter" mode whereby the source tip is essentially flush with the test material or in the "direct transmission" mode where the source rod tip is inserted into the test material. The photons from the source rod are scattered while traversing the test material, resulting in only a fraction of them interacting with and being detected by the two Geiger-Muller (GM) tubes located within the base of the gauge. Photons are counted over a specified period of time and the counts are converted into density measurements based on the internally stored calibration information.

The Humboldt 5001 models contain "suffix" designations (e.g. "5001 EZ"). Humboldt manufactures models designated as "B", "C", "P", "S" and "EZ". These model designations DO NOT differ with regards to sealed source use, shielding design or safety features. These models differ only in the manner of how data is collected, displayed and transferred to other devices (e.g., computers). Therefore, stating "Humboldt Model 5001" is sufficient for licensing purposes.

DETAILS OF CONSTRUCTION:

The sources utilized in this gauge are 40 millicurie (± 10%) Am-241:Be sources and 10 millicurie (± 10%) Cs-137 sources and are described in the table below:

	CDC.805	**HEG-137**	**AMN.V997**	**Am1.NO2**
Isotope	Cs-137	Cs-137	Am-241:Be	Am-241:Be
ANSI/ISO Classification	97C66546	77C66535	97C66545	77C66545
Special Form Certificate	USA/0634/S-96	USA/0356/S	USA/0632/S-96	CZ/1009/S-96

DEVICE TYPE: Portable Moisture and Density Gauge

DETAILS OF CONSTRUCTION (continued):

The Cs-137 source is contained within a 440C stainless steel "source rod" which has been machined out at one end to receive a stainless steel source cup. The source cup has been machined to receive the sealed source and a spring to ensure the source remains stationary within the rod. The source cup is threaded into the source rod and is held in place via a threaded stainless steel plug which has had a high-temperature epoxy is applied to the threads. The plug is tightened to the appropriate torque setting and allowed to cure for 24 hours before additional manipulation. Afterwards, a handle is attached to the source rod and secured using a tamper resistant set screw. Immediate shielding for the Cs-137 source is provided by a 3.4″ high, 2.25″ diameter cylindrical tungsten shield. The 5001 can be equipped with either an 8″ or a 12″ source rod. The overall dimensions of the gauge are as follows:

Length	15.75″
Width	8.66″
Height	18.00″ (with 8″ source rod) or 21.60″ (with 12″ source rod)

The immediate shielding for the Am-241:Be source is provided by a 0.55″ diameter cylindrical lead source cup. The source cup is placed into a cylindrical aluminum source holder, which is attached to the base of the gauge. A lead cap (0.55″ diameter) is placed atop the source cup and threaded plug which has had a high-temperature epoxy applied to the threads is also used to secure this source within the source holder. A "Caution – Radioactive Materials" label is applied over the plug.

The body of the gauge is made mostly of machined 6061-T6 aluminum and has cast lead and cadmium inserts added to provide additional shielding and to enhance the radiation detection performance. The "sliding block" is contained within the gauge base and is fabricated from tungsten. This sliding block provides shielding for the Cesium-137 source while the source is in the "safe" position. The base of the gauge has an access panel that contains a thru-hole for allowing the source rod to move into measurement position. Removal of the plate is necessary to gain access to the sliding block mechanism for lubrication and cleaning.

A securing rod, fabricated from hardened aluminum, is anchored into the gauge body. This rod is indexed with notches at fixed intervals. This feature allows the source rod to be held at various depths while measurements are being made. The source rod and handle assembly are then inserted into the gauge body and the handle is placed over the securing rod. After final securing rod adjustments, a tamper-resistant cap is then applied to the securing rod to prevent the source rod from being removed from the gauge. The gauge body is covered by a molded plastic shell which is secured with screws.

The gauge has two "on-off" indicators; one mechanical and the other electrical. The mechanical indicator is visual verification that the handle is at the top of the securing rod and that the handle does not move when downward pressure is applied to the top of the handle. The electrical indicator is a resistive strip inserted inside the indexed securing rod. This strip is monitored by an electrical pickup in the gauge that correlates measured resistance with source rod position. The relative position is then shown on the LCD display.

DEVICE TYPE: Portable Moisture and Density Gauge

DETAILS OF CONSTRUCTION (continued):

The spring-loaded trigger assembly is integrated into the entire length of the handle, facing towards the gauge. The trigger must be depressed for the handle to disengage the notches in the securing rod and be moved. The overall design of the trigger also ensures that as the gauge is lifted, the trigger is engaged and the source rod is retracted into the safe position before the gauge can be lifted from the surface and moved.

LABELING:

The Model 5001 is labeled in accordance with 15A NCAC 11 .0328 and .1626. Labels are located in the following areas of the device:

(1) pressure-sensitive adhesive label is placed over the top of the handle. This label contains the following information:
   (a) Type and quantity of radioactive material and trefoil;
   (b) Manufacturer's name; and
   (c) Label warnings "CAUTION-RADIOACTIVE MATERIAL" and "DO NOT REMOVE THIS LABEL"

(2) pressure-sensitive adhesive label is placed over the cylindrical aluminum source holder inside the gauge;
   (a) Type and quantity of radioactive material and trefoil;
   (b) Manufacturer's name; and,
   (c) Label warnings "CAUTION-RADIOACTIVE MATERIAL" and "DO NOT REMOVE THIS LABEL"

(3) an aluminum label attached via screws to the rear of the gauge base containing the following information:
   (a) Type and quantity of radioactive material and trefoil;
   (b) Serial number of the gauge;
   (c) Serial numbers and measurement dates for both sources;
   (d) Manufacturer's name and location; and,
   (c) label warnings "NOTIFY CIVIL AUTHORITIES IF FOUND" and "DO NOT REMOVE THIS LABEL"

The Model 5001 in the transport case qualifies as a "Yellow II" type A package with a 0.2 transport index (TI): The transport case is thus labeled on two (2) opposing sides as such: along with the US DOT 7A Type "A" label and the manufacturer's label showing the name and address of the manufacturer, the device model and serial number.

DEVICE TYPE: Portable Moisture and Density Gauge

DIAGRAMS:

See Attachment 1.

CONDITIONS OF NORMAL USE:

The Model 5001 is 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 in excess 15 years under normal use conditions and with proper maintenance. However, the gauge should be returned to Humboldt every five years for a thorough manufacturer's inspection.

The device is designed for the following environments:

Operating temperature	-10°C to 70°C ambient
Pressure	Atmospheric to 15000 meters
Vibration	Tested @ a displacement of 2.5 mm @ 12.5 Hz)
Humidity	98% without condensation
Fire	+600°C (to melt the aluminum base)

DEVICE TYPE: Portable Moisture and Density Gauge

PROTOTYPE TESTING:

The Model 5001 underwent prototype testing for mechanical, structural, and radiological integrity using measurement methodologies and testing procedures found in ANSI Standard N538-1979. The device was tested by the manufacturer for the effects of accidental dropping from a height of one meter onto concrete and penetration by a 5.9 kilogram steel cylinder with a 32 mm rounded point dropped from a height of one meter. Leak testing of the radioactive sources and an exposure rate measurement from the device after the "drop" testing were conducted. An engineering evaluation of the likelihood of source retention in the source housing following a severe accident involving fire was also conducted.

The results of the testing showed: (1) no safety feature failure or stray radiation increase as a result of the two "drop" tests; (2) no loss of radioactive material from the sealed source; and (3) no loss of the shielding integrity of the device at temperatures below 250°C. Although a 250°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 epoxy used to "cold weld" the source cup into the source rod. At this temperature, there would be no loss of shielding around the Cs-137 capsule. The capsule would remain within the source rod, being held there by the threads. At temperatures over 327°C, the lead surrounding the Americium-241:Beryllium source capsule would melt. Though this would result in a loss of shielding to some degree, it is below the temperature rating for the source capsule. Therefore, no radioactive contamination would result at this temperature. The results of the prototype testing and engineering analysis support the assignment of an ANSI standard rating of ANSI-54-164-154-R1.

The three transportation container configurations have all been tested in accordance with the U.S. Department of Transportation Regulations and meet or exceed the requirements for a "Type A" package as designated in Subpart I, 49 CFR Part 173. The three containers were subjected to water spray, free drop, penetration and compression testing as required by DOT Regulations. The cases met the criteria established for these tests and can serve as Type A containers for transporting the Model 5001.

EXTERNAL RADIATION LEVELS:

See Attachment 2.

QUALITY ASSURANCE AND CONTROL:

Humboldt Scientific, Inc. maintains a quality assurance/quality control program which has been deemed acceptable for licensing purposes. The QA/QC manual has been incorporated into the license that authorized manufacturing and distribution of this gauging device.

DEVICE TYPE: Portable Moisture and Density Gauge

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 12 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 Humboldt Scientific, Inc. for repair/disposal. Please note, Humboldt Scientific, Inc. maintains a customer leak test service.

Servicing: The Model 5001 device requires periodic maintenance of two specific gauge components by the gauge user. The scraper ring/sliding shield 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 Humboldt Scientific, Inc. 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.

DEVICE TYPE: Portable Moisture and Density Gauge

Reviewer Note: 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.

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 Humboldt Scientific gauge certificate,

SAFETY ANALYSIS SUMMARY:

The design of the Model 5001 gauge makes the devices safe to operate by personnel trained in radiological safety. The inherent safety features of the device include: (1) sealed sources, doubly 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. Furthermore, a Nuclear Materials Events Database search for events involving leaking source, release of materials/contamination or transportation related events was conducted for 1988 through 2007. Three events were reported to NMED during that time period for a Humboldt device and none noted a leaking source. 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 Humboldt Scientific, Inc. Model 5001 gauge meets and exceeds the requirements to be manufactured and distributed as specifically licensed devices pursuant to applicable regulations listed in 15A NCAC 11.

DEVICE TYPE: Portable Moisture and Density Gauge

REFERENCES:

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

1. Humboldt Scientific, Inc. letters with attachments dated June 27, 2005, July 14, 2006 (received August 31, 2006 all signed by Mahir Al-Nadaf, Vice President, R.S.O.; results of NMED search criteria conducted December 05, 2007; letter with attachments dated March 20, 2008, signed by Mahir Al-Nadaf, Vice President, RSO and electronic message with attachment dated April 18, 2008 from Mahir Al-Nadaf, Vice President, RSO.

ISSUING AGENCY:

North Carolina Radiation Protection Section, Radioactive Materials Branch

Principal Reviewer

J. Marion Eaddy III, Health Physicist Date: April 21, 2008

Concurrence Reviewer:

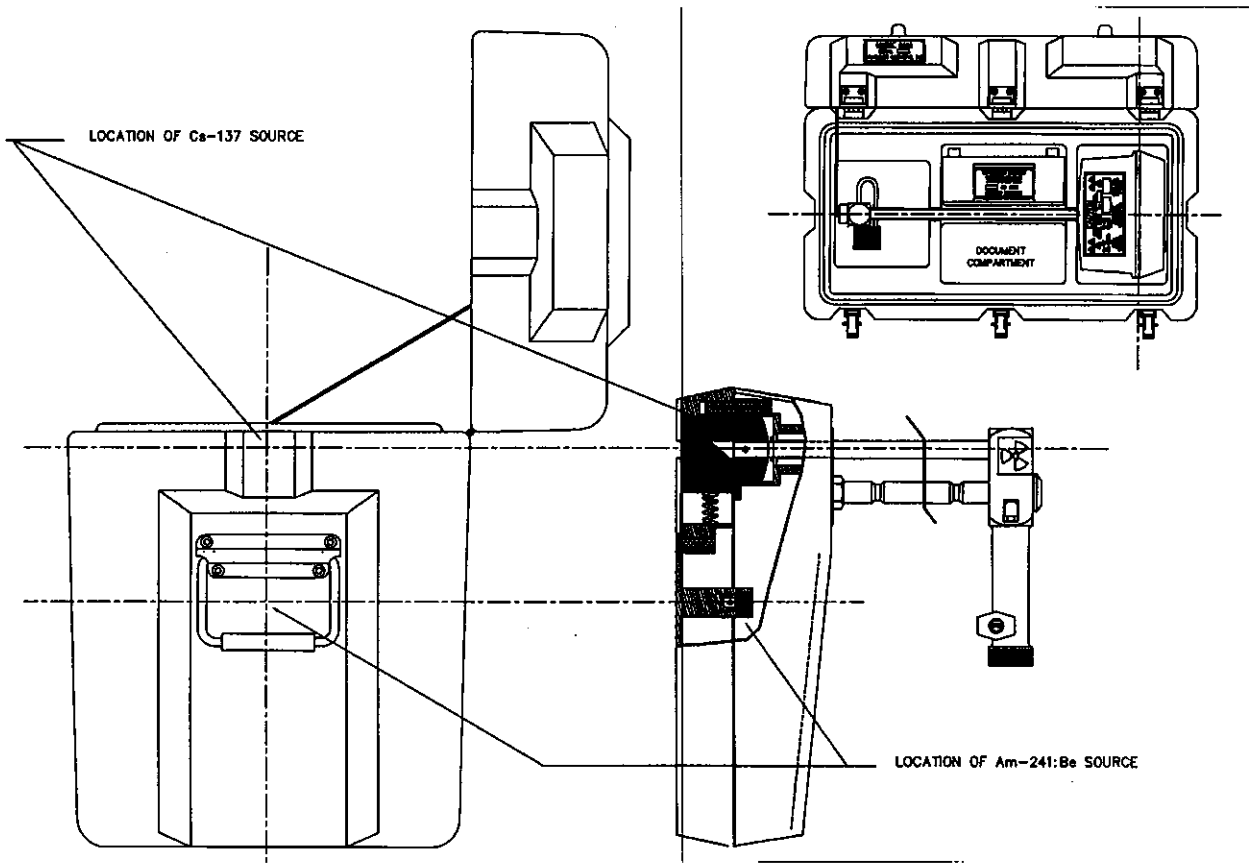
Gerald A. Speight, Health Physicist Date: April 21, 2008

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF DEVICE
AMENDS IN ITS ENTIRETY

NO.: NC-356-D-101-S **DATE:** April 21, 2008 **ATTACHMENT:** 1 of 2

DEVICE TYPE: Portable Moisture and Density Gauge

Attachment 1: Model 5001 Source Locations



REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF DEVICE
AMENDS IN ITS ENTIRETY

NO. : NC-356-D-101-S **DATE:** April 21, 2008 **ATTACHMENT:** 2 of 2

DEVICE TYPE: Portable Moisture and Density Gauge

Attachment 2: Radiation Profiles for Model 5001 Gauge and Gauge in Transport Case

Radiation Profile for Model 5001 Gauge

Location	Surface			5 cm			30 cm			1 meter		
	γ	η	γ+η	γ	η	γ+η	γ	η	γ+η	γ	η	γ+η
Front	2.7	1	3.7	2.1	1	3.1	0.6	0.8	0.8	0.2	0.1	0.3
Back	6.7	0.8	7.5	5.1	0.8	5.9	0.9	0.4	1.3	0.2	0.1	0.3
Left	7.6	2.5	10.1	6.5	2.5	9	1.3	0.4	1.7	0.2	0.2	0.4
Right	7.3	3.0	10.3	5	2	7	1	1	2	0.2	0.1	0.3
Top	7	3	10	5.1	2	7.1	1.1	0.8	1.9	0.1	0.2	0.3
Bottom	4.2	5.0	9.2	2.9	4.5	9.4	0.6	0.8	1.4	0.2	0.2	0.4

Radiation Profile for Model 5100 Gauge in Transport Case

Location	Surface			5 cm			30 cm			1 meter		
	γ	η	γ+η	γ	η	γ+η	γ	η	γ+η	γ	η	γ+η
Front	1.3	1	2.3	1.2	0.8	2	0.8	0.8	1.6	0.2	0.2	0.4
Back	0.6	1.0	1.6	0.7	1	1.7	0.6	0.8	1.4	0.2	0.1	0.3
Left	0.4	0.8	1.2	0.4	0.8	1.2	0.2	0.8	1	0.1	*	0.1
Right	1.2	2	3.2	0.9	1.8	2.7	0.5	1.3	1.8	0.1	0.2	0.3
Top	1.4	0.4	1.8	1.3	0.4	1.7	0.8	0.8	1.6	0.2	*	0.2
Bottom	1.1	1	2.1	1	1	2	0.6	0.8	1.4	0.2	0.1	0.3

Notes:

1. All measurements are in mrem/hr
2. Radiation measurements were for a gauge containing a nominal 10 millicurie Cesium-137 gamma source and a nominal 40 millicurie Americium 241:Beryllium neutron source.
3. Gamma (γ) measurements were obtained with a Ludlum Model 2241-2 with Model 44-2 gamma scintillator, calibrated 04/27/2005.
4. Neutron (η) measurements were obtained with a Ludlum Model `12-4 Neutron Meter with Model 42-31 detector, calibrated 05/23/2005.

* Denotes readings of < 0.1 mrem/hr