LUDLUM MODEL 42-49 & 42-49B
NEUTRON DETECTOR

January 2019

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Section 1

Introduction

The Ludlum Model 42-49 and 42-49B Neutron Detectors are designed for detection of thermal and fast neutrons (0.025 eV to approximately 12 MeV). The neutrons are detected, not directly, but through nuclear reactions, which result in energetically charged particles such as alpha particles. In many instances, intense fields of gamma rays are also found with neutrons. Therefore, it is important to choose a method of neutron detection with the ability to discriminate against these gamma rays in the detection process.

A common reaction for the conversion of slow neutrons into directly detectable particles is $n+{}^{3}He \rightarrow {}^{3}H+{}^{1}H + 0.764$ MeV.

The Ludlum Model 42-49 and 42-49B utilize this reaction in the form of helium-3(^{3}He), which fills the gas proportional tube of the detector

The Model 42-49 and 42-49B are designed to be used with portable counting instruments and has a top bracket that allows for convenient mounting of a portable instrument. (See picture below.) The Model 42-49 consists of a ^{3}He detector (1.6 cm diameter x 2.5 cm thick), surrounded by a high density polyethylene sphere, 19.6 cm (7.7 inches) in diameter. This outer sphere moderates the incoming neutrons and helps provide a near-rem response.

Model 42-49 Detector shown as part of a Model 30-7

Note:

The detector does not contain any consumable materials.

Note:

If the detector is used in a manner not intended by the manufacturer, the detector may not function properly.

The Model 42-49 was first introduced in 2017, and is similar to the 42-49B, sharing the same 7-inch diameter ball. The Model 42-49 has better sensitivity than the 42-49B, similar to the 9-inch remballs, and many customers are happy with the energy response. But some customers noted differences in readings between the Model 42-49 and the older Model 12-4 with its 9-inch ball. It was discovered that the boron content of the inner shell of the 42-49 was not high enough, causing too much of an over-response in the 5 keV region. It was also noted that angular dependence, especially at 180 degrees, was excessive, due to a lack of moderation within the detector entry shaft.

The 42-49B corrects these two issues by increasing the boron content of the inner shell, and by adding a boron moderator and polyethylene spacer in the detector entry shaft. These corrections to the energy response do have a drawback – overall neutron sensitivity is approximately half that of the original 42-49. It is fairly simple (takes less than an hour) to replace these two parts and convert the earlier 42-49 to a 42-49B. The part number of the Ludlum conversion kit with these two parts is 4014-620-01. A recalibration is required after this conversion is made.

Shown above are the two different boron moderators attached to the detector, which fit into a rem ball. The one on the left is a 42-49, and the one on the right is a 42-49B.

Section

2

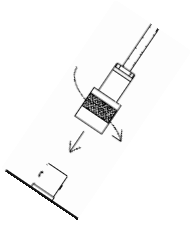
Unpacking and Repacking

Remove the calibration certificate or detector functional check certificate and place it in a secure location. Remove the detector(s) and accessories (if applicable) and ensure that all items listed on the packing list are in the carton. If multiple detectors are included, refer to the calibration certificates for serial number (SN) matches.

To return an instrument or detector for repair or calibration, provide sufficient packing material to prevent damage during shipment.

Every returned instrument must be accompanied by an Instrument Return Form, which can be downloaded from the Ludlum website at www.ludlums.com. Find the form by clicking on the "Support" tab and selecting "Repair and Calibration" from the drop-down menu. Then choose the appropriate Repair and Calibration division where you will find a link to the form.

Connecting to an Instrument



Connect one end of the cable provided to the detector by firmly pushing the connector together while twisting clockwise a quarter of a turn until latched. Repeat the process in the same manner with the other end of the cable and the instrument.

Section 3

Specifications

Detector: 2 atm ^{3}He tube LND 25185 or equivalent

Moderator: 19.6 cm (7.7 in.) diameter high density polyethylene sphere

Compatible Instruments: typically used with portable counting instruments (capable of achieving -2 mV input sensitivity)

Sensitivity:
Model 42-49: 100 cpm/mrem/hr (^{241}AmBe fast neutrons)
Model 42-49B: 45 cpm/mrem/hr (^{241}AmBe fast neutrons)

Gamma Rejection: 10 cpm or less through 10 R/hr (100 mSv/hr) (^{137}Cs)

Detection Range: thermal to approximately 12 MeV

Energy Response: thermal to 12 MeV, follows the radiation protection guide curve for neutron dose

Input Sensitivity: -2 mV

Operating Voltage: approximately 1200 V

Connector: series "C" (others available)

Temperature Range: -20 to 50 °C (-4 to 122 °F)

Size: 25.5 x 19.6 x 19.6 cm (10 x 7.7 x 7.7 in.) (H x W x D), including brackets

Weight: 4.6 kg (10.2 lb)

Section 4

Safety Considerations

Environmental Conditions for Normal Use

Indoor or outdoor use (in a dry environment)

No maximum altitude

Temperature range of -20 to 50 °C (-4 to 122 °F); may be certified for operation at -40 to 65.6 °C (-40 to 150 °F)

Maximum relative humidity of less than 95% (non-condensing)

Pollution Degree 2 (as defined by IEC 664) (Normally only nonconductive pollution occurs. Temporary conductivity caused by condensation is to be expected.)

Cleaning Instructions and Precautions

The detector may be cleaned externally with a damp cloth, using only water as the wetting agent. Do not immerse the instrument in any liquid. Observe the following precautions when cleaning:

1. Turn the instrument electronics OFF.
2. Allow the instrument to sit for one minute.
3. Disconnect the detector cable before cleaning the detector.

Section 5

Calibration

Calibration

To calibrate the detector, the following items are needed:

- Counting instrument: Ludlum Model 2200 Scaler/Ratemeter
- ^{241}AmBe neutron source or equivalent
- ^{137}Cs gamma source for gamma rejection check

Operating Voltage Plateau

- Connect the Model 42-49 to a Model 2200.
- Set Model 2200 input sensitivity to -2 mV.
- Expose the detector to a 20 mrem/hr ^{241}AmBe neutron source.
- "Run a plateau" as follows: Taking one-minute counts, record the count rate for 25-volt incremental steps from 1000 volts through a region in which the count rate steadily increases, becomes relatively constant ("flattens out"), and then increases again. (A typical range will be 1000-1250 volts.) The flattest portion of this region is the desired plateau. The value in the middle of this region is the assumed operating voltage of the detector, subject to the sensitivity and the gamma rejection checks.
- Calculate the sensitivity (cpm/mrem/hr) for the assumed operating voltage as follows:

$$Sensitivity = \frac{CountRate}{Dose - EquivalentRate}$$

For example, an assumed operating voltage is 1100 volts, based upon the flattest part of the plateau. The count rate at that voltage is 2380 counts per minute (cpm), and the neutron field dose-equivalent rate is 20 rem/hr. The sensitivity is calculated as:

$$Sensitivity = \frac{2380\ cpm}{20\ mrem/hr}$$

$$= 119\ cpm/mrem/hr$$

This value should be approximately 120 cpm/mrem/hr.

Gamma Rejection Check

- With the Model 42-49 connected to the Model 2200, adjust the Model 2200 HV to the assumed operating voltage determined above.
- Remove the Model 42-49 detector from the moderator and place in a 10 R/hr ^{137}Cs gamma radiation field.
- Take a one-minute count. If more than 10 counts are observed for the one-minute period, decrease the operating voltage until the count rate drops below 10 cpm; however, ensure that the HV remains in the plateau region determined above.
- Ensure that sensitivity for the selected operating voltage is approximately 120 cpm/mrem/hr.
- Return the Model 42-49 to the moderator.

Conversion Chart

- Expose the detector to an ^{241}AmBe neutron source at a dose-equivalent rate of 400 mrem/hr. Take a one-minute count and record the value, including the range/scale setting of counting instrument.

- Repeat for the dose-equivalent rates shown in Table 1.

The values in Table 1 and their corresponding measured values represent a conversion chart for use in relating other measured values to actual dose-equivalent rates.

Ref. Point (mrem/hr)	Reading (cpm)	Range/ Scale
400		
200		
80		
20		
8		
2		

Table 1

Section

6

Parts List

Model 42-49 Neutron Detector

Reference	Description	Part Number
UNIT	Completely Assembled Model 42-49 Neutron Detector	47-4057
2 EA.	SCREW-6-32 X 3/8 BRASS KNURL	17-8659
*	Model 42-49 SPHERE ASSY	47-4058
4 EA.	SCREW-#8 X ¾ FH SHT MTL	17-9085
*	MODEL 43-4, 324 HANDLE	7005-060
*	7.7 inch SPHERE	7014-858
2 EA.	INSERT E-Z LOK 6-32	20-9066
8 EA.	8 INCH HDPE ROD	29-9985
*	MODEL 42-49 DET + MODERATOR	47-4059
1 EA.	O RING-2-116	16-8293
1 EA.	O RING-2-148	16-8340
2 EA.	SCREW-8-32 X 5/8 SOC SET	17-8765
*	MODEL 42-49 PROBE ASSY	4014-587
*	^{3}He TUBE 25185 2 ATM	01-5793
*	CONNECTOR, UG706/U	4478-011
*	TUBE BODY ASSY	2014-595
*	MODEL 42-30, 42-31 DETECTOR SPACER	7005-056
*	CONNECTOR END	7014-598
*	CBL-MODEL 42-49 RG178 3INCH	8014-599
*	MODEL 42-49 MODERATOR	7014-591
*	MODEL 42-49 DETECTOR STRAP	7014-592

	Reference	Description	Part Number
Model 42-49B Conversion Kit		Model 42-49 Conversion Kit	4014-620-01
	1 EA.	Borated Silicone Shell 5/32 HL	7014-609
	1 EA.	Borated Silicone Shell, 3/4 HL	7014-610
	1 EA.	Borated Silicone Detector Disc	7014-621
	1 EA.	Detector HDPE Spacer Short	7014-622