
**LUDLUM MODEL 42-31H
NEUTRON DETECTOR**

October 2011

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LUDLUM MEASUREMENTS, INC
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STATEMENT OF WARRANTY

Ludlum Measurements, Inc. warrants the products covered in this manual to be free of defects due to workmanship, material, and design for a period of twelve months from the date of delivery. The calibration of a product is warranted to be within its specified accuracy limits at the time of shipment. In the event of instrument failure, notify Ludlum Measurements to determine if repair, recalibration, or replacement is required.

This warranty excludes the replacement of photomultiplier tubes, G-M and proportional tubes, and scintillation crystals which are broken due to excessive physical abuse or used for purposes other than intended.

There are no warranties, express or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description of the face there of. If the product does not perform as warranted herein, purchaser's sole remedy shall be repair or replacement, at the option of Ludlum Measurements. In no event will Ludlum Measurements be liable for damages, lost revenue, lost wages, or any other incidental or consequential damages, arising from the purchase, use, or inability to use product.

RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair or calibration, please send to the address below. All shipments should include documentation containing return shipping address, customer name, telephone number, description of service requested, and all other necessary information. Your cooperation will expedite the return of your equipment.

**LUDLUM MEASUREMENTS, INC.
ATTN: REPAIR DEPARTMENT
501 OAK STREET
SWEETWATER, TX 79556**

**800-622-0828 325-235-5494
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Section

1

Introduction

The Ludlum Model 42-31H Neutron Detector is 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 $n + {}^3\text{He} \rightarrow {}^3\text{H} + {}^1\text{H} + 0.764 \text{ MeV}$.

The Ludlum Model 42-31H utilizes this reaction in the form of helium-3 (${}^3\text{He}$), which fills the gas proportional tube of the detector

The Model 42-31H is 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 42-31H consists of a ${}^3\text{He}$ detector (1.6 cm diameter x 2.5 cm thick), surrounded by a cadmium-loaded polyethylene sphere, 22.9 cm (9 inches) in diameter. A study is available that shows that the 9-inch cadmium-loaded sphere has a response similar to that of a 10-inch diameter rem-responding sphere.



Model 42-31H Detector shown with Model 12-4

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.

Section

2

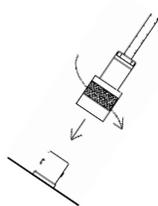
Unpacking and Repacking

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 and affix appropriate warning labels to promote careful handling. The following items and information should also be included to insure quick turnaround time of your equipment.

- instrument(s) and related cable(s)
- brief description as to the reason for return
- description of service requested
- return shipping address
- customer name and telephone number

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.

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3

Specifications

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

Moderator: 22.9 cm (9 in.) diameter cadmium-loaded polyethylene sphere

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

Sensitivity: 100 cpm/mrem/hr ($^{241}\text{AmBe}$ 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: 26 x 22.9 x 22.9 cm (10.3 x 9 x 9 in.) (H x W x D), including brackets

Weight: 6.6 kg (14.5 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
- ²⁴¹AmBe neutron source (Note that the Model 42-31H is energy-dependent.)
- ¹³⁷Cs gamma source for gamma rejection check

Operating Voltage Plateau

- Connect the Model 42-31H to a Model 2200.
- Set Model 2200 input sensitivity to -2 mV.
- Expose the detector to a 20 mrem/hr ²⁴¹AmBe 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:

$$\text{Sensitivity} = \frac{\text{Count Rate}}{\text{Dose - Equivalent Rate}}$$

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 mrem/hr. The sensitivity is calculated as:

$$\begin{aligned} \text{Sensitivity} &= \frac{2380 \text{ cpm}}{20 \text{ mrem/hr}} \\ &= 119 \text{ cpm/mrem/hr} \end{aligned}$$

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

Gamma Rejection Check

- With the Model 42-31H connected to the Model 2200, adjust the Model 2200 HV to the assumed operating voltage determined above.
- Remove the Model 42-31H detector from the moderator and place in a 10 R/hr ¹³⁷Cs 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 42-31H to the moderator.

Conversion Chart

- Expose the detector to an $^{241}\text{AmBe}$ 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

| | <u>Reference</u> | <u>Description</u> | <u>Part Number</u> |
|----------------------------------|------------------|--|--------------------|
| Model 42-31H Neutron Detector | UNIT | Completely Assembled Model 42-31H Neutron Detector | 47-3583 |
| | * | Model 42-31H SPHERE ASSY | 47-1345 |
| | * | FOOT BRACKET | 7005-084 |
| | * | 9-inch BALL | 7002-097 |
| | * | MOUNTING RING | 7005-101 |
| | * | RIGHT-HANDED INST MOUNTING BRACKET | 7363-246 |
| | * | LEFT-HANDED INST MOUNTING BRACKET | 7363-247 |
| | * | MODEL 42-31H PROBE ASSY | 4005-140 |
| | * | ³ He TUBE 25185 2 ATM | 01-5793 |
| | * | CONNECTOR, UG706/U | 4478-011 |
| | * | TUBE BODY ASSY | 2005-092 |
| | * | MODEL 42-30, 42-31 DETECTOR SPACER | 7005-056 |
| | * | CONNECTOR END | 7005-095 |
| | * | CBL-Model 42-30 6-inch R6178 | 8303-856 |