

Direct Scientific

OPERATION
AND
MAINTENANCE
MANUAL

PUG-7N-D

Neutron Monitor

**OPERATION AND MAINTENANCE MANUAL
PUG-7N-D****TABLE OF CONTENTS**

		Page
1	Introduction	3
2	Range and Sensitivity	3
3	PUG-7N-D Counter	3
4	HV	4
5	Batteries	4
6	Controls and Indicators	4
6a	Front Panel	4
6b	Internal	4
7	Principles of Operation	5
8	PNS-20 Probe	5
9	Moderator	6
10	Panel Meter	6
10a	Integrate Mode and Rate Mode	6
10b	Update Times	7
11	Testing	8
12	Programming	8

INTRODUCTION

The PUG-7N-D is a neutron monitoring system, and will measure both fast and slow neutrons. It consists of a PNS-20 detector (probe), an MO-1 moderator, and a PUG-7N-D counter. The probe detects slow (thermal) neutrons when fully exposed, and fast neutrons when it is placed inside the moderator. The moderator absorbs slow neutrons, and slows (thermalizes) fast neutrons to a detectable level. The probe is not sensitive to gamma radiation to well above background levels.

Size: Overall, 10.25" L x 10" H x 6" W
Weight: 8 ¾ lbs.
Shipping Weight: 15 lbs

RANGE AND SENSITIVITY

The stated range of the PUG-7N-D is 0 – 10,000 cps. The instrument uses a digital panel meter with a maximum rating of 20,000 cps and a display range of 6 digits. The meter also has a total mode with an 8 digit display.

Please refer to the Test Data sheet which accompanies your instrument for the calibration results. To a first approximation, each cps corresponds to:

0.17 Bq (2π) from a source in contact with the probe face
OR

1 n/cm.²/sec neutron flux.

PUG-7N-D COUNTER

The PUG-7D Counter is an aluminum box, 4" x 3 ½" x 6 ½", painted in green powder coat. The top of the box is black anodized aluminum, and is the control panel, also referred to as the front panel. The panel is attached to the box by latches at each end, and may be completely removed. All the internal electronics and the batteries hang from the inside of the panel.

Under the panel are two electronic circuit boards and the battery holder. The upper circuit board, closest to the panel, contains the high voltage generator and its two controls. See the Controls section.

The lower circuit board contains the preamplifier for the probe signals and the pulse shaper to supply the meter input. The ten turn potentiometer sets the threshold for the overrange indication in the pulse count LED.

The Counter is attached on the top of the moderator by 4 screws through the bottom of the box. Remove the panel and set it aside to access the screws and remove the Counter for separate use.



Warning! Be sure the panel and its electronics are set down on an insulating surface whenever the top is removed. It will rest on the batteries.

HV

To adjust the high voltage bias, remove the front panel, set it down on a flat surface. There is an adjustment potentiometer on the left side of the upper board, just under the front panel. You will need a small jewelers screwdriver or tweaker. The pot is not multi-turn, and the adjustment is sensitive. You will need to observe the voltage while adjusting it. You will need a very high impedance HV voltmeter. Measure at the center pin of the BNC connector. It may help to make a BNC connector with a pigtailed center wire to use with a clip lead.

BATTERIES

The PUG-7N-D is powered by two 9 volt batteries mounted underneath the bottom circuit board. When the top is lifted out and set aside, it will rest on the batteries. It may be operated in that position if nothing else is touching the circuit boards. When the battery level drops, remove and replace both batteries.

The BAT position on the front panel rotary switch is a battery test. The green LED below that switch will light if the battery voltage is good.

CONTROLS AND CONNECTORS

Front Panel

All the controls and indicators for regular use are on the front panel. The BNC connector for the probe cable is also on the front panel.

Panel Meter	Red Lion CUB5 (See separate section below)
Power	3 position rotary OFF, BAT (Battery test), ON
Battery OK	LED
Counts	LED. Green flash for each pulse at low rates
Volume	Potentiometer
Connector	BNC, for Co-axial cable from probe

The Count Pulse LED will turn red when the pulse rate exceeds a threshold, which is set by the blue multi-turn potentiometer on the lower circuit board.



WARNING. The center pin of the BNC connector carries 500 – 1200 volts DC.

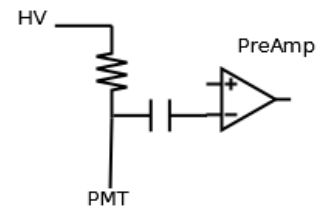
Internal

There are 2 electronic PC boards fastened to the underside of the front panel. On the main board, closest to the panel, there are 2 adjustment potentiometers. The narrow blue 10 turn pot on the right side controls the discriminator level, and the pot on the left side controls the high voltage bias for the probe. These pots should not require adjustment unless the probe is replaced, or a new type of probe is substituted. The discriminator level rejects low level signals from the probe, which are predominantly noise.

The lower circuit board has a ten turn potentiometer which adjusts the pulse rate at which the Counts LED on the front panel changes from green to red.

PRINCIPLES OF OPERATION

The probe consists of powdered boron and zinc sulfide at the face of a photomultiplier tube. A B-10 nucleus absorbs a neutron, and decays to Li-7, emitting an alpha particle. The ZnS material emits a flash of light when the alpha particle strikes it. See the section on the PNS-20 probe for further details.



The photomultiplier tube converts the flash of light into a small negative voltage pulse on its bias voltage input. The pulse is inverted and amplified, then converted to a TTL pulse. The digital panel meter counts the pulses and displays the average arrival rate.

PNS-20 PROBE

The probe consists of:

- A 2" diameter light-tight aluminum housing.
- BNC connector.
- 1.5" diam. plexiglass light pipe, coated with Boric acid and a phosphor.
- 1.5" Photomultiplier tube and socket.
- Voltage divider resistor string.
- Shielded connecting single conductor cable terminating in BNC connectors.



The PNS-20 Slow Neutron Scintillator probe detects thermal neutrons using the boron n-alpha reaction. It delivers approximately 60 cpm (1 cps) per neutron/cm²/second and requires a 900 volt supply. The probe is 8" long x 2" in diameter. It is completely insensitive to gammas in fields below 10R/hr.

TA also makes a scintillation probe for fast neutrons, model PNS-19.

The PNS-20 Probe is fitted with a BNC connector which mates with Model LAM-10L and PUG Portable Counters, and FM-5 series laboratory counting instruments.. It will also mate with any other counting instrument furnishing +500 to +1200 V, well regulated DC and accepting through the same single wire connector negative pulses in the 100 mV to 2.5 V range with an input impedance of 1 megohm or higher.

The scintillator incorporated into the PNS-20 probe uses the Boron n-alpha reaction to detect thermal neutrons. It consists of a 1.5" diameter plexiglass plate grooved on its rear facing surface. The grooves are coated with a mixture of Boric Acid with ZnS(Ag) as a phosphor. The plate is sealed with a transparent window. The window is optically coupled to a 1.5" PMT with a silicone gel closely matching the refractive index of the PMT window. The probe is light tight and should never be opened when connected to a high voltage supply (plugged in, instrument turned on) as permanent damage may result.

If for any reason the probe is to be disassembled be sure to unplug it from the associated instrument.

The probe housing is a light tight anodized aluminum shell closed at each end by polished nickel plated caps. These materials are selected for easy decontamination using wipes either dry or moistened with any mild detergent. There is a cylinder on the side of the probe, fitting a notch in the moderator, so that it may be latched into position within the moderator.

Background count in the absence of a neutron field will normally be a few counts per hour.



Warning: shock hazard exists whenever the probe is opened while the instrument is turned on.



Warning: Exposure of the photomultiplier tube to ambient light while high voltage is applied will result in permanent damage to the tube.

MODERATOR

The MO-1 moderator consists of a 6" long, 6" diameter cylindrical shell of 1/4" aluminum, with gold chem film coating.

The shell is filled with solid polyethylene, which acts to slow down fast neutrons to the thermal range, where they can be detected by the probe.

The end of the moderator, where the probe is inserted, has a pivoted latch and a thumb screw, so that the probe may be locked into position, and not fall accidentally when the instrument is moved.

PANEL METER

The front panel meter is a CUB5, made by Red Lion. This is an 8 digit LCD digital readout with 7 segment 0.4" figures. The meter has many programmable parameters.

There are two buttons on the bezel, SEL on the left and RST on the right, which are used to control and program the meter. We have fully programmed the meter's internal parameters. The settings as shipped are listed in the Programming section. In case it is necessary to reprogram the meter, basic instructions have been extracted from the CUB5 manual and included in this manual, see the Programming section. For further details, please see the CUB5 Manual.

Integrate Mode and Rate Mode

- The front panel display has both Rate (Dose Rate) and Integrate (Accumulated Dose) data buffers in operation all the time. You can look at either (without disturbing the other) by pressing the left Select button (SEL) on the meter.
- When the instrument is turned off and back on, the meter resumes in the same mode.
- To reset the Integrate buffer, push right hand button (RST). The user can disable this button if required. (See the programming section of the manual.) This is useful if

you wish to prevent inadvertent or unauthorized reset during a long integration measurement. The reset function works when the display is in either mode.

- The integrate mode displays a scale multiple of the number of pulses received by the meter. The scale factor used in the PUG-7N-D is 1.0.
- The integrate mode displays up to 8 digits.
- The integrate function is free running, so please use a stop watch or wrist watch to determine how long the PUG-7N-D has been integrating.
- The integrate function retains its value when the instrument is turned off and back on. Accumulation resumes shortly before the meter displays the value after restart.
- In Rate mode the display shows an 'R' on the left and displays 6 digits of count rate.
- The Rate display is a scale multiple of the pulse rate in cps. The scale factor used in the PUG-7N-D is 1.0.

Update Times

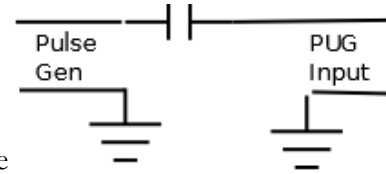
The meter has two update timers, settable in tenths of a second. The low update time is the normal screen refresh time, and 3 seconds is good for most users. The meter displays the number of pulses received during this time, and divides by the time to calculate the count rate, to the number of decimal places programmed by the user.

For example, if the decimal place parameter for Rate mode is set to 2, and the low update rate is 3 seconds, and the meter receives 7 pulses in 3 seconds, it will display 2.33. If the Rate mode is set to display integers (no decimal places) the display will show 2. The settings in the PUG-7N-D are 2 seconds and 1 decimal place.

The high update rate comes into play when the incoming pulse rate is low. TA normally sets this parameter to 12 seconds. At this setting, the meter will wait up to 12 seconds, then display 0 if no pulse has been received. If a pulse is received after the screen refresh time, but before the High update has expired, the meter displays 1 divided by the actual time. If it receives a pulse after 7 seconds, it will display 0.14 (assuming 2 decimal places). The PUG-7N-D will normally display 0 when there are no neutrons to detect.

TESTING

It is sometimes useful to provide the instrument with a known input. If a neutron source is not available, or the probe is questionable, attach the output of a pulse generator through a capacitor. This protects pulse generator from the high voltage on the center pin of the BNC connector. Set the pulse output to a few millivolts, and increase it as necessary.



To measure the high voltage bias, use a very high impedance HV probe and a high impedance voltmeter.

PROGRAMMING

The TBM-15D incorporates a Red Lion CUB5 programmable display. The program parameters are in non-volatile memory and are retained when unit is turned on or off and even if the batteries are removed.

The parameters are divided into a number of modules. Optional features such as an alarm (Setpoint) or serial port (RS-232) increase the number of modules.

The parameters are listed by module in the Red Lion Manual for each meter model. It will help to have a manual to refer to.

The PUG-7N-D is shipped in the program lock mode to prevent accidental changes. In order to change any of the parameters, the jumper on the back of the Red Lion meter must be removed. Remove the front panel and turn it over. There is a jumper from the ground pin (COM) to the user input pin (USR). Loosen the 2 screws, remove the jumper, then tighten the COM screw to insure signal ground contact. Replace the jumper when you are finished changing the parameters.

To change the meter parameters:

- Hold SEL button for 2 seconds. Display will show “Pro”.
- Press RST button once to enter module #1, again for module #2 etc.
- Press SEL to scroll through the settings in that module.
- If the selected parameter is correct, press SEL.
- To change the selected parameter, press RST instead.
- Then make the needed changes.
- When ready, press and hold SEL to store the value.

Some of the meter parameters are numerical values.

To change a numerical parameter:

- 1) Scroll to the desired programming module (1 – 5) with the RST button.
- 2) Scroll to the desired parameter with the SEL button.
- 3) The display will toggle between the parameter name and the current value.
- 4) Press the RST button if you wish to change the value.

- 5) Press the RST button again to highlight the lowest decade.
- 6) Press the RST button again to scroll through the values 0 – 9 in that decade.
- 7) When the selected digit is correct, press SEL to advance to the next decade.
- 8) When all digits are correct, press and hold SEL repeatedly until the left most digit is selected.
- 9) Press and hold SEL until the next choice appears. Then the new value is stored.

Programming Screens

Module - Step #	Function	As Shipped
1-1	Count Modes (cnta-Ud)	cnt ud
1-2	Integrate Mode Decimal Point (cnta-dP)	0
1-3	Integrate Mode Scale Factor (cnta-scf)	1.0
1-4	Counter Reset At Power Up	No
1-5	User Input (USEr INP)	Pro Loc
2-1	Rate Enable (rAtE Enb)	Yes
2-2	Rate Decimal Point (rAtE dP)	0.0
2-3	Rate Display (rAtE dSP)	100
2-4	Rate Input (rAtE INP)	100
2-5	Minimum Update Time (Lo-Udt)	2
2-6	Maximum Update Time (Hi-Udt)	12
3-1	Select Enable (dSPSEL)	Yes
3-2	Reset Enable ((rSt Enb)	Yes
3-3	Display Scroll (dSPS ScroL)	No
3.4	Program Security Code	000
3-5	Fact Set	No

The rest of the parametes are left at the Red Lion factory defaultsts.