
OPERATION MANUAL

Model LET-SW5

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GENERAL INFORMATION

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Far West Technology has been manufacturing radiation measuring devices since 1972.

REPAIR SERVICE

Although we design and manufacture our instruments to a high standard, we realize that repairs are sometimes necessary. If you believe service is needed on this instrument please call our service department before shipping the instrument to us for repair; often we can help you with simple problems. If you do decide to return it to us for repair then please include:

1. Contact person's name
2. Organization or Company name
3. Address
4. Phone number of contact person
5. Description of the problem
6. Anything else you may think important

We will inform you of the repair charges and wait for your authorization before we repair your instrument.

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I. INTRODUCTION

The instrument is a spherical tissue equivalent proportional counter. It is usually filled with tissue equivalent gas at a reduced pressure. An aluminum shell is used as a vacuum tight container for the sphere and is mounted on an aluminum plate, which holds the electrical and gas connection.

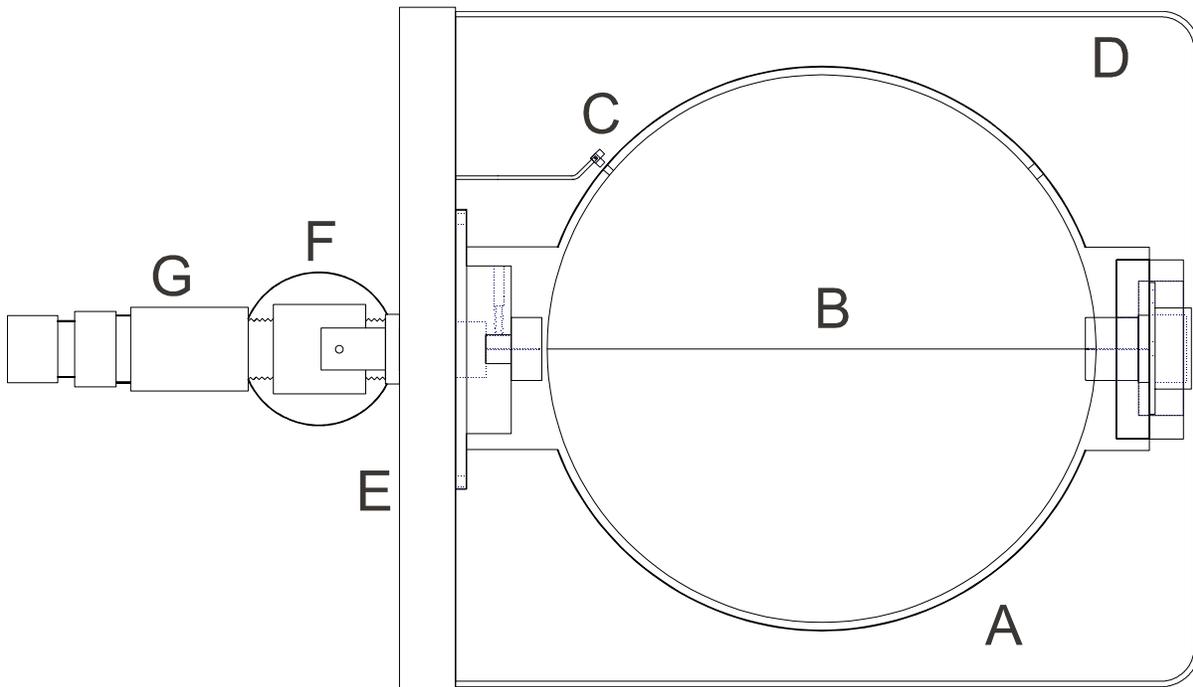
The instrument is generally used to accumulate a pulse height spectrum proportional to the energy deposited in the sensitive volume. This spectrum may then be transformed into a distribution of absorbed dose in LET with the aid of computer processing (or, at less convenience, by hand). Simple electronic processing of the pulse height data as it is accumulated can also be used to allow measurement of exposures in Rads-tissue directly.

II. PHYSICAL CHARACTERISTICS OF THE INSTRUMENT

The detector is a spherical cavity in tissue equivalent plastic (Shonka Type A-150)^{1,2} with a 4.94 inch (12.55 cm) internal diameter. An aluminum can surrounds the TE plastic that provides electrostatic shielding and serves as a vacuum tight container. The aluminum is 0.050 inch (0.127 cm) thick. The plastic sphere is 0.084 inches (0.213 cm) thick, which is sufficient for proton equilibrium at least to 20 MeV.

The collecting wire is positioned on a diameter of the sphere. Guard rings are provided at each end of the wire. This design is similar to those originally published by P.W. Benjamin and associates.⁶⁻⁸

The mounting holes on the base are 10-32.



- A. Sphere, 4.94" id, 0.084" wall thickness, A-150 Tissue Equivalent Plastic
- B. Central Electrode, 0.003" dia SS wire
- C. Cm244 Source Rod, 0.062" dia x 0.115" long, (points up when off)
- D. Cover, 0.050" thick Aluminum, 6.00" id
- E. Baseplate, 0.50" thick Aluminum
- F. Brass bellows valve
- G. Brass quick-connect

Figure 1 Internal construction of LET-SW5 shown with the writing on the base upside down causing the optional source to expose the detector.

III. FILLING THE INSTRUMENT WITH GAS

The standard instrument is provided with a bellows seal valve and a Quick-Connect. This connector mates with a Swagelok B-QC4-D-400 DESO-type connector. These connectors contain spring-loaded plungers that seat against elastomeric o-rings providing a gas-tight seal when there is no connection to the connector. Experience will allow the gas filling tube to be "snapped off". Dirt must not be allowed to get into the Quick-Connect. The bellows seal valve should be turned off before removing the Quick-Connect.

The usual procedure for gas filling is initially, a pump down to 5 to 10 microns with a good quality rotary pump. Liquid nitrogen cold traps may be useful, but have not been found necessary. The instrument is then filled to about 50 cm Hg with tissue equivalent gas and pumped down to 5 to 10 microns. This procedure may be repeated if the instrument has not been in use for some time.

Pump down and filling should be slow to avoid contaminating the detector with the optional alpha source. Alpha particles may be forced into the detector from the gas flowing by the source. Always fill the detector with it in the horizontal position and the writing on the base right side up because this positions the source away from the gas flow. We fill and evacuate it at a rate of about 1 mmHg per second and this takes about 10 minutes to evacuate the detector if it is up to atmosphere. The biggest problem can occur when the chamber is suddenly brought up to atmosphere because of a filling error because this causes the most gas to pass by the source and into the sensitive volume of the chamber.

The instrument is next filled to the proper pressure for operation. This is determined by the tissue equivalent gas density. The methane based T.E. gas mixture is 29.9% CO₂, 2.75% N₂ and 67.54% CH₄ by volume with a density of 1.062 grams per liter at 20°C and 760 mm Hg. The instrument cavity is 4.94 inch (12.55 cm) in diameter and thus a pressure of .57 cm Hg will simulate a cavity of about 1 x 10⁻⁶ meter diameter in density 1.00 tissue. This effective diameter can be made smaller or larger by variation of the gas pressure. A more recent tissue equivalent gas mixture composed of 39.6% CO₂, 5.4% N₂ and 55% propane has been used with equivalent results. Addition of 10% isobutane will provide better operation at very high multiplications.

Gas purity is of considerable importance in counter operation. Poor resolution, gain or a low voltage arc-over point are evidences of gas problems. Water in the gas will invariably cause arc-over. A dew point of -40°C or lower is recommended.

IV. ELECTRICAL CHARACTERISTICS

The end plate carries the signal and high voltage connectors. The high voltage should be negative with respect to ground, i.e. the center wire of the H.V. cable should be positive with respect to the shield. The voltages needed for operation is given below:

Counter Diameter	Gas Pressure	Negative Operating Volts	Arc-Over Voltage
<i>Methane Base TE</i>			
1 micron	.56 cm Hg	550-650	700
2 micron	1.12 cm Hg	650-750	800
<i>Propane Base TE</i>			
1 micron	0.33 cm Hg	450-550	600
2 micron	0.66 cm Hg	550-650	700

There are two connections on the baseplate, SIG and HV. The one in the center (SIG) connects to the center wire of the detector and the other (HV) connects to the TE shell inside the housing. The detector can be biased on one of two ways. The first and preferred method is to connect the negative high voltage to the HV connector and take the signal from the SIG connector. No coupling capacitor is needed in the input of the preamp which should reduce the noise. The other method is ground the HV connector and capacitively couple the positive high voltage through the preamp into the center wire (SIG). Details of specific connections in the preamp should be provided by the manufacturer of the preamp.

Arc-overs should be avoided due to the inevitable insulator carbon tracking which occurs. This can seriously degrade the chamber performance. Large arc-overs can transfer enough charge to destroy the input FET on some preamplifiers. If a solid-state preamplifier is used, it is usually necessary to limit the rate of rise of the high voltage so that switching transients do not destroy the first amplifier stage semi-conductor. If high voltage is applied to the bias connector on your preamplifier, use a positive voltage.

The signal from the detector appears on the connector block marked SIG. This connector mates with BNC cable connector UG-260/U. Low noise cable should be used for best low noise performance. The cable length should be as short as possible to reduce input capacity. There are no coupling capacitors in the signal circuit. The pulses produced are negative going.

The SIG connector should be connected to a low noise preamplifier. The type usually specified for cooled Ge(Li) detectors is suitable. Gain should be approximately 100 to 200 mV/MeV(Ge). The detector output is AC coupled so the preamplifier may not need an input coupling capacitor. This may result in lower noise. Removal of any protection diodes across the input FET will also lower the noise, but the rate of rise of the high voltage must be limited when turning it on or off, in this case. See Figure 2.

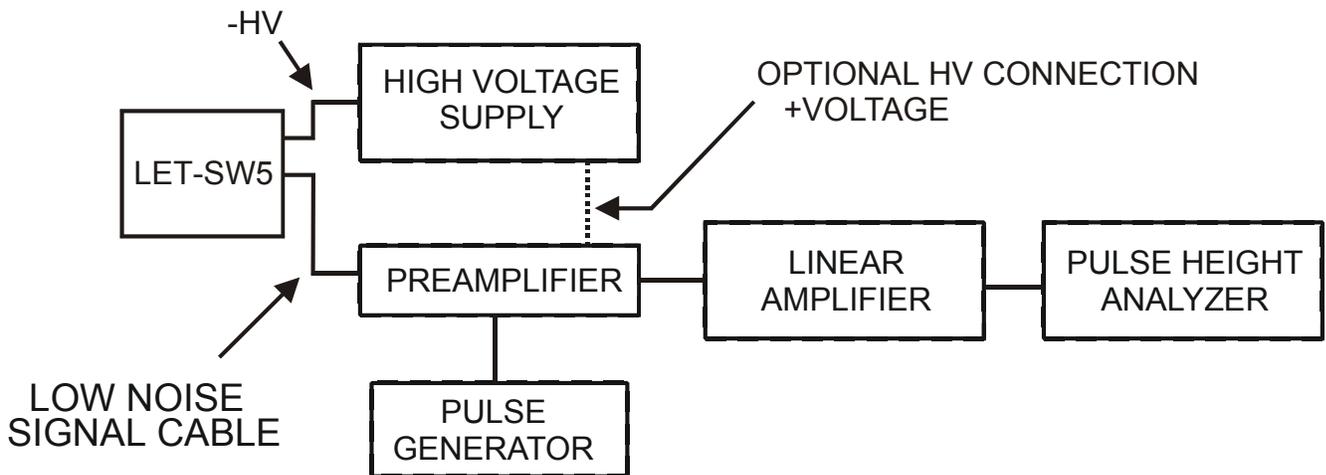


Figure 2 Electrical Interconnection Diagram for LET-SW5 Operation

V. OPTIONAL INTERNAL ALPHA SOURCE

The optional gravity operated ^{244}Cm source is used for gain calibration. The source is positioned so that the ^{244}Cm alpha particles can enter the sphere through a collimator when the connector plate is horizontal and the writing on the base is upside down. The source is "off" when the connector plate is horizontal and the writing on the base is right side up. The source can be either on or off when the detector is up, i.e. suspended by the cables. If you want it on, then position the detector horizontal with the writing on the base upside down, then slowly bring the detector to the vertical position. Since the source is a gravity-operated device, it occasionally may be necessary to gently tap the base to position it properly.

^{244}Cm has a mean alpha energy of 5.80 MeV which averages to 81.72 keV/u over a range of 1u ($1\text{u} = 1 \times 10^{-6}$ meters) in tissue. Because of the collimator, the source produces a peak on a multichannel pulse height analyzer. The center of this distribution is characteristic of the LET of the alpha particle averaged over the detector diameter. Exact work can benefit from fitting a parabola to the upper half of this peak in order to find the precise position of the maximum. The alpha source resolution is relatively poor due to a compromise between source strength, collimator opening and useful count rate.

A plot is included with each detector showing the alpha peak produced by its internal source. Data are included on the graph giving the high voltage used and the gas filling pressure.

VI. TYPICAL SPECTRUM FROM ²⁵²CF NEUTRONS

Plots of the pulse height spectrum derived from a standard ²⁵²CF exposure and from the internal ²⁴⁴Cm source are enclosed with each detector. These data were taken with standardized electronics as a quality control measure and are not representative of the best in low noise circuitry.

VII. TYPICAL OPERATION OF THE INSTRUMENT

The instrument is initially prepared as noted in the section "Filling of the Instrument with Gas", i.e., pump-down and flushing with T.E. gas, a second pump-down and filling to the required pressure. The valve is closed and the Quick-Connect is snapped off freeing the instrument from the gas filling apparatus. The signal and high voltage cables are then connected (using low noise cable in the signal lead). The high voltage power supply is adjusted to provide -600 volts if the detector has an effective diameter of 1 micron. The signal from the preamplifier and through the linear amplifier is presented to a pulse height analyzer.

If the detector has the optional Cm244 source, it is placed in a horizontal position with the writing on the base upside down to turn on the alpha source. The system gain is then adjusted to place the alpha peak in a convenient channel in the pulse height analyzer. For example, at an effective diameter of 1 micron, the average LET of the ²⁴⁴Cm alpha particles is 81.72 keV/u and if the peak is placed near channel 82, then the analyzer display is approximately 1 keV/u per channel.

After this preliminary work, an alpha spectrum is accumulated. Data should be accumulated for at least 10 minutes or more so that the position of the peak may be accurately determined. The alpha source is then turned off by turning the detector so that the writing on the base is right side up.

If the optional source is not used or installed, the gain may be adjusted using the proton drop point. Expose the detector to a neutron field, accumulate a spectrum, and note the location of the channel where the knee in the response indicates the proton drop point. Adjust the gain to place the proton drop point in the desired channel.

Data are usually accumulated at several gain settings so that the limited dynamic range of the pulse height analyzer does not restrict the results. For example, the first run might be from about 40 to 400 keV/u (for the 400 channel analyzer). The second from 6 to 60 keV/u, the third from 1 to 10 and the fourth from noise up to 3 keV/u. This scheme allows overlap between the various segments so that they may be fitted together accurately. Obviously analyzer non-linearities must be known, as well as the precise gain shifts used to select the spectrum segments. We have used a sliding pulse generator to advantage in determining the analyzer non-linearities. A simple very stable mercury pulser can be used to measure the overall gain at the different settings.

After the data are accumulated it is good practice to take a noise spectrum for the highest gain segment. This will allow subtraction of the electronically produced noise and usually allows good data to be obtained down to about 0.5 keV/u. A second alpha spectrum should also be taken to establish detector drift characteristics, if any. Usually the detector can be expected to drift less than 1 channel out of 100 in 8 hours. Drift rates greater than this generally can be traced to gas leakage or outgassing of the plastic. Temperature changes can also cause gain shifts.

VIII. DATA REDUCTION METHODS

Some methods of data reduction are discussed in References 6, 7, and 8. Invariably, computer aided processing is required because of the large number of data points gathered. Smoothing of the data before processing may also be helpful. Both linear and quadratic smoothing have been used with success.

If only certain segments of the data are needed initially a simple program can usually be written for one of the many programmable calculators now on the market. Such a program must include a smoothing routine if it is to be satisfactory.

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