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NRC FORM 213  
(9-85)  
10 CFR 30, 32, 33, 34,  
35 and 40

U.S. NUCLEAR REGULATORY COMMISSION  
APPROVED BY OMB  
319-0120  
Expires 6-31-87

APPLICATION FOR MATERIAL LICENSE

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

<p><b>FEDERAL AGENCIES FILE APPLICATIONS WITH:</b></p> <p>U.S. NUCLEAR REGULATORY COMMISSION DIVISION OF FUEL CYCLE AND MATERIAL SAFETY, KM55 WASHINGTON, DC 20555</p> <p><b>ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS, IF YOU ARE LOCATED IN:</b></p> <p>CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:</p> <p>U.S. NUCLEAR REGULATORY COMMISSION, REGION I NUCLEAR MATERIAL SECTION B 631 PARK AVENUE KING OF PRUSSIA, PA 19406</p> <p>ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:</p> <p>U.S. NUCLEAR REGULATORY COMMISSION, REGION II MATERIAL RADIATION PROTECTION SECTION 101 MARIETTA STREET, SUITE 2600 ATLANTA, GA 30323</p>	<p><b>IF YOU ARE LOCATED IN:</b></p> <p>ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:</p> <p>U.S. NUCLEAR REGULATORY COMMISSION, REGION III MATERIALS LICENSING SECTION 799 ROOSEVELT ROAD GLEN ELLYN, IL 60137</p> <p>ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:</p> <p>U.S. NUCLEAR REGULATORY COMMISSION, REGION IV MATERIAL RADIATION PROTECTION SECTION 611 RYAN PLAZA DRIVE, SUITE 1000 ARLINGTON, TX 76011</p> <p>ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:</p> <p>U.S. NUCLEAR REGULATORY COMMISSION, REGION V MATERIAL RADIATION PROTECTION SECTION 1450 MARIA LANE, SUITE 610 WALNUT CREEK, CA 94596</p>
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PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY (IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION).

<p>1. THIS IS AN APPLICATION FOR (Check appropriate item)</p> <p><input checked="" type="checkbox"/> A. NEW LICENSE</p> <p><input type="checkbox"/> B. AMENDMENT TO LICENSE NUMBER _____</p> <p><input type="checkbox"/> C. RENEWAL OF LICENSE NUMBER _____</p>	<p>2. NAME AND MAILING ADDRESS OF APPLICANT (Include Zip Code)</p> <p>Microbac 4580 McKnight Road Pittsburgh, PA 15237</p>
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3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED

Same as item 2

8912070171 BB0916  
REG1 LIC30  
37-20844-02 PDR

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION	TELEPHONE NUMBER
Mona Gleason	1-412-931-5851

SUBMIT ITEMS 5 THROUGH 11 ON 8 1/2 x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL a. Element and mass number, b. chemical and/or physical form, and c. maximum amount which will be possessed at any one time.	6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.
Addendum A	Addendum B
7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE.	8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.
Addendum C	Addendum E
9. FACILITIES AND EQUIPMENT.	10. RADIATION SAFETY PROGRAM.
Addendum D	Addendum E
11. WASTE MANAGEMENT.	12. LICENSEE FEES (See 10 CFR 170 and Section 170.31)
Addendum F	FEE CATEGORY New AMOUNT ENCLOSED \$ 230.00

13. CERTIFICATION. (Must be completed by applicant) THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, AND 40 AND THAT ALL INFORMATION CONTAINED HEREIN, IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948, 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

SIGNATURE - CERTIFYING OFFICER	TYPED/PRINTED NAME	TITLE	DATE
<i>Mona Gleason</i>	Mona Gleason	Laboratory Director	7-1-88

14. VOLUNTARY ECONOMIC DATA		15. WOULD YOU BE WILLING TO FURNISH COST INFORMATION (dollar and/or staff hours) ON THE ECONOMIC IMPACT OF CURRENT NRC REGULATIONS OR ANY FUTURE PROPOSED NRC REGULATIONS THAT MAY AFFECT YOU? (NRC regulations permit it to protect confidential commercial or financial—proprietary—information furnished to the agency in confidence)								
a. ANNUAL RECEIPTS	b. NUMBER OF EMPLOYEES (Total for entire facility excluding outside contractors)									
<table border="1"> <tr><td>&lt; \$250K</td><td>\$1M - 3.5M</td></tr> <tr><td>\$250K - 500K</td><td>\$3.5M - 7M</td></tr> <tr><td>\$500K - 750K</td><td>\$7M - 10M</td></tr> <tr><td>\$750K - 1M</td><td>&gt; \$10M</td></tr> </table>	< \$250K	\$1M - 3.5M	\$250K - 500K	\$3.5M - 7M	\$500K - 750K	\$7M - 10M	\$750K - 1M	> \$10M	c. NUMBER OF BEOS	<input type="checkbox"/> YES <input type="checkbox"/> NO
< \$250K	\$1M - 3.5M									
\$250K - 500K	\$3.5M - 7M									
\$500K - 750K	\$7M - 10M									
\$750K - 1M	> \$10M									

FOR NRC USE ONLY			
TYPE OF FEE	FILE LOG	FEE CATEGORY	COMMENTS
APP	Jul. 9 1988	3P	
AMOUNT RECEIVED	CHECK NUMBER	APPROVED BY	
\$230	11064	<i>[Signature]</i>	
		DATE	
		7/15/88	

## PRIVACY ACT STATEMENT

Pursuant to 5 U.S.C. 552a(e)(3), enacted into law by section 3 of the Privacy Act of 1974 (Public Law 93-579), the following statement is furnished to individuals who supply information to the Nuclear Regulatory Commission on NRC Form 313. This information is maintained in a system of records designated as NRC-3 and described at 40 Federal Register 45334 (October 1, 1975).

1. **AUTHORITY:** Sections 81 and 161(b) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2111 and 2201(b)).
2. **PRINCIPAL PURPOSE(S):** The information is evaluated by the NRC staff pursuant to the criteria set forth in 10 CFR Parts 30, 32, 33, 34, 35 and 40 to determine whether the application meets the requirements of the Atomic Energy Act of 1954, as amended, and the Commission's regulations, for the issuance of a radioactive material license or amendment thereof.
3. **ROUTINE USES:** The information may be (a) provided to State health departments for their information and use; and (b) provided to Federal, State, and local health officials and other persons in the event of incident or exposure, for their information, investigation, and protection of the public health and safety. The information may also be disclosed to appropriate Federal, State, and local agencies in the event that the information indicates a violation or potential violation of law and in the course of an administrative or judicial proceeding. In addition, this information may be transferred to an appropriate Federal, State, or local agency to the extent relevant and necessary for an NRC decision or to an appropriate Federal agency to the extent relevant and necessary for that agency's decision about you.
4. **WHETHER DISCLOSURE IS MANDATORY OR VOLUNTARY AND EFFECT ON INDIVIDUAL OF NOT PROVIDING INFORMATION:** Disclosure of the requested information is voluntary. If the requested information is not furnished, however, the application for radioactive material license, or amendment thereof, will not be processed. A request that information be held from public inspection must be in accordance with the provisions of 10 CFR 2.790. Withholding from public inspection shall not affect the right, if any, of persons properly and directly concerned need to inspect the document.
5. **SYSTEM MANAGER(S) AND ADDRESS:** U.S. Nuclear Regulatory Commission  
Director, Division of Fuel Cycle and Material Safety  
Office of Nuclear Material Safety and Safeguards  
Washington, D.C. 20555

**Index of Addendums to the Application for a Radioactive  
Material License**

<b>Addendum</b>	<b>Contents</b>
A	Description of radioactive Material
B	Purpose(s) for which Radioactive material will be used
C	Radiation Safety Officer Training of Individual Users
D	Facilities and Equipment
E	Radiation Protection Program
F	Waste Management

Addendum A  
Radioactive Material



Element and Mass Number: Phosphorus - 32

Chemical and/or Physical Form: Aqueous nucleotides

Maximum possession: 1 millicurie

Addendum B

Purposes for Which Licensed Material Will be Used

Licensed material used is incorporated in the GENE-TRAK Systems pre-packaged, pre-labelled, and pre-tagged kit for detection of microorganisms in test specimens. The test is an in-vitro diagnostic assay similar to clinical radio-immunoassays. The usual amount of isotope handled at one time will be 75 microcuries or less.

Addendum C  
Individual Responsible for Radiation Safety Program and  
Their Training and Experience



The Radiation Safety Officer will be **Mona Gleason**.

**Mr. Gleason will receive two days of hands-on training at GENE-TRAK Systems, Framingham, MA.** The training will cover the safe use and handling of radioactive material. A copy of the course outline is appended.

**All laboratory personnel that will be using the GENE-TRAK assays will receive on-site training at Microbac Labs., upon issuance of the license.** The training will consist of two days of training conducted by GENE-TRAK personnel. A certificate of training will be issued to each laboratory staff member upon completion of the on-site training.

The course is two days in duration and covers the following topics:

principles and practices of radiation protection;  
radioactivity measurements, standardization and monitoring techniques and instruments,  
mathematics and calculations basic to use and measurement of radioactivity, and,  
biological effects of radiation.

## CERTIFICATE OF TRAINING

This is to certify that, Mona Gleason,  
from Microbac,  
received training in the performance of the GENE-TRAK Assay and its  
attendant use of Phosphorus-32 labelled material. The training was conducted  
at GENE-TRAK Systems, Framingham, Massachusetts. The training was  
conducted by GENE-TRAK Technical Services Department Personnel. The  
training was conducted on July 14 and 15, 1988

The training covered the following topics:

- a. Principles and practices of Radiation protection
- b. Radioactivity measurements, standardization and monitoring techniques and instruments,
- c. Mathematics and calculations basic to use and measurement of radioactivity, and
- d. biological effects of radiation.

Signed: Bonnie Brause

Date: June 14, 1988

**GENE-TRAK Systems  
Schedule of In-House Training**

**Day 1**

**A.M.**

**Introduction to Gene-Trak Systems  
Review the agenda  
Review of the assay protocol  
Start assay procedure, filter pre-prepared samples  
Discussion of the principles of the procedure will  
accompany each step of the procedure**

**P.M.**

**Introduction to Radioactivity  
Biological Effects of Radiation  
Recordkeeping and Regulatory Requirements  
Viewing of a video tape on radiation protection**

**Day 2**

**A.M.**

**Continue with the test procedure in the laboratory  
Add Pre-Hybridization Solution  
Discussion of radiation protection  
Add Hybridization Solution and Probe  
Continue discussion of radiation protection  
Perform recordkeeping tasks**

**P.M.**

**Radiation measurements and instrumentation  
Count filters and review data  
Clean-up and radioactive spill procedure**

## Technical Training Course outline

1. Introduction to Radioactivity
  - A. Definition
  - B. Types of Radiation
    - i. Modes of Radioactive Decay
    - ii. Units: Curie, DPM, Half-life, Range, etc...
2. Biological Effects of Radiation
  - A. Energy and Injury
  - B. Absorbed Dose
    - i. Units
    - ii. Limits
  - C. Effects of Low Level Exposure
3. Radiation Protection
  - A. Standards for Radiation Protection (10 CFR Part 20)
  - B. Internal and External Exposure
  - C. Time, Distance, Shielding
  - D. Safe Laboratory Practices
  - E. Personal Dosimetry
4. Radiation Measurement
  - A. Surveys
    - i. Geiger-Mueller Counter
  - B. Beta Detection Instrumentation
    - i. Scintillation Counters
    - ii. Gene-Trak Beta Detector
      - a. Principles
      - b. Efficiency



**5. Recordkeeping and Regulatory Requirements**

- A. Radioactive Material License**
- B. Responsibilities of The Radiation Safety Officer**
- C. Posting Requirements**
- D. Recordkeeping**
  - i. Receipt of Radioactive Materials**
  - ii. Contamination Surveys**
  - iii. Waste Disposal**
    - a. Liquid**
    - b. Solid**
  - iv. Inventory**
  - v. Personal Dosimetry**
  - vi. Instrument Calibration**

## Introduction to Radioactivity

Nuclear species are grouped into families having certain common characteristics. A **nuclide** is characterized by the exact nuclear composition. For example,

$^{12}\text{C}$ ,  $^{16}\text{O}$  and  $^{131}\text{I}$   
all are nuclides.

Nuclides having the same atomic number (same number of protons), are called **isotopes**:

$^{125}\text{I}$ ,  $^{127}\text{I}$  and  $^{131}\text{I}$   
all are isotopes.

An isotope is said to be radioactive if the atoms of that isotope are undergoing spontaneous disintegration. This process is known as **radioactivity**.

The general concept is that an unstable nucleus (parent), gives rise to a more stable product (daughter), through radioactive decay. The daughter may still be radioactive and decay again. The result is the transition of one nuclear species to another and the transformation of mass into energy.

There are several modes of radioactive decay. When a neutron is converted to a proton and electron, the electron is ejected from the nucleus and is called a **beta particle**. For example, phosphorus-32 is in an unstable state. In order to become a more stable molecule it must release energy. It does this by emitting an electron that takes with it excess energy. Energy is released in the form of kinetic energy and the energy imparted to the ejected electron. The beta particle has a spectrum of energy that is predicted and can only penetrate a small thickness of solid material.

In decay by **alpha emission**, the nucleus ejects an alpha particle which consists of 2 neutrons and 2 protons (a helium nucleus). Heavy radionuclides, such as uranium-238 and its daughter products undergo a series of alpha and beta decay events to transform into lighter, more stable nuclides. Although very energetic, alpha particles have a very short range in solid material.

Atomic and nuclear processes often result in the emission of electromagnetic radiation such as **x-rays** or **gamma rays**. Electromagnetic radiation is a packet of energy called a **photon**. A photon has no mass or charge and travels at the speed of light. Because of these characteristics, x-rays are deeply penetrating but transfer little energy.

The above modes of radioactive decay are described as **ionizing radiation**. Ionizing radiation is any form of radiation that can directly or indirectly ionize molecules in its path. **Directly ionizing radiation** consists of particles having sufficient energy to produce ionization by collision. Beta particles are the major class of directly ionizing particles, e.g.  $^{32}\text{P}$ ,  $^{14}\text{C}$ ,  $^3\text{H}$ . **Indirectly ionizing radiation** consists of uncharged particles, such as gamma rays and x-rays that can produce an ion pair.

The activity of radioactive material is expressed in terms of the **Curie (Ci)**. 1 Curie is equal to  $2.22 \times 10^{12}$  **disintegrations per minute**. 1 microcurie (1 uCi) =  $2.22 \times 10^6$  DPM.

The **half-life** is the length of time it takes for one half of the atoms to decay to a more stable form. Therefore, the rate of emission of beta particles is directly proportional to the number of radioactive atoms present. Example:

$^{32}\text{P}$  has a half-life of approximately 14 days. If a probe solution contains 100 uCi on day 1, how many days must pass until there are 75 uCi remaining?

7 days.

If 50%, or 50 uCi will be gone after the end of 2 weeks, then 25% or 25 uCi will be gone at the end of 1 week.

The maximum thickness of a substance through which a beta particle will penetrate is referred to as the **range**. The range is related to the density of the material so that if one knows the range in a material of 1 unit density we can divide by the new material density to determine the range. Example:

$^{32}\text{P}$  has a range of 0.6 cm in a material with a density of  $1.0 \text{ gm/cm}^3$  (ie. water and soft tissue). If the density of glass is  $2.3 \text{ gm/cm}^3$ , what is the range of  $^{32}\text{P}$  in glass?



$$\frac{0.8 \text{ cm}}{1.0 \text{ gm / cm}^3} = \frac{X}{2.3 \text{ gm / cm}^3}$$

therefore:

$$X = 0.35 \text{ cm.}$$



## Biological Effects of Radiation

Radiation can cause injury to living cells by transferring energy to molecules with which it interacts. Ionizing radiation disrupts the molecular structure by stripping the orbital electrons from the electron shells. The amount of cell damage is directly proportional to the amount of ionizing radiation. Some repairing occurs, however the unrepaired damage can accumulate resulting in permanent damage to organs and tissue or cancers.

Effects of ionizing radiation depend not only on the amount of energy involved but the location, extent of the region exposed and the duration of the exposure. Radiation is different from other harmful agents, ie. heat, noise, cold, etc., as we can sense these. Radiation has no direct sensory warning.

That's why limits on radiation exposure have been developed. They are derived from epidemiological and laboratory data on the relationship between the radiation exposure and the expected biological effect.

The **absorbed dose** is the amount of energy transferred to the matter divided by the mass of that matter. The absorbed dose can be different in various regions of the body. **Rad**, the radiation absorbed dose, is the term used to describe the absorbed dose.

$$1 \text{ rad} = 6.24 \times 10^7 \text{ MeV/gm}$$

Note. The basic unit of energy is the electron volt (eV). One eV is the amount of energy acquired by an electron when it accelerates through an electrical potential of one volt.  $1.0 \text{ MeV} = 10^6 \text{ eV}$ .

The **dose equivalent** is the basic quantity in radiation protection. The injury produced depends on the amount of energy imparted on matter. Some types of radiation produce greater effects than others with the same amount of energy imparted, for example, an alpha particle produces more injury than an electron. These differences are mainly due the mass of the particles. To provide for these differences the concept of **relative biological effectiveness (RBE)** was developed. The RBE for alpha particles is 20, for neutrons it is 10, and for x-rays, gamma rays and beta particles it is 1.0.

The **rem** is the unit of dose equivalent and is calculated by multiplying the rad by the RBE. In the case of  $^{32}\text{P}$  the rem is equal to the rad and 1 rem is equal to 1000 millirem (mrem).

$$1 \text{ rem} = 1 \text{ rad} \times \text{RBE}$$

Different parts of the body are more or less sensitive to radiation than other parts. Radiation effects the most rapidly growing tissues first and foremost, ie. lens of the eye, intestinal lining, hair follicles and gonads.

Limits on radiation exposure have been developed by the United States Nuclear Regulatory Commission (NRC) and are printed in the Code of Federal Regulations, Title 10, Chapter 1, Part 20. Some of the more important ones are:

Whole body, (including gonads, lenses of the eyes, and red bone marrow).	5.0 rem/yr
Skin	15 rem/yr
Hands	75 rem/yr
Pregnant women (with respect to the fetus).	0.5 rem/yr

It is sometimes easier to appreciate hazards when one compares estimated loss of life expectancy from health risks. The following have been derived by the NRC, Office of Standards and Development, 1980\*\*

<u>Health Risk</u>	<u>Estimated average days of life lost</u>
Smoking (1 pack/day)	2,370 (6.5 years)
Overweight (20%)	985 (2.7 years)
Auto accidents	200
Alcohol consumption (U.S. average)	130
Safest job (teaching)	30
Natural background radiation	8
Medical x-rays	6
1 rem occupational dose*	1
1 rem/yr, 30 years	30
5 rem/yr, 30 years	150

\* industrial average is 0.34 rem/year.

\*\* Miller, B., 1986, Laboratory Safety: Principles and Practices; American Society for Microbiology.

The quantities of radioactive material used in the performance of GENE-TRAK assays are well below what is necessary to cause any type of immediately detectable effect. Of more concern is the potential long term effects that can result from chronic exposure to even low levels of radiation. At the present time there is no threshold dose for these long term effects. Although the risk is small, common sense tells us that radiation exposure in the lab should be kept "As Low As Reasonably Achievable". This **ALARA** concept has been adopted by the NRC and cannot be overemphasized!



## Radiation Protection

As stated earlier, the standards for radiation protection are formulated by the NRC Code of Federal Regulations, Title 10, Part 20, but it is much easier to remember and adopt the ALARA concept. Regardless of the limits of radiation exposure, it should be maintained that the general policy is to avoid any unnecessary exposure to ionizing radiation.

Exposure to radioactivity can be classified as either **internal** or **external exposure**. Internal exposure comes from inhalation, ingestion, or penetration of a radioactive material (e.g. absorption through the skin). Some basic rules for avoiding internal radiation doses are:

Do not eat, drink or smoke in the laboratory  
to avoid accidental ingestion.

Wear protective clothing and gloves to protect the skin  
and avoid possible absorption of radioactive material.

Wash your hands after performing procedures involving  
radionuclides.

In certain chemical forms some radionuclides, e.g.  $^{125}\text{I}$ , are  
volatile. Prevent inhalation by using a fume hood and keep the  
source container capped when volatile chemical forms are  
possible.

Radiation exposure from external sources are those that deliver a dose from outside the body. Protection from external sources of radiation is accomplished through **Time, Distance and Shielding**. Obviously the longer one is exposed to the radiation source, the greater the number of particles will be incident on the body, therefore the greater the dose. We cannot feel radiation, so there is nothing to remind us of the exposure. One can limit the time, and therefore the length of exposure by knowing the procedures well and perfecting technique.

By increasing the distance between you and the source you can also limit exposure. The intensity varies inversely with the square of the distance. Example:

What is the reduction in exposure when a radioactive  
source is move from 10 cm to 100 cm?



The distance is increased by a factor of 10, therefore our equation reads as follows:

$$\frac{1}{d^2} = \frac{1}{10^2} = \frac{1}{100}$$

By moving our source by a factor of 10 we have reduced our exposure 100 times. In other words, the number of beta particles incident on the skin will be 1/100<sup>th</sup> the number at 10 cm.

Another means of reducing radiation exposure is to place a radiation-absorbing shield between yourself and the radionuclide. When working with <sup>32</sup>P, the most commonly used type of shielding is Lucite plastic. Shielding isn't quite as simple as calculating the range of a particle in a particular substance. When a beta particle strikes a target it may result in the emission of x-rays from that target. These x-rays are known as **bremstrahlung radiation**. The efficiency of the x-rays produced increases with increasing atomic number, therefore it is better to shield beta emitters with aluminum or plastics, rather than steel or lead.

Limiting the time of exposure, increasing the distance between you and the source and using a shield are all important things to consider while handling radionuclides. We must not, however, forget the need for safe laboratory practices. Basic laboratory common sense cannot be overemphasized. Do not eat or drink in the laboratory; do not pipette by mouth; wear protective clothing; keep the work area clean and uncluttered; etc... These and other precautions are required by the NRC and are listed in your license application.

Monitoring devices may be recommended and individual users have a right to see reports from these devices at any time. Monitoring devices are more commonly referred to as **film badges**. These will not provide protection, however they are useful even if the risk of exposure is small. Their use insures that unexpected exposure does not go unnoticed.

Film badges themselves are typically a small piece of x-ray film. The film blackens as it becomes exposed to radiation in the same way x-ray film is used to take x-rays of ones body. The blackening is read on a densitometer and is proportional to the amount of exposure. Selective filters provide density differences. The different densities identify general energies and allow for the conversion of the film dose to a tissue

dose. To be effective the badges must be worn whenever one is working with radionuclides. It must be worn by the individual only and not left in the radiation area when not worn.

## Radiation Measurement and Instrumentation

When radiation passes through matter it interacts with atoms and molecules by transferring energy to them. This results in either of two situations. 1. The energy is sufficient enough to strip an orbiting electron from the atom of a molecule. This is known as **ionization** and results in an ion pair (a negatively charged electron and a positively charged atom or molecule). 2. **Excitation** occurs when the electrons are disturbed enough to enter an excited state but not enough to be ejected from the atom or molecule.

The Geiger-Muller counter is a type of ionization chamber. It measures the amount of ionizing radiation. The GM tube responds to radiation by means of ionization induced electrical currents. A volume of gas or air is contained between two electrodes having different voltages. This results in an electrical field between the negatively charged cathode and the positively charged anode. Normally the gas is an insulator and there is no current flowing between the electrodes. However, when the gas is ionized by radiation the charged molecules are attracted to the cathode. This causes a momentary electrical current. The flow of electrons is picked up on an ampmeter where the amount can be read from a scale.

One uses a GM counter to conduct surveys of the work area to monitor for radioactive contamination. The survey meter should be present and operable at all times and should be used to check fingers and hands, clothing and the work area. It should also be used during spill clean up. Although radiation cannot be sensed we are fortunate to have an instrument such as this so that we can monitor of its presence.

When radioactive material reacts with matter and causes excitation or ionization the molecules or atoms of the matter undergo recombination or de-excitation to release energy. Most of this energy is in the form of thermal energy. However, if the energy is released in the form of visible light the material is called a scintillator. An instrument that detects scintillation is known as a scintillation detector.

In scintillation counters used to count gamma rays, the scintillator is a sodium iodide crystal. The radioactive material emits radiation which hits the crystal. Energy in the form of visible light is released and the light energy causes a photocathode to release photoelectrons. The photoelectrons are attracted to a series of dynodes. Each dynode releases more and more photoelectrons and ultimately the number of photoelectrons in this cascade are directly proportional to the



amount of radiation incident on the scintillator.

To count beta radiation, a scintillation cocktail is commonly used to convert the radiation into visible light. The light is captured by a photomultiplier tube which releases photoelectrons as described above. In some cases, however, radiation can be detected without cocktail. The electrons are emitted from the source at various speeds. Because some exceed the speed of light in a particular medium, they release energy in the form of visible light. This phenomenon is known as **Cerenkov Radiation**. When one counts the filter circles in a scintillation counter without cocktail the counts represent the Cerenkov radiation and this is proportional to the beta radiation from the source.

Although these instruments give us readings in proportion to the amount of radiation emitted from a particular sample, the results are not necessarily the true amount of radiation emitted. Instruments that measure radiation each have **particular efficiencies** that they are capable of achieving. Although the efficiency is a function of the type of instrument itself, it is also related to the radionuclide it is measuring. As different radionuclides emit particles or photons at different intensities of energy, it follows that some emissions are more easily detected than others. It is important to know the efficiency of the radiation detector you are using as the source strength can be determined by the count rate of the detector. The following equation is used to convert **Counts Per Minute to Disintegrations Per Minute**.

$$\frac{\text{CPM}}{\text{Efficiency of the Detector}} = \text{DPM}$$

Example: The efficiency of the GENE-TRAK Beta Detector is 40%. If the digital readout displays 400 counts per minute for a filter used during a wipe test, what is the actual value in disintegrations per minute?

$$\frac{400 \text{ CPM}}{0.4} = 1000 \text{ DPM}$$



## Recordkeeping and Regulatory Requirements

In order for an individual to initiate a program that includes the handling of radioactive materials, one must obtain authorization from the Nuclear Regulatory Commission (NRC) or the appropriate state agency. The authorization is in the form of a license specific for the designated material at a specific site. The license is granted after an application has been submitted and its requirements have been met.

Although the specific sites where procedures involving radionuclides are performed are documented in the NRC license, these areas must be clearly posted as a caution to those that have access to the area. A **"Caution Radioactive Material"** plaque is required in a room or area where the radionuclide is stored or used. Stickers with the same warning must be used to appropriately label containers holding radioactive material. A sign of this nature indicates that the amount of radioactive material used is in the range of 10 - 100 uCi. Other warnings, such as "Caution Radiation Area" or "High Radiation Area" should not be used as these indicate that much greater quantities of radioactivity are present.

A radiation safety program is conducted under the authority of a **Radiation Safety Officer (RSO)**. The RSO is responsible for conducting a radiation safety program to insure that all users are aware of the risks, and know the responsibilities for the safe use of radionuclides. The RSO is also responsible for keeping appropriate records for inventory and disposal of radionuclides.

Although the RSO is responsible for overseeing the radiation safety program, individual users are responsible for both complying with the regulations set fourth by the governing agency and the safe use of the radionuclide by himself and others in the facility.

Appropriate and accurate recordkeeping cannot be over emphasized!!!!!! Your records are important legal documents and provide proof of compliance with your license as well as provide for effective administration of the radiation protection program.

### **Receipt of radionuclides.**

Upon arrival, the radiation safety officer is responsible for inspecting the package to insure that it has not been damaged during shipping. A measurement of the amount of radiation emitted from the package is taken to insure that the contents are intact. In addition, wipe tests on both the package and the source container are performed to

determine whether or not the radiation emitted, if any, is due to the source itself or is a result of removable contamination. See Appendix A.

### **Inventory.**

It is important to keep track of the total amount of radionuclide on hand at any one time. As your license restricts your facility to a limited quantity, a record of your inventory is important so that you will not exceed your limit. Total inventory includes both the unused portion of the radionuclide as well as the solid radioactive waste being held for decay. See Appendix B.

### **Dosimetry Reports.**

If dosimetry badges are recommended by the governing agency and a film badge service is established, periodic reports will be sent and should be made available for all users to see and inspect. The reports generally include the exposure for the given period (i.e., one month), quarterly exposure, annual exposure, and accumulated occupational dose.

### **Radiation Surveys.**

Radiation surveys in the form of wipe tests should be performed weekly. Several locations in the laboratory should be tested for removable contamination by rubbing a 100 cm<sup>2</sup> surface with a filter paper circle. The filter paper is then counted in either a scintillation counter or with the GENE-TRAK Beta Detector. Remember to convert CPM to DPM and determine the amount of radioactivity removed from the surface. Choose several locations in your laboratory that are likely to become contaminated, for example, the refrigerator door handle, waterbath handle, sink drain and bench top. In most cases the limit is 500 DPM per 100 cm<sup>2</sup> but keep in mind the ALARA concept. If survey results usually are close to background, but suddenly an area has jumped to nearly 500 DPM, perhaps that area is slightly contaminated. It can never hurt to clean a higher than usual area even though it is less than the limit. See Appendix C.

### **Disposal Records.**

Solid and liquid waste disposal must also be accounted for. Because the quantity of radionuclide being used is low, in most jurisdictions liquid waste can be disposed of down a designated sink drain. There are, however, limits on liquid radioactive waste disposal. It is important to keep up to date records so that these limits are not exceeded. Solid waste, on the other hand, must be stored for a minimum of 10 half lives before it can be disposed of. A record of the initial date of

storage and the date of disposal must be kept on file. See Appendices D and E.

#### **Instrument Calibration.**

Your survey meter must be calibrated annually and the certificate of calibration should be kept on file. The company that will perform the calibration of your survey meter is designated in your Radioactive Material License application. Keep in mind that while your survey meter is out for calibration you must have a replacement on hand. GENE-TRAK will be happy to loan you a survey meter for the period that yours is out.

Your beta detector will be calibrated at the manufacturer and will be checked with standards during the installation. Periodically, standards will be sent to your facility. The standards are to be counted and the data sent to us to determine whether or not your instrument should be recalibrated. Again, GENE-TRAK will send you a loaner as necessary.



## Glossary of Terms

### **Absorbed Dose**

The mean energy of ionizing radiation imparted per unit mass irradiated material at a point of interest.

### **Absorbed Dose Rate**

Absorbed dose delivered per unit time.

### **Absorption**

The process by which radiation imparts some or all of its energy to the material through which it passes.

### **Activity**

The nuclear transformations occurring in a given quantity of material per unit time at a given time.

### **Background Radiation**

Ionizing radiation arising from radioactive materials other than that directly under consideration. Background radiation comes from cosmic rays and other naturally occurring radioactivity that is always present.

### **Beta Particle**

A charged particle emitted from the nucleus of an atom, having a mass and charge equal to that of an electron.

### **Bremsstrahlung**

Secondary photon radiation produced by deceleration of a charged particle passing through matter.

### **Cosmic Ray**

High energy particulate and electromagnetic radiation that originates outside the earth's atmosphere.

### **Curie**

A unit of activity. One curie (Ci) equals  $2.22 \times 10^{12}$  disintegrations per minute.

### **Decay**

The process by which an unstable nucleus spontaneously emits a charged particle or photon.



**Dose Equivalent**

The dose equivalent is used in radiation protection as an indication of the biological effect that will be produced in an irradiated tissue. The dose equivalent is the product of the absorbed dose in tissue (see "rad") and the radiation biological effectiveness (RBE).

**Efficiency**

A measure of the probability that a count will be recorded when radiation is incident on the detector.

**Film Badge**

A packet of photographic film used for the approximate measurement of radiation exposure for personnel monitoring. The film may contain more than one film of differing sensitivities, or it may contain filters which shield parts of the film from certain types of radiation.

**Geiger-Mueller**

A type of ionization chamber which measures the electrical potential between two electrodes that is created by ionizing radiation.

**Half-life**

The time required for a radioactive substance to lose 50% of its activity through radioactive decay.

**Half-value Layer**

The thickness of any material that will reduce the intensity of ionizing radiation by 50%.

**Inverse Square Law**

The intensity of radiation at any distance from a point source varies inversely as the square of that distance.

**Ionization**

The process by which a neutral atom or molecule acquires either a positive or a negative charge due to the transfer of energy from a radioactive source.

**Ionizing Radiation**

Any electromagnetic or particulate radiation capable of producing ions as it passes through matter.

### **Isotopes**

Nuclides having the same atomic number (same number of protons) but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element.

### **Quality Factor**

The linear energy transfer factor by which absorbed doses are multiplied to obtain a quantity that expresses the biological effectiveness of the absorbed dose.

### **Rad**

The basic quantity that characterizes the amount of energy incident on matter.  $1 \text{ Rad} = 6.24 \times 10^7 \text{ MeV/gm}$ .

### **Rem**

A special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor.

### **Relative Biological Effectiveness (RBE)**

The RBE is a factor used to compare the biological effectiveness of the radiation absorbed dose (rads) due to different types of ionizing radiation.

### **Roentgen (R)**

A special unit of exposure referring to photons of electromagnetic radiation.  $1 \text{ R equals } 2.58 \times 10^4 \text{ coulombs per kilogram of air}$ .

### **Scintillation Counter**

An instrument in which light flashes caused by ionizing radiation incident on a scintillator are measured.

### **X-ray**

Penetrating electromagnetic radiation having wavelengths shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. These photons originate from the extra nuclear part of the atom as opposed to a gamma ray which originates from the nucleus.

## Bibliography

1. Sorenson, JA: Physics in Nuclear Medicine. Grune and Stratton, New York, New York. 1980.
2. Shepiro, J: Radiation Protection: A Guide for Scientists and Physicians. Harvard University Press, Cambridge Massachusetts. 1981.
3. Lange, RC: Nuclear Medicine for Technicians. Year Book Publishers, Inc., Chicago, Illinois. 1973.



RADIOACTIVE SHIPMENT RECEIVING/INSPECTION REPORT

1. Isotope: \_\_\_\_\_ Total No. of mCi: \_\_\_\_\_  
 \_\_\_\_\_  
 Date Rec'd \_\_\_\_\_ Time Rec'd \_\_\_\_\_ P.O. No. \_\_\_\_\_
2. Visual Inspection of Vendor's Shipping Carton. If the shipping carton is damaged, notify the RSO immediately.  
 \_\_\_\_\_ Intact \_\_\_\_\_ Punctured \_\_\_\_\_ Wet \_\_\_\_\_ Crushed \_\_\_\_\_ Other (note) \_\_\_\_\_
3. Vendor's Stated Radiation on Shipping Carton Label (s) \_\_\_\_\_  
 (Total in Curies).
4. Closed Shipping Carton Radiation Scan.  
 A. Meter Identification: \_\_\_\_\_  
 B. Background Count (BKG): \_\_\_\_\_ (mRem/hr)  
 C. Activity at 1 meter: \_\_\_\_\_ (mRem/hr)  
 D. Activity carton surface: \_\_\_\_\_ (mRem/hr)

NOTE: If C exceeds 10 mRem/hr or D exceeds mRem/hr, notify the Radiation Safety Officer or Deputy immediately.

5. Open carton(s). Total number of vials: \_\_\_\_\_
6. Do the P.O., Packing Slip & Vials agree as to:  
 A. Radioisotope \_\_\_\_\_ yes \_\_\_\_\_ no, difference \_\_\_\_\_  
 B. Quantity \_\_\_\_\_ yes \_\_\_\_\_ no, difference \_\_\_\_\_  
 C. Chemical Form \_\_\_\_\_ yes \_\_\_\_\_ no, difference \_\_\_\_\_
7. Wipe Results From:  
 A. Outer Shipping Carton  $\left( \frac{\text{cpm} - \text{BKG}}{\text{DPM Factor}} \right) = \text{_____ DPM}$   
 B. Source Container  $\left( \frac{\text{cpm} - \text{BKG}}{\text{DPM Factor}} \right) = \text{_____ DPM}$
8. Survey results from packaging materials and empty shipping carton(s) \_\_\_\_\_ mRem/hr.

If contamination is detected, its source must be located and the RSO notified.

9. A. Disposition of packaging materials \_\_\_\_\_  
 B. Disposition of source container(s) \_\_\_\_\_
10. If NRC/carrier notification is required, log time \_\_\_\_\_  
 Date: \_\_\_\_\_ Person(s) notified: \_\_\_\_\_

Received/Inspected By: \_\_\_\_\_

IG# \_\_\_\_\_  
 Form HP-006-03

Date: \_\_\_\_\_







DISPOSAL RECORD FOR ISOTOPES RELEASED INTO THE SEWERAGE SYSTEM

<u>DATE</u>	<u>ISOTOPE</u>	<u>VOLUME</u>	<u>MICROCURIES</u>	<u>INITIALS</u>
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WHEN DATA HAS BEEN ENTERED ON LINE 40, CONTACT THE RADIATION SAFETY OFFICE  
FOR ANOTHER DISPOSAL RECORD.









RADIOACTIVE SHIPMENT RECEIVING/INSPECTION REPORT

1. Isotope: \_\_\_\_\_ Total No. of mCi: \_\_\_\_\_  
 \_\_\_\_\_  
 Date Rec'd \_\_\_\_\_ Time Rec'd \_\_\_\_\_ P.O. No. \_\_\_\_\_

2. Visual Inspection of Vendor's Shipping Carton. If the shipping carton is damaged, notify the RSO immediately.  
 \_\_\_\_\_ Intact \_\_\_\_\_ Punctured \_\_\_\_\_ Wet \_\_\_\_\_ Crushed \_\_\_\_\_ Other (note) \_\_\_\_\_

3. Vendor's Stated Radiation on Shipping Carton Label (s) \_\_\_\_\_  
 (Total in Curies).

4. Closed Shipping Carton Radiation Scan.  
 A. Meter Identification: \_\_\_\_\_  
 B. Background Count (BKG): \_\_\_\_\_ (mRem/hr)  
 C. Activity at 1 meter: \_\_\_\_\_ (mRem/hr)  
 D. Activity carton surface: \_\_\_\_\_ (mRem/hr)

NOTE: If C exceeds 10 mRem/hr or D exceeds mRem/hr, notify the Radiation Safety Officer or Deputy immediately.

5. Open carton(s). Total number of vials: \_\_\_\_\_

6. Do the P.O., Packing Slip & Vials agree as to:  
 A. Radioisotope \_\_\_\_\_ yes \_\_\_\_\_ no, difference \_\_\_\_\_  
 B. Quantity \_\_\_\_\_ yes \_\_\_\_\_ no, difference \_\_\_\_\_  
 C. Chemical Form \_\_\_\_\_ yes \_\_\_\_\_ no, difference \_\_\_\_\_

7. Wipe Results From:  
 A. Outer Shipping Carton ( cpm - BKG ) / ( DPM Factor ) = \_\_\_\_\_ DPM

B. Source Container ( cpm - BKG ) / ( DPM Factor ) = \_\_\_\_\_ DPM

8. Survey results from packaging materials and empty shipping carton(s) \_\_\_\_\_ mRem/hr.  
 If contamination is detected, its source must be located and the RSO notified.

9. A. Disposition of packaging materials \_\_\_\_\_  
 B. Disposition of source container(s) \_\_\_\_\_

10. If NRC/carrier notification is required, log time \_\_\_\_\_  
 Date: \_\_\_\_\_ Person(s) notified: \_\_\_\_\_

Received/Inspected By: \_\_\_\_\_

IG# \_\_\_\_\_ Date: \_\_\_\_\_  
 Form HP-006-03







DISPOSAL RECORD FOR ISOTOPES RELEASED INTO THE SEWERAGE SYSTEM

<u>DATE</u>	<u>ISOTOPE</u>	<u>VOLUME</u>	<u>MICROCURIES</u>	<u>INITIALS</u>
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WHEN DATA HAS BEEN ENTERED ON LINE 40, CONTACT THE RADIATION SAFETY OFFICE FOR ANOTHER DISPOSAL RECORD.

**Addendum D**  
**Facilities and Equipment**



## A. FACILITIES

A diagram of the laboratory is appended.

## B. EQUIPMENT

Diagnostic tests are completed on a membrane filter and results are determined by the use of the GENE-TRAK Beta Detector.

The Detector is model CTC-4 manufactured by Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, Massachusetts 02172. Performance of the Detector will be routinely checked in accordance with the GENE-TRAK Systems quality control procedure.

A geiger counter, such as a Ludlum 2 or 3 or equivalent, will be used to survey incoming packages and the work area. Calibration of the survey meter will be performed annually and after service and repair by:

Ludlum Measurement Inc.  
Sweetwater, Texas

Personnel monitoring devices will be worn when performing the GENE-TRAK assay. Monitoring will include use of a beta-gamma film badge supplied and processed monthly by:

R. S. Landauer, Jr, and Co.

Shielding composed of one-half inch thick lucite, will be used during handling and storage of the isotope.

MECHANICAL  
ELECTRICAL  
PLUMBING  
ATTACHED TO 1000

6 INCH THICK WALL

2'

4' x 4'

12'

4'

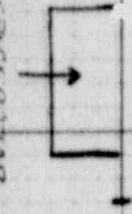
20

MICROLABOR

LABORATORY

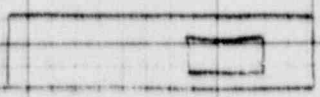
L18 RENCITS

RECEIPTOR



40'

5' x 10' x 10'  
LABORATORY



KEY



109168

"OFFICIAL RECORD COPY" M18

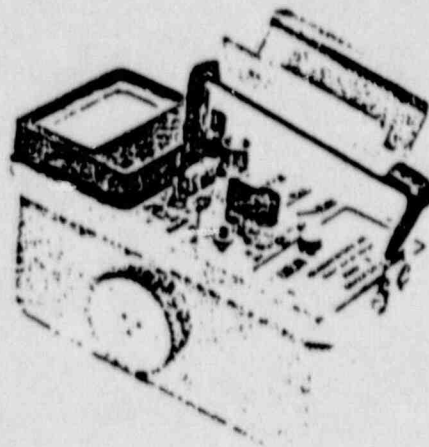
Fig. 10 (Scale 1/8" = 1'-0")

VE. MORGAN, INC. REC. ELIZABETH, N. J. 07208

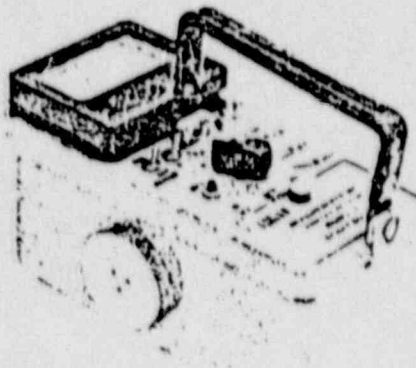
# Ludlum SURVEY METERS

## GEIGER-MUELLER OR SCINTILLATION

SPECIFICATIONS ON REVERSE SIDE



MODEL 2



MODEL 3

### LUDLUM MODEL 2 AND MODEL 3 SURVEY METERS

COMBINE THE MODEL 2 OR MODEL 3 WITH ANY LUDLUM GEIGER MUELLER OR SCINTILLATION PROBE TO ACCOMPLISH YOUR ALPHA-BETA GAMMA-NEUTRON-OR X-RAY COUNTING NEED

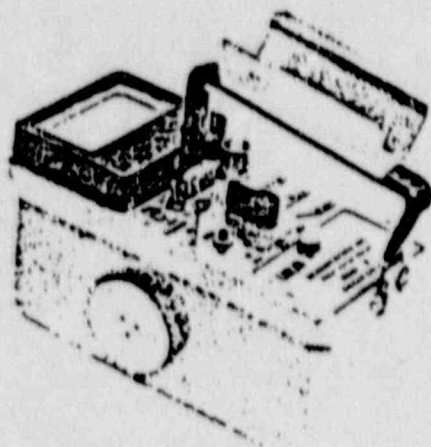
DETECTOR SPECIFICATIONS ON DETECTOR SHEET



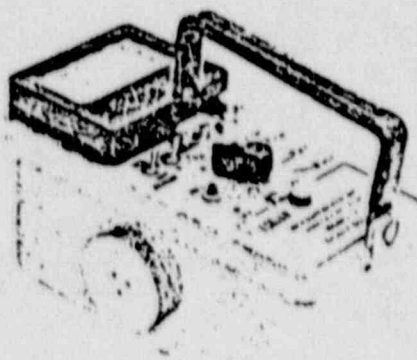
# Ludlum SURVEY METERS

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SPECIFICATIONS ON REVERSE SIDE



MODEL 2



MODEL 3

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DETECTOR SPECIFICATIONS ON DETECTOR SHEET

## THE MODEL 2

Two "D" cell flashlight batteries, replaceable from the front panel, operate this survey meter and also the speaker. The meter is housed in a cast aluminum bezel. The audio system is standard on this counter. Any GM probe offered by Ludlum is compatible with this unit, as well as many scintillators, since an ADJUSTABLE HIGH VOLTAGE is provided.

### HIGHLIGHTS:

- Individual range calibration potentiometers
- Ruggedized Meter
- IC Circuitry
- Temperature compensated
- Electronically regulated power supply
- Corrosion resistant
- All components derated to insure long life
- Liberal one year warranty
- Probe clips furnished at no extra charge, upon request.

### SPECIFICATIONS:

**Range:** Three linear ranges from 0-50 MR/Hr. Meter scale presentation 0-5 MR/Hr (0-5K CPM upon request) with multiples of X.1, X1, and X10.

**Response:** Toggle switch selection for 3 or 11 seconds.

**Sensitivity:** 40 Millivolts.

**Reset:** Push button switch for meter reset.

**High Voltage:** 900 Volts for Geiger Mueller probe

Externally adjustable from 400 to 1500 volts.

**Audio:** A built-in Unimorph speaker system with On-Off switch.

**Connector:** "C" Series.

**Linearity:** Plus or minus 5% of full scale.

**Calibration Stability:** Less than 5% variance to battery end point.

**Meter:** 50 Micro-amp, 2½" diameter.

**Size:** 3.4" X 3.5" X 7.0" (H x W x L, exclusive of handle).

**Weight:** 3.2 pounds, less batteries and detectors.

## THE MODEL 3

This unit incorporates all of the deluxe features found in the Model 2 plus an additional range. The four scale unit allows operation from 0 to 200 MR/Hr. Four scales of 0-2 MR/Hr with multiples of X.1, X1, X10, and X100, (0-5K CPM or 0-50 CPS upon request).

### LUDLUM MEASUREMENTS, INC.

501 Oak Street • Sweetwater, Texas 79556 • Telephone (915) 235-5454

## THE MODEL 2

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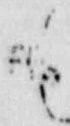
## LUDLUM MEASUREMENTS, INC.

501 Oak Street • Sweetwater, Texas 79556 • Telephone (915) 235-5404



# Ludlum BETA-GAMMA DETECTORS

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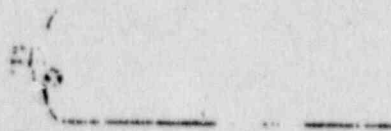
MODEL 44-7  
END WINDOW GEIGER-MUELLER PROBE

WINDOW: 1.4 to 2.0 mg/cm<sup>2</sup> mica.  
WINDOW DIAMETER: 1-3/32" diameter.  
WALL: 0.046 inches stainless steel, plus 0.062 aluminum holder.  
MOUNTING: Aluminum holder.  
DIMENSIONS: 1 1/4" diameter by 5 1/2" long.  
WEIGHT: 10 oz.

Replaceable GM tube  
Removable protective wire screen.

# Ludlum BETA-GAMMA DETECTORS

---



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WINDOW DIAMETER: 1-3/32" diameter.  
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WEIGHT: 10 oz.

MODEL 44-7  
END WINDOW GEIGER-MUELLER PROBE

Replaceable GM tube  
Removable protective wire screen.

COUNTING EQUIPMENT

TYPE OF INSTRUMENT USED / NUMBER AVAILABLE / RADIATION  
DETECTED

DRAFT

MODEL CTC-4

1

Beta

DOSE OR COUNT RANGE

USE

0-100,000 cpm 80KEV

Reading of filters of GENE-TRAK  
assay



COUNTING EQUIPMENT

TYPE OF INSTRUMENT USED / NUMBER AVAILABLE / RADIATION  
DETECTED

DRAFT

MODEL CTC-4

1

Beta

DOSE OR COUNT RANGE

USE

0-100,000 cpm 80KEV

Reading of filters of GENE-TRAK  
assay

## GENE-TRAK™ Beta Detector

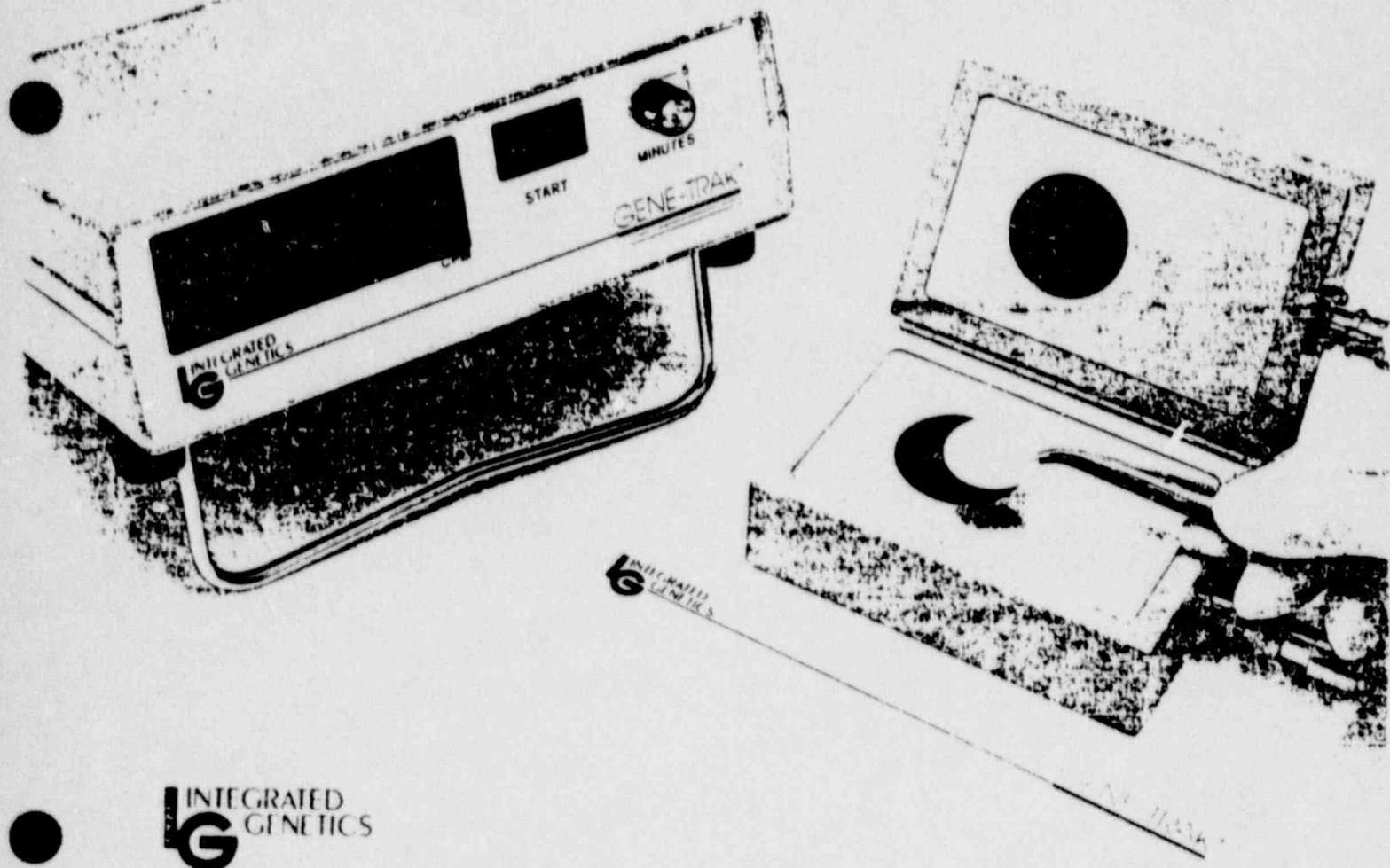
**Now, accurate, reproducible**

**beta emission detection**

**in a compact, easy to use, economical unit.**

Custom designed for use with the GENE-TRAK system, the GENE-TRAK Beta Detector affords unmatched convenience and efficiency in a small, modular bench-top instrument. Compare these features to other beta-particle detectors:

- Unique, custom-designed sensors eliminate the need for and expense of scintillation vials and fluids. Radioactive waste is minimized.
- Three counting times allow maximum operator control and flexibility. The GENE-TRAK Beta Detector automatically displays all readouts in counts per minute for assured consistency and convenience.
- Streamlined controls and audible counting signal make the GENE-TRAK Beta Detector easy to use.
- Filters go directly from drying to counting with no extra handling required.
- Lightweight for ease in handling and portability, the unit's compact design also saves valuable bench space.



**INTEGRATED  
GENETICS**

## GENE-TRAK® Beta Detector

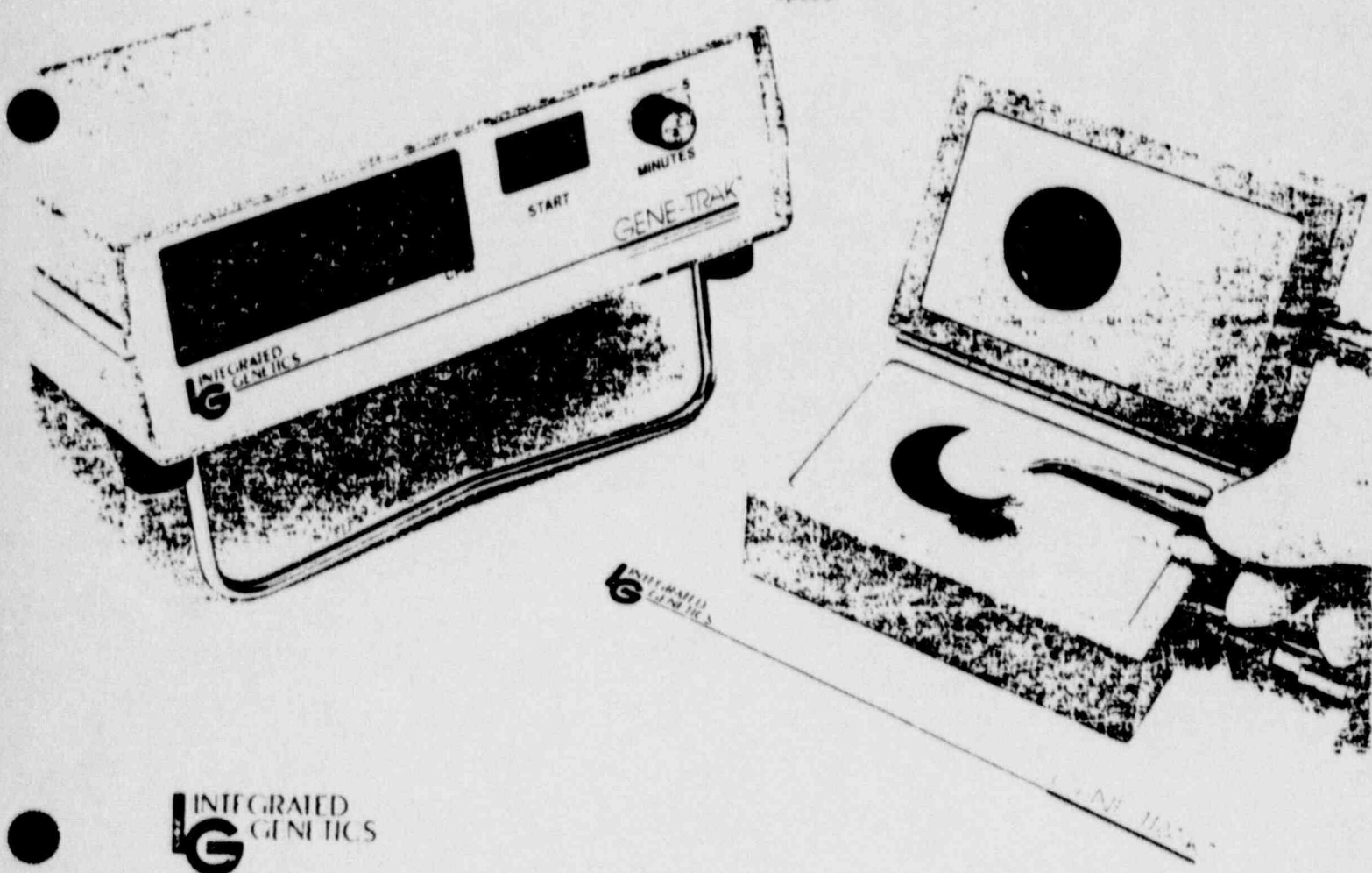
**Now, accurate, reproducible**

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- Lightweight for ease in handling and portability, the unit's compact design also saves valuable bench space.



**INTEGRATED  
GENETICS**





## WARRANTY CERTIFICATE

Ludlum Measurements, Inc. warrants the products covered in this Instruction Manual to be free of defects due to workmanship, materials, and design for a period of twelve months from date of delivery, with the exception of photo tubes and geiger tubes, which are warranted defect free to 90 days.

In event of instrument failure, notify Ludlum Measurements Inc. for repair or replacement. Liability of this warranty is limited to the purchase price of the instrument.

## RECEIVING CONDITION EXAMINATION

Be sure to verify that the shipping carton is received in perfectly good condition. For example, that no damage should be visible.

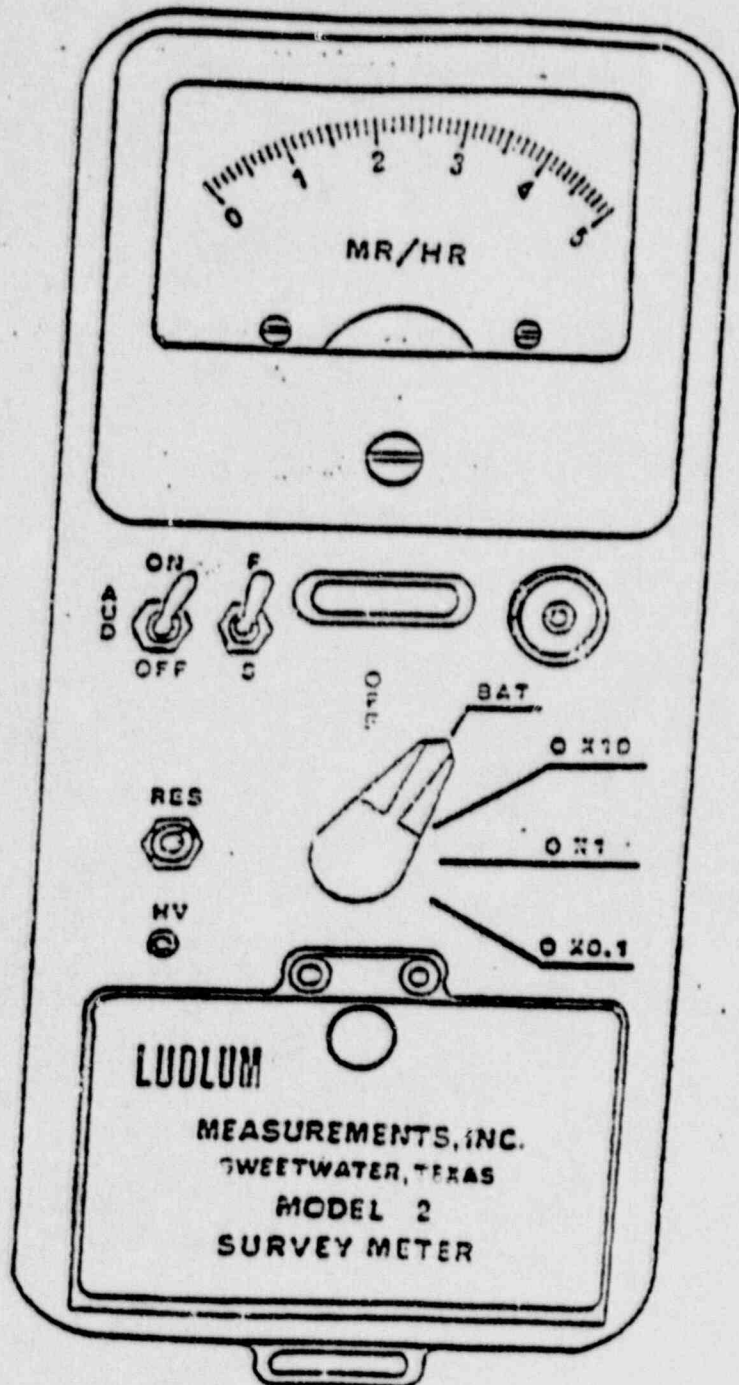
Should the instrument be received in a damaged condition, save the shipping container and the packing material and request an immediate inspection by the carrier.

Ludlum Measurements, Inc. is not responsible for the damage which occurs during shipment but will make every effort to help obtain restitution from the carrier.

## RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair, calibration, etc., please do so by the appropriate method of shipment. All shipments should include documentation containing shipping address, customer name and telephone number, and all other necessary information.

Your cooperation will expedite the return of your equipment.





**LODLUM MODEL 2 SURVEY METER**

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## 1.001.01 MODEL 2 SURVEY METER

### 1. GENERAL

The Model 2 is a portable survey instrument that operates on two standard "D" cell flashlight batteries. The instrument features a regulated high voltage power supply adjustable from 400 to 1500 volts.

The unit body is made of cast-aluminum, including the meter housing. The can is 1/16 aluminum. Other operating features of the instrument include a unimorph speaker mounted to the instrument can with an audio ON-OFF capability, fast-slow meter response, meter reset button and a 5-position switch for selecting battery check or scale multiples of X0.1, X1 and X10. Each range multiplier has its own calibration potentiometer.

Any G-M probe offered by the company will operate on this unit as well as many of the scintillator-type detectors. The instrument is set for 900 volts G-M tube operation. For special requirements, it may be adjusted for operation with any G-M or scintillator tube between 400 and 1500 volts.

The unit is operated with two flashlight batteries for operation from 150° to approximately 32°F. For temperature operation to 0°F, either very fresh alkaline or rechargeable NiCd batteries may be used. Battery drain averages 30 milliamperes.

### 2. SPECIFICATIONS

POWER: two standard "D" size batteries

THREE LINEAR RANGES: from 0 to 50 mR/hr; meter scale presentation - 0 to 5 mR/hr with range multiples of X0.1, X1, X10; 0 to 5K Counts-per-Minute option

SENSITIVITY: 40 millivolts, (+20mV, -16mV)

AUDIO: built-in unimorph speaker with an ON-OFF switch

HIGH VOLTAGE: externally adjustable from 400 to 1500 volts

RESPONSE: 5 or 25 seconds for 90% of final reading

LINEARITY: plus or minus 5% full scale

CALIBRATION STABILITY: less than 1% variance to battery end point

## MODEL 2 SURVEY METER

MOTION: 1mA, pivot-and-jewel movement, 2 1/2-inch scale

CONNECTOR: Series "C", 700 U/G (BNC or MHV may also be provided).

SIZE: 3.4 x 3.5 x 7.0 inches (H x W x L) exclusive of handle

WEIGHT: 3.5 pounds less detector

### 3. DESCRIPTION OF CONTROLS AND FUNCTIONS

Range Multiplier Selector Switch is a 3-position switch marked OFF, BAT, X10, X1, X0.1. Turning the range selector switch from OFF to BAT position provides operator a battery check of the instrument. A BAT check scale on the meter provides a visual means of checking the battery status. Moving the range selector switch to one of the range multiplier positions (X0.1, X1, X10) provides the operator with an overall range of 0-50 mR/hr (0-50K if the CPM scale is installed). Multiply the scale reading by the multiplier for determining the actual reading.

AUDIO ON-OFF Toggle Switch, in the ON position, operates the unimorph speaker, located on the left side of the instrument. The frequency of the clicks is relative to the rate of the incoming pulses. The higher the rate is, the higher the audio frequency. The audio should be turned OFF when not required to reduce battery drain.

Fast-Slow Toggle Switch provides meter response. Selecting the "F" position of the toggle switch provides 90% of final reading in 5 seconds. In "S" position, 90% of final reading takes 25 seconds. When the instrument is set on "F", there is fast response and large meter deviation. When it is set on "S" position, there is a slow response and damped meter deviation.

RBS Button, when depressed, provides a rapid means to drive the meter to zero.

High Voltage Adjustment provides a means to vary the high voltage from 400 to 1500 volts. The high voltage setting may be checked at the connector with an appropriate voltmeter.



## LADLUM MODEL 2 SURVEY METER

Range Calibration Adjustments are recessed potentiometers located on line with each multiplier position. These adjustment controls allow individual calibration for each range multiplier.

### 4. OPERATING PROCEDURES

- 4.1 Slide the battery box button to the rear, open the lid and install two "D" size batteries. Note (+) (-) marks on the inside of the lid. Match battery polarity to these marks.

NOTE: Center post of flashlight battery is positive.

DO NOT TWIST LID BUTTON - It slides to rear.

Close the battery box lid.

- 4.2 Switch the range switch to BAT. The meter should deflect to the battery check portion of the meter scale. If the meter does not respond, recheck that the batteries have proper polarity.
- 4.3 Connect the cable to the instrument and detector.
- 4.4 Turn the instrument range switch to M10. Expose the detector to a check source. The speaker should click with the AUDIO ON-OFF switched to ON.
- 4.5 Move the range switch to the lower scales until a meter reading is indicated. The toggle switch labeled P-S should have fast response in "F", slow response in "S".
- 4.6 Depress the RES switch. The meter should zero.
- 4.7 Proceed to use the instrument.

### 5. CALIBRATION

- 5.1 Detector Operating Point: Adjust the high voltage (HV) control for 900 volts at the instrument connector. Use G-M detectors.

NOTE: If an electrostatic voltmeter is not available, use an ordinary volt-ohm-milliammeter with an attenuator to provide at least 20,000 ohms-per-volt meter resistance. Select the appropriate scale and then adjust the high voltage to read 250 volts.

Do not use a vacuum-tube-type voltmeter for this adjustment unless an external high voltage multiplier probe is used.

Turn the instrument to X10. Expose the instrument to a calibrated gamma field and vary the range calibration adjustment control for proper reading.

- 5.2 Special Use Calibration: For special G-M detector applications, the power supply may be adjusted for 450-volt and 1200-volt G-M tubes. Follow the above procedure, except set the supply at the new operating voltage.

For scintillation counters, connect the scintillator. Expose the unit to a source and develop an operating voltage versus count-rate plot. Set the operating voltage at the flattest portion of this curve; then proceed to adjust each calibration control for the desired meter reading.

- 5.3 Calibrating CPM Scale: To calibrate CPM scale, a precision pulse generator is required. The pulse generator should be capable of providing a 40-millivolt or greater negative pulse with a rise time of 1 microsecond and a pulse-width of 5 microseconds.

Connect the pulse generator to the instrument and adjust the pulse frequency to provide 4/5-scale deflection on the X10 range (40,000 CPM). Adjust the X10 range calibration potentiometer as required. Decrease the pulse frequency by one decade and move the range multiplier switch to the X1 position. Adjust the X1 range calibration potentiometer as required (4,000 CPM). Decrease the pulse frequency by another decade. Move the range multiplier to X0.1 and adjust the calibration potentiometer as required (400 CPM).

3. MAINTENANCE:

NOTE: NEVER STORE THE INSTRUMENT OVER 30 DAYS WITHOUT REMOVING BATTERIES. ALTHOUGH THIS INSTRUMENT WILL OPERATE AT VERY HIGH AMBIENT TEMPERATURES, BATTERY SEAL FAILURE CAN OCCUR AT TEMPERATURES AS LOW AS 10 DEGREES FAHRENHEIT. NEGLECTED BATTERY SEAL FAILURE WILL SURELY CAUSE ONE AWFUL MESS!

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and calibration. Once initial calibration is performed, recalibration should not be required if the batteries are maintained in good condition.

An instrument operational check should be performed prior to each use by exposing the detector to a known source and confirming a proper reading on each scale.

Under certain conditions, NRC requires instrument recalibration every three months. Check the appropriate regulations to determine a recalibration schedule.

Also at three month intervals, the batteries should be removed and the battery contacts cleaned of any corrosion. If the instrument has been exposed to very dusty or corrosive atmosphere, more frequent battery servicing should be used.

Use a spanner wrench to unscrew the battery contact insulators, exposing the internal contacts and battery springs. Removing the handle will facilitate access to these contacts.



LOBLON MODEL 2 SURVEY METER

BILL OF MATERIALS

CIRCUIT BOARD, DRAWING 176 X 4

CAPACITORS

		Part No.
C1	100PF, 3KV, C	
C2	.01MF, 50V, C	04-5532
C3	500PF, 500V, C	04-5523
C4	.0047MF, 100V, P	04-5555
C5	.01MF, 50V, C	04-5510
C6	22MF, 20V, OST	04-5523
C7-C8	100MF, 10V, DST	04-5579
C9	4.7MF, 10V, OST	04-5576
C10	.1MF, 10V, C	04-5578
C11	4.7MF, 10V, OST	04-5521
C12	22MF, 20V, T	04-5578
C13	.01MF, 50V, C	04-5579
C14	.1MF, 10V, C	04-5523
C15	100MF, 10V, OST	04-5521
C16	1MF, 35V, OST	04-5576
C17	.1MF, 10V, C	04-5575
C18	100PF, 3KV, OST	04-5521
C19	.005MF, 2KV, C	04-5532
C20	.001MF, 3KV, C	04-5520
C21-C23	.001MF, 1KV, C	04-5510
C24	.01MF, 50V, C	04-5519
		04-5523

TRANSISTORS

Q4	MPS6534	
Q5-Q6	2N3877	05-5763
Q7	MPS6534	05-5758
		05-5763

INTEGRATED CIRCUITS

U1	CA3096	
U2	CD4093	06-6023
U3	CD4098	06-6030
U4	CA3096	06-6066
U5-U6	LM358	06-6023
		06-6024

LUDLUM MODEL 2 SURVEY METER

DIODES

CR1	1N34A	
CR2-CR5	1N4007	07-6253
CR6-CR10	1N4148	07-6274
CR11	LM385 2-1.2	07-6272
		05-5808

RESISTORS

R1	22K	10-7070
R2	2.7M	10-7029
R3	10K	10-7016
R4	470K	10-7026
R5	1M	10-7028
R6	12K	10-7048
R7	SAT @ 820K	10-7063
R8	1M	10-7028
R9	3.3K	10-7013
R10	560K	10-7027
R11	100K	10-7023
R12	75K	10-7074
R13	1M	10-7028
R14	2.7M	10-7029
R15	82K	10-7022
R17	33K	10-7019
R18	1K	10-7009
R20	270	10-7007
R21	6.2K	10-7023
R22	82K	10-7022
R23	100K	10-7023
R28	220K	10-7066
R29	330 OHM	10-7053
R30	470K	10-7026
R31	75K	10-7074
R32	10K	10-7016
R33	15K	10-7017
R34	100K 1%	12-7557
R35	16.5K 1%	12-7541
R36	10K	10-7016
R37	1.5K	10-7065
R38	200 OHM	10-7006
R39	10M	10-7031
R40	1M	10-7028
R41	SAT (TYP. 2.2K)	10-7012
R42	100K	10-7023
R43	1 GIG OHM	12-7606

WALDON MODEL 2 INVERT METER

TRANSFORMERS

T1	L9050	40-0902
T2	LVPS	40-0940

MISCELLANEOUS

7 EACH	CLOVERLEAF RECEPTACLES 011-6809	18-8771
1 EACH	WALDON 16-06-0007 SMALL RECEPTACLE	18-8792
1 EACH	WALDON 16-06-0004 LARGE PIN	18-8795

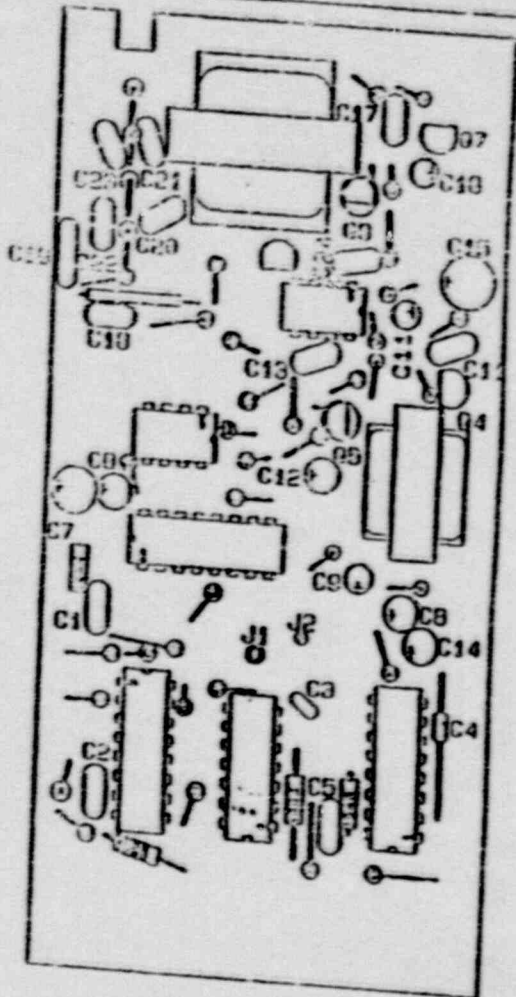
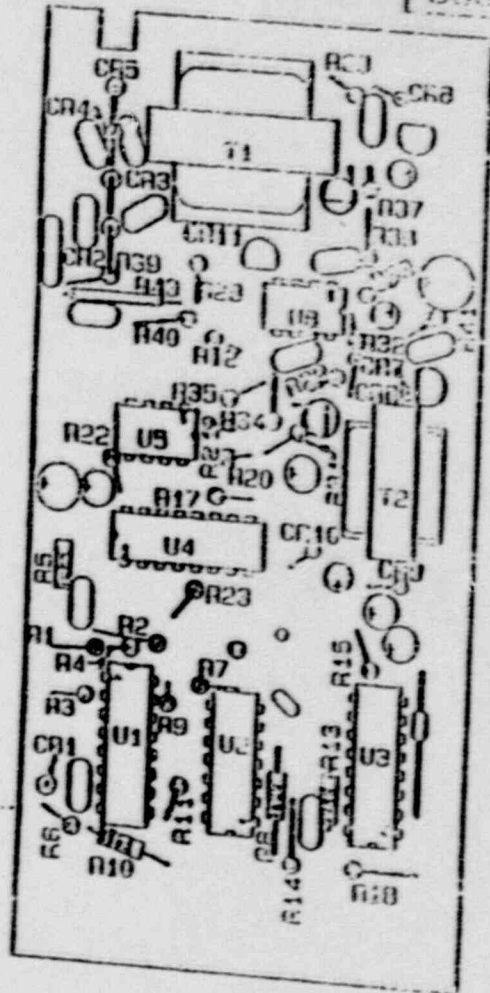
ASSEMBLED CIRCUIT BOARD

5176-001-00





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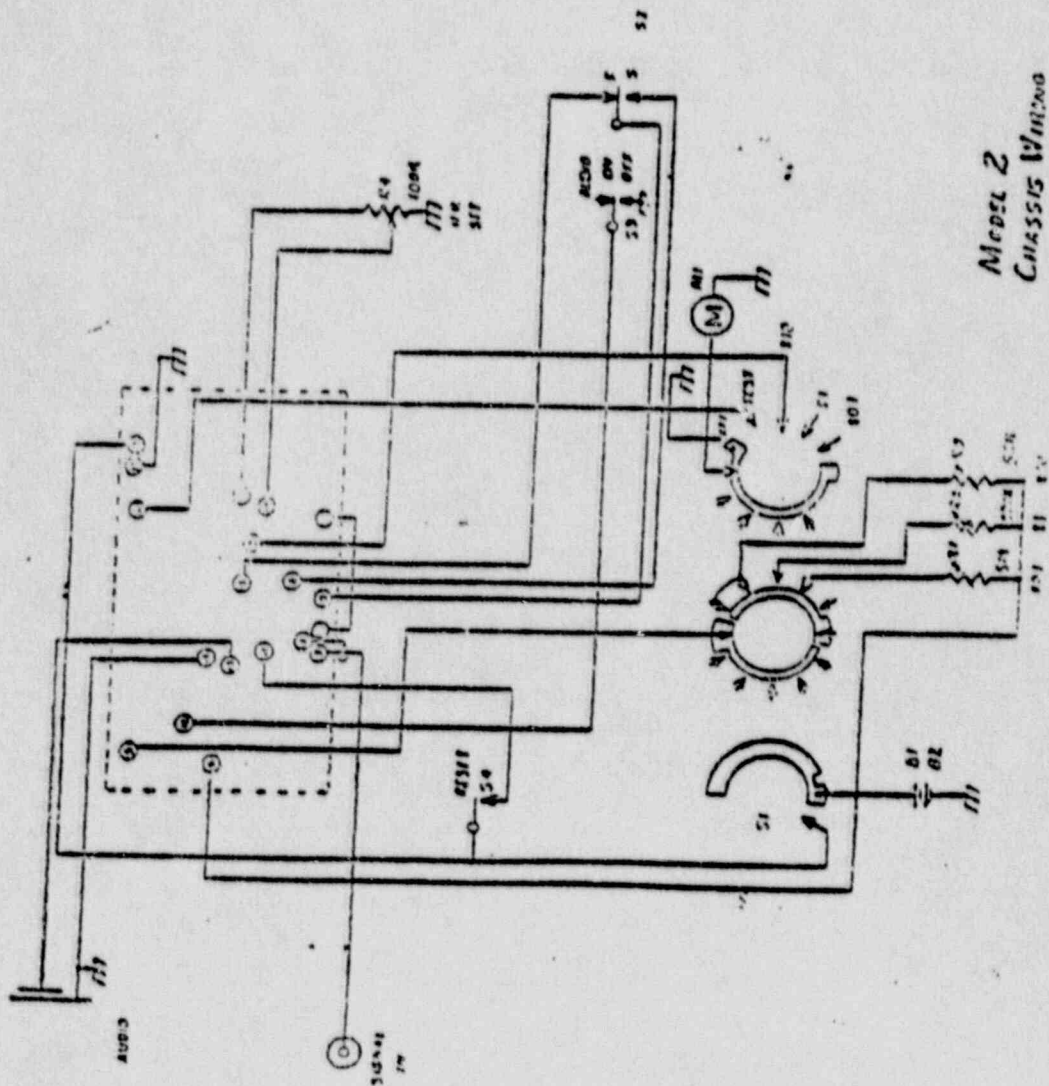
LUDLUM MODEL 2 SURVEY METER

BILL OF MATERIALS

CHASSIS WIRING DIAGRAM, DRAWING NO. 176 X 3

		Part No.
<b>AUDIO</b>		
DS1	DNIMORPE 60690	21-9251
<b>CONNECTOR</b>		
P1	SERIES "C" UG 706/0	13-7751
<b>SWITCHES</b>		
S1	CENTRALAB PA600-210	08-6501
S2	RESPONSE P/S MST 105-D	08-6511
S3	AUDIO ON-OFF MST 105-D	08-6511
S4	RESET 30-1 P/B	08-6517
<b>POTENTIOMETERS</b>		
R1	5M LOCK POTENTIOMETER	09-6753
R2	500K LOCK POTENTIOMETER	09-6752
R3	50K LOCK POTENTIOMETER	09-6773
R4	100K LOCK POTENTIOMETER	09-6703
<b>BATTERY :</b>		
BW1-BW2	"D" DURACELL BATTERY	21-9313
<b>MISCELLANEOUS</b>		
MODEL 2 CASTING		7176-019-01
MODEL 2 BARNES		8176-021-00
PORTABLE HANDLE		8176-021-00
PORTABLE METER		40-1805
MODEL 2 BATTERY BOX LID		7001-012-01
MODEL 295 BATTERY CONTACT SET		40-1707
PORTABLE KNOB		08-6613





Model 2  
CHASSIS WIRING

# Instruction Manual

MODEL 3 SURVEY METER

**LUDDLUM MEASUREMENTS, INC.**  
221 OAK                      015 - 222-5124                      P. O. BOX 220  
DENTON, TEXAS, U.S.A. 75201

DESIGNED AND MANUFACTURED  
OF  
*Scientific and Industrial*  
INSTRUMENTS

## WARRANTY CERTIFICATE

Ludlum Measurements, Inc. warrants the products covered in this Instruction Manual to be free of defects due to workmanship, materials, and design for a period of twelve months from date of delivery, with the exception of photo tubes and geiger tubes, which are warranted defect free to 90 days.

In event of instrument failure, notify Ludlum Measurements Inc. for repair or replacement. Liability of this warranty is limited to the purchase price of the instrument.

### RECEIVING CONDITION EXAMINATION:

Be sure to verify that the shipping carton is received in perfectly good condition. For example, that no damage should be visible.

Should the instrument be received in a damaged condition, save the shipping container and the packing material and request an immediate inspection by the carrier.

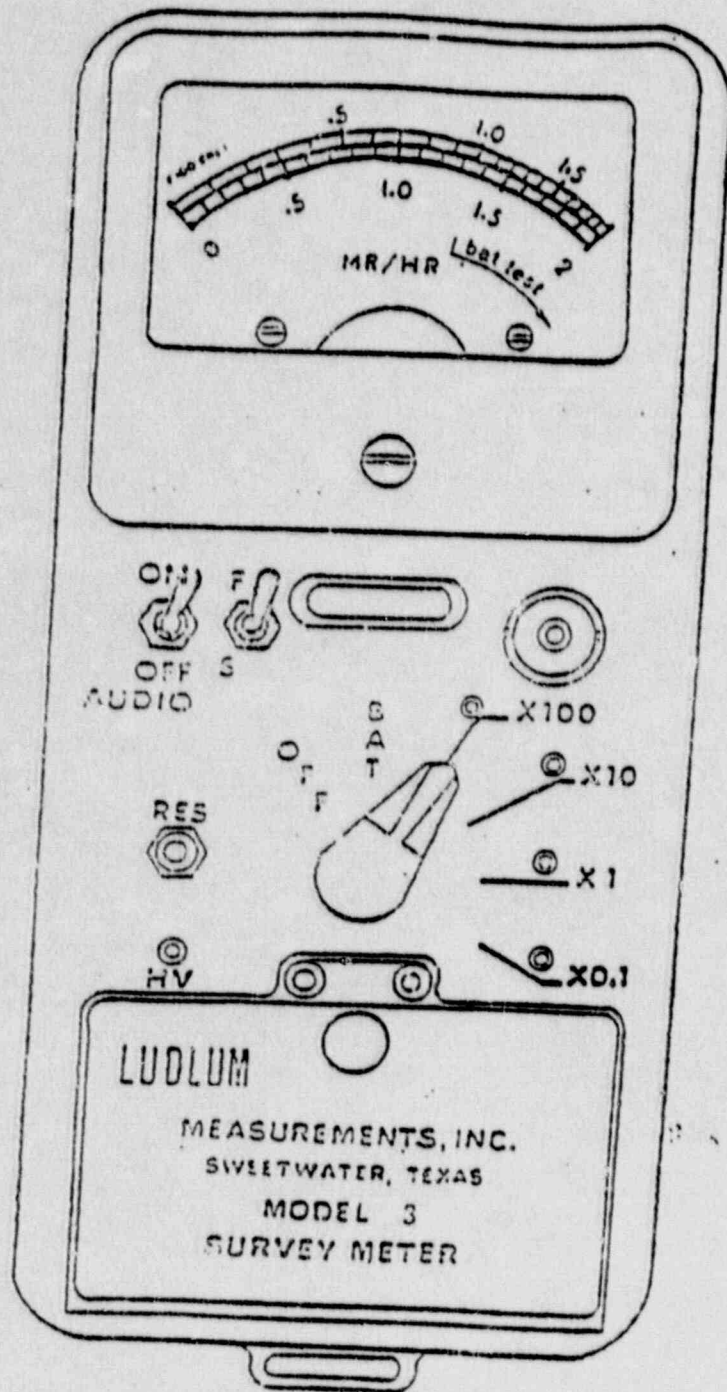
Ludlum Measurements, Inc. is not responsible for the damage which occurs during shipment but will make every effort to help obtain restitution from the carrier.

### RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair, calibration, etc., please do so by the appropriate method of shipment. All shipments should include documentation containing shipping address, customer name and telephone number, and all other necessary information.

Your cooperation will expedite the return of your equipment.





LUDLOW MODEL 3 SURVEY METER

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7. BILLS OF MATERIALS AND SCHEMATICS	7

## **LUDLUM MODEL 3 SURVEY METER**

### **1. GENERAL**

The Model 3 is a portable survey instrument that operates on two standard "D" cell flashlight batteries. The instrument features a regulated high-voltage, power supply adjustable from 400 to 1500 volts and provides a 4-linear range from 0-200 mR/hr.

The unit body is made of cast aluminum, including the meter housing. The can is 1/16 aluminum. Other operating features of the instrument include a unimorph speaker mounted to the instrument can with an audio ON-OFF capability, fast-slow meter response, meter reset button and a 6-position switch for selecting battery check or scale multiples of X0.1, X1, X10 and X100. Each range multiplier has its own calibration potentiometer.

Any G-M probe offered by the company will operate on this unit as well as many of the scintillator-type detectors. The instrument is set for 900-volt, G-M tube operation. For special requirements, it may be adjusted for operation with any G-M or scintillator tube between 400 and 1500 volts.

The unit is operated with two flashlight batteries for operation from 150° to approximately 32°F. For temperature operation to 0°F, either very fresh alkaline batteries or rechargeable NiCd batteries may be used. Battery drain averages 30 milliamperes.

### **2. SPECIFICATIONS**

**POWER:** two standard "D" size batteries

**FOUR LINEAR RANGES:** from 0 to 200 mR/hr; meter scale presentation - 0 to 2 mR/hr with range multiples of X0.1, X1, X10, X100; 0 to 5K Counts-per-Minute option

**SENSITIVITY:** 40 millivolts, (+20mV, -16mV)

**AUDIO:** built-in unimorph speaker with an ON-OFF switch

**HIGH VOLTAGE:** externally adjustable from 400 to 1500 volts

**RESPONSE:** 5 or 25 seconds for 90% of final meter reading

**LINEARITY:** plus or minus 5% full scale LINEARITY.



## ROBINSON MODEL 3 SURVEY METER

**CALIBRATION STABILITY:** less than 1% variance to battery end point

**METER:** 1mA, 2 1/2-inch scale, with pivot-and-jewel suspension

**CONNECTOR:** Series "C", 706 U/G; BNC or MHV may also be provided

**SIZE:** 3.4 x 3.5 x 7.0 inches (H x W x L exclusive of handle)

**WEIGHT:** 3.5 pounds less detector

**FINISH:** drawn-and-cast aluminum, with computer-beige polyurethane enamel and silk-screened nomenclature.

### 3. DESCRIPTION OF CONTROLS AND FUNCTIONS

Range Multiplier Selector Switch is a 6-position switch marked OFF, BAT, X100, X10, X1, X0.1. Turning the range selector switch from OFF to BAT position provides the operator a battery check of the instrument. A BAT check scale on the meter provides a visual means of checking the battery status. Moving the range selector switch to one of the range multiplier positions (X0.1, X1, X10, X100) provides the operator with an overall range of 0-200 mR/hr (0-500K if the CPM scale is installed). Multiply the scale reading by the multiplier for determining the actual reading.

AUDIO ON-OFF Toggle Switch in the ON position operates the unimorph speaker, located on the left side of the instrument. The frequency of the clicks is relative to the rate of the incoming pulses. The higher the rate is, the higher the audio frequency. The audio should be turned OFF when not required to reduce battery drain.

Fast-Slow Toggle Switch provides meter response. Selecting the "F" position of the toggle switch provides 90% of the final meter reading in 5 seconds. In "S" position, 90% of the final meter reading takes 11 seconds. In "F" position there is fast response and large meter deviation. In "S" position there is a slow response and damped meter deviation.

RDS Button, when depressed, provides a rapid means to drive the meter to zero.

## LONDON MODEL 3 SWIVEL METER

High Voltage Adjustment provides a means to vary the high voltage from 400 to 1500 volts. The high voltage setting may be checked at the connector with an appropriate voltmeter.

Range Calibration Adjustments are recessed potentiometers located on line with each multiplier position. These adjustment controls allow individual calibration for each range multiplier.

### 4. OPERATING PROCEDURES

- 4.1 Slide the battery box button to the rear. Open the lid and install two "D" size batteries. Note (+) (-) marks on the inside of the lid. Match the battery polarity to these marks.

NOTE: Center post of flashlight battery is positive.

DO NOT TWIST LID BUTTON - It slides to rear.

Close the battery box lid.

- 4.2 Switch the range switch to BAT. The meter should deflect to the battery check portion of the meter scale. If the meter does not respond, recheck that the batteries have proper polarity.
- 4.3 Connect the cable to the instrument and detector.
- 4.4 Turn the instrument range switch to K100. Expose the detector to a check source. The speaker should click with the AUDIO ON-OFF switched to ON.
- 4.5 Move the range switch to the lower scales until a meter reading is indicated. The toggle switch labeled F-S should have fast response in "F" and slow response in "S".
- 4.6 Depress the RES switch. The meter should zero.
- 4.7 Proceed to use the instrument.

## 5. CALIBRATION

- 5.1 Detector Operating Point: Adjust the HV control for 900 volts at the instrument connector for G-M detectors.

NOTE: If an electrostatic voltmeter is not available, use an ordinary volt-ohm-milliammeter with an attenuator to provide at least 20,000 ohms-per-volt meter resistance. Select the appropriate scale and then adjust high voltage to read 850 volts.

Do not use a vacuum-tube-type voltmeter for this adjustment unless an external high voltage multiplier probe is used.

Turn the instrument to X100. Expose the instrument to a calibrated gamma field and vary the range calibration adjustment control for proper reading.

- 5.2 Special Use Calibration: For special G-M detector applications, the power supply may be adjusted for 450-volt and 1200-volt G-M tubes. Follow the above procedure, only set the supply at the new operating voltage.

For scintillation counters, connect the scintillator. Expose the unit to a source and develop an operating voltage versus count-rate plot. Set the operating voltage at the flattest portion of this curve; then proceed to adjust each calibration control for the desired meter reading.

- 5.3 Calibrating CPM Scale: To calibrate the CPM scale, a precision pulse generator is required. The pulse generator should be capable of providing a 40-millivolt, or greater, negative pulse with a rise time of 1 microsecond and a pulse width of 5 microseconds.

Connect the pulse generator to the instrument and adjust the pulse frequency to provide a 4/5-scale deflection on the X100 range (400,000 CPM). Adjust the X100 range calibration potentiometer as required. Decrease the pulse frequency by decades and adjust each range calibration potentiometer accordingly.



## DUDDON MODEL 3 SURVEY METER

### 6. MAINTENANCE

NOTE: NEVER STORE THE INSTRUMENT OVER 30 DAYS WITH REMOVING BATTERIES. ALTHOUGH THIS INSTRUMENT CAN OPERATE AT VERY HIGH AMBIENT TEMPERATURES, BATTERY SEAL FAILURE CAN OCCUR AT TEMPERATURES AS LOW AS 100° FAHRENHEIT. NEGLECTED BATTERY SEAL FAILURE WILL SURELY CAUSE ONE AWFUL MESS!

Instrument maintenance consists of keeping the instrument clean and periodically checking batteries and calibration. Once initial calibration is performed, recalibration should not be required if batteries are maintained in good condition.

An instrument operational check should be performed prior to each use by exposing detector to a known source and confirming proper reading on each scale.

Under certain conditions, NRC requires instrument recalibration every three months. Check the appropriate regulations to determine recalibration schedule.

Also at three month intervals, the batteries should be removed and the battery contacts cleaned of any corrosion. If the instrument has been exposed to very dusty or corrosive atmosphere, more frequent battery servicing should be used.

Use a spanner wrench to unscrew the battery contact insulators, exposing internal contacts and battery spring. Removing the handle will facilitate access to these contacts.

LOBLON MODEL 3 SURVIVY METER

BILL OF MATERIALS

CIRCUIT BOARD, DRAWING 176 X 17

CAPACITORS

C1	100PF, 3KV, C	
C2	.01MF, 100V, C	04-5532
C3	470PF, 100V, C	04-5523
C4	.0047MF, 100V, P	04-5555
C5	.01MF, 100V, C	04-5513
C6	22MF, 15V, DT	04-5523
C7-C8	100MF, 10V, DST	04-5579
C9	4.7MF, 10V, DT	04-5576
C10	.1MF, 100V, C	04-5578
C11	4.7MF, 10V, DT	04-5521
C12	22MF, 15V, DT	04-5578
C13	.01MF, 100V, C	04-5579
C14-C15	100MF, 10V, DT	04-5523
C16	1MF, 35V, OST	04-5576
C17	.1MF, 100V, C	04-5575
C18	100PF, 3KV, C	04-5521
C19	.0027MF, 3KV, C	04-5532
C20-C23	.0015MF, 3KV, C	04-5520
C24	.01MF, 100V, C	04-5513
C25	470PF, 100V, C	04-5523
		04-5555

TRANSISTORS

Q4	MPS6534	
Q5-Q6	2N3877	05-5763
Q7	MPS6534	05-5758
		05-5763

INTEGRATED CIRCUITS

U1	CA3096	
U2	CD4093	06-6023
U3	CD4098	06-6030
U4	CA3096	06-6066
U5-U6	LM358	06-6023
		06-6024

LUDLUM MODEL 3 SURVIVOR METER

DIODES

CR1	1N34A	07-6253
CR2-CR5	1N4007	07-6274
CR6-CR10	1N4148	07-6272
CR11	LM305, 1.2V	05-5808

RESISTORS

R1	22K	10-7070
R2	2.7M	10-7029
R3	10K	10-7016
R4	470K	10-7026
R5	1M	10-7028
R6	12K	10-7048
R7	1M	10-7023
R8	1M	10-7028
R9	3.3K	10-7013
R10	560K	10-7027
R11	100K	10-7023
R12	75K	10-7074
R13	1M	10-7028
R14	2.7M	10-7029
R15	82K	10-7022
R17	33K	10-7019
R20	270	10-7007
R21	8.2K	10-7015
R22	82K	10-7022
R23	100K	10-7023
R28	SAT	
R29	330 OHM	10-7053
R31	75K	10-7074
R32	10K	10-7016
R33	4.7K	10-7014
R34	100K 10	12-7557
R35	16.5K 10	12-7541
R36	10K	10-7016
R37	1K	10-7009
R38	200 OHM	10-7006
R39	10M	10-7031
R40	1M	10-7028
R41	SAT (TYP.2.2K)	10-7012
R51	75K	10-7074
R52	1 GIG OHM	12-7686
R58	4.7K	10-7014



LUDLOR MODEL 3 SURVEY METER

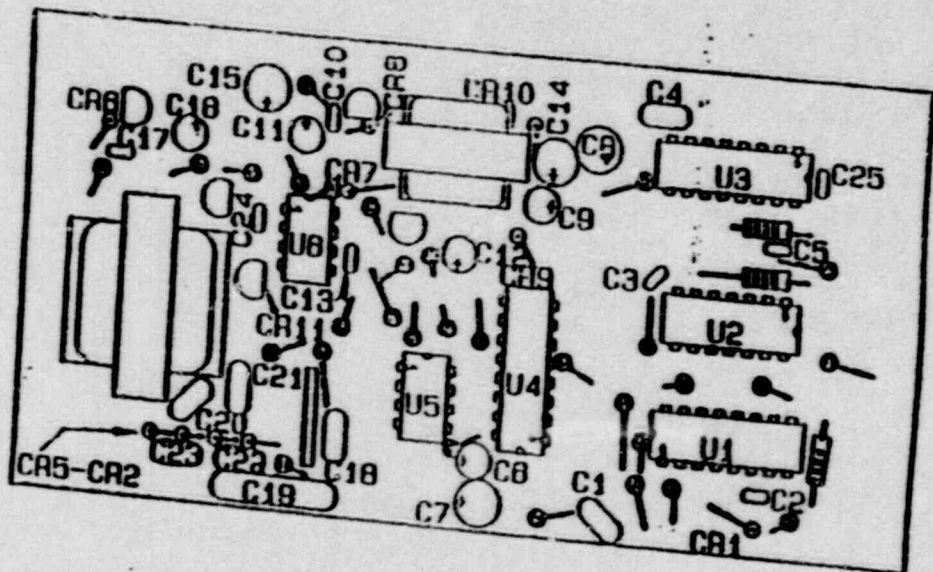
TRANSFORMERS

T1	L8050	
T2	LVP8	40-0902
		40-0944

MISCELLANEOUS

7 EACH	CLOVERLEAF RECEPTACLES 011-6809	18-8771
1 EACH	WALDON 16-06-0007 SMALL RECEPTACLE	18-8792
1 EACH	WALDON 16-06-0004 LARGE PIN	18-8795

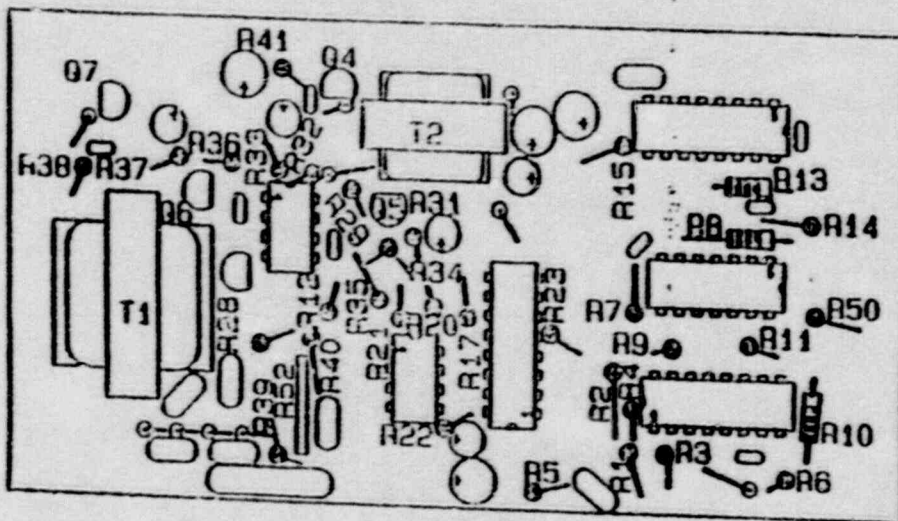




DESC: CIRCUIT BOARD.	
BOARD #: 5176-017	
DWN: S.L.C.	DATE: 10-23-86
DSGN:	DATE:

REV	DATE	BY	CHKD
01	10-23-86	SLC	SLC
02			
03			
04			
05			
06			
07			
08			
09			
10			





DESC: CIRCUIT BOARD	
BOARD #: 5176-017	
DWN: S. I. C.	DATE: 10-23-68
DSGN:	DATE:

00 00  
 100 00 00 00  
 100 00 00 00

ROBSON MODEL 3 SURVEY METER

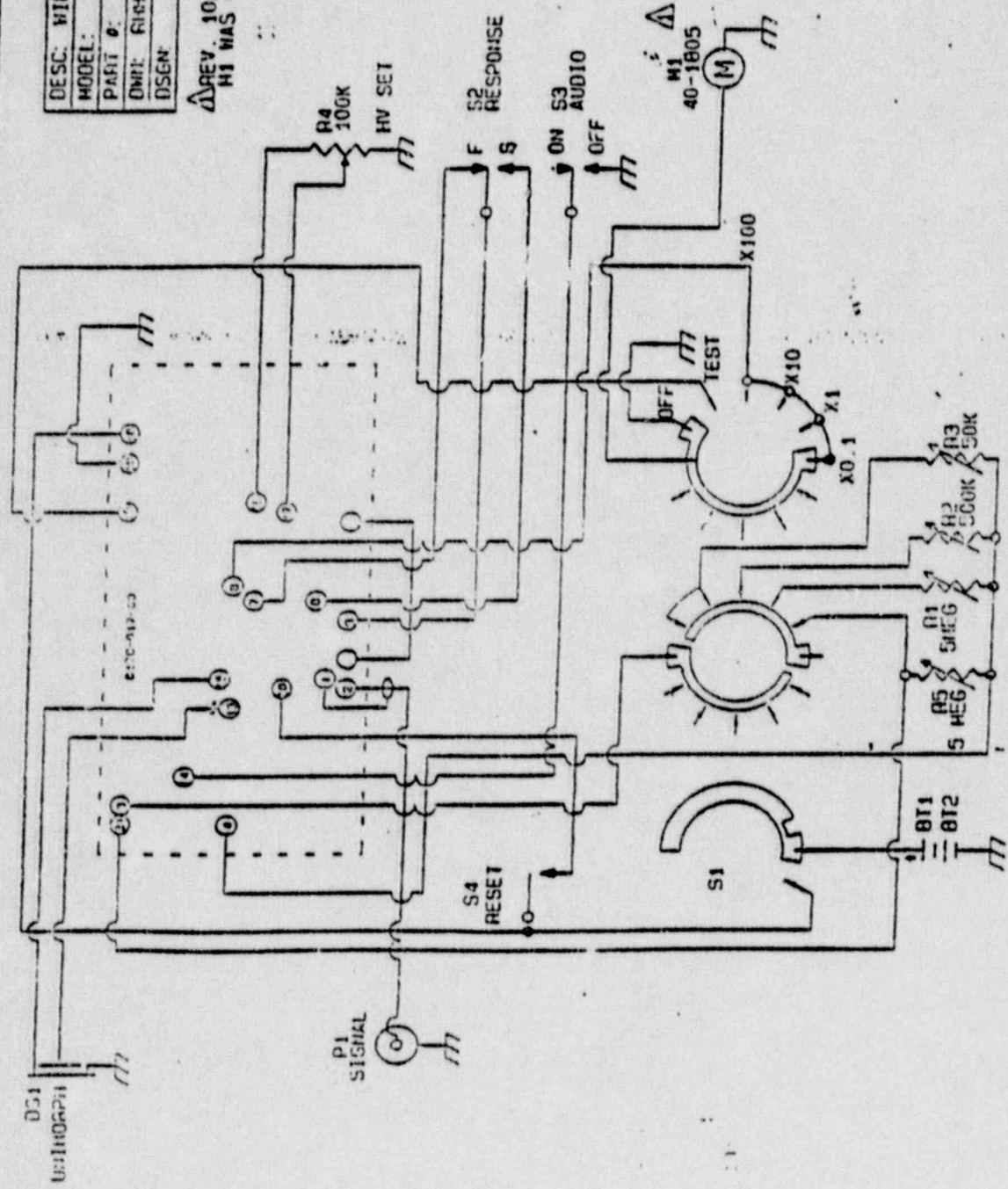
BILL OF MATERIALS

CHASSIS WIRING DIAGRAM, DRAWING NO. 176 X 18

AUDIO		PART NO.
DS1	UNIMORPH 60690	21-523
CONNECTOR		
P1	SERIES "C" UG 706/U	13-773
SWITCHES		
S1	CENTRALAB PA600-210	08-6301
S2	RESPONSE F/S MST 105-D	08-6511
S3	AUDIO ON-OFF MST 105-D	08-6511
S4	RESET 30-1 P/B	08-6511
POTENTIOMETERS		
R42	5M LOCK POTENTIOMETER	09-6711
R43	500K LOCK POTENTIOMETER	09-6711
R44	50K LOCK POTENTIOMETER	09-6711
R45	100K LOCK POTENTIOMETER	09-6711
R46	5M LOCK POTENTIOMETER	09-6711
BATTERY		
BT1-BT2	"D" DURACELL BATTERY	21-5311
MISCELLANEOUS		
MODEL 3 ASSEMBLED CIRCUIT BOARD		5176-017-01
MODEL 3 CASTING		7063-053-01
MODEL 3 HARNESS		0176-020-01
PORTABLE HANDLE		7001-012-01
PORTABLE METER		40-1001
MODEL 3 BATTERY BOX LID		7203-006-01
MODEL 295 BATTERY CONTACT SET		40-1701
PORTABLE KNOB		08-1111

DESC: WIRING 01-6000  
 MODEL: 3  
 PART #: 176-C10  
 DATE: 10/25/60  
 DSGN: I DATE:

REV. 10/80 (46566)  
 H1 WAS 40-1801



11116 LABEL 3 01 1960  
 MILITARY  
 ELECTRONICS  
 LABORATORY



Addendum E  
Radiation Safety Program

## A. Radiation Safety Officer

### The Radiation Safety Officer

The RSO is responsible for the following:

1. Maintaining the radioactive material license in a compliance state.
2. Providing training of personnel to insure that safe procedures in the laboratory are practiced.
3. Providing consultation to management and radiation workers on all matters relating to radiation safety.
4. Be available to respond to any radiation emergency.
5. Reviewing all proposed procedures to insure that staff personnel will not become unnecessarily exposed to radiation. In addition, the RSO will insure that maximum permissible concentrations in air and water are within acceptable limits.
6. Insuring that the following documents are properly posted in the laboratory:
  - a. Radioactive Material license and all supporting documents
  - b. Appropriate state regulations or NRC Parts 19 and 20
  - b Notice to Employees,
  - d. Emergency Procedures
7. Advising radiation workers of any unusual procedures which they must employ in order to reduce unnecessary exposure. Also, advising workers of the location of radioactive material, and their responsibilities with regard to the safe use of radioactive materials.
8. Preparing any requests for license amendments.
9. Conducting a monthly physical inventory of all radioactive material to insure that possession limits are not exceeded.

## B. Health Physics Surveys

On a weekly basis, the RSO will conduct a radiation safety survey of all areas where radioactive materials are used or stored. The surveys will include the following:

1. A survey of the work area by means of wipe tests. Wipe tests will be conducted using 25mm diameter filter paper circles. For each test, a 100 cm<sup>2</sup> area will be wiped, and results determined by counting filters in the Model CTC-4 Beta Detector. This instrument has a counting efficiency for Phosphorus 32 on dry filters of 0.4. Results will be recorded as disintegrations per minute (DPM). Permissible contamination levels have been established at 500 dpm per 100 cm<sup>2</sup>. Contamination detected in excess of this level will be reported immediately to the responsible user who will insure that appropriate decontamination is achieved. Follow-up reports will be submitted to the RSO accordingly.

A standard pattern of wipe tests will be performed weekly in all areas of possible contamination, including benchtop(s), floors, refrigerator door handle, water bath cover, sink used for disposal of aqueous phosphorus -32 waste.

2. Review radioactive material storage areas to insure that materials are properly shielded, stored in double containers and properly labelled.



### C. Authorized Users

The authorized user will be responsible within the department for the daily on-site management of radiation safety. They will report directly to the RSO who has overall responsibility if any of the following occurs:

1. Spill of radioactive material
2. Suspected overexposure of personnel
3. Malfunctioning radiation detection equipment
4. Contaminated shipment of radioactive material
5. Any other conditions that may result in unnecessary radiation exposure.

### D. Procedures for Ordering Radioactive Materials

Prior to placing an order, the inventory will be reviewed to insure that possession limits will not be exceeded. The RSO will review these inventories and related procedures on a monthly basis.

During normal working hours, carriers will be instructed to deliver radioactive material packages directly to the receiving department. There will be no after hour deliveries.

Incoming shipments will be examined visually. If the shipment appears wet or damaged, the RSO will be notified immediately.

The RSO will provide their office and home telephone numbers for any authorized user, and the numbers will be available in the laboratory.

E. Procedure for Safely Opening Packages Containing Radioactive Materials

1. Gloves will be worn to prevent hand contamination.
2. Packages will be visually inspected for any sign of damage (i.e. wetness, crushed, etc) If damage is noted, the procedure will be stopped and the RSD notified.
3. The external surface of the outer package will be surveyed with the survey meter and the results recorded. If a surface exposure rate of greater than 10 m REM/hr is obtained, the procedure will be stopped and the RSD notified.
4. The outer package will be opened in a restricted area in accordance with the manufacturer's directions (if supplied), and the packing slip removed. The inner package will be opened and the contents verified by comparing requisition, packing slip and label on the bottle. The final source container will be checked for breakage of seals or vials, loss of liquid, discoloration of packing materials, etc. The possession limits will be checked to insure they are not exceeded.
5. A wipe test will be performed on the outer surface of the final source container and results recorded. Contamination in excess of 500 dpm per 100 cm<sup>2</sup> will be reported to the RSD
6. Packing materials will be surveyed with the survey meter and results recorded before disposal.

#### F. General Rules for the Safe Use of Radioactive Material

1. laboratory coats and other protective clothing will be worn at all times in areas where radioactive materials are used.
2. Disposable gloves will be worn at all times while handling radioactive materials.
3. There will be no eating, drinking, smoking or application of cosmetics in any area where radioactive material is used or stored.
4. There will no storage of food, drink or personal effects with radioactive materials.
5. Radioactive waste will be disposed of only in specially designated receptacles.
6. No pipetting by mouth will be permitted.
7. Radioactive solutions will be confined in covered containers, plainly identified and labelled with name of compound, radionucleotide, date , activity and indication level , if applicable.
8. Radioactive materials will be locked when personnel are not present.
9. Emergency notification home telephone numbers will be posted in the laboratory.



## 6. Personnel Training Program

The personnel training program will be given to all personnel who work with radioactive materials. The training will be given in the form of lectures and the duration of each session will depend on the extent of applicability to the employees involved. The training program will be of sufficient scope to insure that all personnel receive proper instruction including:

1. Areas where radioactive materials are used or stored.
2. Potent hazards associated with radioactive materials.
3. Radiological safety procedures appropriate to their respective duties.
4. Pertinent regulations and terms of Radioactive Material License.
5. Rules and regulations of the license.
6. Their obligation to report unsafe conditions.
7. Appropriate responses to emergencies or unsafe conditions.
8. Their right to be informed of their radiation exposure.
9. Locations where the license is posted or made available notices and copies of pertinent licenses and license conditions (including applicable correspondence)

Personnel will be properly instructed as follows:

1. Before assuming duties with or in the vicinity of radioactive materials.
2. During annual refresher training.
3. Whenever there is a significant change in duties, regulations or in the terms of the license.

## H. Emergency Procedures

### 1. Radioactive Spills

- a. All persons in the area will be notified when a spill has occurred.
- b. The spill will be covered with absorbent paper to prevent its spread.
- c. Disposable gloves and tongs will be used to clean up the spill. The absorbent paper will be carefully folded, inserted into a plastic bag and disposed of in the radioactive waste container. All other contaminated materials such as disposable gloves will also be inserted into the plastic bag.
- d. The survey will be conducted using a low-range thin-end window G-M survey meter. The area will around the spill, hands and clothing will be checked for contamination.
- e. The incident will be reported to the Radiation Safety Officer.
- f. Decontamination will be accomplished by scrubbing the spill areas with an industrial cleaner using disposable towels until readings on the survey meter indicate background levels have been achieved.
- g. If the spill is on the skin, the area will be flushed thoroughly and washed with mild soap and lukewarm water.

ADDENDUM F  
WASTE MANAGEMENT



Management will insure that the volume of waste is minimized to the lowest practical level.

Short-lived radioactive material will be stored for decay until radioactive levels as measured in a low background area with a low-level survey meter with all shielding removed, have reached background levels, to insure that radiation levels do not exceed natural background. All radiation labels will be removed or obliterated and the waste will subsequently be disposed of in normal trash.

Liquid radioactive waste may be discharged into sanitary sewerage in accordance with the Regulations.

