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SECTION 1 - GENERAL REQUIREMENTS FOR ALL RADIOGRAPHY OPERATIONS

1.1.0 SCOPE AND INTENDED USE OF THIS MANUAL

This manual establishes procedures to be followed in the receipt, use, transport, and control of all sources of radiation owned by Lehigh Testing Laboratories for the purpose of industrial radiography.

1.1.1 Applicability and Distribution

Each of Lehigh's Radiographers and Assistant Radiographers who may be assigned to perform radiography via sealed radioactive sources shall be issued, be trained in, and be required to demonstrate understanding of the following Sections of this Radiation Safety Manual:

Section 1 - General Requirements for all Radiography Operations;
Section 2 - Specific Procedures for Gamma Radiography

Lehigh's NRC license to possess, use and transfer sealed sources and source containers incorporates the requirements in these two sections of the Manual, and none of these provisions may be changed without first obtaining written approval by the NRC. The latest revisions of these sections must be physically present at all gamma radiography operations.

1.1.2 Referenced Documents

- this Manual has been prepared to comply with the following laws, which are incorporated here by reference:

- Title 10, Code of Federal Regulations (Nuclear Regulatory Commission):
  Part 19 - Notices, Instructions and Reports to Workers; Inspections;
  Part 20 - Standards for Protection against Radiation;
  Part 21 - Reporting of Defects and Noncompliance;
  Part 30 - Rules of General Applicability to Domestic Licensing of Byproduct Material;
  Part 34 - Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations;
  Part 71 - Packaging of Radioactive Material for Transport and Transportation of Radioactive Material under Certain Conditions

- Title 49, Code of Federal Regulations (Department of Transportation):
  Parts 170-189 and Parts 390-397 - Transporting Sealed Sources to Field Locations, Packaging of Exposure Devices and Storage Containers in the Vehicles, Posting of Vehicles and Control of Sealed Sources during Transportation

- Applicable Regulations of Agreement States

1.2.0 DEFINITIONS OF KEY TERMS USED IN THIS MANUAL Within the context of industrial radiography at Lehigh, the following terms are used:

Activity - a measure of the strength of a radioactive source. Activity is expressed in terms of Curies (Ci).

Agreement State - a state which has entered into an agreement with the NRC by which the state assumes the responsibility for regulation of certain uses of radioactive material, including industrial radiography. As of November, 1982, in the Northeastern United States, Kentucky, Maryland, New York and New Hampshire are Agreement States. (All others in this region are regulated by the NRC.)

Assistant Radiographer - an individual, who under the personal supervision of a Radiographer, uses radiographic exposure devices, sealed sources or related handling tools or radiation survey instruments in radiography. An Assistant Radiographer has received some training and is being further trained to become a Radiographer.

Byproduct Material - any radioactive material, such as Cobalt-60 or Iridium-192, obtained as a byproduct of running nuclear reactors or making nuclear fuel.

Calendar Quarter - a three month period commencing on January 1, April 1, July 1 or October 1.

Calibration - adjustment of a meter or other instrument via direct comparison with a standard of known properties in order to make it functionally accurate. For example, radiation survey meters are periodically calibrated against a radiation source of known intensity to assure that they can measure radiation dose rates accurately.

Collimator - A small radiation shield made of lead or other heavy metal used in gamma radiography. A collimator is placed on the end of the guide tube and has a small opening through which a narrow cone of radiation escapes when the source is cranked into position. Use of a collimator can greatly reduce the size of the area to which access must be restricted.

Curie - a basic unit to describe the amount of radioactivity in a material. A Curie is a measure of the rate at which a radioactive material throws off particles or disintegrates. One Curie (Ci) is equal to 37 billion disintegrations per second.

Daily - when used in reference to Lehigh's maintenance, inspection, dosimeter or exposure records, "daily" refers to a day during which radiography is conducted.

1.2.0 DEFINITIONS OF KEY TERMS USED IN THIS MANUAL (cont'd)

Decay - The breaking up or disintegration of atoms that have excess energy. Radiation is emitted in the process.

Decay Curve - a graph showing the decreasing radioactivity of a radioactive source as time passes.

Dose - the quantity of radiation absorbed by the body or any portion of the body. Dose can be expressed in units of Roentgens, Rems, or Rads.

Dose Rate - a measure of how fast a radiation dose is being received. It is a dose per unit of time. For example, "The dose rate is 10 milliRems per hour (10 mR/hr)".

Dosimeter, Pocket - a small air-filled ionization chamber (about the size of a cigar) that measures cumulative radiation dose by responding to ionization in the air. The cumulative radiation dose may be determined at any time by reading the position of the quartz fiber hairline on the graduated scale inside the dosimeter.

Drive Cable - a cable used to push a source out of a crank-out camera (such as the Tech/Ops Model 660). Also called a control cable.

Exposure - being exposed to radiation. People can be exposed to a radiation dose, or a film can receive an exposure to radiation. In radiography, an "exposure" or "shot" is the making of a radiograph. Exposure is also a highly technical term meaning the amount of ionization in air caused by x-rays or gamma rays, which is measured in units of Roentgens.

Exposure Device - a container with a shield inside to hold a gamma radiography source. A means is provided to move the source outside of the shield to make radiographs. Also called a "Radiographic Exposure Device" or "Projector" or "Camera".

Film Badge - A radiation monitoring badge worn by personnel which measures cumulative radiation dose. The badge contains a piece of film that is darkened by radiation. The cumulative radiation dose is determined by processing the film and measuring the "darkness" of the film.

Gamma Alarm - a radiation detector that sounds an audible and/or a visible alarm when it detects excessive gamma ray or x-ray radiation.

Guide Tube - a hollow tube through which the radiography source travels when it is cranked out of its shielded position within the camera.

1.2.0 DEFINITIONS OF KEY TERMS USED IN THIS MANUAL (cont'd)

Half-Life - the time required for one-half of the atoms in a radioactive material to disintegrate (lose their radioactivity). The half-life of Iridium-192 is 75 days. Hence, a 50 Curie source of Iridium-192 has an activity of 25 Curies after 75 days, 12.5 Curies after 75 more days, etc.

High Radiation Area - any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 milliRem (100 mR).

Intensity - this term may refer to the strength or activity of a radioactive material ("the source intensity is 60 Ci"), or may be used in referring to dose rates ("the intensity of the radiation at the surface of the container is 20 mR").

Licensee - within the context of this manual, the holder of a license issued by the NRC to receive, possess, use or transfer radioactive material. Lehigh is a "licensee" of the NRC.

NRC - the U.S. Nuclear Regulatory Commission, a federal agency that regulates the use of certain radioactive materials in non-Agreement states.

Occupational Dose - includes exposure of an individual to radiation (a) in a restricted area; or (b) in the course of employment in which the individuals's duties involve exposure to radiation. "Occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy.

Overexposure, Radiation - receiving a radiation dose in excess of regulatory limits. Most radiation overexposures do not have any visible medical symptoms.

Pigtail - The part of a radiography source assembly that includes the short cable and connector. This term sometimes includes the source capsule as well.

Personnel Monitoring Equipment - devices worn or carried by an individual for the purpose of measuring the dose received (e.g., film badges, thermoluminescent dosimeter (TLD) badges, pocket dosimeters, film rings, etc.).

Placard - in transporting radioactive materials, a sign on a vehicle that indicates the vehicle is carrying packages containing radioactive materials that require "Radioactive Yellow III" labels on the packages.

1.2.0 DEFINITIONS OF KEY TERMS USED IN THIS MANUAL (cont'd)

Rad - a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One Rad is the dose corresponding to the absorption of 100 ergs per gram of tissue (one milliRad (mRad) = 0.001 Rad). For gamma rays and x-rays, one Rad is equal to one Roentgen or one Rem.

Radiation Area - for radiography operations at Lehigh, a "Radiation Area" is defined exactly the same as a "Restricted Area", that is, any area accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 2 milliRem (2 mR), or in any 7 consecutive days a dose in excess of 100 milliRem (100 mR).

Radiation Safety Officer - At Lehigh the Radiation Safety Officer is the individual who has been selected by the company to be responsible for active management control of the entire radiation safety program.

Radioactive Isotope - a form (isotope) of an element that exhibits radioactivity. For example, Iridium-192 is a radioactive isotope. Ir-191 and Ir-193 are other isotopes of Iridium, but neither one is radioactive.

Radioactive Material - a material containing unstable or radioactive atoms that break up or decay and emit radiation in the process.

Radioactivity - the emission of radiation from an unstable atom.

Radiographer - at Lehigh, an individual who performs or who, in attendance at a site where sources of radiation are being used, personally supervises the radiographic operations and who is responsible to Lehigh for assuring that the operations comply with the requirements of this manual.

Radiography - the use of penetrating radiation, such as x-rays or gamma rays, to characterize the internal structures of objects nondestructively.

Radiographic Operation - within the context of radiation safety, any operation in which an active source of radiation is used, manipulated or otherwise handled.

Rem - a unit of radiation dose. The Rem is a measure of the dose of any ionizing radiation of body tissue in terms of its estimated biological effect relative to a dose of one Roentgen (R) of x-rays. One Rem is equal to 1000 milliRems (1000 mR)

1.2.0 DEFINITIONS OF KEY TERMS USED IN THIS MANUAL (cont'd)

Restricted Area - any area to which access is controlled by the Radiographer for purposes of protecting individuals from exposure to radiation and radioactive materials. In terms of radiation levels, the Restricted Area is defined to be the same as the "Radiation Area", that is, any area accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 2 milliRem (2 mR), or in any 7 consecutive days a dose in excess of 100 milliRem (100 mR).

Sealed Source - any radioactive material encased in a capsule designed to prevent leakage or escape of the material.

Source Assembly - the radiography source, including the source capsule, the pigtail cable, and its connector to the drive cable.

Source Changer - a shielded container used for transferring encapsulated radioactive sources into exposure devices. The source changer also serves as a shipping container.

Special Form - radioactive material in a form that limits leakage or dispersal of the material. Radiography sources are special form materials because the radioactive material is contained in a steel capsule that has been welded closed.

Storage Container or Shipping Container or Source Changer - the radiation shielded device in which sealed sources may be stored, transported or used for source changing.

Surveillance - during radiography operations, the act of maintaining a constant watch over the worksite and surrounding areas to prevent unauthorized entry into the restricted area.

Survey - an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of the materials and equipment, and measurements of levels of radiation or concentrations of radioactive materials present.

Survey Meter - a portable instrument that measures radiation dose rate (radiation intensity).

1.2.0 DEFINITIONS OF KEY TERMS USED IN THIS MANUAL (cont'd)

Thermoluminescent Dosimeter ("TLD") - a special type of personnel monitoring badge worn by a person to measure cumulative radiation dose. Like the film badge, the TLD allows no immediate reading of cumulative dose; it must be processed first. However, unlike the film badge, the TLD contains a radiation-sensitive crystal, which is somewhat more sturdy and resistant to damage and false readings than is the film in a film badge.

Transport Index - a dimensionless number (rounded up to the first decimal place) expressing the maximum radiation level in mR/hr which has been measured at 3 feet from the surface of a shipping package of radioactive material. The Transport Index designates the degree of control required by a carrier during transport of the package.

Type A Package - A shipping container and its radioactive contents designed, built and tested to meet normal conditions of transportation as specified in 10 C R 71.

Type B Package - A shipping container and its radioactive contents (exceeding Type A quantities) designed, built and tested to meet both the normal conditions of transportation and the hypothetical accident conditions specified in 10 CFR 71.

Unrestricted Area - any area to which access is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

Utilization Report - a written record prepared by the Radiographer which details a particular usage of a particular radioactive source on a particular day.

Warning Labels - in radiogragraphy, the labels attached to a shipment of radioactive material indicating the radioactive contents and dose rates.

1.3.0 DUTIES AND RESPONSIBILITIES OF RADIOGRAPHY PERSONNEL

1.3.1 General Manager

(A) The General Manager shall develop and establish the various policies, systems and general procedures which comprise the Radiation Safety program at Lehigh. He shall be assisted as required by the Radiation Safety Officer and by part-time Consultants in the field of Radiation Safety and Health Physics.

(B) He shall be the direct supervisor of the Radiation Safety Officer and shall be responsible for insuring that the RSO performs his assigned duties stated in 1.3.2.

(C) He shall personally conduct unannounced audits of radiography operations and personnel similar to those normally performed by the RSO, except that the RSO shall be included in his evaluations of radiography personnel. The personal audits by the General Manager shall be conducted at least once every six months, and the results of these audits shall be recorded.

1.3.2 Radiation Safety Officer

The Radiation Safety Officer (RSO) shall be a qualified Radiographer with training in the use of equipment described in this Manual. Other prerequisites for the RSO are a thorough knowledge of management policies, company administrative and operating procedures, and safety procedures related to protection against radiation exposures as set forth in this Manual. The RSO shall report directly to the General Manager, and shall be the direct supervisor of the Assistant RSO, all Radiographers, and all Assistant Radiographers. The RSO has the following specific authority, duties and responsibilities:

(A) Maintain active management control over LTL's radiation safety program for the company.

(B) Assist the General Manager in the establishment, development and revision of procedures or systems concerning radiation safety.

(C) Serve as Lehigh's liaison officer to the Nuclear Regulatory Commission and to Agreement State Agencies on license matters.

(D) Maintain control of procurement and disposal of licensed material.

(E) Conduct the training program for Radiographers and Assistant Radiographers, and examine and certify the competency of them regarding radiation safety.

1.3.2 Radiation Safety Officer (cont'd)

(F) Assure that all radiographic operations comply with the requirements of this manual by by conducting unannounced monthly audits of such operations and quarterly audits of the individual performance of the Assistant RSO, each Radiographer, and each Assistant Radiographer.

(G) Assume control and initiate corrective action in emergency situations.

(H) Investigate the causes of incidents, and determine and initiate appropriate preventive measures.

(I) Maintain the system for evaluating and reporting defects and noncompliances per section 3.3.0 of this manual.

(J) Insure that any duties specifically delegated to the Assistant RSO per 1.3.3 are performed completely, promptly, and accurately, as required by the provisions of this Manual.

1.3.3 Assistant Radiation Safety Officer

The Assistant RSO at Lehigh shall be a qualified Radiographer with training in the use of equipment described in this Manual. Other prerequisites for the Assistant RSO are a thorough knowledge of the operating and emergency procedures regarding protection against radiation exposures as set forth in this Manual. He shall report directly to the RSO, shall be responsible for performing all RSO duties of an emergency nature during the temporary absence of the RSO, and shall perform any of the following duties specifically delegated to him by the RSO:

(A) Maintain the personnel monitoring system, including issuing badges and dosimeters, calibrating the pocket dosimeters, and reviewing the reports of personnel exposures.

(B) Conduct the leak testing program for sealed source containers.

(C) Perform or supervise the performance of source changes.

(D) Perform or supervise the performance of quarterly maintenance of exposure devices and associated equipment.

(E) Perform quarterly inventories of all sources of radiation.

(F) Maintain radiation survey instruments and the calibration program for such instruments.

1.3.3 Assistant Radiation Safety Officer (cont'd)

(G) Assist the RSO in assuring that the required documentation for daily radiographic operations is complete, accurate, and up to date.

1.3.4 Radiation Safety Consultant

The General Manager shall appoint one or more Consultants in the fields of Health Physics, Safe Radiography Practice, Regulatory Requirements, etc. to assist himself and the Radiation Safety Officer in providing direct and indirect training to radiography personnel; to assist in developing, implementing, reviewing or revising the company's Radiation Safety Program; and to provide independent audits of the company's conformance to the requirements of this Manual and all applicable laws, as requested.

1.3.5 Radiographer

At Lehigh, a Radiographer is an individual who performs or personally supervises the performance of industrial radiographic operations. He is personally responsible to the company for insuring compliance with the requirements of the NRC's regulations, with the conditions of the license, and with the requirements of this Manual. Each individual certified as a Radiographer at Lehigh shall have been trained and qualified in accordance with the provisions of Lehigh's Personnel Training Program (see Section 3.1 of this Manual). A Radiographer shall be authorized and responsible for performing the following:

(A) Possess, use or transfer any of the sealed sources for which the company is licensed for purposes of industrial radiography.

(B) Complete Daily Utilization Reports for the radiographic operations he performs, including the complete identification of the radiation sources used, the location where they were used, the total exposure time, where and when they were stored, and the results of all required radiation surveys and daily equipment checks.

(C) Provide on-the-job training and personal supervision to Assistant Radiographers or new Trainees who may be assigned to work with him. The personal supervision shall include (1) the Radiographer's personal presence at the site where the radiation sources are being used; (2) the ability of the Radiographer to give immediate assistance if required; and (3) the Radiographer's watching the Assistant's performance of radiographic operations. Note: Trainees may not handle or manipulate radioactive sources, and it is the Radiographer's responsibility, as crew leader, to assure that the Trainee performs only those functions which are specifically permitted in 1.3.6.

1.3.5 Radiographer (cont'd)

(D) Transport sealed sources between laboratory and field sites, and complete the required documentation for such transportation of sources.

(E) Perform source changes and leak tests as directed.

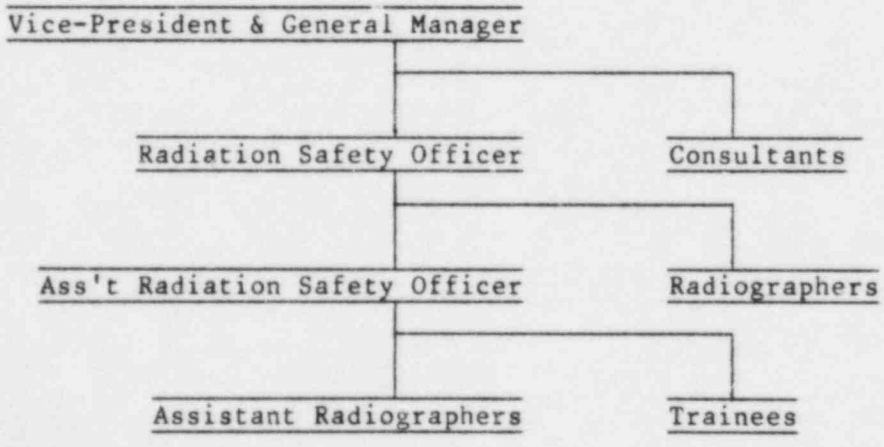
1.3.6 Assistant Radiographer

At Lehigh, an Assistant Radiographer is an individual who, under the direct personal supervision of a qualified Radiographer, may use radiographic exposure devices, sealed sources, radiation survey instruments and related equipment to perform industrial radiography.

1.3.7 Trainee

A Trainee is by definition an untrained, inexperienced individual who is not permitted to attend or witness any radiographic operations until he has first been given the four hours of initial training specified in 3.2.2(A). Upon completion of this initial training, and upon successfully passing the examination thereof, the Trainee shall be permitted to observe radiographic operations involving licensed materials. A Trainee shall not perform or help perform any radiography operations with licensed materials. He may not touch the source container nor operate the crank. He may assist a certified Radiographer only in peripheral functions such as posting, maintaining surveillance and controlling access to the worksite, recordkeeping, etc.

1.3.8 Organizational Chart for Radiation Safety (by supervisory authority)



1.4.0 STANDARDS FOR PROTECTION AGAINST RADIATION

1.4.1 General

(A) This section summarizes the standards for permissible radiation exposure as provided in Title 10, Code of Federal Regulations, Part 20, and in the Delaware Radiation Control Regulations.

(B) In addition to complying with the requirements of this section, every reasonable effort shall be made to maintain radiation exposures at levels which are "as low as reasonably acheivable" (ALARA).

1.4.2 Radiation Dose Limits for Individuals in Restricted Areas

(A) Except as provided in 1.4.2(B), Lehigh shall not permit any individual in a restricted area to receive, in any period of one calendar quarter, a radiation dose in excess of the limits specified in the following table:

	Rems per Calendar Quarter
Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1.25 maximum
Hands and forearms; feet and ankles	18.75 maximum
Skin of whole body.	7.5 maximum

(B) Lehigh may permit an individual in a restricted area to receive a dose to the whole body greater than that permitted in 1.4.2(A), provided that:

1. during any calendar quarter the dose to the whole body from sources of radiation in Lehigh's possession shall not exceed 3 rems;

2. the dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5(N-18) rems, where "N" equals the individuals age in years at his last birthday; and

3. the Radiation Safety Officer has determined the individual's accumulated occupational dose to the whole body on form NRC-4 and has otherwise complied with the requirements of 10 CFR 20, "Determination of prior dose". As used in 1.4.2(B), "dose to the whole body" shall be considered to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

1.4.3 Radiation Dose Limits for Minors

Lehigh shall not possess, use, or transfer sources of radiation in such a manner as to cause any individual within a restricted area, who is under 18 years of age, to receive in any period of one calendar quarter from all sources of radiation in Lehigh's possession a dose in excess of 10 percent of the limits specified in 1.4.2(A).

1.4.4 Radiation Dose Limits in Unrestricted Areas

Except as specifically authorized by the Commission in 10 CFR 20.105(a), Lehigh shall not possess, use or transfer sources of radiation in such a manner as to create in any unrestricted area, radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of:

Two millirems in any one hour, OR

100 millirems in any seven consecutive days.

1.5.0 PERSONNEL MONITORING DEVICES

1.5.1 General

Personnel monitoring equipment, consisting of a thermoluminescent dosimeter ("TLD") and a pocket dosimeter, shall be issued to and must be worn by radiography personnel during all radiography operations. In addition, personnel monitoring equipment shall be issued to and must be worn by any individual who

1. enters a restricted area under such conditions that he receives, or is likely to receive, a dose in excess of 25% of the applicable limits specified in 1.4.2; OR

2. if under 18 years of age enters a restricted area under such conditions that he receives, or is likely to receive, a dose in excess of 5% of the applicable limits specified in 1.4.2; OR

3. enters a high radiation area.

1.5.2 Thermoluminescent Dosimeters - Description

The "TLD" is a special type of personnel monitoring badge worn by a person to measure cumulative radiation dose. It is similar in appearance to the film badge formerly used by Lehigh radiography personnel. Like the film badge, the TLD allows no immediate reading of cumulative dose; it must be mailed to the TLD supplier for special processing. However, unlike the film badge, the TLD contains a radiation-sensitive crystal which stores energy deposited by radiation. The energy deposited can be measured by heating the TLD afterwards and measuring the energy released as light. This light emitted by the TLD is a measure of the radiation dose. The TLD badge is somewhat more rugged and resistant to damage and false readings than is the film in a film badge. However, do not expose the badge to water or high temperatures, for extreme environmental conditions will cause false measurements.

1.5.3 Thermoluminescent Dosimeters - Procedures

(A) New TLD's shall be issued monthly to radiography personnel. Those worn during the previous month shall be turned in promptly to the Assistant RSO, who in turn shall forward them to the supplier for processing.

(B) Your TLD must be stored in the designated rack in the film reading room when not in use. Do not wear the TLD when you are off-duty, and do not leave it in the glove compartment or on the dashboard of a vehicle.

1.5.3 Thermoluminescent Dosimeters - Procedures (cont'd)

(C) Each TLD has a unique identity and is assigned to and worn by only one individual. Never wear a TLD which has someone else's name on it, and never "lend" your TLD to anyone else.

(D) Because your TLD is intended to measure your "whole body" radiation dose, you must wear the TLD and your pocket dosimeter together on the front trunk portion (between your neck and waist) of your body.

(E) The Assistant RSO will keep a few spare, unused TLD's on hand to replace any assigned badges which may have been lost, stolen or damaged. However, make sure the Assistant RSO issues the replacement badge to you so that he can keep the badge records straight.

(F) One TLD shall be maintained as a "Control" - it is not to be worn by personnel, but shall be stored in the designated storage rack and processed monthly with the assigned TLD's to assure that the storage area is free from measurable radiation.

(G) The Assistant RSO shall receive, review and maintain the monthly TLD reports from the supplier. He will inform you and the RSO of any high or unusual results.

1.5.4 Pocket Dosimeters - Description

A Pocket Dosimeter is basically an air-filled ionization chamber that responds to radiation by gradually discharging. You charge the dosimeter at the beginning of your shift, so that the internal scale reads zero. You wear the pocket dosimeter during all radiography operations. Any radiation that you receive during the day will cause the indicator inside the dosimeter to move upwards, from zero. Your final reading, taken at the end of the day, is the total dose in mR you have received that day.

1.5.5 Pocket Dosimeters - Procedures

(A) All of Lehigh's pocket dosimeters shall have a range from zero to 200 mR.

(B) Pocket dosimeters are delicate instruments and must be handled with care. Any suspected damage, such as might result from rough handling or extreme environmental conditions, shall be reported at once to the Assistant RSO.

(C) The Assistant RSO will maintain a group of calibrated, operable pocket dosimeters in the designated rack in the film evaluation room. You may select any one of the dosimeters from this group for your use that day.

1.5.5 Pocket Dosimeters - Procedures (cont'd)

(D) Prior to each daily use, you must charge your dosimeter as follows:

1. place the dosimeter on the charging contact of the charging unit;
2. hold the dosimeter in contact by pressing down against the spring;
3. while looking through the dosimeter at the hairline and scale, turn the adjusting knob until the hairline rests near zero on the scale;
4. remove the dosimeter from the charging unit and recheck the position of the hairline by holding the dosimeter up to a light source;
5. record this initial dosimeter reading on Form 205.

(E) During radiographic operations, you must wear the pocket dosimeter and check its reading frequently.

(F) At the end of radiography operations, you must take a final reading on your pocket dosimeter and record it on Form 205.

(G) If at any time you notice that your dosimeter has become fully discharged (that is, if you cannot see the hairline), you must immediately store and secure the source, stop all radiation work and notify the RSO. Even if the source is safely stored and secured, you may not resume radiographic operations until the RSO carefully evaluates the situation. You must give your TLD badge to the RSO, and he will immediately send it to the processor for measurement.

The RSO will then try to determine what caused your pocket dosimeter to discharge. If you were working with another individual, the RSO will want to know what his dosimeter reads. He may try to determine whether your dosimeter malfunctioned by recharging it and placing it in an area free from radiation for an hour. If the dosimeter again discharges, either partially or totally, it is likely that the dosimeter is faulty and you probably received no overexposure.

1.6.0 RADIATION SURVEYS--INSTRUMENTS AND PROCEDURES

1.6.1 Radiation Survey Meters

(A) Purpose - Radiographers and Assistant Radiographers use the radiation survey meter to detect and measure radiation at the radiography worksite.

(B) Description - The radiation survey meters in use at Lehigh are one of the following models, or their equivalent:

Victoreen 492	(Geiger-Muller Tube)
Victoreen 592	(Ionization Chamber)
Eberline 120G	(Geiger-Muller Tube)
Eberline 130G	(Geiger-Muller Tube)

Each of the radiation survey meters is powered by two D-cell batteries, and the ranges meet the following minimum requirements:

X1 range:	0 to 10 mR/hr;	smallest scale division = 0.5 mR/hr
X10 range:	0 to 100 mR/hr;	smallest scale division = 5.0 mR/hr
X100 range:	0 to 1000 mR/hr;	smallest scale division = 50.0 mR/hr

Note: some models have 0.2 mR/hr as their smallest scale division; only these models may be used when surveying leak test swabs.

(C) Operating Instructions for Survey Meters

1. Insure that the meter has a current calibration sticker. If it has not been calibrated within 90 days, forward the meter to the Assistant RSO and obtain another meter. Under no circumstances shall meters with expired calibrations be used for radiography.

2. Check the strength of the batteries by turning the selector switch to the "BAT" check position (on some models, there is a battery check button which must be depressed). Observe the location of the needle. Turn the selector switch to one of the operating positions and let the meter "warm up" for about two minutes. Return the switch to the "BAT" check position and observe the location of the needle. If the needle is not in the "BAT OK" range, or if it has dropped considerably from the original check position, replace the batteries and repeat the test.

1.6.1 Radiation Survey Meters

(C) Operating Instructions for Survey Meters (cont'd)

3. Next check the meter's response to radiation. To make a reading, turn the selector switch to one of the three range settings. For best reading accuracy, use a range that gives a reading in the upper 80% of the scale. Also for best accuracy, the front of the meter (or the front of the externally mounted detector probe) should be facing the source of the radiation. The needle takes about ten seconds to fully respond, so allow sufficient time before reading the scale. Please note, however, that an approximate reading of dose rate is more important than a precise value, especially when the dose rate is high. Your first survey of the day is usually made at the surface of the source storage vault. From previous experience, you should know about what dose rate to expect. If the meter does not respond as expected, return the meter to the Assistant RSO for maintenance and obtain a properly working instrument.

1.6.2 Methods and Occasions for Conducting Radiation Surveys

The single most important thing that you must do to protect yourself and anyone near you is to perform adequate radiation surveys with your meter. Most of the radiography overexposure accidents reported to the NRC happen because a radiography worker failed to make a survey when he should have, or because he surveyed improperly.

According to NRC regulations, "Survey" means an evaluation of the radiation hazards related to the presence or use of a radiation source. In this sense, a survey is more than a meter reading; in order to be meaningful, the location and duration of the radiation must be considered as well as the dose rate read from the meter.

In general, a radiation survey should be made each time a radiation source is manipulated or moved. Mandatory surveys include the following:

(A) To determine after each exposure that the source has returned to the safe storage position within the shielded exposure device. The entire circumference of the exposure device and the guide tube must be surveyed.

Maximum acceptable radiation level for this type of survey is 2 mR/hr per Curie of Ir-192 at any surface of the exposure device or guide tube. For example, if you are using a 30 Curie source, this survey should result in a radiation level of 60 mR/hr or less. The final survey of this type (that is, after the final exposure is performed, and prior to storage of the exposure device) must be documented on the Daily Utilization Report.

(B) To determine, or to confirm the calculated location of, the boundary of the Restricted Area.

Maximum acceptable radiation level for this type of survey depends on the percentage of the time the source will be exposed. Since a person at the boundary of the Restricted Area must receive no more than 2 mR in any one hour, the maximum acceptable radiation level is 2 mR/hr divided by the fraction of time the source will be exposed. For example, if the source will be exposed for 1/3 of the hour, the maximum acceptable radiation level at the Restricted Area boundary is 2 divided by 1/3, or 6 mR/hr. If the fraction of exposure time is not known in advance, the maximum acceptable radiation level at this boundary is 2 mR/hr. This survey must be documented on the Daily Utilization Report.

1.6.2 Methods and Occasions for Conducting Radiation Surveys (cont'd)

(C) To determine radiation levels at the external surfaces of the lab storage vault, after the licensed material has been placed inside.

Maximum acceptable radiation level for this type of survey is 2 mR/hr. This survey must be documented on the Daily Utilization Report.

(D) Determination of radiation levels in the passenger compartment and at the surfaces of vehicles used for transporting sources and devices.

Maximum acceptable radiation level for each of these surveys is 2 mR/hr. The survey reading determined at the surface of the vehicle must be documented on the Daily Utilization Report.

(E) To confirm that containers of licensed material, either being received by Lehigh or being prepared for shipment by Lehigh, comply with the applicable D.O.T. regulations.
Maximum acceptable radiation level for this type of survey depends on the type of label on the container:

Description of Label	Maximum Dose Rate at Surface	Maximum Dose Rate 3 ft from Surface
Radioactive White I	0.5 mR/hr	None
Radioactive Yellow II	50. mR/hr	1.0 mR/hr
Radioactive Yellow III	200. mR/hr	10. mR/hr

This survey of the maximum dose rate 3 feet from the package surface must be recorded on the receiving papers that accompany any licensed material received by Lehigh. If the material is being shipped by Lehigh, the survey must be recorded as the Transport Index on the shipping document that will be sent with the container.

(F) To determine the approximate level of contamination of leak test swabs prior to mailing them. Note: the smallest scale division of the meter used for this survey shall be 0.2 mR/hr.

Maximum acceptable radiation level fc this type of survey is 0.2 mR/hr. This survey reading, if satisfactory, need not be documented.

1.6.3 If Survey Readings are Higher than the Maximum Allowable

If, while performing any of the surveys described in 1.6.2, the readings obtained are higher than the maximum allowable radiation level for that type of survey, contact the RSO immediately.

1.7.0 DESCRIPTION OF PERMANENT RADIOGRAPHIC FACILITY AT LEHIGH

1.7.1 Storage Vault for Radioactive Materials and Containers

(A) A storage vault is located within the one-story warehouse building at 4027 New Castle Avenue, New Castle, Delaware, just south of Lehigh's main building. This vault has been designed for the permanent storage of all of Lehigh's exposure devices, source changers, dosimeter and survey meter calibrators and all radioactive materials when they are not being used.

(B) This permanent storage facility consists of a locked cabinet-type enclosure, fabricated of 1/4" thick steel plate with movable internal lead sheet shielding. One key to the lock is kept in the Business Office safe, and the others are assigned to Radiographers on duty. The RSO and the Assistant RSO shall maintain control of the keys to the lock on the storage vault.

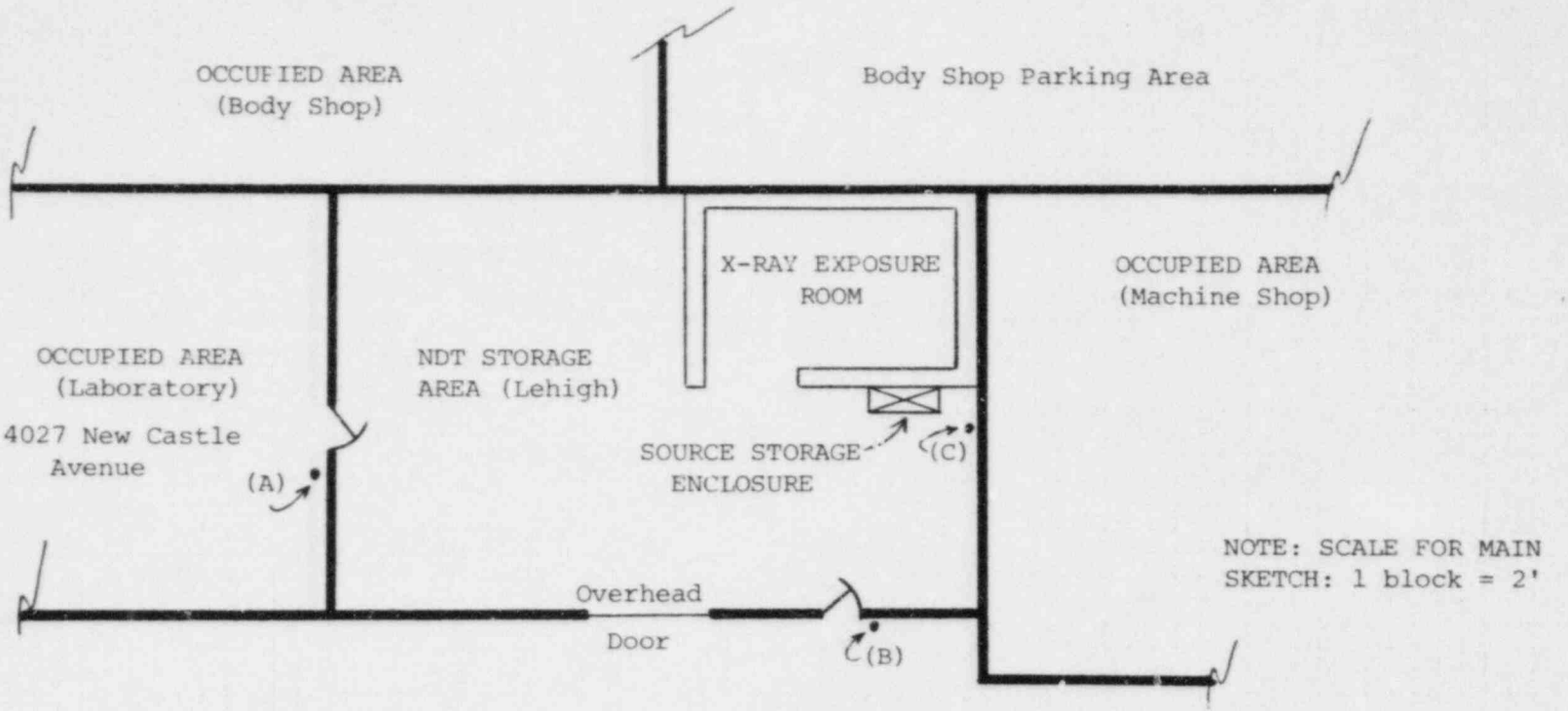
(C) The steel vault, shown in the accompanying sketch (Figure 1.1), has a 12" thick air space at the top and at both sides of the interior shelves, and a 24" air space below the shelves. The vault backs up to a 16" thick, 84" high wall of solid concrete blocks which forms part of an exposure room used for both x-ray and gamma radiography; the hinged steel access doors at the front of the vault are lined with lead sheets.

(D) Proper storage of radioactive materials within this vault consists of placing them toward the right side of the bottom shelf, then covering the sources with lead sheet shielding such that, when the doors are closed and locked, the maximum radiation at any surface of the vault is 2 mR/hr or less. The vault shall be posted with "Caution - Radioactive Materials" warning signs.

(E) The overhead garage door to the storage area is to be locked during all operations involving the use of radiation sources. The two entry doors (a) from the laboratory area, and (b) from the driveway, are both equipped with "CAUTION - RADIATION AREA" warning signs and visible alarms which are activated whenever radiation is detected at the Gammalarm unit, located at (c). Audible alarms are also installed at doors (a) and (b), and these audible alarms activate when an attempt is made to enter the area through either of these doors while the radiation is detected by the Gammalarm unit.

(F) The proper operation of the Gammalarm unit, the visible alarms at the doors, and the audible alarms at the doors shall be tested at intervals not to exceed three months, and records of these tests shall be kept for a minimum of two years.

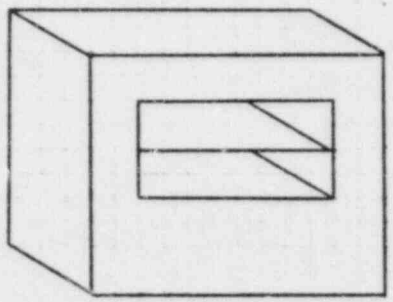
SEE SKETCH OF STORAGE VAULT AND ITS LOCATION ON NEXT PAGE



Outside Dimensions: 6'W x 5'H x 2'D
Inside Dimensions: 4'W x 2'H x 2'D

(shown without hinged front doors)

SKETCH OF SOURCE STORAGE ENCLOSURE
Scale: 1 block=6"



Lehigh Testing Laboratories, Inc.

RADIATION SAFETY MANUAL

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1.8.0 RADIATION CONTROL PROCEDURES REQUIRED AT PERMANENT FACILITY

(A) The exposure room at 4027 New Castle Avenue is surrounded by walls which are semi-permanent and are built of solid cinder blocks, and has a Gammalarm system installed [see paragraphs 1.7.1(D) and 1.7.1(E)], and radiography is performed within this room on a regular basis, and the area is maintained locked except during periods when access to the area is required. For these reasons, the room meets the definition and requirements for a "permanent radiographic installation", per 10 CFR 34.2(h) and 34.29.

(B) However, due to the variety of radiography operations which may be conducted within the exposure room, it is possible that certain areas outside of the shielded exposure room could receive radiation dose levels in excess of 2 mR/hr during radiography operations. Therefore, this area shall be considered a temporary job site for all radiography operations, and all of the controls specified in Section 1.9.0, "Radiation Control Procedures Required at Temporary Jobsites", shall apply.

1.9.0 RADIATION CONTROL PROCEDURES REQUIRED AT TEMPORARY JOBSITES

1.9.1 Security Precautions during Radiography Operations

(A) During each radiographic operation the Radiographer or Assistant Radiographer shall maintain a direct, continuous surveillance to protect against unauthorized entry into the Restricted Area (which at Lehigh is defined to be the same as the Radiation Area - see definitions in Section 1.2.0), except where the High Radiation Area is either equipped with an alarm system or where the area is locked to prevent against unauthorized or accidental entry.

(B) At field sites, each radiographic exposure device, source changer and storage container shall be stored within a locked container whenever not under the constant, direct surveillance of the Radiographer and/or the Assistant Radiographer. Further, the locked container shall be physically secured within a locked vehicle. When this is not feasible, the source shall be locked within its shielded container and stored in a locked room. In either case, all keys shall be carried by the Radiographer, and the vehicle or room shall display warning signs as appropriate. These measures are intended to prevent unauthorized or accidental tampering or removal of the source from the temporary field storage location.

1.9.2 Establishing the Restricted Area (Radiation Area)

(A) Prior to the initial exposure of the radiation source, the Radiographer or Assistant Radiographer shall estimate the approximate locations of the boundary of the Restricted Area. According to the definition of "Restricted Area" (see Section 1.2.0), this boundary is determined such that no areas outside the boundary will receive more than two milliRem in any one hour, nor more than 100 milliRem in any seven consecutive days. Hence, the boundary of the "Restricted Area" is the same as that for the "Radiation Area".

(B) When establishing the boundary between the Restricted and Unrestricted Areas, due consideration may be given to the following factors:

1. Position and Orientation of the Radiation Source
2. Degree to which the Radiation is Collimated
3. Attenuation of the Radiation by Intervening Shielding
4. Occupancy Factors in the Unrestricted Area
5. Duration and Frequency of Planned Exposures

(C) As an aid in establishing the boundary between the Restricted and Unrestricted Areas, tabulations are presented on the next page which list the radiation levels at selected distances for sources of unshielded Iridium 192 at various activity levels. This table is developed from the fact that one Curie of Ir-192 emits about 5.2 Rems per hour at one foot.

TABLE 1.1 - Radiation Levels for Unshielded Iridium-192

Curies	Feet	mR/hr	Curies	Feet	mR/hr	Curies	Feet	mR/hr
5	1	26000	45	1	234000	85	1	442000
5	35	21	45	35	191	85	35	361
5	114	2	45	342	2	85	470	2
10	1	52000	50	1	260000	90	1	468000
10	35	42	50	35	212	90	35	382
10	161	2	50	361	2	90	484	2
15	1	78000	55	1	286000	95	1	494000
15	35	64	55	35	233	95	35	403
15	197	2	55	378	2	95	497	2
20	1	104000	60	1	312000	100	1	520000
20	35	85	60	35	255	100	35	424
20	228	2	60	395	2	100	510	2
25	1	130000	65	1	338000	105	1	546000
25	35	106	65	35	276	105	35	446
25	255	2	65	411	2	105	522	2
30	1	156000	70	1	364000	110	1	572000
30	35	127	70	35	297	110	35	467
30	279	2	70	427	2	110	535	2
35	1	182000	75	1	390000	105	1	598000
35	35	149	75	35	318	105	35	488
35	302	2	75	442	2	105	547	2
40	1	208000	80	1	416000	120	1	624000
40	35	170	80	35	340	120	35	509
40	322	2	80	456	2	120	559	2

Note: The above table includes unshielded dose rates at a distance of 35 feet, because this is the usual distance separating the Radiographer from the source when he is operating the crank assembly.

1.9.3 Posting the Restricted Area (Radiation Area)

After determining the perimeter of the "Restricted Area", which is the same as the "Radiation Area", the Radiographer shall post this perimeter with conspicuous warning signs that state, "CAUTION (OR DANGER) - RADIATION AREA". Ropes or other types of physical barriers may be used along the perimeter to help deter unauthorized or accidental entry into the Restricted Area, and should be used whenever feasible.

1.9.4 Establishing and Posting the High Radiation Area

Using the inverse square law, the Radiographer shall calculate the perimeter of the "High Radiation Area", or the area within which the radiation will be sufficient to expose a person to at least 100 mR in any one hour. Generally speaking, the perimeter of the "High Radiation Area" will be about one-seventh as far from the source as is the perimeter of the "Radiation Area". The Radiographer shall post this "High Radiation Area" perimeter with warning signs stating "CAUTION (OR DANGER) - HIGH RADIATION AREA".

1.9.5 Surveillance of the Restricted Area

You are responsible to see that no one enters the Restricted Area while a radiographic operation is taking place. If it is possible for someone to enter the Restricted Area, you must maintain constant direct visual surveillance of the area and prevent them from entering. If, for any reason, an unauthorized person cannot be prevented from entering the Restricted Area, the source must immediately be retracted to its shielded position within the exposure device and further operations must be suspended until the area is again under control.

1.9.6 Other Controls at the Jobsite

The security guard or another responsible person at the temporary jobsite must be informed that radiographic operations are to be performed, how long they may last, and that access to the area will be restricted.

1.9.7 Documentation

The Radiographer in charge of the crew shall prepare a sketch of the jobsite on the Daily Utilization Report, showing the location and orientation of the source, the position of the High Radiation and Restricted Area perimeters, the type of collimator used, if any, and the nature of any intervening shielding or occupancy factors which may have been considered in establishing of these perimeters. If the perimeter of the Restricted Area is based on the "two millirem in any one hour" criterion, the Radiographer shall also list the maximum total exposure time in any one hour on the Daily Utilization Report.

SECTION 2 - SPECIFIC PROCEDURES FOR GAMMA RADIOGRAPHY

2.1.0 DESCRIPTION OF EXPOSURE DEVICES AND RELATED EQUIPMENT

2.1.1 General Information

Lehigh uses the Tech/Ops Model 660 portable exposure device and its associated equipment to perform industrial radiography with Iridium-192 sources. In use, the Model 660 and the associated equipment (Figure 2.2) positions the Ir-192 source at a predetermined location to perform radiography. The panoramic radiation pattern may be used to full advantage, either for multiple specimen work or for circumferential exposure techniques. In most cases, however, a collimator is used to limit the radiation pattern to a directional beam.

2.1.2 Model 660 Exposure Device

Principles of Operation - The encapsulated radioactive source, which is stored in the center of the exposure device [see Figure 2.1(a)] is attached by means of a short leader cable to the drive cable. The hand crank on the control unit moves the drive cable through the control housing. Figure 2.1(b) shows the source being moved out of the storage position in the exposure device and into the guide tubes. This action occurs by rotating the hand crank in the EXPOSE (counterclockwise) direction. Figure 2.1(c) shows the source reaching the source stop which serves as the mechanical stop at the radiographic focal position. The hand crank will not turn any farther and the odometer in the control unit should indicate a reading which approximates the total length of the combined guide tubes. To return the source to the exposure device (stored position), the hand crank is turned to the full RETRACT (clockwise) position.

The Tech/Ops Model 660 portable exposure device is shown in Figure 2.3. This device is designed as a storage and transport device for an Iridium-192 source having an activity of up to 100 Curies. The Model 660 consists of a steel housing which contains approximately 34 pounds of depleted uranium shielding material. When the source is properly stored in the exposure device, the shielding properties of the depleted uranium reduce radiation intensities in the vicinity of the device to levels well below the regulatory limits.

Figure 2.3 shows both ends of the exposure device. A special fail-safe control unit connector is located at one end. The connector is used to engage the control unit. The control connector has a three-position selector ring--OPERATE, LOCK and CONNECT. For maximum safety when the control

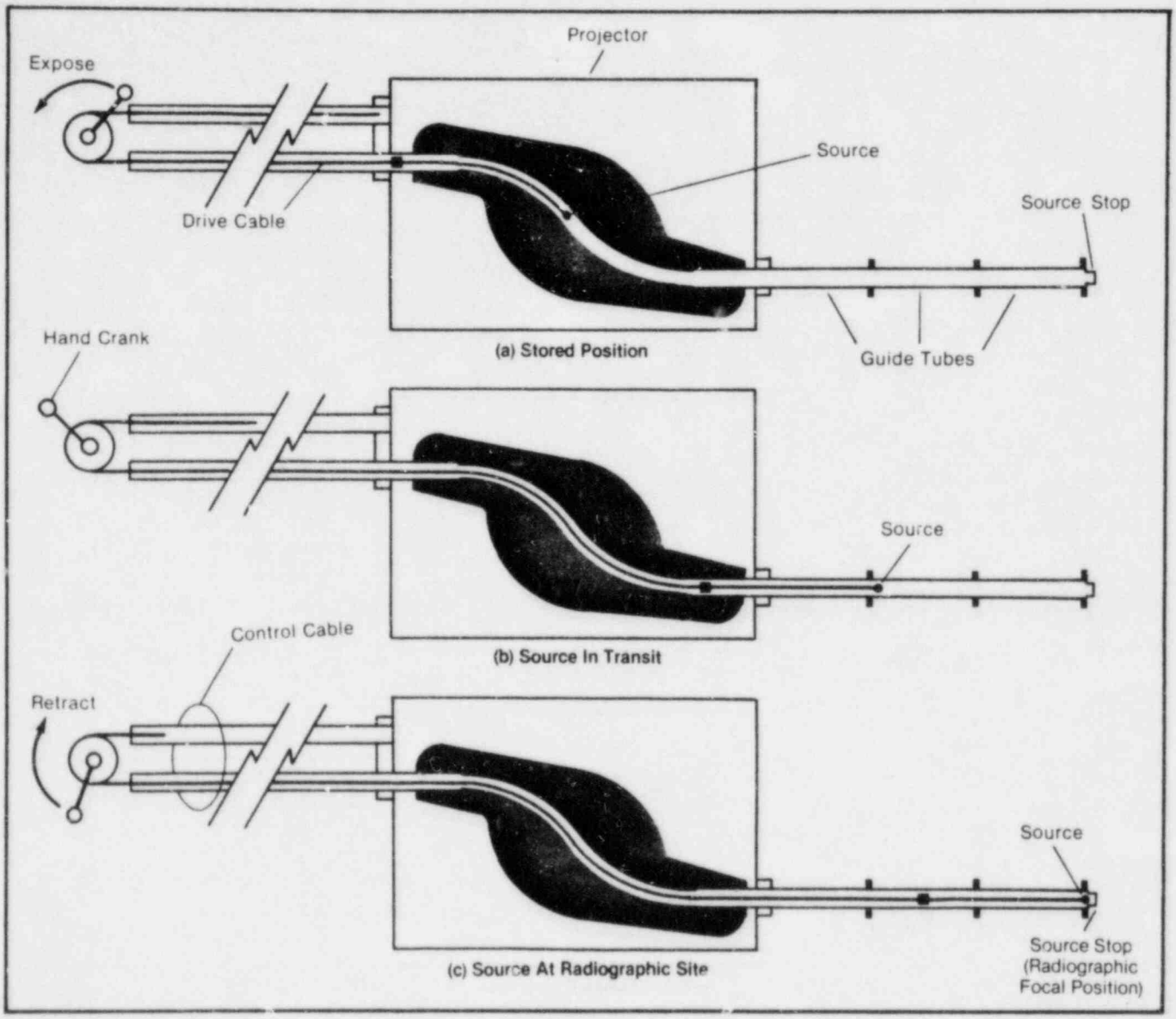


FIGURE 2.1 - Schematic Diagram of the Operation of the Exposure Device

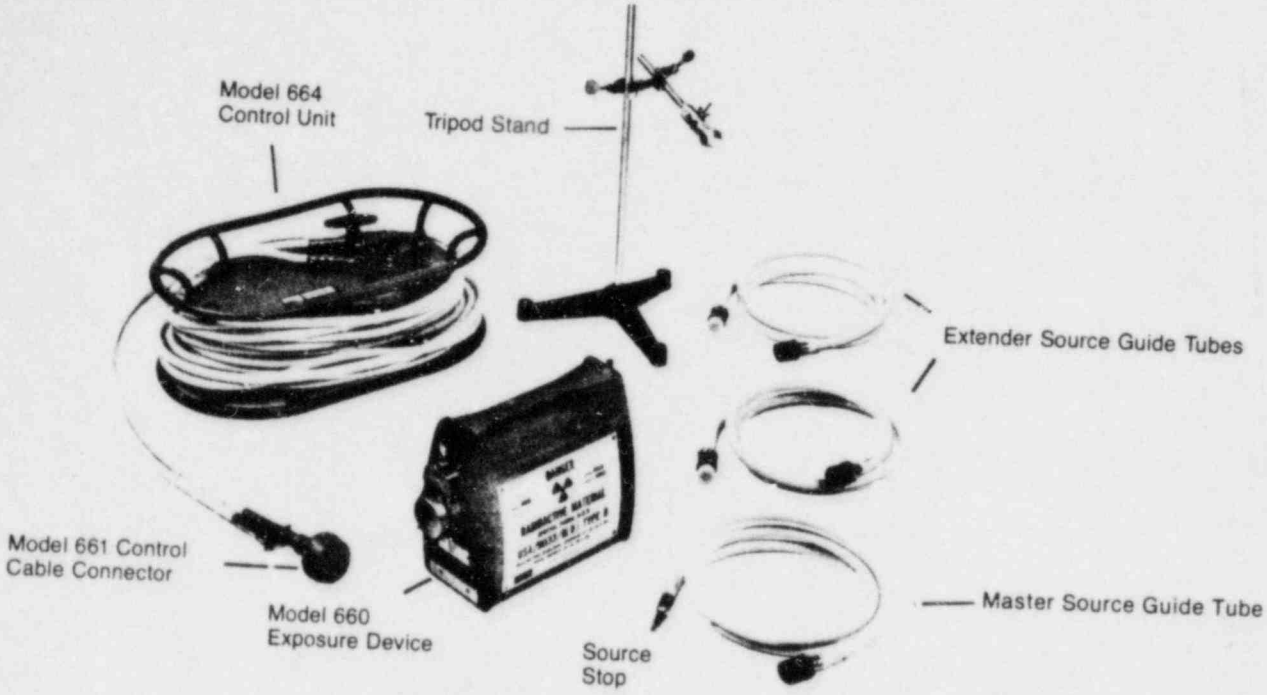


FIGURE 2.2 - Tech/Ops Model 660-664 System for Gamma Radiography

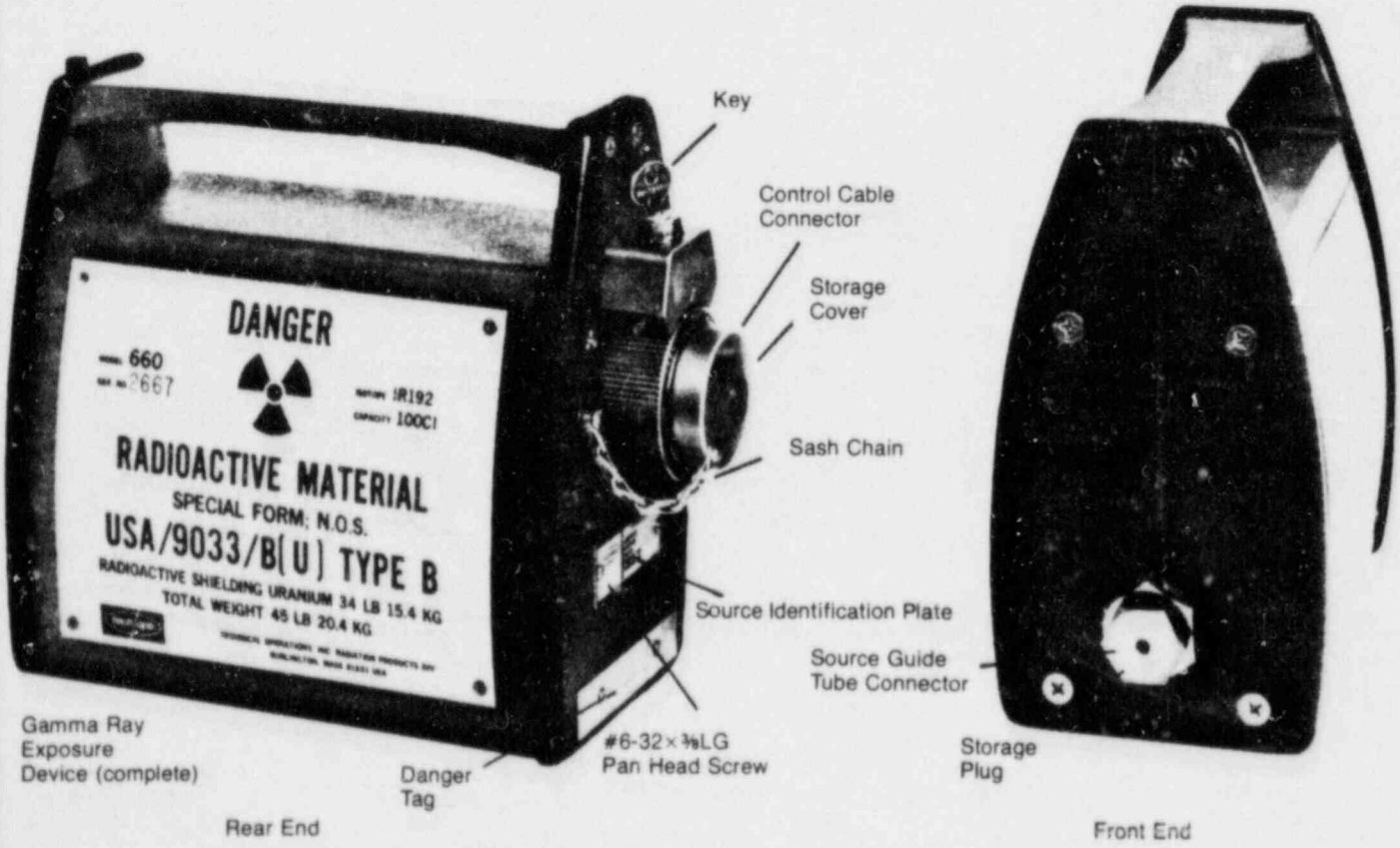


FIGURE 2.3 - Tech/Ops Model 660 Exposure Device

2.1.2 Model 660 Exposure Device (cont'd)

unit and guide tubes are disconnected from the exposure device, the connector must be in the LOCK position with the lock and storage cover engaged and the key removed. All of the connector positions are discussed in detail in Section 2.2.0, "General Operating Procedures for Gamma Radiography Equipment".

The guide tube connector is located at the opposite end of the exposure device. Figure 2.3 identifies the connector. Also shown in Figure 2.3 is the storage plug which must be removed before the guide tubes are connected. The storage plug prevents dirt and dust from entering the exposure device whenever the exposure device is not in use.

2.1.3 Guide Tube Assembly

The guide tube assembly consists of one 7 foot master guide tube and two 7 foot extender guide tubes (see Figure 2.2). The master is the guide tube section which contains the source stop at one end. The source stop must never be operated without using the master guide tube, since dirt may enter the tubes and the source may not retract properly if it is extended beyond the guide tubes.

The two extender sections can be used as necessary to increase the length of the guide tube to 14 or 21 feet. Both master and extender tubes are made from flexible stainless steel tubing with a protective polyvinyl covering.

CAUTION - NEVER OPERATE THIS SYSTEM WITH MORE THAN THREE GUIDE TUBE SECTIONS (MASTER SECTION PLUS TWO EXTENDER SECTIONS--TOTAL LENGTH 21 FEET), BECAUSE THE SOURCE WILL BE UNABLE TO REACH THE SOURCE STOP.

2.1.4 Tripod Stand

The tripod stand provides a means of securing the source stop to allow the source to be positioned at the desired focal position. The stand has adjustable clamps which provide an unlimited degree of positioning flexibility.

2.1.5 Tech/Ops Model 664 Control Unit

This unit consists of a hand crank, odometer, two 25-foot housings, drive cable and cable storage reel. In operation the hand crank controls the movement of the source between the storage position in the exposure device and the exposure position in the master guide tube. The odometer indicates the distance (in feet and inches) that the source has been moved from its storage position.

2.1.5 Tech/Ops Model 664 Control Unit (cont'd)

CAUTION - UNDER NO CIRCUMSTANCES SHALL THE POSITION OF THE SOURCE BE DETERMINED SOLELY BY THE ODOMETER. PHYSICAL RADIATION SURVEYS MUST BE MADE.

The inner helically-wound flexible steel drive cable (the actual controlling element) terminates with the male section of a swivel-type drive cable connector used to securely engage the radioactive source assembly. The drive cable connector permits the disconnection of the control unit from the source assembly. A stop spring is installed at the opposite end of the drive cable to prevent the drive cable from being inadvertently cranked off the drive gear. The control housing is terminated at one end by the Tech/Ops Model 661 control cable connector assembly which mates with the fail-safe connector on the exposure device and at the other end by fittings which attach it to the main frame of the control unit.

2.1.6 Tech/Ops Model A 424-9 Radioactive Source Assembly

The radioactive Iridium-192 source is sealed in a stainless steel capsule firmly attached to one end of a short leader cable. The other end of the leader cable has the female section of a swivel-type connector firmly attached to it to provide a secure connection to the drive cable. The source may be changed using Tech/Ops Models 414 or 650 source changers which also serve as shipping containers.

2.1.7 Tech/Ops Collimators

Various collimators are used to limit the dispersal of the radiation beam:

The Model 714 is a lead mini-collimator with a 60-degree conical beam (for use with standard source stop). Attenuation factor for Ir-192 is 1/70.

Model 654 is a lead collimator which has a frontal port giving a forward beam of 60 degrees by 30 degrees. Attenuation of Ir-192 is 1/200.

Model 799 is tungsten mini-collimator which features a side-emerging beam from a pyramid opening with 60-degree sides. Attenuation is 1/160.

2.2.0 GENERAL OPERATING PROCEDURES FOR GAMMA RADIOGRAPHY EQUIPMENT

2.2.1 General

(A) Gamma radiography equipment may be operated only by a certified Radiographer or an Assistant Radiographer who is working under the direct personal supervision of a Radiographer.

(B) Since the source emits high levels of radiation, it is good practice to operate the the equipment from as great a distance as practical and, if possible, from behind a radiation shield such as a heavy steel or concrete object or the corner of a building.

(C) Radiography must only be performed in a Restricted Area which is marked with the appropriate warning signs and secured against unauthorized entrance (see Section 1.9.0). While assembling the system, it is important to keep the exposure device locked at all times prior to operation.

2.2.2 Daily Inspections of Equipment

Daily inspection of the equipment is required to assure that the equipment is in good operating condition. See Section 2.6.1 for requirements.

2.2.3 Assembly Procedures

(A) Position and secure the source stop of the master source guide tube at the radiographic focal position using the tripod stand and swivel clamps.

(B) Determine where the exposure device will be positioned and connect the extender source guide tubes as required, laying them as straight as possible and with no bend radius less than twenty inches. (A smaller bend radius will restrict the movement of the control cable.)

(C) Remove the storage plug from the exposure device and connect the source guide tube(s) to the exposure device.

(D) Determine where the control unit will be positioned (as far away from the focal position as possible and preferably behind a radiation shield) and lay out the control housing with no bend radius less than 36 inches.

(E) Connect the control unit to the exposure device according to the sequence illustrated in Figures 2.4 through 2.8.

(F) Before operation check all connections and bend radii, and check the position of the source stop, which represents the radiographic focal position of the source.

2.2.3 Assembly Procedures (cont'd)

(G) Recheck the operation of the survey meter by reading the radiation level 6 inches away from the surface of the exposure device. It should read no more than 50 mR/hr for a 100 Curie Ir-192 source.

(H) Unlock the exposure device lock and rotate the selector ring to the OPERATE position. The source is now free to move.

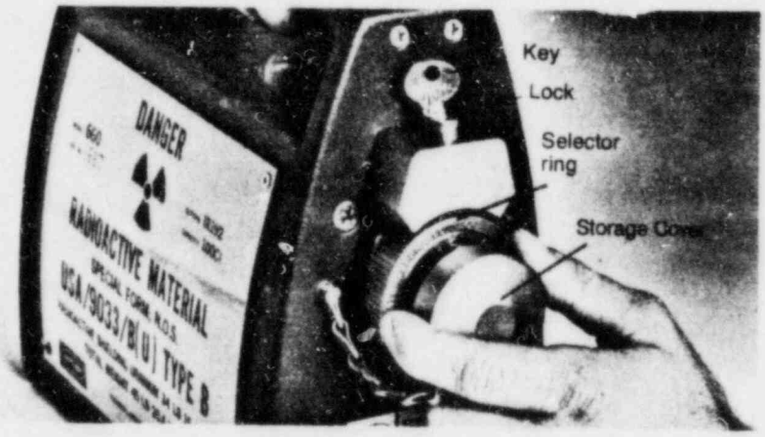


FIGURE 2.4 - Unlock the exposure device with the key provided and turn the selector ring from the LOCK position to the CONNECT position. When the ring is in the CONNECT position, the storage cover will disengage from the exposure device as shown.

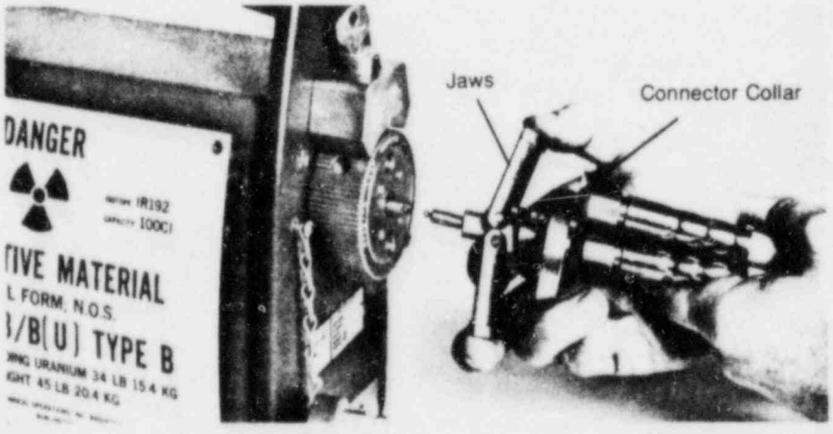


FIGURE 2.5 - Slide the Model 661 connector collar back and open the jaws of the Model 661 connector. This exposes the male portion of the swivel-type drive cable connector as shown.

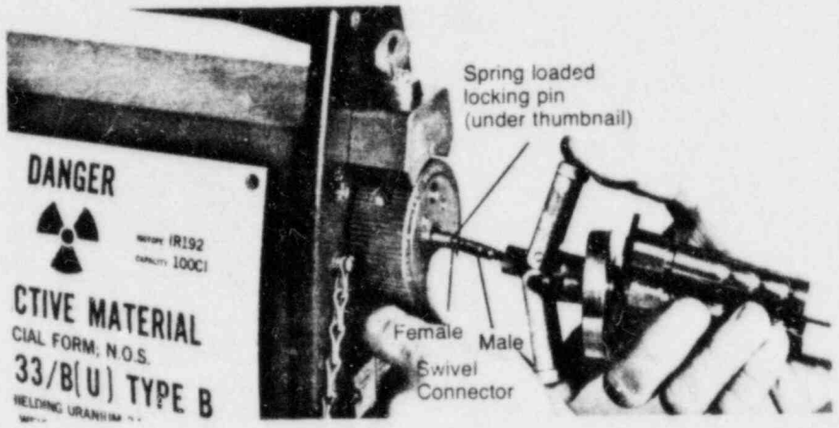


FIGURE 2.6 - Engage the male and female portions of the swivel connector as shown by depressing the spring-loaded locking pin toward the exposure device with the thumbnail. Release the locking pin and test that the connection has been properly made.

FIGURE 2.7 - Close the jaws of the Model 661 connector over the swivel connector.

FIGURE 2.8 - Slide the Model 661 connector collar over the connector jaws. Hold the collar flush against the control unit connector and rotate the selector ring from the CONNECT position to the LOCK position. Keep the exposure device locked until operation is ready to start.

2.2.4 Operating Procedures for the Exposure Device

(A) Return to the control unit. Adjust the odometer reset knob to obtain a 000 reading on the odometer.

(B) Recheck to be sure that no unauthorized persons are inside the Restricted Area.

(C) Rapidly rotate the crank in the EXPOSE (counterclockwise) direction to move the source to the radiographic focal position. The survey meter should read about full scale (1000 mR/hr) for a 100 Curie Iridium-192 source when the source first leaves the exposure device, drop gradually as the source is driven to the focal position, and remain steady during the exposure. The survey meter readings will be substantially reduced if the meter is operated behind a radiation shield or if a collimator is used.

2.2.4 Operating Procedures for the Exposure Device (cont'd)

(D) When the source reaches the source stop, the hand crank will stop turning. Never exert more than 5 ft-lbs of torque on the hand crank, as this may cause damage to the control unit or to the drive cable. The odometer reading will indicate the total distance the source has traveled (approximately 7 feet for each of the guide tube sections that are being used). Set the brake to ON to prevent movement of the source during the exposure.

(E) Figure the specimen exposure time from the moment the source reaches the source stop.

(F) During the exposure, spend as little time as possible in the Restricted Area to minimize personnel exposure.

(G) To return the source to the exposure device after the desired exposure time has elapsed, turn the brake to OFF and rapidly turn the crank in the RETRACT (clockwise) direction until the crank will no longer move. The odometer should read 000. During this process, the survey meter should indicate a continually increasing radiation level up to approximately 1000 mR/hr for a 100 Curie Iridium-192 source, then drop to background level when the source is shielded in the exposure device. CAUTION - UNDER NO CIRCUMSTANCES SHALL THE POSITION OF THE SOURCE BE DETERMINED SOLELY BY THE ODOMETER. PHYSICAL RADIATION SURVEYS MUST BE MADE.

(H) Approach the exposure device with the survey meter and survey the exposure device on all sides. The meter should indicate the same radiation level as observed at the end of the assembly procedure [see paragraph 2.2.3(G)].

(I) Survey the entire source guide tube. If the meter shows a sharp increase, the source could still be exposed or incompletely shielded.

(J) If the source is still exposed, attempt to store it properly by cranking the source a short distance toward the source stop and retracting, repeating if necessary.

(K) If the source becomes jammed in the exposed postion, do not try to retrieve it. Treat the situation as an emergency (see Section 2.5.0).

(L) When the source is properly stored in the exposure device, rotate the selector ring from the OPERATE position to the LOCK position and secure it with the exposure device lock.

NOTE: IF THE SELECTOR RING CANNOT BE ROTATED TO THE LOCK POSITION, THE SOURCE HAS NOT BEEN FULLY RETRACTED. CHECK THE CONTROL UNIT ODOMETER READING. IT SHOULD BE 000. TURN THE HAND CRANK TO THE FULL CLOCKWISE ("RETRACT") DIRECTION.

2.2.5 Disassembly Procedures

(A) Unlock the exposure device and rotate the selector ring from LOCK to CONNECT. The control unit connector will partially disengage.

(B) Refer to Figures 2C through 2G to disengage the control unit from the exposure device.

(C) Replace the storage cover in the control unit connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the exposure device. Survey the entire circumference of the device with the survey meter to insure that the source is properly secured.

(D) Unscrew the source guide tube sections and remove the master guide tube from the tripod stand. Place the plastic caps on the tubes and on the Model 661 connector to prevent dust and dirt from entering the tubes.

(E) Insert the storage plug into the guide tube connector and tighten.

(F) Disassemble the tripod stand and store the components where they will not be subject to any undue stress or abuse. The exposure device itself, of course, must be stored in the shielded storage vault when not in use.

2.3.0 TRANSPORTATION PROCEDURES FOR SEALED SOURCES

2.3.1 Receiving Radioactive Material

(A) When Lehigh orders a package of radioactive material, the RSO shall notify Lehigh's office personnel that a radioactive material delivery is anticipated, and instruct them that either the RSO or the Assistant RSO must be notified immediately upon delivery. If the package is at the carrier's terminal, pickup must be done promptly upon notice of its arrival there.

(B) The Assistant RSO shall receive all shipments of radioactive material for Lehigh. Upon delivery, he shall inspect the crates for signs of external damage, and confirm that the security seal has not been tampered with or removed during shipment. If damage is evident, the carrier's agent should be present while unpacking.

(C) The Ass't RSO shall survey the exposure device with a survey meter as soon as possible, preferably at the time of pickup and no more than 3 hours later if received during working hours. If received after normal working hours, the survey must be made within 18 hours of receipt. Radiation levels must not exceed 200 mR/hr at the surface of the exposure device nor 10 mR/hr at a distance of 3 feet from the surface. Actual radiation levels shall be recorded on the shipping papers. If the radiation levels exceed these limits, the container must be secured in a Restricted Area, and the RSO shall be immediately notified.

(D) If radiation levels are within the limits given above, the source may be placed in the storage vault or transferred to an exposure device.

(E) The source isotope, activity, model number and serial number and the shipping container model number and serial number should already be recorded on the papers received with the delivery from the shipper (e.g. Tech/Ops). The Ass't RSO must record, on the same papers, the date received and the mR/hr at the container surface and at 3 feet from the container surface, then initial the papers and file them in the Radioactive Source file.

2.3.2 Shipping Radioactive Material

The following shipping procedures comply with NRC Regulations 10 CFR Part 71 and DOT Regulations 49 CFR Parts 171 through 179 regarding the transportation of radioactive materials:

(A) Assure that the source is locked into place in its storage position. To check this, the lock should be in the down position, and the selector ring should be immobile. Attach a tamper-proof security seal with an identification mark to the storage plug.

2.3.2 Shipping Radioactive Material (cont'd)

(B) If the shipping container is to be packaged in a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transport. These requirements are outlined in 10CFR Part 71 Appendix A. The shipping container should be put in the outer package with sufficient blocking to prevent any shifting during transportation.

(C) Survey the package with a survey meter at the surface and at a distance of 3 feet from the surface to determine the proper radioactive shipping labels to be applied to the package as required by 49 CFR Part 172.403. The radiation exposure limits for each type of shipping label are:

Description of Label	Maximum Dose Rate at Surface	Maximum Dose Rate 3 ft from Surface
Radioactive White I	0.5 mR/hr	None
Radioactive Yellow II	50. mR/hr	1.0 mR/hr
Radioactive Yellow III	200. mR/hr	10. mR/hr

If radiation levels are above 200 mR/hr at the surface or above 10 mR/hr at 3 feet from the surface, the container must not be shipped.

(D) Properly complete two shipping labels indicating the radioactive isotope (Iridium 192), activity (number of Curies on the shipping date), and the Transport Index. The Transport Index is used only on Yellow II and Yellow III labels and is defined as the maximum radiation level in milliroentgens per hour measured at a distance of 3 feet from the surface of the package. Put these two labels on opposite sides of the container after making sure any previous labels have been removed. The package should be marked with the proper shipping name (Radioactive Material, Special Form, NOS - UN 2974). If the exposure device is packaged inside an outer container, mark the outside package as follows: "INSIDE PACKAGE COMPLIES WITH PRESCRIBED SPECIFICATION - TYPE B USA/9033/B(U)" (in this example, the ID# applies to the Tech/Ops Model 660 Exposure device).

(E) Complete the shipping papers (Form 202) as follows:

1. Radioactive Material - Special Form, NOS - UN 2974
2. Type of Source - Iridium 192
3. Activity of Source - no. of Curies
4. Label Type [as determined from paragraph (C), above]
5. Transport Index [from (D) above]
6. Source Serial No.
7. Container Model No. and Serial No.
8. Container Specification No. For example,
   For Model 650 Source Exchanger: NRC ID# USA/9032/B Type B;
   For Model 660 Exposure Device: NRC ID# USA/9033/B Type B

2.3.2 Shipping Radioactive Material (cont'd)

9. Date of shipment
10. Shipper's (Lehigh's) name and address
11. Consignee's name and address
12. The following statement: "All shipping procedure requirements have been satisfied"
13. The following statement: "This is to certify that the above named materials are properly classified, described, packaged, marked, and labeled, and are in proper condition for transportation, according to the applicable regulations of the U.S. Department of Transportation"
14. Signature and title of the person making the shipment

(F) A copy of the shipping paper will be retained in the Source file.

(G) When shipping a source to another Lehigh location, the following additional procedures will be observed:

1. The responsible person at the destination will be notified concerning the shipment.
2. A copy of the latest leak test certificate will accompany the shipment.

2.3.3 Transporting Radioactive Materials in Lehigh Vehicles

(A) Any vehicle used in transporting radioactive material should be in good operating condition and shall carry the normal complement of safety equipment such as warning signs, rope, a spare tire, a fire extinguisher, set of vehicle tools, and a set of flares. The glove compartment should have the vehicle's registration certificate and a working flashlight.

(B) Only a qualified Radiographer or Assistant Radiographer shall drive the vehicle. Additionally, they must be wearing a pocket dosimeter and a TLD badge, and the vehicle must carry a dosimeter charger and survey meter. A copy of this Radiation Safety Manual shall be carried in the vehicle. If radiography will be done in Maryland or another agreement state, the applicable radiation control laws of that state must also be carried.

(C) Before placing the container in the vehicle and securing it against movement, the operator should ensure that the container is properly packaged, marked, and labeled, and that Form 202 is completed per section 2.3.2 above, and are in the drivers compartment. Only packages qualifying for "Radioactive White I" or "Radioactive Yellow II" shipping labels may be transported in Lehigh vehicles.

(D) The container shall be placed in the vehicle within a locked steel box which is secured within the vehicle to prevent its unauthorized removal. The driver/passenger compartment and the exterior vehicle surface shall be surveyed to assure that radiation levels are below 2 mR/hr. Lead or other shielding materials shall be added, if necessary, to reduce radiation levels to meet this requirement.

2.3.3 Transporting Radioactive Materials (cont'd)

(E) Routes shall be selected so as to minimize travel through densely populated areas, tunnels, narrow streets, etc., and which, to the extent feasible, minimize time in transit. Interstate highway route are preferred.

(F) A completed copy of Form 202 must be in the driver's possession in the vehicle when radioactive materials are being transported. Also, if radiography operations are to be performed in an agreement state, the RSO must generally obtain approval from the state's radiation control agency prior to starting the work. Finally, a current list of emergency phone numbers must be displayed so that a responsible person may be contacted in the event of an accident or other emergency.

2.3.4 Hand Carrying of Radioactive Source Containers

In order to minimize radiation exposure, care must be taken when hand carrying the unit. Dosimeter and TLD badge should be worn on the side of the body closest to the exposure device. If more than one person is present, it is good practice to alternate the hand carrying between them to minimize radiation doses to any one individual. Obviously, no person should be permitted to sit on or lounge against the exposure device.

2.3.5 Shipping Empty Depleted Uranium Containers

(A) Empty container shall be secured and sealed as if it contained a source.

(B) A tag shall be wired or taped to the device indicating the following:

1. Name of shipper (Lehigh), address and phone number.
2. The following statement: "Empty device - This package conforms to the conditions and limitations specified in 49 CFR 173, 424 for excepted radioactive materials. Articles manufactured from depleted uranium, UN 2909".

(C) The container shall be placed in a wooden crate or metal box (minimum interior dimensions 2" larger than container dimensions) and blocked in the center to prevent shifting during transit. The radiation level at the box surface must not exceed 0.5 mR/hr.

(D) The crate or box shall be closed securely to prevent a loss or shifting of the contents. It shall be strong enough to survive rough handling or dropping during transit.

(E) No special markings or labels are required on the outside surface of the box. Remove or completely obliterate old markings or labels.

(F) No special shipping paper entries are required. The device shall be identified as "Inspection Equipment".

2.4.0 PROCEDURES FOR SOURCE CHANGES

2.4.1 General Information

Source changes may be performed using Tech/Ops Models 414 or 650 source changers, which are portable, shielded containers designed to safely contain the radiographic source and to permit field exchange of old for new sources without exposing the operator to unsafe radiation levels. The 650 changer has depleted uranium shielding, and meets the "Type B" packaging requirements for shipping; the Model 414 has lead shielding, does not meet "Type B" requirements, and shall not be used as a shipping container.

Source changes must be performed in a Restricted Area by the Assistant Radiation Safety Officer, or by a qualified Radiographer under the supervision of the Assistant RSO.

2.4.2 Source Changing Procedures

(A) Survey the source changer to insure that the source is in the proper storage position. Radiation levels must not exceed 200 mR/hr at the surface nor 10 mR/hr at 3 feet from the surface.

(B) Position the source changer and exposure device close together so that one section of source guide tube will connect them with no sharp turns or bends. The bend radius of the guide tube should never be less than twenty inches. Smaller bend radii may restrict source movement in the source guide tube.

(C) Remove the storage plug from the exposure device, and attach the source guide tube. Remove the source changer cover and attach the other end of the tube to the empty chamber of the source changer.

(D) Attach the control unit to the exposure device per sec. 2.2.3, "Assembly".

(E) Crank the source rapidly from the exposure device to the source changer. During this process, the survey meter reading should increase (to approximately 1000 mR/hr for a 100 Curie Iridium-192 source) as the source is first exposed, fall slightly as the source is being cranked out, then drop to background when the source is in the source changer.

(F) Approach the source changer and source guide tube with the survey meter to insure that the source is fully within the source changer. Verify that the radiation level does not exceed 200 mR/hr at the changer surface.

(G) Open the source guides and disconnect the drive cable from the source assembly by moving the lock pin down and sliding the drive cable connector ball out through the keyway.

2.4.2 Source Changing Procedures (cont'd)

(H) Disconnect the source guide tube from the source changer. If a replacement source is to be installed in the exposure device, connect the source guide tube to the fitting above the chamber containing the new source and couple the drive cable to the new source. If the source is being removed to service the exposure device, connect the drive cable to the jumper that is clipped inside the storage cover of the exposure device.

(I) Return to the controls and crank the new source (or jumper) into the exposure device. If a new source is being transferred, the survey meter reading should increase as the source leaves the source changer and approaches the exposure device, then drop to background level when the source is shielded in the exposure device. If a jumper is being transferred, the survey meter should indicate only background radiation levels.

(J) Survey the exposure device to insure that the process has been properly completed. Radiation levels should read no more than 50 mR/hr at 6 inches from the surface of the exposure device if a new 100 Curie cource of Iridium-192 has been transferred. If the jumper is in the exposure device, only background radiation should be detected by the survey meter. Rotate the selector ring to the LOCK position.

(K) Survey the source guide tube and the source changer to insure that the source has been correctly transferred.

(L) Secure the source(s) in the source changer in accordance with the appropriate source changer instruction manual.

(M) Disconnect the control unit and source guide tube from the exposure device as in Section 2.2.5, "Disassembly", and disconnect the source guide tube from the source changer.

(N) Remove the source identification plate from the exposure device and attach it with seal wire to the source holddown cap.

(O) If the exposure device contains a source, affix the identification plate of the new source to the exposure device. If not, attach an EMPTY tag to the handle of the exposure device.

(P) If the source changer is to be shipped, survey it to determine the correct shipping label required as in Section 2.3.2(C). (Radiation levels must not exceed 200 mR/hr at the surface nor 10 mR/hr at 3 feet from the surface. Bolt the source changer cover in place and secure it with seal wire. Affix proper shipping labels and return source changer to Tech/Ops.

(Q) For the new source, file the source decay chart and leak test certificate in the Radioactive Source file.

2.5.0 PROCEDURES TO BE FOLLOWED IN EMERGENCY SITUATIONS

2.5.1 Recognizing an Emergency

In an emergency situation, something has gone wrong in some unpredictable manner. You must act to eliminate any danger that exists. You will have to make judgments (and often in a short span of time). To help you make sound judgments in these unforeseen situations, this section provides you with general rules on what to do. These are your EMERGENCY PROCEDURES.

An emergency situation must be recognized before any suitable response can be made. Sometimes recognizing a problem is easy. If you see the source guide tube crushed by a piece of heavy equipment and you cannot retract the source, you know you have a problem.

Sometimes emergencies may not be immediately recognized. A source can disconnect in the guide tube without your knowledge. Illness or fatigue may impair your ability to work properly without your being aware of what is happening. Serious distractions can confuse you and lead you to make errors.

The FIRST STEP is to recognize that a dangerous situation exists. Recognize the conditions that mean a "warning sign." These will provide a signal to alert you to what could be a dangerous situation. By learning what situations have caused accidents in the past, you may be able to avoid an accident if you are in the same situation yourself some day.

2.5.2 Your Immediate Response to Any Emergency - THE FOUR BASIC RULES

What should you do if a critical emergency situation develops, one that you may never encountered before? For example, what would you do if the guide tube were somehow damaged or if a source connection failed so that the exposed source could not be retracted into the exposure device? Once you recognize that an emergency exists, your immediate course of action will determine the extent that the emergency will endanger you or others in the area. There are **FOUR BASIC RULES** that you must follow:

RULE #1: **MOVE AWAY FROM THE EXPOSED SOURCE AND KEEP OTHER PEOPLE AWAY.**

Because of the Inverse Square Law, just a few yards of separation reduces radiation levels considerably. For a 50 Curie Iridium-192 source, moving just 30 feet away reduces the radiation level to less than 300 mR/hr. The worst thing you can do is to touch the source with your hand. Don't try to put the source back into the camera by hand or reconnect it to the drive cable by hand. Touching a 100 Curie Iridium-192 source causes radiation burns in seconds.

2.5.2 Your Immediate Response to Any Emergency - **THE FOUR BASIC RULES**

RULE #2: **RELAX, DON'T PANIC, AND CALMLY ASSESS THE SITUATION**

Now that you are away from the source, you have more time to think about what to do. Don't panic, even if the source cannot be immediately shielded. You must consider your options carefully and deliberately. THINK! Above all, don't try to do anything yourself that you are not trained for.

RULE #3: **ESTABLISH A RESTRICTED AREA, AND MAKE SURE NO ONE ENTERS IT**

Rope off the area, if possible, if this has not already been done. Use a survey meter to make sure the Restricted Area is properly established.

Rule #4: **NOTIFY THE RSO WITHOUT LEAVING THE RESTRICTED AREA UNATTENDED**

If there is no one there to help, you should remain in the area if possible, but not too close to the source. Sooner or later someone will come along. Ask him to notify your RSO that you need help. If you can't get in touch with the RSO for some reason, contact the Assistant RSO or the General Manager. A list of important phone numbers appears on the first page of the Appendix to this Manual.

2.5.3 Special Procedures for Specific Emergency Situations

In the vast majority of emergency situations, following the four basic rules above will minimize the danger to you or to anyone else in the area. However, there are several potential emergency situations for which you must take certain additional precautions or actions:

(A) Exposure of Non-Monitored Personnel

In the event of an accident involving the exposure or possible exposure of non-monitored personnel to radiation, you must take down their names, ages, addresses, and all other relevant facts concerning the incident (for example, their position with respect to the radiation source; the total time the source was exposed while they were present; the type and location of intervening shielding, if any, etc.) and be prepared to report this information to the RSO.

2.5.3 Special Procedures for Specific Emergency Situations

(B) Theft or other Loss of a Radioactive Source

In the event of the theft or loss of a source of radioactive material or source container, you will have to supply the RSO and the local civil authorities with as much relevant information as you can concerning the circumstances of the loss, such as the the last known location of the source or container. If possible, the RSO will attempt to relocate the source using survey meters and triangulation methods. You may be requested to assist him.

(C) Accident Involving a Vehicle Which is Transporting a Source (Inoperable Survey Meter)

In the event of a vehicular accident involving licensed radioactive materials, the Radiographer must implement the four basic procedures in 2.5.2; however, what if you discover that your survey meter has been damaged and is now inoperable? In all such emergencies involving inoperable survey meters, the Radiographer shall use calculations or the chart included in Section 1.9.2 of this Manual to establish the perimeter of the restricted area, assuming that the source is in the exposed position inside the vehicle. In the case of a minor accident where it can be visually determined that the source is safely stored in its container, no restriction of area is required. However, no active usage of the source may be made until a calibrated, operable meter can be obtained to replace the inoperable meter and confirm that no excessive radiation is being emitted. If you eventually obtain a working survey meter and if you determine that there is no abnormal radiation leakage, and if the vehicle is driveable, you may return to your assignment.

2.5.4 When the NRC must be Notified

It is the responsibility of the Radiation Safety Officer to notify the Director of the NRC Inspection and Enforcement Regional Office in King of Prussia, PA (see telephone number - first page of appendix to this manual) upon learning of any of the following:

Loss or Theft of Licensed Material; Incidents involving Licensed Material; or Overexposures to Personnel.

The type of notification required, if any, varies with the severity of the matter. The RSO shall determine the nature and immediacy of notification required. In some cases, the law (10 CFR 20) requires immediate notification by phone; in other cases, a written report is required within 30 days.

2.6.0 INSPECTION/MAINTENANCE PROCEDURES FOR GAMMA RADIOGRAPHY EQUIPMENT

2.6.1 Daily Inspection of Gamma Radiography Equipment

Prior to the start of radiography operations each day, during the assembly of the equipment, the Radiographer shall perform an inspection of the equipment he is issued. Specifically, he shall perform the following checks:

(A) Insure that all required equipment is on hand, including proper personnel monitoring equipment, two survey meters (one spare), sufficient warning signs, rope, spare batteries and, if at a field location, all of the vehicle tools and miscellaneous equipment listed in 2.3.3.

(B) Miscellaneous - visually insure that all labels, safety caps, screws are in place for all equipment.

(C) Survey meters - check the battery strength, calibration status and response to radiation as described in 1.6.1(C). Record the initial survey reading of the exposure device on the Daily Utilization Report. Readings over 200 mR/hr at the surface of a Model 660 containing 100 Curies of Iridium 192 are abnormal.

(D) Inspect the entire length of each source guide tube section and control housing to insure that each section is free from cuts, dents, flattened areas, or any other physical damage.

(E) Inspect the end fittings to insure that they are tightly connected. Check the threads on the fittings, the control cable connector and the male source connector for dirt build-up or damage.

(F) During the first exposure of the shift, check the operation of the selector ring, the odometer, the lock assembly and the control crank. If operation is difficult, retract the source to the stored position and survey the equipment according to the operating instructions (Par. 2.2.4). The equipment must be serviced before further operation.

(G) The Radiographer shall record the results of this daily inspection on the Daily Utilization Report.

2.6.2 Quarterly Maintenance Procedures for Gamma Radiography Equipment

At intervals not to exceed three months, the Assistant Radiation Safety Officer shall insure that all Lehigh radiographic exposure devices and related equipment are given thorough maintenance servicing according to the following procedures. These procedures shall be performed by Radiographers or by Assistant Radiographers under the personal supervision of Radiographer.

(A) Control Unit: Drive Cable, Control Housings and Source Guide Tubes - Disassembly

1. Disconnect the control unit from the exposure device.

2. Turn the hand crank of the control unit in the EXPOSE (counterclockwise) direction until the crank will no longer turn. Do not use force, as this may damage the drive wheel inside the control box. The emergent cable should be cranked into a bucket or other container to keep it clean.

3. Disconnect the control housing from the RETRACT side of the crank and remove the stop spring from the drive cable. The drive cable will now pass through the crank.

4. Turn the crank until the control unit is totally disconnected.

5. Pull the drive cable out through the Model 661 control cable connector and coil it with a radius of no less than 4 inches.

6. Remove the Model 661 control cable connector and connector plug from the control housings, and disconnect the other control housing from the crank. Label the housings for proper reassembly.

7. Clean the drive cable with chlorothene and flush the control housings and source guide tubes.

8. Using forced air, thoroughly dry the drive cable, control housings and guide tubes. Any remaining solvent can cause permanent damage.

9. Check the source guide tubes for binding by holding them vertical and dropping a dummy source (or jumper) through them.

10. Wipe the guide tubes and control housings with a cloth soaked in chlorothene and flex them to check for internal damage. Damage is evidenced by a crunching feeling when the housing or tube is bent. While doing this, feel for dents. Cut, flattened or burnt control housings or guide tubes should be repaired or replaced.

11. The guide tubes or control housings may be covered with tape where only the outer plastic is cut through.

2.6.2 Quarterly Maintenance Procedures for Gamma Radiography Equipment

(A) Control Unit: Drive Cable, Control Housings and Source Guide Tubes - Disassembly (cont'd)

12. Using a Model 550 no-go guage, check the male connector of the drive cable. If the ball of the connector fits through the hole of the guage or the ball shank fits into the slot in the guage, the connector is worn and the cable must be replaced.

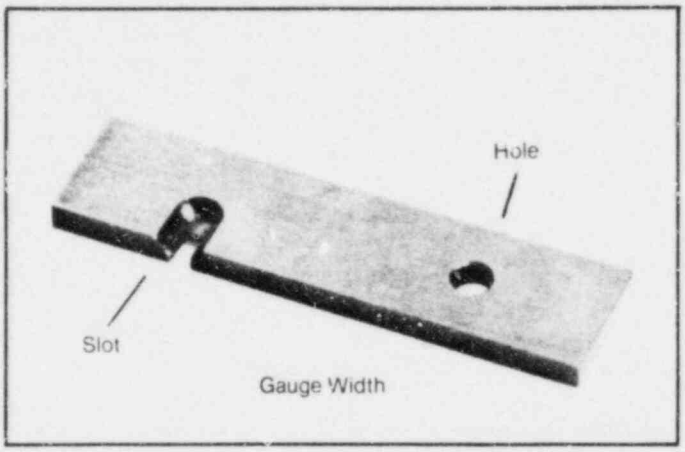


FIGURE 2.9 - Model 550 NO-GO Guage

13. Lightly grease the cable using TEXACO "Uni-Temp" grease. Other greases may form tars or corrosive compounds when exposed to radiation.

(B) Crank Assembly: Model 664 Control Unit - Disassembly

1. Remove the control housing and drive cable from the crank assembly as described in the previous paragraphs. Refer to Figure 2.10 to aid in disassembly and for component identification of replacement parts.

2. Remove the control box housing (4) from the frame (11) by unscrewing the four binder head screws and 3/8" nuts (1).

3. Remove the crank arm assembly (3) from the control box housing by removing the 5/16" hex head bolt (2).

CAUTION - Make sure the cable adapters stay in the lower control box during separation. Care should be taken to avoid possible injury from or loss of the tension-loaded wear strip.

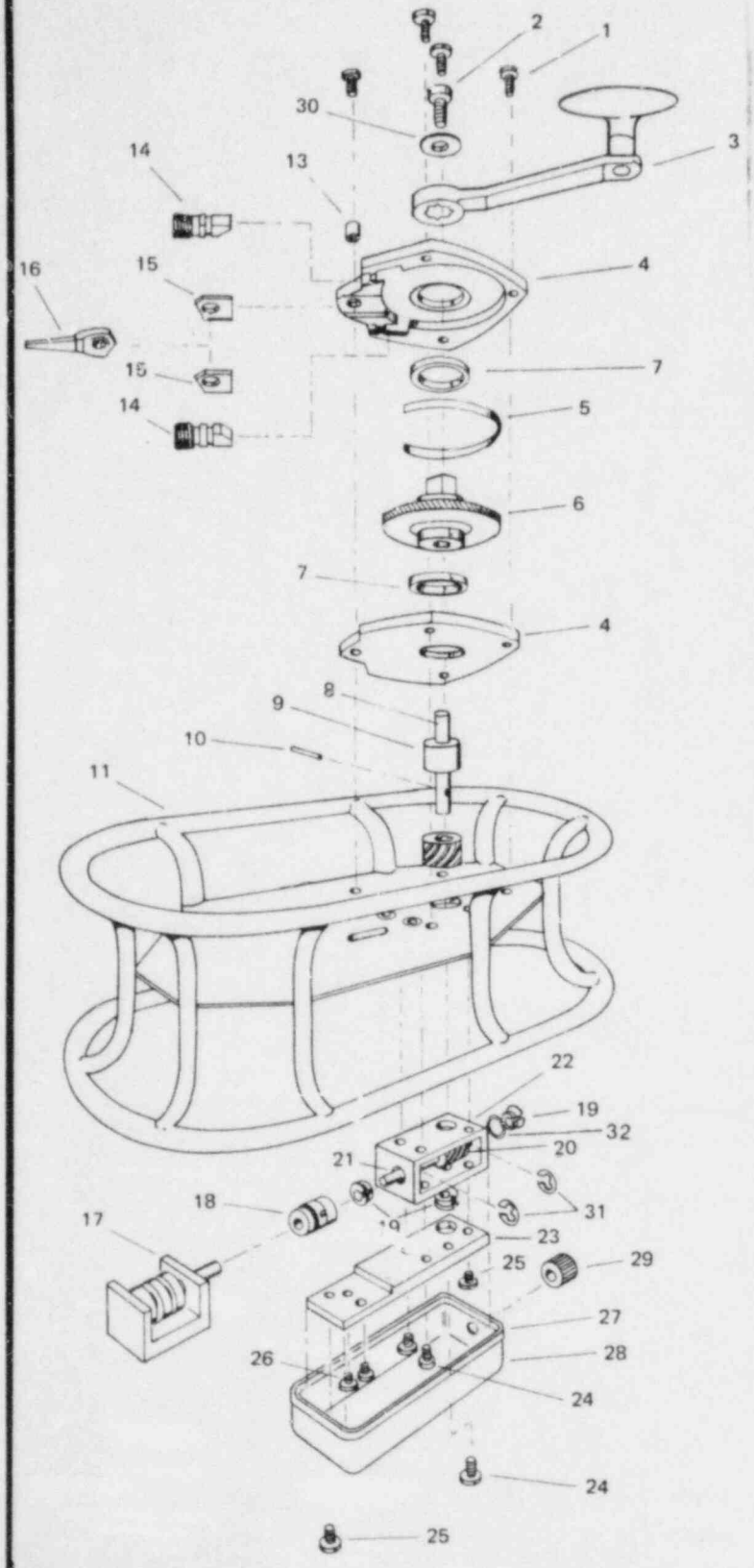


FIGURE 2.10 - Model 664

Control Unit--Exploded View

1	————	#10-32 x 1-¼ Bind. Hd. Screw and #10-32 Elastic Stop-Nut (4 Each Required).
2	————	5/16-18 x 5/8 Hex. Bolt (AN 10-5)
3	B68901	Crank Arm Assembly
4	C68900-1	Control Box Housing (2 Required)
5	A68900-7	Wear Strip
6	C68900-9	Drive Wheel
7	————	Ball Bearing Assembly
8	A66404-1	Gear Shaft
9	————	Oilite Bearing—Bost. Gear #B48-3
10	————	Dowell Pin—3/32 Dia. 5/16 Lg.
11	D66410	Frame
12	————	Helical Gear—Bost. Gear #H2410L
13	————	Brake Bearing—Bost. Gear #B35-4
14	B68900-2	Cable Adapter (2 Required)
15	A68900-4	Brake Jaw (2 Required)
16	A68900-3	Brake Arm
17	————	Odometer—Durant #3Y-8822-R-S-AC
18	A66403-4	Coupling
19	————	Nylon Bearing—Thomson #4L2-FF (3 Required)
20	————	Helical Gear—Bost. Gear #H2412L
21	A66403-3	Odometer Connecting Shaft
22	B66403-2	Gear Box
23	B66403-1	Mounting Plate
24	————	#8-32 x 3/8 Bind. Screw (3 Required)
25	————	#8-32 x 1/4 Bind. Hd. Screw (2 Required)
26	————	#4-40 x 1/4 Bind. Hd. Screw (2 Required)
27	————	Rubber Gasket—Greene Rubber Co. #GR-121
28	B66403-5	Cover
29	————	Reset Knob—Raytheon #70-1-2
30	————	5/16 Bevel Washer
31	————	Grip Ring, Tru-Arc #5555-25(2 Required)
32	————	E-Ring, Tru-Arc #5133-25

2.6.2 Quarterly Maintenance Procedures for Gamma Radiography Equipment

(B) Crank Assembly: Model 664 Control Unit - Disassembly (cont'd)

4. Separate the two halves of the control box housing, keeping the cable adapters in the lower control box housing to ensure the wear strip (5) does not fly out. Remove the drive wheel (6), wear strip (5), two cable adapters (14), two brake jaws (15), brake arm (16) and brake bearing (13).

5. The two ball bearing assemblies (7) in each side of the control housing may be left in place.

6. Remove the reset knob (29) by loosening the two set screws, and remove the odometer cover (28) by removing the two large binder head screws fastening it to the mounting plate.

7. Check the odometer unit for proper operation. The unit should turn freely and without excessive play. Clean the helical gear (20) with chlorothene and lightly grease it with TEXACO "Uni-Temp" grease. If the odometer assembly is defective, it must be replaced as a unit.

8. To service the odometer assembly remove the unit from the frame by unscrewing the three flat head machine screws holding the gear box (22) to the frame (11).

(C) Crank Assembly: Model 664 Control Unit - Reassembly

1. Clean all the control box parts in chlorothene and dry them thoroughly with forced dry air (15 psi maximum). Inspect for damage and excessive wear. Replace any defective parts.

2. Lightly grease all moving parts at their contact surfaces with TEXACO "Uni-Temp" grease.

3. Place two cable adapters (14) in the lower control box housing (4) with the angled sides facing inward in order to provide clearances for the drive wheel(6).

4. Place the wear strip in the control housing.
CAUTION - Insert the wear strip with care, since it will be under tension and could pop out.

5. Place the drive wheel (6) in the lower control box housing (4).

6. Position the two brake jaws (15), brake bearing (13) and brake arm (16) in the lower control box housing. Install the brake jaws with the worn sides away from the drive wheel, as this increases their life.

2.6.2 Quarterly Maintenance Procedures for Gamma Radiography Equipment

(C) Crank Assembly: Model 664 Control Unit - Reassembly (cont'd)

7. Place the upper control box housing over the lower control box housing while keeping them level, and press them together.

8. Check the control box for proper reassembly by turning the shaft. It should spin freely. If not, disassemble and reinspect the parts for damage and proper alignment. Reassemble and check the operation again.

9. Mount the odometer assembly on the frame (11) by securing the gear box (22) with three flat head machine screws.

10. Secure the odometer cover (28) to the mounting plate (23) with two binder head screws, and secure the odometer reset knob (29) to the shaft by tightening the two set screws.

11. Mount the control box onto the frame (11) and secure with the four large binder head screws and 3/8" nuts. Secure the crank arm assembly (3) to the shaft with the 5/16" bevel washer (30) and 5/16" hex head bolt (2).

12. After complete reassembly, check for proper operation by turning the crank: it should spin freely. Run the drive cable through the control box and turn the crank. It should turn easily and with no snags. Set the brake to ON and attempt to turn the crank. It should not turn with moderate pressure. Do not apply excessive pressure to the crank, as this may cause damage. If the control box fails any of these tests, disassemble, check the parts for damage and proper alignment, then reassemble and check for proper operation again.

CRANK ASSEMBLY - MODEL 693 CONTROL UNIT

To service the 693 control unit, perform the following steps:

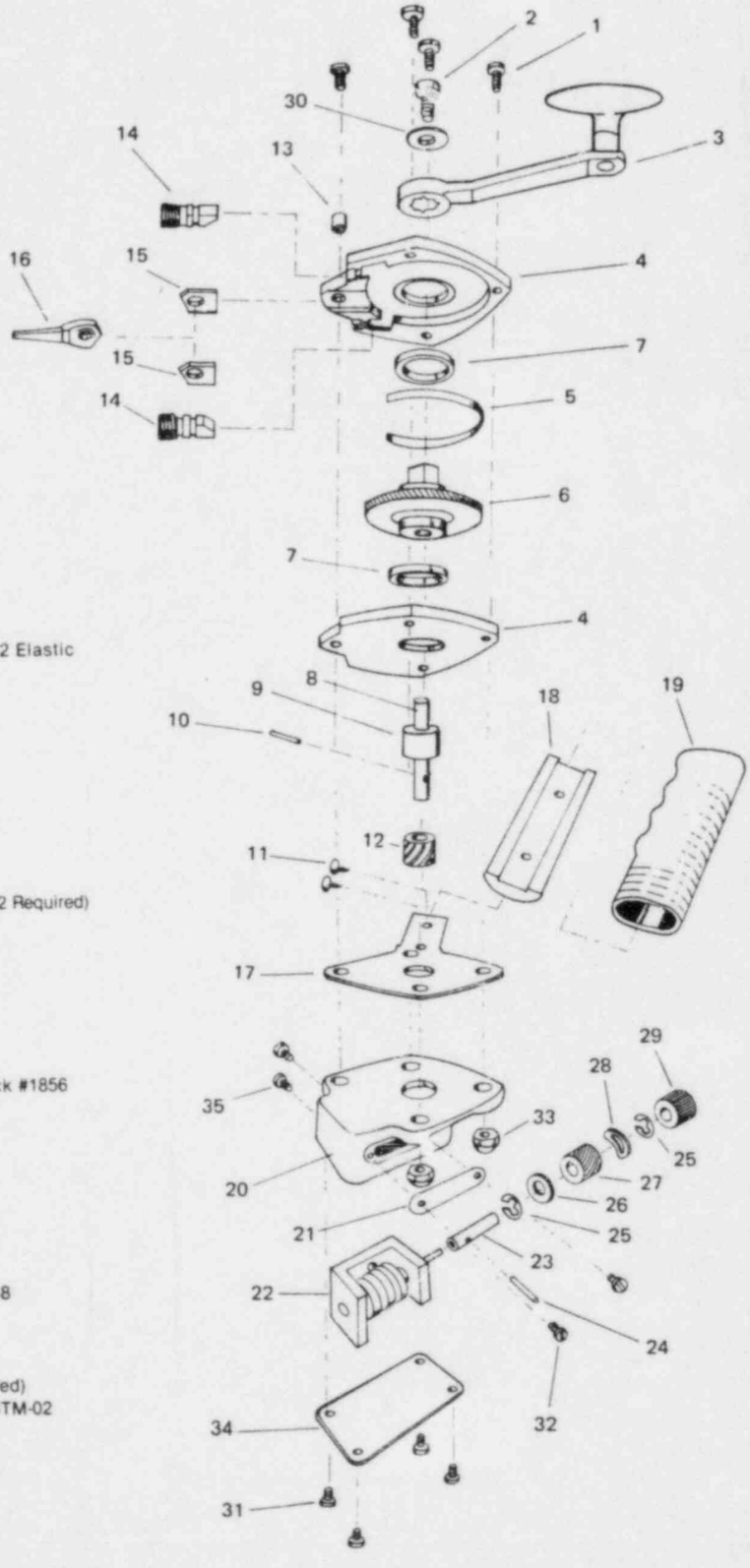
1. Follow steps 1-5, Disassembly, Model 664 Crank Assembly. Refer to Figure 2.11 for further disassembly and for part identification numbers.

2. Remove the odometer mount cover (34) from the odometer mount (20) and check the odometer unit for proper opearation. The unit should turn freely and without excessive play. Clean the helical gear (27) with chlorothene and lightly grease it with TEXACO "Uni-Temp" grease. If the odometer assembly is defective, it must be replaced as a unit.

3. To service the odometer, remove the odometer mount cover (30) from the odometer mount (20), remove the odometer reset knob (29) by unscrewing the two set screws, and unscrew the two attaching large round head screws (35).

FIGURE 2.11 Model 693

Control Unit--Exploded View



1	————	#10-32 x 1-¼ Bind. Hd. Screw and #10-32 Elastic Stop-Nut (4 Each Required).
2	— —	5/16-18 x 5/8 Hex. Bolt (AN 10-5)
3	B68901	Crank Arm Assembly
4	C68900-1	Control Box Housing (2 Required)
5	A68900-7	Wear Strip
6	C68900-9	Drive Wheel
7	————	Ball Bearing Assembly
8	69302-1	Gear Shaft
9	————	Oilite Bearing—Bost. Gear #B48-5
10	————	Dowell Pin—3/32 Dia. 5/16 Lg.
11	————	#8 Sheet Metal Screws 5/8 Lg. Flat Head (2 Required)
12	————	Helical Gear—Bost. Gear #H2410L
13	————	Brake Bearing—Bost. Gear #B35-4
14	B68900-2	Cable Adapter (2 Required)
15	A68900-4	Brake Jaw (2 Required)
16	A68900-3	Brake Arm
17	C69201-1	Control Handle
18	B69201-2	Handle Filler
19	————	Handle Grip Hunt-Wilde #FG-1-1/4 Stock #1856
20	C69301-1	Odometer Mount
21	A69301-3	Window
22	————	Counter Durant #3Y-8822-R-AC
23	A69303-1	Odometer Drive Shaft
24	————	Roll Pin, 1/16 Dia. x 1/4 Lg.
25	————	E-Ring, Tru-Arc #5133-25 (2 Required)
26	————	Spacer, Pic #B8-11 (1/4 Dia. x 1/8 Lg.)
27	————	Helical Gear—Bost. Gear #H2412L
28	————	Spring Washer, Shakeproof #3502-14-48
29	————	Reset Knob—Raytheon #70-1-2
30	————	5/16 Bevel Washer
31	————	#8-32 x 3/8 Bind. Screw (4 Required)
32	————	#4-40 x 3/16 Bind. Hd. Screw (2 Required)
33	————	10-32 Locknut, Elastic Stop Nut #22 NTM-02 (4Required)
34	A69301-2	Odometer Mount Cover
35	————	4-40 x 1/2 Rd. Hd. Screw (2 Required)

4. Follow steps 1-8, Reassembly, Model 664 Assembly.

5. Resecure the odometer to the odometer mount (20) and secure the odometer reset knob (29) and odometer mount assembly cover (34) in place.

6. Secure the control box to the control handle (17) and odometer mount (20) with the four large binder head screws and 3/8" nuts, and secure the crank arm assembly (3) to the shaft with the 5/16" bevel washer and 5/16" hex head bolt. Follow step 12 of the previous section for checking of operation.

CRANK ASSEMBLY - MODEL 692 CONTROL UNIT

1. Follow steps 1-5, Disassembly, Model 664 Assembly. Refer to figure 2.12 for further disassembly and for part identification numbers.

2. Follow steps 1-8, Reassembly, Model 664 Assembly.

3. Secure the control box to the control handle (17) with the four large binder head screws and 3/8" nuts, and secure the crank arm (3) to the shaft with the 5/16" bevel washer and 5/16" hex head bolt. Follow step 12, Reassembly, Model 664 Assembly, to check operation.

(D) Control Unit: Drive Cable, Control Housings and Source Guide Tubes - Reassembly

1. Attach the control housing to the EXPOSE side of the control box and to the Model 661 connector.

2. Feed the drive cable into the control housing as far as it will go. As the drive cable is being fed in, feel the resistance to the drive cable to detect any binding of the cable. This indicates a dent in the control housing which should be repaired or replaced.

3. Turn the hand crank until the drive cable is protruding, and screw the stop spring to the end of the drive cable.

4. Connect other control housing to the crank and to the connector plug.

5. Turn the crank fully to the RETRACT position and watch for any binding of the drive cable to check the other section of the control housing for dents. Repair or replace the control housing if necessary.

6. Place plastic dust caps on the ends of the source guide tubes and Model 661 control cable connector to eliminate dust accumulation.

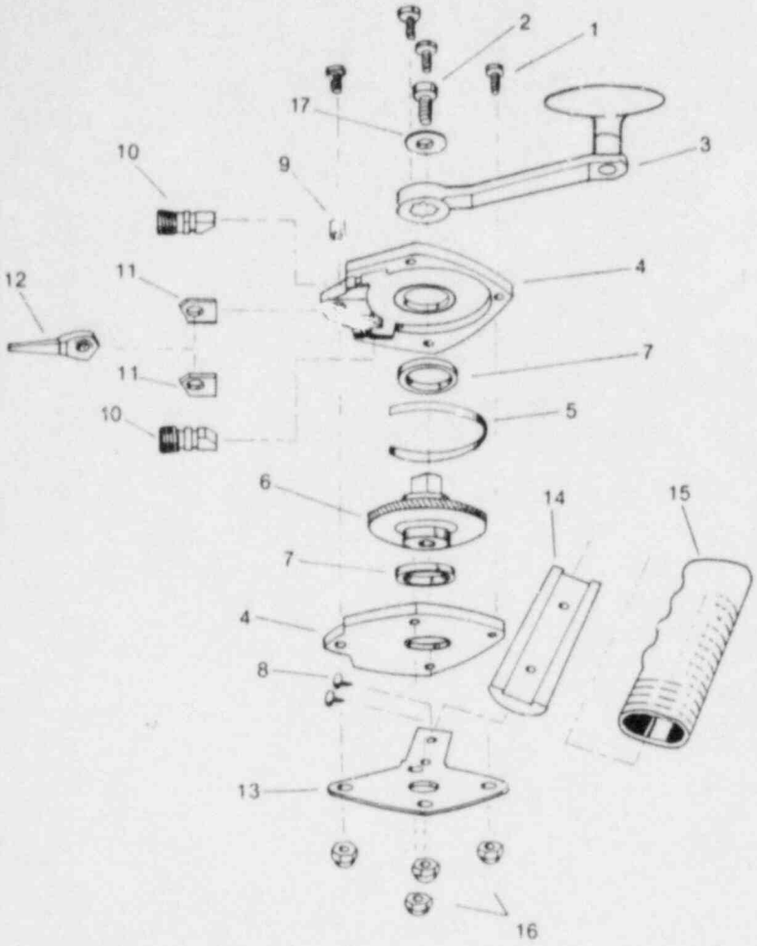


FIGURE 2.12 Model 692

Control Unit Exploded View

1	————	#10-32 x 1-¼ Bind. Hd. Screw and #10-32 Elastic Stop-Nut (4 Each Required).
2	————	5/16-18 x 5/8 Hex. Bolt (AN 10-5)
3	B68901	Crank Arm Assembly
4	C68900-1	Control Box Housing (2 Required)
5	A68900-7	Wear Strip
6	C68900-9	Drive Wheel
7	————	Ball Bearing Assembly
8	————	#8 Sheet Metal Screws 5/8 Lg. Flat Head (2 Required)
9	————	Brake Bearing—Bost. Gear #B35-4
10	B68900-2	Cable Adapter (2 Required)
11	A68900-4	Brake Jaw (2 Required)
12	A68900-3	Brake Arm
13	C69201-1	Control Handle
14	B69201-2	Handle Filler
15	————	Handle Grip Hunt-Wilde #FG-1-1/4 Stock #1856
16	————	10-32 Locknut, Elastic Stop Nut #22 NTM-02 (4Required)
17	————	5/16 Bevel Washer

2.6.2 Quarterly Maintenance Procedures for Exposure Devices

(E) Model 660 Exposure Device

In general, maintenance service to the exposure device is not part of the required quarterly maintenance procedures, unless there is a definite need to do so, as determined by the RSO or by the Assistant RSO. Disassembly of an exposure device containing a source can be dangerous. Also, disassembly of a properly functioning exposure device may cause more problems than it solves, especially if the device it not perfectly reassembled. Therefore, when an exposure device requires major maintenance, this shall be performed only by the manufacturer.

(F) Final Inspection of all Equipment

1. Check the system for proper reassembly. Check all connections and fittings for tightness. Check for proper operation of the control unit and control unit connector assembly.

2. Reload the source in the exposure device by following Section 2.4.0, Source Changes.

3. Survey the exposure device on all sides to ensure that radiation levels do not exceed 200 mR/hr at the surface nor 10 mR/hr at 3 feet from the surface.

4. Check the exposure device for the proper labels.

(G) Documentation of Quarterly Maintenance

The results of the above quarterly maintenance procedures on exposure devices and related equipment shall be documented by the Assistant Radiation Safety Officer on Lehigh Form 203, "Quarterly Inspection and Maintenance Report", and filed in the RSO's Quarterly Equipment Maintenance file.

2.6.3 Quarterly Inventory of Radioactive Materials and Devices

At intervals not to exceed three months, the Assistant RSO shall conduct a quarterly physical inventory to account for every licensed material received and in Lehigh's possession.

For each sealed source, the inventory shall include the activity (on the date of the inventory), the type (e.g., Ir-192), the date received, the model no. and serial no. of the source material, and the make, model, serial no. and physical location of the device in which the sealed source is contained. Form 204 shall be used to document this information.

2.6.4 Leak Testing of Radioactive Source Assemblies

Sealed source assemblies used in exposure devices must be tested for leakage of radioactivity at intervals not to exceed six months. Leak testing shall be performed by the Assistant Radiation Safety Officer in accordance with the following procedures:

(A) Leak tests shall be performed using the Tech/Ops Model 518 Leak Test Kit, which contains a flexible swab holder with swab; a vial of EDTA solution; a plastic envelope; a mailing box; and an identification sheet.

(B) Be sure the source is fully retracted and secured in the exposure device. Use a survey meter to insure that radiation levels are normal.

(C) Remove source guide tube from front of exposure device or remove the shipping plug.

(D) Wet the swab with EDTA solution. Shake off excess and insert swab into the hole in the shield. Wipe the interior of the hole thoroughly by rotating the swab holder.

(E) Withdraw the swab and place in the plastic envelope.

(F) The swab should now be surveyed by turning the survey meter to its most sensitive range. Place the meter in a low background area and move the swab in its plastic envelope toward the swab (not the swab to the meter).

(G) If there is no indication on the meter, or if the indication is no more than 0.2 mR/hr above background, put the plastic envelope with the swab in the mailing box and mail to:

Tech/Ops Incorporated
40 North Avenue
Burlington, Massachusetts 01803

Be sure to fill out and return the identification sheet.

(H) If the swab should show more than 0.2 mR/hr, DO NOT MAIL IT. Contact Tech/Ops for specific instructions.

(I) When received by Tech/Ops, the swab will be subjected to a radio-assay, and a leak test certificate of the results will be mailed by Tech/Ops to Lehigh. This leak test certificate will be retained by the Assistant RSO in the Source File for a period of not less than two years.

2.7.0 FORMS AND RECORDKEEPING REQUIREMENTS--RADIOGRAPHY OPERATIONS

The following documentation of radiography activities shall be maintained in files controlled by the Radiation Safety Officer and/or the Assistant RSO. Each document is referenced elsewhere in this Manual. All records shall be kept available for review by the NRC for a minimum of two years, unless otherwise specified below.

(A) FORM 201: Daily Utilization Report

This form shall be used to record each active usage of each radioactive source used in an exposure device for purposes of industrial radiography. For each usage, the Radiographer in charge of the crew shall record all applicable information completely and accurately, sign it, and submit the handwritten original to the Assistant RSO immediately upon completion of each daily shift. The Assistant RSO shall review and sign the form, then attach it to the billing sheet for the work and submit it to the RSO for final review. The form shall then be filed in the chronclogical "Utilization Log" file.

(B) FORM 202: Transport Record for Radioactive Sources

This document is used to record all shipments and vehicle transports of radiographic sources which originate from Lehigh. The form must be completed by the Radiographer prior to each assignment requiring transport of a source to a field site, and prior to shipping a souce back to the supplier. These forms shall be filed in the chronological Utilization Log.

(C) FORM 203: Quarterly Inspection and Maintenance Report

This form is a checklist based on the procedures required in section 2.6.2., shall be signed by the Radiographer in charge of the assignment and shall be reviewed and signed by the Assistant RSO prior to filing in the "Quarterly Maintenance" file.

(D) FORM 204: Quarterly Inventory of Radioactive Materials

This form shall be used to document the quarterly inventory made by the Assistant RSO in accordance with section 2.6.3. The Assistant RSO shall complete and sign the form, then submit it to the RSO for review and filing in the "Quarterly Inventory" file.

(E) FORM 205: Quarterly Pocket Dosimeter Record

Each individual shall record his initial and final pocket dosimeter readings on this form each day he is engaged in radiography operations. The Assistant RSO shall maintain these forms, one for each worker. At the end of each calendar quarter, the sheet shall be filed in the individual's personnel file. This data shall be compared to the TLD reports.

2.8.0 NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; NRC INSPECTIONS

This section describes Lehigh's obligations to workers engaged in radiography per 10 CFR 19.

2.8.1 Posting of Notices to Workers

The following postings shall be maintained in the radiography film evaluation area for all radiography workers:

(A) In accordance with 10 CFR 19.11(b), copies of the following documents are available in the RSO's office for examination or review by employees:

1. 10 CFR 19, as amended: Requirements for notices, instructions, and reports to workers;

2. 10 CFR 20, as amended: Standards for protection against radiation;

3. NRC License No. 07-01173-03, as amended: This license and the conditions and limitations thereof comprise the NRC's authorization to Lehigh to receive, possess, use and transport specified radioactive materials for purposes of industrial radiography;

4. Lehigh Radiation Safety Manual, Sections 1 and 2, as amended: This establishes the company's written operating and emergency procedures for industrial radiography via sealed radioactive sources;

(B) Any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to 10 CFR 2, Subpart B; and any response from Lehigh to the NRC. Any such documents shall be posted within two working days after receipt or dispatch, and shall remain posted for a minimum of five working days or until action correcting the violation has been completed, whichever is later.

(C) Form NRC-3, "Notice to Employees", as amended.

2.8.2 Instructions to Workers

Per 10 CFR 19.12 all individuals working in or frequenting any portion of a restricted area shall be informed of or instructed in each of the following matters by the RSO:

1. of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area;

2.8.2 Instructions to Workers (cont'd)

2. of the health protection problems associated with such radioactive materials or such radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of the protective devices employed;

3. to observe, to the extent within the worker's control, the applicable provisions of Commission regulations and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas;

4. of their responsibility to report promptly to the RSO and the General Manager any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation or to radiactive materials;

5. in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material;

6. of the radiation exposure reports the workers may request pursuant to the following section.

The extent of these instructions by the RSO shall be commensurate with the potential radiological healtrh protection problems in the restricted area.

2.8.3 Notifications and Reports to Individuals

Radiation exposure data for an individual, and the results of any measurements, analyses, and calculations, shall be reported to the individual as specified in 10 CFR 19.13. All such reports shall be made upon specific request of the individual, except for reports of overexposures (see 10 CFR 20.405), and upon termination of employment (see 10 CFR 20.408). The latter two reports to individuals are mandatory, and copies of these mandatory reports must also be sent to the NRC.

2.8.4 NRC Inspections

Workers are hereby instructed that they may consult privately with NRC inspectors during routine inspections, or may personally request an inspection if they believe that Lehigh has violated NRC regulations, the license provisions, or the requirements of this manual in such a manner as to result in excessive or in unnecessary exposures to personnel whether actual or potential.

SECTION 3 - ADMINISTRATIVE INFORMATION REGARDING RADIATION SAFETY

3.1.0 DESCRIPTION OF TRAINING PROGRAM FOR RADIOGRAPHY PERSONNEL

Lehigh's training program in radiation safety, as required by 10 CFR 34, is described in this section. Personnel engaged in radiography at Lehigh shall be designated either as a Trainee, as an Assistant Radiographer, or as a Radiographer.

3.1.1 Training of Individuals to be Assistant Radiographers

(A) Initial Classroom Instruction for Trainees

Trainees will be given a minimum of four hours of formal classroom instruction by the RSO, covering each of the following topics:

1. Responsibilities, duties and limitations of an Assistant Radiographer;
2. Basic principles of radiation safety--the characteristics, effects, measurement and methods of controlling radiation;
3. The use of personnel monitoring devices and survey instruments;
4. Operation of Lehigh's exposure devices and related equipment;
5. Controls used in radiographic operations; Emergency procedures;
6. Lehigh's Radiation Safety Manual and applicable Federal Regulations.

Trainees will also be required to complete the General Dynamics programmed instructional texts on Radiography, Vol. I: "Origin and Nature of Radiation", and Vol. II: "Radiation Safety".

(B) Written Examination for Trainees

Upon completion of the above classroom instruction, the Trainee shall be given a written examination by the Radiation Safety Officer to assure that he understands the content of the classroom instruction, and that he appreciates the importance of strict adherence to the provisions in the Radiation Safety Manual. This written examination shall consist of a minimum of twenty-five questions, and the minimum percentage of acceptable responses shall be 75%. Any incorrect response shall be reviewed with the Trainee to assure his thorough understanding of the subject material.

(C) On-the-Job Training for Trainees

After successfully passing the examination described above, the Trainee shall then be permitted to accompany a Radiographer to a radiography worksite to witness the Radiographer's use of exposure devices and associated equipment. The Radiographer shall provide on-the-job training in the proper use of survey meters, posting and restricting access to the Radiation Area, and recordkeeping procedures. During this initial

3.1.1 Training of Individuals to be Assistant Radiographers

(C) On-the-Job Training for Trainees (cont'd)

on-the-job training period, however, the Trainee will not be permitted to personally handle or manipulate the exposure device, the crank, or any storage containers. The Trainee's initial on-the-job training period shall last a minimum of one week.

(D) Trainee's Certification as an Assistant Radiographer

When the Trainee has completed the minimum on-the-job training period, the RSO will document the dates and jobs at which the Trainee was present, and shall then issue to him a certificate as an Assistant Radiographer.

3.1.2 Training of Assistant Radiographers to be Radiographers

Upon successful completion of the requirements for Assistant Radiographer, and certification thereof by the RSO, the individual shall immediately begin his training to be a Radiographer. This training shall consist of the following:

(A) Educational Instruction for Prospective Radiographers

Prospective Radiographers shall be given a minimum 32 additional hours of instruction by the RSO covering the following topics. Some of the general topics may be taught via programmed instructional texts and media presentations instead of classroom sessions.

1. Basic principles of radiation safety: atomic theory, isotopes; characteristics and biological effects of gamma radiation; measurement of radiation activity, dose rate, exposure; radioactive decay;
2. Control of radiation exposure - time, distance, and shielding factors;
3. Correlating TLD badge report data with daily pocket dosimeter records;
4. Responsibilities and lines of authority for all radiography personnel;
5. Regulatory standards for protection against radiation; "ALARA";
6. [illegible]nt, calibrations; mandatory surveys;
7. [illegible]llance of radiographic worksites;
8. [illegible] devices;
9. [illegible] procedures;
[illegible]rements; leak testing procedures;
[illegible] procedures; study of case
[illegible]s:damaged exposure device or
[illegible]el; loss or theft of source.

3.1.2 Training of Assistant Radiographers to be Radiographers

(B) On-the-Job Training for Prospective Radiographers

Prospective Radiographers shall witness the use of radiographic exposure devices and associated equipment by a qualified Radiographer and shall personally use such devices and equipment under the direct supervision of the Radiographer. Specifically, the Assistant Radiographer shall be given on-the-job training in each of the following radiographic operations:

1. Conducting radiation surveys and proper posting of radiographic sites;
2. Proper use of radiographic exposure devices, including proper assembly and disassembly procedures, and proper handling of the control unit, cables, use of plugs, locking device, and collimators;
3. Transportation procedures;
4. Recordkeeping requirements for Radiographers;
5. Inspection and maintenance procedures for radiography equipment.

During this supervised on-the-job training, the prospective Radiographer shall practice performing the various operations carefully and deliberately, but without undue delay. The minimum period of on-the-job training time as an Assistant Radiographer shall be three months.

(C) Written and Practical Examinations for Prospective Radiographers

After completing the classroom training and satisfying the requirements for on the job training described in the previous paragraphs, the prospective Radiographer will be given a two-part examination:

1. Practical examination - the prospective Radiographer will be requested to demonstrate his radiographic competency by performing selected radiographic operations. He shall perform such operations without assistance, but under constant supervision and scrutiny of the RSO. Grading of the Practical Examination shall be based on a minimum of 10 "checkpoints" of correct procedure, and a 100% score is required.

   Written examination - the written test for qualification of Radiographers shall consist of fifty questions, covering each topic in par. 3.1.3(A), and the minimum acceptable score is 80%. Any incorrect responses shall be reviewed by the RSO with the individual to assure that he understands what the correct answers should have been and why.

   Note - Incorrect responses to certain questions on critical safety aspects may be cause for failure of this examination, regardless of the overall grade.

3.1.2 Training of Assistant Radiographers to be Radiographers

(D) Certification of Radiographers

Upon successful completion of the educational instruction, the on-the-job training, the Practical Examination, and the written examination, the individual will be issued his Certification as a Radiographer by the RSO.

3.1.3 Training Requirements for Personnel having Prior Radiography Experience

For an individual having prior experience as a Radiographer or Assistant Radiographer with another company, and prior to the individual's being assigned to perform any radiographic operations at Lehigh, the Radiation Safety Officer shall:

(A) Verify and obtain documentation of any prior training and experience with the individual's previous employer(s).

(B) Provide classroom instruction as required to the individual covering those portions of Lehigh's Radiation Safety Manual which may be unique.

(C) Provide training as required with the specific equipment used at Lehigh (exposure devices, survey meters, collimators, alarm systems, etc.).

(D) If the individual is a prospective Assistant Radiographer, administer the written examination specified in section 3.1.2(B).

(E) If the individual is a prospective Radiographer, administer the written and practical examinations specified in section 3.1.3(C) to the individual.

(F) The time frame in which these steps are accomplished shall be determined by the RSO as applicable to the individual.

3.1.4 Periodic ("Refresher") Training

Periodic training shall be provided to update radiographic personnel every twelve months or when any of the changes listed below are made:

(A) Revisions to the Radiation Safety Manual;
(B) Revisions to NRC or agreement state regulations;
(C) Substantial changes or additions to radiographic equipment or survey instruments
(D) Any other change, ignorance of which which might result in unnecessary safety hazards to any individual.

In addition to the above refresher training subjects, hazardous incidents shall be discussed among all radiography personnel, with an emphasis on prevention of similar incidents.

3.1.5 Instructors and Examiners

The instructors and examiners for the personnel training program shall be selected by the General Manager. They shall have sufficient personal education, training and first-hand experience to qualify them as Radiographers. Certain portions of the classroom instruction may be performed by commercial organizations or Consultants, but the ultimate responsibility for examinations, on-the-job training, and instructions specific to Lehigh, shall rest with the Radiation Safety Officer.

3.2.0 INTERNAL MANAGEMENT CONTROLS FOR RADIATION SAFETY

3.2.1 General

This section describes the internal system by which Lehigh Testing Laboratories will control the receipt, possession, and use of licensed radioactive material in accordance with the provisions of the license, the applicable NRC regulations, and specifically with the requirements of this Manual. Ultimate responsibility for this internal inspection system rests with the General Manager, the Radiation Safety Officer, and the Assistant Radiation Safety Officer, as specified below. Note: the responsibilities for maintaining internal control of radiation safety are excerpted from the overall responsibilities in section 1.3.

3.2.2 Duties of Responsible Personnel

(A) General Manager

1. The General Manager shall develop and establish the various policies, systems and general procedures which comprise the Radiation Safety program at Lehigh. He shall be assisted as required by the Radiation Safety Officer and by part-time Consultants in the field of Radiation Safety and Health Physics.

2. He shall be the direct supervisor of the Radiation Safety Officer and responsible for insuring that the RSO performs his assigned duties.

3. He shall personally conduct unannounced audits of radiography operations and personnel similar to those normally performed by the , except that the RSO shall be included in the General Manager's evaluation of personnel. The personal audits by the General Manager shall be conducted at least once every six months, and document the results.

(B) Radiation Safety Officer

The Radiation Safety Officer (RSO) shall be a qualified Radiographer with training in the use of equipment described in this Manual. Other prerequisites for the RSO are a thorough knowledge of management policies, company administrative and operating procedures, and safety procedures related to protection against radiation exposures as set forth in this Manual. The RSO shall report directly to the General Manager, and shall be the direct supervisor of the Assistant RSO, all Radiographers, and all Assistant Radiographers. The RSO has the following specific authority, duties and responsibilities with regard to Lehigh's internal inspection system:

1. Maintain active management control of the radiation safety program for the company.

3.2.2 Duties of Responsible Personnel

(B) Radiation Safety Officer (cont'd)

2. Assist the General Manager in the establishment, development and revision of procedures or systems concerning radiation safety.

3. Serve as Lehigh's liaison officer to the Nuclear Regulatory Commission and to Agreement State Agencies on license matters.

4. Maintain personal and direct control over the procurement and disposal of licensed material.

5. Conduct the training program for Radiographers and Assistant Radiographers, and examine and certify their competency.

6. Assure that all radiographic operations comply with the requirements of this manual by conducting unannounced monthly audits of such operations, including an actual performance evaluation of the Assistant RSO, each Radiographer, and each Assistant Radiographer at least once each quarter. The results of these audits shall be recorded on Form 208, and shall be filed in the "Management Audits" file.

7. Personally assume control and initiate corrective action in emergency situations.

8. Personally investigate the causes of incidents, and determine and initiate appropriate preventive measures.

9. Maintain system for evaluating and reporting defects and noncompliances per section 3.3.0 of this manual.

10. Insure that any duties specifically delegated to the Assistant RSO are performed completely, promptly, and accurately, as required by the provisions of this manual.

(C) Assistant Radiation Safety Officer

The Assistant RSO at Lehigh shall be a qualified Radiographer with training in the use of equipment described in this Manual. Other prerequisites for the Assistant RSO are a thorough knowledge of the operating and emergency procedures regarding protection against radiation exposures as set forth in this Manual. He shall report directly to the RSO, shall be responsible for performing all RSO duties of an emergency nature during the temporary absence of the RSO, and shall perform any of the following duties specifically delegated to him by the RSO:

3.2.2 Duties of Responsible Personnel

(C) Assistant Radiation Safety Officer (cont'd)

1. Maintain the personnel monitoring system, including issuing badges and dosimeters, calibrating the pocket dosimeters, and reviewing the reports of personnel exposures.

2. Perform or personally supervise the leak testing program for sealed source containers.

3. Perform or personally supervise the performance of source changes.

4. Perform or personally supervise quarterly maintenance of exposure devices and associated equipment.

5. Perform quarterly inventories of all sources of radiation.

6. Maintain radiation survey instruments and the calibration program for such instruments.

7. Assist the RSO in assuring that the required documentation for daily radiographic operations is complete, accurate, and up to date.

(D) Radiation Safety Consultant

The General Manager shall appoint one or more Consultants in the fields of Health Physics, Safe Radiography Practice, Regulatory Requirements, etc. to assist himself and the Radiation Safety Officer in providing direct and indirect training to radiography personnel; to assist in developing, implementing, reviewing or revising the company's Radiation Safety Program; and to provide independent audits of the company's conformance to the requirements of this Manual and all applicable laws, as requested.

3.2.3 Qualifications of Responsible Personnel

The names and qualifications of each of the responsible personnel described above are documented in the Appendix.

3.2.4 Nature and Frequency of Internal Inspections

The RSO will make monthly audits of radiographic operations and quarterly inspections of all radiographic personnel, as specified in the above paragraphs. The General Manager will personally conduct two or more such audits annually to supplement the RSO's evaluations. Also, the performance of the RSO shall be evaluated in the General Manager's audits.

3.2.4 Nature and Frequency of Internal Inspections (cont'd)

The General Manager will also audit the RSO's performance at least once every twelve months. The inspections and evaluations by the General Manager will not only be be concerned with the ability of the individuals to follow these procedures, but will include an assessment of individual attitudes regarding radiation safety.

3.2.5 Procedures for Reporting Deficiencies

See section 3.3.0.

3.3.0 EVALUATION AND REPORTING OF DEFECTS AND NONCOMPLIANCES

As applicable to Lehigh's radiography activities, 10 CFR 21 requires that, if the General Manager obtains information reasonably indicating that a substantial safety hazard exists due to either equipment defects or to a failure to comply with any regulation or license provision, he shall immediately notify the Commission, unless he has actual knowledge that the Commission has been adequately informed of the defect or noncompliance.

3.3.1 Posting Requirements

Per 10 CFR 21.6, Lehigh is required to post current copies of the following documents:(A) Section 206 of the Energy Reorganization Act of 1974; and (B) a notice describing the regulations in 10 CFR 21 and Lehigh's procedures for evaluating defects and noncompliance. The responsible officer to whom reports shall be made at Lehigh is the General Manager.

3.3.2 Method of Evaluation of Defects and Noncompliances

The existence of equipment defects or procedural noncompliances may come to the attention of the General Manager in various ways. Any radiography worker is urged to report such matters to the RSO and to the General Manager as they arise. Investigations and analyses of radiographic incidents or accidents may disclose either equipment defects or procedural noncompliances as their cause. The General Manager shall be given copies of all such investigations or analyses made by the RSO. Finally, the results of the monthly audits of radiography operations and of the quarterly inspections of radiography personnel, regardless of whether they are performed by the RSO (see 3.2.2 B), an independent Consultant (3.2.2 D), or by the General Manager himself (3.2.2 A), shall be documented and forwarded to the General Manager for immediate review.

Any defects or noncompliances identified, regardless of their source, shall immediately be evaluated in terms of their potential to result in a substantial safety hazard. If required, the General Manager will personally notify the NRC in accordance with the first paragraph above.

3.3.3 Corrective Actions for Noncompliances

A meeting shall be held between the General Manager and the individual(s) determined to be responsible for any noncompliance. Enforcement actions may range from additional training to suspension or dismissal, depending on the seriousness of the noncompliance.

Subsequent audits shall concentrate on areas where noncompliances had existed, to assure that the corrective actions have been effective.

3.4.0 CALIBRATIONS OF SURVEY METERS AND POCKET DOSIMETERS

3.4.1 Calibration of Survey Meters

Calibration of a radiation survey meter must be performed at intervals not exceeding three months and after each repair or adjustment of the meter. Calibrations may be performed internally, by the Assistant RSO, or may be performed at one of the following facilities:

Technical Operations, Inc.
Burlington, Massachusetts 01803

Radiation Management Corp.
Philadelphia, Pennsylvania 19101

The manufacturer of the survey meter, or any other facility having adequate capabilities for survey meter calibrations.

If survey meters are calibrated at Lehigh by the Assistant RSO, the following procedure shall be used. THIS PROCEDURE REQUIRES THE USE OF RADIOACTIVE MATERIAL. ALL SAFETY REQUIREMENTS OF THIS MANUAL SHALL BE FOLLOWED WITHOUT DEVIATION.

(A) Equipment - survey meter shall be calibrated with the Tech/Ops Model 773 Calibration Unit. This unit is a self-contained Cesium-137 storage container, and is designed to emit radiation in the range from 2.5 to 750 mR/hr, depending on the distance between the meter and the unit. The unit is constructed of a steel housing with internal lead shielding, and contains a source of Cesium-137 having an activity of approximately 165 milliCuries (new).

(B) The calibrator exposes the survey meter to a precisely determined radiation dose, with which the actual reading on the meter is compared. In accordance with the inverse square law, the unit is positioned at varying distances from the meter, depending on the specific dose level to be calibrated. The unit has built-in calculating aids which enable the user to determine the correct distance for each selected dose level.

(C) Meters shall be calibrated at a minimum of two points in each range; the highest and lowest points should be separated by at least 50% of the scale. For example, if the range is from 0-10 mR/hr, two points selected might be 2.5 and 7.5 mR/hr.

3.4.1 Calibration of Survey Meters (cont'd)

(D) Once the meter has been placed at the proper distance from the unit the operator exposes the source by pulling the source control rod up. The resultant beam of radiation, which shall be aimed directly at the meter in a horizontal plane, is collimated by a 60 degree conical port at the side of the unit. The operator should stand far enough from the meter so that unnecessary personnel exposures are avoided.

(E) After waiting fifteen seconds, read the position of the needle on the meter. Immediately return the source to the storage position by pushing the source control rod down to its original position.

(F) If necessary, adjust the meter to the known value and repeat the test. Then set the meter at the next calibrating distance/dose level.

(G) The meter is considered to be satisfactorily accurate if, after adjustment and retest, it indicates within 20% of the actual dose level at a minimum of two points in each range.

The calibration and maintenance of radiation survey meters at Lehigh is the responsibility of the Assistant RSO. Records of meter calibrations shall include the date, the make, model and serial no. of the meter, and all data points checked. If calibrations are performed internally, Form 207 shall be used to record the results. Meter calibration records shall be maintained for at least two years in the Calibration file.

Meters which are awaiting repairs or calibration or which are otherwise not to be used must be tagged or labeled "Out of Service".

3.4.2 Calibration of Pocket Dosimeters

Each pocket dosimeter shall be calibrated by exposure to a radiation source of known intensity at intervals not to exceed twelve months. All calibrations shall be performed by the Assistant RSO using the Dosimeter Calibrator designed for that purpose. This unit contains a sealed source of Cesium-137 (less than 10 milliCuries). The Cesium-137 emits radiation such that, if a dosimeter is placed in one of the eight holes in the outer ring, it should read 50 mR after 24.8 hours. If placed in one of the four holes in the inner ring, it should read 50 mR after 6.2 hours. (Note: these are 1978 values; they should be adjusted according to the decay curve for this source; Ce-137 has a half-life of 33 years).

Results of these calibrations shall be recorded on Form 206 and maintained in the Calibration file. Dosimeters found to be 30% or more inaccurate shall be removed from service and replaced. Should a dosimeter be dropped, it must be removed from service and recalibrated before being used again.

3.5.0 FORMS AND RECORDKEEPING REQUIREMENTS--ADMINISTRATIVE

(A) Form 206: Certificate of Calibration - Pocket Dosimeters

This shall be completed by the Assistant RSO for all calibrations of pocket dosimeters, which are required on an annual basis. These records shall be reviewed by the RSO and filed in the Calibrations file.

(B) Form 207: Certificate of Survey Meter Calibration

Records of survey meter calibrations performed by an outside agency may be documented on that agency's form, provided that the agency's form provide substantially the same details as those shown on Form 204. When meters are calibrated internally by the Assistant RSO, Form 204 shall be used. The Assistant RSO shall insure that the calibration stickers are supported by such appropriate documentation, and that all records are filed in the "Calibrations" file.

(C) FORM 208 Management Audit of Radiographic Operations

At least once during each calendar month, the RSO shall conduct an audit of radiographic operations and shall record the results on this form. Also, at least once during each calendar quarter, each radiography worker shall be included in these audits, including the Assistant RSO (Note: the General Manager and independent Consultants will also perform such audits, and may use this same form.)

EMERGENCY TELEPHONE NUMBERS OF RESPONSIBLE MANAGEMENT PERSONNEL

HERMAN L. OSTROFF, RADIATION SAFETY OFFICER

(Bus): (302) 655-7358
(Res): (302) 475-3505 or (302) 539-6178

HUGH F. CANN, ASS'T RADIATION SAFETY OFFICER

(Bus): (302) 655-7358
(Res): (302) 998-6236

IF NEITHER OF THE ABOVE INDIVIDUALS CAN BE REACHED, CALL

LEONARD A. WESTON, GENERAL MANAGER

(Bus): (302) 655-7358
(Res): (302) 738-6961

-OR-

F. BRUCE KOVACS, RADIATION SAFETY CONSULTANT

(Res): (201) 361-0139

ADMINISTRATIVE INFORMATION REGARDING RADIATION SAFETY

CORPORATE INFORMATION

Ownership and Officers

Lehigh Testing Laboratories, Inc. is a wholly-owned subsidiary of Massachusetts Materials Research, Inc., located at 241 West Boylston Street, West Boylston, MA 01583. The President of the corporation is:

Dr. David Krashes
Rhodes Road
Princeton, MA 01541
(President & Treasurer)

(Dr. Krashes is the only individual who owns at least 10% of the issued and outstanding stock of the parent company.)

Other officers of the corporation are:

Bennett C. Wilson
49 Sunnyside Avenue
Holden, MA 01520
(Director & Secretary)

James K. Gardener, Jr.
81 Whitehall Drive
Tallmadge, OH 44278
(Director)

Preston W. Hall, Jr.
Townsend Drive
West Boylston, MA 01583
(Director)

Leonard A. Weston
3 Tally-Ho Circle
Newark, DE 19711
(Vice-President & General Mgr. - Lehigh)

SUPPLIERS OF THERMOLUMINESCENT DOSIMETER BADGES

(A) R. S. LANDAUER, JR. & CO.
Div. of Tech/Ops, Inc.
Glenwood Science Park
Glenwood, IL 60425

Tel: (312) 755-7000

(B) EBERLINE INSTRUMENT CORP.
PO Box 2108
Santa Fe, NM 87501

Tel: (505) 471-3232

MANUFACTURERS OF POCKET DOSIMETERS IN USE AT LEHIGH

The pocket dosimeters in current use are all 0-200 mR, and are used in all of Lehigh's radiographic operations, whether the radiation source is a radioactive isotope or an x-ray generating machine.

Pocket dosimeters are one of the following models, or equivalent:

(A) VICTOREEN 541 (Victoreen Instrument Co., Cleveland OH 44104)

(B) DCA Model 862 (Dosimeter Corp. of America, Cincinnati, OH 45242)

DOSIMETER CALIBRATOR:

The unit used to calibrate Lehigh pocket dosimeters is a source of Cesium-137, less than 10 microCuries, purchased from the Eon Corp., Brooklyn, NY. (S/N 311)

DOSIMETER CHARGERS:

All charging units for Lehigh's pocket dosimeters are Victoreen Model 2000A, or equivalent.

DAILY UTILIZATION REPORT

Date/Time:_____ Location Used:_____

LTL Job No., Customer:_____

Isotope Type: IRIDIUM 192 Source S/N:_____ Activity this Date:_____ Curies

Make/Model of Device in which Isotope is Used: TECH/OPS MODEL NO._____

Device S/N:_____ Initial Survey at Surface of Device:_____mR/hr

Vehicle (if used):_____ Survey at Surface of Vehicle:_____mR/hr

Survey in Passenger Compartment:_____mR/hr

Daily Equipment Checks: Survey Meter:_____ Guide Tubes:_____ Fittings:_____

Exposure Device:_____ Control Crank:_____ Selector Ring:_____ Lock:_____

Total No. of Exposures Made:_____ Total Time for all Exposures:_____min

Max Exp Time, any One Hour:_____min; Date/Time Stored:_____

Storage Location:_____

Final Surveys at Device Surface:_____mR/hr; at Surface of Vault:_____mR/hr

Radiographer:_____Assistant:_____

Additional Comments:_____

_____

_____

Sketch position and orientation of source and crank, show perimeter of restricted area, with survey values. Show walls, shields, etc. Collimator used:_____

TRANSPORT RECORD FOR RADIOACTIVE MATERIALS

Proper Shipping Name: RADIOACTIVE MATERIAL, SPECIAL FORM, N.O.S. - UN 2974

Type of Source: IRIDIUM-192

Activity of Source: _____ Curies

Label Type: RADIOACTIVE _____

Transport Index: _____

Source Serial No: _____

Container Model No: _____

Container Serial No: _____

Container Specification No: NRC ID# USA/ _____ /B TYPE B

Date of Shipment: _____

Shipper: LEHIGH TESTING LABORATORIES, INC.
4027 NEW CASTLE AVE., PO BOX 1241
WILMINGTON, DE 19899

Destination: _____

_____

_____

_____

ALL SHIPPING PROCEDURE REQUIREMENTS HAVE BEEN SATISFIED.

Shipper's Certification: THIS IS TO CERTIFY THAT THE ABOVE NAMED MATERIALS ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED, AND LABELED, AND ARE IN PROPER CONDITION FOR TRANSPORTATION, ACCORDING TO THE APPLICABLE REGULATIONS OF THE U.S. DEPARTMENT OF TRANSPORTATION.

Signed for Shipper: _____ Date _____

QUARTERLY INSPECTION AND MAINTENANCE REPORT

Exposure Device: TECH/OPS MODEL 660 S/N _____ Crank S/N:_____

Source Type: IRIDIUM-192 Model: TECH/OPS A 424-9 S/N:_____ Activity:____Ci

Date Inspected:_____ Inspected By:_____

INSPECTION CHECKLIST	COMPLETED
1. Perform a source change as specified in section 2.4.0	___
2. Clean the drive cables as specified in the procedure.	___
3. Inspect connector on control cable with Tech/Ops 550 gage.	___
4. Clean the drive cable housings as specified.	___
5. Dissassemble and clean crank mechanism; examine for wear or damage.	___
6. Lightly grease and reassemble the crank mechanism.	___
7. Lightly grease and install the drive cable.	___
8. Set the odometer to zero.	___
9. Clean the exposure device as specified (do not disassemble).	___
10. Examine exposure device for: shielding placement;	___
proper operation of locking ring;	___
proper labeling.	___
11. Inspect the connector on the exposure device with the 550 gage.	___
12. Lubricate the locking mechanism.	___
13. Remove source from the changer and replace it in exposure device; examine operating characteristics for:	___
looseness of crank handle;	___
proper number of turns;	___
proper odometer operation;	___
firm stopping of crank handle when the source reaches stored position.	___
14. Clean the source guide tubes as specified.	___
15. Repairs made, repairs recommended, or other comments:	___

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

QUARTERLY INVENTORY OF RADIOACTIVE MATERIALS

DATE INVENTORY PERFORMED: _____

ISOTOPE TYPE	SERIAL NO.	DATE REC'D	REC'D FROM	DEVICE MODEL	DEVICE S/N	ACTIVITY

ALL RADIOACTIVE MATERIALS ARE STORED IN THE SHIELDED STORAGE VAULT LOCATED AT 4027 NEW CASTLE AVE., WILMINGTON, DELAWARE UNLESS OTHERWISE NOTED BELOW.

REMARKS:

PREPARED BY: _____
(signature) (title) (date)

NEXT INVENTORY DUE: _____

QUARTERLY POCKET DOSIMETER RECORD

Employee: _____ S/S# _____

MONTH/YR _____ MONTH/YR _____ MONTH/YR _____

DAY	S/N	INIT	FINAL	DOSE	S/N	INIT	FINAL	DOSE	S/N	INIT	FINAL	DOSE
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
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21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												

MONTHLY TOTAL: _____ MONTHLY TOTAL: _____ MONTHLY TOTAL: _____

QUARTERLY TOTALS: FILM BADGE OR TLD BADGE: _____; POCKET DOSIMETER: _____

COMMENTS:

CERTIFICATE OF CALIBRATION - POCKET DOSIMETERS

DOSIMETER MAKE, MODEL, SERIAL NO.	STANDARD DOSE	MEASURED DOSE

Calibration Source Standard: Cesium-137 Device: _____

Approximate Activity this Date: _____

All readings are in mR. All pocket dosimeters read from 0 to 200 mR unless otherwise noted.

THIS CERTIFIES THAT THE POCKET DOSIMETERS LISTED ABOVE HAVE EACH BEEN CALIBRATED ON _____ ACCORDING TO LEHIGH'S WRITTEN PROCEDURE AND ARE CAPABLE OF MEASURING RADIATION DOSAGES TO WITHIN A 30% ACCURACY TOLERANCE. THESE POCKET DOSIMETERS MUST BE RECALIBRATED ON OR BEFORE _____

Calibrations perf rme' by: _____ _____ _____
(signature) (title) (date)

CERTIFICATE OF SURVEY METER CALIBRATION

MAKE: _____

MODEL: _____

SERIAL NO. _____

SCALE	RADIATION LEVEL	METER READING	RADIATION LEVEL	METER READING

All readings, unless otherwise noted, are in mR/hr. Meter readings shown are after adjustment, if any.

Calibration Source Standard: Cesium 137 Device: _____

Activity this date: _____

THIS DOCUMENT CERTIFIES THAT THE ABOVE INSTRUMENT WAS CALIBRATED ON _____ ACCORDING TO LEHIGH'S WRITTEN PROCEDURE AND IS CAPABLE OF MEASURING RADIATION LEVELS IN ALL THREE RANGES TO WITHIN A 20% ACCURACY TOLERANCE. IN ACCORDANCE WITH THE REQUIREMENTS OF NRC REGULATION 10 CFR 34.24, THIS INSTRUMENT MUST BE RECALIBRATED ON OR BEFORE _____.

REMARKS:

Calibration performed by _____
(signature) (title) (date)

MANAGEMENT AUDIT OF RADIOGRAPHIC OPERATIONS

Date & time _____ Location: _____

RT personnel audited: _____

Type of audit: Announced: _____ Unannounced: _____

Operations observed during audit: _____

_____

_____

_____

Audit Checklist:	SAT	UNSAT	N/A
a. Pocket dosimeter initial reading logged	___	___	___
b. Survey made after each exposure & before storage	___	___	___
c. Survey made of transporting vehicle	___	___	___
d. Exposure device handling techniques	___	___	___
e. Transportation conducted/documented properly	___	___	___
f. Daily inspection of equipment performed/recorded	___	___	___
g. Dosimeters checked periodically during shift	___	___	___
h. Proper source security and storage	___	___	___
i. Utilization Report completed properly at this time	___	___	___
j. All required equipment on hand	___	___	___
k. Survey meter properly calibrated	___	___	___
l. Proper film badge or TLD badge	___	___	___
m. Restricted area properly established, posted and monitored	___	___	___
n. High radiation area properly posted	___	___	___
o. Misc. records audit	___	___	___
p. Other _____	___	___	___

Description of unsatisfactory findings: _____

_____

_____

_____

_____

Corrective actions: _____

_____

_____

_____

Audit performed by: _____
(signature) (title) (date)

LEHIGH TESTING LABORATORIES

QUALIFICATIONS OF RESPONSIBLE PERSONNEL FOR RADIATION SAFETY MANAGEMENT

LEONARD A. WESTON - VICE PRESIDENT & GENERAL MANAGER

EDUCATION

1967 - Bachelor of Science, Marquette University
1969 - Master of Science, Marquette University
Both degrees received in Mechanical Engineering, Metallurgy and Materials Science Option

RELEVANT ADDITIONAL COURSES

1974 - "Radiographic Testing" - General Dynamics (40 hrs)
1974 - "Industrial Radiography" - E. I. DuPont de Nemours & Co. (40 hrs)
1975 - "Occupational Safety and Health" - Del. Tech. & Comm. College
1978 - "Level III RT Refresher Course - Spring Garden College

WORK EXPERIENCE

1969-1970: Texas Instruments, Inc. Attleboro, Massachusetts
Materials Division, Thermostat and Specialty Metals Department
PRODUCT ENGINEER

1970-1972: Massachusetts Materials Research, Inc., Worcester, Mass.
(Independent materials consulting and testing laboratory)
PROJECT METALLURGIST

1972-1974: Lehigh Testing Laboratories, Inc., Wilmington, DE.
(Affiliate of Massachusetts Materials Research)
TECHNICAL DIRECTOR - Responsible for overall reliability of all technical functions via training of technicians and establishment of standard procedures and quality control manual.

1974-Present: Lehigh Testing Laboratories, Inc.,
GENERAL MANAGER - Continuation of activities and responsibilities as Technical Director, plus comprehensive management responsibilities, including Quality Control and Radiation Safety. Promoted to VICE PRESIDENT of Corporation May, 1977.
Assisted in establishing Operating and Emergency Procedures for Gamma Radiography (1978). Direct Supervisor of Radiation Safety Officer.

MISCELLANEOUS EXPERIENCE

1967 - 69: Metallurgy Instructor, Marquette University
1967 - Elected to Pi Tau Sigma, National Mechanical Engineering Honors Society
1976 - Registered Professional Engineer (Delaware #5037)
1976 - Certified by examination as Level III in RT, MT, and PT
1977, 78, 79, 80 - Lecturer on Welding Technology for Delcastle Vo-Tech School, Wilmington, DE
1978 - Metallurgy Instructor - Salem County (N.J.) School System

HERMAN L. OSTROFF - RADIATION SAFETY OFFICER

1969-1973: Phoenix Steel Corporation, Claymont, DE - Radiographer Level II by examination

1972: Attended Eastman Kodak School of Industrial Radiography, Rochester, NY. (40 hrs)

1973-1977: Phoenix Steel Corp., Claymont, DE - NDT Supervisor, Certified as Level III by examination (UT, RT, PT, MT).

1975-1977: Worked in excess of 100 hours as Assistant Radiographer with Astrotech, Inc., under their NRC License. Trained in safe handling of exposure devices and related equipment, surveying techniques, establishing and controlling restricetd areas etc.

1976: Attended Tech/Ops 40-hour course: "The Safe Use of Isotopes in Industrial Radiography"

1977-1978: Plymouth Tube Company, Horsham, PA - Certified as NDT Level III in Radiography by examination

1980- Lehigh Testing Laboratories, Inc., Wilmington, DE; NDT Level II and Level III in Radiography; Radiation Safety Officer

HUGH F. CANN - ASSISTANT RADIATION SAFETY OFFICER

1960 - Employed in Radiography Department at Lehigh Testing Laboratories, Wilmington, DE as Radiographer. Started as Trainee in 1960, received extensive on-the-job training in radiation safety and control throughout this period, leading to certification as Level II Radiographer, Chief Radiographer, and, in 1980, as Assistant Radiation Safety Officer.

1974: Attended 40 hour course in Radiography, with major emphasis on Radiation Safety held by by E.I. DuPont CO., Inc.

1977: Began review program on Radiation Safety aspects of Isotope Radiography in preparation for application for NRC license for radiography via sealed sources

1978: Qualified by examination as Radiographer upon completion of instruction, training, and examination requirements administered by RSO

1979- Employed as Chief Radiographer in NDT department and as Ass't Radiation Safety Officer. Has received several hundred hours of job training and instructions from Lehigh Radiation Safety Officers in various functions and responsibilities of RSO. Has demonstrated thorough understanding of the equipment, NRC regulations, Lehigh's Operating and Emergency Procedures and supervision of same.

1979: Appointed Assistant Radiation Safety Officer.

F. BRUCE KOVACS - CONSULTANT

Mr. Kovacs is currently employed by Lehigh Testing Laboratories, Wilmington, DE as a part-time Consultant in radiation safety, regulatory requirements and radiography procedures. He has assisted the General Manager in reviewing and revising the Radiation Safety Manual, and has audited Lehigh's radiography program from an independent standpoint. He may assist with the training of radiography personnel.

EMPLOYMENT HISTORY

Foster Wheeler Energy Corporation, Livingston, New Jersey
1977 to 1983: Sr. Radiographer & Corporate Radiation Safety Officer
Responsible for the administration and control of the industrial radiography and radiation safety program for the FWEC Equipment Division manufacturing plants and construction sites. Duties included:
1) All company contact with the Nuclear Regulatory Commission and Agreement State agencies regarding required licensing of radioactive materials and x-ray machines used in radiography;
2) Coordination with construction management concerning assignment of field NDE personnel and movement of radioactiave sources and other equipment;
3) On-site training, testing, and certification of NDE personnel;
4) On-site auditing of all worsites sites to assure regulatory compliance;
5) Preparation and distribution of written NDE and radiation safety operating and training procedures;

1974 to 1977: Quality Control Engineer
Responsible for providing assistance to the Senior Radiographer in administration of the FWEC radiography program, as described above. Other duties included performance of outside source inspections and limited field radiographic assignments.

Consolidated X-Ray Service Corp., Woodbridge, New Jersey
1972-73 Summer and Midterm Vacations: Level II Radiographer (SNT-TC-1A)
Radiation sources included Iridium 192, Cobalt 60 and x-ray machines.

Conam Inspection, Inc., Rahway, New Jersey
1967-71 Summer and Midterm Vacations: Level II Radiographer (SNT-TC-1A)

EDUCATION
Bachelor of Science, Mechanical Engineering
Florida Institute of Technology, June 1973

QUALIFICATIONS
NDE Level III - Radiographic Examination & Visual Examination (SNT-TC-1A)
NDE Level II - Liquid Penetrant Examination (SNT-TC-1A)

PROFESSIONAL AFFILIATIONS
Committee Member - Subcommittee on Nondestructive Examination (SC-V) and Subgroup on Radiography (SG-RT), ASME Boiler and Pressure Vessel Committee
Member - American Society of Mechanical Engineers, Charter Member - NDE Engineering Subdivision
Member - American Society for Nondestructive Testing

Lehigh Testing Laboratories - Radiation Safety Program

TYPICAL QUESTIONS AND ANSWERS USED IN WRITTEN EXAMINATIONS

FOR ASSISTANT RADIOGRAPHERS AND RADIOGRAPHERS

Note: The questions presented here are samples only; they represent the general level of difficulty and variety of topics covered in actual exams. These particular questions, however, will not necessarily be used. Questions intended only for Radiographer's exam are preceded by an "R". Assistant Radiographer's exams consist of 25 questions minimum; Radiographer's exams consist of 50 questions minimum.

1. Gamma and x-radiation damages human body tissue by a process known as _____. ANS: ionization

R2. When a body tissue cell is damaged by radiation,
   a) the cell may lose its ability to reproduce
   b) the cell may die
   c) damage is caused by knocking an electron out of its atom's orbit
   d) all of the above ANS: (d)

3. The basic difference between X-rays and gamma rays is
   a) their RBE
   b) their origin
   c) their ability to damage cells of human tissue
   d) that gamma rays are electromagnetic radiation
   ANS: (b)

R4. Radiation hazard to humans exists from
   a) natural radiation
   b) primary and scattered radiation
   c) primary beams only
   d) all types of radiation except electromagnetic radiation
   ANS: (b)

5. (T) or (F): Materials exposed to gamma rays and x-rays become radioactive and dangerous to handle. ANS: (T)

6. The most penetrating type of radiation from radioisotopes is
   a) beta particles
   b) alpha particles
   c) gamma rays
   d) x-rays ANS: (c)

7. Radioactive half-life is
   a) the time it takes one-half of the atoms of a radioisotope to disintegrate
   b) the time it takes one-half of a radioactive material to be passed from the body as waste material
   c) the time needed to rid the body of one-half of a radioactive material by a combination of biological elimination and radioactive decay
   ANS: (a)

R8. Biological half-life is
a) the time it takes one-half of the atoms of a radioisotope to disintegrate
b) the time it takes one-half of a radioactive material to be passed from the body as waste material
c) the time needed to rid the body of one-half of a radioactive material by a combination of biological elimination and radioactive decay
ANS: (b)

R9. Effective half-life is
a) the time it takes one-half of the atoms of a radioisotope to disintegrate
b) the time it takes one-half of a radioactive material to be passed from the body as waste material
c) the time needed to rid the body of one-half of a radioactive material by a combination of biological elimination and radioactive decay
ANS: (c)

10. The Roentgen is a measure of
a) alpha radiation
b) X-rays and gamma rays
c) beta radiation
d) all of the above ANS: (d)

11. (T) or (F): An exposure of one Roentgen of gamma radiation equals an absorbed dose of one rad ANS: (T)

12. The whole-body radiation dose must normally be limited to a dose of
a) 1 1/4 rems per calendar quarter
b) 18 3/4 rems per calendar quarter
c) 7 1/2 rems per calendar quarter
d) 5 rems per calendar quarter
ANS: (a)

13. For a given exposure, the most serious radiation exposure is to the
a) whole body
b) feet and ankles
c) skin
d) hands and forearms ANS: (a)

14. (T) or (F): A person who is 10 years old would be subject to greater radiation damage from a given exposure than a person age 27.
ANS: (T)

R15. A person must be _____ years old to be allowed to work in a radiation area ANS: 18

R16. [five points] There are five variables which influence the effect that radiation doses have on individuals. List them.
ANS: Age; general health; amount of dose; time period over which dose is received; portion of body receiving the dose

R17. The formula for finding permissible accumulated dose is
a) 12 (N-18)
b) 18 (5+N)
c) 5 (N-18)
d) 12 d(N+18) ANS: (c)

R18. (T) or (F): Some body cells are more sensitive to radiation than others
ANS: (T)

R19. The earliest indicators of radiation damage may be detected in the
a) nerve cells
b) skin cells
c) bone cells
d) blood cells ANS: (d)

R20. The MLD for humans is the radiation dose
a) that causes the first death
b) that causes slight, temporary blood changes
c) that is considered lethal to all persons exposed
d) that causes 50% of those exposed to die
ANS: (d)

21. Portable instruments used to monitor radiation areas are called
a) film badges
b) survey meters
c) personnel monitoring devices
d) area meters ANS: (b)

22. Devices attached to the clothing of people working in radiation areas for measurement of radiation are called
a) survey instruments
b) G-M counters
c) personnel monitoring devices
d) portable rate meters ANS: (c)

23. The normal operating range of a pocket dosimeter is
a) 0 to 200 mR
b) 50 to 500 mR
c) 0 to 200 mR/hr
d) 25 to 250 R ANS: (a)

24. The film badge operates on the principle that ____ darkens radiographic film.
a) light
b) heat
c) ionizing radiation
d) alpha particles ANS: (c)

25. Radiation intensity at 6 feet from an isotope is 40 R/hr. At what distance would the intensity be reduced to 10 R/hr? _____
ANS: 12 feet

26. (T) or (F): A person who receives an overexposeure to gamma radiation poses a hazard to others. ANS: (F)

27. The primary hazard in radiography comes from
a) internal radiation
b) gamma rays and alpha particles
c) beta particles
d) external radiation ANS: (d)

28. The basic unit that expresses gamma or x-radiation exposure is the
    a) Rem
    b) Rad
    c) Roentgen
    d) RBE
    ANS: (c)

29. The abbreviation "R" stands for _____.
    ANS: Roentgen

30. The abbreviation "mr" stands for _____.
    ANS: milliRoentgen (or milliRem)

31. The term "rad" stands for _____ _____ _____.
    ANS: radiation absorbed dose

32. The term "Rem" stands for _____ _____ _____.
    ANS: Roentgen equivalent man

33. (T) or (F): A given radiation dose will cause less damage if received over a long period of time than if received over a short period of time.
    ANS: (F)

34. The radiation effects which can be passed on to the offspring or to a later generation of a person receiving radiation are called
    a) future effects
    b) genetic effects
    c) somatic effects
    d) radiosensitive effects
    ANS: (b)

35. (T) or (F): It is possible to receive a dose considerably above the regulatory limits without showing detectable radiation effects.
    ANS: (T)

36. In relation to radiation effects, MLD stands for _____

    _____ _____.
    ANS: median lethal dose

37. The MLD for humans is _____Rems (fill in from below) whole body exposure within a 24 hour period.
    a) 250
    b) 500
    c) 750
    d) 1,000
    ANS: (b)

38. (T) or (F): Radiation measuring devices operate on the principle of ionization.
    ANS: (T)

39. Survey meters provide
    a) cumulative readings of radiation exposure
    b) radiation exposure rate readings
    c) readings which must be checked on a separate reading device
    d) only readings of gamma radiation
    ANS: (b)

40. Which statement about the TLD badge is true?
    a) It provides an immediate indication of radiation exposure.
    b) It is easily exposed by alpha particles.
    c) It has the advantage of providing a permanent record.
    d) All of the above. ANS: (c)

41. The pocket dosimeter has the advantage of
    a) being more accurate than the film badge or TLD badge
    b) providing a permanent record of radiation exposure
    c) providing an immediate indication of radiation exposure
    d) All of the above. ANS: (c)

42. (T) or (F): When wearing a pocket dosimeter, there is no need to wear a film badge or TLD badge at the same time.
    ANS: (F)

43. The intensity at one foot for a 10 Curie source of Iridium-192 is 52 R/hr. What is the intensity for 20 Curies of Iridium 192 at 20 feet? _____
    ANS: 0.26 R/hr or 260 mR/hr

44. The three basic factors used to reduce exposure to radiation are _____, _____, and _____.
    ANS: time, distance, shielding

45. If a person receives 3 mR/hr at a certain distance from a radiation source, what would his exposure be if he remained there for 8 hours?
    ANS: 24 mR/hr

R46. If "I" is intensity and "D" is distance, give the mathematical formula for the relationship between "I" and "D" for radiation dose.

_____ ANS: $I_1 \times D_1^2 = I_2 \times D_2^2$

R47. If radiation intensity is 180 R/hr at 2 feet from a source, how far would a 2 mR/hr perimeter be from the radiation source? _____
    ANS: 600 feet

R48. At ten feet from a source, the radiation intensity is 150 mR/hr. What is the intensity at one foot? _____
    ANS: 15,000 mR/hr or 15 R/hr

R49. Radiation intensity at six feet from a source is 40 R/hr. At what distance would the intensity be reduced to 10 R/hr? _____
    ANS: 12 feet

R50. How often do survey meters require calibration? _____
    ANS: at intervals not to exceed 3 months

51. What are the four basic rules you must follow in an emergency situation?

    ANS: 1. Move away from the exposed source and keep other people away.
    2. Relax, don't panic, and calmly assess the situation.
    3. Establish a Restricted Area, and make sure no one enters it.
    4. Notify the RSO without leaving the Restricted Area unattended.

R52. [1 pt. ea.] What is the maximum survey reading you should get at the: (ANS)

-passenger area of a vehicle transporting a source? _____ mR/hr 2

-surface of the same vehicle? _____ mR/hr 2

-surface of a model 660 containing 50 Ci of Ir-192? _____mR/hr 100

-front surface of the storage vault? _____mR/hr 2

-surface of a container labeled "Radioactive White I"? _____mR/hr 0.5

-surface of a container labeled "Radioactive Yellow II"? _____mR/hr 50

-3 feet from the same surface? _____mR/hr 1

-surface of a container labeled "Radioactive Yellow II"? _____mR/hr 200

-3 feet from the same surface? _____mR/hr 10

R53. [1 pt ea.] Define each of the following: (ANS: see manual, section 1.2)

-agreement state:

-radioactivity:

-transport index:

-high radiation area:

-restricted area:

R54. [1 pt ea>] According to Lehigh's Radiation Safety Manual, who may INDEPENDENTLY (without the presence or assistance of anyone else) perform each of the following functions? (A) GM; (B) RSO; (C) Ass't RSO; (D) Consultant; (E) Radiographer; (F) Assistant Radiographer; (G) Trainee

-issues pocket dosimeters
-establishes overall policy for Radiation Safety
-set up a restricted area boundary
-perform daily maintenance inspection on a crank
-perform a leak test
-perform a source change
-calibrate a pocket dosimeter
-contact the NRC about a safety problem
-perform daily maintenance on an exposure device
-perform a quarterly inventory
-audit the performance of a Radiographer
-calibrate a survey meter
-drive a vehicle containing radioactive material
-maintain surveillance and restrict access to a worksite
-read and record pocket dosimeter readings
-notify the RSO about an emergency situation
-carry an exposure device from the vehicle to the worksite