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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 (all) - General Requirements for all Radiography Operations
Section 2 (all) - Specific Procedures for Gamma Radiography
Section 3.3 - Evaluation & Reporting of Defects and Noncompliances
Appendix A - Emergency Telephone Numbers
Appendix D - Notice to Employees Concerning Radiation Safety Program

Lehigh's NRC license to possess, use and transfer sealed sources and source containers is based on and incorporates the requirements in this Manual, and none of these provisions may be changed without first obtaining written approval by the NRC. In addition, the NRC performs periodic inspections of Lehigh radiography operations, and any resulting corrective actions established by Lehigh shall be incorporated as conditions of the license. Copies of the latest revisions of this Manual and of Lehigh's NRC license shall 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 (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 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 1 meter 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 which is designed, built and tested to meet the normal conditions of transportation as specified in 10 CFR 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 (Source 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 radiography, 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 policies, systems and general procedures which comprise the Radiation Safety program at Lehigh. He shall be assisted 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 conduct unannounced audits of radiography operations and personnel similar to those performed by the RSO, except that the RSO shall be included in his evaluations of radiography personnel. Each person engaged in radiography operations, including the RSO, shall be audited by the General Manager at intervals not to exceed 12 months.

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 conducting unannounced audits of operations performed by the Assistant RSO, each Radiographer, and each Assistant Radiographer. Each of these individuals shall be audited by the RSO at intervals not to exceed 3 months (see 3.2.4).

(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 Source 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 1.3.7.

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.

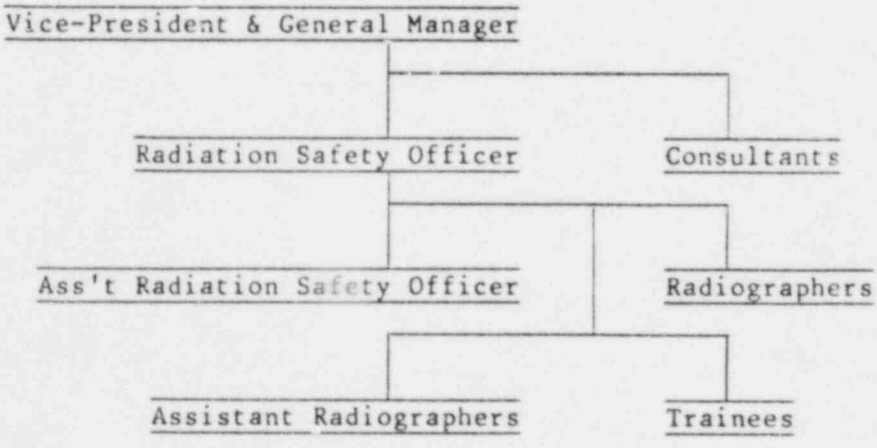
1.3.6 Assistant Radiographer

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 3.1.2(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)



1.5.0 PERSONNEL MONITORING DEVICES

1.5.1 General

Personnel monitoring equipment, consisting of a thermoluminescent dosimeter (or "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:

(A) 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

(B) 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 10% of the applicable limits specified in 1.4.2; OR

(C) 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.

*NOTE: Workers engaged in radiography operations must be at least 18 years of age.

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. For example, if you are using a 30 Curie source, this survey should result in a radiation level of 60 mR/hr or less.

If the source is properly stored in the exposure device, survey readings along the guide tube itself should be no higher than at other locations which are the same distance from the exposure device. For example, if the source is properly stored, a survey of a point on the guide tube six feet from the device should be no higher than at a point six feet on the other side of the device.

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 Source 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 Source 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 source has been placed inside. Alternatively, if the source is stored in another location at the end of radiography operations, (for example, locked inside a vehicle or storage room at a temporary field site), the boundary of the unrestricted area must be surveyed and recorded (in these examples, this would be the exterior surfaces of the vehicle or storage room). Maximum acceptable radiation level for this type of survey is 2 mR/hr. This survey must be documented on the Source 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 Source 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 1 m 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

The survey of the maximum dose rate 1 meter 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 for 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, you must treat this situation as an EMERGENCY. See the emergency procedures in section 2.5.

1.7.0 DESCRIPTION OF PERMANENT RADIOGRAPHIC FACILITY AT LEHIGH

1.7.1 Storage Vault for Radioactive Materials and Containers

(A) The storage vault for Lehigh's radioactive materials and their containers is located in the company's NDT Department, which is in the one-story 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. The vault is kept locked at all times, except when materials are being placed inside or being removed from storage.

(C) The steel vault, shown in the sketch at the end of this section, 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 22" 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. Thus, the areas surrounding the vault may be treated as unrestricted areas when radiographic operations are not taking place in the adjacent exposure room. The vault shall be posted with "Caution - Radioactive Materials" warning signs.

1.7.2 Radiation Cell for Performing Radiographic Operations

(A) The exposure room or radiation cell which serves as Lehigh's permanent radiographic facility is located within the one-story warehouse building at 4027 New Castle Avenue, New Castle, Delaware, just south of Lehigh's main building. The room has inside dimensions of 12' x 20' and is surrounded by 22" thick x 84" high walls constructed of solid concrete blocks (density 147 lb/cu.ft.). The floor is a 4" concrete slab over earth. The roof is 16' above the floor and consists of wood framing and plywood surfacing.

1.7.2 Radiation Cell for Performing Radiographic Operations (cont'd)

(B) The exposure room is located in the SW corner of the NDT Department, which has overall dimensions of approximately 34' x 52'. Beyond the south wall of the NDT Dep't is a parking lot for a body shop; beyond the west wall of the NDT Dep't is a machine shop; beyond the east wall of the NDT Dep't is a lab/storage room; and beyond the north wall of the NDT Dep't is a driveway and parking lot. All walls surrounding the NDT Dep't consist of standard 8" thick hollow cinder blocks. See the sketch of Lehigh's exposure room, the NDT Department and the adjacent areas on the following page.

(C) There is one entrance to the exposure room, approximately 8' wide, from the NDT Dep't. During radiographic operations, portable lead shielding panels, each 1/4" thick x 36" wide x 84" high, are positioned in an overlapping fashion across the entranceway [see 1.8.1(E)]. The Radiographer manipulates the crank and maintains surveillance from point (E).

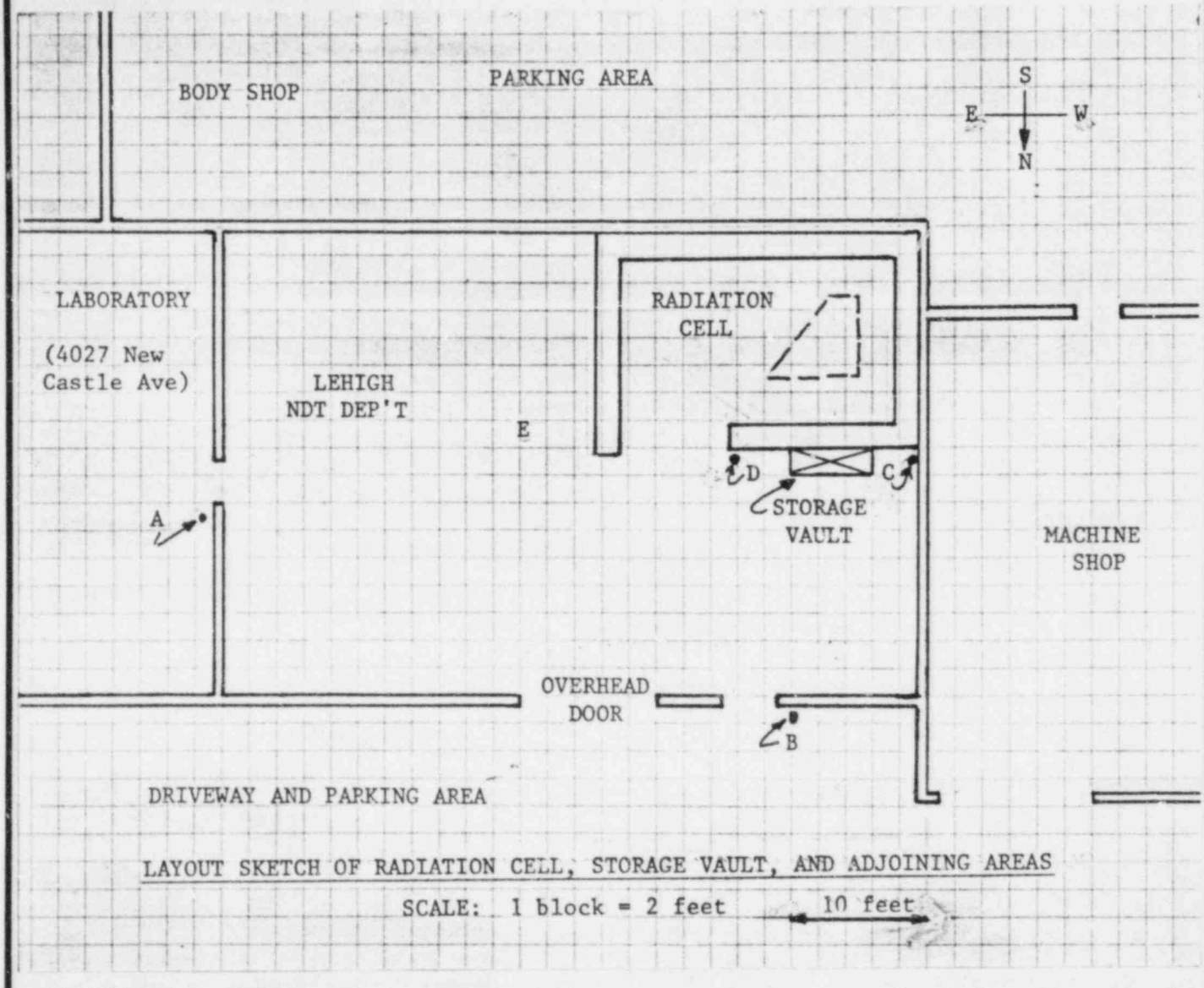
(D) The exposure room is a High Radiation Area during radiographic operations. The entire NDT Department is a Restricted Area during radiographic operations. All other adjacent areas -- the body shop parking lot, the machine shop, the lab/storage room, and the driveway and parking lot -- are treated as Unrestricted Areas for the reasons discussed in section 1.8.0.

(E) The overhead garage door entrance to the NDT Dep't is either closed and locked during all operations involving the use of radiation sources, or, if open, it is roped off and surveillance is continuously maintained to prevent unauthorized individuals from entering. The garage door or the rope barrier across the doorway is posted with "CAUTION - RADIATION AREA" warning signs. There are two other entrance doors to the NDT department: (A) from the laboratory area, and (B) from the driveway. Both of these doors are also equipped with "CAUTION - RADIATION AREA" warning signs.

(F) A Gammalarm unit is positioned at the side of the entranceway to the exposure room, at a height of approximately four feet [point (C)]. When radiation is detected by the Gammalarm, a visible alarm (flashing red light) is activated on this unit. In addition, an "electric eye", activated by the Gammalarm, is positioned at point (D), across the entranceway to the exposure room. If, during radiography operations, the light beam is broken, such as by unauthorized or inadvertent entry into the High Radiation Area, an audible alarm will sound. Other visible alarms, located outside each of the two entance doors at (A) and (B), are activated whenever radiation is detected at the Gammalarm unit. Audible alarms are also installed at doors (A) and (B). The audible alarms sound when an attempt is made to open either of these doors while radiation is detected by the Gammalarm.

(G) Operational checks of the Gammalarm , the electric eye, and the visible and audible alarms shall be tested at intervals not to exceed three months, and records of these tests shall be kept for at least two years.

SEE SKETCH OF RADIATION CELL, STORAGE VAULT AND ADJACENT AREAS - NEXT PAGE



LAYOUT SKETCH OF RADIATION CELL, STORAGE VAULT, AND ADJOINING AREAS

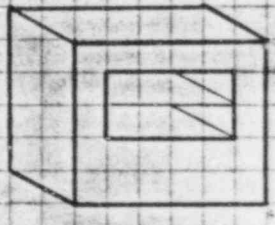
SCALE: 1 block = 2 feet — 10 feet

SKETCH OF SOURCE STORAGE VAULT

(shown without hinged doors)

SCALE: 1 block = 1 foot

Inside dim. 4'w x 2'h x 2'd
Outside dim. 6'w x 5'h x 2'd



1.8.0 RADIATION CONTROL PROCEDURES REQUIRED AT PERMANENT FACILITY

1.8.1 Restrictions on the Use of Radioactive Materials at Permanent Facility

When constant surveillance cannot be maintained of all unrestricted areas surrounding the permanent radiographic facility at 4027 New Castle Avenue, the following operating restrictions are in effect:

(A) A collimator, having an attenuation factor of at 1/20 or less, must be used. (The Tech/Ops Model 799 Mini-Tungsten collimator meets this requirement.) Whenever feasible from a technical standpoint, the Tech/Ops Model 527 collimator (attenuation 1/1000) must be used in the permanent facility.

(B) The primary radiation beam shall not be directed above the horizontal plane.

(C) The radiation source must be placed no higher than 3 feet above floor level.

(D) The source must be positioned within the area outlined by the lines painted on the floor. These lines keep the source at least 3 feet from the south and west walls of the exposure room, and not in line with the entranceway.

(E) Portable lead shields shall be positioned across the entranceway to the radiation exposure room so that a minimum of 1/2" of lead or 22" of solid concrete shielding lies between the source and any point on the north wall.

(F) Maximum exposure time in any one hour is limited as follows:

MAXIMUM EXPOSURE MINUTES IN ANY ONE HOUR = 1000 / SOURCE ACTIVITY

For example, the maximum exposure time in any one hour is 10 minutes for 100 Ci; 20 minutes for 50 Ci; 40 minutes for 25 Ci, 50 minutes for 20 Ci, etc.

With the above restrictions of radiographic operations, the exposure room is a High Radiation Area; the entire NDT Department is a Restricted Area; and all other adjacent areas -- the body shop parking lot, the machine shop, the lab/storage room, and the driveway and parking lot -- may be treated as Unrestricted Areas (see section 1.8.2).

Variances from the above restrictions may be made only upon authorization of the RSO. For example, when substantially larger collimators than the Model 799 are used, the RSO may authorize a variance, as long as the Unrestricted Areas meet the requirements stated in 1.4.4. However, Radiographers must obtain prior approval for such variances from the RSO, and the specific reasons for the variance must be documented on the Utilization Report.

1.8.2 "Worst-Case" Radiation Levels in Areas Surrounding Radiation Cell

With restrictions (A) through (E) in effect, the "worst case" for radiation dosages in any Unrestricted Area surrounding the radiation cell at 4027 New Castle Ave. occurs under the following conditions:

Source: Iridium 192, 105 Curies
Collimator: "Mini-tungsten" (Tech/Ops Model 799; attenuation = 1/20)
Location: 3 ft from south wall, 3 ft above floor
Orientation: Toward south wall

Under these "worst case" conditions, the maximum dose rate measured in the Unrestricted Areas beyond the south wall was 3 mR/hr. Now, applying restriction (F) yields a maximum exposure time in any one hour of 10 minutes, and a maximum dose of 0.5 mR in any one hour in the Unrestricted Area beyond the south wall, well below the regulatory requirement.

If the source is now located on the angled line running from the right edge of the entranceway, and directed through 1/2" of lead shielding toward the garage door, the maximum dose rate measured at the garage door is 12 mR/hr. With restriction (F), this reduces to a maximum of 2 mR in any one hour.

1.8.3 Special Restrictions Regarding the Roof Over the Radiation Cell

The maximum dosage measured on the roof, directly above the radiation cell, for either of the above conditions was 104 mR/hr. Applying restriction (F) yields "worst-case" radiation level of 17 mR in any one hour on the roof..

Because radiation levels on the roof, directly above the radiation cell, may be higher than 2 mR in any one hour, the following additional procedures apply to radiography operations performed within the radiation cell:

(A) The roof shall be treated as a Restricted Area by Radiographers.

(B) Prior to radiographic operations at the permanent radiographic facility, the Radiographer shall assure that no individuals are on the roof.

(C) The only access to the 16' high roof is by using a ladder. The Radiographer shall assure that warning signs are affixed to the top edges of the walls where ladder access to the roof could be made. The warning signs read:

DANGER - RADIATION AREA

ACCESS TO THIS ROOF IS PROHIBITED
CONTACT LEHIGH TESTING LABORATORIES
RADIATION SAFETY OFFICER
CALL 655-7358 OR 655-0697

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 kept by the Radiographer, and the vehicle or room shall display warning signs as appropriate. A survey shall be made and recorded of the unrestricted area surrounding the field storage vehicle or room per 1.6.2 (C). 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. 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	16	100	45	35	191	85	35	361
5	35	21	45	48	100	85	35	361
5	114	2	45	342	2	85	470	2
10	1	52000	50	1	260000	90	1	468000
10	23	100	50	35	212	90	35	382
10	35	42	50	51	100	90	68	100
10	161	2	50	361	2	90	484	2
15	1	78000	55	1	286000	95	1	494000
15	28	100	55	35	233	95	35	403
15	35	64	55	53	100	95	70	100
15	197	2	55	378	2	95	497	2
20	1	104000	60	1	312000	100	1	520000
20	32	100	60	35	255	100	35	424
20	35	85	60	56	100	100	72	100
20	228	2	60	395	2	100	510	2
25	1	130000	65	1	338000	105	1	546C00
25	35	106	65	35	276	105	35	446
25	36	100	65	58	100	105	72	100
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	39	100	70	60	100	110	76	100
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	43	100	75	62	100	105	77	100
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	46	100	80	64	100	120	79	100
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. The 2 mR/hr and 100 mR/hr radiation levels were selected because they are commonly used for establishing the boundaries of the Restricted Area and the High Radiation Area, respectively.

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 would be 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 Source 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 position of any intervening shielding which may have been considered in establishing 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 Source Utilization Report.

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.

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

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

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 693 Pistol-Grip Control Unit

This crank is similar to Model 664, except that no reel is included.

2.1.7 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.

2.1.8 Tech/Ops Collimators

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

Model 527 "Rayguide" lead collimator (4.5" x 8" long) features the use of beam-shaping discs for either panoramic (20° x 360°) or directional (60°) exposures. Attenuation factor for Ir-192 is 1/1000.

Model 654 is a lead collimator (3.5" diameter x 3.75" long) which mounts directly on the 660 exposure device and which has a front port giving a forward beam of 60° by 30°. Attenuation of Ir-192 is 1/200.

Model 714 is a lead mini-collimator (3.5" wide x 4.5" long x 1.75" thick) used with a standard source stop. The radiation beam emerges from a side port as a 60° cone. Attenuation factor for Ir-192 is 1/70.

Model 799 is tungsten mini-collimator (1.5" diameter x 1.875" long) which fits over the source stop. The 799 features a side-emerging beam from a pyramid opening with 60° sides. Attenuation of Ir-192 is 1/20.

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 POSTED WITH THE APPROPRIATE WARNING SIGNS AND IS SECURED AGAINST ENTRY BY UNAUTHORIZED PERSONS (SEE SECTIONS 1.8.0 AND 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) BEFORE PROCEEDING FURTHER, THE RADIOGRAPHER MUST NOW ESTABLISH AND POST THE RADIATION AND HIGH RADIATION AREAS AS SPECIFIED IN SECTIONS 1.8.0 AND 1.9.0, AND MUST START MAINTAINING CONTINUOUS SURVEILLANCE OVER THE RESTRICTED AREA TO KEEP ALL UNAUTHORIZED PERSONS FROM ENTERING.

(H) 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.

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

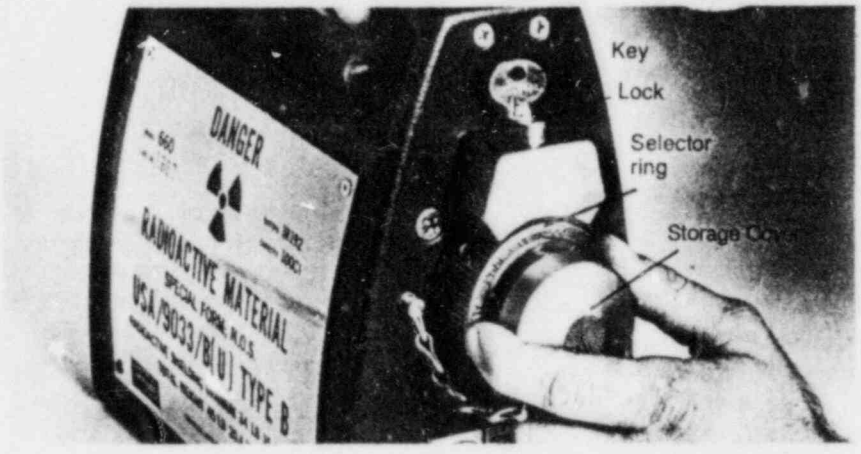


FIGURE 2.4 - Unlock the exposure device with the key provided and turn the selector ring from the LOCK position to the CONNECT position. When the ring is in the CONNECT position, the storage cover will disengage from the exposure device as shown.

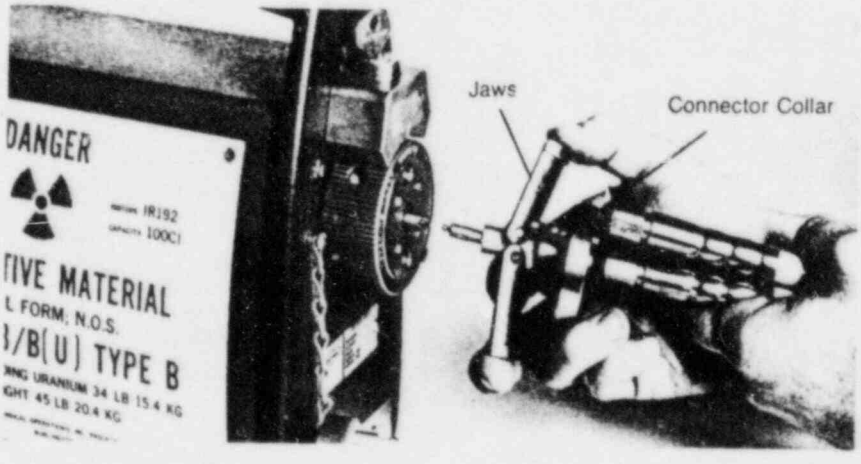


FIGURE 2.5 - Slide the Model 661 connector collar back and open the jaws of the Model 661 connector. This exposes the male portion of the swivel-type drive cable connector as shown.

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 FIRST EXPOSURE, PERFORM A SURVEY OF THE BOUNDARY OF THE RESTRICTED AREA TO ASSURE THAT RADIATION LEVELS IN UNRESTRICTED AREAS DO NOT EXCEED THE LIMITS SPECIFIED IN 1.9.2. Also, during the exposure, the Radiographer must 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.

2.3.0 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 1 meter 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 1 meter 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 1 meter 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 1 m 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 1 meter 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 1 meter 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

2.4.0 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 1 meter 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 source 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 1 meter 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. Or, if your radiation surveys give you readings that are higher than the maximum allowable (section 1.6.2), or are otherwise higher than what you expect, you must treat the situation as an emergency.

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 and to be 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.

2.5.3 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 Regional Administrator, U.S. Nuclear Regulatory Commission, Region I, King of Prussia, PA (215) 337-5000 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, 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 inspect all of the equipment he will use. 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 Source 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, the control cable, and the 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) Prior to the first exposure of the shift, check the operation of the selector ring, the odometer, the lock assembly and the control crank. If any of these components are difficult to operate, the equipment must be serviced before further using them in radiographic operations.

(G) The Radiographer shall record the results of this daily inspection on the Source Utilization Report. In addition, if any defects are found with any equipment, such defects shall be reported to the RSO immediately. The Radiographer shall not attempt to use defective equipment. All defective equipment shall be tagged "DEFECTIVE - DO NOT USE" and removed from service. Any equipment that has been removed from service shall be noted on the next "Quarterly Inspection and Maintenance Report" (see the following section).

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. 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 1 meter from the surface.

3. 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.

(H) Defective Equipment

If any defects are found with any equipment, such defects shall be reported to the RSO immediately. The Radiographer shall not attempt to use defective equipment. All defective equipment shall be tagged "DEFECTIVE - DO NOT USE" and removed from service. Any equipment that has been removed from service shall be noted on the "Quarterly Inspection and Maintenance Report".

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 towards the meter (not the meter to the swab).

(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: Source 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 chronological "Utilization Reports" 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.

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 Instruction for Trainees

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

1. Responsibilities, duties and limitations of an Assistant Radiographer;
2. The characteristics, effects, measurement and control of 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 receive at least two hours of additional field demonstrations in the proper use of the Lehigh's radiographic equipment.

(B) Written Examination for Trainees

Upon completion of the above instruction, the Trainee shall be given a written examination by the Radiation Safety Officer to assure that he understands the content of the 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 25 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 will 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 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 for a minimum period of one week.

3.1.1 Training of Individuals to be Assistant Radiographers (cont'd)

(D) Trainee's Certification as an Assistant Radiographer

When the Trainee has satisfied the requirements of 3.1.1 (A), (B), and (C), and upon review and approval of the qualifications and required documentation by the General Manager, the individual will be issued his Certificate as an Assistant Radiographer. A copy of this Certificate shall be issued to the individual in a wallet-sized card, and he is required to have this card in his possession at all radiography worksites.

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 of 34 additional hours of instruction by the RSO covering the following topics. These 34 hours specifically exclude any instructional hours received prior to being certified as an Assistant Radiographer, and exclude any on-the-job training hours. However, some of the general topics may be taught via programmed instructional texts and media presentations instead of classroom sessions, and some of the topics dealing with equipment and other non-theoretical, "practical" topics are best demonstrated during actual operations.

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. Radiation surveys--equipment, calibrations; mandatory surveys;
7. Proper posting, and surveillance of radiographic worksites;
8. Operating procedures for exposure devices;
9. Procedures for changing sources;
10. Transportation, storage and security procedures;
11. Daily and quarterly maintenance requirements; leak testing procedures;
12. Recordkeeping requirements;
13. Emergency procedures: general, specific procedures; study of case histories of actual emergency situations:damaged exposure device or meter; exposure to unmonitored personnel; loss or theft of source.
14. Special conditions of Lehigh's NRC License.

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 and surveillance of radiographic worksites;
2. Proper maintenance, use and storage of radiographic exposure devices, and related equipment, including proper inspection and assembly procedures, and proper handling of the control unit, cables, use of plugs, locking device, and collimators;
3. Proper use of personnel monitoring devices;
4. Transportation, security, leak testing and source change procedures;
5. Recordkeeping requirements for Radiographers;
6. Evaluating and reporting defects and non-compliances.

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 20 "checkpoints" of correct procedure, and a 100% score is required.

2. Written examination - the written test for qualification of Radiographers shall consist of fifty questions, covering each topic in par. 3.1.2(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 overall grade.

3.1.2 Training of Assistant Radiographers to be Radiographers

(D) Certification of Radiographers

When the individual has satisfied the requirements of 3.1.2 (A), (B), and (C), and upon review and approval of the qualifications and required documentation by the General Manager, the individual will be issued his Certificate as an Radiographer. A copy of this Certificate shall be issued to the individual in a wallet-sized card, and he is required to have this card in his possession at all radiography worksites.

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 RSO 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 3.1.1(B).

(E) If the individual is a prospective Radiographer, administer the written and practical examinations specified in section 3.1.2(C).

(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 by the RSO to update radiographic personnel at intervals not to exceed twelve months on the following:

(A) Revisions to the Radiation Safety Manual;
(B) Revisions to NRC or agreement state regulations;
(C) Major changes/additions to radiographic equipment or survey instruments;
(D) Results of NRC inspections, if any, and of management audits.

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.

3.1.6 Documentation of Personnel Training and Qualifications

Qualification records for all radiography personnel shall be maintained by the RSO. These records shall include the name, date of birth, social security no., and radiography start date, thorough documentation of the nature and extent of all education, instruction, and on-the-job training; copies of current examinations with test scores; and a copy of the certification that the individual has achieved (Assistant Radiographer or Radiographer).

The following forms have been developed specifically for this personnel training and certification program:

Form 209 - "Statements and Acknowledgements Required from Each New Employee in Radiography; Part 2: Acknowledgement of Initial Classification as a Trainee"

Form 210 - "Personnel Qualification and Certification - Ass't Radiographer"

Form 211 - "Personnel Qualification and Certification - Radiographer"

Form 212 - "LTL Radiation Safety Training - Personnel Record"

All qualification records shall be maintained by the RSO for a minimum of three years.

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 conduct unannounced audits of radiography operations and personnel similar to those performed by the RSO, except that the RSO shall be included in the General Manager's evaluation of personnel. If the RSO personally performs radiography, then he shall be audited by the General Manager performing radiographic operations. Each worker shall be audited by the General Manager at intervals not to exceed twelve months, and the results of these audits shall be documented.

(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 audits of such operations, including actual performance evaluations of the Assistant RSO, each Radiographer, and each Assistant Radiographer at intervals not to exceed 3 months. The results of these audits shall be recorded on Form 208, and shall be filed in the "Audits by RSO" 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 Audits of Personnel by RSO and GM

The RSO will make audits of each individual who performs radiographic operations at intervals not to exceed 3 months. The General Manager will personally conduct similar audits of each radiography worker at intervals not to exceed 12 months. Evaluation of the RSO shall also be included in the General Manager's audits. If the RSO also performs radiography, then the GM's audits shall include the RSO performing radiographic operations.

3.2.4 Nature and Frequency of Internal Audits of Personnel by RSO and GM (cont'd)

There may be situations where a particular radiography worker has not participated in radiography operations for a period exceeding three months. If the period of inactivity is greater than three months, either the RSO or the General Manager shall audit the performance of the individual during his first reassignment to radiographic operations. If the period of inactivity is greater than six months, the individual shall also be given refresher training as required, and, before he may be reassigned responsibilities as a Radiographer, he shall be required to successfully complete the Practical Examination for Radiographers. If the the period of inactivity is greater than twelve months, the individual shall be required also to pass another written examination.

The personnel audits performed by the RSO and the GM are intended to evaluate not only the individuals' degree of compliance with these procedures, but also an assessment of overall attitudes of the individuals regarding radiation safety. These audits shall be recorded on Form 208, "Management Audits of Radiography Operations & Personnel"

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 audits of radiography operations and 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 each 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, and the position of the three built-in attenuators (transmission factors 0.25, 0.10, and 0.10). 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). Cesium-137 has a half-life of 30 years, so correction factors must be changed approximately every two years to account for the decay of the calibrating source.

(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 30 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

As discussed in section 3.2, the RSO shall conduct an unannounced audit of each radiography worker at intervals not to exceed 3 months, and shall record the results on this form. The General Manager and independent Radiation Safety Consultants will also perform periodic audits of radiography operations and workers, and may use this same form.

(D) FORMS 209 thru 212: Personnel Qualifications

Per section 3.1, the following forms have been developed specifically for the personnel training and certification program:

Form 209 - "Statements and Acknowledgements Required from Each New Employee in Radiography; Part 2: Acknowledgement of Initial Classification as a Trainee"

Form 210 - "Personnel Qualification and Certification - Assistant Radiographer"

Form 211 - "Personnel Qualification and Certification - Radiographer"

Form 212 - "LTL Radiation Safety Training - Personnel Record"

EMERGENCY TELEPHONE NUMBERS

A. RESPONSIBLE MANAGEMENT PERSONNEL AT LEHIGH

HERMAN L. OSTROFF, RADIATION SAFETY OFFICER

(Bus): (302) 655-7358
(Res): (302) 655-0697

HUGH F. CANN, ASS'T RADIATION SAFETY OFFICER

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

LEONARD A. WESTON, GENERAL MANAGER

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

BRUCE KOVACS, RADIATION SAFETY CONSULTANT

(Res): (203) 721-1271

B. REGULATORY AGENCIES

U.S. NUCLEAR REGULATORY COMMISSION (isotope radiography performed in Delaware & in other non-agreement states)
Region I - Office of Inspection and Enforcement
631 Park Avenue
King of Prussia, PA 19406
(215) 337-5000 (24 hrs)

STATE OF DELAWARE (X-ray radiography operations)
Division of Public Health
Bureau of Radiological Control
Capitol Square
Dover, DE 19801
(302) 736-4731

STATE OF MARYLAND (all isotope radiography performed in Maryland)
Division of Radiation Control
Department of Health and Mental Hygiene
201 Preston Street
Baltimore, MD 21202
(301) 383-2744

QUALIFICATIONS OF RESPONSIBLE PERSONNEL FOR RADIATION SAFETY MANAGEMENT

LEONARD A. WESTON - VICE PRESIDENT & GENERAL MANAGER

EDUCATION

1967 - B.S. Marquette University: Mech. Eng'g.; Metallurgy and Mat'ls Science
1969 - M.S. Marquette University: Mech. Eng'g.; Metallurgy and Mat'ls Science
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 - 72 Massachusetts Materials Research, Inc., Worcester, MA; (Independent materials consulting and testing laboratory); PROJECT METALLURGIST

1972-Pres Lehigh Testing Laboratories, Inc., Wilmington, DE; (Wholly-owned subsidiary of Mass. Materials Research, Inc.); TECHNICAL DIRECTOR (1972) responsible for overall technical management; GENERAL MANAGER (1974) comprehensive management responsibilities, including Quality Assurance and Radiation Safety. Promoted to VICE-PRESIDENT (1977). Assisted in establishing Operating and Emergency Procedures for Gamma Radiography (1978). Direct Supervisor of Radiation Safety Officer.

MISCELLANEOUS

1967 - 69 Metallurgy Instructor, Marquette University
1976 Registered Professional Engineer (Delaware #5037)
1976 Certified by examination as Level III in RT, MT, and PT
1977 - 80 Lecturer on Welding Technology, Delcastle Vo-Tech School
1978 - 79 Metallurgy Instructor - Salem County (N.J.) School System

HERMAN L. OSTROFF - RADIATION SAFETY OFFICER

1969 - 73 Phoenix Steel Corp., Claymont, DE - RADIOGRAPHER Level II (by exam)
1972 Attended 40-hr Kodak course in Industrial Radiography, Rochester, NY
1973 - 77 Phoenix Steel Corp., Claymont, DE - NDT SUPERVISOR, Certified as NDT 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. Received extensive training in their Operating and Emergency Procedures
1976 Comp. 40-hr Tech/Ops course: "Safe Use of Isotopes in Ind. Radiography"
1977 - 78 Plymouth Tube Company, Horsham, PA - Certified as NDT Level III in RT
1980 - Lehigh Testing Laboratories, Inc., Wilmington, DE; NDT Level II and Level III in Radiography; MANAGER, NDE; RADIATION SAFETY OFFICER
1984 Comp. 16-hr Tech/Ops "Radiation Safety Program Administrator's Seminar"

QUALIFICATIONS OF RESPONSIBLE PERSONNEL FOR RADIATION SAFETY MANAGEMENT (cont'd)

HUGH F. CANN - ASSISTANT RADIATION SAFETY OFFICER

1960 - Employed in Radiography Department at Lehigh Testing Laboratories, Wilmington, DE. 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 Received initial training program regarding 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 - Promoted to CHIEF RADIOGRAPHER in Lehigh's NDT department; has received several hundred hours of special job training and instruction from Lehigh's Radiation Safety Officers in various radiation safety and regulatory matters. Has demonstrated thorough understanding of the equipment, NRC regulations, and Lehigh's internal radiation safety procedures applicable to industrial radiography.

1979 Appointed ASSISTANT RADIATION SAFETY OFFICER.

F. BRUCE KOVACS - RADIATION SAFETY CONSULTANT

EDUCATION

1973 B.S. Mech. Eng'g., Florida Institute of Technology

EMPLOYMENT HISTORY

1967 - 73 Summer and Midterm Vacations: Conam Inspection, Inc. and Consolidated X-Ray Service Corp., Woodbridge, NJ; LEVEL II RADIOGRAPHER (SNT-TC-1A)

1974 - 83 Foster Wheeler Energy Corporation, Livingston, New Jersey - 1974 to 1977: QUALITY CONTROL ENGINEER: Assisted Sr. Radiographer in administering FWEC radiography program. Other duties included performance of outside source inspections and limited field radiographic assignments. 1977 to 1983: SR. RADIOGRAPHER (NDE Level III) and RADIATION SAFETY OFFICER: Managed the radiography and radiation safety programs for multiple FWEC manufacturing plants and construction sites. Duties included: 1) Liaison for company to the NRC and Agreement State agencies regarding licensing of radioactive materials and x-ray machines; 2) Assignment of field NDE personnel and radioactive sources; 3) On-site training, testing, and certification of NDE personnel; 4) Auditing of worksites to assure regulatory compliance; and 5) Preparation of written procedures for NDE and radiation safety.

SOURCE UTILIZATION REPORT

Date/Time: _____; Location Used: _____

Lehigh Job No: _____; Customer Name: _____

EQUIPMENT ID: Isotope Type: IRIDIUM 192; Source S/N: _____; Activity: _____Curies;

Exposure Device - TECH/OPS Model _____; S/N:_____; Crank Model No:_____;

Crank S/N: _____; Survey Meter(A) - Model: _____; S/N:_____;

Survey Meter(B) - Model: _____; S/N: _____; Collimator:_____

DAILY EQUIPMENT INSPECTION CHECKLIST: Device: _____; Lock:_____; End Fittings:_____

Safety Caps, Screws: ___; Control Cable: ___; Warning Labels: ____; Selector Ring: ___;

Control Crank: ___; Guide Tubes: ___; Survey Meter(A): ___; Cal.Due Date: _____;

Survey Meter(B): ____; Cal.Due Date: _____; Operational Check of System: ____

REQUIRED DOCUMENTATION CHECKLIST: Oper. & Emerg. Proc.: ____; LTL License & Amend.: ___;

Personal Dosimetry Record: ____; Record of Personal Qualifications (Pocket Card): _____;

Special Requirements For All Work in Maryland: Quarterly Maint. Record for All Equipment

Being Used: _____; Source Decay Curve: _____; Copy of Maryland Regulations: _____;

Copy of Notification to Maryland Officials Regarding Lehigh's Work Schedule: _____

USAGE & STORAGE OF SOURCE: Total Number of Exposures Made: _____; Total Time for all

Exposures: _____min; Maximum Exposure Time in any One Hour: _____min

Date/Time Source Stored: _____; Storage Location: _____

MANDATORY RADIATION SURVEYS: Initial Survey at Surface of Exposure Device: _____mR/hr;

Vehicle Used (if any) _____; Vehicle Surveys - At Surface: _____mR/hr;

Inside Passenger Compartment: _____mR/hr; Final Survey Readings - At Surface of

Device: _____mR/hr; At Surface of Vault: _____mR/hr; At Boundary of Unrestricted Area

Surrounding Temporary Field Storage Location, if not in Lab Storage Vault: _____mR/hr

REMARKS (Describe any unusual occurrences, malfunctions, etc): _____

_____

_____

_____

SKETCH OF RADIOGRAPHIC SETUP: Show sketch on reverse side of this sheet. Note that a separate sketch is required for each different radiographic set-up. Show the position and orientation of source; show perimeter and approximate dimensions of restricted area with actual survey values; and show position of crank, walls, shields, barrier ropes, etc.

Signatures: _____

(Radiographer in charge) (Assistant Radiographer) (SUR approved by)

LTL Form 201 (Rev 8-13-84)

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 _____

Form 202 (Rev 11-30-83)

QUARTERLY INSPECTION AND MAINTENANCE REPORT

NOTE: A separate report sheet is required for each Device/Crank/Source set-up.

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

INSPECTION CHECKLIST	COMPLETED
1. Clean the drive cables as specified in the procedure.	___
2. Inspect connector on control cable with Tech/Ops 550 gage.	___
3. Clean the drive cable housings as specified.	___
4. Dissassemble and clean crank mechanism; examine for wear or damage.	___
5. Lightly grease and reassemble the crank mechanism.	___
6. Lightly grease and install the drive cable.	___
7. Set the odometer to zero.	___
8. Clean the exposure device as specified (do not disassemble).	___
9. Examine exposure device for: proper operation of locking ring; labels	___
10. Inspect the connector on the exposure device with the 550 gage.	___
11. Lubricate the locking mechanism.	___
12. Crank: examine operating characteristics for:	
(a) free but firm turning of crank handle;	___
(b) proper number of turns; proper odometer operation;	___
(c) firm stopping of crank handle when source reaches stored position	___
13. Clean the source guide tubes as specified.	___

14. Repairs made, repairs recommended, or other comments:_____

_____

_____

_____

_____

_____

_____

15. Defective equipment removed from service: _____

_____

_____

_____

Date of Maintenance: _____ Inspected By: _____

Form 203 (Rev 8-10-84)

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: _____

Form 204 (Rev 11-30-83)

QUARTERLY POCKET DOSIMETER RECORD

Employee:_____ S/S#_____

DAY	MONTH/YR S/N	INIT	FINAL	DOSE	MONTH/YR S/N	INIT	FINAL	DOSE	MONTH/YR 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:

Form 205 (Rev 11-30-83)

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

Form 206 (Rev 11-30-83)

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)

Form 207 (Rev 11-30-83)

MANAGEMENT AUDIT OF RADIOGRAPHY PERSONNEL & OPERATIONS

NOTE: ATTACH COPY OF APPLICABLE SOURCE UTILIZATION REPORT (Form 201) TO THIS AUDIT

Date & time _____ Location: _____

RT personnel audited: _____

_____

Operations observed during audit: _____

_____

_____

_____

AUDIT CHECKLIST

	SAT	UNSAT	N/A
a. Pocket dosimeter - init. reading logged, checked periodically	___	___	___
b. Proper film badge or TLD badge; worn properly	___	___	___
c. Survey meter - valid calibration, operating properly	___	___	___
d. Daily inspection of equipment performed and recorded properly	___	___	___
e. All required equipment and documentation on hand	___	___	___
f. Survey of transporting vehicle performed and documented	___	___	___
g. Transportation conducted properly; Form 202 completed	___	___	___
h. Restricted area properly established, posted and monitored	___	___	___
i. High radiation area properly posted	___	___	___
j. Device surveyed after each exposure & before storage	___	___	___
k. Exposure device handling techniques - radiation doses ALARA	___	___	___
l. For 4027 New Castle Ave: all special restrictions in effect	___	___	___
m. Proper source security and storage	___	___	___
n. Source Utilization Report, incl. sketch, complete & accurate	___	___	___
o. Other _____	___	___	___

Description of unsatisfactory findings: _____

_____

_____

_____

_____

Corrective actions: _____

_____

_____

_____

Audit performed by: _____

(signature) (title) (date)

Form 208 (Rev 8-13-84)

Lehigh Testing Laboratories, Inc.
4029 NEW CASTLE AVENUE • P.O. BOX 1241 • WILMINGTON, DELAWARE 19899 • 302-655-7358

STATEMENTS AND ACKNOWLEDGMENTS REQUIRED FROM EACH NEW EMPLOYEE IN RADIOGRAPHY

EMPLOYEE:_____ S/S NO:_____

DATE OF BIRTH._____ DATE HIRED:_____

As a newly-hired employee of Lehigh Testing Laboratories, Inc., assigned to work in the field of Industrial Radiography, I hereby acknowledge and certify the following (strike out the statement in each group that does not apply):

1. STATEMENT AND ACKNOWLEDGMENT OF MY OCCUPATIONAL DOSE DURING CURRENT CALENDAR QUARTER

EITHER: (A) I have not received any occupational dose of radiation during the current calendar quarter;

OR: (B) I have received an occupational dose during the current calendar quarter from sources of radiation possessed or controlled by companies other than Lehigh. The nature and amount of this occupational dose is as follows:

_____

_____

_____
(signature of individual) (date)

2. STATEMENT AND ACKNOWLEDGMENT OF MY INITIAL CLASSIFICATION AS A TRAINEE

EITHER: (A) I have had no previous training or experience in the fields of industrial radiography or radiation safety. I understand that my employment at Lehigh is conditional, and that I must successfully complete a minimum of twelve hours of formal classroom training, and I must also pass a written examination before I may attend any radiographic operations of any kind. Upon satisfactory completion of the instruction and written exam, I understand that I may then be assigned to attend and witness, but not participate in, certain radiographic operations to fulfill my initial field training requirements. After completing at least one week of this field training, I will be eligible for certification as an Assistant Radiographer. I fully understand that, until I receive this formal certification from the General Manager, I am classified as a Trainee, and I am not permitted to participate or assist in radiography or any other operations using licensed sources of radioactive material.

OR: (B) I do have a certain amount of training and/or experience in industrial radiography and/or radiation safety from my prior employment. However, I fully understand that I will initially be classified a Trainee, and am not permitted to participate or assist in any radiographic operations until I have received instruction in (at least) LTL's Operating and Emergency Procedures and license conditions, AND until I pass written and practical exams, AND until my qualifications have been approved and certified by the General Manager.

_____
(signature of individual) (date)

Lehigh Testing Laboratories, Inc.
4029 NEW CASTLE AVENUE • P.O. BOX 1241 • WILMINGTON, DELAWARE 19899 • 302-655-7358

PERSONNEL QUALIFICATION AND CERTIFICATION STATEMENT

EMPLOYEE:_____ S/S NO:_____

DATE OF BIRTH:_____ DATE HIRED:_____

The above-named individual, an employee in good standing at Lehigh Testing Laboratories, Inc., has satisfied all the applicable requirements regarding education, training, experience, and demonstrated practical ability, as specified in Lehigh's Radiation Safety Manual, and is hereby certified to assume the responsibilities of

ASSISTANT RADIOGRAPHER

_____
(signature of Radiation Safety Officer) (date)

_____
(signature of Vice-President/General Manager) (date)

This certification is effective_____, and expires upon the termination of this individual's employment at Lehigh Testing Laboratories in Industrial Radiography. Documentation of all necessary qualifications for this position are contained in this employee's personnel file.

****

DUTIES AND RESPONSIBILITIES OF AN ASSISTANT RADIOGRAPHER:

At Lehigh, an Assistant Radiographer is an individual who, while under the constant, direct personal supervision of a qualified Radiographer, may use radiographic exposure devices, sealed radioactive sources, radiation survey instruments and related equipment to perform industrial radiography. Under no circumstances shall an Assistant Radiographer independently handle radiographic exposure devices, source changers or shipping containers, nor shall he independently perform any radiographic operations.

****

Acknowledgement: I hereby acknowledge that I have completed all of the required education, training and experience requirements for the position of Assistant Radiographer at Lehigh Testing Laboratories, Inc., and fully understand my duties and responsibilities of this position, including the restrictions thereof, as specified in the above paragraph.

_____
(signature of individual) (date)

Form 210 (Rev. 1-12-84)

Lehigh Testing Laboratories, Inc.
4029 NEW CASTLE AVENUE • P.O. BOX 1241 • WILMINGTON, DELAWARE 19899 • 302-655-7358

PERSONNEL QUALIFICATION AND CERTIFICATION STATEMENT

EMPLOYEE:_____ S/S NO:_____

DATE OF BIRTH:_____ DATE HIRED:_____

The above-named individual, an employee in good standing at Lehigh Testing Laboratories, Inc., has satisfied all the applicable requirements regarding education, training, experience, and demonstrated practical ability, as specified in Lehigh's Radiation Safety Manual, and is hereby certified to assume the responsibilities of

RADIOGRAPHER

_____ _____
(signature of Radiation Safety Officer) (date)

_____
(signature of Vice-President/General Manager) (date)

This certification is effective_____, and expires upon the termination of this individual's employment at Lehigh Testing Laboratories in Industrial Radiography. Documentation of necessary qualifications for this position are contained in the employee's personnel file.

****

DUTIES AND RESPONSIBILITIES OF A 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 of such operations with NRC regulations and the conditions of Lehigh's NRC license, as specified in Lehigh's Radiation Safety Manual. His responsibilities include providing on-the-job training and personal supervision to Assistant Radiographers who may be assigned to work with him. Such personal supervision shall include (1) the Radiographer's personal presence at the worksite; (2) the ability to give immediate assistance if required; and (3) the Radiographer watching the Assistant's performance of all radiographic operations.

****

Acknowledgement: I hereby acknowledge that I have completed all of the required education, training and experience requirements for the position of Radiographer at Lehigh Testing Laboratories, Inc., and fully understand my duties and responsibilities in this position, as specified in the above paragraph and in Lehigh's Radiation Safety Manual.

_____
(signature of individual) (date)

Form 211 (Rev. 1-12-84)

LTL RADIATION SAFETY TRAINING - PERSONNEL RECORD

Name of Individual: _____ S/S No: _____

Date of Birth: _____ Start Date in Radiography: _____

The above individual has completed the following elements of Radiation Safety Training:

	Date Compl.	Approvals GM	Approvals RSO
1. Received a personal copy of Lehigh's Operating and Emergency Procedures, Lehigh's Byproduct Materials License, and 10 CFR, Parts 19, 20, and 34, (including latest revisions of each)			
2. Received a minimum of 2 hours instruction on the proper use of Lehigh's personnel monitoring equipment, survey meters, and radiographic equipment, plus a minimum of 4 hours of initial classroom instruction covering an introduction to federal regulations applicable to radiography; basic principles of radiation safety; and the essential requirements of Lehigh's Radiation Safety Manual, including the duties/limitations of an Assistant Radiographer, performing radiation surveys, controls used at radiographic worksites, emerg. procedures, and license conditions. Instructor(s): _____ Total hrs: _____			
3. Written Exam: Successfully passed, with a score of 75% or better, a written, closed-book examination of at least 25 questions Score: ____/____=____%			
4. On the Job Training - witnessed the proper use of exposure devices, survey meters, related equipment and operations for a minimum period of one week:			
5. Received certification as an Assistant Radiographer			
6. Received additional training and instruction (excluding on-the-job training) covering all subjects specified in 3.1.2(A) of LTL Radiation Safety Manual. Total instructional hours (excluding those received for par #2 above) must be a minimum of 34. Instructor(s) _____ Total hrs: _____			
7. On-the-Job Training - completed a minimum of three months of on-the-job training in radiographic operations under direct supervision of qualified Radiographer. These operations included: the proper maintenance, use, and storage of exposure devices and related equipment; conducting radiation surveys; posting and surveillance of worksites; use of personnel monitoring devices; transportation and security procedures; leak testing; source changes; and the evaluation and reporting of defects and noncompliances.			
8. Written exam: Successfully passed, with a score of 80% or better, a written, closed-book exam of at least 50 questions covering the above instruction and on-the-job training. Score: ____/____=____%			
9. Practical exam: Demonstrated competence in performing selected radiography operations; minimum of 20 checkpoints were evaluated.			
10. Received certification as a Radiographer			

Form 212 (Rev 8-13-84)

PRACTICAL EXAMINATION FOR RADIOGRAPHERS - RADIATION SAFETY PROCEDURES

NAME: _____ DATE OF EXAM: _____

Lehigh's Radiation Safety Manual requires that, before an individual may be certified as a Radiographer, he must be given a "Practical Examination" by the RSO to assure that he is able to properly apply his or her training in radiation safety to actual radiographic operations. The prospective Radiographer shall perform these operations without prompting or any other assistance, but under constant supervision.

CHECKLIST: The individual taking this practical examination shall be given a radiography assignment by the RSO. The RSO shall evaluate the candidate's compliance with Lehigh's radiation safety procedures, using at least 20 checkpoints taken from the following list. Each applicable checkpoint shall be rated either "S" (satisfactory), "U" (unsatisfactory), or "NA" (not applicable). A 100% score is required to pass the examination. Copies of all forms used or filled in by the candidate shall be attached to this sheet.

____ 1. Pocket dosimeter - valid calibration; fully charged at start of shift; initial reading entered in log; worn properly

____ 2. Pocket dosimeter - reading checked periodically

____ 3. Proper film badge (or TLD); worn properly

____ 4. Survey meter - valid calibration

____ 5. Survey meter - operational check conducted

____ 6. All required paperwork on hand

____ 7. Storage vault surveyed before source is removed

____ 8. Daily equipment inspections performed and documented properly

____ 9. Source properly secured for transport

____ 10. Transport of source - vehicle surveys performed and documented

____ 11. Transport record properly completed

____ 12. Boundary of restricted area established accurately, confirmed by actual survey, and documented on Source Utilization Record

____ 13. Proper posting of warning signs at boundary of radiation area

____ 14. Proper posting of warning signs at boundary of high radiation area

____ 15. Proper assembly of crank, guide tubes, control cable, collimator

____ 16. Proper surveillance maintained during exposure

____ 17. Survey of exposure device performed after each exposure

____ 18. Followed special restrictions applicable to permanent facility: collimation, source position, orientation, time limits, shielding, etc.

____ 19. Source properly secured in storage location at end of operations

____ 20. Surveyed and documented on Utilization Record the radiation levels in the unrestricted levels surrounding the storage location

____ 21. Utilization Record, incl. sketch, complete and accurate

____ 22. Dosimeter reading logged at end of shift

SCORE: _____ EXAMINER: _____

LEHIGH TESTING LABORATORIES, INC.

SAMPLE EXAMINATION QUESTIONS FOR ASSISTANT RADIOGRAPHERS

NOTE: The questions presented here are examples of the level of difficulty and variety of topics covered in actual exams. These particular questions, however, may not necessarily be used. Examinations for qualifying individuals to be Assistant Radiographers shall consist of at least 25 of these questions. These questions (and any other questions selected by the examiner) are intended to determine the candidate's knowledge of an Assistant Radiographer's responsibilities, of Lehigh's operating and emergency procedures, and of the equipment he would normally use. This is a closed-book examination, but a calculator is permitted.

1. A radiation survey meter reads 10 mR/hr. How long will it take before a dose of 2 mrem is delivered? _____ minutes.

2. If you have 3 sources of 5, 10, and 15 curies activity and you place them together, what is the activity of the combined source? _____ curies.

3. Does a gamma radiography source make the radiographed objects radioactive? _____

4. How often must Lehigh's survey meters be calibrated? _____

5. What two types of dosimetry must be worn by a radiographer on the job?

_____

_____

According to Lehigh's Radiation Safety Manual, what are the "Four Basic Rules" you must follow in an emergency situation?

6. _____
7. _____
8. _____
9. _____

What are the three basic methods used by radiographers to keep radiation dosages "as low as reasonably achievable"?

10. decrease the _____
11. increase the _____
12. increase the _____

13. After each radiography exposure, you must make a radiation survey. What is the major reason for doing this survey?

_____

_____

_____

14. What is the reason for using a self-reading pocket dosimeter on the job?

_____

_____

_____

15. How frequently must your dosimeter reading be recorded on paper?

_____

16. The Tech/Ops Model 660 has a selector ring which may be rotated to any of three positions. Name them.

_____

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

18. The type of distinctive warning label that must be applied to the surface of a package containing radioactive material is determined by:
____ (a) The dose rates at the surface and at 1 meter from the surface.
____ (b) The weight of the material.
____ (c) The transport index.
____ (d) The type of vehicle in which the package will be shipped.

19. While performing radiography, you note that your pocket dosimeter reads off scale. What should you do? (Select the BEST answer)
____ (a) recharge your dosimeter and continue working
____ (b) first document the malfunctioning dosimeter in the dosimeter logbook, then obtain another dosimeter before resuming radiographic operations.
____ (c) stop work, notify the RSO, and turn in your film badge or TLD so that it may be sent out for immediate processing.
____ (d) perform a radiation survey to insure that radiation levels are as expected. If so, get another dosimeter and finish the job.

20. What is the MOST important thing you can do to avoid an overexposure to radiation?
____ (a) Always wear the personnel dosimetry provided
____ (b) Always make proper radiation surveys.
____ (c) Request that an alarming dosimeter be provided to you
____ (d) Keep a daily log of pocket dosimeter readings.

21. When properly stored, a 100 curie source of Iridium 192 should give a dose rate at the surface of a Model 660 exposure device of no more than:
____ (a) 2 mr/hr
____ (b) 50 mr/hr
____ (c) 100 mr/hr
____ (d) 200 mr/hr

22. When properly stored, a 100 curie source of Iridium 192 should give a dose rate at a distance 6" from the surface of a Model 660 of no more than:
____ (a) 2 mr/hr
____ (b) 50 mr/hr
____ (c) 100 mr/hr
____ (d) 200 mr/hr

23. Who may perform daily inspections of gamma radiography equipment?
____ (a) A radiographer, alone
____ (b) An assistant radiographer, alone
____ (c) A trainee, alone
____ (d) None of the above
____ (e) Either (a) or (b)

24. The normal operating range of a pocket dosimeter used by Lehigh is
____ (a) 0 to 200 mR
____ (b) 0 to 200 mR/hr
____ (c) 0 to 200 R
____ (d) 0 to 200 R/hr

25. T____ F____ Anyone who is not a Radiographer or an Assistant Radiographer may not enter a restricted area

26. T____ F____ The maximum allowable dose rate in an area that has unrestricted access is 5 mR in any one hour.

27. T____ F____ Restricted areas must always be enclosed by ropes or other barriers

28. T____ F____ You must survey the boundary of the high radiation area during every exposure of the source.

29. T____ F____ You must survey the boundary of the radiation area during every exposure of the source.

30. T____ F____ You must survey the boundary of the restricted area during every exposure of the source.

31. T____ F____ If the restricted area does not have locked doors, an alarm, or an automatic source retraction device, you must maintain surveillance of the entire restricted area to make sure no one enters.

32. T____ F____ You must survey the camera with a survey meter after every exposure of the source.

33. T____ F____ If you have a reliable pocket dosimeter, you do not also have to have a film or TLD badge.

34. T____ F____ You must read your pocket dosimeter after each exposure.

35. T____ F____ You must recharge your pocket dosimeter weekly.

36. T____ F____ You can leave a camera untended in the back of a pickup truck if the source is locked and the key is removed.

37. T____ F____ You must check to be sure your camera is in good working order each day before starting work.

38. T____ F____ An audible and visible alarm system is required at all permanent radiographic worksites.

ANSWERS TO SAMPLE EXAMINATION QUESTIONS FOR ASSISTANT RADIOGRAPHERS

1. 12
2. 30
3. no
4. 90 days
5. pocket dosimeter plus film badge or TLD
6-9. Move away from the source and keep other people away; Relax, don't panic, and calmly assess the situation; Establish a restricted area, and make sure no one enters it; and Notify the RSO without leaving the restricted area unattended.
10. time
11. distance
12. shielding
13. to assure that the source has fully returned to its original storage position within the exposure device
14. to permit immediate measurement of radiation dose received
15. at the end of each shift when radiography operations are performed
16. Operate, Lock, Connect
17. c
18. a
19. c
20. b
21. d
22. b
23. a
24. a
25. T
26. F
27. F
28. F
29. F
30. F
31. T
32. T
33. F
34. F
35. F
36. F
37. T
38. T

LEHIGH TESTING LABORATORIES, INC.

SAMPLE EXAMINATION QUESTIONS FOR RADIOGRAPHERS

NOTE: The questions presented here are examples of the level of difficulty and variety of topics covered in actual exams. These particular questions, however, may not necessarily be used Examinations for qualifying individuals to be Radiographers shall consist of at least 50 questions, and a majority of the questions shall deal with practical problems and with the operating and emergency procedures. Any of the sample questions for Assistant Radiographers may also be used in examining prospective Radiographers. These questions (and any other questions selected by the examiner) are intended to determine the candidate's knowledge of a Radiographer's responsibilities, of Lehigh's operating and emergency procedures, and of the equipment he would normally use. This is a closed-book examination, but a calculator is permitted.

1. If the HVL of lead shielding for IR-192 is 0.2", how thick must a lead collimator be to reduce the dose from an IR-192 source by a factor of 8?

_____

The Tech/Ops Model 660 exposure device should never be used with more than
2. _____ guide tube sections (having a total length of approximately
3. _____ feet), because with more sections the source would be unable to reach the source stop.

4. If a source of IR-192 has an activity of 100 Curies on January 1, what would be the activity of the source on August 15? _____

5. You plan to make six exposures at a field location. Each exposure will take 5 minutes. Based on your past experience, you know that it will take you a minimum of 15 minutes for setup time between exposures. Your first exposure is at 3:30 p.m. From past measurements you know that at 100 feet from the source the dose rate will be 20 mR/hr during these exposures. What would be the maximum dose received by a person standing 100 feet from the source in any one hour?

_____
_____
_____

6. You will be using a 100-curie iridium-192 source. What will the dose rate be at a distance of 100 feet from the source? (Note: For iridium-192 the dose rate at 1 foot from a 1 curie source is 5.2 R/hr).

_____
_____
_____

7. Repeat the previous except calculate the dose rate at 200 feet instead of 100 feet.

_____
_____
_____

8. For the same 100-curie iridium-192 source, at what distance will the dose rate be 100 mR/hr?

_____
_____
_____

MULTIPLE CHOICE QUESTIONS

9. Whole-body radiation dose must normally be limited to
____ (a) 1.25 rems per calendar quarter
____ (b) 18.75 rems per calendar quarter
____ (c) 7.5 rems per calendar quarter
____ (d) 5.0 rems per calendar quarter

10. The formula for calculating permissible accumulated dose is
_____(a) 12 (N - 18)
_____(b) 18 (5 + N)
_____(c) 5 (N -18)
_____(d) 12 D(N + 18)

11. Radiography sources are:
_____(a) Special form radioactive material
_____(b) Normal form radioactive material
_____(c) Safe radioactive material

12. The "transport index" refers to:
_____(a) The surface dose rate of a package containing radioactive material.
_____(b) The highest dose rate at 1 meter from the surface of a package containing radioactive material.
_____(c) The dose rate at the surface of a truck carrying packages containing radioactive material.
_____(d) The dose rate in the driver's compatment of a truck carrying packages containing radioactive material.

13. A Radioactive Yellow II warning label is applied to packages with a transport index of:
_____(a) 0
_____(b) Between 0 and 1
_____(c) Between 1 and 10
_____(d) Between 10 and 100

14. A package contains radioactive material. The highest dose rate at the surface is 25 mR/hr and the highest dose rate at 1 meter from the surface is 2.5 mR/hr. The proper radioactive warning label to apply on two opposite sides of the package would be:
_____(a) A Radioactive Yellow III label.
_____(b) A Radioactive Yellow II label.
_____(c) A Radioactive White I label.
_____(d) No label is required; the dose rate is too low.

15. What age restrictions are imposed on radiographers?
_____(a) must be over 21
_____(b) must be over 18
_____(c) must be over 18 for males, over 21 for females
_____(d) must be between 18 and 65

16. If you arrive at a job and find that your survey meter is not operating properly, what should you do?

____ (a) Complete the job quickly while keeping a close check on your pocket dosimeter.
____ (b) Use past experience to judge where the restricted area boundary should be and complete the job.
____ (c) Send an assistant to obtain a new instrument while you complete the first exposure.
____ (d) Get a properly operating survey meter before starting radiography

17. The following states are agreement states:

____ (a) Delaware
____ (b) Pennsylvania
____ (c) Maryland
____ (d) New Jersey
____ (e) None of the above

18. According to Lehigh's NRC license, the maximum activity per individual source of Iridium 192 that we may purchase or use is:

____ (a) 50 curies
____ (b) 100 curies
____ (c) 200 curies
____ (d) unlimited

19. The Tech/Ops Model 660 is designed as storage, transport and exposure device for

____ (a) Cobalt 60 only
____ (b) Iridium 192 only
____ (c) Either Cobalt 60 or Iridium 192
____ (d) any radioactive isotope having up to 120 curies

20. At Lehigh, who may be assigned by the RSO to perform a leak test?

____ (a) A radiographer, alone
____ (b) An assistant radiographer, alone
____ (c) A trainee, alone
____ (d) None of the above

21. How often must leak tests be performed?

____ (a) at intervals not to exceed 3 months
____ (b) at intervals not to exceed 6 months
____ (c) at least once during each calendar quarter
____ (d) at least twice during each calendar year

22. At Lehigh, who may be assigned by the RSO to perform equipment maintenance?

____ (a) A radiographer, alone
____ (b) An assistant radiographer, alone
____ (c) A trainee, alone
____ (d) None of the above

23. How often must equipment maintenance be performed?
____ (a) at intervals not to exceed 3 months
____ (b) at intervals not to exceed 6 months
____ (c) at least once during each calendar quarter
____ (d) at least twice during each calendar year

24. At Lehigh, who may be assigned by the RSO to perform inventories?
____ (a) A radiographer, alone
____ (b) An assistant radiographer, alone
____ (c) A trainee, alone
____ (d) None of the above

25. How often must inventories be performed?
____ (a) at intervals not to exceed 3 months
____ (b) at intervals not to exceed 6 months
____ (c) at least once during each calendar quarter
____ (d) at least twice during each calendar year

TRUE OR FALSE QUESTIONS

26. T____ F____ Any vehicle carrying a package containing radioactive material that has a Radioactive Yellow III warning label always needs to be placarded on all four sides.

27. T____ F____ The use of x-rays to perform industrial radiography is regulated by the Nuclear Regulatory Commission.

28. T____ F____ If your company has an NRC license and the job site is in an Agreement State, you must notify the state before starting work there

29. T____ F____ If you have been overexposed to radiation, your company must tell you that you have been overexposed.

30. T____ F____ You can request that the NRC conduct an inspection of your company if you think there are safety problems.

31. T____ F____ You may talk privately to NRC inspectors during inspections.

32. T____ F____ Lost or stolen sources must be promptly reported to the NRC or to Agreement State officials, whichever is applicable.

33. T____ F____ A person who receives an overexposure to gamma radiation poses a biological hazard to others.

34. T____ F____ A 10 year old person would probably be more seriously affected by a given radiation dose than would a 27 year old person.

MATCHING - Select the BEST answer from the right-hand column for each of the items in the left-hand column

35. ____	Attenuation factor for T/O 714 lead mini-collimator	(a)	2
36. ____	Attenuation factor for T/O 654 lead collimator	(b)	30
37. ____	Attenuation factor for T/O 799 tungsten mini-collim.	(c)	50
38. ____	Half-life of Ir-192 (no. of days)	(d)	1000
39. ____	Max. exposure minutes in any one hour at 4027 NCA	(e)	1/160
40. ____	Max. mR/hr @ surface of package for Yellow II label	(f)	75
41. ____	Max. allowable mR/hr at any surface of storage vault	(g)	1/70
42. ____	Gammalarm must be checked every how many days	(h)	1/200
43. ____	Max mR in any 7 days for an unrestricted area	(i)	52
44. ____	No. of milliRems in one Rem	(j)	1
45. ____	Max acceptable mR/hr at surface of 660 with 100 ci	(k)	1.75
46. ____	Max mR/hr at 1 meter from a Yellow II package	(l)	100
47. ____	R/hr for 10 curies of Ir-192 at 1 foot	(m)	90
48. ____	Approx. HVL of solid concrete (inches) for Ir-192	(n)	36
49. ____	Max height (in) for a source used at 4027 NCA	(o)	7
50. ____	Approximate length of each guide tube section (ft)	(p)	200

ANSWERS TO SAMPLE EXAMINATION QUESTIONS FOR RADIOGRAPHERS

1. 0.6"
2. 3
3. 21
4. 12.5 curies
5. 5 mR
6. 52 mR/hr
7. 13 mR/hr
8. about 72 feet
9. a
10. c
11. a
12. b
13. b
14. a
15. b
16. d
17. c
18. b
19. b
20. a
21. b
22. a
23. a
24. a
25. a
26. F (only if any exterior surface of the outermost container exceeds 50 mR/hr)
27. F
28. T
29. T
30. T
31. T
32. T
33. F
34. T
35. g
36. h
37. e
38. f
39. b
40. c
41. a
42. m
43. l
44. d
45. p
46. j
47. i
48. k
49. n
50. o