NRC FORM 313 (7-86) 10 CFR 30, 32, 33, 34, 35 and 40

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED BY OMB 3150-0120
Expires: 5-31-87

APPLICATION FOR MATERIAL LICENSE

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

APPLICATIONS FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

U.S. NUCLEAR REGULATORY COMMISSION
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY, NMSS
WASHINGTON, DC 20555

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS. IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION I
NUCLEAR MATERIALS SAFETY SECTION B
631 PARK AVENUE
KING OF PRUSSIA, PA 19406

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION II
NUCEAR MATERIALS SAFETY SECTION
101 MARIETTA STREET, SUITE 2900
ATLANTA, GA 30323

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION III
MATERIALS LICENSING SECTION
799 ROOSEVELT ROAD
GLEN ELLYN, IL 60137

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
MATERIAL RADIATION PROTECTION SECTION
611 RYAN PLAZA DRIVE, SUITE 1000
ARLINGTON, TX 76011

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION V
NUCLEAR MATERIALS SAFETY SECTION
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CA 94596

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION.

1. THIS IS AN APPLICATION FOR (Check appropriate item)

- [ ] A. NEW LICENSE
- [X] B. AMENDMENT TO LICENSE NUMBER 37-21067-01
- [X] C. RENEWAL OF LICENSE NUMBER 37-21067-01

2. NAME AND MAILING ADDRESS OF APPLICANT (Include Zip Code)

PENNSYLVANIA SHIPBUILDING COMPANY
FOOT OF MORTON AVENUE
CHESTER, PENNSYLVANIA 19013

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED

Within Plant at Foot of Morton Avenue
Chester, Pennsylvania 19013

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION: FRANZ H. NOLL, P.E.

TELEPHONE NUMBER: (215) 499-3063

SUBMIT ITEMS 5 THROUGH 11 ON 8½ x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL
a. Element and mass number; b. chemical and/or physical form; and c. maximum amount which will be possessed at any one time.

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE.

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.

9. FACILITIES AND EQUIPMENT.

10. RADIATION SAFETY PROGRAM.

11. WASTE MANAGEMENT.

12. LICENSEE FEES (See 10 CFR 170 and Section 170.31)
FEE CATEGORY: 3. 0
AMOUNT ENCLOSED: $ 700.00

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

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

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

SIGNATURE—CERTIFYING OFFICER	TYPED/PRINTED NAME	TITLE	DATE
Rockwell Holman	ROCKWELL HOLMAN	VICE PRESIDENT OF QUALITY IMPROVEMENT	02-25-87

14. VOLUNTARY ECONOMIC DATA

a. ANNUAL RECEIPTS

[ ]	< $250K	[ ]	$1M - 3.5M
[ ]	$250K - 500K	[ ]	$3.5M - 7M
[ ]	$500K - 750K	[ ]	$7M - 10M
[ ]	$750K - 1M	[X]	> $10M

b. NUMBER OF EMPLOYEES (Total for entire facility excluding outside contractors): 1,500

c. NUMBER OF BEDS: N/A

d. WOULD YOU BE WILLING TO FURNISH COST INFORMATION (Dollar and/or staff hours) ON THE ECONOMIC IMPACT OF CURRENT NRC REGULATIONS OR ANY FUTURE PROPOSED NRC REGULATIONS THAT MAY AFFECT YOU? (NRC regulations permit it to protect confidential commercial or financial—proprietary—information furnished to the agency in confidence)

[X] YES [ ] NO

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	COMMENTS	APPROVED BY
Renewal	Mar. 6 I	30	8801290204 870825 REG1 LIC30 37-21067-01 PDR	S. Kimberley
AMOUNT RECEIVED	CHECK NUMBER			DATE
$700	020222		106864	3/6/87

SUPPLEMENT TO NRC FORM 313

ITEM 5

Element and Mass No.	Physical Form	Maximum Amount
(a) Ir 192	Sealed Source	300 ci + 20%
(b) Co 60	Sealed Source	33 ci + 10%
(c) Co 60	Source Rod	15 mci + 10%
(d) Ce 137	Source Rod	150 mci + 10%

ITEM 6

(a) Industrial Radiography

(b) Industrial Radiography

(c) Calibration of Survey Meters

(d) Calibration of Survey Meters

ITEM 7

Franz H. Noll, P.E. Radiation Safety Officer

Attended 40 hrs. - Dupont Industrial Radiography Course and 40 hrs. Tech/Ops Radiation Safety Course.
Performed X- and Gamma Radiography since 1972.

ITEM 8

Radiographic Technicians receive a 40 hr. initial Training Course. Periodic training of 8 hrs. duration will be given on an annual basis.

ITEM 9

Whenever possible, radiographic operations are performed inside of a permanently shielded exposure room, see Attachment No. 1 of the NRC License No. 37-21067-01. Whenever exposures are made outside of the exposure room, the procedures outlined in Attachment No. 4 of the NRC License are strictly adhered to.

SUPPLEMENT TO NRC FORM 313

ITEM 10

See License No. 37-21067-01, Attachment No. 5, Pages 34 through 62 for initial training and Pages 66 through 70 for periodic annual training.

ITEM 11

Upon receipt of a new radiographic source, the depleted source is returned to the source manufacturer for disposal.

LICENSE FOR USE OF BY-PRODUCT MATERIAL

FOR INDUSTRIAL RADIOGRAPHY

N.R.C. LICENSE NO.: 37-21067-01

LICENSEE: PENNSYLVANIA SHIPBUILDING COMPANY
P.O. Box 89
CHESTER, Pennsylvania 19016

PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

License No. 37-21067-01
Attachments

PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

License No. 37-21067-(
Attachments

Pennsylvania Shipbuilding

DESCRIPTION OF PERMANENTLY ESTABLISHED RADIOGRAPHY FACILITIES

1. Location

The permanent Radiographic facility is located in the Southeast corner of the Pipe Shop (Department 34), Central Yard, Chester, Pennsylvania. It is an open type building with a roof height of approximately three stories. There is no second floor in the Main Shop area where the Radiographic Facility is located. There are no stairs or ladders to the direct line of radiation. The Shop Bridge Crane is remotely controlled by a crane operator on the ground.

No buildings of any height which could receive direct Radiation exist around the Radiographic Room.

2. Physical Description

The Radiographic Area lies within an area comprised of a double course block and concrete wall 8'-6" high. Access to this area is by a single route through two (2) locked doors. The inner door is lead shielded and seals the maze entrance during radiographic exposures. It is equipped with a Tech/Ops Gammalarm which is interlocked with the shielded access entrance door. The detection of 2mR/hr. or more of X-or gamma radiation will cause the red lights to flash. It will also cause the alarm buzzer to sound when the door is not closed.

The magnetic door lock cannot be released from the outside while radiation in excess of 2mR/hr. is present in the exposure room.

When an exposure has been completed and the radiation level has dropped to less than 2mR/hr. , the Gammalarm changes from red to green light, indicating a safe condition. The door lock may now be released by pushing a button adjacent to the door. The shielded door may be unlocked at any time from the inside.

The Gammalarm System and the door interlock are tested by the Radiation Safety Officer or Assistant Radiation Safety Officer at intervals not to exceed three months. Records of the operational tests will be kept on file for a period of two years.

A wide angle mirror is located in a manner that permits the Radiographer to observe the facility at all times from the manipulating area.

Pennsylvania Shipbuilding

3. Radiographic Work Area

The safe work area within this facility is defined by a yellow line forming a rectangle 4' from the walls and a maximum height of 5' from the floor. All radiographic work is to be performed within this area.

4. Source Limitations

This facility is designed for use of:

a. 120 ci of Ir^{192} - Automation Industries Model 520 with a collimator having a minimum attenuation factor of 100, provided the 70° included angle of primary beam is either straight up or down.
The use of Ir^{192} sources without collimators require written permission from the Radiation Safety Officer.

b. Using a CO^{60} source - Tech/Ops Model 741 with a collimator having a minimum attenuation factor of 60, provided the primary beam is either straight up or down requires written permission from the Radiation Safety Officer. Exposing a CO 60 Radiography Source inside the radiographic exposure lab without collimation is not permitted.

c. 165 mci of Cs^{137} - Tech/Ops Model 773 calibration Unit.

5. Surveys

Inital surveys were made and are on file using the worst possible set-up(beam aimed directly at wall). All surveys indicated safe operation of the facility at 2mR/hr. or less on the outside surface of all walls.

A recorded survey is required once on eight (8) hour shift of operation.

A survey of the source tube and camera to insure proper positioning of the source in the camera is required after each exposure.

6. Storage Vault

The storage vault is an enclosure constructed from 8" solid concrete blocks and with an 8" reinforced concrete roof (See Sketches on pages 5 & 6). The floor comprises a 4" reinforced concrete slab with 16" high concrete pedestals for the Automation Industries Model 520 Projectors for Ir 192 and the Tech/Ops Model 773 Cs 137 projector for calibration.

Pennsylvania Shipbuilding

A vertical 1 inch thick steel plate has been placed behind the door for storage of a Tech/Ops Model 741 Projector containing a 33 ci max. CO 60 source.

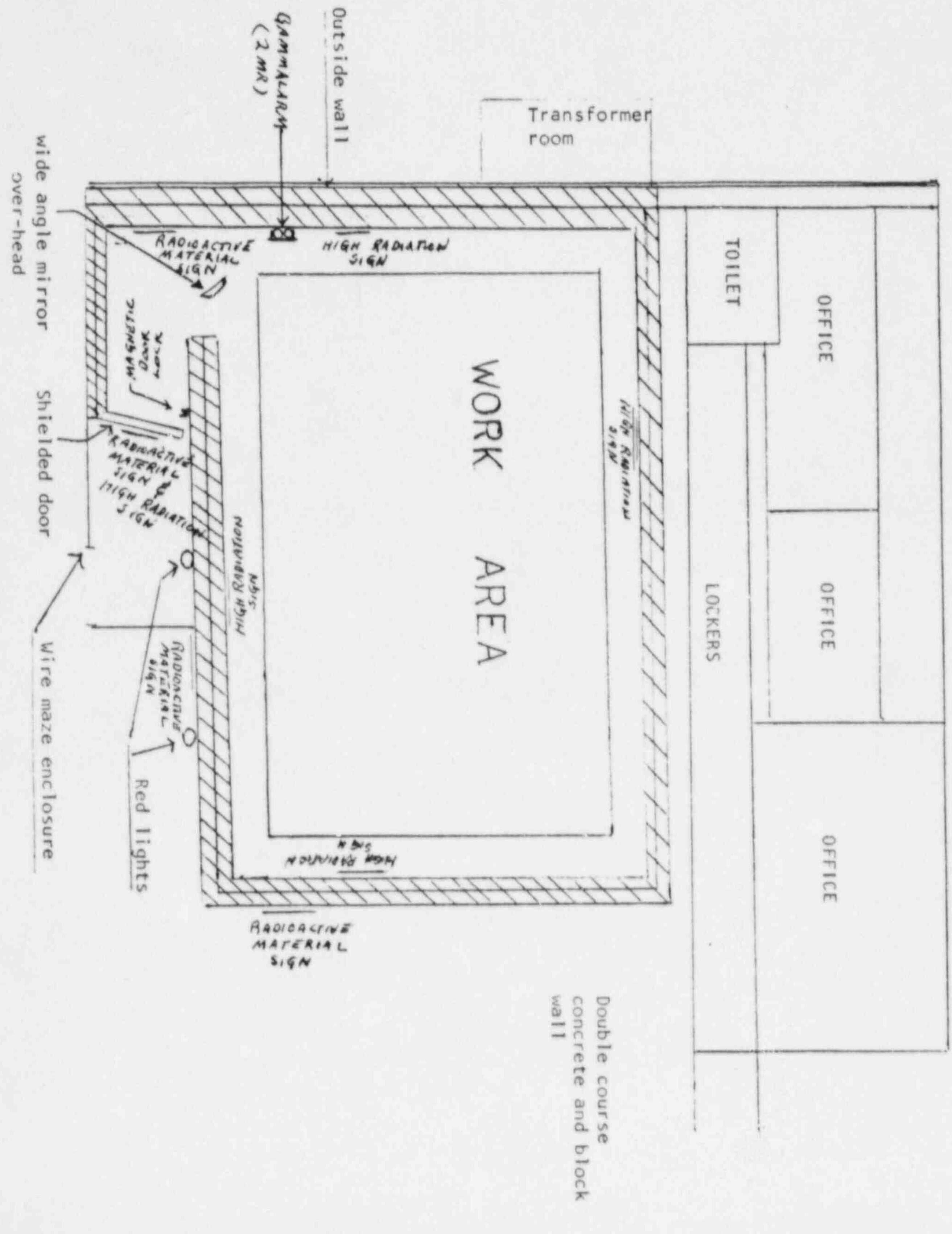
The storage vault is located at the east end of the Cleaner Building and 5'-4" away from that building. It is surrounded on three sides by a 6 foot high chain link fence extending from the Cleaner Building and 5'-4" away from the storage vault. At the east side of the chain link fence is a 3 foot wide gate secured by a heavy duty type padlock.

Caution - Radiation Area signs are attached to the North and South sides of the chain link fence and to the gate at the east side, "Caution - Radioactive Material - No Unauthorized Personnel" signs are attached to the concrete wall of the vault at each side of the steel door.

Outside and inside lighting fixtures are provided for the safety of personnel.

All isotope projectors are stored in the vault when not in use.

PENNSYLVANIA SHIPBUILDING COMPANY



Form 482-770

PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

PREPARED BY: F. H. NOLL, P.E.

CHECKED BY:

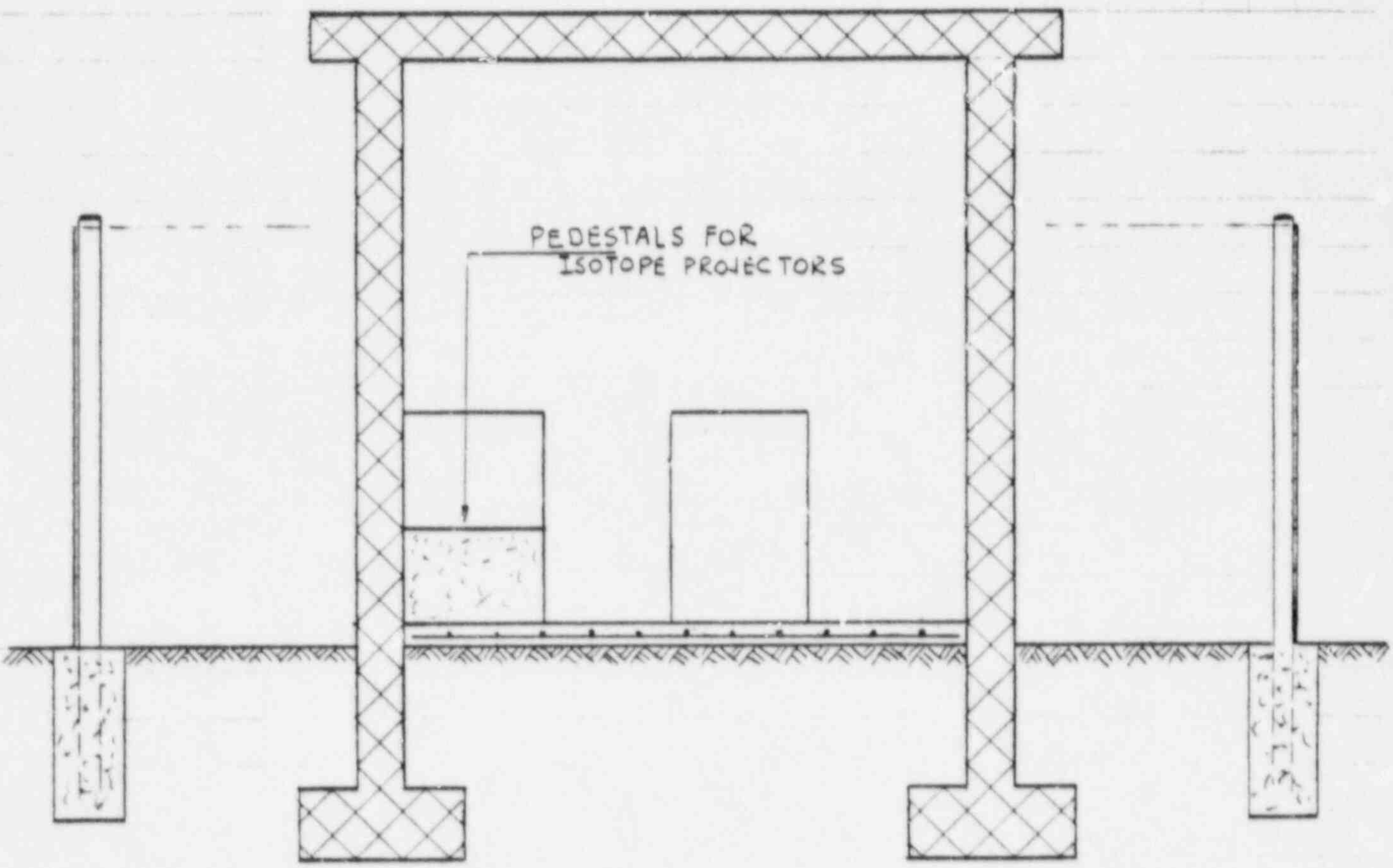
CHARGE

PROJ. NO.

TITLE: STORAGE VAULT FOR ISOTOPE CAMERAS

ELEVATION VIEW

DATE



Form 482-770

PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

PREPARED BY: F.H. NOLL, P.E.

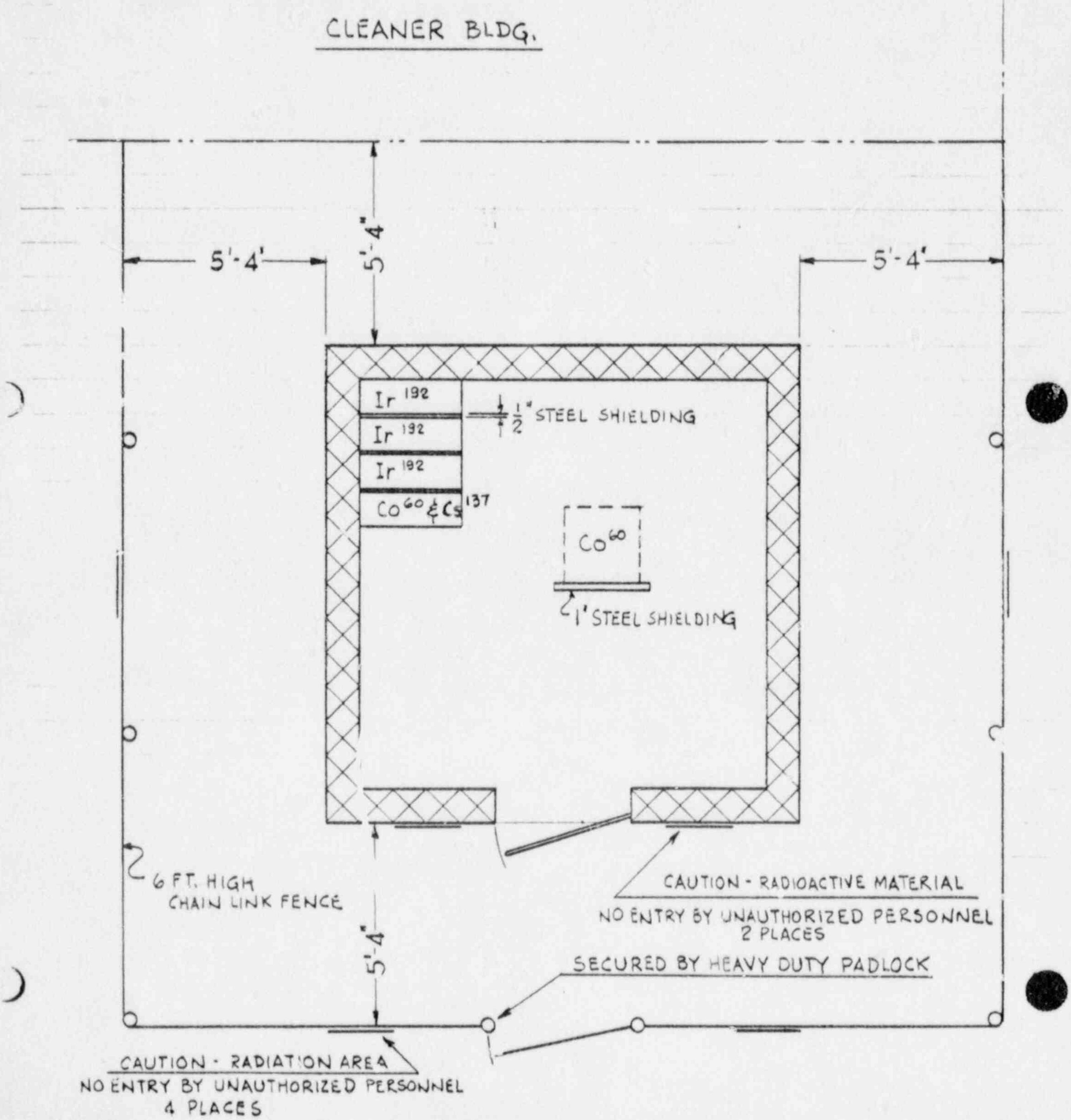
CHECKED BY:

CHARGE

PROJ. NO.

TITLE: STORAGE VAULT FOR ISOTOPE CAMERAS PLAN VIEW

DATE



PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

SURVEY METERS

MAKE	MODEL NUMBER	RANGE
Ludlum	4	0-1000 mR/hr.
Eberline	E-130G	0-1000 mR/hr.

Calibration is performed every ninety (90) days and after any Maintenance is performed.

All calibration of Survey Meters is performed in the permanent facilities by qualified Radiographers. Repair of Survey Meters is performed by Penn Ship's Electronic Shop personnel.

PENNSYLVANIA SHIPBUILDING COMPANY
CHESTER, PENNSYLVANIA 19016

License No. 37-21067-01
Attachment No.3

PERSONNEL MONITORING

1. Film Badges are supplied bi-weekly for all Radiography Personnel. Bi-weekly reports are received and kept on file in the Radiographic Office.
   Film Badge Service - R.S. Landauer, Jr. & Co.

2. Dosimeters are available for all personnel. The following types of pocket dosimeters are being used at the present time:

Mfr.	Model No.	Range
Victoreen	541A	0-200 mR
Stephen	None	0-200 mR

3. Victoreen Dosimeter chargers, Model Number 2000A are available to all personnel in the Film Processing Room.

Pennsylvania Shipbuilding

STANDARD OPERATING PROCEDURE FOR SAFE HANDLING OF RADIOACTIVE MATERIAL

OPERATION OF RADIOGRAPHIC CAMERAS USING RADIOISOTOPES

The three types of cameras utilized by Penn Ship are:

A. Automation Industries Model 520 cameras with 100 ci + 20% maximum of Ir 192 are used for Radiography. The operation for these devices is covered in Paragraphs 1,2, and 3 below.

B. Technical Operations, Inc. Model 741 Camera with 30 ci + 10% maximum of CO 60 are also used for Radiography. The operation for this camera is detailed in Paragraphs 1 and 3 below.

C. Technical Operations, Inc. Model 773 Camera with 150 mci + 10% maximum of CS 137 is used to calibrate the survey meters. The operating procedures for this camera are detailed under "calibration of survey meters".

(1) Unrestricted Area Techniques

a. Take at least one operable survey meter with you that has a current calibration tag attached.

b. Remove the camera to be used from the vault and check the radiation intensity outside of the camera (50 mR/hr. max. at 6 inches for Automation Ind. Model 520 camera, and 200 mR/hr. max. at any exterior surface or 10 mR/hr. at one meter from any exterior surface for Tech/Ops. Model 741 camera). The radiation level at 6 inches and one meter, respectively, is to be recorded in the applicable line of the Radiographer's Report.

c. Transport the camera to the area where the Radiography is to be performed by using only the authorized vehicle with radiation placards. If any other vehicle is used, it must have the necessary radiation placards attached.

d. Upon arrival at the job site, calculate the distance from the source to the restricted area perimeter. Rope off the restricted area perimeter so that exposure to individuals will not exceed 2mR in any one hour. Post the "Caution - Radiation Area" signs conspicuously along this perimeter.

The potential exposure dose of 2 millirem in any one hour is the product of radiation intensity as indicated on the survey meter and actual exposure time. For instance, an exposure of 10 minute duration has to be made. The restricted area perimeter must be as close as possible to the source; the actual reading on the survey meter at the rope is 12 mR/hr. The last exposure ended at 9:45 a.m. The exposure in question cannot commence until 10:45 a.m. The exposure following will have to wait until 11:55 a.m.

e. Using the same technique, calculate the distance from the isotope position to the 100 mR per hour isodose line and post signs bearing the radiation symbol and the words, "Caution - High Radiation Area," in a manner that can be seen from any approach.

f. Remove dust plugs from camera and connect source tube or collimator to the camera. Inspect source tube for damage, if used.

g. Connect the crank assembly cable to the end fitting on the source pig tail, and the crank assembly to the camera. Extend crank assembly out as far as possible from camera. (Leave camera locked.)

h. Make sure that area is completely free of personnel.

i. With film in place, unlock camera, and quickly crank out isotope to the full extent. Survey the perimeter of the restricted area. The radiation level at the perimeter is not to exceed the level calculated in Para. d above.

When the exposure time has elapsed, quickly crank source into camera. Survey the source tube and the camera to ascertain that the source is fully retracted in the camera. Lock camera.

j. For repeat exposures, repeat Step "i" until complete.

k. Upon completion of exposures for that area and after completing surveys as required in Step "i," load camera into radiation transportation vehicle and return to vault.

l. Survey the Automation Ind. Model 520 camera at 6 inches and the Tech/Ops Model 741 camera at all exterior surfaces and at one meter (3'-3 3/8") from all exterior surfaces of the camera. The radiation levels at 6 inches and one meter, respectively, of the last daily survey are to be recorded on the Radiographer's Report. Store camera on empty shelf in vault. Survey the vault area. Check that all radiation and radioactive material signs are in place on perimeter fence.

m. Complete all of the information required on the Radiographer's Report in triplicate. One copy is filed under survey records, one copy filed under job number, and one copy is filed for the customer.

Pennsylvania Shipbuilding

(2) Radiographic Enclosure Technique

a. On arrival, check the radiation level outside of the vault. If radiation exists in excess of 2mR/hr., notify the Radiation Safety Officer. Open vault and remove the camera to be used. Check the radiation level at six inches from the camera and record on the Radiographers Report in the appropriate space

NOTE: For limitations of radioactive sources to be used in the radiographic enclosure, see page 2 of attachment No. 1.

b. Load camera in authorized radiation vehicle (one that has the proper radiation placards) and proceed to the Radiographic enclosure located in the southeast corner of the Pipe Shop.

c. Unlock the lead shielded door and ascertain that no unauthorized personnel are in the area. Check that all radiation placards are in place and the outside red lights have been turned on.

d. Set up camera in proper location and remove dust plugs, connect the source tube and/or collimator to the camera as required, after checking source tube and/or collimator for possible damage.

e. Connect the control cable assembly to the camera.

f. After rechecking the area for unauthorized personnel, unlock the camera.

g. All exposures are to be made with the collimated radiation beam directed either straight up or down, and all exposure "set-ups" are to be made within the confines of the yellow line that is located on the floor, four (4) feet from each wall.

h. Close shielded door and insure the lock is engaged.

i. With film in place, quickly crank out the source to the full extent. During the exposure, survey radiation levels at the outside enclosure wall. Monitor the Gammalarm for an unsafe condition (if buzzer sounds, investigate the cause such as the door not being properly closed and locked. If buzzer does not go off, return the source to the stored position).

j. At the conclusion of each shot, return the isotope into the camera, unlock the shielded door, survey the camera and source tube to insure that the isotope is in the proper storage position and lock camera.

k. At the conclusion of the work period, all related gamma ray equipment is to be properly stored and the camera transported back to the vault.

l. At the vault just prior to storing the camera, check the radiation level at six inches from the camera and record the readings on the Radiographers Report in the appropriate place.

m. Close vault and lock, check radiation in area (if in excess of 2mR/hr, report to Radiation Safety Officer), check that caution signs are in place.

n. Complete Radiographers Report and turn in to the X-Ray Office.

(3) <u>SPECIAL INSTRUCTIONS FOR SHIPBOARD OPERATIONS OF SHIPS WITH ASSIGNED CREWS ABOARD</u>

a. All instructions for open air technique are applicable to shipboard operations plus the following Procedures.

b. Notify the Captain or Watch Officer in advance that you are going going to perform gamma ray inspection and of the area that must be cleared. It is especially important for foreign speaking crews that someone in charge has a clear understanding of what you are doing and can assist you in assuring that all personnel are out of the area. If no one aboard can communicate with you, find the port engineer for the ship and work thru him.

c. Use the necessary number of assistant radiographers to rope off and guard all decks involved in the area where radiation occurs which could expose an individual to more than 2 milliroentgens in any one hour.

d. When the camera must be used over the side of a ship that is afloat, a stout line at least 30 foot long with a float attached mus . securely attached to the camera in case it goes overboard. The line and float will aid in recovering the isotope.

(4) Operation Of The Technical Operations Model 773 Calibration Unit- Calibration Of Survey Meters

a. The calibration of survey meters shall be performed by a qualified Radiographer who has been evaluated by the Radiation Safety Officer in the calibration procedure. The Radiographic Technician only is fully responsible for the safe operation of the calibration unit.

b. Survey Vault area for radiation (if radiation intensity is in excess of 2mR/hr, report to the Radiation Safety Officer). Remove Tech/Ops Model 773 Calibration Unit and survey. Proceed to the radiographic enclosure in the southeast corner of the Pipe Shop.

c. Turn on the Survey Meter. Check the battery indication of the Survey Meter which must be in the "OK" range. Let the Survey Meter warm up for at least 5 minutes for stabilization of the electronic circuitry. Turn the selector switch to the "x 100" range.

d. Using the Inverse Square Law, determine the distance at which the radiation intensity is 800 mR/hr. Place the Survey Meter at this distance.

e. Unlock the handle of the Calibration Unit and lift the source rod to the upper limit. Read the Survey Meter. If necessary, adjust the Meter until the reading is within +/-10% of the actual radiation intensity.

f. Place the 0.25 attenuator in the radiation beam. The actual radiation intensity is now 200 mR/hr. Repeat step e.
If it was necessary to adjust the Meter in order to obtain a reading of 200 mR/hr +/ -10%, a reading at the 800 mR/hr intensity shall again be taken.

g. Place the 0.10 attenuator closest to the projector housing in the radiation beam, then remove the 0.25 attenuator from the beam. The actual radiation intensity at the location of the Survey Meter is now 80mR/hr. Without moving the Survey Meter, turn the selector switch to the " x 10" range. Repeat step e.

h. In addition to the 0.10 attenuator, place the 0.25 attenuator in the radiation beam. The actual radiation intensity at the Survey Meter is now 20mR/hr. Repeat step e.
If it was necessary to adjust the Meter in order to obtain a reading of 20mR/hr +/ -10%, a reading at the 80 mR/hr intensity shall again be taken.

i. Place the second 0.10 attenuator in the radiation beam and remove the 0.25 attenuator. The actual radiation intensity at the location of the Survey Meter is now 8 mR/hr. Turn the selector switch to the "x1" range. Repeat step e.

j. In addition to the two 0.10 attenuators, place the 0.25 attenuator in the radiation beam. The actual radiation intensity at the location of the Survey Meter is now 2 mR/hr.
Repeat step e.
If it was necessary to adjust the Survey Meter in order to obtain a reading of 2 mR/hr +/-10%, a reading at the 8 mR/hr intensity shall again be taken.

k. Continue above steps, until all Survey Meters are calibrated. Lower the source rod and lock the handle of the Calibration Unit. Survey the Calibration Unit and return it to the vault.

l. Lock the vault and survey the area. Return keys to the X-Ray Office.

m. Complete the calibration labels by adding the date of calibration, next due date, and the technician's initial. Attach the calibration labels to the Survey Meters.
Survey Meters that fail to read within +/-10% of the actual radiation intensity are to be taken to Penn Ship's Electronic Shop for repair.

Pennsylvania Shipbuilding

STANDARD OPERATING PROCEDURE

FOR

THE SAFE OPERATION OF THE AUTOMATIC INDUSTRIES MODEL 43868

SOURCE CHANGER

1. The Automation Industries 43868 source changer may be used as a temporary storage container for radioactive sources, Technical Operations Model #866 or equal only while performing maintenance or repair on camera A. I. Model 520. It also can be used when it is necessary to transfer a radioactive source from one camera A.I. Model 520 to another. The following steps will be followed when using the source changer.

a. Check transfer tube for damage and cleanliness (Note: tube is open at both ends, check by looking though). Check crank assembly connector and if okay, remove dust plugs from camera and connect crank assembly to camera and transfer tube to both, camera and source changer. Crank source out of camera and into source changer as far as it will go. Survey the camera, the source tube and the source changer to insure that the source is properly positioned in the source changer. Disconnect tube at source changer. Disengage the source pigtail from the crank assembly cable. Fully retract control cable. Disconnect the control cable and the transfer tube from the camera. Lock camera and source changer.

b. To move the source back into the camera, survey the camera to insure that it is empty. Survey the source changer to insure that the isotope is properly positioned. Connect the control cable and the source tube to the camera. Crank out enough cable to connect the crank assembly cable to the source cable. Connect the source tube to source changer. Crank the source back into the camera. Survey the camera, source tube and source changer to insure that the source is properly positioned in the camera. Disconnect control cable and store.

STANDARD OPERATING PROCEDURE
FOR
THE SAFE OPERATION OF THE TECH/OPS MODEL TO-771
SOURCE CHANGER

The Tech/Ops Model TO-771 source changer - shipping container is designed for transferring encapsulated radioisotope sources into radiographic cameras, such as the Model No. TO-741. The following steps will be followed when using the source changer:

1. All personnel involved with the operation must wear monitoring devices, i.e. film badge and dosimeter.
2. Monitor all operations with a calibrated, operable survey meter.
3. Upon receipt of the source changer, survey the source changer to ensure that the source is in the proper storage position. State on the proper receiving record the maximum radiation intensity measured at all external surfaces and at 3 feet from all external surfaces (maximum permissible is 200 mR/hr and 10 mR/hr. respectively).
   This survey shall be performed within 3 hours if the source changer is received during normal working hours, or within 18 hours if received after normal working hours.
4. Locate the source changer and projector in a restricted area. Locate the devices so as to avoid sharp bends in the guide tube or control housing.
5. Set the projector as for an exposure.
6. Remove the cover plates from the source changer by breaking the seal wires and removing the bolts.
7. Connect one end of a guide tube extension to the projector and the other end to the fitting of the empty chamber in the source changer. Insure that the selector ring is in the unlock position.
8. At the projector controls, crank the source from the projector to the source changer.
9. Approach the projector with the survey meter. Survey the projector on all sides, survey the guide tube and survey the source changer on all sides to ensure the source has been properly transferred. The maximum radiation level at the source changer should be less than 200 milliroentgens per hour at contact.
10. Rotate the selector ring to the LOCK position and depress the plunger lock. Disconnect the guide tube from the source changer. Disconnect the drive cable from the source assembly by moving the lock pin down and sliding the drive cable connector out through the keyway.

11. Couple the drive cable to the new source by depressing the lock pin, sliding the drive cable connector into the keyway, and releasing the lock pin. Test for proper engagement. Connect the guide tube to the fitting chamber. Unlock the key operated plunger lock and rotate the selector ring to the UNLOCK position.
12. At the projector controls, crank the source from the source changer to its storage position in the projector.
13. Approach the projector with the survey meter. Survey the projector on all sides, survey the guide tube, and survey the source changer on all sides to ensure the source has been properly transferred.
14. Lock the projector.
15. Disconnect the source guide tube from the source changer.
16. Affix the identification plate of the new source to the projector and attach the identification plate of the old source to the source changer chamber in which the source has been installed.
17. Again insure that the old source is secured in the source changer, the selector ring is in the LOCK position and the key operated plunger lock is engaged.
18. Bolt the source changer cover plates in place and seal wire.
19. Survey all exterior surfaces of the source changer to ensure that the radiation level does not exceed 200 milliroentgens per hour at contact.
20. Measure the radiation level three feet from all exterior surfaces of the source changer and ensure that the radiation level is less than 10 milliroentgens per hour. The maximum radiation level measured three feet from any exterior surface is the Transport Index. (Example: With a maximum radiation level of 2.2 milliroentgens per hour, the Transport Index is 2.2).
21. Complete the appropriate "RADIOACTIVE" shipping labels. For contents, list the radioisotope contained, Cobalt 60. Indicate the activity as the number of Curies. Record the Transport Index determined above.
22. Apply the "RADIOACTIVE" shipping labels, properly completed, to two opposite sides of the container.
23. Return the container to Technical Operations, Inc.

For completion of Shipping Manifest, see paragraph 27 of page 12.

STANDARD OPERATING PROCEDURE FOR
THE SAFE OPERATION OF THE
TECH/OPS MODEL TO-650 SOURCE CHANGER

The Tech/Ops Model TO-650 Source Changer/Shipping Container is designed for transferring encapsulated radioistope sources into radiographic projectors, such as the Automation Industries Model No. 520. The following steps shall be followed:

1. All personnel involved with the operation must wear personal monitoring devices, i.e. film badge and dosimeter.
2. Monitor all operations with a calibrated, operable survey meter.
3. Upon receipt of the source changer, survey the source changer to ensure that the source is in the proper storage position. State on the receiving record the maximum radiation intensity measured at all external surfaces and at 3 feet from external surfaces (maximum permissible is 200 mR/hr and 10 mR/hr, respectively). This survey shall be performed within 3 hours if the source changer is received during normal working hours, or within 18 hours if received after normal working hours.
4. Place the source changer and the projector in the radiographic enclosure in the southeast corner of the Pipe Shop. Locate the devices so as to avoid sharp bends in the guide tube or control cable housing.
5. Set the projector as for an exposure.
6. Remove the cover from the source changer by breaking the seal wire and removing the bolts.
7. Remove the source holddown cap by breaking the seal wire and unbolting.
8. Connect one end of a guide tube extension to the projector and the other end to the fitting above the empty chamber in the source changer.
9. Close and latch the source guides.
10. At the projector control, crank the source from the projector to the source changer.
11. Approach the projector with the survey meter. Survey the projector on all sides, survey the guide tube, and survey the source changer on all sides to ensure the source has been properly transferred. The maximum radiation level at the source changer should be less than 200 milliroentgens per hour at contact.

12. Open the source guides. Disconnect the drive cable from the source assembly by moving the lock pin down and sliding the drive cable connector out through the keyway.

13. Disconnect the guide tube from the source changer. Connect the guide tube to the fitting above the chamber containing the new source.

14. Couple the drive cable to the source by depressing the lock pin, sliding the drive cable connector into the keyway, and releasing the lock pin. Test for proper engagement.

15. Close and latch the source guides.

16. At the projector control, crank the source from the source changer to its storage position in the projector.

17. Approach the projector with the survey meter. Survey the projector on all sides, survey the guide tube, and survey the source changer on all sides to ensure the source has been properly transferred.

18. Lock the projector.

19. Disconnect the source guide tube from the source changer.

20. Affix the identification plate of the new source to the projector and attach the identification plate of the old source to the source holddown cap of the source changer.

21. Bolt the source holddown cap in place and seal wire.

22. Bolt the source changer cover in place and seal wire.

23. Survey all exterior surfaces of the source changer to ensure that the radiation level does not exceed 200 mR/hr at contact.

24. Measure the radiation level three feet from all exterior surfaces of the source changer and ensure that the radiation level is less than 10 mR/hr. The maximum radiation level measured three feet from any exterior surface is the Transport Index (Example: with a maximum radiation level of 2.2 mR/hr, the Transport Index is 2.2).

25. Complete the appropriate "RADIOACTIVE" shipping labels (two required). For contents, list the radioisotope contained, i.e. IRIDIUM 192. Indicate the activity of the source as the number of Curies. Record the Transport Index as determined above.

26. Apply the "RADIOACTIVE" shipping labels, properly completed, to two opposite sides of the container.

27. Properly complete the shipping papers and return the container "shipping prepaid" to Technical Operations, Inc.

The shipping papers must include the following information:

a. Contents

b. Name of Radionuclide

c. Physical form

d. Activity of the source

e. Category of label

f. Transport Index

g. USNRC Identification No.

h. Shippers Certification:

"This is to certify that the above named material is properly classified, described, packaged, marked and labeled and is in proper condition for transport according to the applicable regulations of the Department of Transportation."

STANDARD OPERATING INSTRUCTIONS

FOR

RADIATION ACCIDENTS

In case of any accident involving radiation the following steps will be taken. (Any time an isotope can not be returned to the safe position in the camera, it shall be treated as an accident).

1. Survey the Area and rope-off the area at the point where radiation is 2 MR/HR or less.

2. Get assistance to guard the area (any Penn Ship employees may be used for guards).

3. If possible, shield isotope as much as practical without exceeding 150 mREm exposure as indicated by your dosimeter.

4. Notify the Radiation Safety Officer immediately:

   F. Noll - Radiation Safety officer
   Home (302) 737-8334
   Work Extension 3063

5. Do not attempt to recover any radioactive material without the assistance of the Radiation Safety Officer present.

6. The Radiation Safety Officer shall report the incidents as listed below to the following address:

   U.S. Nuclear Regulatory Commission
   Office of Inspection and Enforcement
   631 Park Avenue
   King of Prussia, Pa 19406
   Tel: (215) 337-5000

6.1 Immediate Notification

NRC shall be notified immediately by telephone and teletype of any incident which may have caused or threatens to cause exposure of the whole body of any individual to 25 Rems or more of radiation; exposure of the skin of the whole body of any individual of 150 Rems or more of radiation; or exposure of extremities (feet, ankles, hands, or forearms) of any individual to 375 Rems or more of radiation.

6.2 Twenty-four Hour Notification

NRC shall be notified within 24 hours by telephone and teletype of any incident which may have caused or threatens to cause exposure of the whole body of any individual to 5 Rems or more of radiation; exposure of the skin of the whole body of any individual to 30 Rems or more of radiation; or exposure of the extremities (feet, ankles, hands or forearms) of any individual to 75 REms or more of radiation.

6.3 Thirty Day Notification

NRC shall be notified within 30 days of any incident which may have caused or threatens to cause exposure for any individual in excess of the following:

1.25 Rems per calender quarter to the whole body
7.50 Rems per calender quarter to the skin of the whole body
18.75 Rems per calender quarter to extremeties, i.e. feet, ankles, hands and forearms

Penn Ship may permit an individual in a restricted area to receive a total occupational dose to the whole body greater than listed above, provided the total occupational dose to the whole body does not exceed 3 Rems per calender quarter, and the excessive dose added to the accumulated occupational lifetime dose to the whole body does not exceed 5 (N-18).

7. Radiographic operations shall be conducted in a manner such that no individual in an unrestricted area will receive more than the following:

2 millirems in any one hour to the whole body
100 millirems per week to the whole body
500 millirems per year to the whole body

STANDARD OPERATING INSTRUCTION

FOR

RECOVERY OF RADIOACTIVE SOURCES

1. After receiving notification of an accident involving a radioactive source, the Radiation Safety Officer will:

    a. Obtain and record all of the facts concerning the accident and will observe the area to insure that all warnings and safeguards are properly positioned and are adequate.

    b. Calculate the radiation and time factors for personnel that would be involved in making a recovery.

    c. Make a decision as to whether or not to attempt the recovery or to call in outside help.

2. If recovery is to be attempted, the Radiation Safety Officer will:

    a. Insure that all personnel involved in the recovery, have current Film Badges, Dosimeter, and an adequate number of currently calibrated Survey Meters.

    b. Use lead sheets, available in the permanent facility, to shield the isotope as much as possible.

    c. Use other shielding material as much as possible, to lower radiation exposure to personnel involved in recovery.

    d. Use poles and manipulators deviced for special needs. Practice with these tools and rehearse the recovery operation outside of the radiation area.

    e. Estimate the time limit for each man and for each operation to be performed.

    f. Proceed with planned recovery.

3. Notify the Nuclear Regulatory Commission Regional Office of the accident if radiation in excess of the allowable limits of 10 CFR 20 has occurred.

STANDARD OPERATING PROCEDURE FOR PERSONNEL MONITORING

A. Personnel performing or assisting in any radiography are wearing at all times:

(1) Pocket Dosimeter
(2) Current Film Badge

The pocket dosimeter and Film Badge are contained in a pouch and worn on a belt.

B. Personnel engaged in Radiography will have in their possession at all times while on the job an operable Survey Meter that has a current Calibration Tag attached.

C. At the start of each shift all personnel will zero their Pocket Dosimeter as follows:

(1) Insert Dosimeter into Calibration Unit

(2) Turn knob of calibration Unit until a zero is obtained on the dosimeter.

(3) Dosimeters that cannot be set to zero shall be turned into the X-Ray Office for disposition.

D. Dosimeters will be checked for readings at least every hour while performing Radiography. A reading of 100 MR or higher is cause for an investigation as to the reason.

E. In case of a Dosimeter reading off scale; the Radiation Safety Officer shall be notified who will fully investigate the cause.

F. Radiographers and Assistant Radiographers will log the reading of their Dosimeter on the Radiographers Report at the completion of each job.

G. Each dosimeter shall be checked at least once every year. The dosimeter is to be placed in a known radiation field. The reading must be within plus or minus 30 percent of the calculated value.

H. Survey Meters shall be used as outlined in Section I on "Safe Handling of Radioactive Material."

I. Survey Meters are delicate instruments and must be handled with great care In case of inclimate weather they should be wrapped in a piece of clear plastic as that will not hinder the operation of the Unit and will keep them dry.

STANDARD OPERATING PROCEDURE

FOR

MAINTENANCE OF RECORDS

The following records shall be maintained in the X-Ray Office by the Radiation Safety Officer:

(1) Records of Instrument Calibration.

(2) Records of Leak Test Results.

(3) Quarterly Inventory Reports.

(4) Equipment Utilization Record (on Radiographers Report)

(5) Radiation Surveys for every Radiographic set-up (on Radiographers Report).

(6) Daily Dosimeter Reading Record Log.

(7) Film Badge Reports.

(8) Receipts of Radioactive Materials.

(9) Certificates for Source Disposal.

STANDARD OPERATING PROCEDURE
FOR
DAILY INSPECTION OF RADIOGRAPHIC EQUIPMENT

A. Daily Inspect Projectors for:

1. Any impairment of locking mechanism.
2. Any physical damage to the device which may impair its operation.
3. Any dirt or sludge build-up at the two female threads and within the device.
4. Any damage to the source connector or cable.
5. Dust plugs in place.
6. Any abnormal radiation emanating from projector.

B. Daily Inspect Source Positioner and Indicators for:

1. Any physical damage to the handle and indicator assembly which may impair its operation.
2. Any physical damage to cable conduit which may prevent free movement of cable.
3. Proper operation of crank and indicator mechanism.
4. Any physical damage to connector or drive cable.
5. Any physical damage to male threads on conduit end fitting.
6. Any dirt of sludge build-up on the cable that may impair its operation.
7. Any wear of connector.
8. Any change in shape of connector.

C. Daily Inspect Source Tubes for:

1. Any physical damage that may prevent free movement of source through tube.
2. Any physical damage to fitting or end cap.
3. Any dirt or sludge build-up that may affect free movement of source through tube.

D. Daily inspection must be performed prior to use of the exposure device and attachments on each day the device is used.

E. Record the condition of the equipment used on the Radiographer's Report in the appropriate space. Any faulty equipment shall be tagged and reported to the Radiation Safety Officer.

STANDARD OPERATING PROCEDURE

FOR

QUARTERLY INSPECTION AND MAINTENANCE

OF RADIOGRAPHIC EQUIPMENT

Inspection of all radiographic equipment shall be performed under the direct supervision of the Radiation Safety Officer or Manager of Quality Assurance at intervals not to exceed 3 months as follows (see also Attachment No. 6):

1. Remove all radiographic cameras from the vault area and place in the permanent radiographic facility.

2. Layout all control devices.

3. Layout all source tubes.

4. Check for accountability of all of the above and notify the Radiation Safety Officer if any handling equipment is missing.

5. Inspect cameras for the following:

   a. Serial Number of isotope, secure and in place.

   b. Exterior for visible damage.

   c. Plug for damage to threads and ease of operation.

   d. Lock for ease of operation and lubricate as necessary.

6. Inspect crank assemblies as follows:

   a. Check crank for ease of operation. If difficult to operate, disassemble and lubricate. If lubrication does not correct the problem, tag and remove from service and turn into maintenance for repair or replacement.

   b. Extend the control cables and examine it for kinks, rust, and lubrication.

7. Inspect all source tubes as follows:

   a. Layout all source tubes and inspect.

   b. Inspect entire length of tube for kink, dents, and frayed ends.

   c. Extend a control cable and run through all source tubes to check for any blockage.

   d. Inspect threads for damage.

   e. Tag and remove any defective source tube from service and turn into maintenance for repair or rep'acement.

TRAINING PROGRAM

TO TRAIN INEXPERIENCED PERSONNEL

TO BE ASSISTANT RADIOGRAPHERS

TRAINING PROGRAM FOR TRAINING INEXPERIENCED PERSONNEL TO BECOME ASSISTANT RADIOGRAPHERS

The training of inexperienced personnel to become Assistant Radiographers will primarily be done by the coach and pupil method and on the job training. It will include two days of classroom training conducted by the Radiation Safety Officer, see page 3 of attachment #5 for the course outline.

The trainee will be issued a copy of Penn Ship's Standard Operating Instructions. Moreover, he will have access to the Quality Assurance Library on the General Dynamics Programmed Instruction Handbook on Radiographic Testing. After a minimum work experience of three months as a trainee, he will be required to take the Level I examination for Radiography and the Assistant Radiographers Safety Test, see pages 4 through 18. The minimum required passing grades are 80% and 75%, respectively.

Upon satisfactory completion of the "NDT Level I Radiographer's Examination" and the "Assistant Radiographer's Safety Test", he may be assigned duties as an Assistant Radiographer (A.S.N.T. Level I).

TRAINING FOR ASSISTANT RADIOGRAPHERS

1. Personnel hired by the company to work in the Radiography Department will be given sixteen (16) hours of instruction and orientation as follows:

Day 1

7:00 - 10:00	Lecture on Radiation Hazards a. Health hazards of Radiation b. Responsibility to self and others c. Radiation measuring equipment available
10:00 - 11:00	Demonstration of Equipment used. a. Film badge b. Dosimeters c. Survey meters
11:00 - 1:30	Pennsylvania Shipbuilding Company Standard Operating Instructions issued and explained.
1:30 - 3:30	Federal Regulation Requirements

Day 2

7:00 - 9:00	Familiarization with operation of the permanent Radiographic facility.
9:00 -11:30	Familiarization with other Radiographic Operatio within the Ship Yard.
12:00 - 2:30	Level I Examination for Radiography
2:30 - 3:30	Assistant Radiographer's Safety Test.

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

NAME: ______________________ DATE: ______________________

GRADE: ______________________

1. In film radiography, penetrameters are usually placed:

   a. between the intensifying screen and the film.

   b. on the source side of the test object.

   c. on the film side of the test object.

   d. between the operator and the radiation source.

2. Cobalt 60 used in nondestructive testing emit:

   a. alpha particles
   c. gamma rays

   b. neutrons
   d. X-rays

3. Three liquids which are essential to process an exposed film properly are:

   a. stop bath, acetic acid, and water.

   b. developer, stop bath, and H_2O_2.

   c. developer, fixer and water.

   d. acetic acid, fixer, and stop bath.

4. The two most common caused for excessively high density radiographs are:

   a. insufficient washing and overdevelopment.

   b. contaminated fixer and insufficient washing.

   c. overexposure and contaminated fixer.

   d. overexposure and overdevelopment.

5. The time required for one half of the atoms in a particular sample of radioactive material to disintegrate is called:

   a. the inverse square law.
   c. a half life.

   b. a cur'e.
   d. the exposure time.

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

6. The ability to detect a small discontinuity or flaw is called:

   a. radiographic contrast
   b. radiographic sensitivity
   c. radiographic density.
   d. radiographic resolution.

7. Movement, geometry, and screen contact are three factors that affect radiographic:

   a. contrast.
   b. unsharpness.
   c. reticulation.
   d. density.

8. The most widely used unit of measurement for measuring the rate at which the output of a gamma ray source decreases is the:

   a. curie
   b. roentgen
   c. half life
   d. MEV

9. Small amounts of exposure to X-rays or gamma rays:

   a. will have a cumulative effect which must be considered when monitoring for maximum permissible dose.
   b. will be beneficial since they build up an immunity to radiation poisoning.
   c. will have no effect on human beings.
   d. will have only a short-term effect on human tissues.

10. A dose of ________ would be dangerous, if not fatal, if applied to the entire body in a short period of time.

   a. 1.5 to 15 r
   b. 25 to 70 r
   c. 200 to 800 r
   d. all of the above doses would most likely be fatal.

11. When doing gamma ray radiography with high-intensity emitters, the sources are best handled:

   a. directly by personnel equipped with special protective clothing.
   b. by remote handling equipment which permits the operator to remain several yards away at all times.
   c. directly by personnel with special protective clothing except when radiographs are being made.
   d. by the same methods used for low-intensity emitters.

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

12. When radiographing a part which contains a large crack, the crack will appear on the screen as a:

    a. dark, intermittent or continuous line.

    b. light irregular line.

    c. either a dark or light line.

    d. fogged area on the radiograph.

13. X-ray tube current is controlled by:

    a. the current passing through the filament.

    b. the distance from the cathode to the anode.

    c. the type of material used in the target.

    d. the voltage and waveform applied to the X-ray tube.

14. Radiographic sensitivity, in the context of defining the minimum flaw, depends on:

    a. graininess of the film.

    b. the unsharpness of the flaw image in the film.

    c. the contrast of the flaw image on the film.

    d. all three of the above.

15. As the kilovoltage applied to the X-ray tube is raised:

    a. X-rays of longer wavelength and more penetrating power are produced.

    b. X-rays of shorter wavelength and more penetrating power are produced.

    c. X-rays of shorter wavelength and less penetrating power are produced.

    d. X-rays of longer wavelength and less penetrating power are produced.

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

16. Primary radiation which strikes a film holder or cassette through a thin portion of the specimen will cause scattering into the shadows of the adjacent thicker portions producing an effect called:

 a. radiation imaging. c. undercut.

 b. spotting. d. unsharpness.

17. Which of the following materials is suitable for use in vessels or pails used to mix processing solutions?

 a. stainless steel c. galvanized iron

 b. aluminum d. tin.

18. As a check on the adequacy of the radiographic technique, it is customary to place a standard test piece on the source side of the specimen. This standard test piece is called a:

 a. reference plate c. penetrameter

 b. lead screen d. illuminator

19. The duration of an exposure is usually controlled by:

 a. controlling the milliamperage.

 b. a timer.

 c. controlling the source-to-film distance.

 d. a choke coil in the filament transformer.

20. The three main steps in processing a radiograph are:

 a. developing, frilling, and fixation.

 b. developing, fixation, and washing.

 c. exposure, developing, and fixation.

 d. developing, reticulating, and fixation.

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

21. Lead foil screens are used in radiography:

    a. to improve the quality of the radiograph by preferentially reducing the effect of scatter radiation.

    b. to reduce the exposure time.

    c. both a and b are reasons for using lead foil screens.

    d. neither a or b are reasons for using lead foil screens.

22. To prevent back scatter from reaching an X-ray film, it is customary to:

    a. back the exposure holder with a thick sheet of lead.

    b. place a mask between the specimen and the front surface of the film.

    c. back the exposure holder with a thick layer of cardboard.

    d. place a filter near the X-ray tube.

23. The purpose of agitating an X-ray film during development is to:

    a. protect the film from excessive pressure.

    b. renew the developer at the surface of the film.

    c. disperse unexposed silver grains on the film surface.

    d. prevent reticulation.

24. When manually processing films, the purpose for sharply tapping hangers two or three times after the films have been lowered into the developer is to:

    a. disperse unexposed silver grains on the film surface.

    b. prevent frilling.

    c. dislodge any air bubbles clinging to the emulsion.

    d. all of the above.

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

25. The activity of the developer solution is maintained stable by:

a. constant agitation.

b. maintaining processing solutions within the recommended temperature range.

c. avoiding contamination from the wash bath.

d. addition of replenisher.

26. The purpose of fixation is:

a. to remove all the undeveloped silver salts of the emulsion.

b. to fix the developed silver as a permanent image.

c. to harden the gelatin.

d. all of the above.

27. For best results when manually processing film, solutions should be maintained within a temperature range of:

a. 65°F and 75°F

b. 65°C and 75°C

c. 75°F and 85°F

d. 75°C and 85°C

28. Water spots on films can be minimized by:

a. rapid drying of wet film.

b. immersing wet film for 1 or 2 minutes in a wetting agent solution.

c. by using a fresh fixer solution.

d. by cascading water during the rinse cycle.

29. A photographic record produced by the passage of X- or gamma rays through a specimen onto a film is called a:

a. fluoroscopic image

b. radiograph

c. isotopic reproduction

d. none of the above

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

30. In order to achieve uniformity of development over th. area of an X-ray film during manual processing:

a. the film should be placed in a dryer after being developed.

b. The developer should be agitated by means of mechanical stirrers or circulating pumps.

c. the film should be agitated while in the developer.

d. the film should be transferred directly from the developer to the fixer.

31. When referring to a "1T, 2T, or 4T" hole in the ASME Boiler Code, ASTM, or armed forces penetrameter, the T refers to:

a. the part thickness
b. the penetrameter thickness
c. the time of exposure
d. the time for developing

32. The density difference between two selected portions of a radiograph is known as:

a. unsharpness
b. radiographic contrast
c. specific activity
d. subject density

33. The intensity of X-radiation is measured in:

a. roentgens
b. ergs.
c. roentgens per unit of time.
d. H & D units.

34. When producing radiographs, if the kilovoltage is increased:

a. the subject contrast decreases.

b. the film contrast decreases.

c. the subject contrast increases.

d. the film contras reases.

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART I

35. The accidental movement of the specimen or film during exposure or the use of a focus-film distance that is too small will:

    a. produce a radiograph with poor contrast.

    b. make it impossible to detect large discontinuities.

    c. result in unsharpness of the radiograph.

    d. result in a fogged radiograph.

36. A properly exposed radiograph that is developed in a developer solution at a temperature of 58°F. will be:

    a. overdeveloped.

    b. underdeveloped.

    c. fogged.

    d. damaged by frilling.

37. A good radiograph is obtained using a milliamperage of 15 ma and an exposure time of 1/2 minute. What exposure time will be necessary to produce an equivalent radiograph is the milliamperage is changed to 5 ma and all other conditions remain the same?

    a. 4-1/2 minutes.

    b. 1-1/2 minutes.

    c. 3 minutes.

    d. 1/6 minute.

38. Lead screens in contact with the film during exposure:

    a. increase the photographic action on the film largely by reason of the electron emission and partly by the secondary X-rays generated in the lead.

    b. absorb the shorter wavelength scattered radiation more than the long wavelength primary radiation.

    c. intensify the photographic effect of the scatter radiation more than that of the primary radiation.

    d. none of the above.

39. The sharpness of the outline in the image of the radiograph is a measure of:

    a. subject contrast.

    b. radiographic definition.

    c. radiographic contrast.

    d. film contrast.

40. An unshielded isotope source gives a dosage rate of 900 mr. per hr. at 10 feet. What would the unshielded dosage rate be at 30 feet?

    a. 300 mr/hr.

    b. 600 mr/hr.

    c. 100 mr/hr.

    d. 2700 mr/hr.

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL I - RADIOGRAPHIC TESTING

PART 2

Name: ____________________

Grade: ____________________ Date: ____________________

ANSWER QUESTIONS 'TRUE' OR 'FALSE'

1. It is not necessary to create rope barriers for a radiation are when there are no personnel working in the surrounding area. F

2. The sharpness of the outline in the image of the radiograph is a measure of the subject contrast. F

3. Agitating film during manual processing achieves uniformity of development over the area of an X-ray. T

4. A cobalt-60 capsule will have a half life of 5.3 years. T

5. Upon completing an X-ray exposure and turning the equipment off, personnel may enter the exposure area without fear of radiation exposure. T

6. White 'crescent-shaped' marks on an exposed radiograph are most likely caused by crimping film before exposure. T

7. Water spots on films can be minimized by immersing wet film for one (1) minute in a wetting agent solution. T

8. A curie is the equivalent of .001 millicuries. F

9. The technique variable that is most commonly used to adjust subject contrast is source to film distance. F

10. Shim stock is used when the thickness of the parent material exceeds one-half ($\frac{1}{2}$) inch. F

11. When making an exposure, the plane of maximum interest should be parallel to the film as far as the shape of the specimen will allow. T

Attachment No. 5

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL 1 - RADIOGRAPHIC TESTING

PART 2

12. The penetrating ability of an X-ray beam is governed by milliamperage. F

13. When speaking of intensity, the term 'R/h' refers to Roentgens per hour. T

14. In order to decrease geometric unsharpness the film should be as far as possible from the object being radiographed. F

15. The penetrameter is used to measure the size of discontinuities in a part. F

16. The most common material used to provide protection against X-rays is lead. T

17. The normal development time for manually processing radiographs is 3 to 8 minutes in processing solutions at 60°F. F

18. Lead screens in direct contact with X-ray film intensifies the primary radiation more than the scatter radiation. T

19. A sheet of lead with an opening cut in the shape of the part to be radiographed may be used to decrease the effect of scattered radiation which undercuts the speciment. Such a device is called a mask. T

20. Two X-ray machines operating at the same nominal kilovoltage and milliamperage settings may give not only different intensities, but also different qualities of radiation. T

PENNSYLVANIA SHIPBUILDING COMPANY

NDT LEVEL 1

PRACTICAL RADIOGRAPHIC TEST

Name:____________________ Date:______________

Grade:________________

1. Loaded film cassette properly ______________
2. Properly placed location markers. ______________
3. Selected correct penetrameter(s) ______________
4. Properly placed penetrameter(s) ______________
5. Affixed all required information ______________
6. Selected correct shim(s) ______________
7. Properly placed cassette ______________
8. Aligned radiation source for proper beam direction ______________
9. Selected and measured for proper FFD. ______________
10. Determined and selected proper source activity ______________
11. Selected correct time for exposure ______________
12. Used proper film processing techniques ______________
13. If needed, properly adjusted exposure time for correct density ______________

TYPICAL TEST

PRIOR TO ASSIGNMENT AS

ASSISTANT RADIOGRAPHER

ASSISTANT RADIOGRAPHERS SAFETY TEST

1. Radiation can cause:

   a. Death
   b. Sterility
   c. Deformities
   d. All of the above

2. Doubling the distance from a radioactive source will reduce radiation:

   a. 2 times
   b. 1/2 times
   c. 1/4 times
   d. 4 times

3. As an assistant radiographer you may:

   a. Handle the source and perform direct radiographic inspection
   b. Handle the equipment under the supervision of a Radiographer
   c. Perform leak checks
   d. Perform radiography after you have been checked out

4. Your dosimeter will register

   a. How much radiation you have received
   b. The rate of radiation you are receiving
   c. How much radiation is being emitted from the source
   d. All of the above

5. If your film badge is lost you should:

   a. Get a blood test immediately
   b. Get a new one from someone
   c. Borrow one that is not being used
   d. Report it to your supervisor immediately

6. If after setting your dosimeter to zero you find it off scale two hours later and cannot read it, you should:

   a. Continue to work
   b. Report it to your supervisor immediately
   c. Borrow one and continue to work
   d. Re-set it to zero and continue to work

7. The only way to determine that an isotope is properly stored in a camera is to survey the camera and source tube with a:

    a. Film badge
    b. Dosimeter
    c. Survey meter
    d. All of the above

8. A survey meter will tell you:

    a. The radiation rate per hour
    b. The radiation rate per minute
    c. The dose of radiation received
    d. All of the above.

9. Survey meters are calibrated every:

    a. month
    b. 2 months
    c. 3 months
    d. 4 months

10. In accordance with Pennsylvania Shipbuilding Company's Standard Operating Procedure you must rope-off the Radiographic area at:

    a. The 2.5 milliroentgens per hour line
    b. The 1 milliroentgens per hour line
    c. A distance so that no one can receive radiation exposure in excess of 2 mRem in any one hour.
    d. The 5 milliroentgens per hour line.

11. In an unrestricted area (outside of the roped-off area) radiation must be at a level so no person can receive more than:

    a. 2 millirem in any one hour
    b. 100 millirem per week
    c. 500 millirem per year.
    d. None of the above.
    e. All of the above.

12. To post the "Caution - High Radiation" warning signs, you must:

    a. Use a survey meter to find the 100 MR/HR isodose line
    b. Post them 10 feet from the source
    c. Calculate the distance
    d. Post them next to the source

13. You are required to check your dosimeter every ________ while performing radiography:

    a. Hour
    b. 2 Hours
    c. 4 Hours
    d. 8 Hours

14. You must enter your dosimeter reading on the Radiographers Report:

    a. At the completion of a job
    b. At the end of the day
    c. Either a. or b., whichever comes first
    d. None of the above

15. Radiographers are permitted _______ Rem per year of radiation

    a. 5
    b. 10
    c. 15
    d. 20

16. When working with a Radiographer performing radiographic inspection you must have with you your personal:

    a. Survey meter and a film badge
    b. Film badge and a dosimeter
    c. Survey meter and a dosimeter
    d. Flash light and a dosimeter

17. A number of curies of a radioactive source is:

    a. The physical size of the isotope
    b. The number of parts that make up an isotope
    c. The weight of the isotope
    d. The activity of the isotope

18. You may independently perform radiographic inspection as an Assistant Radiographer:

    a. As long as the Radiographers sets you up and checks on you from time to time
    b. After the Radiation Safety Officer or Assistant Radiation Safety Officer checks you out on the job
    c. After you have taken the Radiation Safety test
    d. None of the above

License No. 37-21067-01

Attachment No. 5

PENNSYLVANIA SHIPBUILDING COMPANY

19. The Standard Operating Instructions:

    a. Are to be used as a guide
    b. Are for the information of higher authorities
    c. Must be adhered to at all times
    d. None of the above

20. It is to your benefit to:

    a. Keep track of your exposure record
    b. Know the NRC limits of exposure
    c. Avoid all unnecessary exposure
    d. All of the above

TRAINING OF ASSISTANT RADIOGRAPHERS

TO BECOME RADIOGRAPHERS

TRAINING PROGRAM FOR TRAINING ASSISTANT RADIOGRAPHERS TO BECOME RADIOGRAPHERS

Assistant Radiographers will be given 40 hours of formal classroom instruction in radiation safety, see pages 32 and 33 of attachment #5, and will be given the General Dynamics Programmed Instruction Course to complete during his time spent as an Assistant Radiographer which will be at least but not limited to 9 months duration.

Upon completion of at least 9 months on the job training as an assistant radiographer, the candidate will be given the radiographic test, pages 21 through 30 of attachment #5 requiring a score of 80% and the practical radiographic test, page 31 of attachment #5 requiring a score of 85% with the provision that questions 1 through 5 of the practical radiographic test will have to be answered correctly. The radiation safety test, pages 34 through 50 of attachment #5 will require a score of 75% for a passing grade.

After satisfactory performance of the above, the candidate may be assigned duties as a radiographer.

PART I

Name: ______________________

Grade: ______________________ Date: ______________________

1. If it was necessary to radiograph a 7" thick steel product, which of the following gamma-ray sources would most likely be used?

   a. Cobalt-60
   b. Thulium-170
   c. Iridium-192
   d. Cesium-137

2. A cobalt-60 gamma-ray source has an approximate practical thickness limit of:

   a. 2-1/2 inches of steel or its equivalent.
   b. 4 inches of steel or its equivalent.
   c. 7-1/2 inches of steel or its equivalent.
   d. 11 inches of steel or its equivalent.

3. The absorption of gamma-rays from a given source when passing through matter depends on:

   a. The atomic number, density, and thickness of the matter.
   b. The Young's modulus value of the matter.
   c. The Poisson's ratio value of the matter.
   d. The specific activity value of the source.

4. Cobalt-60 is reported to have a half life of 5.3 years. By how much should exposure time be increased (over that used initially to produce excellent radiographs when the cobalt-60 source was new) when the source is two years old?

   a. No change in exposure time is needed.
   b. Exposure time should be about 11 per cent longer.
   c. Exposure time should be about 37 per cent longer.
   d. Exposure time should be from 62 to 100 per cent longer.

5. The focal spot in an X-ray tube:

   a. Is inclined at an angle of 30° from the normal to the tube axis.
   b. Is maintained at a high negative voltage during operations.
   c. Should be as large as possible to ensure a narrow beam of primary radiation.
   d. Should be as small as possible without unduly shortening the life of the tube.

6. The specific activity of an isotopic source is usually measured in:

   a. Mev (million-electron-volts)
   b. Ci/gm (curies per gram)
   c. R/hr (roentgens per hour)
   d. c/min (counts per minute)

7. The primary form of energy conversion when electrons strike a target in an X-ray tube results in the production of:

   a. Primary X-rays.
   b. Secondary X-rays.
   c. Short wavelength X-rays.
   d. Heat.

8. An X-ray film having wide latitude also has, by definition:

   a. Poor definition.
   b. Low contrast.
   c. High speed.
   d. None of the above.

9. The purpose for circulating oil in some types of X-ray tubes is:

   a. To lubricate moving parts.
   b. To absorb secondary radiation.
   c. To decrease the need for high current.
   d. To dissipate heat.

10. An X-ray tube with a small focal-spot is considered better than one with a large focal-spot when it is desired to obtain:

   a. Greater penetrating power.
   b. Better definition.
   c. Less contrast.
   d. Greater film density.

11. Thin sheets of lead foil in intimate contact with X-ray film during exposure increase film density because:

   a. They fluoresce and emit visible light which helps expose the film.
   b. They absorb the scattered radiation.
   c. They prevent back-scattered radiation from fogging the film.
   d. They emit electrons when exposed to X- and gamma-radiation which help darken the film.

12. X-ray tubes are often enclosed in a shockproof casing in order to:

   a. Dissipate heat.
   b. Protect the operator from high voltage shock.
   c. Shield the tube from secondary radiation.
   d. Increase the efficiency of the rectifier.

13. In X-ray radiography, alternating current must be changed to pulsating direct current in order to satisfy the need for unidirectional current. This change may be accomplished by:

    a. Transformers
    b. Rectifiers
    c. Anodes
    d. Cathodes

14. When radiographing to the 2-2T quality level, an ASTM penetrameter for 2.5 inch steel has a thickness of:

    a. One-half inch
    b. 2.5 mils
    c. 5 mils
    d. 50 mils

15. A good cobalt-60 shot is made on a 3" steel casting using an exposure time of 10 minutes and a source-to-film distance of 36 inches. If it is necessary to change the source-to-film distance to 24", what exposure time would produce a similar radiograph if all other conditions remain the same?

    a. 1.6 min.
    b. 4.4 min.
    c. 6.4 min.
    d. 8.8 min.

16. When sharp, black, bird-foot shaped marks which are known not to correspond with any discontinuities appear at random on radiographs, they are probably caused by:

    a. Prolonged development in old developer.
    b. Exposure of the film by natural cosmic ray showers during storage.
    c. Static charges caused by friction.
    d. Inadequate rinsing after fixing.

17. The adjustment of tube current in conventional X-ray tube circuits is made by:

    a. Adjusting the filament heating current.
    b. Adjusting the target-to-cathode distance.
    c. Inserting resistance in the anode lead.
    d. Opening the shutter on the X-ray tube port.

18. An ASTM penetrameter for use when inspecting a one-half inch thick steel plate to the 2-2T quality level using a 15-inch source-to-film distance would be made of:

    a. 5 mil thick aluminum.
    b. 50 mil thick aluminum or steel.
    c. 10 mil thick steel.
    d. 2 mil strip of any metallic material.

19. The kilovoltage applied to an X-ray tube affects:

a. The quality of the beam.
b. The intensity of the beam.
c. Both a and b.
d. Neither a or b.

20. Besides serving as a filter, screens of high atomic number, such as lead and lead antimony, also:

a. Decrease the source-to-film distance needed for a proper radiograph.
b. Provide some image intensifying action.
c. Permit the use of higher speed film.
d. Decrease the graininess in a radiograph.

21. The range of thickness over which densities are obtained that are satisfactory for interpretation is a measure of the:

a. Subject contrast of a radiograph.
b. Sensitivity of a radiograph.
c. Latitude of a radiograph.
d. Definition of a radiograph.

22. Almost all gamma radiography is performed with:

a. Natural isotopes.
b. Artificially produced isotopes.
c. Radium.
d. Thulium-170

23. The amount of unsharpness or blurring of a radiograph is:

a. Directly proportional to the object-to-film distance and inversely proportional to the size of the focal spot.
b. Directly proportional to the size of the focal spot and inversely proportional to the source-to-object distance.
c. Inversely proportional to the object-to-film distance and directly proportional to the source-to-object distance.
d. Inversely proportional to the size of the focal spot and the object-to-film distance.

24. Images of discontinuities close to the source side of the specimen become less clearly defined as:

a. Source-to-object distance increases.
b. The thickness of the specimen increases.
c. The size of the focal spot decreases.
d. The thickness of the specimen decreases.

25. X-ray films with large grain size:

a. Will produce radiographs with better definition than film with small grain size.

b. Have slower speeds than those with a relatively small grain size.

c. Have higher speeds than those with a relatively small grain size.

d. Will take longer to expose properly than film with relatively small grain size.

26. The specific activity of cobalt-60 depends on:

a. The time the material has been in the atomic pile.

b. The atomic number of the material.

c. The quality of the non-activated material.

d. The Young's Modulus value of the material.

27. The most commonly used target material in an X-ray tube is:

a. Copper

b. Carbon

c. Carbide

d. Tungsten

28. A device which is basically a combination of magnet and transformer designed to guide and accelerate electrons in a circular orbit to very high energies is called a:

a. Electrostatic belt generator.

b. Linear accelerator.

c. Betatron.

d. Toroidal electromagnetic-type X-ray tube.

29. A general rule governing the application of the geometric principles of shadow formation states that:

a. The X-rays should proceed from as large a focal spot as other considerations will allow.

b. The distance between the radiation source and the material examined should be as small as practical.

c. The film should be as far as possible from the object being radiographer.

d. The central ray should be as nearly perpendicular to the film as possible, to preserve spatial relationships.

30. The X-ray absorption of a specimen depends on:

a. The thickness and density of the material.

b. The atomic number of the material.

c. Both a and b.

d. Neither a or b.

31. The radiographic absorption of a material will tend to become less dependent upon the composition of the material when:

a. The kilovoltage is increased.
b. The source-to-film distance is decreased.
c. The kilovoltage is decreased.
d. A filter is used.

32. The formula $\frac{\text{milliamperes} \times \text{time}}{\text{distance}^2}$ is:

a. Used to calculate film gradient.
b. The reciprocity law.
c. Used to determine radiographic contrast.
d. The exposure factor.

33. X-ray exposure holders and cassettes often incorporate a sheet of lead foil in the back which is not in intimate contact with the film. The purpose of this sheet of lead foil is:

a. To act as an intensifying screen.
b. To protect the film from back scatter.
c. Both a and b.
d. Neither a or b.

34. The interval between the time a film is placed in a fixer solution and the time when the original diffuse, yellow milkiness disappears is known as:

a. Clearing time.
b. fixing time.
c. Hardening time.
d. Oxidation time.

35. Improper geometric factors, poor contact between film and lead-screen screens, and graininess of film are possible causes of:

a. High film density.
b. Poor definition.
c. Fogged film.
d. Low film density.

36. A radiograph is taken at a voltage of 500 kv. If the voltage is increased with a resultant increase in the energy of radiation while all other conditions remain the same:

a. The graininess of the film will increase significantly if a high speed film is used.
b. The graininess of the film will decrease significantly if a low-speed film is used.
c. The graininess of the film will increase significantly if a Class I film is used.
d. There will be little change in the graininess of the film.

37. The quantity of radiation striking a unit area of film:

a. Is the product of radiation intensity and time.

b. Is the intensity per unit of time.

c. Is directly proportional to intensity and inversely proportional to time.

d. Varies exponentially with time and directly with intensity.

38. Which of the following factors will not materially influence the image density of a radiograph?

a. The type of film used.

b. The size of the film.

c. The total amount of radiation emitted by the X-ray or gamma-ray source.

d. The intensifying action of the screen.

39. Because of geometrical factors such as source size, source-to-specimen distance and specimen-to-film distance, there can be a lack of perfect sharpness at the edges of indications. The unsharpness caused by geometrical factors may be referred to as the:

a. Astigmatic effect.

b. Penumbral shadow.

c. Focus variation.

d. None of the above.

40. The quantitative measure of film blackening is referred to as:

a. Definition.

b. Photographic density.

c. Film contrast.

d. Radiographic contrast.

NDT LEVEL II - RADIOGRAPHIC EXAMINATION

PART 2

NAME: ______________________ GRADE: ______________________

DATE: ______________________ EXAMINER: ______________________

1. The inverse square law is used to calculate:

   a. Source to film distance
   b. Radiation exposure.
   c. Radiation intensities
   d. Radiographic density

2. A source of Iridium 192, whose half-life is 75 days, provides an optimum exposure of a given test object today in a period of 20 minutes. Five months from now, what exposure time would be required for the same radiographic density, under similar exposure conditions?

   a. 10 minutes
   b. 20 minutes
   c. 1 hour 20 minutes
   d. 6 hours

3. One method of reducing radiographic contrast is to:

   a. increase the distance between the radiation source and the object.
   b. decrease the distance between the object and the film.
   c. decrease the wavelength of the radiation used.
   d. increase development time within manufacturer's recommendations.

4. In comparison with lower-voltage radiographs, high-energy radiographs show:

   a. greater contrast
   b. greater latitude
   c. greater amounts of scatter radiation relative to primary beam intensity.
   d. none of the above.

5. Filters placed between the X-ray tube and specimen tend to reduce scatter radiation undercutting the specimen:

   a. by absorbing the longer wavelength components of the primary beam.
   b. by absorbing the shorter wavelength components of the primary beam.
   c. by absorbing back-scatter radiation
   d. by decreasing the intensity of the beam

6. The isotopic sources of a given activity have two different specific activity values. The source with the higher specific activity value will:

   a. be of smaller physical size than the source with a lower specific activity.
   b. have a shorter half-life than the source with a lower specific activity
   c. produce harder gamma rays than the source with a lower specific activity
   d. be of larger physical size than the source with the lower specific activity.

7. A radiograph made with an exposure of 12 mA per minute has a density of 0.8 in the region of maximum interest. It is desired to increase the density to 2.0 in this area. By reference to a characteristic curve of the film, it is found that the difference in log E between a density of 0.8 and 2.0 is 0.76. The antilogarithm of log 0.76 is 5.8. What must the new exposure time be to produce a radiograph with a density of 2.0?

   a. 9.12 rmA per minute
   b. 21.12 mA per minute
   c. 69.6 mA per minute
   d. 16.0 mA per minute

8. Excessive subject contrast caused when the thickness range in the test specimen is too great for the radiation quality used may be corrected by:

   a. increasing the kilovoltage
   b. using a filter at the X-ray tube and increasing the exposure time.
   c. both a. and b. are methods for correcting excessive subject contrast.
   d. decrease the exposure time.

9. Two factors which greatly affect the suitability of the target material in an X-ray tube are:

   a. tensile strength and yield strength.
   b. melting point and magnetic strength
   c. electrical resistance and tensile strength
   d. atomic number and melting point.

10. The reason the expousre time must be increased by a factor of four when the source-to-film distance is doubled is:

   a. The intensity of radiation decreases at an exponential rate when the source-to-film distance is increase.
   b. The quality of radiation is inversely proportional to the square root of the distance from the source to the film.
   c. The intensity of radiation is inversely proportional to the square of the distance from the source to the film.
   d. The scattered radiation effect is greater as the source-to-film distance increases.

11. Which of the following techniques variables is most commonly used to adjust subject contrast:

   a. source-to-film distance
   b. milliamperage
   c. kilovoltage
   d. focal point size

12. Attenuation of gamma rays in the energy range commonly used for testing takes place through:

   a. photoelectric absorption
   b. compton absorption
   c. both a. and b.
   d. neither a. nor b.

13. Which of the following is not a factor in determining subject contrast:

    a. nature of the specimen.
    b. the radiation quality used
    c. the type of film used
    d. intensity and distribution of the scattered radiation.

14. If an exposure time of 60 seconds and a source-to-film distance of 4 feet is necessary for a particular exposure, what exposure time would be needed for an equivalent exposure if the source-to-film distance is changed to 5 feet?

    a. 75 seconds
    b. 94 seconds
    c. 48 seconds
    d. 38 seconds

15. Film selection for an X-ray exposure depends on:

    a. thickness of the part
    b. the material of the specimen
    c. the voltage range of the X-ray machine
    d. all of the above.

16. Lead screens are put in direct contact with the film to:

    a. increase the photographic action on the film
    b. absorb the longer wavelength scattered radiation
    c. intensify the photographic effect of the primary more than the scattered radiation.
    d. all of the above.

17. With respect to quality, what three factors must be considered in selecting a source-to-film distance.

    a. Source activity, type of film, type of screens
    b. source activity, size of film, thickness of material
    c. source size, source activity, specimen-to-film distance
    d. source size, specimen thickness, geometric unsharpness

18. The range of specimen thickness that can be adequately recorded on the radiograph is refered to as the:

    a. sensitivity of the radiograph
    b. latitude of the radiograph
    c. accuracy of the radiograph
    d. intensity of the source

19. Three liquids which are essential to process an exposed film properly are:

    a. stop both, acetic acid, and water
    b. developer, stop both, and H_2O_2
    c. developer, fixer and water
    d. acetic acid, fixer, and stop bath

20. For best results when manually processing film, solution should be maintained within a temperature range of:

    a. 65°F and 75°F
    b. 65°C and 75°C
    c. 75°F and 85°F
    d. 75°C and 85°C

PENNSYLVANIA SHIPBUILDING COMPANY

PRACTICAL RADIOGRAPHIC TEST

Name: ______________________ DATE: ______________________

Grade ______________________

1. Properly figured radiation area boundaries. __________
2. Properly posted "Radiation Area and High Radiation Caution" Signs around areas. __________
3. Had proper film badge in his possesion. __________
4. Had Dosimeter properly zeroed and on his person. __________
5. Made surveys of area and equipment as required. __________
6. Identified subject piece correctly. __________
7. Properly placed location markers __________
8. Selected correct penetrameter (s). __________
9. Properly placed penetrameter (s) __________
10. Affixed all required information __________
11. Selected correct shim (s) __________
12. Properly placed cassette. __________
13. Aligned radiation source for proper beam direction. __________
14. Selected and measured for proper source distance. __________
15. Calculated correct exposure time. __________
16. Follow proper processing techniques. __________

RADIATION SAFETY TRAINING OUTLINE

FOR ASSISTANT RADIOGRAPHERS TO BECOME RADIOGRAPHERS

Objective - To train employees to handle radioactive material in a manner that will prevent excessive radiation exposure to themselves and others.

Equipment - Victoreen Survey Meter - Ionization Chamber Type
Eberline and Ludlum Survey Meter - Geiger Tube type
Victoreen Dosimeter.
Automation Indust. Camera Model 520
Tech/Ops Camera Model 714
Tech/ops Calibr. Camera Model 773
Film Badges
Source Tube
Crank Assembly
Shielding Material (lead & steel)

References - General Dynamics, Programmed Instruction Handbook
Picker Handbook, Safe Handling of Radioisotopes in Industrial Radiography.

Subject Outline

Day 1 7:00 - 9:00 - Atoms

(a) Structure
(b) Atomic - Mass number
(c) Ionization

9:00 - 11:30
12:00 - 13:30 - Radiation

(a) Alpha - Beta - Gamma Radiation
(b) Secondary or Scatter Radiation
(c) Energies of Radiation
(d) Curie
(e) Half Life

13:30 - 14:00 - iz #1

14:00 - 15:30 - se Square Law

Day 2 7:00 - 10:00 - Inverse Square Law (cont'd)

10:00 - 11:30 - Student Participation in working the inverse Square law.

12:00 - 14:30 - Student Participation (cont'd)

14:30 - 15:30 - Theoretical Applicatio of Calibrating Survey Meters

Subject Outline - (cont'd)

Day 3 7:00 - 8:30 - Quiz #2

8:30 -10:30 - Measurement of Radiation

(a) Survey Meter
(b) Dosimeter
(c) Film Badge
(d) Geiger Counter

10:30 -11:30 - Quiz #3

12:00 -13:30 - Review

13:30 -15:30 - Midterm Examination

Day 4 7:00 -11:30 - Practical Demonstration in Lab.

(a) Operating the Autom. Industr. Model 520 Projector

(b) Expose survey meter with Tech/Ops Projector Model 773
(c) Demonstrate back scatter using lead numbers on back side of film.
(d) Demonstrate shielding using Tech/ops Proj Model 773.
(e) Care and maintenance of equipment.

12:00 -14:30 - Motivation

(a) Health Hazard of Radiation
(b) Radiation damage to human tissue
(c) Personnel responsibilities to self and others

14:30 -15:30 - Quiz #4

Day 5 7:00 -10:30 - Federal Standards of Radiation Protection

(a) 10 CFR 20

(b) 10 CFR 30

(c) 10 CFR 34

(d) 10 CFR 19

10:30 - 11:30 - Quiz #5

12:00 - 13:00 - Review

13:00 - 15:30 - Final Examination

PENNSYLVANIA SHIPBUILDING COMPANY

DATE:________________ NAME:________________

Quiz No. 1 - Structure of Matter; Radiation and Radioactivity

1. Describe the structure of an atom of $_4BE^9$.

2. How do isotopes of an element differ?

3. Describe Gamma radiation.

4. Define the following:

   Element:

   Electron:

   Compton Effect:

   Photoelectric Effect:

   Halflife:

   Radioactivity:

   Curie:

PENNSYLVANIA SHIPBUILDING COMPANY

DATE:__________________ NAME:______________________

Quiz No. 2 - Control of Radiation Exposure

1. Explain how time, distance and shielding can be used to control radiation exposure.

2. What is the radiation level at 1 foot from a 36 ci IR^{192} source?
   What is the intensity at six feet from the source?
   What is the intensity at ten feet from the source?
   How long could a person remain ten feet from the source and receive only 3 mrem?

3. What is the radiation level at 1 foot from a 12 ci CO^{60} source?
   What is the intensity at 20 feet from the source?
   What would the intensity at 20 feet be using 3" of lead shielding?
   Using 5.4 inches of steel?

4. What is the radiation level at 1 foot from a 100 ci IR^{192} source?
   What is the intensity at 40 feet?
   What would the intensity at 50 feet be using 2 inches of steel for shielding?
   How long could a person remain there and receive only 2 mrem?

Quiz No. 2

5. A radiographer has a survey instrument with three scales (0-10 mr/hr, 0-100 mr/hr, 0-1000 mr/hr). He intends to use a 50 mci source of CO^{60} to calibrate this instrument. At what distances should the meter be placed and what would the radiation levels be at these distances?

6. A Gamma ray projector contains initially 80 ci of IR^{192}. What would the activity be in 74 days? In 222 days?

7. An IR^{192} source is located behind 1 inch of steel at a distance of 30 feet from the radiographer. He measures the intensity as 120 mr/hr. What is the activity of the source?

8. A 10 ci CO^{60} source is stuck in an unshielded position. What is the distance to the "High Radiation Area" and "Restricted Areas" boundaries?

PENNSYLVANIA SHIPBUILDING COMPANY

DATE:________________ NAME:________________

Quiz No. 3 - Measurement of Radiation

1. Describe how a dosimeter measures radiation exposures?

2. Describe how a film badge measures radiation exposures?

3. Describe how an ionization chamber measures radiation intensity?

4. What are the major advantages and disadvantages of film badges and pocket dosimeters as personnel monitoring devices?

5. What are desirable characteristics of a good survey instrument?

6. How frequently must survey instruments be calibrated?
Describe in details how an instrument with three ranges (0-10mr/hr, 0-100mr/hr, 0-1000mr/hr) would be calibrated using 50 mci of CS^{137}.

Quiz No. 3

7. What radiation surveys would be performed before, during, and after a radiographic exposure?

8. A dosimeter initially reads 5 mR. After being exposed to an IR^{192} source at a distance of 5 feet for three minutes, the dosimeter is retrieved and it reads 123 mR. What is the activity of the source?

PENNSYLVANIA SHIPBUILDING COMPANY

MIDTERM EXAMINATION

DATE: ____________________ NAME: ______________________

Please show all calculations in the spaces provided. If additional space is needed, use the back of the page or attach additional sheets.

1. What is the radioactive halflife of an isotope?

2. What is the unit of:

   a. Activity of a source?

   b. Intensity of a source?

   c. Radiation exposure?

3. How is radiation exposure measured?

4. How can radiation exposure be minimized?

5. What is the principle of a pocket dosimeter?

6. How is radiation exposure measured on film badges?

7. When making an exposure, at what time will surveys be conducted? How are these surveys conducted?

Midterm Examination

8. What are the radiation intensity limits of an IR^{192} projector holding a 100 ci max. source with the source in stored position?

9. What are the permissible intensities at:

   a. The radiation area boundary?

   b. The restricted area boundary?

10. What is the radiation intensity 1 foot from a 30 ci CO^{60} source? What is the intensity 15 feet from the source? What would the intensity at 15 feet be using 3 inches of lead shielding? Using 12 inches of concrete shielding?

11. How long can a radiographer remain 20 feet from a 30 ci CO^{60} source and receive only 118 mrem?

12. A radiographer has a survey instrument with two scales (0-100 mr/hr and 0-1000 mr/hr). He intends to use 50 mci of CS^{137} to calibrate this instrument. At what distances should the meter be placed, and what would the radiation levels be at these distances?

13. A Gamma ray projector contains initially 60 ci of IR^{192}. What would the activity be after 74 days? 148 days?

Midterm Examination

14. What is the distance from a 10 ci CO^{60} source to the restricted boundary?

15. What is the intensity 25 feet from a 100 ci IR^{192} source? What would the intensity be with 4" of steel shielding?
How long could a person remain there and receive 100 mrem?

PENNSYLVANIA SHIPBUILDING COMPANY

DATE:____________________ NAME:____________________

Quiz No. 4 - Effects of Radiation on the Human Body

1. How does radiation cause damage to living matter?

2. What is meant by the Somatic Effects of Radiation?

3. What is meant by the Genetic Effects of Radiation?

4. What are some of the symptoms of acute whole body radiation exposure?

5. What are some of the symptoms of acute extremity radiation exposure?

PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

DATE:______________________ NAME:______________________

Quiz No. 5 - N.R.C. Regulations of Radiation Exposure

1. List the exposure limits for adults in a restricted area.

2. Henry Jones (age at his last birthday was 37) has a recorded lifetime accumulted dose (records and assumed) of 82 Rems; can he receive more than 1.25 Rems per quarter? If so, Why?

3. List the exposure limits for adults in an unrestricted area.

4. What constitutes a restricted area? A radiation area? A high radiation area?

5. When must radiographers use personnel monitoring devices? What type of devices must be used?

PENNSYLVANIA SHIPBUILDING COMPANY

Quiz 5 (Cont'd)

6. What must be included in utilization logs?

7. How often must leak tests be performed?
What is the acceptance criteria?
What notification must be made if a test exceeds this limit?

8. How frequently must survey meters be calibrated?
Describe how to properly calibrate a survey meter?

9. How often must inspection and maintenance of radiographic devices be performed?

PENNSYLVANIA SHIPBUILDING COMPANY

FINAL EXAMINATION

DATE:____________________ NAME:________________________

Please show all calculations in the spaces provided. If additional space is needed, use the back of the page or attach additional sheets.

1. What is the minimum required range of a pocket dosimeter?

2. What are the actions to be taken when a dosimeter discharges beyond its range?

3. Describe the following effects of radiation on the human body:

   a. Somatic effects?

   b. Genetic effects?

4. What are the maximum permissible radiation exposures to radiographers?

5. What are the maximum radiation exposures to any individual in an unrestricted area?

6. How often must survey instruments be calibrated?

Final Examination

7. What steps are to be taken when a malfunction occurs with the exposure devices?

8. What is the radiation level 50 feet from a 100 ci IR^{192} source? What would the intensity at 50 feet be using 2" of steel for shielding? How long could a person remain there and receive only 2 mrem?

9. A radiographer has a survey instrument with three scales (0-10 mR/hr, 0-100 mR/hr, and 0-1000 mR/hr). He intends to use a 20 mci source of CO^{60} to calibrate this instrument. At what distances should the meter be placed from the source and what would the radiation levels be at these distances?

10. A Gamma ray projector contains initially 100 ci of IR^{192}. What would the activity be in 74 days? In 222 days?

11. An IR^{192} source is located behind 1 inch of steel at a distance of 20 feet from the radiographer. He measures the intensity as 120 mR/hr. What is the activity of the source?

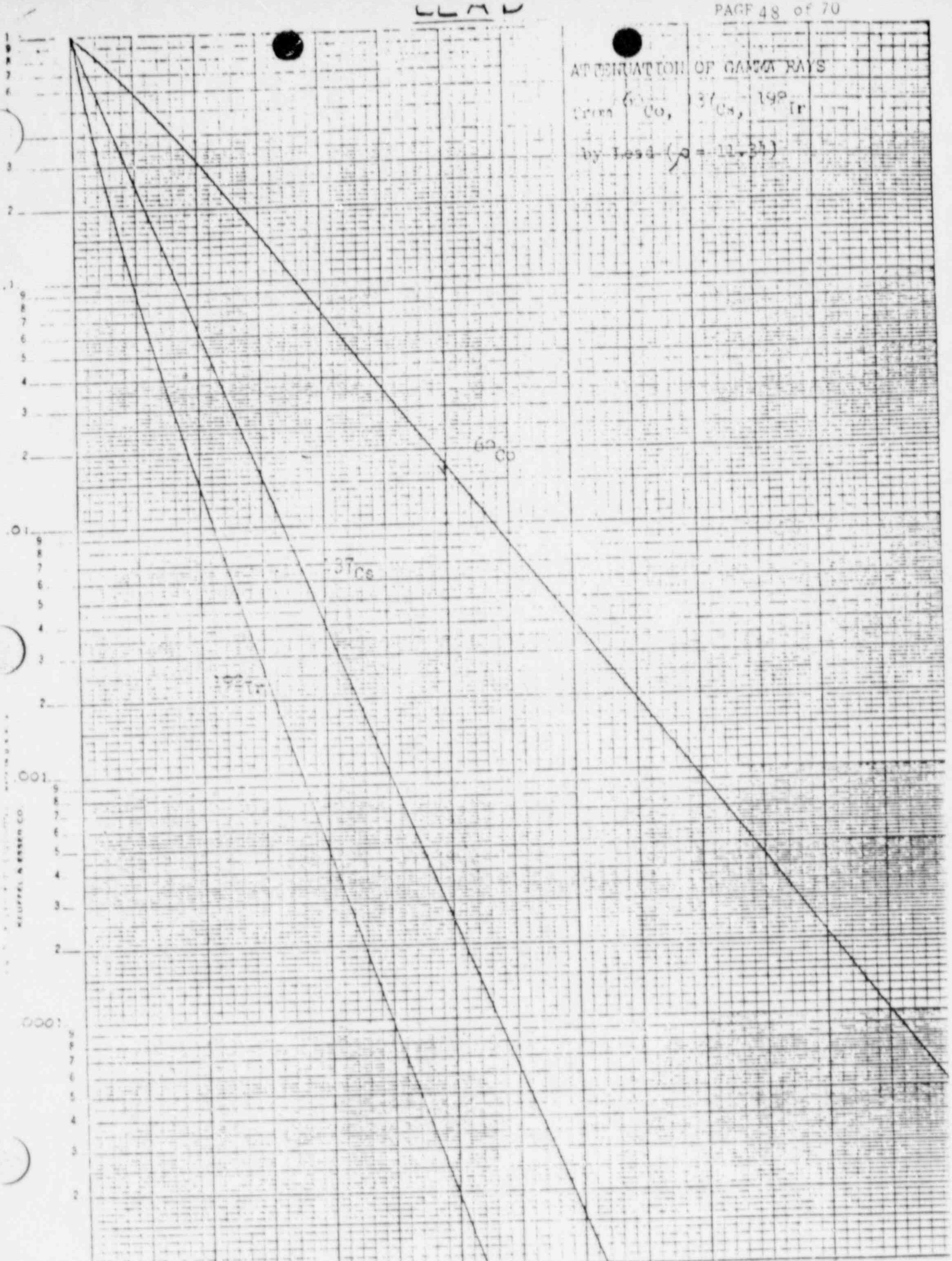
12. A 10 ci CO^{60} source is stuck in an unshielded position. What is the distance to the "High Radiation" boundary and "Restricted Area" boundary?

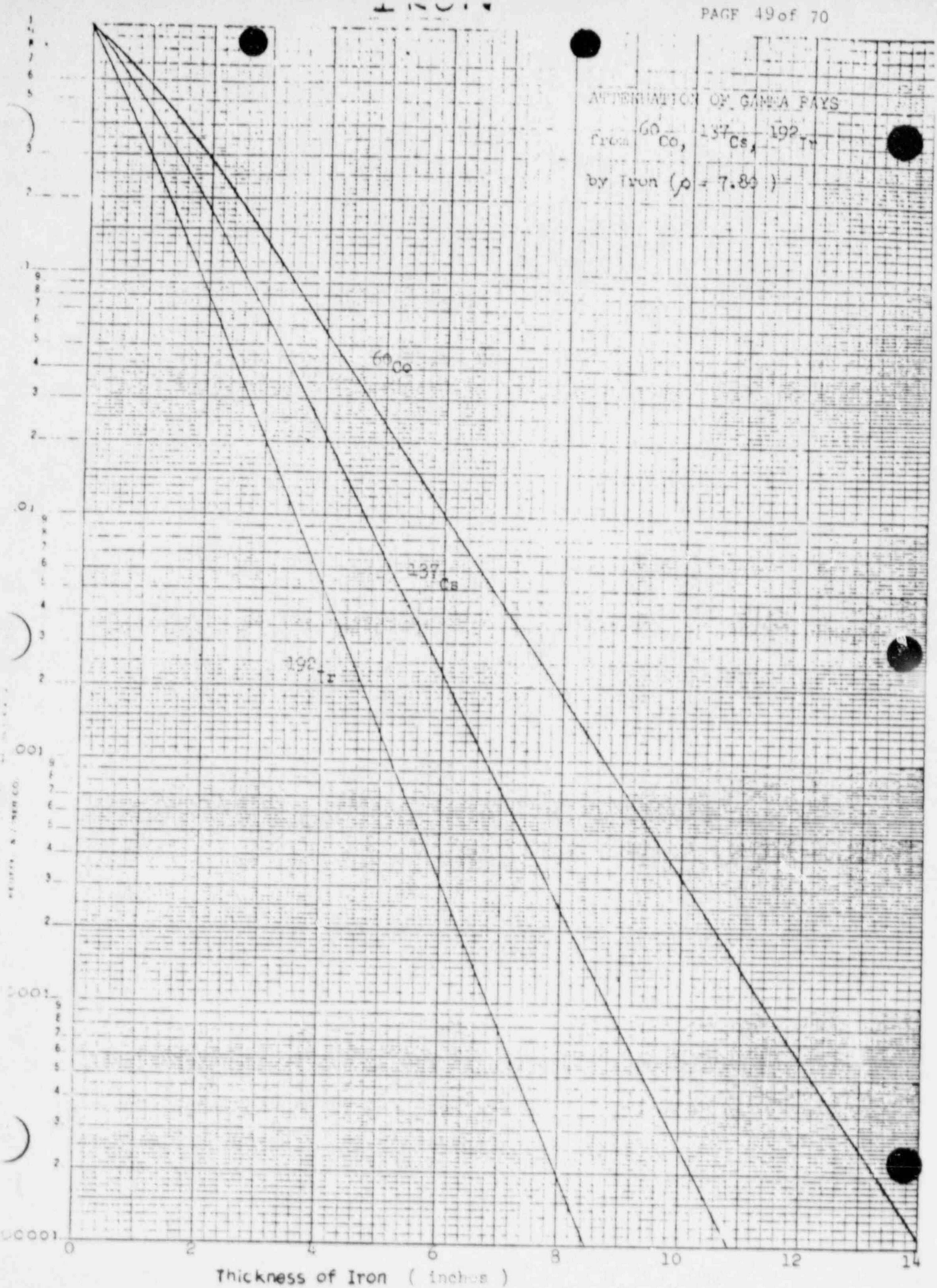
13. A dosimeter initially reads 5 mR. After being exposed to an IR^{192} source for 3 minutes at a distance of 5 feet, the dosimeter is retrieved and it reads 123 mR. What is the activity of the source?

14. What is the radiation intensity at 5 feet from a 30 ci CO^{60} source?
What is the intensity at 15 feet using 7.4 inches of steel for shielding?
How long could a person remain there and receive only 2 mrem?

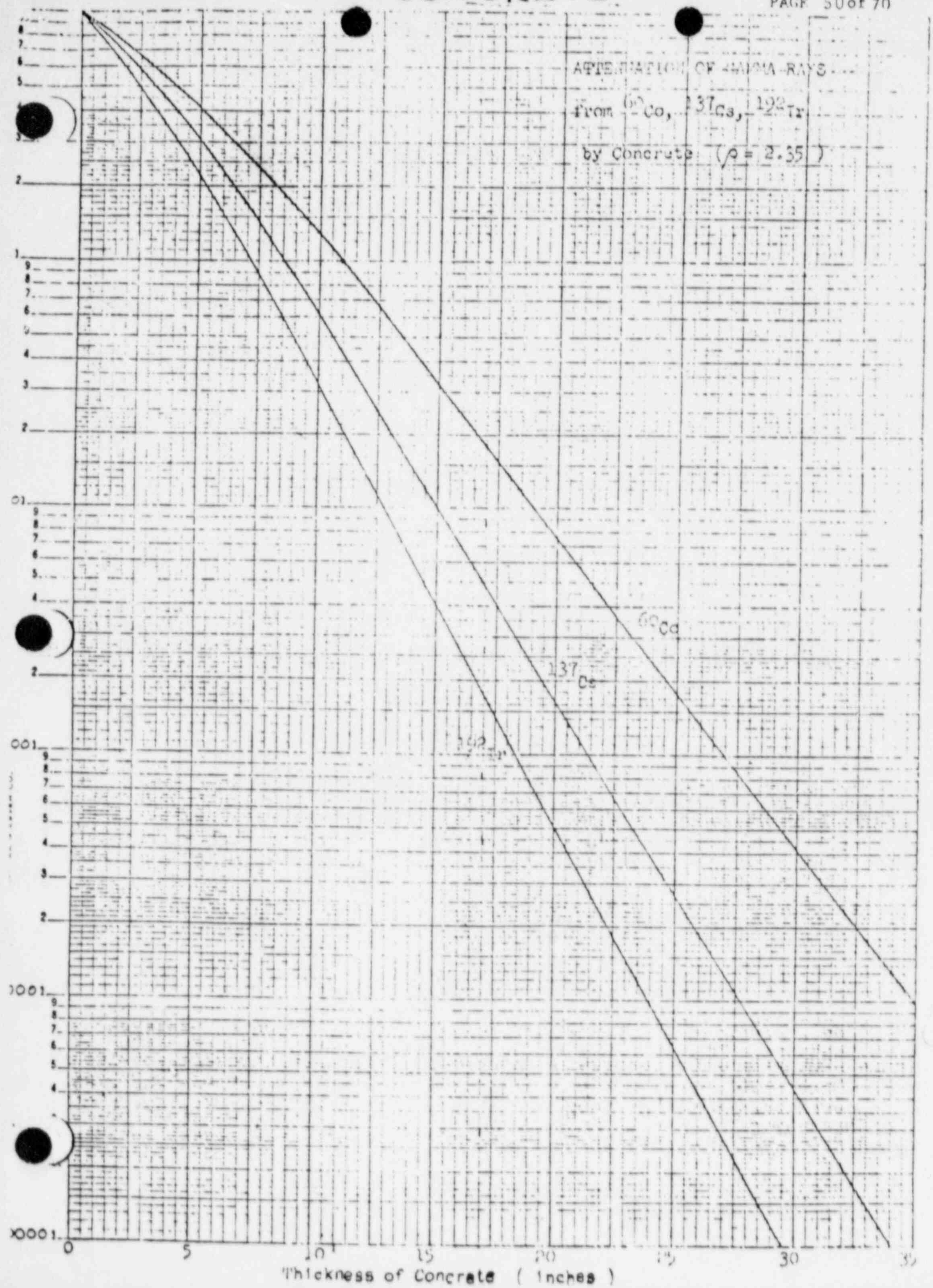
15. What is the radiation level at 1 foot from a 12 ci CO^{60} source?
What is the intensity at 20 feet from the source?
What would the intensity at 20 feet be using 3 inches of lead shielding?
Using 17 inches of concrete?

LEAD


ATTENUATION OF GAMMA RAYS
from ^{60}Co, ^{137}Cs, ^{192}Ir
by Lead (ρ = 11.34)
^{60}Co
^{137}Cs
^{192}Ir
1
.1
.01
.001
.0001
.00001
0
1
2
3
4
5
6
Thickness of Lead (Inches)
KEUFFEL & ESSER CO.


ATTENUATION OF GAMMA RAYS
from ^{60}Co, ^{137}Cs, ^{192}Ir
by Iron (ρ = 7.86)
^{60}Co
^{137}Cs
^{192}Ir
.01
.001
.0001
0
2
4
6
8
10
12
14
Thickness of Iron (inches)

CONCRETE


ATTENUATION OF GAMMA RAYS
from ^{60}Co, ^{137}Cs, ^{192}Ir
by Concrete (ρ = 2.35)
^{60}Co
^{137}Cs
^{192}Ir
.01
.001
.0001
0
5
10
15
20
25
30
35
Thickness of Concrete (inches)

PENNSYLVANIA SHIPBUILDING COMPANY

Answers to Quiz. No. 1 - Structure of Matter: Radiation and Radioactivity

1. An atom of Be^9 has 4 protons and an approx. atomic weight o. 9.

2. By the number of neutrons and hence, the atomic weight.

3. Gamma radiation is electromagnetic radiation. It is caused by disintegration of radioactive material.

4. Element: An element is a substance which cannot be chemically further divided into simpler substances.

   Electron: An electron is a negatively charged particle.

   Compton Effect: An electron is stricken by a gamma ray, thereby freeing it from the atom. Another gamma ray with less energy emerges.

   Photoelectric Effect: All the energy of a gamma ray is transmitted to an electron, therby knocking the electron out of its orbit.

   Halflife: Halflife is the time period during which the activity of radioactive material, due to decay, reduces to half.

   Radioactivity: The spontaneous decay of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.

   Curie: Curie is a measure of the activity of radioactive material. One curie is equal to 3.7×10^{10} disintegrations per second.

Answer to Quiz No. 2 - Control of Radiation Exposure

1. Decrease of time spend in a radiation area, as well as increase of distance and/or shielding will reduce radiation exposure.

2. $I_1 = 36 \times 5.9 = 212.4$ R/hr

   I_2 at 6 ft. $= 212.4 \frac{1^2}{6^2} = 5.9$ R/hr

   I_2 at 10 ft. $= 212.4 \frac{1^2}{10^2} = 2.12$ R/hr

   $T = \frac{.003}{2.12} = 0.0014$ hr. = 5.1 sec.

3. $I_1 = 12 \times 14.5 = 174$ R/hr.

   I_2 at 20 ft. $= 174 \frac{1^2}{20^2} = 0.435$ R/hr. = 435 mR/hr.

   With 3" Pb; $I_s = 435 \times 0.017 = 7.4$ mR/hr.

   With 5.4 Fe: $I_s = 435 \times 0.017 = 7.4$ mR/hr.

4. $I_1 = 5.9 \times 100 = 590$ R/hr.

   I_2 at 40 ft. $= 590 \frac{1^2}{40^2} = 0.369$ R/hr. = 369 mR/hr.

   With 2" Fe, I_2 at 50 ft. $= 590 \frac{.08}{50^2} = 0.0189$ R/hr. = 18.9 mR/hr.

   $T = \frac{2}{18.9} = 0.106$ hr. = 6.36 min.

5. $d_2 = \sqrt{d_1^2 \frac{I_1}{I_2}}$ $I_1 = 0.05 \times 14.5 = 0.725$ R/hr.

I_2	2	8	20	80	200	800	mR/hr.
d_2	19.04	9.52	6.02	3.01	1.90	0.95	FT

PENNSYLVANIA SHIPBUILDING COMPANY

Answer to Quiz No. 2 - Control of Radiation Exposure (Page #2)

6. Activity after 74 days (1 Halflife) = $\frac{80}{2^1}$ = 40 ci

Activity after 222 days (3 halflifes) = $\frac{80}{2^3}$ = 10 ci

7. I_s = 120 mR/hr. = 0.12 R/hr.

I_2 at 30 ft. = 0.12/0.3 = 0.4 R.hr.

$I_1 = 0.4 \frac{30^2}{1^2}$ = 360 R/hr. Act. = 360/5.9 = 61 ci

8. I_1 = 10 X 14.5 = 145 R/hr.

d_2 at 100 mR/hr = $\sqrt{1^2 \frac{145}{0.10}}$ = 38 Ft.

d_2 at 2 mR/hr = $\sqrt{1^2 \frac{145}{0.002}}$ = 269 Ft.

PENNSYLVANIA SHIPBUILDING COMPANY

Answers to Quiz No. 3 - Measurement of Radiation

1. The electrostatic charge moves the two fibers apart. When ionization occurs, the dosimeter loses its charge and the fibers move closer together.

2. A film badge measures radiation exposure by darkening of the film.

3. Ionization creates a small voltage between two electrodes in the ionization chamber. The voltage is amplified and displayed on the meter.

4. Film badge: Advantage: Permanent record. Disadvantage: Takes time for processing.

   Dosimeter: Advantage: Instant readout. Disadvantage: Inaccurate, no permanent record, discharges when jarred.

5. Compactness, ruggedness, portability. Should have at least three scales: 0-10 mR/hr. 0-100 mR/hr and 0-1000 mR/hr.

6. Survey meters must be calibrated at least once every 3 months.

   I_1 = 0.05 X 3.44 = 0.172R/hr = 172mR/hr.

   $$d_2 = \sqrt{d_1^2 \frac{I_1}{I_2}}$$

I_2	2	8	20	80	200	800	mR/hr
d_2	9.27	4.64	2.93	1.47	0.93	0.46	Ft.

   The readings must be within ± 10% of the check points.

7. Before: Check that the source is properly stored.
   During: Confirm the restricted area boundary.
   After: Check that the source is properly stored.

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Answers to Quiz No. 3 - Page 2

8. Exposure is 123 - 5 = 118 mR.

I_2 at 5 F_t = 118 $\frac{60}{3}$ = 2360 mR/hr = 2.36 R/hr.

I_1 = 2.36 $\frac{5^2}{1^2}$ = 59 R/hr.

Activity = 59/5.9 = 10 ci

PENNSYLVANIA SHIPBUILDING COMPANY

Answer to Mid term Examination

1. Halflife is the time period in which half the atoms of a particular radioactive substance disintegrate into another nuclear form.

2. Curies

   R/hr or MR/hr

   Rem or mRem

3. By its effect or ionization.

4. Reduction of time in the radiation area, increase of distance and/or shielding.

5. The electrostatic charge moves the two fibers apart. When ionization occurs, the electrometer loses its charge and the fibers move closer together.

6. By film darkening. The film density is directly related to radiation exposure.

7. Before an exposure, survey the camera to ascertain that the source is properly stored. During an exposure, survey the boundary of the restricted area. After an exposure, with a survey meter approach the camera from the rear. Check the sides of the camera and the length of the guide tube to make certain that the source has been retracted properly.

8. Intensity at 6 in. from any surface of the projector must be less than 50 mR/hr.

9. 5 mR/hr.

   2 mR/hr.

10. $I_1 = 30 \times 14.5 = 435$ R/hr.

    I_2 @ 15 ft. $= 435 \frac{1^2}{15^2} = 1.933$ R/hr $= 1933$ mR/hr.

    With 3" Pb; $I_s = 1933 \times .017 = 32.87$ mR/hr.

    With 12" concr.: $I_s = 1933 \times .075 = 145$ mR/hr.

Answer to Midterm Examination (Page #2)

11. $I_1 = 30 \times 14.5 = 435$ R/hr.

I_2 at 20 ft. $= 435 \frac{1^2}{20^2} = 1.088$ R/hr $= 1088$ mR/hr.

$T = 118/1088 = 0.108$ hr $= 6.5$ min.

12. $I_1 = 0.05 \times 3.44 = 0.172$ R/hr. $= 172$ mR/hr

$d_2 = \sqrt{d_1^2 \frac{I^1}{I_2}}$

I_2		20	80	200	800		mR/hr
d_2		2.93	1.47	0.93	0.46		FT

13. Activity after 74 days (1 halflife) $= 60/2^1 = 30$ ci

Activity after 148 days (2 halflife) $= 60/2^2 = 15$ ci

14. $I_1 = 10 \times 14.5 = 145$ R/hr

$d_2 = \sqrt{1^2 \frac{145}{.002}} = 269$ ft.

15. $I_1 = 100 \times 5.9 = 590$ R/hr

I_2 at 25 ft $= 590 \frac{1^2}{25^2} = 0.944$ R/hr $= 944$ mR/hr.

With 4" Fe; $I_s = 944 \times .005 = 4.72$ mR/hr.

$T = 100/4.72 = 21.19$ hrs.

PENNSYLVANIA SHIPBUILDING COMPANY

Answer to Quiz No. 4 - Effects of Radiation on the Human Body

1. Radiation damages human cells through ionization.

   It renders the cells unable to reproduce themselves.

2. Somatic effects due to harmful doses of radiation are experienced by the individual who received the exposure.

3. Genetic effects due to harmful doses of radiation will be experienced by future generations.

4. Nausea, vomiting, and diarrhea. In extreme cases, possible death.

5. Redness and radiation burns. Later blackening of the extremity, and possible amputation.

PENNSYLVANIA SHIPBUILDING COMPANY

Answer to Quiz No. 5 - N.R.C. Regulations of Radiation Exposure

1. 1.25 R per calendar quarter for whole body.

   18.75 R per calendar quater to extremeties

2. Accumulated dose allowed = 5 (N-18)

   = 5 (37-18)

   = 95 Rems

   Henry Jones can receive up to 3 Rems per calender quarter, until his life time exposure record equals 5 (N-18). At that time, his exposure cannot exceed 1.25 Rems per calender quarter (N.R.C. part 20, paragraph 20.101).

3. 2 mR/hr.

   100 mR/week.

   500 mR/year.

4. In a restricted area, the radiation level is in excess of 2 mR/hr.

   In a radiation area, the radiation level is in excess of 5 mR/hr.

   In a high radiation area, the radiation level is in excess of 100 mR/hr.

5. Monitoring devices must be worn when making an exposure or entering a radiation area.

6. The minimum information to be shown in the utilization log is as follows:

   (a) Make and model number of storage container, (b) Name of radiographer to whom the radiographic device is assigned, (c) The location and (d) The date it had been used.

7. Leak tests must be performed not to exceed six months or when a source had been changed. A source is acceptable, if less than 0.005 μci is detected. If a test exceeds this limit the source must be withdrawn from use immediately and notification be made to the Radiation Control Division.

8. A survey meter must be calibrated at least once every 3 months. Two points of each range are to be selected which are 50% apart. The readings must be within ± 10% of the points selected.

9. Radiographic devices must be inspected daily for kinks or damage of the control cable and guide tubes. Maintenance is to be done on a quarterly basis.

PENNSYLVANIA SHIPBUILDING COMPANY

Answers to Final Examination

1. 0 - 200 mR

2. The film badge must be processed immediately. The individual must not be employed in radiography, until the radiation exposure report is received. Remember, a dosimeter which went off scale constitutes an emergency situation.

3. a. Somatic effects - Somatic effects due to harmful doses of radiation will be experienced by the individual who received the exposure.

   b. Genetic effects - Genetic effects due to harmful doses of radiation will be experienced by future generations.

4. 1.25 R/3 months for whole body.
   18.75 R/3 months to extremeties.

5. 3 mR/hr.
   100 mR/week
   500 mR/year

6. At least once every 3 months, and after repairs.

7. Secure the ar a, seal off the restricted area boundary. Get additional help, if needed. Contact the Radiation Safety Officer, at once.

8. $I_1 = 100 \times 5.9 = 590$ R/hr

   $I_s = 590 \frac{1^2}{50^2} \times .08 = 0.019$ R/hr = 18.9 mR/hr

   $T = 2/18.9 = 0.106$ hr = 6.35 min.

9. $I_1 = .02 \times 14.50 = 0.29$ R/hr = 290 mR/hr $\quad d_2 = \sqrt{d_1^2 \frac{I_1}{I_2}}$

I_2	2	8	20	80	200	800	mR/hr
d_2	12.04	6.02	3.81	1.90	1.20	0.60	Ft.

Answers to Final Examination

10. After 74 days, $I_1 = 100/2^1 - 50$ ci

    After 222 days, $I_1 = 100/2^3 = 12.5$ ci

11. $I_2 = 120/.3 = 400$ mR/hr = 0.4 R/hr

    $I_1 = 0.4 \frac{20^2}{1^2} = 160$ R/hr Activity = 160/5.9 = 27.12 ci

12. Distance to Restr. Area boundary = $\sqrt{1^2 \frac{145}{.002}} = 269.26$ ft

    Distance to High Radiat. Area boundary = $\sqrt{1^2 \frac{145}{.10}} = 38.08$ ft

13. Exposure = 123 - 5 = 118 mR $I_2 = 118 \frac{60}{3} = 2360$ mR/hr = 2.36 R/hr

    $I_1 = 2.36 \frac{5^2}{1^2} = 59$ R/hr

    Activity = 59/5.9 = 10 ci

14. $I_1 = 30 \times 14.5 = 435$ R/hr

    At 5 ft, $I_2 = 435 \frac{1^2}{5^2} = 17.4$ R/hr = 17,400 mR/hr

    At 15 ft and 7.4" Fe, $I_s = 435 \frac{1^2}{15^2} \times .003 = 0.0058$ R/hr - 5.8 mR/hr

    T = 2/5.8 = 0.345 hr = 20.7 min.

15. $I_1 = 12 \times 14.5 = 174$ R/hr

    At 20 ft, $I_2 = 174 \frac{1^2}{20^2} = 0.435$ R/hr = 435 mR/hr

    At 20 ft and 3" Pb, $I_s = 435 \times .017 = 7.4$ mR/hr

    At 20 ft and 17" concr., $I_s = 435 \times .018 = 7.8$ mR/hr

TRAINING REQUIREMENTS FOR PERSONNEL WITH PREVIOUS RADIOGRAPHIC EXPERIENCE

TRAINING OF RADIOGRAPHERS WITH PREVIOUS EXPERIENCE

Newly hired personnel will be on a thirty day probationary period regardless of past experience. This thirty day period is for the evaluation of the persons ability and qualifications as it pertains to Radiography only. During this period, they will be given an orientation of the facilities. Moreover, they will be given a 40 hour Radiation Safety Course, pages 34 through 50 of attachment #5. Several quizzes and examination must be taken with a required minimum average score of 75%.

Prior to being assigned radiographers, newly hired personnel with previous experience in radiography will be given the Radiographic Examination, pages 21 thorugh 30 of attachment #5 requiring a score of 80%. The practical examination, page 31 requires a score of 85% with the provision that questions 1 through 5 must be answered correctly.

In the event that they do not successfully pass the written and practical tests, they will be given the entire training program for Assistant Radiographers or released.

ANNUAL TRAINING

At least eight (8) hours of classroom training will be given all radiographers and radiographer's assistant on an annual basis.

The annual training will generally consist of a review on the following topics:

a. Atomic structure of matter.

b. The inverse square law.

c. Shielding.

d. Review of Standard Operating Instructions.

e. Calibration of Survey Meters.

f. Subjects as designated by the Radiation Safety Officer.

At the end of the annual periodic training course, an examination will be given, see pages 66 through 70. A passing grade of 75% is required.

RADIOGRAPHERS QUALIFICATION TEST #1

All answers must be completed.
All calculations must be included with answers
Time limit: 2 hours
Passing grade: 75%

1. Define the duties of a radiographer employed by Penn Ship Co.

2. What is a curie?

3. What is the difference between a Roentgen and A Rem?

4. What is the principle difference between X-Rays and Gamma Rays?

5. X and Gamma Rays entering and passing through your body cause no pain. How do they cause damage?

6. How can ionizing radiation be detected?

7. Describe a pocket dosimeter and it's principle of operation.

8. What is a survey meter? How does it function?

9. What is the maximum amount of X or Gamma radiation per hour any nonoccupational person may receive?

10. In strict accordance with the N.R.C. rules, may a nonoccupational person remain at a radiation intensity of 30 mR/hr. for a period of one minute, provided subsequent exposures under the same conditions are not repeated at a rate of more than one exposure within 15 minutes.

11. Is the condition described in question #10 legal in accordance with Penn Ship's procedure for the safe handling of radiographic equipment?

12. If you drop your dosimeter and it is discharged, can you continue to work with your film badge until you return to your office?

13. Who is responsible for the accurate reading of the dosimeters at the end of each shift?

14. John Doe who was 37 years old at his last birthday has a recorded lifetime accumulated dose of 82 Rems. Can he receive more than 1.25 Rems per calender quarter? If so, why?

Pennsylvania Shipbuilding

15. Is the condition described in question #14 legal in accordance with Penn Ship's procedure for the safe handling of radiographic equipment?

16. What is the N.R.C. definition of a "Restricted Radiation Area"? A "High Radiation Area"?

17. How do the signs differ in wording for the two areas in question #16"

18. How often must a survey meter be calibrated?

19. Must a survey record of each exposure "Set up" be made?

20. Why is it necessary to survey the camera and the length of the source tube, if used each time a source has been returned?

21. You are using 325 m ci of Cobalt 60 (without shielding). What distance from the source will you place the ropes and signs to the "Restricted Area Perimeter (CO 60 - 14.5 mR/hr at 1 Ft per m ci)

22. You are taking a panoramic exposure of a cylindrical vessel of 10 Ft. outside diameter. The radiation level on the outside of the vessel is 2 R/hr. At what distance will the radiation intensity be 2mR/hr?

23. If the above exposure is for 20 minutes, what would the distance be to the perimeter at the radiation intensity which would limit an exposure to a maximum of 2 mR/in any one hour?

24. Where do you place the "High Radiation" signs and how do you make this determination?

25. What procedure would you follow if for some reason you could not return the isotope into the safe position of the camera?

Acceptable Answers to the Radiographer's Qualification Test

1. A radiographer is a trained individual who uses or supervises the use of isotopes in complete compliance with all N.R.C. and State Regulations, the conditions of the license and his company's rules and regulations. He is responsible to the licensee for complete compliance of the above rules.

2. A curie is that amount of radioactive material which will disintegrate at the rate of 37 billions atoms per second (3.7×10^{10} d.p.s.)

3. A Roentgen is a measure of X or Gamma radiation. A Rem is a measure of exposure of body tissue to ionizing radiation in terms of it's "Relative Biological Effect" which is equivalent to a dose of one Roentgen of X or Gamma radiation.

4. X and Gamma radiation is electro-magnetic radiation. The only difference is the way they are produced. Gamma radiation is emitted when unstable atoms disintegrate. X-rays are produced in an x-ray tube. Either will produce ionization at the same rate.

5. X and Gamma radiation passing through human tissue ionize the atoms that compose cells. Some cells are destroyed, others undergo changes. Some cells are readily replaced. those in the reproductive system will not, thus have a cumulative effect.

6. Radiation can be detected and measured by a survey meter, dosimeter, or film badges. The dosimeter and film badge are important and necessary instruments to register accumulated dose for recording purposes. The only safe and effective method of determining radiation and it's intensity, at the moment of exposure is the use of a calibrated survey meter. A calibrated survey meter must be used at each radiographic site.

7. A pocket dosimeter is a small electroscope that measures the absorbed dose of X or Gamma Radiation. This type of electroscope is shaped like a pen, the case and fiber are insulated from each other. When charged, the fiber is repelled from the case and held in a fixed position by the electrical charge. X or Gamma radiation entering the ionization chamber within the case ionizes the air. The electrical charge of the fiber is reduced in direct proportion to the radiation. This causes the fiber to move upscale, thus measuring radiation exposure.

8. A survey meter is a precision instrument that measures radiation intensity in units of mR/hr or R/hr. It consists of an ionization chamber and a-sociated electronic circuits. Radiation entering the chamber causes an electric current to flow which is in direct proportion to the radiation. This current is amplified and indicated on a meter.

9. Nonoccupational persons shall not receive more than 2 mRem in any one hour, or 100 mRem in any seven consecutive days, or 500 mRem per year. These are maximum radiation exposure doses.

10. Yes, in accordance with N.R.C. regulations "Standards for Protection against Radiation", part 20, para. 20.105.

11. Yes

12. No. An operative dosimeter and film badge must be worn by radiographic personnel during radiographic operations.
If a dosimeter moves off scale for any reason at all, it is treated as an emergency. The individual must not work in radiography, until his film badge has been processed and the dosimetry report received, at which time a disposition can be made.

13. All radiographers and assistant radiographers must read his dosimeter every hour and record his total exposure at the end of the shift.

14. John Doe's permissible lifetime exposure equals 5(N-18) = 5(37-18) = 95 Rem. Since John's recorded exposure dose is less than 95 Rem, he could receive up to 3 Rem per calender quarter, but not to exceed 5 Rem in any consecutive 365 days.

15. Yes

16. A "Restricted Area" is defined as the area accessible to occupational personnel, in which the radiation levels are in excess of 2 mR/hr. Within a "High Radiation Area", the radiation levels are in excess of 100 mR/hr.

17. The "Restricted Area" is roped off and posted with signs reading "Caution - Radiation Area". The "High Radiation Area" is posted with signs reading "Caution - High Radiation Area."
On both signs, the standard radiation symbol is in magneta or purple on yellow background (N.R.C. Part 20, para. 20.203 (b) and (c))

18. A survey meter must be calibrated at least once every three (3) months and after repairs. The actual readings must be within +/- 10% of the calculated values. Record must be maintained in accordance with N.R.C. Part 31, para. 31.104.

PENNSYLVANIA SHIPBUILDING COMPANY

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19. Each radiographic "Set up" must be surveyed and recorded. After the source has been returned to the camera, the camera must be surveyed to assure that the source is properly stored. The permanent facility must be surveyed at least once every shift when radiography is performed.

20. The camera and the full length of the source tube must be surveyed each time the source is retracted to assure that the source is properly stored within the camera.

21. 325 mci of Co 60 unshielded should require a radius of approx. 49 feet to reduce radiation intensity to less than 2 mR/hr.

22. The distance to the "Restricted Area" permieter (2 mR/hr) would be 158.1 Feet.

23. The distance would be 91.3 feet.

24. Calculate the distance to the "High Radiation Area" perimeter (100 mR/hr) using the Inverse Square Law.

25. Survey the area, secure the area by ropes and "Radiation Area" signs at the 2 mR/hr perimeter. If needed, obtain additional personnel to guard the area. Notify the Radiation Safety Officer.

License No. 37-21067-01

Attachment No. 6

Rev. A - 12/08/86

PENNSYLVANIA SHIPBUILDING COMPANY

MANAGEMENT QUARTERLY INSPECTION PROCEDURE

A Management Inspection of facilities and Operating Equipment will be conducted at least every quarter and this form shall be completed and signed. This inspection Procedure to be performed by the following Personnel.

F. Noll - Radiation Safety Officer

A. Inspect Vault Area

(1) Signs and Condition

(2) Fence

(3) Building

(4) Locking Merchanism

B. Inspect the permanent facility

(1) Proper signs, posted lights and condition

(2) Shielded door lock for proper operation

(3) Observation mirror

(4) Equipment properly stowed

C. Inspect all operational equipment

(1) Lay-out all control cables - extended cables and inspect for signs of wear, breakage, lubrication and ease of operation.

(2) Lay-out all source tubes and inspect for obvious damage. Extend a control cable and run through source tubes to check for any blockage.

(3) Lay-out Cameras check operation of locking mechanism.

(4) Examine all Cameras for any physical damage.

INSPECTING OFFICIAL

Date____________________

REMARKS

PENNSYLVANIA SHIPBUILDING COMPANY

License No. 37-21067-01
Attachment No. 6

D. Evaluate a Radiographic Operation and for compliance with NRC and Pennsylvania Shipbuilding Standard Operating Procedure. List name of Radiographer and Assistant Radiographers checked____________________________Date.

E. Inspect calibration records for survey meters.

F. Inspect daily exposure log for completeness.

G. Inspect records of survey for all exposure set ups.

H. Check for proper posting of licenses and NRC Form 3 at the following locations:

Main Office	Boiler Shop
Safety Dept.	Main Gate
North Yard Fab. Shop	North Yard Gate
47 Fab. Shop	Dispensary

I. Fill out Quarterly Inspection Report and post on bulletin board in X-ray Office and file superceded report in the Quality Assurance Office.

INSPECTING OFFICIAL

Date______________

REMARKS

ORGANIZATIONAL STRUCTURE
FOR CONTROL OF RADIATION PROGRAMS

Mr. Ronald J. Stevens PRESIDENT

Mr. Rockwell Holman, VICE PRESIDENT - of Quality Improvement

Mr. Michael Lubragge, Manager of Quality Assurance Department

Mr. Lubragge has been a member of management in the Quality Assurance activity since 1970. He is reporting N.D.T. activities to Mr. Holman..

Mr. Franz H. Noll, P.E., Radiation Safety Officer.

Mr. Noll has held administrative position in N.D.T. Departments since 1974 and as Radiation Safety Officer since 1976. Prior to his involvement with N.D.T., he has held positions as Design and Project Engineer for approximately thirteen (13) years. He attended the Dupont School of "Industrial Radiography" and the Tech/Ops Course of "Radiation Safety Aspects of Isotope Radiography".
As Radiation Safety Officer at Pennsylvania Shipbuilding Company, he is directly responsible for all management functions in the Radiography Department, including training and certification of N.D.T. Technicians in accordance with Pennsylvania Shipbuilding Company's procedure No. Q.A.I.I. 70-7.

LISTED BELOW ARE N.D.T. TECHNICIANS
EMPLOYED BY PENNSYLVANIA SHIPBUILDING COMPANY

Mr. Nicholas C. Verruno, Radiographer

Mr. Verruno is an experienced Radiographer who is performing X-Ray Radiography since 1952 and Gamma-Ray Radiography since 1955. He attended the Radiation Safety Course at Budd Company in 1961.

Mr. Joseph L. Fasano, Radiographer

Mr. Fasano is an experienced Radiographer who is performing X-and Gamma Radiography since 1966. He attended a 52 hour Radiography Course in 1969 sponsored by A.S.N.T. He worked as an Assistant Radiographer for a period of one year prior to being assigned a certified radiographer.

Mr. John M. Carrero, Radiographer

Mr. Carrero is an experienced Radiographer who is performing X-and Gamma Ray Radiography since 1969.

Mr. George A. Murphy, Radiographer

Mr. Murphy is an experienced Radiographer who is performing Gamma Radiography since 1974.

N.D.T. TECHNICIANS

Continued......

Mr. Robert E. Hazel, Radiographer

Mr. Hazel has been involved in radiography, both X-Ray and Gamma Ray since 1964.

Mr. Leon E. Hosier, Radiographer

Mr. Hosier started in our Radiography Department on 7. June 1982. He has been given a total of 96 hours of classroom training for Radiography up to Level II and Radiation Safety for Radiographers. On June 6 and 7 1985 he successfully passed the examinations for Radiation Safety and Radiography - Level II.

PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

License No. 37-21067-01
Attachment No. 8

Rev. A-8/31/84

LEAK TEST PROCEDURE

Radioisotope cameras must be leak tested at intervals not to exceed 6 months, or whenever a source has been replaced.

The following person only shall perform leak tests:

Mr. Franz H. Noll - Radiation Safety Officer

Leak Test Kits shall be Tech/Ops Model 518.

SMEAR TEST

Automation Industries Model 520 and Tech/Ops Model 741 cameras:

a. Turn a calibrated survey meter to its lowest range and let it warm up for several minutes.

b. Remove the snout end plug (source tube attachment) from the camera.

c. Wet the swab with EDTA solution. Shake off excess solution from the swab.

d. Insert the swab into the "S"-tube of the camera as far as possible. Wipe the inside of the "S"-tube by rotating the swab.

e. After removing the swab, replace the snout end plug.

f. Approach the meter with the swab. If the reading on the meter is in excess of 0.2 mR/hr. do not mail the test kit, but advise Tech/Ops.

g. Place the swab into the plastic envelope provided. Place the plastic envelope with the swab into the shipping box together with the completed form.

h. Return the leak test kit to Tech/Ops for Radio-Essay.

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Rev. A - 8/31/84

Technical Operations Model 773 Cs^{137} Calibration Camera:

a. Turn a calibrated survey meter to its lowest range and let it warm up for several minutes.

b. Wet the swab with EDTA solution. Shake off excess solution from the swab.

c. Unlock the camera.

d. Lift up the source rod all the way. Wipe the entire rod with the wetted swab.

e. Drop the source rod of the camera and lock.

f. Approach the meter with the swab. If the reading on the meter is in excess of 0.2 mR/hr., do not mail the test kit, but advise Tech/Ops.

g. Place the swab into the plastic envelope provided. Place the plastic envelope with the swab into the shipping box together with the completed form.

h. Return the leak test kit to Tech/Ops for Radio-Essay.

Test Results shall be maintained in the X-Ray Office for inspection by the Nuclear Regulatory Commission. The maximum removable contamination shall not exceed 0.005 microcuries.

PENNSYLVANIA SHIPBUILDING COMPANY

CHESTER, PENNSYLVANIA 19016

License No. 37-21067-01
Attachment No. 9

Rev. A - 8/31/84

QUARTERLY AUDITS OF RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS

At intervals not to exceed 3 months, each radiographer and radiographer's assistant shall be audited by the Radiation Safety Officer in the course of radiography in order to assure proper performance of radiographic operations. The audits shall include as a minimum:

a. Use of personnel monitoring devices; i.e., film badge and dosimeter.
b. Use of calibrated and operable survey meters.
c. Exposure arrangement.
d. Ropes and placards at "Restricted Area" and "High Radiation Area" perimeters.
e. Proper survey of camera and source tube after each exposure.

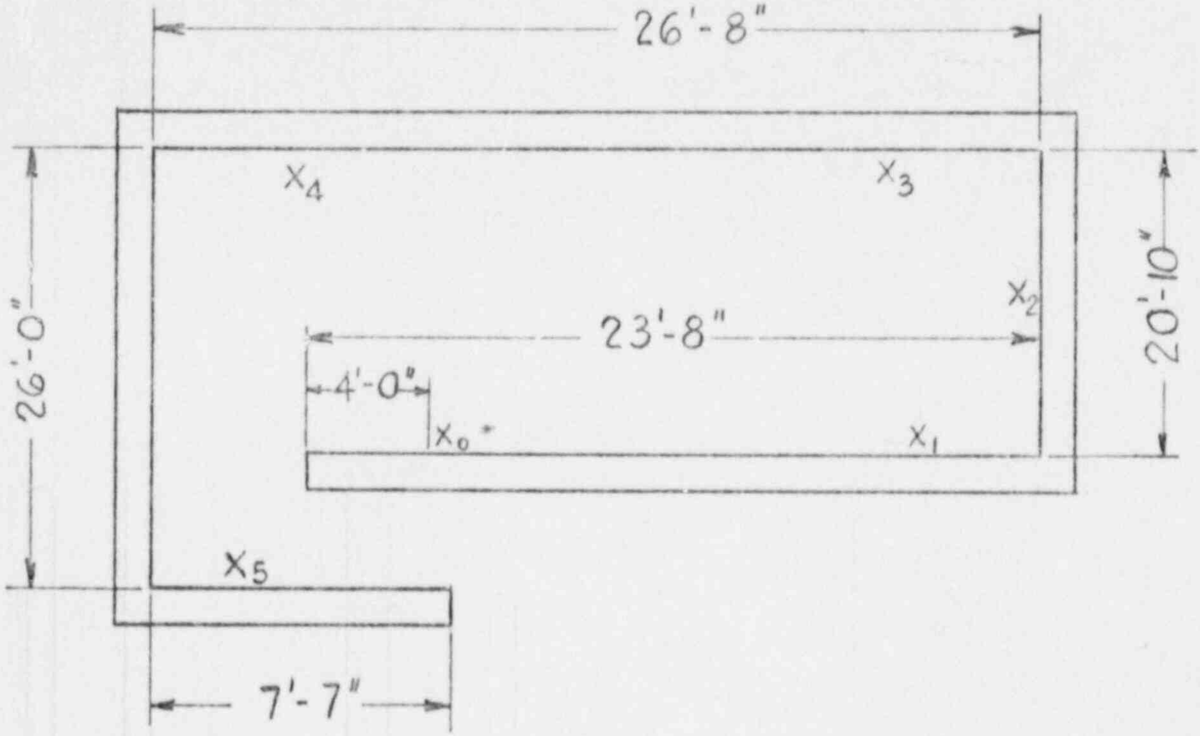
Immediately following the audit, the findings of the audit shall be discussed with the supervisor and radiographers involved.

In case of any default or deliberate and/or negligent deviation from Penn Ship's Operating or Emergency Procedures, the supervisor and acting radiographer involved shall, depending on the seriousness of the infraction, receive a letter of reprimand, possible time off without pay up to and including discharge.

The internal audits shall be documented and the records kept on file in the X-Ray Office for a minimum of three years.

Pennsylvania Shipbuilding

MAXIMUM ALLOWABLE RADIOACTIVE SOURCE ACTIVITIES TO BE USED INSIDE RADIOGRAPHIC EXPOSURE LAB



Thickness of wall = 24" concrete

Assume a specific gravity of concrete of 2.35 which equals = 147 lbs./ft^3

Check the attenuation of Gamma Rays through the Lab wall using the T/O Model 866, S/N 325, Ir^{192} source.

Activity on 6. November 1986 = 79.43 ci

The source is located at a distance of 4'-0" from the inside of the Lab wall.

Intensity I_1 = 79.43 x 5.9
= 468.66 R/hr

Calculated intensity at outside wall $I_s = \frac{468.66 \times 9.6 \times 10^{-5}}{6^2}$

= 0.0125 R/hr

= 12.5 m R/hr

Pennsylvania Shipbuilding

In order to verify the construction of the Lab wall, actual exposures were made with the same parameters as used in the calculations above. The source was positioned at locations X_0, X_1, etc, approximately 3'-2" off the ground. The primary radiation beam was directed perpendicular to the concrete wall. The intensities were measured with a Survey Meter Ludlum Model 4, S/N 4124. The maximum intensity observed was 3.6 mR/hr.

Based on above investigations, the following maximum allowable source activities were established.

Distance from inside wall in ft	Iridium 192 W/O Collimation	Iridium 192 With Collimation	Cobalt 60 With Collimation
4	12.7 ci	120 ci	12.7 ci
5	17.3 ci	120 ci	17.3 ci
6	22.6 ci	120 ci	22.6 ci
7	28.6 ci	120 ci	28.6 ci
8	35.3 ci	120 ci	35.4 ci
9	42.7 ci	120 ci	42.8 ci
10	50.8 ci	120 ci	50.9 ci

When using a collimator, the direction of the primary radiation beam must be either straight up or down.

A graph "distance vs. maximum allowable activity" is plotted on page 4.

Pennsylvania Shipbuilding

LIMITS OF RADIOACTIVE SOURCE ACTIVITY IN LAB

Emissivity of Ir^{192}	= 5.9 R/hr/ft/ci
Emissivity of CO^{60}	= 14.5 R/hr/ft/ci
Attenuation factor of Ir^{192} collimator	$= t_1 = 100$
Attenuation factor of CO^{60} collimator	$= t_2 = 60$
Attenuation factor of 24" thick concrete for Ir^{192}	$= t_3 = 9.6 \times 10^{-5}$
Attenuation factor of 24" thick concrete for CO^{60}	$= t_4 = 2.34 \times 10^{-3}$
Maximum radiation intensity of outside Lab	= 0.002 R/hr

d is distance from the source to outstide Lab Wall

Maximum allowable activity for Ir^{192} w/o collimation	$= \frac{0.002}{5.9\ t_3} \times d^2$
Maximum allowable activity for Ir^{192} with collimation	$= \frac{0.002\ t_1}{5.9\ t_3} \times d^2$
Maximum allowable activity for CO^{60} with collimation	$= \frac{0.002\ t_2}{14.5\ t_4} \times d^2$

Form 482-770

CALCULATION SHEET

SUN SHIPBUILDING & DRY DOCK CO.
CHESTER, PA.

PREPARED BY: F. H. Troll

CHECKED BY:

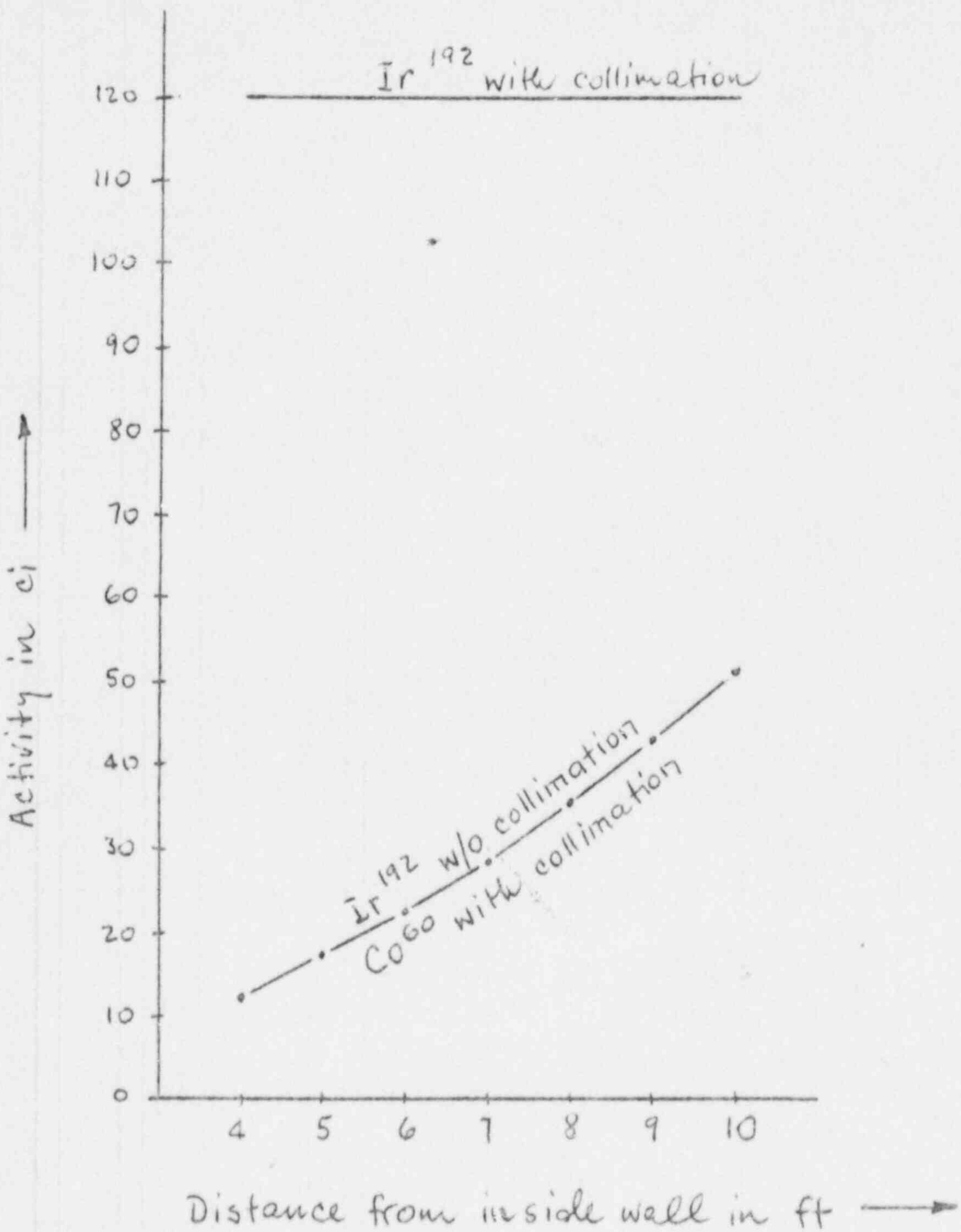
CHARGE PROJ. NO.

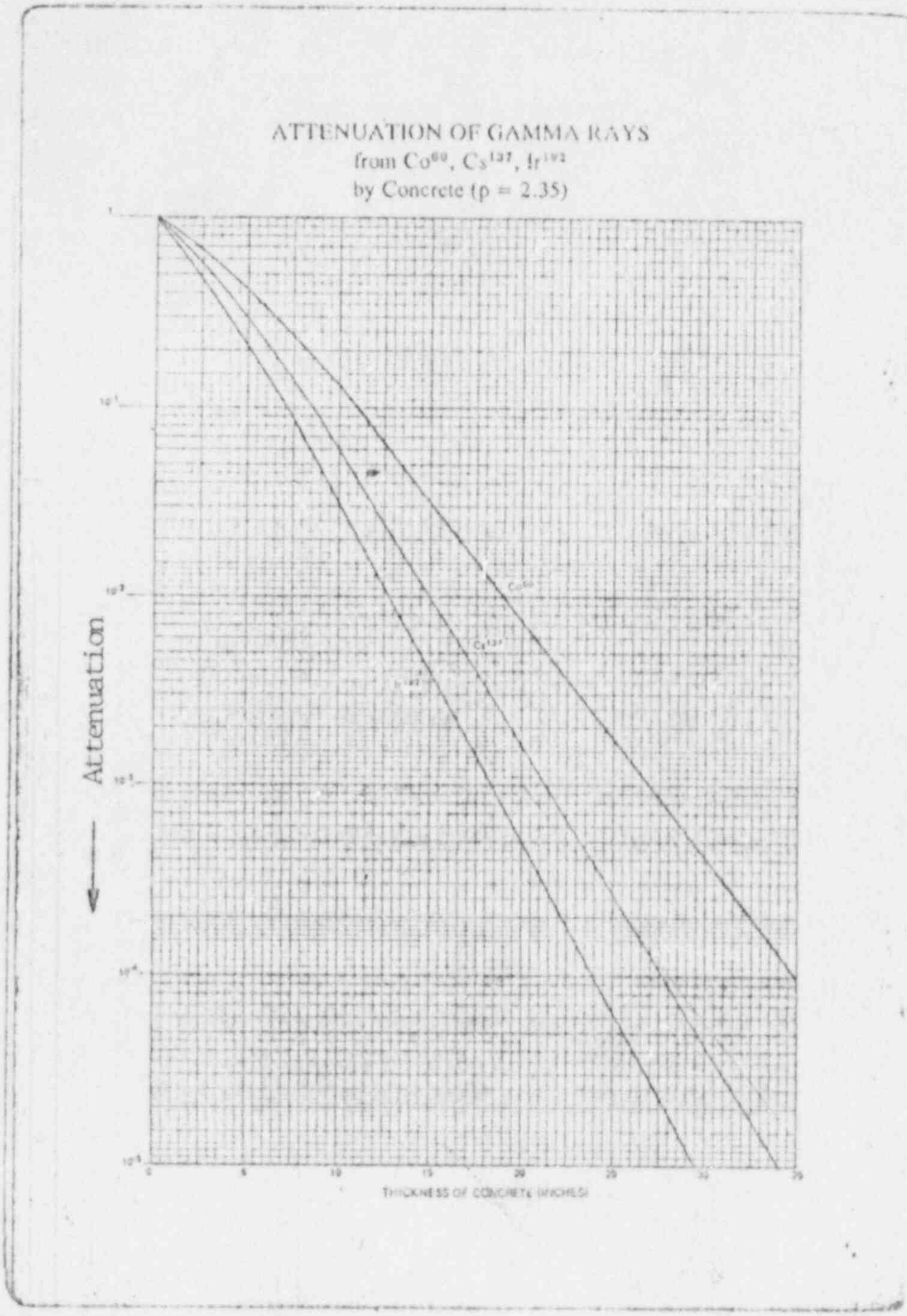
TITLE: Radiographic Exposure Lab

max. allow. source activity vs. distance from source to inside wall

SHEET 4 of 6

DATE 11-5-1986





NOTE: Above table was extracted from the Radiation Safety Handbook

"Isotope Radiography" published by Technical Operations, Inc.

Pennsylvania Shipbuilding

SUMMARY

1. The calculations yield safe operations inside the radiographic exposure lab using Ir^{192} sources up to 120 ci with collimation.
2. For exposing Ir^{192} sources without collimation and CO^{60} sources with collimation see pages 2 and 4.
3. Exposing a CO^{60} radiography source inside the radiographic exposure lab without collimation is not permitted.

03 19732
03310
6/87

BETWEEN: William O. Miller, Chief
License Fee Management Branch
Office of Administration

John E. Glenn, Chief
Nuclear Materials Section B
Division of Engineering and
Technical Programs

LICENSE FEE TRANSMITTAL

A. REGION I

1. APPLICATION ATTACHED

Applicant/Licensee: Pennsylvania Shipbuilding Co.

Application Dated: 2-25-87

Control No.: 106864

License No.: 37-21067-01

2. FEE ATTACHED

Amount: $700

Check No.: 020222

3. COMMENTS

Signed SLJ

Date 3-3-87

B. LICENSE FEE MANAGEMENT BRANCH

1. Fee Category and Amount: 30 $700

2. Correct Fee Paid. Application may be processed for:

Amendment ______

Renewal ✓

License ______

Signed S. Kimberley

Date 3/6/87

REGION I FORM 213
(MARCH 1983)