

MAGNA CHEK, INC.
NONDESTRUCTIVE TESTING LABORATORIES
2125 RIGGS STREET
WARREN, MI 48091
(313) 756-4070

MCI RADIATION SAFETY PROGRAM MANUAL

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MCI RADIATION SAFETY PROGRAM MANUAL

SECTION II - GENERAL INFORMATION

A. Purpose and Scope

Magna Chek, Inc., has established the MCI Radiation Safety Program to provide internal administrative control over the safe operation of its radiographic facilities in accordance with the applicable Nuclear Regulatory Commission Rules and Regulations.

B. Applicable Documents

The following parts of Title 10, Chapter 1, Code of Federal Regulations - Energy, United States Nuclear Regulatory Commission, Rules and Regulations are included at the end of Section II.

1. 10 CFR Part 19 - "Notices, Instructions, and Reports to Workers; Inspections"
2. 10 CFR Part 20 - "Standards for Protection Against Radiation"
3. 10 CFR Part 21 - "Reporting of Defects and Noncompliance"
4. 10 CFR Part 30 - "Rules of General Applicability to Domestic Licensing of Byproduct Material"
5. 10 CFR Part 34 - "Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations"
6. 10 CFR Part 40 - "Domestic Licensing of Source Material"
7. 10 CFR Part 71 - "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions"
8. 10 CFR Part 170 - "Fees For Facilities and Materials Licenses"

C. Definitions - as used in this Manual

1. "Dose" - the amount of radiation absorbed by an object, body, or any part of the body, expressed in units of roentgens, rems, or rads.
2. "Dose Rate" - amount of radiation absorbed per unit of time.
3. "High Radiation Area" - any area, accessible to personnel, where the radiation dose to a person could exceed 100 millirem in any one hour.
4. "Licensed Material" - source material, special nuclear material, or byproduct materials.
5. "Radiation Area" - any area accessible to personnel, where the radiation dose to a person could exceed 5 millirem in any one hour or 100 millirem in any 5 consecutive days.
6. "Radiation Safety Officer (RSO)" - the individual responsible for the administration of the policies and requirements of the MCI Radiation Safety Program.
7. "Radioactive Material" - any material producing Gamma rays.
8. "Radiographer" - any individual who performs or personally supervises radiographic operations in accordance with the requirements of the MCI Radiation Safety Program Manual and is responsible to the licensee for assuring compliance with the NRC Rules and Regulations and conditions of the license.
9. "Radiographer's Assistant" - any individual who, under the direct supervision of a radiographer, uses radiographic exposure devices, sealed sources or radiation survey instruments in radiography.
10. "Radiographic Exposure Device" - any radiation-shielded instrument containing a sealed source fastened or contained therein in which the sealed source may be moved from a shielded position for the purpose of radiographic exposure.
11. "Radiography" - the examination of the structure of materials by utilizing sealed sources or byproduct materials.
12. "Restricted Area" - any area accessible to personnel, where the radiation dose to a person could exceed 2 millirem in any one hour or 100 millirem in any one week.
13. "Sealed Source" - any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material.
14. "Storage Container" - a device in which sealed sources are transported or stored.

USNRC Regulations deleted in this copy

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SECTION III - ORGANIZATIONAL STRUCTURE AND INTERNAL INSPECTION SYSTEM

A. General

Section III describes the organizational structure and internal inspection system by which Magna Chek will control the receipt, possession, and use of licensed radioactive material in accordance with the provisions of the license conditions, applicable Nuclear Regulatory Commission regulations, and MCI Operating and Emergency Procedures.

B. Organizational Structure

The organizational structure of Magna Chek, Inc. pertaining to the Radiography Program is as follows:

1. Corporation
2. President/Radiation Safety Training Director
3. Radiation Safety Officer
4. Radiographer
5. Assistant Radiographer

C. Program Responsibilities

1. President/Radiation Safety Training Director

Duties include the following responsibilities:

- a. overall responsibility of the Radiation Safety Program
- b. establishing and conducting the training program for radiographers and assistant radiographers, and examining and determining competence of radiographic personnel
- c. establishment of a leak test program
- d. establishment of an internal inspection system
- e. development of Operating and Emergency Procedures
- f. establishment of a personnel monitoring program
- g. establishment of a survey meter calibration program
- h. establishment of the recordkeeping system
- i. establishment of procedures for evaluating and reporting defects and noncompliance pursuant to 10 CFR Part 21.

- j. assuming control and instituting corrective action in emergency situations and investigating the cause of incidents and determining necessary preventive action

2. Radiation Safety Officer

Duties include the following responsibilities:

- a. serving as the licensee's liaison officer with the Nuclear Regulatory Commission on license matters
- b. maintaining control of procurement and disposal of licensed material
- c. maintaining up-to-date Operating and Emergency Procedures
- d. maintaining the personnel monitoring program
- e. procuring, maintaining and calibration of radiation survey instruments
- f. assisting the Radiation Safety Training Director in conducting the training program for radiographers and assistant radiographers, and examining and determining competence of radiographic personnel
- g. establishment and maintaining storage facilities
- h. maintaining the leak testing program
- i. maintaining exposure devices, radiography facilities and associated equipment
- j. maintaining the internal inspection system
- k. performing source replacement operations
- l. conducting quarterly inventories and maintaining source utilization records
- m. maintaining the licensee's recordkeeping system
- n. reviewing and ensuring maintenance of those records kept by radiographers and assistant radiographers
- o. assuming control and instituting corrective action in emergency situations and investigating the cause of incidents and determining necessary preventive action
- p. acting in an advisory capacity to the licensee's management and radiography personnel

3. Radiographers and Assistant Radiographers

Duties include the following responsibilities:

- a. reporting of all deficiencies and discrepancies to the Radiation Safety Officer or other management officials
- b. performance of the duties listed in Section VIII of this Manual - MCI Operating and Emergency Procedures

D. Personnel Qualifications

The personnel assigned the duties of maintaining active management control of the Radiation Safety Program shall be qualified radiographers with training in the use of all radiographic equipment used at Magna Chek, and shall have thorough knowledge of management policies, company administrative and operating procedures, and radiation protection safety procedures. The qualifications, training,

and experience of those personnel holding the positions of Radiation Safety Training Director and Radiation Safety Officer are listed at the end of Section III.

E. Internal Inspections

1. Management and the RSO shall conduct unannounced on-the-job inspections of all radiographic personnel at intervals not to exceed 3 months.
2. Management shall conduct an internal inspection/review of records maintained by the RSO at intervals not exceeding 3 months.
3. The Radiation Safety Officer shall inspect the records maintained by radiographers and assistant radiographers on a monthly basis.

F. Recording and Reporting Deficiencies

1. The results of quarterly internal inspections by Management and the RSO shall be recorded on an Internal Inspection Audit Record, and this Record shall be retained for two years. Deficiencies shall be corrected immediately, with additional training required if deemed necessary to ensure the elimination of reoccurrence. Follow-up inspections may be made at the discretion of Management to determine that the discrepancies and/or deficiencies have been satisfactorily resolved.
2. The results of the monthly review of records by the RSO shall be documented on the RSO Records Review Log. Any deficiencies shall be reported to management and reviewed with the personnel involved to eliminate the possibility of their reoccurrence.

QUALIFICATION AND TRAINING SUMMARY

Lawrence E. Jones

Present Position: President & Radiation Safety Training Director

Total Experience: Nuclear Weapons - 2 years
X-rays up to 300 KVP - 19 years
Iridium 192 up to 100 curies - 12 years
Cobalt 60 up to 100 curies - 9 years

Formal Training: USNAS North Island Naval Air Station - San Diego, CA
40 Hrs. Nuclear Weapons Loading School

Technical Operations, Inc. - Burlington, MA
40 Hrs. Radiation Safety Aspects of Isotope Radiography

Technical Operations, Inc. - Burlington, MA
40 Hrs. Administration of Isotope Radiography Safety
Programs Seminar

Past Employment:

Dates *****	Location *****	Work Description *****
11/59 - 11/60	USN 7th Fleet	nuclear weapons loading, fusing timer setting, weapon systems maintenance
07/60 - 11/60	Larpen Test Labs San Diego, CA	X-ray Technician, fixed equipment - aerospace components
11/60 - 10/62	Fairchild Camera & Instrument	X-ray Technician, fixed & portable- aircraft & aerospace components
11/62 - 03/63	X-Ray Industries Detroit, MI	X-ray Technician, fixed - NDT on automotive, aerospace & armor parts
08/63 - 10/71	Magnaflux Corp. Detroit, MI	NDT radiography, X-ray & gamma-ray, Lab & Field - Lab Supervisor, RSO, Radiography Course Instructor
11/71 - present	Magna Chek, Inc. Warren, MI	President & Radiation Safety Train- ing Director - responsible for all radiography in lab & field

QUALIFICATION AND TRAINING SUMMARY

David B. Cardwell

Present Position: Radiation Safety Officer, Radiography Dept. Supervisor

Total Experience: X-rays up to 300 KVP - 6 years
Iridium 192 up to 100 curies - 8 years
Cesium 137 up to 100 mCi - 6 years
Cobalt 60 up to 250 curies - 3 years

Formal Training: 06/76 - Testmaster Inspection Co., Perrysburg, OH
40 Hrs. Radiation Safety in Gamma Radiography

01/78 - EXAM Company, Perrysburg, OH
16 Hrs. Radiation Safety Procedures

06/79 - Technical Operations, Inc. - Burlington, MA
40 Hrs. Radiation Safety Aspects of Isotope Radiography

12/79 - Consumers Power Co. - Jackson, MI
8 Hrs. Radiation Safety in Nuclear Power Plants

01/81 - Consumers Power Co. - Jackson, MI
8 Hrs. Calibration of Radiation Survey Instruments

07/82 - Magna Chek, Inc. - Warren, MI
16 Hrs. Radiation Safety Procedures

05/83 - Technical Operations, Inc. - Burlington, MA
40 Hrs. Administration of Isotope Radiography Safety
Programs Seminar

05/83 - Technical Operations, Inc. - Burlington, MA
16 Hrs. Inspection & Maintenance of Tech/Ops Gamma Ray
Exposure Devices

Continued on next page

QUALIFICATION AND TRAINING SUMMARY

David B. Cardwell - continued

Past Employment:

Dates *****	Location *****	Work Description *****
06/76 - 12/77	Testmaster Insp. Co. Perrysburg, OH	Nondestructive Testing - gamma ray exposure devices (Iridium 192)
01/78 - 01/79	EXAM Company Perrysburg, OH	Nondestructive Testing - gamma ray exposure devices (Iridium 192)
04/79 - 06/82	Consumers Power Co. NDT Laboratory Jackson, MI	Nondestructive Testing - X-ray and gamma ray (Ir 192, Cs 137). Nuclear Power Plant Inspection, assistant RSO - duties included inspection & maintenance of exposure devices, calibration of survey instruments
07/82 - present	Magna Chek, Inc. Warren, MI	Nondestructive Testing - X-ray and gamma ray (Ir 192, Cs 137, Co 60), Radiography Department Supervisor, Radiation Safety Officer

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SECTION IV - DESCRIPTION OF RADIOGRAPHIC FACILITIES

A. Isotope Exposure Area

1. General Description

The temporary exposure cell is located within the Magna Chek building at 2125 Riggs Street in Warren, Michigan. Figure 1 at the end of Section IV is an overall view of the exposure cell and shows the location and dimensions of the existing walls, door and Isotope Storage Area located inside the exposure cell. Figure 2 at the end of Section IV is an overall view of the Magna Chek building and shows the orientation of the exposure cell and the surrounding areas in relation to the entire building. Because the cell is a temporary exposure site, it and the surrounding areas (if necessary) must be posted accordingly and kept under direct surveillance at all times during radiographic operations by a qualified radiographer.

2. Safety Features

The exposure cell is equipped with a Tech/Ops Model 492D Gammalarm which flashes a red warning light inside the cell whenever the radiation levels inside the exposure cell exceed 2 mR/hr. This alarm is connected to red warning lights outside the exposure cell above the door which also flash if the radiation levels inside the exposure cell exceed 2 mR/hr. A switch connecting an audible alarm to the Gammalarm is activated whenever the exposure cell door is opened when the Gammalarm is in the red warning mode. An electrical safety and door interlock system operates whenever the Picker Model 590 Cobalt 60 exposure device is utilized. The Picker 590 exposure device will not operate unless ALL of the following conditions are met:

- 1) the exposure cell door is closed
- 2) the main power to the Picker control panel is "on"
- 3) the control panel timer is set and the timer switch is "on"
- 4) the exposure key switch on the control panel is activated.

If any of the switches or connections listed above are opened before an exposure, the Picker 590 shutter will remain closed. If the door is opened or if a power failure interrupts electricity to the control panel during an exposure, the Picker 590 shutter will automatically close to the safe shielded position.

3. Exposure Cell Walls

Solid concrete blocks measuring 8" x 8" x 16" or 8" x 8" x 8" were used in the cell construction and have a density of 135 pounds per cubic foot. The walls measure ten feet high and vary from two to three feet in thickness, as shown in Figure 1. Internal surfaces of the walls near the cell door are posted with "CAUTION - HIGH RADIATION AREA" signs. External wall surfaces are posted with "CAUTION - RADIATION AREA" signs. When necessary, additional surrounding areas are posted as restricted areas during radiographic operations.

4. Exposure Cell Door

The purpose of the exposure cell door is to prohibit unauthorized entry into the area, provide protection from scattered radiation and provide an exit during an emergency. The door is kept locked at all times when not under the direct surveillance of a qualified radiographer, and keys are issued only to qualified radiographers. The door is equipped with two safety features as described above in Part A.3 of this section. The door is posted with three types of signs: "CAUTION - HIGH RADIATION AREA", "CAUTION - RADIATION AREA" and "CAUTION - RADIOACTIVE MATERIALS".

5. Exposure Cell Roof

The roof of the building is twenty feet high and there exists no permanent means of access to the roof except by portable ladders, access to which are controlled by the Radiation Safety Officer. There is a High Radiation Area barrier erected on the roof above the exposure cell area, the boundaries of which are ten feet away from the inside faces of the exposure cell walls. This boundary is posted with "CAUTION - HIGH RADIATION AREA" signs. There is a Restricted Area barrier along the perimeter of the roof of the building, posted with "CAUTION - RADIATION AREA" signs. Prior to radiographic operations, a visual check is made to ensure that no personnel are on the roof subject to possible radiation exposure.

B. Isotope Storage Area

The permanent facility for storage of radiographic exposure devices, storage containers, calibration devices, and other isotope equipment is located within the Magna Chek building at 2125 Riggs Street in Warren, Michigan. The isotope storage vault is located inside the temporary exposure cell as shown in Figure 1 at the end of Section IV. The exposure cell access doors are locked at all times when not under the direct surveillance of a radiographer. The isotope storage vault located inside is constructed of 1/8" steel walls with 1/4" lead shielding used to keep maximum radiation levels at the outside surface of the vault below 2 mr/Hr. The vault is also padlocked to prevent access to unauthorized personnel. The door and sides of the isotope storage vault are posted with "CAUTION - RADIOACTIVE MATERIAL" signs which are yellow and magenta and show the radiation symbol. The outside of the exposure cell itself has similar signs posted reading "CAUTION - RADIOACTIVE MATERIAL" and "CAUTION - RADIATION AREA".

FIGURE 1
EXPOSURE CELL

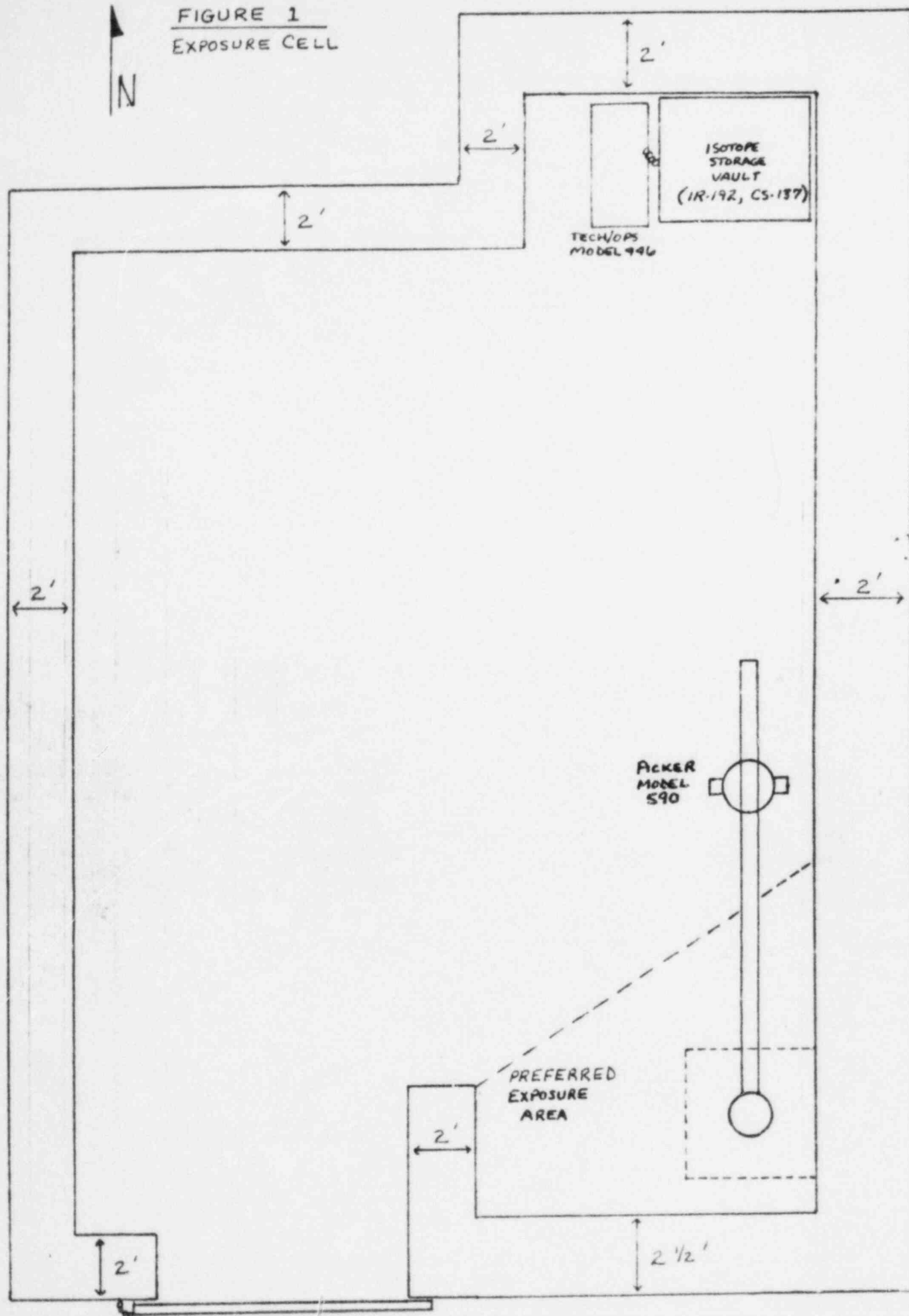
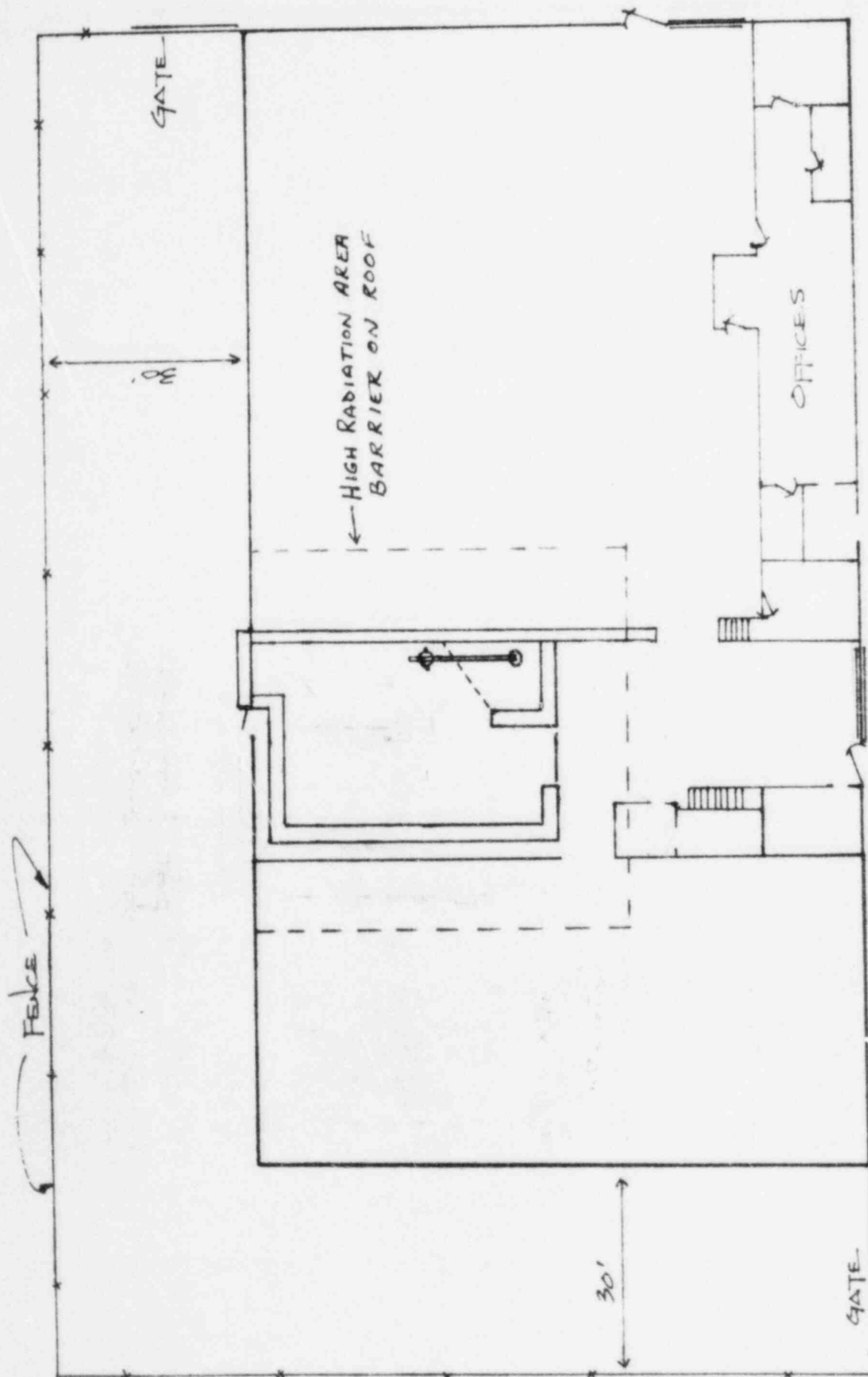
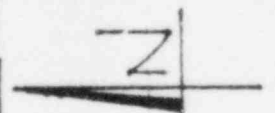


FIGURE 2



MAGNA COKER, INC.
WARREN, MICHIGAN
MAGNA COKER BUILDING AND
SURROUNDING FACILITIES
NO SCALE

PAGE STREET



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SECTION V - RADIATION SAFETY TRAINING PROGRAM

A. General

The Radiation Safety Training Program is designed to assure the technical competence and knowledge of safety procedures of those personnel performing isotope radiography at Magna Chek. Personnel engaged in isotope radiography shall be designated as either Trainees, Assistant Radiographers, or Radiographers, and are under the supervision of the Radiation Safety Officer.

B. Initial Training

1. Training of individuals to be Assistant Radiographers

a. classroom training - 16 hours, divided as follows:

- 1) General Principles - Radiation Physics (2.0 hours)
- 2) Effects of Radiation (2.0 hours)
- 3) Radiation Detection and Measurement (2.0 hours)
- 4) NRC Rules and Regulations (2.0 hours)
- 5) MCI Operating and Emergency Procedures (8.0 hours)

b. on-the-job training - 1 week, covering the following subjects:

- 1) Proper Use of Survey Instruments
- 2) Posting and Surveillance of Radiation Boundaries
- 3) Operation of Tech/Ops 660 Iridium 192 Exposure Device
- 4) Operation of Tech/Ops 446 Cobalt 60 Exposure Device
- 5) Operation of Picker 590 Cobalt 60 Exposure Device

c. examinations

- 1) written examination - in order to qualify as an Assistant Radiographer, the Trainee shall be given a written examination upon completion of the classroom and on-the-job training. This exam will emphasize the content of the classroom instruction and the importance of strict adherence to the MCI Operating and Emergency Procedures. This exam shall consist of a minimum of 25 questions, and shall

require a passing grade of at least 75 %. Any incorrect answers shall be reviewed with the Trainee to ensure he understands the material. A typical Assistant Radiographer Exam is included at the end of Section V.

- 2) practical examination - upon successful completion of the written examination, the Trainee shall demonstrate a working knowledge of survey techniques, boundary posting, equipment operation, and emergency procedures to the satisfaction of the RSO or Training Director.

2. Training of Assistant Radiographers to be Radiographers

a. classroom training - 40 hours, divided as follows:

- 1) Duties and responsibilities of radiographers (1.0 hour)
- 2) USNRC Rules and Regulations (2.0 hours)
- 3) MCI Operating and Emergency Procedures (6.0 hours)
- 4) Fundamentals of Radiation Safety (4.0 hours)
 - a. characteristics of gamma radiation
 - b. units of radiation dose and quantity of radioactivity
 - c. hazards of exposure to radiation
 - d. levels of radiation from licensed material
 - e. methods of controlling radiation dose
- 5) Radiation Detection Instruments (3.0 hours)
 - a. use of radiation survey meters
 - b. survey techniques
 - c. use of film badges and dosimeters
- 6) Operation of Radiographic Exposure Devices (8.0 hours)
 - a. Tech/Ops 660 Iridium 192 Exposure Device
 - b. Tech/Ops 726 Cesium 137 Exposure Device
 - c. Tech/Ops 446 Cobalt 60 Exposure Device
 - d. Picker 590 Cobalt 60 Exposure Device
- 7) Inspection, Maintenance and Calibration (5.0 hours)
 - a. inspection and maintenance of exposure devices
 - b. leak testing of radioactive sealed sources
 - c. calibration of survey instruments and dosimeters
 - d. source changing instructions and procedures
- 8) Transportation and Storage Procedures (2.0 hours)
- 9) Radiographic Field Locations (3.0 hours)
- 10) Case Histories of Radiography Accidents (2.0 hours)
- 11) Reporting of Defects and Noncompliance (1.0 hour)
- 12) Recordkeeping requirements (3.0 hours)

b. on-the-job training - 3 months, during which time the prospective radiographer shall witness the operation of radiographic exposure devices and related equipment by a qualified radiographer and shall personally use such devices and equipment under the direct supervision of a radiographer. He shall demonstrate proficiency in the following areas:

- 1) use of personnel monitoring devices
- 2) radiation survey techniques
- 3) posting and surveillance of radiographic sites
- 4) operation of Tech/Ops 660 Iridium 192 Exposure Device

- 5) operation of Tech/Ops 446 Cobalt 60 Exposure Device
- 6) operation of Picker 590 Cobalt 60 Exposure Device
- 7) operation of Tech/Ops 726 Cesium 137 Exposure Device
- 8) calibration of Survey Instruments and Dosimeters
- 9) leak testing of sealed sources - swab samples
- 10) emergency procedures
- 11) recordkeeping requirements

This training will be supervised by the Radiation Safety Officer. The prospective radiographer shall observe at least 40 radiographic operations performed by qualified radiographers and shall perform at least 20 radiographic operations under the direct supervision of a qualified radiographer.

c. examinations

- 1) written examination - in order to qualify as a Radiographer, the candidate shall be given a written examination upon completion of the classroom and on-the-job training. This exam will consist of 50 questions, with a minimum passing score of 80 %. Emphasis of the exam will be on the safety aspects of radiography and the Radiation Safety Officer will have the discretion to decide whether certain key areas of the examination must be answered correctly in order to pass the exam, regardless of whether the test score is 80 % or higher. All incorrect answers will be reviewed to ensure the candidate understands the material covered. A typical Radiographer Exam is included at the end of Section V.
- 2) practical examination - upon successful completion of the written examination, the candidate shall demonstrate his knowledge and proficiency of the subjects covered in the training to the satisfaction of the Radiation Safety Officer. A sample Practical Exam Checklist is included at the end of Section V.

3. New employees with radiographic experience

Magna Chek will take the following measures before assigning new employees to radiographic operations, regardless of previous work history:

- a. Record work experience, previous training, and radiation history. Substantiate by telephone contact with previous employer, if possible.
- b. Train employee in MCI Operating and Emergency Procedures and use of specific radiographic equipment utilized at Magna Chek (survey instruments, exposure devices, etc.)
- c. Administer written and practical exams. The extent of any additional training necessary will be determined by the RSO or Training Director.

C. Periodic Training

1. Periodic training classes shall be given to update radiographic personnel annually or when changes are made concerning any of the following areas:
 - a. revision of the MCI Radiation Safety Program
 - b. revision of the MCI Operating and Emergency Procedures
 - c. changes in any applicable USNRC Rules and Regulations
 - d. changes or additions to radiographic equipment, survey instruments, or policies
 - e. other circumstances dictating a need for additional training of radiographic personnel
2. This training will be conducted by the RSO or Training Director to ensure continued knowledge and proficiency in all areas of the Radiation Safety Program. This training will be followed by a written quiz designed to cover the topics discussed during the training class.

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NAME.....
DATE.....
SCORE.....

RADIATION SAFETY EXAMINATION - ASSISTANT RADIOGRAPHER

TEST NO. RS-01-AR

1. Gamma and X-radiation damage human body tissue by a process known as
2. When a body tissue cell is damaged by radiation,:
 - a) the cell may lose its ability to reproduce.
 - b) the cell may die.
 - c) damage is caused by knocking an electron out of the orbit of its parent atom.
 - d) all of the above.
3. The basic difference between X-rays and Gamma rays is:
 - a) their RBE.
 - b) their origin.
 - c) their ability to damage cells of human tissue.
 - d) that Gamma rays are electromagnetic radiation.
4. Radiation hazard to humans exists from:
 - a) natural radiation.
 - b) primary and scattered radiation.
 - c) primary beams only.
 - d) all types of radiation except electromagnetic radiation.
5. Materials exposed to Gamma rays and X-rays become radioactive and dangerous to handle.

True () False ()
6. The most penetrating radiation from radionuclides is:
 - a) Beta particles.
 - b) Alpha particles.
 - c) Gamma rays.
 - d) X-rays.

7. Radioactive (or physical) half-life is:

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

8. If your pocket dosimeter is found to be completely discharged (off scale), you should:

- a) consider the dosimeter to be faulty and ask the RSO for another dosimeter.
- b) rezero the dosimeter and continue to work until you can notify the RSO.
- c) stop radiographic operations immediately and notify the RSO at once.
- d) mail your film badge to Landauer to see if an overexposure has occurred.

9. Assistant Radiographers must:

- a) pass a training course and written examination in order to work with radioactive materials.
- b) always be under the direct supervision of a Radiographer when working with radioactive sources.
- c) wear personnel monitoring devices when in radiation areas.
- d) comply with all of the above statements.

10. The roentgen is a measure of:

- a) Alpha radiation.
- b) X-rays and Gamma rays.
- c) radiation damage to human cells.
- d) all of the above.

11. The exposure of one roentgen of Gamma radiation equals an absorbed dose of one rad.

True () False ()

12. The whole-body radiation dose must normally be limited to a dose of:

- a) 1.25 rems per calendar quarter.
- b) 18.75 rems per calendar quarter.
- c) 7.5 rems per calendar quarter.
- d) 5 rems per calendar quarter.

13. The most serious radiation exposure is to the:
- a) whole body.
 - b) feet and ankles.
 - c) skin.
 - d) hands and forearms.
14. A person who is 10 years old would be subject to greater radiation damage from a given exposure than a person age 27.
- True () False ()
15. A person must be years old to be allowed to work in a radiation area.
16. Name the three most widely used methods of reducing radiation exposure to radiation workers.
- a)
 - b)
 - c)
17. The formula for finding permissible accumulated dose is
- a) $12 (N-18)$
 - b) $18 (5+18)$
 - c) $5 (N-18)$
 - d) $12 (N+18)$
18. Some body cells are more sensitive to radiation than others.
- True () False ()
19. The earliest indications of radiation damage may be detected in the:
- a) nerve cells.
 - b) bone cells.
 - c) skin cells.
 - d) blood cells.
20. The MLD for humans is the radiation dose:
- a) that causes the first death.
 - b) that causes slight, temporary blood changes.
 - c) that is considered lethal to all persons exposed.
 - d) that caused 50% of those exposed to die.

21. Portable instruments used to monitor radiation areas are called:
- a) film badges.
 - b) survey meters.
 - c) personnel monitoring devices.
 - d) area meters.
22. Devices attached to the clothing of people working in radiation areas for measurement of radiation are called:
- a) survey instruments.
 - b) G-M counters.
 - c) personnel monitoring devices.
 - d) portable rate meters.
23. The normal operating range of a pocket dosimeter is:
- a) 0 to 200 mr.
 - b) 0 to 75 r/hr.
 - c) 50 to 500 mr.
 - d) 25 to 250 r.
24. The film badge operates on the principle that film is exposed by:
- a) light.
 - b) ionizing radiation.
 - c) heat.
 - d) Alpha particles.
25. Radiation intensity at 5 feet from an isotope is 40 R/hr. At what distance would the intensity be reduced to 10 R/hr?

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RADIATION SAFETY EXAMINATION - ASSISTANT RADIOGRAPHER

TEST NO. RS-01-AR - ANSWER SHEET

- | | |
|---------------|-------------------------------|
| 1. IONIZATION | 14. TRUE |
| 2. D | 15. 18 |
| 3. B | 16. TIME, DISTANCE, SHIELDING |
| 4. B | 17. C |
| 5. FALSE | 18. TRUE |
| 6. C | 19. D |
| 7. A | 20. D |
| 8. C | 21. B |
| 9. D | 22. C |
| 10. B | 23. A |
| 11. TRUE | 24. B |
| 12. A | 25. 10 FEET |
| 13. A | |

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PRACTICAL EXAM - ASSISTANT RADIOGRAPHERS

NAME: EXAMINER:
DATE: REVIEW RESULTS:
SCORE:

AREAS OF EXAMINATION	RESULTS/REMARKS
1) Proper use of personnel monitoring devices
2) Proper use of radiation survey techniques
3) Posting and surveillance of radiation boundaries
4) Daily inspection procedures (exposure devices)
5) Operation of Tech/Dps 660 Ir 192 exposure device
6) Operation of Tech/Dps 446 Co 60 exposure device
7) Operation of Picker 590 Co 60 exposure device
8) Knowledge of emergency procedures
9) Knowledge of NRC Rules & Regulations
10) Recordkeeping requirements

MAGNA CHEK, INC.
2125 RIGGS STREET
WARREN, MI 48091

NAME.....
DATE.....
SCORE.....

RADIATION SAFETY EXAMINATION - RADIOGRAPHER

TEST NO. RS-01-R

1. Gamma and X-radiation damage human body tissue by a process known as:
.....

2. A person who becomes exposed to radiation can spread contamination to other personnel.

True () False ()

3. The primary radiation hazard in radiography comes from:

- a) internal contamination.
- b) gamma rays and Alpha particles.
- c) Beta particles.
- d) external radiation exposure.

4. The basic unit of measurement used to express gamma or x-ray exposure to humans is the:

- a) roentgen.
- b) curie.
- c) becquerel.
- d) MLD.

Give the definitions to the following:

5. MLD -
.....

6. Collimator -
.....

7. Radioactive decay -

8. Curie -
.....
9. Roentgen -
.....
10. What is the difference between "mR" and "R" ?
.....
11. What is the approximate half-life of Iridium 192?
.....
12. What is the maximum amount of curies that a Tech/Ops Model 660 Iridium 192 exposure device may contain per Magna Chek's NRC license?
.....
13. What is the source of the majority of an average citizen's radiation exposure?
.....
14. The whole-body radiation dose must normally be limited to a maximum dose of:
a. 1 1/4 rems per calendar quarter.
b. 18 3/4 rems per calendar quarter.
c. 5 rems per calendar quarter.
d. 20 millirem per working day.
15. If your pocket dosimeter is found to be completely discharged (off scale), you should:
a) consider the dosimeter to be faulty and ask the RSO for another dosimeter.
b) rezero the dosimeter and continue to work until you can notify the RSO.
c) stop radiographic operations immediately and notify the RSO at once.
d) mail your film badge to Landauer to see if an overexposure has occurred.

16. Radiographers must:

- a) pass a training course and written examination in order to work with radioactive materials.
- b) always be under the direct supervision of a the Radiation Safety Officer when working with radioactive sources.
- c) wear personnel monitoring devices only when in High Radiation Areas.
- d) comply with all of the above statements.

17. A given radiation dose will cause less damage if it is received over a very short period of time than if it is received over a much longer period of time.

True ()

False ()

18. The most serious radiation exposure is to the:

- a) whole body.
- b) feet and ankles.
- c) skin.
- d) hands and forearms.

19. The radiation effects which can be passed on to the offspring or to a later generation of a person receiving radiation are called:

- a) future effects.
- b) genetic effects.
- c) somatic effects.
- d) radiocentric effects.

20. Name the three most widely used methods of reducing radiation exposure to radiation workers.

- a)
- b)
- c)

21. The formula for finding permissible accumulated dose is

- a) $12 (N-18)$
- b) $18 (5+18)$
- c) $5 (N-18)$
- d) $12 (N+18)$

22. The earliest indications of radiation damage may be detected in the:
- a) nerve cells.
 - b) brain cells.
 - c) skin cells.
 - d) blood cells.
23. Portable instruments used to monitor radiation areas are called:
- a) film badges.
 - b) survey meters.
 - c) personnel monitoring devices.
 - d) area meters.
24. Devices attached to the clothing of people working in radiation areas for measurement of radiation are called:
- a) survey instruments.
 - b) G-M counters.
 - c) personnel monitoring devices.
 - d) portable rate meters.
25. Survey meters provide:
- a) protection against harmful radiation.
 - b) radiation exposure rate measurements.
 - c) an excuse to be in a Restricted Area.
 - d) only readings of gamma radiation.
26. Pocket dosimeters work using a:
- a) quartz fiber electroscope.
 - b) G.M. tube.
 - c) nuclear fission principle.
 - d) small battery for a power source.
27. Name two advantages of using a film badge for personnel monitoring.
- a)
 - b)
28. The pocket dosimeter has the advantage of:
- a) being more accurate than a film badge.
 - b) providing a permanent record of exposure.
 - c) providing an immediate reading of exposure.
 - d) all of the above.

29. The distance to the Restricted Area boundary for an unshielded 100 curie Iridium 192 unshielded source is:

.....

30. The inverse square law as applied to radiation theory states that:

- a) radiation intensity varies inversely as the square of the time spent near the source.
- b) radiation intensity varies proportionally with the distance from the source.
- c) radiation intensity varies inversely as the square of the distance from the source.

31. How often must survey meters be calibrated?

.....

32. What are the limitations of an Assistant Radiographer?

.....

.....

33. What is the maximum length of source guide tube that can be attached to a Tech/Ops Model 660 or Model 446 exposure device? Why?

.....

.....

34. What is the maximum permissible radiation levels at a Restricted Area boundary during radiographic operations?

.....

35. Name the two common types of survey meter instruments.

a)

b)

36. Name the five parts of the NRC Rules and Regulations that apply to radiographic operations.
- a)
 - b)
 - c)
 - d)
 - e)
37. If the radiation intensity of an isotope is 22 R/hr at 10 feet, what is the radiation intensity at 100 feet?
- a) 2.2 mR/hr
 - b) 11 R/hr
 - c) 220 mR/hr
 - d) none of the above
38. If a 20 curie Iridium 192 source requires a 10 minute exposure time to penetrate 2 inches of steel, what is the distance to the High Radiation Area boundary?
-
39. What is the most common factor causing radiation overexposures?
-
40. When repeated surveys show no change in the radiation levels of an exposure device, there is no need for further time-wasting surveys.
- True () False ()
41. When an source becomes stuck outside the exposure device, you should:
- a) run for your life.
 - b) immediately telephone the RSO.
 - c) establish and maintain a restricted area boundary.
 - d) try to replace the source in storage by hand.
42. What are the maximum radiation levels for a radioactive package during transport?
-

43. How often are sealed sources required to be leak tested?

.....

44. What four documents must be filled out when performing radiographic operations?

a.

b.

c.

d.

45. What four things must you have present in order to perform radiographic operations?

a)

b)

c)

d)

46. Who is responsible for the safe operation of exposure devices?

.....

47. Touching or almost touching a radiographic source for only a few seconds can cause radiation burns.

True () False ()

48. After receiving an extremely high radiation dose (400 to 500 rems),:

a) workers develop a tolerance to lower radiation levels.

b) death can follow within days.

c) no noticeable symptoms should appear.

d) workers should be kept away from film due to the high radiation levels they are emitting.

49. Using a Cobalt 60 source, you use your survey meter to measure a dose rate of 5 mR/hr at 50 feet from the source. Where should you post the Restricted Area Boundary if you desire a 2 mR/hr radiation level at the boundary?

.....

50. What is the most important thing you can do to avoid an overexposure to radiation?

- a) Always wear the personnel dosimetry provided.
- b) Always make proper radiation surveys.
- c) Request that an audible alarm be provided for use.
- d) Keep a daily log of pocket dosimeter readings.

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RADIATION SAFETY EXAMINATION - RADIOGRAPHER

TEST NO. RS-01-R - ANSWER SHEET

1. Ionization
2. False
3. D
4. A
5. Mean Lethal Dose - the radiation dose that would kill half of those persons exposed within 30 days (400 to 500 rem acute dose)
6. A device used to confine the radiation beam within an assigned angle
7. Disintegration of the nucleus of an unstable nuclide by spontaneous emissions of charged particles and/or photons.
8. Basic unit to describe the intensity or strength of a radioactivity in a material; a measure of the rate at which a radioactive material throws off particles or disintegrates.
9. Unit of radiation dose; unit of exposure to ionizing radiation.
10. There are 1000 milliroentgens in 1 roentgen.
11. 74 days
12. 120 curies
13. Natural radiation
14. A
15. C
16. A
17. False
18. A
19. B
20. Time, distance, shielding
21. C
22. D
23. B
24. C
25. B
26. A
27. - provides a permanent record of exposure
- is readily available
- able to distinguish between different energies of radiation
- quite accurate for exposures greater than 100 mRem
- little image fading as a function of age
- can record a wide range of dosages
28. C
29. 543 feet
30. C

TEST NO. RS-01-R - ANSWER SHEET (CONTINUED)

31. At intervals not exceeding 3 months and after instrument servicing.
32. Must be under the direct supervision of a Radiographer when working with or around radioactive materials or exposure devices.
33. 21 feet (3 guide tube sections), because any longer source travel allowed could result in the drive cable disconnecting from the crank-out assembly, making retrieval of the source difficult or dangerous.
34. 2 mR/hr
35. a) Geiger-Muller tube
b) ionization chamber
36. a) 10CFR Part 19 - Notices, Instructions and Reports to Workers, Inspections
b) 10CFR Part 20 - Standards for Protection Against Radiation
c) 10CFR Part 21 - Reporting of Defects and Noncompliance
d) 10CFR Part 34 - Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations
e) 10CFR Part 71 - Packaging of Radioactive Material for Transport
37. C
38. 34.4 feet
39. improper radiation surveys
40. False
41. C
42. a) Less than 200 mR/hr at the surface
b) Less than 10 mR/hr at 1 meter from the surface
43. at intervals not to exceed 6 months
44. a) Daily Inspection Checklist
b) Radiographic Utilization Record
c) Isotope Sign-Out Log
d) Dosimeter Record
45. a) film badge
b) dosimeter
c) survey meter
d) Operating and Emergency Procedures
46. Radiographer
47. True
48. B
49. 79 feet
50. B

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PRACTICAL EXAM - RADIOGRAPHERS

NAME: EXAMINER:
DATE: REVIEW RESULTS:
SCORE:

AREAS OF EXAMINATION	RESULTS/REMARKS
1) Proper use of personnel monitoring devices
2) Proper use of radiation survey techniques
3) Posting and surveillance of radiation boundaries
4) Operation of Tech/Ops 660 Ir 192 exposure device
5) Operation of Tech/Ops 446 Co 60 exposure device
6) Operation of Picker 590 Co 60 exposure device
7) Operation of Tech/Ops 726 Cs 137 exposure device
8) Inspection and maintenance of exposure devices
9) Leak testing of radioactive sealed sources
10) Calibration of survey instruments and dosimeters
11) Source changing procedures
12) Knowledge of emergency procedures
13) Recordkeeping requirements

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MCI RADIATION SAFETY PROGRAM MANUAL

SECTION VI - RADIATION DETECTION AND PERSONNEL MONITORING SYSTEM

A. Survey Meters

Survey meters shall be capable of measuring from a minimum of two milliroentgens per hour through one roentgen per hour, and shall be calibrated as stated in Section VI, Part D.1. The types of survey meters to be used to conduct radiation surveys at Magna Chek are listed below:

Manufacturer & Model *****	Meter Type *****	Instrument Ranges *****
Victoreen Corp. 592B	ion chamber	0-10, 0-100, 0-1000 mR/hr
Victoreen Corp. 492	G.M. tube	0-10, 0-100, 0-1000 mR/hr
Eberline Corp. E-120B	G.M. tube	0-10, 0-100, 0-1000 mR/hr
Gamma Industries 250B	G.M. tube	0-10, 0-100, 0-1000 mR/hr

B. Dosimeters

Dosimeters shall have a range from zero to at least 200 milliroentgens, and shall be checked for accuracy as stated in Section VI, Part D.1. The types of dosimeters in use at Magna Chek are listed below:

Manufacturer *****	Model *****	Range *****
Victoreen Corporation	541A	0-200 mR
Victoreen Corporation	541R	0-200 mR
Dosimeter Corp. of America	862	0-200 mR
Landsverk Corp.	IM-9F/PD	0-200 mR

C. Film Badges

Magna Chek contracts a monthly film badge service for personnel monitoring. This service is provided by R.S. Landauer, Jr. & Co., Glenwood Science Park, Glenwood, IL 60425

D. Calibration of Survey Meters and Dosimeters

Survey meter and dosimeter calibration procedures are found in Section VIII of this Manual - MCI Operating and Emergency Procedures.

1. Frequency of calibration

- a. Survey meters shall be calibrated at intervals not to exceed 3 months and after each instrument servicing.
- b. Dosimeters shall be checked at intervals not exceeding 1 year for correct response to radiation, accuracy, and drift. They shall also be rechecked after the dosimeter reading has gone off scale for any reason.

2. Equipment

Calibration of survey meters and dosimeters at Magna Chek shall be performed using a Tech/Ops Model 726 Meter Calibration Kit, which contains a Cesium 137 sealed source, maximum 100 millicuries.

3. Personnel Qualifications

Survey meter and dosimeter calibration procedures shall be performed by qualified radiographers whose training is outlined in Section V of this Manual.

4. Outside Agencies

Calibration by companies other than Magna Chek, Inc., shall be performed by one of the following:

- a. Technical Operations, Inc.
Radiation Products Division
40 North Avenue
Burlington, MA 01803
- b. The survey meter manufacturer or its designated area service center:
 - 1) Victoreen Corporation
 - 2) Gamma Industries
 - 3) Eberline Corporation

E. Leak Testing of Sealed Sources

Leak testing procedures are found in Section VIII of this Manual - MCI Operating and Emergency Procedures.

1. Frequency of testing

Sealed sources shall be tested for leakage and contamination at intervals not to exceed six months.

2. Equipment

Leak testing of sealed sources shall be done using one of the following commercial leak test kits:

- a. Tech/Ops Leak Test Kit Model 518.
- b. Gamma Industries Kowipe Leak Test Kit.

3. Personnel Qualifications

Leak testing procedures shall be performed by qualified radiographers whose training is outlined in Section V of this Manual.

4. Test Smear Evaluation

- a. evaluation of leak test smears obtained using the Tech/Ops Leak Test Model 518 shall be performed by Tech/Ops, Inc., Radiation Products Division, 40 North Avenue, Burlington, MA
- b. evaluation of leak test smears obtained using the Gamma Industries Kowipe Leak Test Kit shall be performed by Gamma Industries, 2255 Ted Dunham Avenue, Baton Rouge, LA.

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SECTION VI: - SAMPLE FORMS AND DOCUMENTS

A. Forms Maintained by Management/RSO

1. Isotope Quarterly Inventory Record
2. Dosimeter Calibration & Assignment Log
3. Survey Meter Calibration & Assignment Log
4. Isotope Shipping & Receiving Log
5. Internal Inspection Audit Record
6. RSO Records Review Log
7. Notification Records

B. Forms Maintained by Radiographers

1. Isotope Sign-Out Log
2. Radiographic Utilization Record
3. Daily Inspection Checklist
4. Notification Record
5. Dosimeter Record
6. Survey Meter Calibration Certificate/Worksheet
7. Dosimeter Calibration Certificate/Worksheet
8. Tech/Ops 51B Leak Test Form
9. Gamma Industries Kowipe Leak Test Form
10. Radioisotope Receiving Record
11. Quarterly Maintenance & Inspection Record

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ISOTOPE QUARTERLY INVENTORY RECORD - ... Quarter, 1984

DATE PERFORMED: PERFORMED BY:

Isotope	Source S/N	Exposure Device Model & S/N	Storage Location	Activity
Ir 192	Tech/Ops 660, S/N 2866	.....	.. Curies
Ir 192	Tech/Ops 660, S/N 2333	.....	.. Curies
Co 60	Tech/Ops 446, S/N 60 Curies
Co 60	Picker Cyclops 590, S/N 102 Ci.
Cs 137	Tech/Ops 726, S/N 172 mCi

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DOSIMETER CALIBRATION & ASSIGNMENT LOG

REV. DATE - 11/29/84

Dosimeter Make/Model	S/N	50 mR	150 mR	Cal. Date	Due Date	Assigned To:
Dosimeter Corp. 862	706721	45	142	09/19/84	12/19/84	L.E. Jones
Dosimeter Corp. 862	9120918	50	142	09/19/84	12/19/84	R. Tomasek
Victoreen 541 R	6513C	54	172	09/19/84	12/19/84	D. Cardwell
Victoreen 541 R	66214	55	159	09/19/84	12/19/84	W. Singleton
Victoreen 541 R	7453C	37	120	11/29/84	02/28/85	J. Abusalah
Victoreen 541 R	8295C	45	136	09/19/84	12/19/84	T. Diroff
Victoreen 541 R	8713A	42	135	09/19/84	12/19/84	D.J. Walker
Victoreen 541 R	8730A	35	105	11/29/84	02/28/85	R. Murray
Landsverk IM-9F/PD	06089	58	158	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	11008	56	145	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	13567	55	145	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	14370	60	165	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	18094	52	155	11/29/84	02/28/85	spare
Landsverk IM-9F/PD	28186	63	148	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	28839	62	158	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	32208	52	152	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	56650	60	150	11/28/84	02/28/85	spare
Landsverk IM-9F/PD	65051	60	160	11/28/84	02/28/85	spare

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SURVEY METER CALIBRATION AND ASSIGNMENT LOG

REV. DATE - 11/27/84

Survey Meter Make/Model	Serial No.	Cal. Date	Due Date	Assignment/Status
Eberline E-120G	2645	11/27/84	2/27/85	Magna Chek Lab
Eberline E-120G	2646	9/19/84	12/19/84	Magna Chek Lab
Gamma Industries 250B	2249	9/19/84	12/19/84	Magna Chek Lab
Victoreen 492	650	9/19/84	12/19/84	Magna Chek Lab
Victoreen 492	4917	METER NEEDS REPAIR		NOT IN SERVICE
Victoreen 592B	1734	METER NEEDS REPAIR		NOT IN SERVICE
Victoreen 592B	3170	METER NEEDS REPAIR		NOT IN SERVICE
Victoreen 592B	3953	11/27/84	2/27/85	Aero Inspection
Victoreen 592B	4694	METER NEEDS REPAIR		NOT IN SERVICE

Refer to individual Survey Meter Calibration Forms for Meter Certification Data

ISOTOPE SHIPPING AND RECEIVING LOG

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MCI RADIATION SAFETY PROGRAM - INTERNAL INSPECTION AUDIT RECORD

DATE: AUDITOR:

INSPECTING:
.....

LAST INSPECTION: NEXT INSPECTION:

DEFICIENCIES

.....
.....
.....
.....
.....
.....

CORRECTIVE ACTION

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MANAGEMENT REVIEW & REMARKS

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RSO RECORDS REVIEW LOG

DATE: PERFORMED BY:

RECORDS *****	REVIEWED *****	DISCREPANCIES NOTED *****
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Isotope Sign-Out Logs
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Daily Inspection Checklists
-----------------------------	-------	-------

Radiographic Utilization Records
----------------------------------	-------	-------

Notification Records
----------------------	-------	-------

Dosimeter Records
-------------------	-------	-------

Survey Meter Calibration Worksheets
-------------------------------------	-------	-------

Dosimeter Calibration Worksheets
----------------------------------	-------	-------

Leak Test Forms
-----------------	-------	-------

Radioisotope Receiving Records
--------------------------------	-------	-------

Quarterly Maintenance & Inspection Records
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MCI RADIATION SAFETY PROGRAM - NOTIFICATION RECORD

DATE: ***** PREPARED BY: *****

DEFICIENCY

CORRECTIVE ACTION

RSO REVIEW & REMARKS

[illegible]

DEVICE: S/N:

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RADIOGRAPHIC UTILIZATION RECORD

DATE: LOCATION OF USE: W.O.#

RADIOGRAPHER: DOSIMETER S/N:

DOSIMETER READINGS: STARTmR FINISHmR TOTALmR

ASSISTANT : DOSIMETER S/N:

DOSIMETER READINGS: STARTmR FINISHmR TOTALmR

DAILY INSPECTION CHECKLIST COMPLETED: INITIALS:

SURVEY METER MODEL NO.: S/N: CAL. DUE:

RADIOGRAPHIC SOURCE: X-RAY Co 60 Ir 192 Cs 137

SOURCE S/N: ACTIVITY: DEVICE S/N:

SURVEY OF DEVICE: INITIALmR/hr FINALmR/hr

NO. OF EXPOSURES: TOTAL EXPOSURE TIME:

REMARKS

RADIATION LEVELS AT POSTED BOUNDARIES:

DESCRIBE AREA

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DAILY INSPECTION CHECKLIST

DATE: CRANK ASSY. S/N: EXPOSURE DEVICE S/N:

- 1. Film badge, dosimeter and at least one survey meter available.
- 2. Perform battery check of survey meter.
- 3. Check calibration due dates of dosimeter and survey meter.
- 4. Recharge dosimeter.
- 5. Perform an operational check of survey meter.
- 6. Check the exposure device for valid leak test date, decay curve, proper labeling and that a maintenance inspection has been performed within the last three months.
- 7. Inspect the exposure device for any obvious defects and cleanliness.
- 8. Check for proper operating characteristics of the exposure device locking mechanism and selector knob.
- 9. Check the source pigtail keyway with Tech/Ops Model 550 No-Go gauge.
- 10. Check the control unit assembly, source guide tube and extension for correct operation, cleanliness and any irregularities such as kinks, flat spots, cuts or wear. Check that a maintenance inspection has been performed within the last three months.
- 11. Check drive cable end pin with Tech/Ops Model 550 No-Go gauge.
- 12. Check for proper operation of emergency mechanisms, source position indicator lights, shutter and interlock mechanisms. (PICKER CYCLOPS)
- 13. Check for sufficient supply of signs, ropes, tapes and collimators.
- 14. Document on the Radiographic Utilization Record that the Daily Inspection Checklist has been completed.
- 15. Document any equipment malfunctions and/or defects on a Notification Record and forward the form to the RSO. If components essential to the safe operation of the device are found to be defective or in poor operating condition, tag the equipment out of service and notify the RSO immediately.

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MCI RADIATION SAFETY PROGRAM - NOTIFICATION RECORD

DATE: *****

PREPARED BY: *****

DEFICIENCY

CORRECTIVE ACTION

RSO REVIEW & REMARKS

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DOSIMETER RECORD - 1st Quarter, 1984 (01/25/84 - 04/24/84)

NAME: DOSIMETER NO.:

DATE	DOSE	DATE	DOSE	DATE	DOSE
01/25/83	02/25/84	.....	03/25/84	.....
01/26/83	02/26/84	.....	03/26/84	.....
01/27/83	02/27/84	.....	03/27/84	.....
01/28/83	02/28/84	.....	03/28/84	.....
01/29/83	02/29/84	.....	03/29/84	.....
01/30/83	XX/XX/XX	...XX...	03/30/84	.....
01/31/83	XX/XX/XX	...XX...	03/31/84	.....
02/01/84	03/01/84	.....	04/01/84	.....
02/02/84	03/02/84	.....	04/02/84	.....
02/03/84	03/03/84	.....	04/03/84	.....
02/04/84	03/04/84	.....	04/04/84	.....
02/05/84	03/05/84	.....	04/05/84	.....
02/06/84	03/06/84	.....	04/06/84	.....
02/07/84	03/07/84	.....	04/07/84	.....
02/08/84	03/08/84	.....	04/08/84	.....
02/09/84	03/09/84	.....	04/09/84	.....
02/10/84	03/10/84	.....	04/10/84	.....
02/11/84	03/11/84	.....	04/11/84	.....
02/12/84	03/12/84	.....	04/12/84	.....
02/13/84	03/13/84	.....	04/13/84	.....
02/14/84	03/14/84	.....	04/14/84	.....
02/15/84	03/15/84	.....	04/15/84	.....
02/16/84	03/16/84	.....	04/16/84	.....
02/17/84	03/17/84	.....	04/17/84	.....
02/18/84	03/18/84	.....	04/18/84	.....
02/19/84	03/19/84	.....	04/19/84	.....
02/20/84	03/20/84	.....	04/20/84	.....
02/21/84	03/21/84	.....	04/21/84	.....
02/22/84	03/22/84	.....	04/22/84	.....
02/23/84	03/23/84	.....	04/23/84	.....
02/24/84	03/24/84	.....	04/24/84	.....

.....

DOSIMETER TOTALS:

01/25 - 02/24 02/25 - 03/24 03/25 - 04/24

FILM BADGE TOTALS:

01/25 - 02/24 02/25 - 03/24 03/25 - 04/24

1st QUARTER TOTALS:

01/25/84 - 04/24/84 DosimetermRem Film BadgemRem

.....

M A G N A C H E K, I N C.
NONDESTRUCTIVE TESTING LABORATORIES
2125 RIGGS STREET
WARREN, MI 48091
(313) 756-4070

SURVEY METER CALIBRATION CERTIFICATE/WORKSHEET

DATE :

CUSTOMER:

SURVEY METER MAKE/MODEL: S/N:

CALIBRATOR MAKE/MODEL: Technical Operations Model 726 S/N: 172

CALIBRATOR SOURCE: Cesium 137 S/N: S-306 ACTIVITY: ... mCi

CALIBRATION DATA

METER SCALE	KNOWN RADIATION INTENSITY	METER RESPONSE	ACCEPTABLE
-------------	---------------------------	----------------	------------

x1	2.5 mR/hr mR/hr
----	-----------	------------	-------

	7.5 mR/hr mR/hr
--	-----------	------------	-------

x10	25 mR/hr mR/hr
-----	----------	------------	-------

	75 mR/hr mR/hr
--	----------	------------	-------

x100	250 mR/hr mR/hr
------	-----------	------------	-------

	750 mR/hr mR/hr
--	-----------	------------	-------

CALIBRATED BY :
-----------------	-------

CALIBRATION DUE ON OR BEFORE:
-------------------------------	-------

REMARKS :
-----------	-------

MAGNA CHEK, INC.
NONDESTRUCTIVE TESTING LABORATORIES
2125 RIGGS STREET
WARREN, MI 48091
(313) 756-4070

DOSIMETER CALIBRATION CERTIFICATE / WORKSHEET

DATE OF ISSUE:/..../..

DOSIMETER MAKE/MODEL: S/N:
CALIBRATOR MAKE/MODEL: Technical Operations Model 726 S/N: 172
CALIBRATOR SOURCE: Cesium 137 S/N: S-306 ACTIVITY: .. mCi

CALIBRATION DATA

CHECKPOINT #1: Dosimeter exposed to dose of 50 mR - Readings: ... mR
CHECKPOINT #2: Dosimeter exposed to dose of 150 mR - Reading: ... mR
DRIFT CHECK: Less than .. mR in 24 hour period

Readings must be within +/- 30% of both 50 mR and 150 mR checkpoints.
Maximum drift allowed - 2% of scale (4 mRem).

CALIBRATION PERFORMED BY:
CALIBRATION DUE ON OR BEFORE:/..../...
REMARKS :

Tech/Ops40 NORTH AVENUE
BURLINGTON, MA. 01803
(617) 272-2000**518
LEAK TEST**

Co. Name _____ P.O. No. _____

Street _____ NRC or _____

State License No. _____

City, State _____

Projector _____
Model No. _____ Serial No. _____Source _____
Model No. _____ Serial No. _____ Curies _____

IR-192 _____ CO-60 _____ CS-137 _____ Other _____

Wipe _____
Performed By _____ Date _____

The United States Nuclear Regulatory Commission requires that radiographic sources be tested for evidence of leaking at the time of manufacture and thereafter at not more than six-month intervals.

The amount of removable contamination must not exceed 0.005 microcuries. If the test shows more than 0.005 microcurie of removable contamination, the source and equipment must be immediately taken out of service and be repaired or be disposed of. Please note that this source must be tested again on or before _____

FOR TECH-OPS USE ONLY

ORIGINAL

GAMMA INDUSTRIES*A Division of Nuclear Systems, Inc.***HOME OFFICE**2255 Ted Dunham Avenue
Baton Rouge, Louisiana 70821
(504) 383-7791 - Telex 5864733320 Tavenor Drive
Houston, Texas 77034
(713) 944-7676
Telex 775677**KOWIPE****LEAK****TEST****KIT**

COMPANY: _____

ADDRESS: _____

SOURCE

MANUFACTURER: _____

DATE OF TEST: _____

ISOTOPE: _____

SOURCE STRENGTH (ci): _____

SOURCE

SERIAL NO. _____

REMARKS: _____

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WARREN, MI 48091
(313) 756-4070

RADIO-ISOTOPE RECEIVING RECORD

DATE - .../.../... PERFORMED BY -

SOURCE TYPE -

SOURCE ACTIVITY -

SOURCE MODEL NO. -

SOURCE SERIAL NO. -

SHIPPING CONTAINER MODEL NO. -

SHIPPING CONTAINER SERIAL NO. -

INSPECT FOR DAMAGE TO CONTAINER.....

RADIATION LEVEL AT EXTERIOR SURFACE -
(Must not exceed 200 mRem/hr)

RADIATION LEVEL AT 3 FEET FROM SURFACE -
(Must not exceed 10 mRem/hr)

SHIPPING CONTAINER PLACED IN STORAGE VAULT -

QUARTERLY MAINTENANCE & INSPECTION RECORD - TECH/OPS MODEL 660 EXPOSURE DEVICES

... Quarter, 1984

Tech/Ops Model 660 Exposure Device	S/N -
Tech/Ops Model 693 Control Unit	S/N -
Tech/Ops Master Source Guide Tube	S/N -
Tech/Ops Extender Source Guide Tube	S/N -
Tech/Ops Extender Source Guide Tube	S/N -

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part D, Section 1.

REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

Tech/Ops Model 693 Control Unit and Source Guide Tubes

- 1) Remove the drive cable from the control unit - clean, lubricate and check the end connector with Model 550 no-go gauge as specified in Part D, Section 1a.
- 2) Dissassemble the control housings and source guide tubes - clean and check for wear and damage as specified in Part D, Section 1a.
- 3) Disassemble the control unit crank assembly - clean, lubricate and check all parts for any damage and wear as specified in Part D, Section 1a.
- 4) Reassemble the control unit (crank assembly, odometer and control housings - check for proper operation as specified in Part D, Section 1a.

Tech/Ops Model 660 Exposure Device

- 1) Survey the device to ensure proper radiation levels and document readings on the Radiographic Utilization Record.
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked or damaged housing, cleanliness, missing parts, etc.
- 3) Inspect the key lock assembly for correct operation and cleanliness; lubricate the locking plunger.
- 4) Check the control unit connector assembly for correct operation and cleanliness.
- 5) Check the female drive cable connector of the source for wear with Model 550 no-go gauge.
- 6) Complete Maintenance performed - NOTE: Steps 3 through 5 may be replaced by Part D, Section 1c (Tech/Ops Model 660 Exposure Device - COMPLETE MAINTENANCE), only if a Tech/Ops Model 650 source changer is available and AFTER THE SOURCE HAS BEEN REMOVED FROM THE EXPOSURE DEVICE.

DATE: PERFORMED BY: DUE:

QUARTERLY MAINTENANCE & INSPECTION RECORD - TECH/DPS MODEL 446 EXPOSURE DEVICES

... Quarter, 1984

Tech/Dps Model 446 Exposure Device	S/N -
Tech/Dps Model 664 Control Unit	S/N -
Tech/Dps Master Source Guide Tube	S/N -
Tech/Dps Extender Source Guide Tube	S/N -
Tech/Dps Extender Source Guide Tube	S/N -

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part O, Section 2.

REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

Tech/Dps Model 664 Control Unit and Guide Tubes

- 1) Disassemble the control unit hand crank, cleaning and lubricating the various parts as specified in Part O, Section 2a.
- 2) Reassemble the control unit & drive cable and check for proper operation as specified in Part O, Section 2a.
- 3) Check the control unit housing and source guide tubes for wear and damage as specified in Part O, Section 2a.
- 4) Inspect the key lock assembly for correct operation and cleanliness as specified in Part O, Section 2a.

Tech/Dps Model 446 Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record.
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked or damaged housing, cleanliness, missing parts, etc.
- 3) Check the shipping plug, locking bar, and lock for wear and ease of operation.

DATE: PERFORMED BY: DUE:

QUARTERLY MAINTENANCE & INSPECTION RECORD - TECH/OPS MODEL 726 EXPOSURE DEVICES

... Quarter, 1984

Tech/Ops Model 726 Exposure Device S/N -

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part 0, Section 3.

REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

Tech/Ops Model 726 Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record.
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked housing, cleanliness, missing parts, etc.
- 3) Inspect the key lock assembly and source locking bar for wear, damage, cleanliness and ease of operation.
- 4) Check the source rod for wear, damage, cleanliness and ease of operation.
- 5) Check the exposure timer for proper operation.

DATE: PERFORMED BY: DUE:

QUARTERLY MAINTENANCE & INSPECTION RECORD - PICKER MODEL 590 EXPOSURE DEVICE

... Quarter, 1984

Picker Model 590 Cyclops Exposure Device S/N -

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part D, Section 4.

REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

Picker Model 590 Cyclops Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record.
- 2) Inspect the exposure device head for proper labeling and any obvious defects such as loose screws, burnt out warning lights, missing parts, etc.
- 3) Inspect the key lock assembly for correct operation and cleanliness; lubricate the locking plunger
- 4) Disassemble the control panel and check for broken wires, loose connections, replace bulbs if necessary.
- 5) Reassemble the control panel and check operation of the timer and key mechanisms.
- 6) Check the duration of the transit from storage position to exposed position.
- 7) Check that proper sequence of warning lights is occurring during source exposure.
- 8) Check the duration of the transit from exposed position to storage position.
- 9) Check that proper sequence of warning lights is occurring during source retraction.
- 10) Check the operation of the emergency stop bar on the control panel.
- 11) Check the operation of the door interlock switch, checking for loose connections, excessive wear, etc.
- 12) Check the operation of the device spring when simulating an electrical power failure.

DATE: PERFORMED BY: DUE:

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NONDESTRUCTIVE TESTING LABORATORIES
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WARREN, MI 48091
(313) 756-4070

MCI RADIATION SAFETY PROGRAM MANUAL

SECTION VIII - MCI OPERATING AND EMERGENCY PROCEDURES

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4. 10 CFR Part 34 - "Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations"
5. 10 CFR Part 71 - "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions"

Part A - Emergency Telephone Numbers

Magna Chek, Inc.	(313) 756-4070
Lawrence E. Jones, President (Home)	(313) 664-0305
Thomas B. Diroff, Plant Manager (Home)	(313) 474-3249
David B. Cardwell, Radiation Safety Officer (Home)	(517) 784-7241
Roy W. Murray, Radiographer (home)	(313) 545-6327
Dean J. Walker, Radiographer (home)	(313) 389-2635
U.S. Nuclear Regulatory Commission (Region III, Chicago)	(312) 790-5500
Michigan Health Department (Dept. of Radiological Health)	(517) 337-6100
Technical Operations, Inc. (Burlington, MA)	(617) 272-2000 (800) 225-1383
Gamma Industries, Inc. (Baton Rouge, LA)	(504) 388-0800 (800) 535-8132

Part B - Responsibilities of Personnel

The duties and responsibilities of the radiographer may not be delegated to the assistant radiographer. The radiographer must be physically present at the location where radiography is being performed.

1. Radiographers

Radiographers shall be responsible for:

- a. compliance with the conditions of Magna Chek's license, applicable Nuclear Regulatory Commission Rules and Regulations, and the MCI Operating and Emergency Procedures,
- b. the safe operation of radiographic exposure devices containing sealed sources for which Magna Chek is licensed, in accordance with the above Rules and Procedures,
- c. direct supervision of Assistant Radiographers working with radiographic exposure devices or in radiation work areas,
- d. posting proper radiation boundaries, conducting surveys of those boundaries and surveys of radiographic exposure devices, and documenting the findings of those surveys,
- e. performing survey meter and dosimeter calibrations, leak test smears, source changes, quarterly inspection and maintenance on radiographic exposure devices and related equipment as specified in these procedures,
- f. providing on-the-job training for Trainees and Assistant Radiographers,
- g. maintaining those records specified in Part C of these procedures, Recordkeeping Requirements.

2. Assistant Radiographers

Assistant Radiographers shall be responsible for:

- a. compliance with the conditions of Magna Chek's license, applicable Nuclear Regulatory Commission Rules and Regulations, and the MCI Operating and Emergency Procedures,
- b. the safe operation of radiographic exposure devices containing sealed sources for which Magna Chek is licensed, in accordance with the above Rules and Procedures, UNDER THE DIRECT SUPERVISION OF A QUALIFIED RADIOGRAPHER,
- c. assisting the Radiographer in posting proper radiation boundaries, conducting surveys of those boundaries and surveys of radiographic exposure devices, and documenting the findings of those surveys,
- d. maintaining those records specified in Part C of these procedures, Recordkeeping Requirements.

Part C - Recordkeeping Requirements

1. Radiographers

Radiographers shall be responsible for maintaining the following documents:

- a. Isotope Sign-Out Logs
- b. Radiographic Utilization Records
- c. Daily Inspection Checklists
- d. Notification Records
- e. Dosimeter Records
- f. Survey Meter Calibration Worksheets
- g. Dosimeter Calibration Worksheets
- h. Tech/Ops 518 Leak Test Forms
- i. Gamma Industries Kowipe Leak Test Forms
- j. Radioisotope Receiving Records
- k. Quarterly Maintenance & Inspection Records

2. Assistant Radiographers

Assistant Radiographers shall be responsible for maintaining the following documents under the direct supervision of a Radiographer:

- a. Isotope Sign-Out Logs
- b. Radiographic Utilization Records
- c. Daily Inspection Checklists
- d. Notification Records
- e. Dosimeter Records

Part D - Storage and Security of Exposure Devices

1. Laboratory Storage

- a. Radiographic devices and storage containers shall be locked at all times when not in use, to prevent accidental movement of the sealed source.
- b. When not in use, Radiographic devices and storage containers shall be stored in the isotope storage vault, located inside the exposure cell.
- c. The isotope storage vault is to remain locked at all times, and is posted with magenta and yellow warning signs containing the words, "CAUTION - RADIOACTIVE MATERIALS", and the radiation symbol, and is posted with magenta and yellow warning signs containing the words, "CAUTION - RADIATION AREA", and the radiation symbol.
- d. The exposure cell is to remain locked at all times when not in use, and is posted with magenta and yellow warning signs containing the words, "CAUTION - RADIOACTIVE MATERIALS", and the radiation symbol, and is posted with magenta and yellow warning signs containing the words, "CAUTION - RADIATION AREA", and the radiation symbol.

2. Temporary Field Storage

- a. Radiographic devices and storage containers shall be locked at all times when not in use, to prevent accidental movement of the sealed source.
- b. When not in use, Radiographic devices and storage containers shall be stored in a locked temporary storage area.
- c. Temporary storage areas shall be selected so that any point accessible to unauthorized personnel shall not exceed a 2 mR/hr radiation dose rate.
- d. The storage area is to remain locked at all times when not in use, and shall be posted with magenta and yellow warning signs containing the words, "CAUTION - RADIOACTIVE MATERIALS", and the radiation symbol.
- e. If a transporting vehicle is to be used as a temporary storage area, the vehicle shall be posted with magenta and yellow warning signs containing the words, "CAUTION - RADIOACTIVE MATERIALS", and the radiation symbol. The area outside the vehicle is an unrestricted area, and the radiation level at 18 inches from the surface of the vehicle shall not exceed 2 mR/hr.

Part E - Emergency Procedures

WARNING: IF A RADIOACTIVE SOURCE BECOMES DISCONNECTED, NOTIFY THE RSO IMMEDIATELY. DO NOT ATTEMPT TO RECOVER THE SOURCE UNDER ANY CIRCUMSTANCES. RETRIEVAL OF DISCONNECTED SOURCES WILL BE PERFORMED BY TECHNICAL OPERATIONS, INC. PERSONNEL ONLY.

1. Plant Emergency

In the event of a plant emergency in an area adjacent to a radiographic device, such as fire or an accident involving plant personnel, the following instructions are to be carried out:

- a. Return the source to its shielded position.
- b. Perform the physical radiation survey of the device to ensure that the source is in the shielded position. LOCK THE DEVICE.
- c. Remove source guide tubes and control cables (if applicable) and insert any shipping plugs.
- d. Remove device from danger area and return it to its storage location if possible. If necessary, set up a temporary storage site in a safe location per Part D of the MCI Operating and Emergency Procedures.
- e. If the device cannot be removed from a danger area, set up a restricted area as specified in Part I of the MCI Operating and Emergency Procedures, and continue to monitor this area.
- f. Notify the Radiation Safety Officer or other Company Official for further instructions.

2. Exposure of Non-Monitored Personnel

In the event of an accident involving the exposure of non-monitored personnel to radiation, the following instructions should be carried out:

- a. Use proper survey techniques to determine the source is in a shielded position.
- b. If not in a shielded position, post and monitor a restricted boundary as specified in Part I of the MCI Operating and Emergency Procedures.
- c. Obtain names, telephone numbers and addresses of non-monitored personnel involved. Retain those personnel at the site if possible.
- d. Obtain all pertinent facts involving the accident and contact the Radiation Safety Officer for further instructions.
- e. The RSO shall determine the course of action and shall notify the NRC in accordance with CFR Part 20, as necessary.

3. Accidents Involving Sealed Sources

In the event of an accident to the sealed source or radiographic device, such as a falling object hitting device, the following instructions are to be carried out:

- a. Return the source to its shielded position, if possible.
- b. Perform the physical radiation survey of the device to ensure that the source is in the shielded position. LOCK THE DEVICE.
- c. Remove source guide tubes and control cables (if applicable) and insert any shipping plugs.
- d. If unable to return the source to storage, or the survey readings are abnormal, post a restricted area as specified in Part I of the MCI Operating and Emergency Procedures, and continue to monitor this area.
- e. Notify the Radiation Safety Officer or other Company Official for further instructions.
- f. Do not use the device until the Radiation Safety Officer has made a thorough inspection of the device and approves its use.

4. Vehicular Accidents Involving Sealed Sources

In the case of a vehicular accident involving a sealed source or radiographic exposure device, the following instructions are to be carried out:

- a. Major damage to vehicle or survey instrument, including source storage area.
 - 1) If the survey meter is operable, determine if the source is in the shielded position, and survey to ensure no damage resulting in abnormal radiation levels occurred. If not in the stored position, or if survey results are abnormal, post and monitor a restricted area as specified in Part I of the MCI Operating and Emergency Procedures.
 - 2) If the survey meter is inoperable, use calculations or the chart listed at the end Part E to establish the perimeter of the restricted area, assuming that the source is in the exposed position inside the vehicle. Continue to monitor this restricted boundary until the exact location and condition of the source has been determined.
 - 3) Notify the Radiation Safety Officer or other Company official for further instructions.
- b. Minor damage to the vehicle, no damage to source storage area.
 - 1) If the survey meter is operable, determine if the source is in the shielded position, and survey to ensure no damage resulting in abnormal radiation levels occurred. If not in the stored position, or if survey results are abnormal, post and monitor a restricted area as specified in Part I of the MCI Operating and Emergency Procedures.
 - 2) Notify the Radiation Safety Officer or other Company official for further instructions.

5. Loss of Sealed Sources

In the event of loss or theft of a sealed source, the following instructions are to be carried out:

- a. Obtain all information on the last known location of the source.
- b. Notify the Radiation Safety Officer or other Company official for further instructions.
- c. The following shall be performed by the Radiation Safety Officer:
 - 1) Check the last known location of the source with survey meter and locate source using triangulation method if possible.
 - 2) Check exposure to non-monitored personnel and follow the instructions listed above in Part E - Exposure to Non-Monitored Personnel
 - 3) Notify the Nuclear Regulatory Commission in accordance with CFR Part 20, as necessary.

6. Unavailability of Radiographers

- a. Prior to establishing a temporary radiographic worksite, the appropriate contractor personnel shall be provided with a copy of the Emergency Telephone Numbers listed in Part A of the MCI Operating and Emergency Procedures.
- b. In the event of an accident or sudden illness of the radiographer(s), the contractor shall have instructions to contact any one of the individuals on the list (preferably the Radiation Safety Officer).
- c. The contacted individual shall assume responsibility for the situation and determine the necessary course of action.

7. Notification and Reports of Incidents to NRC

The Radiation Safety Officer shall notify the Nuclear Regulatory Commission by telephone, telegraph, or in writing in accordance with the requirements of CFR Part 20, as applicable.

DISTANCE CHART FOR IRIDIUM ¹⁹²

Distance In Feet

CURIE STRENGTH	Unshielded		.25" Lead Shielding		.5" Lead Shielding	
	2 mR/hr	100 mR/hr	2 mR/hr	100 mR/hr	2 mR/hr	100 mR/hr
	A	B	C	D	E	F
1	55	8	28	4	17	3
10	172	25	86	13	53	8
20	243	35	121	18	75	11
25	272	39	136	20	84	12
30	298	43	149	22	92	13
35	322	46	160	23	99	14
40	344	49	172	25	106	15
45	365	52	183	26	113	16
50	385	55	193	28	119	17
55	403	57	202	29	125	18
60	421	60	211	30	130	19
65	438	62	219	31	135	20
70	455	65	228	33	140	20
75	471	67	236	34	145	21
80	486	69	243	35	150	22
85	501	71	251	36	155	22
90	516	73	258	37	159	23
95	530	75	265	38	164	24
100	544	77	272	39	168	24
105	557	79	279	40	172	25
110	570	81	285	41	176	25
115	583	83	292	42	180	26
120	595	85	298	43	184	26

FORMULAS: X=CURIE STRENGTH

Unshielded	$A = \sqrt{2950 \times}$
	$B = \sqrt{59 \times}$
.25" Lead	$C = \sqrt{737.5 \times}$
	$D = \sqrt{14.75 \times}$
	$E = \sqrt{280 \times}$
.5" Lead	$F = \sqrt{5.605 \times}$

All Distances In Feet Are
Rounded Up To The Nearest
Whole Foot

Part F - Personnel Monitoring

1. General Requirements

- a. Personnel monitoring equipment, consisting of a film badge and a dosimeter, shall be issued to and worn by all radiography personnel. In addition, personnel monitoring equipment shall be issued to and worn by any individual who:
 - 1) enters a restricted area under such conditions that he receives, or is likely to receive, a whole body dose in excess of 300 mRem in any calendar quarter,
 - 2) if under the age of eighteen, enters a restricted area under such conditions that he receives, or is likely to receive, a whole body dose in excess of 60 mRem in any calendar quarter,
 - 3) enters a high radiation area.
- b. Each film badge shall be identified by the wearer's Social Security number and may be worn only by the person to which it is assigned.
- c. Pocket dosimeters and film badges shall be kept in the Laboratory Supervisor's office when not in use, and shall be assigned to personnel by the Radiation Safety Officer.
- d. The control badges shall be stored in a radiation-free area and processed with the personnel badges.

2. Pocket Dosimeters

- a. Dosimeters shall be worn on the front of the body, between the shoulders and the waist so that they will accurately reflect the whole body dose of the wearer.
- b. Dosimeters are delicate instruments and should be handled with care. Suspected damage, such as might result from rough handling or from dropping the instrument, shall be reported at once to the Radiation Safety Officer.
- c. Dosimeters shall be charged to zero at least once per day, prior to performing radiographic operations or entering a restricted area, and this charging shall be documented on the Daily Equipment Checklist. The charging procedure for dosimeters is as follows:
 - 1) Check the calibration due date on the dosimeter. If not in calibration, return the dosimeter to the Radiation Safety Officer. DO NOT USE a dosimeter that is not in calibration.
 - 2) Insert the dosimeter into the charging socket.
 - 3) Holding the dosimeter in contact by pressing down against the spring, look through the dosimeter at the hairline and scale.
 - 4) Turn the adjusting knob until the dosimeter hairline reads slightly below zero.
 - 5) Remove the dosimeter from the charger and verify the hairline position by looking at the dosimeter against a light source.

- 6) Repeat steps 2 through 5 if necessary to achieve an initial reading of zero. If repeated attempts fail to zero the dosimeter, notify the Radiation Safety Officer and obtain a different dosimeter. DO NOT USE a dosimeter that cannot be zeroed.
- d. Dosimeters shall be checked frequently throughout the workday, at intervals not to exceed four hours.
 - 1) If the reading is suspected to not be accurately reflecting the dose you expect, notify the RSO and obtain a different dosimeter.
 - 2) If the reading is above or near half-scale (100 mRem), rezero the dosimeter to eliminate the possibility of the dosimeter accidentally going offscale.
 - 3) If at anytime it is noted that the dosimeter has fully discharged (gone offscale), the wearer shall stop radiographic operations immediately and shall notify the Radiation Safety Officer. The RSO shall have the film badge immediately processed to determine if an overexposure has occurred. The RSO shall also recalibrate the dosimeter to determine if it is still functioning properly before returning it to service.

3. Film Badges

- a. Film badges are provided to Magna Chek by Landauer & Co., on a monthly basis. New film badges shall be issued on the 25th of each month to radiographic personnel. Badges from the previous period shall be promptly returned to the Radiation Safety Officer for processing by the supplier.
- b. Film badges shall be placed in a holder provided by the supplier, and worn facing outward on the front of the body, between the shoulders and the waist so that they will accurately reflect the whole body dose of the wearer.
- c. Film badges are delicate instruments and should be handled with care. Suspected damage, such as might result from rough handling or from water or light leakage, shall be reported at once to the Radiation Safety Officer.
- d. The Radiation Safety Officer shall receive, review, and maintain the film badge reports from the supplier. Radiographic personnel shall be informed of any high or unusual results. A copy of the most recent report shall be posted for display on the employee bulletin board.

Part G - Radiation Surveys

1. Survey Instruments

- a. Radiation surveys shall be conducted using calibrated survey meters. Check the front of any survey instrument before using for the Calibration Due Date. If not in calibration, return it to the Radiation Safety Officer for calibration. DO NOT USE a survey meter that is not in calibration.
- b. The survey meters in use at Magna Chek measure radiation dose rates in mR/hr units. The meters may be used in any one of three ranges:
 - 1) x1 range, 0-10 mR/hr in 0.2 mR/hr divisions.
 - 2) x10 range, 0-100 mR/hr in 2.0 mR/hr divisions.
 - 3) x100 range, 0-1000 mR/hr in 20 mR/hr divisions.
- c. Radiation measurements are performed by turning the selector switch to one of the three operating ranges. Note the meter readings after allowing a minimum of 5 seconds response time.

2. Survey Requirements

The following radiation surveys are required to be performed:

- a. Initial survey of a radiographic device or source changer prior to use.
 - 1) The entire circumference of the device shall be surveyed to determine that the source is in the stored position.
 - 2) This reading shall be recorded on the Radiographic Utilization Record for comparison against later surveys of the device.
- b. Determination after an exposure that the source has returned to the safe storage position in the device or source changer.
 - 1) The entire circumference of the device shall be surveyed to determine that the source is in the stored position after each exposure. This survey shall include any source guide tubes that may be attached to the device.
 - 2) This reading may be compared to the initial survey of the device to determine if the source is in the safe stored position.
- c. Final survey of a radiographic device or source changer prior to securing the device.
 - 1) The entire circumference of the device shall be surveyed to determine that the source is in the stored position prior to securing the device.
 - 2) This reading shall be recorded on the Radiographic Utilization Record.
- d. Determination of the boundary of the restricted area.
 - 1) The proper location of the boundary of the restricted area shall be confirmed or adjusted as necessary by a physical radiation survey before or during the initial radiographic

- exposure. The survey results and boundary dimensions shall be recorded on the Radiographic Utilization Record.
- 2) The proper location of the boundary of the restricted area shall be confirmed or adjusted as necessary by a physical radiation survey at anytime the source positioning for an exposure is substantially different from that of the previous exposure. Due consideration shall be given to areas above and below the radiographic worksite. The survey results and boundary dimensions shall be recorded on the Radiographic Utilization Record.
- e. Determination of radiation levels at external surfaces of storage facilities.
 - 1) Laboratory storage facilities - a survey of the outside of the isotope storage vault after storing a radiographic device or source changer shall be conducted to ensure that the radiation levels do not exceed 2 mR/hr.
 - 2) Temporary field storage facilities - a survey of all sides of the storage area shall be conducted to ensure that the radiation levels at areas accessible to unauthorized personnel do not exceed 2 mR/hr.
- f. Determination of radiation levels in and around vehicles used for transporting or storing sources and devices.
 - 1) Passenger compartment - surveys shall be conducted to ensure that the radiation levels do not exceed 2 mR/hr anywhere inside the passenger compartment of a vehicle used to transport radioactive sources or devices.
 - 2) Outside of vehicle - surveys of exterior surfaces shall be conducted to assure that radiation levels do not exceed 2 mR/hr at 18 inches from the surface of the vehicle.
- g. Determination of radiation levels at external surfaces of shipping containers - receiving and shipping.
 - 1) Receiving radioactive material - upon receipt of a package of radioactive material, survey the exterior surfaces of the package to assure that the radiation levels do not exceed 200 mR/hr at the surface of the container and 10 mR/hr at 1 meter. These survey results shall be recorded on the Radio-Isotope Receiving Report.
 - 2) Shipping radioactive material - survey the device to assure radiation levels do not exceed 200 mR/hr at the surface and 10 mR/hr at one meter from the surface. See Part N of the MCI Operating and Emergency Procedures for further instructions.
- h. Determination of approximate radiation levels of leak test smears prior to mailing for evaluation.
 - 1) After obtaining a leak test smear, survey the smear in a low background area on the meter's most sensitive range (x1). If the reading exceeds 0.2 mR/hr, contact the Radiation Safety Officer. DO NOT MAIL if the smear exceeds 0.2 mR/hr. See Part M of the MCI Operating and Emergency Procedures for further instructions.

Part H - Transporting Sealed Sources to Field Locations

1. Securing Sealed Sources in Vehicles

- a. The radiographic exposure device shall be secured within the transporting vehicle to prevent shifting within the vehicle during transportation. This shall be accomplished by the use of an outer shipping container which will be securely fastened to the vehicle.
- b. The shipping container shall be constructed of wood and lead sheet, and shall be secured to the vehicle by either chains or a nut and bolt configuration.
- c. The area of the vehicle in which the shipping container is located shall remain locked at all times unless under the direct supervision of a radiographer.

2. Surveys of Vehicles

- a. Passenger compartment - surveys shall be conducted to ensure that the radiation levels do not exceed 2 mR/hr anywhere inside the passenger compartment of a vehicle used to transport radioactive sources or devices.
- b. Outside of vehicle - surveys of all exterior surfaces shall be conducted to assure that radiation levels do not exceed 2 mR/hr at 18 inches from the surface of the vehicle.

3. Posting of Vehicles

- a. The outside of the transporting vehicle shall be placarded on all four sides at any time a package with a "Radioactive Yellow - III" label is shipped.
- b. The outside of the transporting vehicle shall be posted with "Caution - Radioactive Material" signs if it is to be used as a temporary storage facility.

Part I - Controlling Access to Radiographic Areas

1. Definitions

- a. Restricted Area - any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive a dose in excess of 2 mRem in any 1 hour, 100 mRem in any 7 consecutive days, or 500 mRem during a calendar year to persons continually present.
- b. High Radiation Area - any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive a dose in excess of 100 mRem in any 1 hour.

2. Field Sites

- a. Determination and Posting of the Restricted Area Boundary
 - 1) Prior to using the exposure device, the Radiographer shall calculate the location of the boundary of the Restricted Area.
 - 2) Factors in such calculation should be the source strength (curies) to be used, the type and amount of collimation to be used and other shielding that may be available.
 - 3) The perimeter shall be roped off and posted with yellow and magenta warning signs which show the international radiation symbol and which read "CAUTION - RADIATION AREA".
 - 4) The entire Restricted Area perimeter shall be surveyed and adjusted as necessary during the first exposure of the source.
- b. Determination and Posting of the High Radiation Boundary
 - 1) After determining and posting the Restricted Area boundary, the Radiographer shall calculate the location of High Radiation Boundary.
 - 2) Calculations of this boundary should be based on the location of the Restricted Area boundary and the inverse square law.
 - 3) This boundary shall be posted with yellow and magenta warning signs which show the international radiation symbol and which read "CAUTION - HIGH RADIATION AREA".
 - 4) The actual radiation levels at this boundary need not be verified by physical survey since it could result in unnecessary exposure to personnel.
- c. Control of Access to Restricted Areas
 - 1) The Restricted Area Boundary shall be monitored at all times by the Radiographer or Assistant Radiographer to prevent entry by unauthorized personnel.
 - 2) The Radiographer shall inform the appropriate contractor personnel at the worksite of the importance of maintaining the boundary during radiographic operations, and enlist his help in keeping unauthorized persons out of the Restricted Area.

- 3) If, for any reason, unauthorized personnel cannot be prevented from entering the Restricted Area, the source shall be immediately retracted to its stored position and further operations shall be suspended until the situation is resolved to the satisfaction of the Radiographer that no unauthorized persons shall enter the Restricted Area.

3. Laboratory

a. Posting of Signs and Boundaries

- 1) "CAUTION - RADIOACTIVE MATERIALS" signs shall be posted on the storage area of the Picker 590 and on the door and walls of the exposure cell.
- 2) "CAUTION - HIGH RADIATION AREA" signs shall be posted on the outside of the exposure cell door, inside the exposure cell placed in such a manner to be seen by anyone about to enter the exposure cell, and along the fenced boundary on the roof of the building.
- 3) "CAUTION - RADIATION AREA" signs shall be posted on the door and walls of the exposure cell, and along the perimeter of the roof of the building.
- 4) The entire Restricted Area boundary along the door and walls of the exposure cell shall be surveyed during the first exposure of the source. If radiation levels are found in excess of 2 mR/hr beyond the exposure cell walls, the Restricted Area perimeter shall be roped off and posted with yellow and magenta warning signs which show the international radiation symbol and which read "CAUTION - RADIATION AREA".

b. Control of Access to Restricted Areas

- 1) The temporary exposure cell containing the Picker 590 Cyclops Cobalt 60 exposure device shall be kept locked when an exposure is taking place and when the cell is not in use.
- 2) The keys to the cell and the Picker 590 shall be accessible only to qualified Radiographers employed by Magna Chek, Inc.
- 3) The Restricted Area Boundary shall be monitored at all times by the Radiographer or Assistant Radiographer to prevent entry by unauthorized personnel.
- 4) Prior to performing radiographic operations in the exposure cell, a visual survey roof shall be performed to ensure that no personnel are present on the roof of the building inside of the posted Restricted Area or High Radiation Boundaries.

Part J - Operation of Radiographic Exposure Devices

1. General Requirements

- a. Only qualified and trained Radiographers may operate radiographic exposure devices. Assistant Radiographers may operate radiographic exposure devices ONLY UNDER THE DIRECT SUPERVISION OF A RADIOGRAPHER.
- b. Radiography must only be performed in a Restricted Area, as defined in Part I of the MCI Operating and Emergency Procedures.
- c. Prior to the start of radiographic operations, the Radiographer shall be sure that the following criteria are met:
 - 1) at least one working, calibrated survey meter is available,
 - 2) current film badges and calibrated, rezeroed dosimeters are in use for himself and the Assistant Radiographer(s),
 - 3) A copy of the MCI Operating and Emergency Procedures are on the worksite.

2. General Radiographic Procedures

- a. Have a copy of the MCI Operating and Emergency Procedures, film badge, calibrated dosimeter, and calibrated survey meter for use.
- b. Start a Radiographic Utilization Record.
- c. Sign out the radiographic exposure device on the Isotope Sign-Out Log.
- d. Remove the exposure device from the isotope storage area.
- e. Perform the initial radiation survey of the exposure device and record it on the Radiographic Utilization Record.
- f. Perform the daily equipment check and record it on a Daily Inspection Checklist.
- g. Establish and post the calculated Restricted Area Boundary and High Radiation Boundary.
- h. Assemble the exposure device accessories (control unit, source guide tubes, etc.) as required.
- i. Position the exposure device for the radiographic operation.
- j. Unlock the exposure device, and expose the source.
- k. Survey the Restricted Area Boundary and adjust if necessary.
- l. Retract the source into the exposure device at the end of the calculated exposure time.
- m. Survey the exposure device, including any attached source guide tubes to assure the source is in the stored position.
- n. Lock the exposure device.
- o. Repeat steps (i) through (n) as necessary to complete the radiographic operation.
- p. After concluding radiographic operations, perform the final radiation survey of the exposure device and record it on the Radiographic Utilization Record.
- q. Disassemble the exposure device (if applicable) and return to storage.

- r. Survey the outside of the storage area.
- s. Sign the exposure device back in on the Isotope Sign-Out Log.
- t. Remove the Restricted Area Boundary and High Radiation Boundary.
- u. Complete the Radiographic Utilization Record and forward to the Radiation Safety Officer.
- v. Document the radiation dose received on a Dosimeter Record.

3. Daily Inspection of Equipment

Prior to use of radiographic exposure devices, a daily inspection check of equipment must be performed. This check shall be documented on the Daily Inspection Checklist, found on the back on the Radiographic Utilization Record. The Radiographic Utilization Record should be filled out at the same time that the Daily Inspection Checklist is performed. Step by step instructions for both documents are listed below (numbers coincide with those steps on the Daily Inspection Checklist):

- 1) Film badge, dosimeter and at least one survey meter available. These items must be available prior to performing radiographic operations.
- 2) Perform battery check of survey meter. If batteries are low, replace before proceeding.
- 3) Check calibration due dates of dosimeter and survey meter. Dosimeters and survey meters may not be used if not in calibration.
- 4) Recharge dosimeter. Follow steps listed in Part F of the MCI Operating and Emergency Procedures.
- 5) Perform an operational check of survey meter at the surface of the isotope storage area to assure that the meter is working properly.

At this time, the information concerning personnel and equipment to be used (Radiographers, Assistant Radiographers, dosimeters, survey meters, and exposure devices) should be filled out on the Radiographic Utilization Record. The Isotope Sign-Out Log for the isotope and exposure device to be used should also be started at this time. On the appropriate Log, check the date the source is to be used, note whether the device will be used for lab or field use, note the location of any field radiography to be performed, and the Radiographer should sign his initials indicating the exposure device has been removed from the isotope storage area. Once the exposure device has been signed out, the initial survey of the exposure device shall be performed and shall be documented on the Radiographic Utilization Record.

- 6) Check the exposure device for valid leak test date, decay curve, proper labeling and that a maintenance inspection has been performed within the last three months. This information is attached to the exposure device in a clear plastic envelope.

- 7) Inspect the exposure device for any obvious defects and cleanliness. Document any discrepancies on the Notification Record.
- 8) Check for proper operating characteristics of the exposure device locking mechanism, as clarified below:
 - a) Tech/Ops 660 - check the lock assembly and selector ring.
 - b) Tech/Ops 726 - check the lock and source rod movement.
 - c) Tech/Ops 446 - check the lock assembly located on the control unit crank-out assembly.
 - d) Picker 590 - check the lock assembly located on the head of the device in the exposure cell.
- 9) Check the source pigtail keyway with no-go gage (applies only to the Tech/Ops 660 exposure device).
- 10) Check the control unit assembly, source guide tube and extension guide tubes for correct operation, cleanliness and any irregularities such as kinks, flat spots, cuts or wear. Check that a maintenance inspection has been performed within the last three months on the equipment (applies only to Tech/Ops 660 and Tech/Ops 446 exposure devices).
- 11) Check drive cable end pin with no-go gage (applies only to Tech/Ops 660 exposure device).
- 12) Check for proper operation of emergency mechanisms, source position indicator lights, shutter and interlock mechanisms. (applies only to Picker 590 Cyclops exposure device).
- 13) Check for sufficient supply of signs, ropes and collimators.
- 14) Document on the Radiographic Utilization Record that the Daily Inspection Checklist has been completed.
- 15) Document any equipment malfunctions and/or defects on a Notification Record and forward the form to the RSO. If components essential to the safe operation of the device are found to be defective or in poor operating condition, tag the equipment out of service and notify the RSO immediately.

4. Operation of Tech/Ops Model 660 Iridium 192 Exposure Device

a. Assembly

After the Daily Inspection Checklist has been completed, follow the assembly instructions listed below:

- 1) Determine where exposure device and control unit will be positioned during the exposure and lay out the control housing with no bend radii less than 36 inches.
- 2) Unlock the exposure device with the key and turn the selector ring from the LOCK position to the CONNECT position. When the ring is in the CONNECT position, the storage cover will disengage from the exposure device. Store the cover in the holes provided in the handle of the exposure device.
- 3) Slide the connector collar back and open the jaws of the connector. This exposes the male portion of the swivel type drive cable connector.

- 4) Engage the male and female portions of the swivel connector by depressing the spring-loaded locking pin toward the exposure device with the thumbnail. Release the locking pin and test that the connection has been properly made.
- 5) Close the jaws of the connector over the swivel connector and slide the connector collar over the connector jaws.
- 6) Holding the collar flush against the control unit connector, rotate the selector ring from the CONNECT position to the LOCK position. Depress the plunger lock assembly, securely locking the exposure device. Keep the device locked until the radiographic operation is ready to start.
- 7) Position and secure the source stop of the master source guide tube at the desired radiographic focal position, and connect any extension source guide tubes or collimators as required, laying the guide tubes as straight as possible with no bend radii smaller than 20 inches. WARNING: NEVER OPERATE THE SYSTEM WITH MORE THAN A TOTAL OF THREE GUIDE TUBE SECTIONS, INCLUDING THE MASTER.
- 8) Remove the storage plug from the exposure device and connect the source guide tube(s) to the exposure device. Do not stand or look directly into the front of the exposure device with the storage plug removed, due to the high radiation levels that are emitted when it is removed.
- 9) Before operation, check all connections and bend radii, and check the position of the source stop, which represents the radiographical focal position of the source when in the exposed position.
- 10) Unlock the lock assembly plunger and rotate the selector ring to the OPERATE position. The source is now free to move.

b. Operation

- 1) Return to the control unit. Adjust the odometer reset knob to obtain a 000 reading on the odometer. Recheck that no unauthorized personnel are inside the Restricted Area.
- 2) Rapidly rotate the crank in the EXPOSE (counterclockwise) direction to move the source to the radiographic focal position. When the source emerges from the exposure device, there should be a rapid increase in radiation intensity as observed on the survey meter. The intensity should gradually decrease as the source moves toward the source stop. As the source enters the collimator (if used), there should be a significant drop in the radiation intensity, which should remain steady during the duration of the exposure. The survey meter readings will be substantially reduced if the meter is operated behind a radiation shield or if a collimator is used.
- 3) When the source reaches the source stop of the master source guide tube, the hand crank will stop turning. Never exert more than 5 ft-lbs of torque on the hand crank, as this may cause damage to the control unit or drive cable. The odometer

reading will indicate the total distance the source has traveled (approximately 7 ft. for each section of guide tube used). Set the brake to ON to prevent movement of the source during the exposure.

- 4) During the exposure, survey the Restricted Area boundary as specified in Part G of the MCI Operating and Emergency Procedures. Spend as little time as possible in the Restricted Area to minimize personnel exposure.
- 5) To return the source to its stored position in the exposure device after the desired exposure time has elapsed, turn the brake OFF and rapidly turn the crank in the RETRACT (clockwise) direction until the crank will no longer move. The odometer should read 000. During this process, the survey meter should indicate a continually increasing radiation level as it travels through the source guide tubes, then drop to background level once the source is shielded in the exposure device.
- 6) Approach the exposure device with the survey meter and survey the exposure device on all sides. The survey results should be the same as the initial survey of the device that was recorded on the Radiographic Utilization Record.
- 7) Survey the entire source guide tube length with the survey meter. If the meter shows a sharp increase in radiation intensity, the source could still be exposed or incompletely shielded.
- 8) If the source is still exposed, attempt to store it properly by cranking the source a short distance toward the source stop and retracting it, repeating if necessary. If the source becomes jammed in an exposed position, DO NOT TRY TO RETREIVE THE SOURCE. Treat the situation as an emergency - post and monitor the Restricted Area boundaries and notify the Radiation Safety Officer or other Company official for further instructions.
- 9) When the source is properly stored in the exposure device, rotate the selector ring from the OPERATE position to the LOCK position and secure it by locking the plunger lock assembly. NOTE: If the selector ring cannot be rotated to the LOCK position, the source has not been fully retracted to the safe storage position. Check the control unit odometer. It should be 000. Turn the hand crank to the full clockwise (RETRACT) direction.

c. Disassembly

- 1) Unscrew the source guide tube(s) from the exposure device.
- 2) Insert the shipping plug into the guide tube connector and tighten.
- 3) Unlock the exposure device with the key and turn the selector ring from the LOCK position to the CONNECT position.

- 4) Slide the connector collar back and open the jaws of the connector, exposing the swivel connection.
- 5) Disengage the male and female portions of the swivel connector by depressing the spring-loaded locking pin toward the exposure device with the thumbnail.
- 6) Close the jaws of the connector and slide the connector collar over the connector jaws, protecting the male portion of the swivel type drive cable connector.
- 7) Replace the storage cover over the selector assembly, and rotate the selector ring from the OPERATE position to the LOCK position. Secure it by locking the plunger lock assembly.

5. Operation of Tech/Ops Model 726 Cesium 137 Exposure Device

After the Daily Inspection Checklist has been completed, follow the operation instructions listed below:

- a. Place the exposure device in a restricted area so that the directional port is aimed horizontally. To minimize the effects of scatter radiation, place the device no closer than 16 feet from any wall.
- b. Unlock the exposure device lock.
- c. Set the timer on the device for the desired exposure time.
- d. Raise the source locking bar.
- e. Standing away from the port of the device, expose the source by manually raising the source rod. Movement of the source rod should be accomplished as quickly as possible to minimize exposure to personnel. In no case should anyone enter the area of the radiation beam emitting from the port or expose any part of his body to the radiation beam.
- f. The source will automatically return to the storage position when the preset time has elapsed. If it is necessary to return the source to the stored position before the preset time has elapsed, turn the timer knob to zero and manually return the source to the storage position by pushing the source rod downward.
- g. Lower the source locking bar and lock the exposure device.
- h. Approach the exposure device with the survey meter and survey the exposure device on all sides. The survey results should be the same as the initial survey of the device that was recorded on the Radiographic Utilization Record.
- i. Repeat steps (b) through (h) as necessary to complete the radiographic operation.

6. Operation of Tech/Ops Model 446 Cobalt 60 Exposure Device

a. Assembly

After the Daily Inspection Checklist has been completed, follow the assembly instructions listed below:

- 1) Unlock the chain lock to the isotope storage vault and position the exposure device where desired for the radiographic operation.
- 2) Unlock the exposure device storage compartment and remove the control unit, control cable, and source guide tubes.
- 3) Unreel the control cable from the control unit, and lay out the control cable with no bend radii less than 36 inches, making sure the plunger lock assembly on the control unit is securely locked. Keep the device locked until the radiographic operation is ready to start.
- 4) Position and secure the source stop of the master source guide tube at the desired radiographic focal position, and connect any extension source guide tubes or collimators as required, laying the guide tubes as straight as possible with no bend radii smaller than 20 inches. WARNING: NEVER OPERATE THE SYSTEM WITH MORE THAN A TOTAL OF THREE GUIDE TUBE SECTIONS, INCLUDING THE MASTER.
- 5) Unlock the storage plug locking bar lock and remove the storage plug from the exposure device. Do not stand or look directly into the front of the exposure device with the storage plug removed, due to the high radiation levels that are emitted when it is removed.
- 6) Connect the source guide tube(s) to the exposure device.
- 7) Before operation, check all connections and bend radii, and check the position of the source stop, which represents and radiographical focal position of the source when in the exposed position.
- 8) Return to the control unit. Unlock the plunger lock assembly on the control unit. The source is now free to move.

b. Operation

- 1) Adjust the odometer reset knob to obtain a 000 reading on the odometer. Recheck that no unauthorized personnel are inside the Restricted Area.
- 2) Rapidly rotate the crank in the EXPOSE (counterclockwise) direction to move the source to the radiographic focal position. When the source emerges from the exposure device, there should be a rapid increase in radiation intensity as observed on the survey meter. The intensity should gradually decrease as the source moves toward the source stop. As the source enters the collimator (if used), there should be a significant drop in the radiation intensity, which should remain steady during the duration of the exposure. The survey meter readings will be substantially reduced if the meter is operated behind a radiation shield or if a collimator is used.
- 3) When the source reaches the source stop of the master source guide tube, the hand crank will stop turning. Never exert more than 5 ft-lbs of torque on the hand crank, as this may

cause damage to the control unit or drive cable. The odometer reading will indicate the total distance the source has traveled (approximately 7 ft. for each section of guide tube used). Set the brake to ON to prevent movement of the source during the exposure.

- 4) During the exposure, survey the Restricted Area boundary as specified in Part G of the MCI Operating and Emergency Procedures. Spend as little time as possible in the Restricted Area to minimize personnel exposure.
- 5) To return the source to its stored position in the exposure device after the desired exposure time has elapsed, turn the brake OFF and rapidly turn the crank in the RETRACT (clockwise) direction until the crank will no longer move. The odometer should read 000.. During this process, the survey meter should indicate a continually increasing radiation level as the source travels through the source guide tube(s), then drop to background level once the source is shielded in the exposure device.
- 6) Lock the plunger lock assembly on the control unit.
- 7) Approach the exposure device with the survey meter and survey the exposure device on all sides. The survey results should be the same as the initial survey of the device that was recorded on the Radiographic Utilization Record.
- 7) Survey the entire source guide tube length with the survey meter. If the meter shows a sharp increase in radiation intensity, the source could still be exposed or incompletely shielded.
- 8) If the source is still exposed, attempt to store it properly by cranking the source a short distance toward the source stop and retracting it, repeating if necessary. If the source becomes jammed in an exposed position, DO NOT TRY TO RETREIVE THE SOURCE. Treat the situation as an emergency - post and monitor the Restricted Area boundaries and notify the Radiation Safety Officer or other Company official for further instructions.

c. Disassembly

- 1) Unscrew the source guide tube(s) from the exposure device.
- 2) Insert the shipping plug into the guide tube connector and lock the locking bar into place.
- 3) Coil up the control cable onto the control unit, making sure the plunger lock assembly on the control unit remains locked.
- 4) Place the control unit, control cable, and source guide tubes into the exposure device storage compartment and lock the handle.
- 5) Move the exposure device into its storage position near the isotope storage vault and secure the chain lock.

7. Operation of Picker Corp. Model 590 Cyclops Cobalt 60 Unit

After the Daily Inspection Checklist has been completed, follow the operation instructions listed below:

- a. Turn on the main power switch on the left side of the control panel. A green light will appear on both the control panel and on the head of the exposure device. Green lights indicate the source is in the shielded position, red lights indicate the source is in an exposed position.

NOTE: If both green lights do not activate when the main power switch is turned on, or if any red lights activate when the main power switch is turned on, stop radiographic operations and notify the Radiation Safety Officer immediately. Survey the area and establish a Restricted Area boundary if necessary.

- b. Position the head of the exposure device for the radiographic operation.
- c. Unlock the plunger lock assembly on the head of exposure device, making sure not to rotate the yellow source assembly cannister. The source is now free to move.
- d. Close and lock the exposure cell door as you leave the exposure cell, making sure the interlock switch is activated. The control panel will not operate without the closed cell door activating the interlock.
- d. Set the timer on the control panel for the desired exposure time.
- e. Insert the key into the control panel, press the timer button, and momentarily turn the key clockwise in the panel. Remove the key from the control panel. Both green and red lights should appear on the control panel, indicating the source is moving out of the shielded position and into the exposed position. This transition from shielded position to exposed position takes approximately 7 seconds. When the source reaches the exposed position, the green light will go out, leaving only the red light on, indicating the source is in the exposed position.
- f. Survey the exposure cell walls and door (Restricted Area boundary) and adjust the boundary if necessary.
- g. The source will automatically return to the shielded position when the preset time has elapsed. As it returns to the shielded position, both green and red lights will be activated. The red light will go out once the source has reached the shielded position. If it is necessary to return the source to the shielded position before the preset time has elapsed, press the EMERGENCY bar on the control panel.
- h. Check the control panel after the exposure is completed to make sure that only the green light is on, indicating the source is in the shielded position before entering the exposure cell.

- i. Unlock the exposure cell door and enter, surveying the area until you can verify that the source is in the shielded position. Only the green light should be activated on the exposure device head. Survey the exposure device to make sure it is in the shielded position, and lock the plunger lock assembly on the head of the exposure device.
- j. Repeat steps (a) through (i) until the radiographic operation is completed. Once completed, turn off the main power switch on the control panel.

Part K - Source Change Procedures

1. General Requirements

- a. Only trained and qualified Radiographers or Assistant Radiographers under the direct supervision of a trained and qualified Radiographer shall perform source change operations at Magna Chek.
- b. Magna Chek radiographic personnel shall only perform source change operations involving Tech/Ops A424-9=660 Ir 192 sealed sources, Tech/Ops Model 660 Exposure Devices, and Tech/Ops Model 650 Source Changers.
- c. Refer to Part N of the MCI Operating and Emergency Procedures for procedures on receiving and shipping radioactive sources.

2. Specific Source Change Procedures

These procedures deal only with source change operations involving Tech/Ops A424-9=660 Ir 192 sealed sources, Tech/Ops Model 660 Exposure Devices, and Tech/Ops Model 650 Source Changers.

a. Preparing the Tech/Ops Model 660 exposure device

- 1) Have a copy of the MCI Operating and Emergency Procedures, film badge, calibrated dosimeter, and calibrated survey meter for use.
- 2) Start a Radiographic Utilization Record, to document the transfer of the old source from the exposure device and the transfer of the new source into the exposure device.
- 3) Perform the daily equipment check and record it on the Daily Inspection Checklist.
- 4) Sign out the Tech/Ops Model 660 exposure device on the Isotope Sign-Out Log.
- 5) Remove the Tech/Ops Model 660 exposure device from the isotope storage vault and perform the initial radiation survey of the exposure device and record it on the Radiographic Utilization Record. (Note: record the results of 3 surveys on this Radiographic Utilization Record - the initial survey with the old source in the device, the survey with no source in the device, and the final survey with the new source in the device.)
- 6) Establish and post the calculated Restricted Area Boundary and High Radiation Boundary.
- 7) Determine where the exposure device and control unit will be positioned during the source change operation and lay out the control housing with no bend radii less than 36 inches.
- 8) Unlock the exposure device with the key and turn the selector ring from the LOCK position to the CONNECT position. When the

- ring is in the CONNECT position, the storage cover will disengage from the exposure device. Store the cover in the holes provided in the handle of the exposure device.
- 9) Slide the connector collar back and open the jaws of the connector. This exposes the male portion of the swivel type drive cable connector.
- 10) Engage the male and female portions of the swivel connector by depressing the spring-loaded locking pin toward the exposure device with the thumbnail. Release the locking pin and test that the connection has been properly made.
- 11) Close the jaws of the connector over the swivel connector and slide the connector collar over the connector jaws.
- 12) Holding the collar flush against the control unit connector, rotate the selector ring from the CONNECT position to the LOCK position. Depress the plunger lock assembly, securely locking the exposure device. Keep the device locked until the source change operation is ready to start.
- 13) Prepare the Tech/Ops Model 650 Source Changer for exchange of sources using the instructions below.

b. Preparing the Tech/Ops Model 650 Source Changer

- 1) Have a copy of the MCI Operating and Emergency Procedures, film badge, calibrated dosimeter, and calibrated survey meter for use.
- 2) Start a Radiographic Utilization Record, to document the transfer of the old source into the source changer and the transfer of the new source from the source changer.
- 3) After removing the Tech/Ops Model 650 Source Changer from the isotope storage vault, perform the initial radiation survey of the source changer and record it on the Radiographic Utilization Record. One side of the source changer will emit higher radiation levels due to the placement of the sealed source on that side. Record the highest survey reading found. (Note: record the results of 3 surveys on this Radiographic Utilization Record - the initial survey with the new source in the changer, the survey with both sources in the changer, and the final survey with the old source in the changer.)
- 4) Inspect the source changer for any obvious defects and cleanliness and record it on the Daily Inspection Checklist.
- 5) Position the source changer where the source exchange will be made.
- 6) Break the seal wire and remove the bolts securing the cover.
- 7) Lift off the cover and remove the source decay chart, leak test results, shipping labels, seal wires, and instruction manual located in the underside of the cover. Check that the leak test was performed within the last 6 months and that the results were within acceptable limits.

- 8) Remove the source identification plate which is attached to the source changer near the new source. This ID plate will be attached to the Tech/Ops Model 660 exposure device at the completion of the source change.
- 9) Break the seal wire attached to the source holddown cap and loosen the cap bolt.
- 10) Carefully remove the source holddown cap, exposing the female swivel connection of the new source.

WARNING: When the source holddown cap is removed, the source connector end is exposed. Special care should be taken to avoid dislodging the source from its position in the source changer.

- 11) Close and latch the source guides on the source changer.
- 12) Follow the instructions below for connecting the Tech/Ops Model 660 exposure device to the Tech/Ops Model 650 Source Changer and completing the source exchanges.

c. Connecting the devices and completing the source change operation

- 1) Remove the shipping plug from the Tech/Ops Model 660 exposure device. Connect a source guide tube EXTENSION to the exposure device and connect the other end to the EMPTY CHAMBER on the source changer, keeping the guide tube as straight as possible with no bend radii smaller than 20 inches.
- 2) Unlock the plunger lock assembly on the Tech/Ops Model 660 exposure device and rotate the selector ring to the OPERATE position. The source is now free to move.
- 3) Return to the control unit. Recheck that no unauthorized personnel are inside the Restricted Area.
- 4) Turn the crank in the EXPOSE (counterclockwise) direction to move the source from the exposure device to the source changer. When the source emerges from the exposure device, there should be a rapid increase in radiation intensity as observed on the survey meter, followed by a significant drop in the radiation intensity when the source reaches the source changer.
- 5) When the source reaches the source changer, the hand crank will stop turning. Never exert more than 5 ft-lbs of torque on the hand crank, as this may cause damage to the control unit or drive cable. Set the brake to the ON position to prevent movement of the source.
- 6) Approach the exposure device and source changer with the survey meter and survey all sides of the exposure device, the entire guide tube length, and all sides of the source changer. If the meter shows a sharp increase in radiation intensity, the source could still be exposed or incompletely shielded. The radiation level should not exceed 200 mR/hr at the surface of the Tech/Ops Model 650 Source Changer.

- 7) Open the source guides on the source changer, exposing the swivel connection. Carefully disengage the male and female portions of the swivel connector by depressing the spring-loaded locking pin toward the source changer with the thumbnail.

WARNING - Do not move the source more than 1/2" from its stored position, or extremely dangerous radiation levels can occur.

- 8) Disconnect the source guide tube extension from the source changer, making sure to protect the male end of the drive cable connector.
- 9) Conduct the survey of the exposure device with no source and the the survey of the source changer with two sources and document the results of the surveys on the respective Radiographic Utilization Records for the exposure device and source changer.
- 10) Connect the source guide tube extension with the male end of the drive cable connector exposed to the source changer fitting above the chamber containing the new source.
- 11) Engage the male and female portions of the swivel connector by depressing the spring-loaded locking pin toward the exposure device with the thumbnail. Release the locking pin and test that the connection has been properly made.

WARNING - Do not move the source more than 1/2" from its stored position, or extremely dangerous radiation levels can occur.

- 12) Close and latch the source guides on the source changer.
- 13) Return to the control unit. Recheck that no unauthorized personnel are inside the Restricted Area.
- 14) Set the brake to the OFF position, and turn the crank in the RETRACT (clockwise) direction to move the source from the source changer to the exposure device. When the source emerges from the source changer, there should be a rapid increase in radiation intensity as observed on the survey meter, followed by a significant drop in the radiation intensity when the source reaches the exposure device.
- 15) When the source reaches the exposure device, the hand crank will stop turning. Never exert more than 5 ft-lbs of torque on the hand crank, as this may cause damage to the control unit or drive cable. Set the brake to the ON position to prevent movement of the source.

- 16) Approach the exposure device and source changer with the survey meter and survey all sides of the exposure device, the entire guide tube length, and all sides of the source changer. If the meter shows a sharp increase in radiation intensity, the source could still be exposed or incompletely shielded. The radiation level should not exceed 200 mR/hr at the surface of the Tech/Ops Model 650 Source Changer or the Tech/Ops Model 660 exposure device.
- 17) Once it has been determined that the source is in the shielded position inside exposure device, rotate the selector ring from the OPERATE position to the LOCK position and secure it by locking the plunger lock assembly.
- 18) Open the source guides on the source changer and disconnect the source guide tube extension.
- 19) Disconnect the source guide tube from the exposure device, insert the shipping plug into the guide tube connector and tighten.
- 20) Carefully place the source holddown cap into position over the old source in the source changer. Tighten the holddown cap bolt and attach a new seal wire which was included with the changer.
- 21) Remove the source identification plate for the old source from the exposure device and replace with the source identification plate for the new source.
- 22) Attach the source identification plate for the old source to the source changer holddown cap above the chamber where the old source is located.
- 23) Place the source changer cover in position and secure with the cover bolts. Attach a new wire seal which was included with the changer.
- 24) Unlock the exposure device with the key and turn the selector ring from the LOCK position to the CONNECT position.
- 25) Slide the connector collar back and open the jaws of the connector, exposing the swivel connection.
- 26) Disengage the male and female portions of the swivel connector by depressing the spring-loaded locking pin toward the exposure device with the thumbnail.
- 27) Close the jaws of the connector and slide the connector collar over the connector jaws, protecting the male portion of the swivel type drive cable connector.
- 28) Replace the storage cover over the selector assembly, and rotate the selector ring from the OPERATE position to the LOCK position. Secure it by locking the plunger lock assembly.
- 29) Perform the final radiation surveys of the exposure device and source changer and record the results of the surveys on their respective Radiographic Utilization Records.
- 30) Return the exposure device and source changer to the isotope storage vault. Lock the door and survey the outside of the storage vault.

- 31) Sign the exposure device back in on the Isotope Sign-Out Log, noting that a source change was performed, and include the serial number of the new source.
- 32) Remove the Restricted Area Boundary and High Radiation Boundary.
- 33) Complete the Radiographic Utilization Records for both the Tech/Ops Model 660 exposure device and the Tech/Ops Model 650 Source Changer and forward the reports along with the new source paperwork (decay chart, shipping papers, etc.) to the Radiation Safety Officer.
- 34) Document the radiation dose received on a Dosimeter Record.

Part L - Calibration of Survey Meters and Dosimeters

1. General Requirements

- a. Only qualified and trained Radiographers may operate radiographic exposure devices, including devices used for the calibration of survey instruments and dosimeters. Assistant Radiographers may operate such devices ONLY UNDER THE DIRECT SUPERVISION OF A RADIOGRAPHER.
- b. Because exposure devices used for calibration are capable of emitting high radiation levels, calibration of survey instruments and dosimeters must be performed only in a Restricted Area, as defined in Part I of the MCI Operating and Emergency Procedures.
- c. Prior to the start of the calibration procedure, the Radiographer shall be sure that the following criteria are met:
 - 1) at least one working, calibrated survey meter is available,
 - 2) current film badges and calibrated, rezeroed dosimeters are in use for himself and the Assistant Radiographer(s),
 - 3) A copy of the MCI Operating and Emergency Procedures are on the worksite.
- d. The general radiographic procedures listed in Part J of the MCI Operating and Emergency Procedures shall be adhered to in addition to any procedures listed for specific exposure devices.

2. Operation of Tech/Ops Model 726 Exposure Device

After the Daily Inspection Checklist has been completed, follow the operation instructions listed below:

- a. Place the exposure device in a restricted area so that the directional port is aimed horizontally. To minimize the effects of scatter radiation, place the device no closer than 16 feet from any wall.
- b. Unlock the exposure device lock.
- c. Set the timer on the device for the desired exposure time.
- d. Raise the source locking bar.
- e. Standing away from the port of the device, expose the source by manually raising the source rod. Movement of the source rod should be accomplished as quickly as possible to minimize exposure to personnel. In no case should anyone enter the area of the radiation beam emitting from the port or expose any part of his body to the radiation beam.
- f. The source will automatically return to the storage position when the preset time has elapsed. If it is necessary to return the source to the stored position before the preset time has elapsed, turn the timer knob to zero and manually return the source to the storage position by pushing the source rod downward.
- g. Lower the source locking bar and lock the exposure device.

- h. Approach the exposure device with the survey meter and survey the exposure device on all sides. The survey results should be the same as the initial survey of the device that was recorded on the Radiographic Utilization Record.
- i. Repeat steps (b) through (h) as necessary to complete the calibration operations.
- j. After concluding operations, perform the final radiation survey of the exposure device and record it on the Radiographic Utilization Record.

3. Calibration Procedures for Survey Meters

Survey meter response must be checked on each range of the meter at 2 different points, separated by 50% of the scale. These points of calibration shall be 2.5 mR/hr and 7.5 mR/hr for the x1 range, 25 mR/hr and 75 mR/hr for the x10 range, and 250 mR/hr and 750 mR/hr for the x100 range. Survey meters shall be calibrated at intervals not to exceed 3 months and after servicing of the instrument.

- a. Position the exposure device so that the directional port is aimed horizontally, and no closer than 16 feet from any wall to minimize scatter radiation.
- b. Position a support stand horizontally from the exposure device so that the center of the ionization chamber or G.M. tube of the survey meter is in alignment with the center of the directional port of the exposure device.
- c. Install new batteries in the survey meter, and allow the meter to warm up for a minimum of 10 minutes.
- d. Calculate the current source strength of the Cesium 137 source, using the initial source strength, half-life, and age of the source.
- e. Calculate the distances from the exposure device to obtain the intensities of the calibration points listed above, using the inverse square law and the charts included at the end of Part L of the MCI Operating and Emergency Procedures.
- f. Place the survey meter on the support stand at the distance to the desired calibration point, making sure that the meter can be read from outside the primary beam of the exposure device.
- g. Following the exposure device operating procedures listed above, expose the source only long enough for the survey meter response to stabilize. Record the meter response on the Survey Meter Calibration Certificate.
- h. Repeat steps (f) and (g) for all calibration points on each range of the survey meter. The survey meter response for each calibration point must be within $\pm 20\%$ of the actual radiation intensity to be considered calibrated.

- #### 4. Calibration Procedures for Dosimeters

- a. Position the exposure device so that the directional port is aimed horizontally, and no closer than 16 feet from any wall to minimize scatter radiation.
- b. Position a support stand horizontally from the exposure device so that the center of the dosimeter(s) is in alignment with the center of the directional port of the exposure device.
- c. Calculate the current source strength of the Cesium 137 source, using the initial source strength, half-life, and age of the source.
- d. Calculate the distance from the exposure device to obtain a radiation intensity of 750 mR/hr, using the inverse square law and the charts included at the end of Part L of the MCI Operating and Emergency Procedures.
- e. Rezero the dosimeter(s) and place them (no more than 4 at one time) on the support stand at the calculated distance.
- f. Following the exposure device operating procedures listed above, expose the source for 4 minutes to deliver a radiation dose of 50 mRem to the dosimeters. After the exposure, read the response of the dosimeter(s) and record the readings on the Dosimeter Calibration Certificate.
- g. Rezero the dosimeter(s) and place them (no more than 4 at one time) on the support stand at the calculated distance.

- h. Following the exposure device operating procedures listed above, expose the source for 12 minutes to deliver a radiation dose of 150 mRem to the dosimeters. After the exposure, read the response of the dosimeter(s) and record the readings on the Dosimeter Calibration Certificate.
- i. The dosimeter response for each calibration point must be within $\pm 30\%$ of the actual radiation dose delivered to be considered calibrated.
- j. If the dosimeter response is not within $\pm 30\%$, the dosimeter cannot be calibrated and shall be tagged and returned to the Radiation Safety Officer for disposal.
- k. If the dosimeter responses are within the $\pm 30\%$ requirements, the dosimeter shall be rezeroed and checked for leakage by storing it in a radiation-free environment for a 24 hour period. The dosimeter shall be read and any leakage shall be documented on the Dosimeter Calibration Certificate. The maximum amount of leakage permissible shall be 2% (4 mRem).
- l. Complete the Dosimeter Calibration Certificate and forward to the Radiation Safety Officer. If the dosimeter has acceptable responses and passes the leakage test, a calibration sticker shall be attached to the dosimeter. This sticker shall indicate the serial number of the meter, the date of calibration, the date the next required calibration is due, and the initials of the person who performed the calibration.

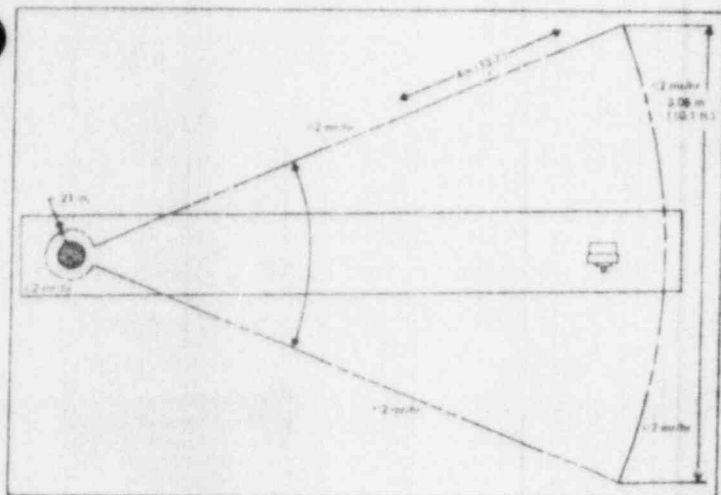


Figure 1

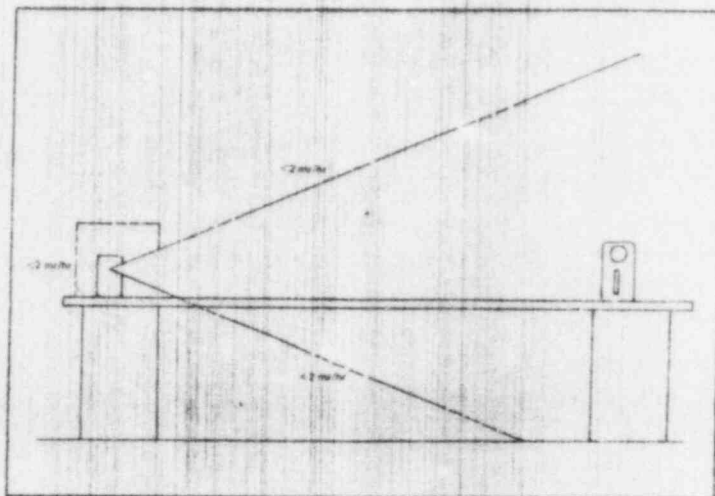


Figure 2

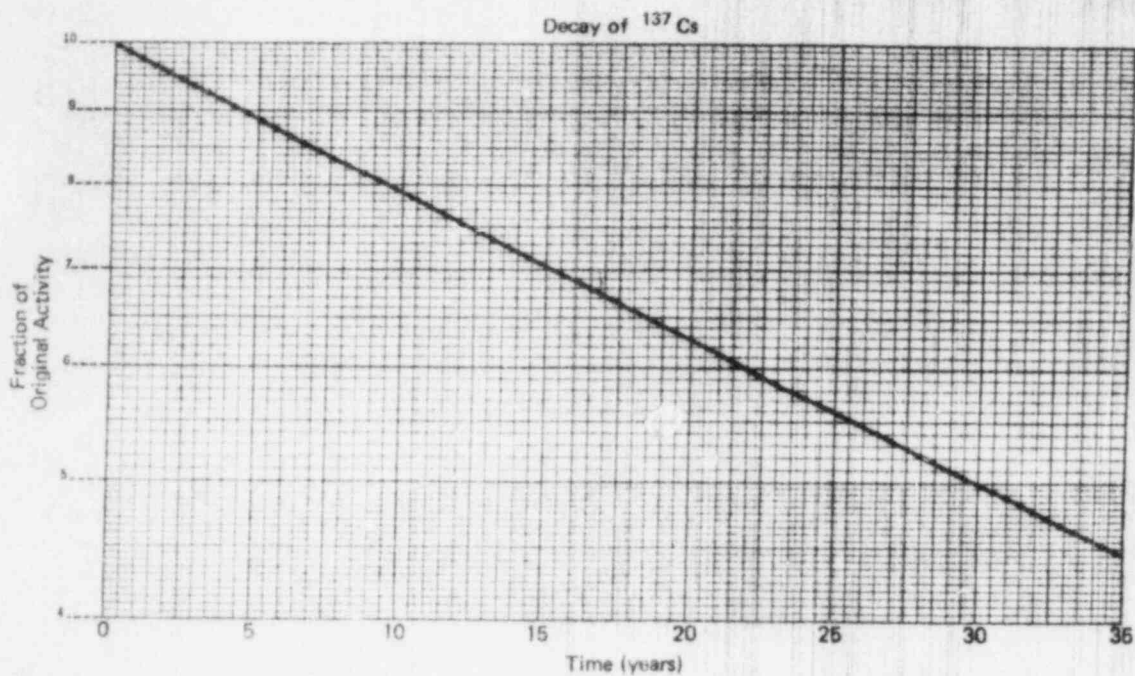


TABLE I

PART A 110m Ci ¹³⁷Cs

DOSE (mr/hr)	DISTANCE IN AIR		DISTANCE W ATTENUATOR	
	CM	IN	CM	IN
1500	15.3	6.03		
750	21.7	8.53		
500	26.5	10.45		
250	37.5	14.77		
150	48.4	19.06		
75	68.5	26.97	15.3	6.03
50	83.9	33.03	18.8	7.40
25	118.7	46.73	26.5	10.45
15	153.2	60.31	34.3	13.5
7.5	216.6	85.28	48.4	19.06
5	265.3	104.5	59.3	23.35
2.5	375.2	147.72	83.9	33.03
2	419.5	165.16	93.8	36.93

PART B 105m Ci ¹³⁷Cs

1500	14.9	5.89		
750	21.2	8.33		
500	25.9	10.20		
250	36.7	14.43		
150	47.3	18.62		
75	66.9	26.34	15.0	5.89
50	82.0	32.28	18.3	7.20
25	115.9	45.63	25.9	10.20
15	149.7	58.94	33.4	13.15
7.5	211.7	83.35	47.3	18.62
5	259.2	102.05	58.0	22.83
2.5	366.6	143.33	82.0	32.28
2	409.9	161.38	91.7	36.10

PART C 100m Ci ¹³⁷Cs

1500	14.6	5.75		
750	20.7	8.15		
500	25.3	9.96		
250	35.8	14.09		
150	46.2	18.19		
75	68.3	26.89	14.6	5.75
50	80.0	31.5	17.9	7.05
25	113.1	44.53	25.3	9.96
15	146.1	57.52	32.7	12.87
7.5	206.6	81.34	46.2	18.19
5	253.0	99.6	56.6	22.28
2.5	357.7	140.55	80.0	31.5
2	400	157.5	89.4	35.20

PART D 95m Ci ¹³⁷Cs

DOSE (mr/hr)	DISTANCE IN AIR		DISTANCE W ATTENUATOR	
	CM	IN	CM	IN
1500	14.2	5.59		
750	20.1	7.93		
500	24.7	9.71		
250	34.9	13.73		
150	45.0	17.72		
75	63.7	25.08	14.2	5.59
50	78.0	30.71	17.4	6.85
25	110.3	43.43	24.7	9.71
15	142.4	55.9	31.8	12.52
7.5	201.3	79.25	45.0	17.72
5	246.6	97.09	55.1	21.69
2.5	348.7	137.28	78.0	30.71
2	390.5	153.75	87.2	34.33

PART E 90m Ci ¹³⁷Cs

1500	13.9	5.47		
750	19.6	7.71		
500	24.0	9.45		
250	33.9	13.35		
150	43.8	17.25		
75	62.0	24.41	13.9	5.47
50	75.9	29.88	17.0	6.
25	107.3	42.25	24.0	9.45
15	138.6	54.57	31.0	12.20
7.5	196.0	77.17	43.8	17.25
5	240.0	94.5	53.7	21.14
2.5	339.4	133.62	75.9	29.88
2	379.7	149.21	84.9	33.43

PART F 85m Ci ¹³⁷Cs

1500	13.5	5.31		
750	19.0	7.5		
500	23.3	9.17		
250	33.0	13.0		
150	42.6	16.77		
75	60.2	23.70	13.5	5.31
50	73.8	29.05	16.5	6.49
25	104.3	41.06	23.3	9.17
15	134.2	52.83	30.1	11.85
7.5	190.4	74.96	42.6	16.77
5	233.2	91.81	52.0	20.47
2.5	328.6	129.37	73.8	29.05
2	368.8	145.20	82.5	32.5

Part M - Leak Testing Procedures

1. General Requirements

- a. Sealed sources shall be tested for leakage and contamination at intervals not to exceed six months.
- b. Leak testing of sealed sources shall be done using one of the following commercial leak test kits:
 - 1) Tech/Ops Model 518 Leak Test Kit
 - 2) Gamma Industries Kowipe Leak Test Kit.
- c. Leak testing procedures shall be performed only by qualified Radiographers or Assistant Radiographers under the direct supervision of a Radiographer.
- d. Evaluation of leak test smears obtained using the Tech/Ops Model 518 Leak Test Kit shall be performed by Tech/Ops, Inc., Radiation Products Division, 40 North Avenue, Burlington, MA
- e. Evaluation of leak test smears obtained using the Gamma Industries Kowipe Leak Test Kit shall be performed by Gamma Industries, 2255 Ted Dunham Avenue, Baton Rouge, LA.

2. Instructions for Tech/Ops Model 518 Leak Test Kit

Contents of the Tech/Ops Model 518 Leak Test Kit include a vial of EDTA solution, flexible swab holder with swab, plastic envelope, mailing box, and the leak test form.

- a. Wet the swab with EDTA solution. Shake off excess and obtain the leak test smear following the specific procedures listed below in Part M - 4, Specific Leak Test Smear Procedures.
- b. Place the swab in the plastic envelope and seal with tape.
- c. Take the swab to a low background area and turn the survey meter to the x1 range. Monitor the swab by moving the swab in its plastic envelope to the meter, not the meter to the swab.
- d. If there is no indication on the meter, or if the indication is no more than 0.2 mR/hr above background, put the plastic envelope with the swab in the mailing box. Fill out the Leak Test Form and mail the form and swab in the mailing box to Tech/Ops, Inc., 40 North Ave., Burlington, MA 01803.
- e. If the meter shows a reading of more than 0.2 mR/hr from the swab, DO NOT MAIL. Notify the Radiation Safety Officer who will contact Tech/Ops for specific instructions.

3. Instructions for Gamma Industries Kowipe Leak Test Kit

Contents of the Gamma Industries Kowipe Leak Test Kit include a packet of solution powder, 2 sticks with swabs attached in plastic envelopes, and the leak test form.

- a. Mix the solution by adding 2 ounces of water to the powder.
- b. Wet the first swab with the solution. Shake off excess and obtain the leak test smear following the specific procedures listed below in Part M - 4, Specific Leak Test Smear Procedures.
- c. Place the swab back in the plastic envelope and seal with tape.
- d. Repeat the leak test smear using the second swab without wetting the swab, following the specific procedures listed below in Part M - 4, Specific Leak Test Smear Procedures.
- e. Place the swab back in the plastic envelope and seal with tape.
- f. Take the swabs to a low background area and turn the survey meter to the x1 range. Monitor the swabs by moving the them in their plastic envelopes to the meter, not the meter to the swabs.
- g. If there is no indication on the meter, or if the indication is no more than 0.2 mR/hr above background, fill out the Leak Test Form and mail the form and swabs in an envelope to Gamma Industries, 2255 Ted Dunham Ave., Baton Rouge, LA 70821.
- h. If the meter shows a reading of more than 0.2 mR/hr from the swab, DO NOT MAIL. Notify the Radiation Safety Officer who will contact Gamma Industries or Tech/Ops, Inc. for specific instructions.

4. Specific Leak Test Wipe Procedures.

- a. Tech/Ops Model 660 exposure device
 - 1) Remove the exposure device from the isotope storage vault. Survey the device to make sure the source is in the shielded position.
 - 2) Remove the shipping plug from the front of the exposure device. Do not stand in front of or look directly into the front of the exposure device with the shipping plug removed, due to the high radiation levels that are emitted.
 - 3) Insert the swab into the hole in the device. Wipe the interior of the hole thoroughly by rotating the swab holder several times.
 - 4) Withdraw the swab and wipe the shipping plug cable end where it is in contact with the source.
 - 5) Place the swab in the plastic envelope and seal.
 - 6) Replace the shipping plug back into the exposure device and return the device to the isotope storage vault.
- b. Tech/Ops Model 726 exposure device
 - 1) Remove the exposure device from the isotope storage vault and place in a restricted area. Survey the device to make sure the source is in the shielded position.

- 2) Remove the lock and raise the source locking bar.
 - 3) Wipe the top of the source rod with the swab.
 - 4) Making sure to stay out of the radiation beam, raise the source rod to the exposed position and thoroughly wipe the exposed portion of the source rod.
 - 5) Lower the source rod and survey the exposure device to make sure that the source is in the shielded position.
 - 6) Place the swab in the plastic envelope and seal.
 - 7) Lower the source locking bar and secure with the lock. Return the device to the isotope storage vault.
- c. Tech/Ops Model 446 exposure device
- 1) Survey the exposure device to make sure the source is in the shielded position.
 - 2) Unlock the storage plug locking bar lock and remove the storage plug from the exposure device. Do not stand in front of or look directly into the front of the exposure device with the storage plug removed, due to the high radiation levels that are emitted.
 - 3) Insert the swab into the hole in the device. Wipe the interior of the hole thoroughly by rotating the swab holder several times.
 - 4) Withdraw the swab and wipe the shipping plug cable end where it is in contact with the source.
 - 5) Place the swab in the plastic envelope and seal.
 - 6) Replace the storage plug back into the exposure device and lock the locking bar in place.
- d. Picker 590 Cyclops exposure device
- 1) Survey the exposure device to make sure the source is in the shielded position.
 - 2) Remove the collimator from the head of the exposure device.
 - 3) Insert the swab through the opening and thoroughly wipe the exposure port.
 - 4) Place the swab in the plastic envelope and seal.
 - 5) Replace the collimator on the exposure device and return to it to the storage position.

Part N - Shipping & Receiving Radioactive Sources

1. Shipping Procedures

- a. Assure that the source is secured in the proper shielded storage position in the shipping package.
- b. If the shipping package is to be placed inside a crate or other outer packaging, sufficient packing must be used to prevent shifting of the inner package during transportation.
- c. Attach a security seal with an identification mark to the package closure.
- d. Survey the package at the surface and at one meter from the surface to determine the proper radioactive shipping labels to be applied to the package. Use the table below to determine which shipping label to apply.

TYPE OF SHIPPING LABEL *****	MAXIMUM PERMISSIBLE RADIATION LEVEL	
	at surface *****	at one meter *****
Radioactive White I	0.5 mR/hr	None
Radioactive Yellow II	50 mR/hr	1.0 mR/hr
Radioactive Yellow III	200 mR/hr	10 mR/hr

NOTE: Packages with surface radiation intensities in excess of 200 mR/hr or with radiation intensities at one meter from the surface in excess of 10 mR/hr cannot be shipped.

- e. Properly complete two shipping labels indicating the contents (Iridium 192, Cesium 137, or Cobalt 60), the number of curies and the transport index. The transport index is the dimensionless number (rounded up to the first decimal place) expressing the maximum radiation level in millirem per hour at one meter from the package surface.
- f. Remove any old shipping labels from the package. Apply two properly completed shipping labels to two opposite sides of the package.
- g. Mark the outside of the package with the proper shipping name (Radioactive Material, Special Form, n.o.s.) and identification number (UN 2974) if not already marked.
- h. If the shipping package is inside a crate or other outer packaging, mark the outside package "INSIDE PACKAGE COMPLIES WITH PRESCRIBED SPECIFICATIONS" and list the appropriate Department

- of Transportation specification number or USNRC Type B number and the words "Type A" or "Type B" if applicable.
- i. Properly complete the shipping papers indicating:
 - 1) Proper shipping name (Radioactive Material, Special Form, n.o.s.), and identification number (UN 2974).
 - 2) Name of the Radionuclide (Iridium 192, Cesium 137, Cobalt 60, Uranium 238).
 - 3) Physical and chemical form (or Special Form).
 - 4) Activity of Source (expressed in curies or millicuries).
 - 5) Category of Label applied (Radioactive Yellow II, etc.).
 - 6) Transport Index.
 - 7) USNRC Identification Number or DOT Specification Number (i.e. USNRC: USA/9032/B or DOT-7A).
 - 8) Shipper's certification:

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

NOTE: If the package includes depleted uranium as shielding material, the shipping papers must also include the following information:

Radioactive Device, n.o.s.; UN2911
Uranium 238; Solid Metal; curies

- j. Forward a copy of all shipping papers to the Radiation Safety Officer.

2. Receiving Procedures

- a. Upon receipt of a package of radioactive material, survey the exterior surfaces of the package to assure that the radiation intensity does not exceed 200 mR/hr.
- b. Survey at one meter from the exterior surfaces of the package to assure that the radiation levels do not exceed 10 mR/hr.
- c. Record the results of these surveys on the Radioisotope Receiving Report. If any of the limits are exceeded, notify the Radiation Safety Officer, who will in turn notify the final delivering carrier and the Nuclear Regulatory Commission in accordance with 10CFR Part 20.
- d. Record on the Receiving Record the source model number, serial number, radioisotope, activity, shipping package model number and serial number. Inspect the package for any evidence of physical damage. Record the results of this inspection on the Receiving Report.
- e. Assure that the shipping package is locked and secure the package in the isotope storage vault.
- f. Complete the Receiving Record and forward to the Radiation Safety Officer.

Part D - Quarterly Inspection and Maintenance of Equipment

1. Tech/Ops Model 660 Exposure Device and Related Equipment

The following inspection and maintenance shall be performed on Tech/Ops Model 660 exposure devices and related equipment at intervals not to exceed 3 months, and shall be documented on the Quarterly Inspection and Maintenance Record.

a. Tech/Ops Model 693 Control Unit and Source Guide Tubes

- 1) Remove the drive cable from the control unit by cranking it in the EXPOSE direction until the crank will no longer turn. Disconnect the control housing from the RETRACT side of the crank and remove the stop spring from the drive cable. Turn the crank until the drive cable is totally disconnected. Pull the remaining drive cable out of the control unit and place the cable in a bucket filled with approximately 1 quart of solvent (chloroethene or equivalent). Thoroughly clean any foreign material from the cable after letting it soak for 5 to 10 minutes. Thoroughly dry the cable and lightly lubricate with Grade MIL-G-2387A grease (Texico Uni-Temp or equivalent). Using a Model 550 no-go gauge, check the male connector of the drive cable. If the ball of the connector fits through the hole of the gauge or the ball shank fits into the slot in the gauge, the connector is worn and the cable must be replaced.
- 2) Flush the control housings and source guide tubes with solvent and thoroughly dry using compressed dry air (15 psi maximum). Wipe the outside of the control housings and source guide tubes with a cloth soaked in solvent and thoroughly dry. Flex the control housings and source guide tubes to check for any internal damage. Damage is evidenced by a crunching feeling when the housing or guide tube is bent. While doing this, feel for dents along the entire length of all guide tubes and both control housings. Cut, flattened or burnt control housings or guide tubes should be repaired or replaced. They may be covered with protective tape where only the outer plastic is cut through. Check the source guide tubes for binding by holding them vertical and dropping a dummy source or jumper through them.
- 3) Remove the control box housing from the handle by unscrewing the four binder head screws and 3/8" nuts. Remove the crank arm assembly from the control box housing by removing the 5/16" hex head bolt. Separate the two halves of the control box housing, keeping the cable adapters in the lower control box housing to ensure the wear strip does not fly out. Remove the drive wheel, wear strip, two cable adapters, two brake jaws, brake arm and brake bearing. The two ball bearing assemblies in each side of the control housing may be left in place. Remove the odometer mount cover from the odometer

mount and check the odometer unit for proper operation. The unit should turn freely and without excessive play. Clean the helical gear with solvent and lightly lubricate. If the odometer assembly is defective, it must be replaced as a unit. Clean all the control box parts in solvent and thoroughly dry them before assembly. Inspect for damage and excessive wear. Replace any defective parts. Lightly lubricate all moving parts at their contact surfaces.

- 4) Place the two cable adapters in the lower control box housing, with the angled sides facing inward in order to provide clearances for the drive wheel. Place the wear strip in the control housing. Place the drive wheel in the lower control box housing. Position the two brake jaws, brake bearing and brake arm in the lower control box housing. When installing the brake jaws, face the worn sides away from the drive wheel, as this increases their life. Place the upper control box housing over the lower control box housing while keeping them level, and press them together. Check the control box for proper reassembly by turning the shaft. It should spin freely. If not, disassemble and reinspect the parts for damage and proper alignment. Reassemble and check the operation again. Resecure the odometer to the odometer mount and secure the odometer reset knob and odometer mount assembly cover in place. Secure the control box to the control handle and odometer mount with the four large binder head screws and 3/8" nuts. Secure the crank arm assembly to the shaft with the 5/16" bevel washer and 5/16" hex head bolt. After complete assembly, check for proper operation by turning the crank, it should spin freely. Run the drive cable through the control box and turn the crank. It should turn easily and with no snags. Set the brake to ON and attempt to turn the crank. It should not turn with moderate pressure. Do not apply excessive pressure to the crank, as this may cause damage. If the control unit fails any of these tests, disassemble, check the parts for damage and proper alignment, then reassemble and check for proper operation again. Attach the control housing to the EXPOSE side of the control box and to the connector plug. Feed the drive cable into the control housing as far as it will go. As the drive cable is being fed in, feel the resistance to the drive cable to detect any binding of the cable. This indicates a dent in the control housing which should be repaired or replaced. Turn the hand crank until the drive cable is protruding, and screw the stop spring to the end of the drive cable. Connect the other control housing to the crank and to the connector plug. Turn the crank fully to the RETRACT position and watch for any binding of the drive cable to check the other section of the control housing for dents. Repair or replace the control housing if necessary.

- b. Tech/Ops Model 660 Exposure Device - ROUTINE MAINTENANCE
- 1) Survey the device to ensure proper radiation levels and document readings on the Radiographic Utilization Record
 - 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked or damaged housing, cleanliness, missing parts, etc.
 - 3) Inspect the key lock assembly for correct operation and cleanliness; lubricate the locking plunger
 - 4) Check the control unit connector assembly for correct operation and cleanliness
 - 5) Check the female drive cable connector of the source for wear with Model 550 no-go gauge. If the gauge width can fit into the female slot, the connector is worn and the source must be replaced.
 - 6) If a Tech/Ops Model 650 Source Changer is available, a complete disassembly and maintenance inspection of the exposure device shall be performed as specified in the following instructions of section 1c, Complete Maintenance.
- c. Tech/Ops Model 660 Exposure Device - COMPLETE MAINTENANCE

THE FOLLOWING INSPECTION AND MAINTENANCE PROCEDURES ARE TO BE FOLLOWED ONLY AFTER THE RADIOGRAPHIC SOURCE HAS BEEN REMOVED FROM THE EXPOSURE DEVICE. IF A TECH/OPS MODEL 650 SOURCE CHANGER IS NOT AVAILABLE FOR THE REMOVAL OF THE SOURCE, DO NOT PERFORM THE COMPLETE MAINTENANCE ON THE EXPOSURE DEVICE. ONLY PERFORM THE ROUTINE MAINTENANCE LISTED IN SECTION B ABOVE.

- 1) Check the female drive cable connector of the source for wear with Model 550 no-go gauge. If the gauge width can fit into the female slot, the connector is worn and the source must be replaced.
- 2) To service the exposure device, remove the source following the source changing procedures listed in Part K of the MCI Operating and Emergency Procedures.
- 3) After removing the source, remove the Danger Tag (secured with rivets) from the bottom of the rear plate of the exposure device.
- 4) Remove the rear plate by unscrewing the six phillips head screws securing it to the exposure device body.
- 5) Unlock the connector lock, and then remove the lock assembly and control unit connector assembly by unscrewing the six socket head screws securing them to the rear plate.
- 6) Disassemble the control unit connector assembly, referring to Figure 1A at the end of Part D for order of removal. There are several spring loaded parts in the connector assembly, so care should be taken that these parts are not lost or damaged.
- 7) To disassemble the lock assembly, refer to Figure 1B for order of removal. Remove the lock from the lock retainer by unscrewing the screw and turning the key about 90 degrees.

- 8) Remove the front end plate from the exposure device, and remove the guide tube connector and retaining ring. The handle may be left on the front plate.
- 9) Clean all parts in solvent. Clean the S-Tube in the exposure device by running a cloth soaked with solvent through it several times. Thoroughly dry all parts using dry compressed air (15 psi maximum). Dry the S-Tube by running a dry cloth through the tube.
- 10) Inspect all parts for damage or excessive wear, and replace if necessary. Lightly lubricate all moving parts at their contact surfaces.
- 11) Reassemble the front end plate, and secure it to the exposure device with the proper screws.
- 12) Reassemble the lock by placing the return springs and spring guides into the lock, depressing the internal plunger, inserting the lock into the lock retainer, and securing the lock with the set screw.
- 13) Attach the lock assembly to the rear plate with the two socket head screws.
- 14) Reassemble the control unit connector assembly as follows:
 - a) Place the compression spring on the hub of the selector ring retainer. The spring should be firmly seated over the hub. Then place the sleeve on top of the compression spring.
 - b) Place the selector body on a flat surface so that it is resting on its 5/8" hub.
 - c) Insert the two short compression springs and locking pins into the holes on the edge of the selector body.
 - d) Place the selector ring over the selector body while restraining the locking pins. Ensure that the lettering (OPERATE-LOCK-CONNECT) on the selector ring is facing up and that the stop pin on the selector body is in the cam slot of the selector ring.
 - e) Hold the selector ring and selector body together and place them over the selector ring retainer with spring and sleeve. Align the resulting assembly such that the two large holes in the selector ring retainer line up with the two large holes in the selector body. The internal locking cam will partially block these holes.
 - f) Insert the anti-rotation lugs and long compression springs into the two large holes in the selector body. Secure the resulting assembly onto the rear plate with four socket head screws. The word OPERATE should be facing outward, and should be in the 12 o'clock position.
- 15) Connect the jumper to the short length drive cable and insert the cable through the rear end plate and control unit connector assembly.

- 16) Insert the U-tool into the control unit connector assembly and check the operation by turning the selector ring from OPERATE to CONNECT several times. If the connector assembly does not operate properly, disassemble and inspect the parts for damage and proper alignment. Relubricate the parts and reassemble.
- 17) Secure the rear end plate to the exposure device and handle using the six attaching phillips head screws and replace the protective plate (Danger Tag) over the bottom two rear plate screws using pop rivets.
- 18) Check the system for proper reassembly. Check all connections and fittings for tightness. Check for proper operation of the control unit and control unit connector assembly.
- 19) Transfer the source from the source changer to the exposure device following the instructions listed in Part K of the MCI Operating and Emergency Procedures.
- 20) Survey the device to ensure proper radiation levels and document readings on the Radiographic Utilization Record

2. Tech/Ops Model 446 Exposure Device and Related Equipment

The following inspection and maintenance shall be performed on the Tech/Ops Model 446 exposure device and related equipment at intervals not to exceed 3 months, and shall be documented on the Quarterly Inspection and Maintenance Record.

a. Tech/Ops Model 664 Control Unit and Guide Tubes

- 1) Make sure that the source shipping plug is locked in place before performing any maintenance on the control unit. Disconnect the control housing from the RETRACT side of the crank. Remove the control box housing from the frame by unscrewing the four binder head screws and 3/8" nuts. Remove the crank arm assembly from the control box housing by removing the 5/16" hex head bolt. Separate the two halves of the control box housing, keeping the cable adapters in the lower control box housing to ensure the wear strip does not fly out. Remove the drive wheel, wear strip, two cable adapters, two brake jaws, brake arm and brake bearing. The two ball bearing assemblies in each side of the control housing may be left in place. Remove the reset knob by loosening the two set screws, and remove the odometer cover by removing the two large binder head screws fastening it to the mounting plate. Check the odometer unit for proper operation. The unit should turn freely and without excessive play. Clean the helical gear with solvent and lightly lubricate. If the odometer assembly is defective, it must be replaced as a unit. Clean all the control box parts in solvent and thoroughly dry them before assembly. Inspect for damage and excessive wear. Replace any defective parts. Lightly lubricate all moving parts at their contact surfaces.

- 2) Place the two cable adapters in the lower control box housing, with the angled sides facing inward in order to provide clearances for the drive wheel. Place the wear strip in the control housing. Place the drive wheel in the lower control box housing. Position the two brake jaws, brake bearing and brake arm in the lower control box housing. When installing the brake jaws, face the worn sides away from the drive wheel, as this increases their life. Place the upper control box housing over the lower control box housing while keeping them level, and press them together. Check the control box for proper reassembly by turning the shaft. It should spin freely. If not, disassemble and reinspect the parts for damage and proper alignment. Reassemble and check the operation again. Mount the odometer assembly on the frame by securing the gear box with three flat head machine screws. Secure the odometer cover to the mounting plate with two binder head screws, and secure the odometer reset knob to the shaft by tightening the two set screws. Mount the control box onto the frame and secure with the four large binder head screws and 3/8" nuts. Secure the crank arm assembly to the shaft with the 5/16" bevel washer and 5/16" hex head bolt. After completing assembly, check for proper operation by turning the crank. It should spin freely. Disassemble and place the drive cable into the track and reassemble the unit. If the control unit fails any of these tests, disassemble, check the parts for damage and proper alignment, then reassemble and check for proper operation again. Attach the control housing to the RETRACT side of the control box.
- 3) Flush the source guide tubes with solvent and thoroughly dry using compressed dry air (15 psi maximum). Wipe the outside of the control housings and source guide tubes with a cloth soaked in solvent and thoroughly dry. Flex the control housings and source guide tubes to check for any internal damage. Damage is evidenced by a crunching feeling when the housing or guide tube is bent. While doing this, feel for dents along the entire length of all guide tubes and both control housings. Cut, flattened or burnt control housings or guide tubes should be repaired or replaced. They may be covered with protective tape where only the outer plastic is cut through. Check the source guide tubes for binding by holding them vertical and dropping a dummy source or jumper through them.
- 4) Inspect the key lock assembly for ease of operation, making sure that the hand crank will not move when the lock is in the locked position. Clean and lightly lubricate the moving surfaces.

b. Tech/Ops Model 446 Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record.
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked or damaged housing, cleanliness, missing parts, etc.
- 3) Check the shipping plug, locking bar, and lock for wear and ease of operation. Lubricate if necessary.

3. Tech/Ops Model 726 Exposure Device

The following inspection and maintenance shall be performed on Tech/Ops Model 726 exposure devices and related equipment at intervals not to exceed 3 months, and shall be documented on the Quarterly Inspection and Maintenance Record.

a. Tech/Ops Model 726 Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record.
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked housing, cleanliness, missing parts, etc.
- 3) Inspect the key lock assembly and source locking bar for wear, damage, cleanliness and ease of operation.
- 4) In a properly posted Restricted Area, check the source rod for wear, damage, cleanliness and ease of operation.
- 5) Check for timer for proper operation.

4. Picker Corp. Model 590 Cyclops Exposure Device

The following inspection and maintenance shall be performed on Picker Corp. Model 590 Cyclops exposure device and related equipment at intervals not to exceed 3 months, and shall be documented on the Quarterly Inspection and Maintenance Record.

a. Picker 590 Exposure Device Control Panel, Head and Safety Features

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record.
- 2) Inspect the exposure device head and exposure cell entrances for proper labeling and any obvious defects such as loose screws, burnt out warning lights, missing parts, etc.
- 3) Inspect the key lock assembly on the exposure device head for correct operation and cleanliness. Lubricate the locking plunger if necessary.
- 4) Disassemble the control panel and check for any broken wires or loose connections. Replace light bulbs if necessary.
- 5) Reassemble the control panel and check operation of both timer mechanisms. Check the operation of the key mechanisms.

- 6) Check the duration of the transit from storage position to exposed position. This should be approximately 5 to 7 seconds.
- 7) Check that proper sequence of warning lights is occurring during the source exposure. The green light should be on when the power switch is activated at the control panel. The green and red lights should be on during the transit from storage position to exposed position. Once in the exposed position, the green light should go off, leaving only the red light to indicate that the source is in the exposed position.
- 8) Check the duration of the transit from exposed position to storage position. This should be approximately 5 to 7 seconds.
- 9) Check that proper sequence of warning lights is occurring during source retraction. The red light should be on when the source is in the exposed position. The green and red lights should be on during the transit from the exposed position to the storage position. Once in the storage position, the red light should go off, leaving only the green light to indicate that the source is in the stored position.
- 10) Check the operation of the emergency stop bar on the control panel. Depressing this bar should cause the source to be retracted during an exposure.
- 11) Check the operation of the door interlock switch, checking for loose connections or excessive wear of the whisker switch. Check to be sure that the source is retracted if the door is opened. Check to be sure that the control panel will not activate an exposure if the door is left open.
- 12) Check the operation of the exposure device spring when simulating an electrical power failure by unplugging the control panel from the electrical socket while an exposure is on. The source should retract to the storage position. Plug the control panel back in and survey the exposure device to make sure the source has retracted to the storage position.

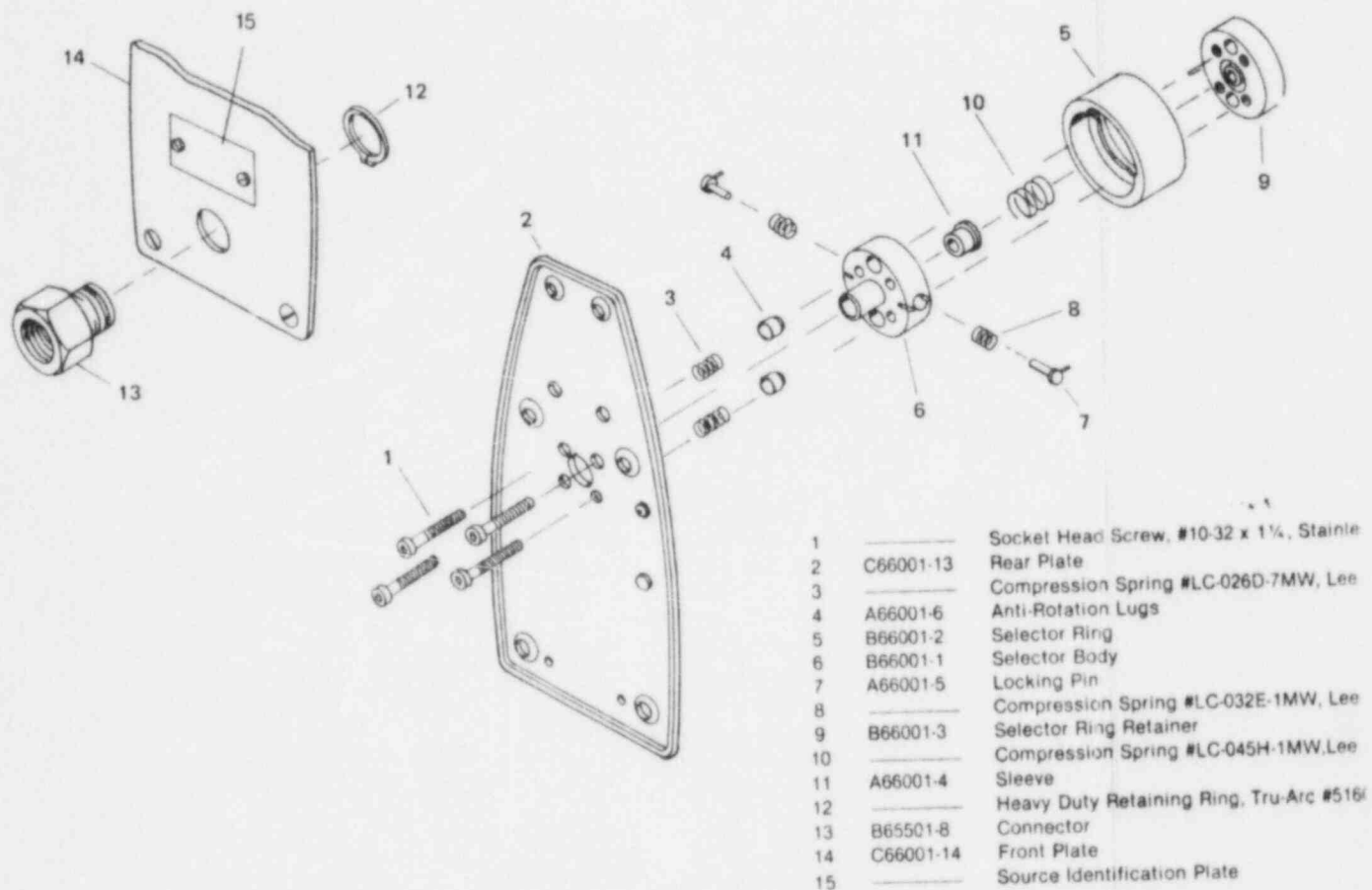


Figure 1A - Rear End Plate and Control Unit Connector—Exploded View

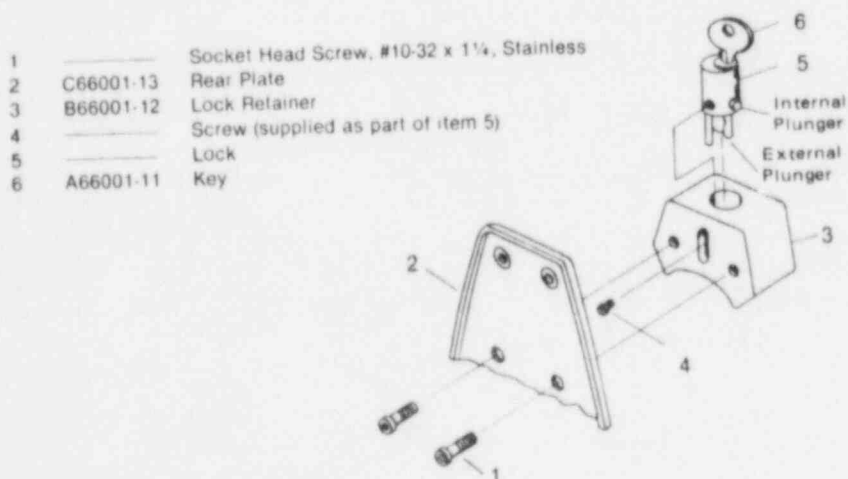


Figure 1B - Lock Assembly—Exploded View

Part P - Sample Forms and Documents

1. Isotope Sign-Out Log
2. Daily Inspection Checklist
3. Radiographic Utilization Record
4. Notification Record
5. Dosimeter Record
6. Survey Meter Calibration Certificate/Worksheet
7. Dosimeter Calibration Certificate/Worksheet
8. Tech/Ops 518 Leak Test Form
9. Gamma Industries Kowipe Leak Test Form
10. Radioisotope Receiving Record
11. Quarterly Maintenance & Inspection Records

[illegible]

DEVICE: S/N:

MAGNA CHEK, INC.
NONDESTRUCTIVE TESTING LABORATORIES
2125 RIGGS STREET
WARREN, MI 48091
(313) 756-4070

RADIOGRAPHIC UTILIZATION RECORD

DATE: LOCATION OF USE: W.O.#

RADIOGRAPHER: DOSIMETER S/N:

DOSIMETER READINGS: STARTmR FINISHmR TOTALmR

ASSISTANT : DOSIMETER S/N:

DOSIMETER READINGS: STARTmR FINISHmR TOTALmR

DAILY INSPECTION CHECKLIST COMPLETED: INITIALS:

SURVEY METER MODEL NO.: S/N: CAL. DUE:

RADIOGRAPHIC SOURCE: X-RAY Co 60 Ir 192 Cs 137

SOURCE S/N: ACTIVITY: DEVICE S/N:

SURVEY OF DEVICE: INITIALmR/hr FINALmR/hr

NO. OF EXPOSURES: TOTAL EXPOSURE TIME:

REMARKS

RADIATION LEVELS AT POSTED BOUNDARIES:

DESCRIBE AREA

MAGNA CHEK, INC.
NONDESTRUCTIVE TESTING LABORATORIES
2125 RIGGS STREET
WARREN, MI 48091
(313) 756-4070

DAILY INSPECTION CHECKLIST

DATE: CRANK ASSY. S/N: EXPOSURE DEVICE S/N:

- 1. Film badge, dosimeter and at least one survey meter available.
- 2. Perform battery check of survey meter.
- 3. Check calibration due dates of dosimeter and survey meter.
- 4. Recharge dosimeter.
- 5. Perform an operational check of survey meter.
- 6. Check the exposure device for valid leak test date, decay curve, proper labeling and that a maintenance inspection has been performed within the last three months.
- 7. Inspect the exposure device for any obvious defects and cleanliness.
- 8. Check for proper operating characteristics of the exposure device locking mechanism and selector knob.
- 9. Check the source pigtail keyway with Tech/Ops Model 550 No-Go gauge.
- 10. Check the control unit assembly, source guide tube and extension for correct operation, cleanliness and any irregularities such as kinks, flat spots, cuts or wear. Check that a maintenance inspection has been performed within the last three months.
- 11. Check drive cable end pin with Tech/Ops Model 550 No-Go gauge.
- 12. Check for proper operation of emergency mechanisms, source position indicator lights, shutter and interlock mechanisms. (PICKER CYCLOPS)
- 13. Check for sufficient supply of signs, ropes, tapes and collimators.
- 14. Document on the Radiographic Utilization Record that the Daily Inspection Checklist has been completed.
- 15. Document any equipment malfunctions and/or defects on a Notification Record and forward the form to the RSO. If components essential to the safe operation of the device are found to be defective or in poor operating condition, tag the equipment out of service and notify the RSO immediately.

MAGNA CHEK, INC.
NONDESTRUCTIVE TESTING LABORATORIES
2125 RIGGS STREET
WARREN, MI 48091
(313) 756-4070

MCI RADIATION SAFETY PROGRAM - NOTIFICATION RECORD

DATE: PREPARED BY:

DEFICIENCY

.....

CORRECTIVE ACTION

.....

RSO REVIEW & REMARKS

.....

.....

MAGNA CHEK, INC.
 NONDESTRUCTIVE TESTING LABORATORIES
 2125 RIGGS STREET
 WARREN, MI 48091
 (313) 756-4070

DOSIMETER RECORD - 1st Quarter, 1984 (01/25/84 - 04/24/84)
 ~~~~~

NAME: ..... DOSIMETER NO.: .....

| DATE<br>~~~~~ | DOSE<br>~~~~~ | DATE<br>~~~~~ | DOSE<br>~~~~~ | DATE<br>~~~~~ | DOSE<br>~~~~~ |
|---------------|---------------|---------------|---------------|---------------|---------------|
| 01/25/83      | .....         | 02/25/84      | .....         | 03/25/84      | .....         |
| 01/26/83      | .....         | 02/26/84      | .....         | 03/26/84      | .....         |
| 01/27/83      | .....         | 02/27/84      | .....         | 03/27/84      | .....         |
| 01/28/83      | .....         | 02/28/84      | .....         | 03/28/84      | .....         |
| 01/29/83      | .....         | 02/29/84      | .....         | 03/29/84      | .....         |
| 01/30/83      | .....         | XX/XX/XX      | ...XX...      | 03/30/84      | .....         |
| 01/31/83      | .....         | XX/XX/XX      | ...XX...      | 03/31/84      | .....         |
| 02/01/84      | .....         | 03/01/84      | .....         | 04/01/84      | .....         |
| 02/02/84      | .....         | 03/02/84      | .....         | 04/02/84      | .....         |
| 02/03/84      | .....         | 03/03/84      | .....         | 04/03/84      | .....         |
| 02/04/84      | .....         | 03/04/84      | .....         | 04/04/84      | .....         |
| 02/05/84      | .....         | 03/05/84      | .....         | 04/05/84      | .....         |
| 02/06/84      | .....         | 03/06/84      | .....         | 04/06/84      | .....         |
| 02/07/84      | .....         | 03/07/84      | .....         | 04/07/84      | .....         |
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| 02/09/84      | .....         | 03/09/84      | .....         | 04/09/84      | .....         |
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| 02/13/84      | .....         | 03/13/84      | .....         | 04/13/84      | .....         |
| 02/14/84      | .....         | 03/14/84      | .....         | 04/14/84      | .....         |
| 02/15/84      | .....         | 03/15/84      | .....         | 04/15/84      | .....         |
| 02/16/84      | .....         | 03/16/84      | .....         | 04/16/84      | .....         |
| 02/17/84      | .....         | 03/17/84      | .....         | 04/17/84      | .....         |
| 02/18/84      | .....         | 03/18/84      | .....         | 04/18/84      | .....         |
| 02/19/84      | .....         | 03/19/84      | .....         | 04/19/84      | .....         |
| 02/20/84      | .....         | 03/20/84      | .....         | 04/20/84      | .....         |
| 02/21/84      | .....         | 03/21/84      | .....         | 04/21/84      | .....         |
| 02/22/84      | .....         | 03/22/84      | .....         | 04/22/84      | .....         |
| 02/23/84      | .....         | 03/23/84      | .....         | 04/23/84      | .....         |
| 02/24/84      | .....         | 03/24/84      | .....         | 04/24/84      | .....         |

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DOSIMETER TOTALS:

01/25 - 02/24 02/25 - 03/24 03/25 - 04/24

FILM BADGE TOTALS:

01/25 - 02/24 02/25 - 03/24 03/25 - 04/24

1st QUARTER TOTALS:

01/25/84 - 04/24/84 DosimetermRem Film BadgemRem

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M A G N A C H E K, I N C.  
 NONDESTRUCTIVE TESTING LABORATORIES  
 2125 RIGGS STREET  
 WARREN, MI 48091  
 (313) 756-4070

SURVEY METER CALIBRATION CERTIFICATE/WORKSHEET  
 .....

DATE : .....

CUSTOMER: .....

SURVEY METER MAKE/MODEL: ..... S/N: .....

CALIBRATOR MAKE/MODEL: Technical Operations Model 726 S/N: 172

CALIBRATOR SOURCE: Cesium 137 S/N: S-306 ACTIVITY: ... mCi

CALIBRATION DATA

| METER SCALE | KNOWN RADIATION INTENSITY | METER RESPONSE | ACCEPTABLE |
|-------------|---------------------------|----------------|------------|
| x1          | 2.5 mR/hr                 | .... mR/hr     | .....      |
|             | 7.5 mR/hr                 | .... mR/hr     | .....      |
| x10         | 25 mR/hr                  | .... mR/hr     | .....      |
|             | 75 mR/hr                  | .... mR/hr     | .....      |
| x100        | 250 mR/hr                 | .... mR/hr     | .....      |
|             | 750 mR/hr                 | .... mR/hr     | .....      |

.....

CALIBRATED BY : .....

CALIBRATION DUE ON OR BEFORE: .....

REMARKS : .....

.....

M A G N A C H E K, I N C.  
NONDESTRUCTIVE TESTING LABORATORIES  
2125 RIGGS STREET  
WARREN, MI 48091  
(313) 756-4070

DOSIMETER CALIBRATION CERTIFICATE / WORKSHEET  
\*\*\*\*\*

DATE OF ISSUE: ..../../..

DOSIMETER MAKE/MODEL: ..... S/N: .....  
CALIBRATOR MAKE/MODEL: Technical Operations Model 726 S/N: 172  
CALIBRATOR SOURCE: Cesium 137 S/N: S-306 ACTIVITY: .. mCi

CALIBRATION DATA

CHECKPOINT #1: Dosimeter exposed to dose of 50 mR - Reading: ... mR  
CHECKPOINT #2: Dosimeter exposed to dose of 150 mR - Reading: ... mR  
DRIFT CHECK: Less than .. mR in 24 hour period

\*\*\*\*\*  
Readings must be within +/- 30% of both 50 mR and 150 mR checkpoints.  
Maximum drift allowed - 2% of scale (4 mRem).  
\*\*\*\*\*

CALIBRATION PERFORMED BY: .....

CALIBRATION DUE ON OR BEFORE: ..../../..

REMARKS : .....

.....



**Tech/Ops**40 NORTH AVENUE  
BURLINGTON, MA. 01803  
(617) 272-2000**518  
LEAK TEST**

Co. Name \_\_\_\_\_ P.O. No. \_\_\_\_\_  
Street \_\_\_\_\_ NRC or \_\_\_\_\_  
City, State \_\_\_\_\_ State License No. \_\_\_\_\_  
Projector \_\_\_\_\_ Serial No. \_\_\_\_\_  
Model No. \_\_\_\_\_  
Source \_\_\_\_\_ Serial No. \_\_\_\_\_ Curies \_\_\_\_\_  
Model No. \_\_\_\_\_  
IR-192 \_\_\_\_\_ CO-60 \_\_\_\_\_ CS-137 \_\_\_\_\_ Other \_\_\_\_\_  
Wipe \_\_\_\_\_  
Performed By \_\_\_\_\_ Date \_\_\_\_\_

The United States Nuclear Regulatory Commission requires that radiographic sources be tested for evidence of leaking at the time of manufacture and thereafter at not more than six-month intervals. The amount of removable contamination must not exceed 0.005 microcuries. If the test shows more than 0.005 microcurie of removable contamination, the source and equipment must be immediately taken out of service and be repaired or be disposed of. Please note that this source must be tested again on or before \_\_\_\_\_

FOR TECH-OPS USE ONLY

ORIGINAL

**GAMMA INDUSTRIES**  
*A Division of Nuclear Systems, Inc.*  
**HOME OFFICE**  
2255 Ted Dunham Avenue  
Baton Rouge, Louisiana 70821  
(504) 383-7791 - Telex 586473  
**9320 Taverot Drive**  
Houston, Texas 77034  
(713) 944-7676  
Telex 775677

# KOWIPE LEAK TEST KIT

COMPANY: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
SOURCE MANUFACTURER: \_\_\_\_\_  
DATE OF TEST: \_\_\_\_\_  
ISOTOPE: \_\_\_\_\_  
SOURCE STRENGTH (ci): \_\_\_\_\_  
SOURCE SERIAL NO. \_\_\_\_\_  
REMARKS: \_\_\_\_\_

M A G N A C H E K, I N C.  
NONDESTRUCTIVE TESTING LABORATORIES  
2125 RIGGS STREET  
WARREN, MI 48091  
(313) 756-4070

\*\*\*\*\*  
RADIO-ISOTOPE RECEIVING RECORD  
\*\*\*\*\*

DATE - .../.../... PERFORMED BY - .....

SOURCE TYPE - .....

SOURCE ACTIVITY - .....

SOURCE MODEL NO. - .....

SOURCE SERIAL NO. - .....

SHIPPING CONTAINER MODEL NO. - .....

SHIPPING CONTAINER SERIAL NO. - .....

INSPECT FOR DAMAGE TO CONTAINER.....

RADIATION LEVEL AT EXTERIOR SURFACE - .....  
(Must not exceed 200 mRem/hr)

RADIATION LEVEL AT 3 FEET FROM SURFACE - .....  
(Must not exceed 10 mRem/hr)

SHIPPING CONTAINER PLACED IN STORAGE VAULT - .....

\*\*\*\*\*

# QUARTERLY MAINTENANCE & INSPECTION RECORD - TECH/OPS MODEL 660 EXPOSURE DEVICES

... Quarter, 1984

|                                     |             |
|-------------------------------------|-------------|
| Tech/Ops Model 660 Exposure Device  | S/N - ..... |
| Tech/Ops Model 693 Control Unit     | S/N - ..... |
| Tech/Ops Master Source Guide Tube   | S/N - ..... |
| Tech/Ops Extender Source Guide Tube | S/N - ..... |
| Tech/Ops Extender Source Guide Tube | S/N - ..... |

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part D, Section 1.

## REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

### Tech/Ops Model 693 Control Unit and Source Guide Tubes

- 1) Remove the drive cable from the control unit - clean, lubricate and check the end connector with Model 550 no-go gauge as specified in Part D, Section 1a. ....
- 2) Dissassemble the control housings and source guide tubes - clean and check for wear and damage as specified in Part D, Section 1a. ....
- 3) Disassemble the control unit crank assembly - clean, lubricate and check all parts for any damage and wear as specified in Part D, Section 1a. ....
- 4) Reassemble the control unit (crank assembly, odometer and control housings - check for proper operation as specified in Part D, Section 1a. ....

### Tech/Ops Model 660 Exposure Device

- 1) Survey the device to ensure proper radiation levels and document readings on the Radiographic Utilization Record. ....
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked or damaged housing, cleanliness, missing parts, etc. ....
- 3) Inspect the key lock assembly for correct operation and cleanliness; lubricate the locking plunger. ....
- 4) Check the control unit connector assembly for correct operation and cleanliness. ....
- 5) Check the female drive cable connector of the source for wear with Model 550 no-go gauge. ....
- 6) Complete Maintenance performed - NOTE: Steps 3 through 5 may be replaced by Part D, Section 1c (Tech/Ops Model 660 Exposure Device - COMPLETE MAINTENANCE), only if a Tech/Ops Model 650 source changer is available and AFTER THE SOURCE HAS BEEN REMOVED FROM THE EXPOSURE DEVICE. ....

DATE: ..... PERFORMED BY: ..... DUE: .....

# QUARTERLY MAINTENANCE & INSPECTION RECORD - TECH/OPS MODEL 446 EXPOSURE DEVICES

... Quarter, 1984

|                                     |             |
|-------------------------------------|-------------|
| Tech/Ops Model 446 Exposure Device  | S/N - ..... |
| Tech/Ops Model 664 Control Unit     | S/N - ..... |
| Tech/Ops Master Source Guide Tube   | S/N - ..... |
| Tech/Ops Extender Source Guide Tube | S/N - ..... |
| Tech/Ops Extender Source Guide Tube | S/N - ..... |

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part O, Section 2.

## REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

### Tech/Ops Model 664 Control Unit and Guide Tubes

- 1) Disassemble the control unit hand crank, cleaning and lubricating the various parts as specified in Part O, Section 2a. ....
- 2) Reassemble the control unit & drive cable and check for proper operation as specified in Part O, Section 2a. ....
- 3) Check the control unit housing and source guide tubes for wear and damage as specified in Part O, Section 2a. ....
- 4) Inspect the key lock assembly for correct operation and cleanliness as specified in Part O, Section 2a. ....

### Tech/Ops Model 446 Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record. ....
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked or damaged housing, cleanliness, missing parts, etc. ....
- 3) Check the shipping plug, locking bar, and lock for wear and ease of operation. ....

DATE: ..... PERFORMED BY: ..... DUE: .....

QUARTERLY MAINTENANCE & INSPECTION RECORD - TECH/OPS MODEL 726 EXPOSURE DEVICES

... Quarter, 1984

Tech/Ops Model 726 Exposure Device S/N - .....

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part O, Section 3.

REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

Tech/Ops Model 726 Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record. ....
- 2) Inspect the exposure device for proper labeling and any obvious defects such as loose screws, cracked housing, cleanliness, missing parts, etc. ....
- 3) Inspect the key lock assembly and source locking bar for wear, damage, cleanliness and ease of operation. ....
- 4) Check the source rod for wear, damage, cleanliness and ease of operation. ....
- 5) Check the exposure timer for proper operation. ....

DATE: ..... PERFORMED BY: ..... DUE: .....

# QUARTERLY MAINTENANCE & INSPECTION RECORD - PICKER MODEL 590 EXPOSURE DEVICE

... Quarter, 1984

Picker Model 590 Cyclops Exposure Device S/N - .....

NOTE: For specific quarterly maintenance and inspection procedures, refer to the MCI Operating and Emergency Procedures, Part 0, Section 4.

## REQUIRED QUARTERLY MAINTENANCE/INSPECTION CHECKLIST

REMARKS

Picker Model 590 Cyclops Exposure Device

- 1) Survey the device to ensure proper radiation readings and document readings on the Radiographic Utilization Record. ....
- 2) Inspect the exposure device head for proper labeling and any obvious defects such as loose screws, burnt out warning lights, missing parts, etc. ....
- 3) Inspect the key lock assembly for correct operation and cleanliness; lubricate the locking plunger ....
- 4) Disassemble the control panel and check for broken wires, loose connections, replace bulbs if necessary. ....
- 5) Reassemble the control panel and check operation of the timer and key mechanisms. ....
- 6) Check the duration of the transit from storage position to exposed position. ....
- 7) Check that proper sequence of warning lights is occurring during source exposure. ....
- 8) Check the duration of the transit from exposed position to storage position. ....
- 9) Check that proper sequence of warning lights is occurring during source retraction. ....
- 10) Check the operation of the emergency stop bar on the control panel. ....
- 11) Check the operation of the door interlock switch, checking for loose connections, excessive wear, etc. ....
- 12) Check the operation of the device spring when simulating an electrical power failure. ....

DATE: ..... PERFORMED BY: ..... DUE: .....

Part Q - Nuclear Regulatory Commission Rules and Regulations

The following parts of Title 10, Chapter 1, Code of Federal Regulations - Energy, United States Nuclear Regulatory Commission, Rules and Regulations are included in Part Q of the MCI Operating and Emergency Procedures.

1. 10 CFR Part 19 - "Notices, Instructions, and Reports to Workers; Inspections"
2. 10 CFR Part 20 - "Standards for Protection Against Radiation"
3. 10 CFR Part 21 - "Reporting of Defects and Noncompliance"
4. 10 CFR Part 34 - "Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations"
5. 10 CFR Part 71 - "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions"

USNRC Regulations deleted in this copy