RADIATION SAFETY MANUAL - RADIOGRAPHY

INDEX

70184

INDEX

CHAPTER ONE

INTRODUCTION

INTRODUCTION

Industrial Radiography, one of the most reliable and widely used methods on non-destructive testing, is of prime importance in industry.

One of the most important phases of radiography is the safe handling of sources of radiation and protection of personnel against radiation.

When making application for a Radioactive Materials License, the Company must submit written operating procedures which it intends to follow in addition to those imposed by licensing authorities. When these tentative procedures are approved, a license is issued. Although in some instances, the procedures may seem unduly restrictive or intended only to make the job more difficult, they have come about, in most cases, because unsafe handling or operations have resulted in overexposure of individuals to radiation.

In order to protect ourselves and others and to safeguard our license, operations must be conducted cautiously, diligently and with respectful regard for radiation.

Each radiographer is issued a copy of Chapters 1 through 5 of this manual and is required to keep it up-to-date by making necessary changes as they are issued.

It is mandatory that radiographers be thoroughly familiar with and strictly comply with the contents of this manual. Audits and re-evaluation will be conducted to assure that this is being done.

CHAPTER TWO

Federal Regulations

70184

CHAPTER TWO

FEDERAL REGULATIONS

I Notices, Instructions and Reports to Workers: Inspections
(Title 10, Part 19 - Code of Federal Regulations)

II Standard for Protection Against Radiation
(Title 10, Part 20 - Code of Federal Regulations

III Reporting of Defects and Noncompliance
(Title 10, Part 21 - Code of Federal Regulations

IV Radiation Safety Requirements for Radiographic Operations
(Title 10, Part 34 - Code of Federal Regulations)

PART 19

NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

Sec.

Authority: Secs. 53, 63, 81, 103, 104, 161, 186, 68 Stat. 930, 933, 935, 936, 937, 948, 955, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201, 2236, 2282); sec. 201, 88 Stat. 1242, as amended by Pub. L. 94-79, 89 Stat. 413 (42 U.S.C. 5841). Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273); §§ 19.11(a), (c), (d), and (e) and 19.12 are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)); and §§ 19.13 and 19.14(a) are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

40 FR 8774

§ 19.1 Purpose.

The regulations in this part establish requirements for notices, instructions, and reports by licensees to individuals participating in licensed activities, and options available to such individuals in connection with Commission inspections of licensees to ascertain compliance with the provisions of the Atomic Energy Act of 1954, as amended, Title II of the Energy Reorganization Act of 1974, and regulations, orders, and licenses thereunder regarding radiological working conditions.

46 FR 51281

§ 19.2 Scope.

The regulations in this part appy to all persons who receive, possess, use, or transfer material licensed by the Nuclear Regulatory Commission pursuant to the regulations in Parts 30 through 35, 40, 60, 70 or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter.

38 FR 22217 | 46 FR 51281

§ 19.3 Definitions.

As used in this part:

(a) "Act" means the Atomic Energy Act of 1954, (68 Stat. 919) including any amendments thereto;

(b) "Commission" means the United States Nuclear Regulatory Commission;

(c) "Worker" means an individual engaged in activities licensed by the Commission and controlled by a licensee, but does not include the licensee.

(d) "License" means a license issued under the regulations in Parts 30 through 35, 40, 60, 70, or 72 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 of this chapter and licenses to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter. "Licensee" means the holder of such a license.

38 FR 22217

(e) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

§ 19.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

40 FR 8774

§ 19.5 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street, NW., Washington, D.C.; or at 7920 Norfolk Avenue, Bethesda, Maryland.

38 FR 22217

§ 19.11 Posting of notices to workers.

(a) Each licensee shall post current copies of the following documents: (1) The regulations in this part and in Part 20 of this chapter; (2) the license, license conditions, or documents incorporated into a license by reference, and amendments thereto; (3) the operating procedures applicable to licensed activities; (4) any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Subpart B of Part 2 of this chapter, and any response from the licensee.

(b) If posting of a document specified in paragraph (a) (1), (2) or (3) of this section is not practicable, the licensee may post a notice which describes the document and states where it may be examined.

[47 FR 30452]

(c) Each licensee and applicant shall post Form NRC-3, (Revision 6-82 or later) "Notice to Employees," as required by Parts 30, 40, 50, 60, 70, 72, and 150 of this chapter.

38 FR 22217

(d) Documents, notices, or forms posted pursuant to this section shall appear in a sufficient number of places to permit individuals engaged in licensed activities to observe them on the way to or from any particular licensed activity location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

(e) Commission documents posted pursuant to paragraph (a)(4) of this section shall be posted within 2 working days after receipt of the documents from the Commission; the licensee's response, if any, shall be posted within 2 working days after dispatch by the licensee. Such documents shall remain posted for a minimum of 5 working days or until action correcting the violation has been completed, whichever is later.

§ 19.12 Instructions to workers.

All individuals working in or frequenting any portion of a restricted area shall be kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed; shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of Commission regulations

70184

and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas; shall be instructed of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation or to radioactive material; shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and shall be advised as to the radiation exposure reports which workers may request pursuant to § 19.13. The extent of these instructions shall be commensurate with potential radiological health protection problems in the restricted area.

§ 19.13 Notifications and reports to individuals.

(a) Radiation exposure data for an individual, and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual, shall be reported to the individual as specified in this section. The information reported shall include data and results obtained pursuant to Commission regulations, orders or license conditions, as shown in records maintained by the licensee pursuant to Commission regulations. Each notification and report shall: be in writing; include appropriate identifying data such as the name of the licensee, the name of the individual, the individual's social security number; include the individual's exposure information; and contain the following statement:

38 F.R. 22217

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulation 10 CFR Part 19. You should preserve this report for further reference.

(b) At the request of any worker, each licensee shall advise such worker annually of the worker's exposure to radiation or radioactive material as shown in records maintained by the licensee pursuant to § 20.401(a) and (c).

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later; shall cover, within the period of time specified in the request, each calendar quarter in which the worker's activities involved exposure to radiation from radioactive materials licensed by the Commission; and shall include the dates and locations of licensed activities in which the worker participated during this period.

(d) When a licensee is required pursuant to § 20.405 or § 20.408 of this chapter to report to the Commission any exposure of an individual to radiation or radioactive material the licensee shall also provide the individual a report on his exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Commission.

44 F.R. 38352

(e) At the request of a worker who is terminating employment in a given calendar quarter with the licensee in work involving radiation dose, or of a worker who, while employed by another person, is terminating assignment to work involving radiation dose in the licensee's facility in that calendar quarter, each licensee shall provide to each such worker, or to the worker's designee, at termination, a written report regarding the radiation dose received by that worker from operations of the licensee during that specifically identified calendar quarter or fraction thereof, or provide a written estimate of that dose if the finally determined personnel monitoring results are not available at that time. Estimated doses shall be clearly indicated as such.

§ 19.14 Presence of representatives of licensees and workers during inspections.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect materials, activities, facilities, premises, and records pursuant to the regulations in this chapter.

38 F.R. 22217

(b) During an inspection, Commission inspectors may consult privately with workers as specified in § 19.15. The licensee or licensee's representative may accompany Commission inspectors during other phases of an inspection.

(c) If, at the time of inspection, an individual has been authorized by the workers to represent them during Commission inspections, the licensee shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

(d) Each workers' representative shall be routinely engaged in licensed activities under control of the licensee and shall have received instructions as specified in § 19.12.

(e) Different representatives of licensees and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

(f) With the approval of the licensee and the workers' representative an individual who is not routinely engaged in licensed activities under control of the license, for example, a consultant to the licensee or to the workers' representative, shall be afforded the opportunity to accompany Commission inspectors during the inspection of physical working conditions.

(g) Notwithstanding the other provisions of this section, Commission inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee to enter that area.

§ 19.15 Consultation with workers during inspections.

(a) Commission inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Commission regulations and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

(b) During the course of an inspection any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which he has reason to believe may have contributed to or caused any violation of the act, the regulations in this chapter, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material under the licensee's control. Any such notice in writing shall comply with the requirements of § 19.16(a).

(c) The provisions of paragraph (b) of this section shall not be interpreted as authorization to disregard instructions pursuant to § 19.12.

38 F.R. 22217

§ 19.16 Requests by workers for inspections.

(a) Any worker or representative of workers who believes that a violation of the Act, the regulations in this chapter, or license conditions exists or has occurred in license activities with regard to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Director of Inspection and Enforcement, to the Director of the appropriate Commission Regional Office, or to Commission inspectors. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of workers. A copy shall be provided the licensee by the Director of Inspection and Enforcement, Regional Office Director, or the inspector no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Commission, except for good cause shown.

(b) If, upon receipt of such notice, the Director of Inspection and Enforcement or Regional Office Director determines that the complaint meets the requirements set forth in paragraph (a) of this section, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pur-

§ 19.17 Inspections not warranted; informal review.

(a) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines, with respect to a complaint under § 19.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, he shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee may submit an opposing written statement of position with the Executive Director for Operations who will provide the complainant with a copy of such statement by certified mail. Upon the request of the complainant, the Executive Director for Operations or his designee may hold an informal conference in which the complainant and the licensee may orally present their views. An informal conference may also be held at the request of the licensee, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Executive Director for Operations shall affirm, modify, or reverse the determination of the Director of Inspection and Enforcement or of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reason therefor.

(b) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines that an inspection is not warranted because the requirements of § 19.16(a) have not been met, he shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of § 19.16(a).

38 FR 22217

§ 19.20 Employee protection.

Employment discrimination by a licensee or a contractor or subcontractor of a licensee against an employee for engaging in protected activities under this part or Parts 30, 40, 50, 60, 70, 72, or 150 of this chapter is prohibited.

47 FR 30452

§ 19.30 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder.

40 FR 8774

A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

38 FR 22217

§ 19.31 Application for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 19.32 Discrimination prohibited.

No person shall on the ground of sex be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity licensed by the Nuclear Regulatory Commission. This provision will be enforced through agency provisions and rules similar to those already established, with respect to racial and other discrimination, under title VI of the Civil Rights Act of 1964. This remedy is not exclusive, however, and will not prejudice or cut off any other legal remedies available to a discriminatee.

40 FR 8774

PART 20

STANDARDS FOR PROTECTION AGAINST RADIATION

PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

AUTHORITY: Secs. 53, 63, 65, 81, 103, 104, 161, 68 Stat. 930, 933, 935, 936, 937, 948, as amended; 42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201. For the purposes of sec. 223, 68 Stat. 958, as amended; 42 U.S.C. 2273, §§ 20.401-20.408, issued under sec. 161o., 68 Stat. 950, as amended; 42 U.S.C. 2201(o). Secs. 202, 206, Pub. L. 93-438, 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846), unless otherwise noted.

SOURCE: 25 FR 10914, Nov. 17, 1960, unless otherwise noted.

NOMENCLATURE CHANGES: 40 FR 8783, Mar. 3, 1975; 45 FR 14200, Mar. 5, 1980.

GENERAL PROVISIONS

§ 20.1 Purpose.

(a) The regulations in this part establish standards for protection against radiation hazards arising out of activities under licenses issued by the Nuclear Regulatory Commission and are issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974. [40 FR 8774]

(b) The use of radioactive material or other sources of radiation not licensed by the Commission is not subject to the regulations in this part. However, it is the purpose of the regulations in this part to control the possession, use, and transfer of licensed material by any licensee in such a manner that the total dose to an individual (including exposures to licensed and unlicensed radioactive material and to other unlicensed sources of radiation, whether in the possession of the licensee or any other person, but not including exposures to radiation from natural background sources or medical diagnosis and therapy) does not exceed the standards of radiation protection prescribed in the regulations in this part. [44 FR 32332]

(c) In accordance with recommendations of the Federal Radiation Council, approved by the President, persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable. The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest. [40 FR 58847]

§ 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed pursuant to the regulations in Parts 30 through 35, 40, 60, 70, or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) purusant to Part 72 of this chapter. [45 FR 58281]

§ 20.3

§ 20.3 Definitions.

(a) As used in this part:

(1) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

(2) "Airborne radioactive material" means any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases; [40 FR 8774]

(3) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

(4) "Calendar quarter" means not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be such that no day is included in more than one calendar quarter or omitted from inclusion within a calendar quarter. No licensee shall change the method observed by him of determining calendar quarters except at the beginning of a calendar year. [40 FR 42567]

(5) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives;

(6) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government; 25 FR 10914

(7) "Individual" means any human being;

(8) "Licensed material" means source material, special nuclear material, or by-product material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter;

(9) "License" means a license issued under the regulations in Parts 30 through 35, 40, 60, 70, or 72 of this chapter. "Licensee" means the holder of such license; 45 FR 58281

(10) "Occupational dose" includes exposure of an individual to radiation (i) in a restricted area; or (ii) in the course of employment in which the individual's duties involve exposure to radiation, provided, that "occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy of such individual. 25 FR 10914

(11) "Person" means: (i) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department (except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244)), any State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (ii) any legal successor, representative, agent, or agency of the foregoing. 40 FR 8774

(12) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light; 25 FR 10914

(13) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission;

(14) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residental quarters, although a separate room or rooms in a residential building may be set apart as a restricted area; 25 FR 13952

(15) "Source material" means: (i) Uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium or (c) any combination thereof. Source material does not include special nuclear material. 27 FR 5905

(16) "Special nuclear material" means: (i) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (ii) any material artificially enriched by any of the foregoing but does not include source material; 25 FR 10914

(17) "Unrestricted area" means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters. 25 FR 13952

(18) "Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 *et seq.*) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151). 45 FR 14199

(19) "Termination" means the end of employment with the licensee or, in the case of individuals not employed by the licensee, the end of a work assignment in the licensee's restricted areas in a given calendar quarter, without expectation or specific scheduling of reentry into the licensee's restricted areas during the remainder of that calendar quarter. 44 FR 32332

(b) Definitions of certain other words and phrases as used in this part are set forth in other sections, including:

(1) "Airborne radioactivity area" defined in § 20.203;

(2) "Radiation area" and "high radiation area" defined in § 20.202;

(3) "Personnel monitoring equipment" defined in § 20.202;

(4) "Survey" defined in § 20.201;

(5) Units of measurement of dose (rad, rem) defined in § 20.4;

(6) Units of measurement of radioactivity defined in § 20.5.

§ 20.4 Units of radiation dose. 25 FR 10914

(a) "Dose," as used in this part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section.

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad)=0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem)=0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

(1) A dose of 1 r due to X- or gamma radiation;

(2) A dose of 1 rad due to X-, gamma, or beta radiation;

(5) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives;

(6) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government; (25 FR 10914)

(7) "Individual" means any human being;

(8) "Licensed material" means source material, special nuclear material, or by-product material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter;

(9) "License" means a license issued under the regulations in Parts 30 through 35, 40, 60, 70, or 72 of this chapter. "Licensee" means the holder of such license; (46 FR 58281)

(10) "Occupational dose" includes exposure of an individual to radiation (i) in a restricted area; or (ii) in the course of employment in which the individual's duties involve exposure to radiation, provided, that "occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy of such individual. (25 FR 10914)

(11) "Person" means: (i) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department (except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244)), any State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (ii) any legal successor, representative, agent, or agency of the foregoing. (40 FR 8774)

(12) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light; (25 FR 10914)

(13) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission;

(14) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residental quarters, although a separate room or rooms in a residential building may be set apart as a restricted area; (25 FR 13952)

(15) "Source material" means: (i) Uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium or (c) any combination thereof. Source material does not include special nuclear material. (27 FR 5905)

(16) "Special nuclear material" means: (i) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (ii) any material artificially enriched by any of the foregoing but does not include source material; (25 FR 10914)

(17) "Unrestricted area" means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters. (25 FR 13952)

(18) "Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 *et seq.*) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151). (43 FR 14199 • 45 FR 14199)

(19) "Termination" means the end of employment with the licensee or, in the case of individuals not employed by the licensee, the end of a work assignment in the licensee's restricted areas in a given calendar quarter, without expectation or specific scheduling of reentry into the licensee's restricted areas during the remainder of that calendar quarter. (41 FR 32352)

(b) Definitions of certain other words and phrases as used in this part are set forth in other sections, including:

(1) "Airborne radioactivity area" defined in § 20.203;

(2) "Radiation area" and "high radiation area" defined in § 20.202;

(3) "Personnel monitoring equipment" defined in § 20.202;

(4) "Survey" defined in § 20.201;

(5) Units of measurement of dose (rad, rem) defined in § 20.4;

(6) Units of measurement of radioactivity defined in § 20.5.

§ 20.4 Units of radiation dose.

(a) "Dose," as used in this part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section. (25 FR 10914)

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad)=0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem)=0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

(1) A dose of 1 r due to X- or gamma radiation;

(2) A dose of 1 rad due to X-, gamma, or beta radiation;

(3) A dose of 0.1 rad due to neutrons or high energy protons;

(4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye; If it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in paragraph (c)(3) of this section, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

NEUTRON FLUX DOSE EQUIVALENTS

Neutron energy (Mev)	Number of neutrons per square centimeter equivalent to a dose of 1 rem (neutrons/cm²)	Average flux to delivery 100 millirem in 40 hours (neutrons/cm² sec.)
Thermal	970×10^6	670
0.0001	720×10^6	500
0.005	820×10^6	570
0.02	400×10^6	280
0.1	120×10^6	80
0.5	43×10^6	30
1.0	26×10^6	18
2.5	29×10^6	20
5.0	26×10^6	18
7.5	24×10^6	17
10	24×10^6	17
10 to 30	14×10^6	10

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in §§ 20.101 to 20.104, inclusive, may be assumed to be equivalent to the "air dose". For the purpose of this part "air dose" means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of highest dosage rate.

§ 20.5 Units of radioactivity.

(a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies. One curie = 3.7×10^{10} disintegrations per second (dps) = 2.2×10^{12} disintegrations per minute (dpm). Commonly used submultiples of the curie are the millicurie and the microcurie:

(1) One millicurie (mCi) = 0.001 curie (Ci) = 3.7×10^7 dps.

(2) One microcurie (μCi) = 0.000001 curie = 3.7×10^4 dps.

(b) [Deleted 40 FR 50704.]

(c) [Deleted 39 FR 23990.]

§ 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.7 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C.; or at 7920 Norfolk Avenue, Bethesda, Maryland.

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

§ 20.101 Radiation dose standards for individuals in restricted areas.

(a) In accordance with the provisions of § 20.102(a), and except as provided in paragraph (b) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from radioactive material and other sources of radiation a total occupational dose in excess of the standards specified in the following table:

REMS PER CALENDAR QUARTER

1. Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1¼
2. Hands and forearms; feet and ankles	18¾
3. Skin of whole body	7½

(b) A licensee may permit an individual in a restricted area to receive a total occupational dose to the whole body greater than that permitted under paragraph (a) of this section, provided:

(1) During any calendar quarter the total occupational dose to the whole body shall not exceed 3 rems; and

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

(3) The licensee has determined the individual's accumulated occupational dose to the whole body on Form NRC-4, or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of § 20.102. As used in paragraph (b), "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

§ 20.102 Determination of prior dose.

(a) Each licensee shall require any individual, prior to first entry of the individual into the licensee's restricted area during each employment or work assignment under such circumstances that the individual will receive or is likely to receive in any period of one calendar quarter an occupational dose in excess of 25 percent of the applicable standards specified in § 20.101(a) and § 20.104(a), to disclose in a written, signed statement, either: (1) That the individual had no prior occupational dose during the current calendar quarter, or (2) the nature and amount of any occupational dose which the individual may have received during that specifically identified current calendar quarter from sources of radiation possessed or controlled by other persons. Each licensee shall maintain records of such statements until the Commission authorizes their disposition.

(b) Before permitting, pursuant to § 20.101(b), any individual in a restricted area to receive an occupational radiation dose in excess of the standards specified in § 20.101(a), each licensee shall:

(1) Obtain a certificate on Form NRC-4, or on a clear and legible record containing all the information required in that form, signed by the individual showing each period of time after the individual attained the age of 18 in which the individual received an occupational dose of radiation; and

(2) Calculate on Form NRC-4 in accordance with the instructions appearing therein, or on a clear and legible record containing all the information required in that form, the previously accumulated occupational dose received by the individual and the additional dose allowed for that individual under § 20.101(b).

(c)(1) In the preparation of Form NRC-4, or a clear and legible record containing all the information required in that form, the licensee shall make a reasonable effort to obtain reports of the individual's previously accumulated occupational dose. For each period for which the licensee obtains

such reports, the licensee shall use the dose shown in the report in preparing the form. In any case where a licensee is unable to obtain reports of the individual's occupational dose for a previous complete calendar quarter, it shall be assumed that the individual has received the occupational dose specified in whichever of the following columns apply:

25 FR 10914

Part of body	Column 1—Assumed exposure in rems for calendar quarters prior to Jan. 1, 1961	Column 2—Assumed exposure in rems for calendar quarters beginning on or after Jan. 1, 1961
Whole body, gonads, active blood-forming organs, head and trunk, lens of eye	3¼	1¼

41 FR 18300

(2) The licensee shall retain and preserve records used in preparing Form NRC-4 until the Commission authorizes their disposition.

25 FR 10914

If calculation of the individual's accumulated occupational dose for all periods prior to January 1, 1961 yields a result higher than the applicable accumulated dose value for the individual as of that date, as specified in paragraph (b) of § 20.101, the excess may be disregarded.

41 FR 52300

§ 20.103 Exposure of individuals to concentrations of radioactive materials in air in restricted areas.

(a)(1) No licensee shall possess, use, or transfer licensed material in such a manner as to permit any individual in a restricted area to inhale a quantity of radioactive material in any period of one calendar quarter greater than the quantity which would result from inhalation for 40 hours per week for 13 weeks at uniform concentrations of radioactive material in air specified in Appendix B, Table I, Column 1.[1][2][3] If the radioactive material is of such form that intake by absorption through the skin is likely, individual exposures to radioactive material shall be controlled so that the uptake of radioactive material by any organ from either inhalation or absorption or both routes of intake[4] in any calendar quarter does not exceed that which would result from inhaling such radioactive material for 40 hours per week for 13 weeks at uniform concentrations specified in Appendix B, Table I, Column 1.

(2) No licensee shall possess, use, or transfer mixtures of U-234, U-235, and U-238 in soluble form in such a manner as to permit any individual in a restricted area to inhale a quantity of such material in excess of the intake limits specified in Appendix B, Table I, Column 1 of this part. If such soluble uranium is of a form such that absorption through the skin is likely, individual exposures to such material shall be controlled so that the uptake of such material by any organ from either inhalation or absorption or both routes of intake[4] does not exceed that which would result from inhaling such material at the limits specified in Appendix B, Table I, Column 1 and footnote 4 thereto.

41 FR 52300

(3) For purposes of determining compliance with the requirements of this section the licensee shall use suitable measurements of concentrations of radioactive materials in air for detecting and evaluating airborne radioactivity in restricted areas and in addition, as appropriate, shall use measurements of radioactivity in the body, measurements of radioactivity excreted from the body, or any combination of such measurements as may be necessary for timely detection and assessment of individual intakes of radioactivity by exposed individuals. It is assumed that an individual inhales radioactive material at the airborne concentration in which he is present unless he uses respiratory protective equipment pursuant to paragraph (c) of this section. When assessment of a particular individual's intake of radioactive material is necessary, intakes less than those which would result from inhalation for 2 hours in any one day or for 10 hours in any one week at uniform concentrations specified in Appendix B, Table I, Column 1 need not be included in such assessment, provided that for any assessment in excess of these amounts the entire amount is included.

(b)(1) The licensee shall, as a precautionary procedure, use process or other engineering controls, to the extent practicable, to limit concentrations of radioactive materials in air to levels below those which delimit an airborne radioactivity area as defined in § 20.203(d)(1)(ii).

(2) When it is impracticable to apply process or other engineering controls to limit concentrations of radioactive material in air below those defined in § 20.203(d)(1)(ii), other precautionary procedures, such as increased surveillance, limitation of working times, or provision of respiratory protective equipment, shall be used to maintain intake of radioactive material by any individual within any period of seven consecutive days as far below that intake of radioactive material which would result from inhalation of such material for 40 hours at the uniform concentrations specified in Appendix B, Table I, Column 1 as is reasonably achievable. Whenever the intake of radioactive material by any individual exceeds this 40-hour control measure, the licensee shall make such evaluations and take such actions as are necessary to assure against recurrence. The licensee shall maintain records of such occurrences, evaluations, and actions taken in a clear and readily identifiable form suitable for summary review and evaluation.

41 FR 52300

47 FR 16162

(c) When respiratory protective equipment is used to limit the inhalation of airborne radioactive material pursuant to paragraph (b)(2) of this section, the licensee shall use equipment that is certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA). The licensee may make allowance for this use of respiratory protective equipment in estimating exposures of individuals to this material provided that:

41 FR 52300

41 FR 79219

[1] Since the concentration specified for tritium oxide vapor assumes equal intakes by skin absorption and inhalation, the total intake permitted is twice that which would result from inhalation alone at the concentration specified for H 3 S in Appendix B, Table I, Column 1 for 40 hours per week for 13 weeks.

[2] For radon-222, the limiting quantity is that inhaled in a period of one calendar year. For radioactive materials designated "Sub" in the "Isotope" column of the table, the concentration value specified is based upon exposure to the material as an external radiation source. Individual exposures to these materials may be accounted for as part of the limitation on individual dose in § 20.101. These nuclides shall be subject to the precautionary procedures required by § 20.103(b)(1).

[3] Multiply the concentration values specified in Appendix B, Table I, Column 1, by 6.3×10^{4} ml to obtain the quarterly quantity limit. Multiply the concentration value specified in Appendix B, Table I, Column 1, by 2.5×10^{6} ml to obtain the annual quantity limit for Rn-222.

[4] Significant intake by ingestion or injection is presumed to occur only as a result of circumstances such as accident, inadvertence, poor procedure, or similar special conditions. Such intakes must be evaluated and accounted for by techniques and procedures as may be appropriate to the circumstances of the occurrence. Exposures so evaluated shall be included in determining whether the limitation on individual exposures in § 20.103(a)(1) has been exceeded.

[5] Regulatory guidance on assessment of individual intakes of radioactive material is given in Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations and Assumptions for a Bioassay Program," single copies of which are available from the Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, upon written request.

(1) The licensee selects respiratory protective equipment that provides a protection factor greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table I, Column 1 of this part. The equipment so selected shall be used so that the average concentration of radioactive material in the air that is inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by any individual using the equipment, does not exceed the values specified in Appendix B, Table I, Column 1 of this part. For the purposes of this paragraph, the concentration of radioactive material in the air that is inhaled when respirators are worn may be estimated by dividing the ambient concentration in air by the protection factor specified in Appendix A of this part. If the exposure is later found to be greater than estimated, the corrected value shall be used; if the exposure is later found to be less than estimated, the corrected value may be used.

(2) The licensee maintains and implements a respiratory protection program that includes, as a minimum: air sampling sufficient to identify the hazard, permit proper equipment selection and estimate exposures; surveys and bioassays as appropriate to evaluate actual exposures; written procedures regarding selection, fitting, and maintenance of respirators, and testing of respirators for operability immediately prior to each use; written procedures regarding supervision and training of personnel and issuance records; and determination by a physician prior to initial use of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protective equipment.

(3) A written policy statement on respirator usage shall be issued covering such things as: use of practicable engineering controls instead of respirators; routine, nonroutine, and emergency use of respirators; and periods of respirator use and relief from respirator use. The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other condition that might require such relief.

(4) The licensee uses equipment within limitations for type and mode of use and provides proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(d) Unless otherwise authorized by the Commission, the licensee shall not assign protection factors in excess of those specified in Appendix A of this part in selecting and using respiratory protective equipment. The Commission may authorize a licensee to use higher protection factors on receipt of an application (1) describing the situation for which a need exists for higher protection factors, and (2) demonstrating that the respiratory protective equipment will provide these higher protection factors under the proposed conditions of use.

(e) Where equipment of a particular type has not been tested and certified, or had certification extended, by NIOSH/MSHA, or where there is no existing schedule for test and certification of certain equipment, the licensee shall not make allowance for this equipment without specific authorization by the Commission. An application for this authorization must include a demonstration by testing, or on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(f) Only equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA shall be used as emergency devices.

(g) The licensee shall notify, in writing, the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D at least 30 days before the date that respiratory protective equipment is first used under the provisions of this section.

§ 20.104 Exposure of minors.

(a) No licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual within a restricted area who is under 18 years of age, to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in the table in paragraph (a) of § 20.101.

(b) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area, who is under 18 years of age to be exposed to airborne radioactive material possessed by the licensee in an average concentration in excess of the limits specified in Appendix B, Table II of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than a week.

(c) The provisions of §§ 20.103(b)(2) and 20.103(c) shall apply to exposures subject to paragraph (b) of this section except that the references in §§ 20.103(b)(2) and 20.103(c) to Appendix B, Table I, Column 1 shall be deemed to be references to Appendix B, Table II, Column 1.

§ 20.105 Permissible levels of radiation in unrestricted areas.

(a) There may be included in any application for a license or for amendment of a license proposed limits upon levels of radiation in unrestricted areas resulting from the applicant's possession or use of radioactive material and other sources of radiation. Such applications should include information as to anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that the proposed limits are not likely to cause any individual to receive a dose to the whole body in any period of one calendar year in excess of 0.5 rem.

(b) Except as authorized by the Commission pursuant to paragraph (a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

(c) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," shall comply with that part.

§ 20.106 Radioactivity in effluents to unrestricted areas.

(a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix B, Table II of this part, except as authorized pursuant to § 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

(b) An application for a license or amendment may include proposed limits higher than those specified in paragraph (a) of this section. The Commission will approve the proposed limits if the applicant demonstrates:

(1) That the applicant has made a reasonable effort to minimize the radioactivity contained in effluents to unrestricted areas; and

(2) That it is not likely that radioactive material discharged in the effluent would result in the exposure of an individual to concentrations of radioactive material in air or water exceeding the limits specified in Appendix B, Table II of this part.

(c) An application for higher limits pursuant to paragraph (b) of this section shall include information demonstrating that the applicant has made a reasonable effort to minimize the radioactivity discharged in effluents to unrestricted areas, and shall include, as pertinent:

(1) Information as to flow rates, total volume of effluent, peak concentration of each radionuclide in the effluent, and concentration of each radionuclide in the effluent averaged over a period of one year at the point where the effluent leaves a stack, tube, pipe, or similar conduit;

(2) A description of the properties of the effluents, including: 29 FR 14434

(i) Chemical composition;

(ii) Physical characteristics, including suspended solids content in liquid effluents, and nature of gas or aerosol for air effluents;

(iii) The hydrogen ion concentrations (p^H) of liquid effluents; and

(iv) The size range of particulates in effluents released into air.

(3) A description of the anticipated human occupancy in the unrestricted area where the highest concentration of radioactive material from the effluent is expected, and, in the case of a river or stream, a description of water uses downstream from the point of release of the effluent.

(4) Information as to the highest concentration of each radionuclide in an unrestricted area, including anticipated concentrations averaged over a period of one year:

(i) In air at any point of human occupancy; or

(ii) In water at points of use downstream from the point of release of the effluent.

(5) The background concentration of radionuclides in the receiving river or stream prior to the release of liquid effluent.

(6) A description of the environmental monitoring equipment, including sensitivity of the system, and procedures and calculations to determine concentrations of radionuclides in the unrestricted area and possible reconcentrations of radionuclides.

(7) A description of the waste treatment facilities and procedures used to reduce the concentration of radionuclides in effluents prior to their release.

(d) For the purposes of this section the concentration limits in Appendix B, Table II of this part shall apply at the boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution, dispersion, or decay between the point of discharge and the boundary. 29 FR 14434

(e) In addition to limiting concentrations in effluent streams, the Commission may limit quantities of radioactive materials released in air or water during a specified period of time if it appears that the daily intake of radioactive material from air, water, or food by a suitable sample of an exposed population group, averaged over a period not exceeding one year, would otherwise exceed the daily intake resulting from continuous exposure to air or water containing one-third the concentration of radioactive materials specified in Appendix B, Table II of this part.

(f) The provisions of paragraphs (a) through (e) of this section do not apply to disposal of radioactive material into sanitary sewerage systems, which is governed by § 20.303. 46 FR 18525

(g) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standard for Nuclear Power Operations," shall comply with that part.

§ 20.107 Medical diagnosis and therapy.

Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

§ 20.108 Orders requiring furnishing of bio-assay services.

Where necessary or desirable in order to aid in determining the extent of an individual's exposure to concentrations of radioactive material, the Commission may incorporate appropriate provisions in any license, directing the licensee to make available to the individual appropriate bio-assay services and to furnish a copy of the reports of such services to the Commission. 25 FR 10914

Precautionary Procedures

§ 20.201 Surveys.

(a) As used in the regulations in this part, "survey" means an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive material present. 25 FR 10914

(b) Each licensee shall make or cause to be made such surveys as (1) may be necessary for the licensee to comply with the regulations in this part, and (2) are reasonable under the circumstances to evaluate the extent of radiation hazards that may be present. 46 FR 3567

§ 20.202 Personnel monitoring.

(a) Each licensee shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by:

(1) Each individual who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable value specified in paragraph (a) of § 20.101.

(2) Each individual under 18 years of age who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent of the applicable value specified in paragraph (a) of § 20.101. 25 FR 10914

(3) Each individual who enters a high radiation area.

(b) As used in this part,

(1) "Personnel monitoring equipment" means devices designed to be worn or carried by an individual for the purpose of measuring the dose received (e.g., film badges, pocket chambers, pocket dosimeters, film rings, etc.);

(2) "Radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirems;

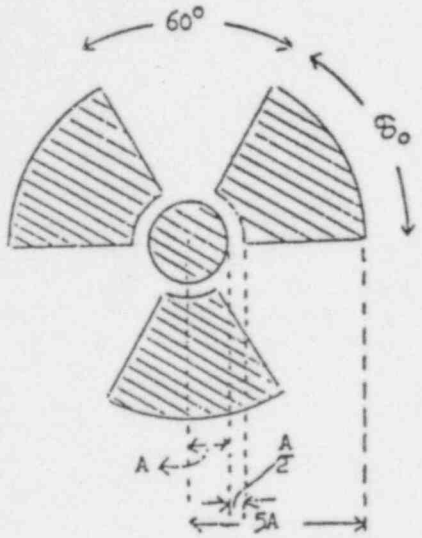
(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

§ 20.203 Caution signs, labels, signals and controls.

(a) *General.* (1) Except as otherwise authorized by the Commission, symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this section is the conventional three-bladed design:

RADIATION SYMBOL

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.



35 FR 5033

(2) In addition to the contents of signs and labels prescribed in this section, licensees may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation or to radioactive material.

(b) *Radiation areas.* Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

RADIATION AREA

(c) *High radiation areas.* (1) Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

HIGH RADIATION AREA

[1] Or "Danger"

(2) Each entrance or access point to a high radiation area shall be:

(i) Equipped with a control device which shall cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirems in 1 hour upon entry into the area; or

(ii) Equipped with a control device which shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering the high radiation area and the licensee or a supervisor of the activity are made aware of the entry; or

(iii) Maintained locked except during periods when access to the area is required, with positive control over each individual entry.

(3) The controls required by paragraph (c)(2) of this section shall be established in such a way that no individual will be prevented from leaving a high radiation area.

35 FR 5033

(4) In the case of a high radiation area established for a period of 30 days or less, direct surveillance to prevent unauthorized entry may be substituted for the controls required by paragraph (c)(2) of this section.

(5) Any licensee, or applicant for a license, may apply to the Commission for approval of methods not included in paragraphs (c)(2) and (4) of this section for controlling access to high radiation areas. The Commission will approve the proposed alternatives if the licensee or applicant demonstrates that the alternative methods of control will prevent unauthorized entry into a high radiation area, and that the requirement of paragraph (c)(3) of this section is met.

42 FR 64619

(6) Each area in which there may exist radiation levels in excess of 500 rems in one hour at one meter from a sealed radio-active source [1] that is used to irradiate materials shall: [2]

43 FR 2167

(i) Have each entrance or access point equipped with entry control devices which shall function automatically to prevent any individual from inadvertently entering the area when such radiation levels exist; permit deliberate entry into the area only after a control device is actuated that shall cause the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and prevent operation of the source if the source would produce radiation levels in the area that could result in a dose to an individual in excess of 100 mrem in one hour. The entry control devices required by this paragraph (c)(6) shall be established in such a way that no individual will be prevented from leaving the area.

42 FR 64619

(ii) Be equipped with additional control devices such that upon failure of the entry control devices to function as required by paragraph (c)(6)(i) of this section the radiation level within the area, from the sealed source, shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make an individual attempting to enter the area aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of such failure of the entry control devices.

(iii) Be equipped with control devices such that upon failure or removal of physical radiation barriers other than the source's shielded storage container the radiation level from the source shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier. When the shield for the stored source is a liquid, means shall be provided to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding. Physical radiation barriers that com-

[1] This paragraph (c)(6) does not apply to radioactive sources that are used in teletherapy, in radiography, or in completely self-shielded irradiators in which the source is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual. This paragraph (c)(6) also does not apply to sources from which the radiation is incidental to some other use nor to nuclear reactor generated radiation other than radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators.

[2] These requirements apply after Mar. 14, 1978. Each person licensed to conduct activities to which this paragraph (c)(6) applies and who is not in compliance with the provisions of this paragraph on Mar. 14, 1978, shall file with the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, on or before June 14, 1978, information describing in detail the actions taken or to be taken to achieve compliance with this paragraph by Dec. 14, 1978, and may continue activities in conformance with present license conditions and the provisions of the previously effective § 20.2034 until such compliance is achieved. For such persons compliance must be achieved not later than Dec. 14, 1978.

prise permenent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of this paragraph (c)(6)(iii). (42 FR 64619)

(iv) Be equipped with devices that will automatically generate visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device which shall be installed in the area and which can prevent the source from being put into operation.

(v) Be controlled by use of such administrative procedure and such devices as are necessary to assure that the area is cleared of personnel prior to each use of the source preceding which use it might have been possible for an individual to have entered the area. (43 FR 2167)

(vi) Be checked by a physical radiation measurement to assure that prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour. (42 FR 64619)

(vii) Have entry control devices required in paragraph (c)(6)(i) of this section which have been tested for proper functioning prior to initial operation with such source of radiation on any day that operations are not uninterruptedly continued from the previous day or before resuming operations after any unintended interruption, and for which records are kept of the dates, times, and results of such tests of function. No operations other than those necessary to place the source in safe condition or to effect reparis on controls shall be conducted with such source unless control devices are functioning properly. The licensee shall submit an acceptable schedule for more complete periodic tests of the entry control and warning systems to be established and adhered to as a condition of the license.

(viii) Have those entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through such portals. Exit portals for processed materials shall be equipped to detect and signal the presence of loose radiation sources that are carried toward such an exit and to automatically prevent such loose sources from being carried out of the area.

(7) Licensees with, or applicants for, licenses for radiation sources that are within the purview of paragraph (c)(6) of this section, and that must be used in a variety of positions or in peculiar locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (c)(6) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, for approval, prior to use of safety measures that are alternative to those specified in paragraph (c)(6) of this section, and that will provide at least an equivalent degree of personnel protection in the use of such sources. At least one of the alternative measures must include an entry-preventing interlock control based on a physical measurement of radiation that assures the absence of high radiation levels before an individual can gain access to an area where such sources are used. (43 FR 2167)

(d) *Airborne radioactivity areas.* (1) As used in the regulations in this part "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive materials composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix B, Table I, Column 1 of this part; or (ii) any room, enclosure, or operating area in which airborne radioactive material composed wholly or partly of licensed material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in Appendix B Table I, Column 1 of this part. (25 FR 10914)

(2) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

AIRBORNE RADIOACTIVITY AREA

(e) *Additional requirements.* (1) Each area or room in which licensed material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in an amount exceeding 10 times the quantity of such material specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in any amount exceeding one hundred times the quantity specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words: (25 FR 10914)

CAUTION [1]

RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Except as provided in paragraph (f)(3) of this section, each container of licensed material shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to paragraph (f)(1) of this section shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information [2] to permit individuals handling or using the containers, or working in the vicinity thereof, to take precautions to avoid or minimize exposures.

(3) Notwithstanding the provisions of paragraph (f)(1) of this section labeling is not required: (31 FR 10514)

(i) For containers that do not contain licensed materials in quantities greater than the applicable quantities listed in Appendix C of this part.

(ii) For containers containing only natural uranium or thorium in quantities no greater than 10 times the applicable quantities listed in Appendix C of this part.

(iii) For containers that do not contain licensed materials in concentrations greater than the applicable concentrations listed in Appendix B, Table I, Column 2, of this part.

(iv) For containers when they are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established by the regulations in this part.

(v) For containers when they are in transport and packaged and labeled in accordance with regulations of the Department of Transportation. (31 FR 10514, 31 FR 19546)

(vi) For containers which are accessible [2] only to individuals authorized to handle or use them, or to work in the vicinity thereof, provided that the contents are identified to such individuals by a readily available written record.

(vii) For manufacturing or process equipment, such as nuclear reactors, reactor components, piping, and tanks.

[1] Or "Danger".

[2] As appropriate, the information will include radiation levels, kinds of material, estimate of activity, date for which activity is estimated, mass enrichment, etc.

(4) Each licensee shall, prior to disposal of an empty uncontaminated container to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials. [43 FR 22171]

§ 20.204 Same: exceptions. [25 FR 10914]

Notwithstanding the provisions of § 20.203,

(a) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level twelve inches from the surface of the source container or housing does not exceed five millirem per hour.

(b) Rooms or other areas in hospitals are not required to be posted with caution signs, and control of entrance or access thereto pursuant to § 20.203(c) is not required, because of the presence of patients containing byproduct material provided that there are personnel in attendance who will take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the regulations in this part. [35 FR 5033]

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours provided that (1) the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations in this part and; (2) such area or room is subject to the licensee's control. [25 FR 10914]

(d) A room or other area is not required to be posted with a caution sign, and control is not required for each entrance or access point to a room or other area which is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with regulations of the Department of Transportation.[1] [35 FR 5033]

[1] For example, containers in locations such as water-filled canals, storage vaults, or hot cells.

§ 20.205 Procedures for picking up, receiving, and opening packages. [39 FR 17972]

(a)(1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b)(1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactive contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries.

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours. [39 FR 17972]

(2) If removable radioactive contamination in excess of 0.01 microcuries (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify[1] the final delivering carrier and, by telephone and telegraph, mailgram or facsimile, the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D of this part. [41 FR 16445]

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	25,000	1000
Special Form	1	20

[1] The definitions of "transport group" and "special form" are specified in § 71.4 of this chapter.

[1] The reporting requirements in § 20.205 have been approved by GAO under number B-180 225 (R 0054).

(c)(1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours. [39 FR 17972]

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour,

the licensee shall immediately notify by telephone and telegraph mailgram, or facsimile, the director of the appropriate NRC Regional Office listed in Appendix D, and the final delivering carrier. [41 FR 16445]

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened. [39 FR 17972]

§ 20.206 Instruction of personnel. [48 FR 22220]

Instructions required for individuals working in or frequenting any portion of a restricted area are specified in § 19.12 of this chapter.

§ 20.207 Storage and control of licensed materials in unrestricted areas. [40 FR 26678]

(a) Licensed materials stored in an unrestricted area shall be secured from unauthorized removal from the place of storage.

(b) Licensed materials in an unrestricted area and not in storage shall be

tended under the constant surveillance and immediate control of the licensee.

Waste Disposal

§ 20.301 General requirement.

No licensee shall dispose of licensed material except:

(a) By transfer to an authorized recipient as provided in the regulations in Parts 30, 40, 60, 70 or 72 of this chapter, whichever may be applicable; or

(b) As authorized pursuant to § 20.302; or

(c) As provided in § 20.303, applicable to the disposal of licensed material by release into sanitary sewerage systems, or in § 20.306 for disposal of specific wastes, or in § 20.106 (Radioactivity in effluents to unrestricted areas).

§ 20.302 Method for obtaining approval of proposed disposal procedures.

(a) Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

(b) The Commission will not approve any application for a license to receive licensed material from other persons for disposal on land not owned by the Federal government or by a State government.

(c) The Commission will not approve any application for a license for disposal of licensed material at sea unless the applicant shows that sea disposal offers less harm to man or the environment than other practical alternative methods of disposal.

§ 20.303 Disposal by release into sanitary sewerage systems.

No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of paragraphs (b)(1) or (2) of this section.

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix B, Table I, Column 2 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix B, Table I, Column 2 of this part; and

(d) The gross quantity of licensed and other radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one curie per year. The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system may not exceed 5 curies per year for hydrogen-3 and 1 curie per year for carbon-14. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

§ 20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration except for materials listed under § 20.306 or as specifically approved by the Commission pursuant to §§ 20.106(b) and 20.302.

§ 20.306 Disposal of specific wastes.

Any licensee may dispose of the following licensed material without regard to its radioactivity:

(a) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of medium, used for liquid scintillation counting; and

(b) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of animal tissue averaged over the weight of the entire animal; provided however, tissue may not be disposed of under this section in a manner that would permit its use either as food for humans or as animal feed

(c) Nothing in this section, however, relieves the licensee of maintaining records showing the receipt, transfer and disposal of such byproduct material as specified in § 30.51 of this chapter; and

(d) Nothing in this section relieves the licensee from complying with other applicable Federal, State and local regulations governing any other toxic or hazardous property of these materials.

§ 20.401 Records of surveys, radiation monitoring, and disposal.

(a) Each licensee shall maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required under § 20.202 of the regulations in this part. Such records shall be kept on Form NRC-5, in accordance with the instructions contained in that form or on clear and legible records containing all the information required by Form NRC-5. The doses entered on the forms or records shall be for periods of time not exceeding one calendar quarter.

(b) Each licensee shall maintain records in the same units used in this part, showing the results of surveys required by § 20.201(b), monitoring required by §§ 20.205(b) and 20.205(c), and disposals made under §§ 20.302, 20.303, and deleted § 20.304.

(c)(1) Records of individual exposure to radiation and to radioactive material which must be maintained pursuant to the provisions of paragraph (a) of this section and records of bioassays, including results of whole body counting examinations, made pursuant to § 20.108, shall be preserved until the Commission authorizes disposition.

(2) Records of the results of surveys and monitoring which must be maintained pursuant to paragraph (b) of this section shall be preserved for two years after completion of the survey except that the following records shall be maintained until the Commission authorizes their disposition: (i) Records of the results of surveys to determine compliance with § 20.103(a); (ii) in the absence of personnel monitoring data, records of the results of surveys to determine external radiation dose; and (iii) records of the re-

sults of surveys used to evaluate the release of radioactive effluents to the environment.

[45 FR 71761] (3) Records of disposal of licensed material made pursuant to §§ 20.302, 20.303, and deleted § 20.304 [1] are to be maintained until the Commission authorizes their disposition.

(4) Records which must be maintained pursuant to this part may be the original or a reproduced copy or microform if such reproduced copy or microform is duly authenticated by authorized personnel and the microform is capable of producing a clear and legible copy after storage for the period specified by Commission regulations.

[41 FR 16300] (5) If there is a conflict between the Commission's regulations in this part, license condition, or technical specification, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this part for such records shall apply unless the Commission pursuant to § 20.501, has granted a specific exemption from the record retention requirements specified in the regulations in this part.

§ 20.402 Reports of theft or loss of licensed material.

[34 FR 7500] (a) Each licensee shall report by telephone to the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D of this part, immediately after its occurrence becomes known to the licensee, any loss or theft of licensed material in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

[41 FR 16445] (b) Each licensee who is required to make a report pursuant to paragraph (a) of this section shall, within thirty (30) days after he learns of the loss or theft, make a report in writing to the appropriate NRC Regional Office listed in Appendix D of this part with copies to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, setting forth the following information:

[34 FR 7500] (1) A description of the licensed material involved, including kind, quantity, chemical, and physical form;

(2) A description of the circumstances under which the loss or theft occurred;

(3) A statement of disposition or probable disposition of the licensed material involved;

(4) Radiation exposures to individuals, circumstances under which the exposures occurred, and the extent of possible hazard to persons in unrestricted areas;

(5) Actions which have been taken, or will be taken, to recover the material; and

(6) Procedures or measures which have been or will be adopted to prevent a recurrence of the loss or theft of licensed material.

(c) Subsequent to filing the written report the licensee shall also report any substantive additional information on the loss or theft which becomes available to the licensee, within 30 days after he learns of such information.

(d) Any report filed with the Commission pursuant to this section shall be so prepared that names of individuals who may have received exposure to radiation are stated in a separate part of the report.

§ 20.403 Notifications of incidents.

[41 FR 16445] (a) *Immediate notification.* Each licensee shall immediately notify by telephone and telegraph, mailgram, or facsimile, the Director of the appropriate NRC Regional Office listed in Appendix D of this part of any incident involving byproduct, source, or special nuclear material possessed by him and which may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more or radiation; or exposure of the feet, ankles, hands or forearms of any individual to 375 rems or more of radiation; or

[27 FR 6905] (2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II of this part; or

(3) A loss of one working week or more of the operation of any facilities affected; or

[43 FR 43965] (4) Damage to property in excess of $200,000.

[41 FR 16445] (b) *Twenty-four hour notification.* Each licensee shall within 24 hours notify by telephone and telegraph, mailgram, or facsimile, the Director of the appropriate NRC Regional Office listed in Appendix D of this part of any incident involving licensed material possessed by him and which may have caused or threatens to cause:

[27 FR 6905] (1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II of this part; or

[43 FR 43965] (3) A loss of one day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $2,000.

[42 FR 6822-78 FR 6905] (c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

[43 FR 13434] (d) For nuclear power reactors licensed under § 50.21 or § 50.22, the incidents included in paragraph (a) and paragraph (b) in this section shall in addition be reported pursuant to § 50.72.

§ 20.404 [Reserved]

§ 20.405 Reports of overexposures and excessive levels and concentrations.

[42 FR 20138] (a) In addition to any notification required by § 20.403, each licensee shall make a report in writing within 30 days to the Regional Office listed in Appendix D of this part, with a copy to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, of:

[43 FR 29270] (1) Each exposure of an individual to radiation in excess of the applicable limits in §§ 20.101 or 20.104(a) or the license; (2) each exposure of an individual to radioactive material in excess of the applicable limits in §§ 20.103(a)(1), 20.103(a)(2), 20.104(b) or the license; (3) levels of radiation or concentrations of radioactive material in a restricted area in excess of any other applicable limit in the license; (4) any incident for which notification is required by § 20.403; and (5) levels of radiation or concentrations of radioactive material (whether or not involv-

[1] Section 20.304 provided for burial of small quantities of licensed materials in soil. Notice of its deletion appears in the FEDERAL REGISTER of October 30, 1980 (45 FR 71762).

ing excessive exposure of any individual) in an unrestricted area in excess of ten times any applicable limit set forth in this part or in the license.

Each report required under this paragraph shall describe the extent of exposure of individuals to radiation or to radioactive material, including estimates of each individual's exposure as required by paragraph (b) of this section; levels of radiation and concentrations of radioactive material involved; the cause of the exposure, levels or concentrations; and corrective steps taken or planned to assure against a recurrence. [43 FR 39270]

(b) Any report filed with the Commission pursuant to paragraph (a) of this section shall include for each individual exposed the name, social security number, and date of birth, and an estimate of the individual's exposure. The report shall be prepared so that this information is stated in a separate part of the report.

(c) In addition to any notification required by § 20.403, each licensee shall make a report in writing within 30 days to the appropriate NRC Regional Office listed in Appendix D, with a copy to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, of levels of radiation or releases of radioactive material in excess of limits specified by 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," or in excess of license conditions related to compliance with 40 CFR Part 190. Each report required under this paragraph shall describe the extent of exposure of individuals to radiation or to radioactive material; levels of radiation and concentrations of radioactive material involved; the cause of the exposure, levels or concentrations; and corrective steps taken or planned to assure against a recurrence, including the schedule for achieving conformance with 40 CFR Part 190 and associated license conditions. [46 FR 18525]

§ 20.406 [Reserved]

§ 20.407 Personnel monitoring reports.

Each person described in § 20.408 of this part shall, within the first quarter of each calendar year, submit to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, the reports specified in paragraphs (a) and (b) of this section covering the preceding calendar year.[1] All other persons specifically licensed by the Commission shall, within the first quarter of calendar years 1979 and 1980, submit to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, the reports specified in paragraphs (a) and (b) of this section covering the preceding calendar years 1978 and 1979.[1] [43 FR 44827]

(a) A report of either (1) the total number of individuals for whom personnel monitoring was required under § 20.202(a) or § 34.33(a) of this chapter during the calendar year; or (2) the total number of individuals for whom personnel monitoring was provided during the calendar year: *Provided, however,* That such total includes at least the number of individuals required to be reported under paragraph (a)(1) of this section. The report shall indicate whether it is submitted in accordance with paragraph (a)(1) or (a)(2) of this section. If personnel monitoring was not required to be provided to any individual by the licensee under §§ 20.202(a) or 34.33(a) of this chapter during the calendar year, the licensee shall submit a negative report indicating that such personnel monitoring was not required.

(b) A statistical summary report of the personnel monitoring information recorded by the licensee for individuals for whom personnel monitoring was either required or provided, as described in paragraph (a) of this section, indicating the number of individuals whose total whole body exposure recorded during the previous calendar year was in each of the following estimated exposure ranges: [43 FR 44827]

Estimated whole body exposure range (rems)[1]	Number of individuals in each range
No measurable exposure	
Measurable exposure less than 0.1	
0.1 to 0.25	
0.25 to 0.5	
0.5 to 0.75	
0.75 to 1	
1 to 2	
2 to 3	
3 to 4	
4 to 5	
5 to 6	
6 to 7	
7 to 8	
8 to 9	
9 to 10	
10 to 11	
11 to 12	
12+	

[1]Individual values exactly equal to the values separating exposure ranges shall be reported in the higher range.

The low exposure range data are required in order to obtain better information about the exposures actually recorded. This section does not require improved measurements.

[1]A licensee whose license expires or terminates prior to, or on the last day of the calendar year, shall submit reports at the expiration or termination of the license, covering that part of the year during which the license was in effect.

§ 20.408 Reports of personnel monitoring on termination of employment or work.

(a) This section applies to each person licensed by the Commission to: [43 FR 44827]

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2(r) of this chapter;

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter;

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium or any combination thereof pursuant to Part 70 of this chapter; [46 FR 13971]

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter; or [46 FR 58281]

(6) Possess or use at any one time, for processing or manufacturing for distribution pursuant to Parts 30, 32, or 33 of this Chapter, byproduct material in quantities exceeding any one of the following quantities:

Radionuclide[1]	Quantity in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iridium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

[1]The Commission may require, as a license condition, or by rule, regulation or order pursuant to § 20.502, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

(b) When an individual terminates employment with a licensee describe in paragraph (a) of this section, or an individual assigned to work in such a licensee's facility but not employed by the licensee, completes the work assignment in the licensee's facility, the licensee shall furnish to the Director [43 FR 44827]

[1]The Commission will evaluate the data obtained for 1978 and 1979 pursuant to this paragraph, and the benefits derived therefrom and may take action, including publication of notice of proposed rulemaking, to extend or otherwise modify this reporting requirement.

43 FR 44827

of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, a report of the individual's exposures to radiation and radioactive material, incurred during the period of employment or work assignment in the licensee's facility, containing information recorded by the licensee pursuant to §§ 20.401(a) and 20.108. Such report shall be furnished within 30 days after the exposure of the individual has been determined by the licensee or 90 days after the date of termination of employment or work assignment, whichever is earlier.

38 FR 22220

§ 20.409 Notifications and reports to individuals.

(a) Requirements for notifications and reports to individuals of exposure to radiation or radioactive material are specified in § 19.13 of this chapter.

(b) When a licensee is required pursuant to §§ 20.405 or 20.408 to report to the Commission any exposure of an individual to radiation or radioactive material, the licensee shall also notify the individual. Such notice shall be transmitted at a time not later than the transmittal to the Commission, and shall comply with the provisions of § 19.13(a) of this chapter.

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

25 FR 10914

§ 20.501 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 20.502 Additional requirements.

The Commission may, by rule, regulation, or order, impose upon any licensee such requirements, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

ENFORCEMENT

40 FR 8774

§ 20.601 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Atomic Energy Act of 1954, as amended, or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder. A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act, or section 206 of the Energy Reorganization Act of 1974, or any rule, regulation, or order issued thereunder, or any term, condition, or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

40 FR 8774

NOTE: The reporting and record keeping requirements contained in this part have been approved by the General Accounting Office under B-180225 (R0043), (R0044), and (R0084).

PART 21

REPORTING OF DEFECTS AND NONCOMPLIANCE

GENERAL PROVISIONS

NOTIFICATION

PROCUREMENT DOCUMENTS

INSPECTIONS, RECORDS

ENFORCEMENT

Authority: Secs. 161i and 161o, Pub. L. 83-703, 68 Stat. 949 and 950, as amended, sec. 234, Pub. L. 91-161, 83 Stat. 444; secs. 201 and 206, Pub. L. 93-438, 88 Stat. 1242 and 1246, as amended (42 U.S.C. 2201(i), 2201(o), 2282, 5841, 5846).

GENERAL PROVISIONS

42 FR 28891

§ 21.1 Purpose.

The regulations in this part establish procedures and requirements for implementation of section 206 of the Energy Reorganization Act of 1974. That section requires any individual director or responsible officer of a firm constructing, owning, operating or supplying the components of any facility or activity which is licensed or otherwise regulated pursuant to the Atomic Energy Act of 1954, as amended, or the Energy Reorganization Act of 1974, who obtains information reasonably indicating: (a) That the facility, activity or basic component supplied to such facility or activity fails to comply with the Atomic Energy Act of 1954, as amended, or any applicable rule, regulation, order, or license of the Commission relating to substantial safety hazards or (b) that the facility, activity, or basic component supplied to such facility or activity contains defects, which could create a substantial safety hazard, to immediately notify the Commission of such failure to comply or such defect, unless he has actual knowledge that the Commission has been adequately informed of such defect or failure to comply.

42 FR 28891

46 FR 58281

§ 21.2 Scope.

The regulations in this part apply, except as specifically provided otherwise in Parts 31, 34, 35, 40, 60, 70, or 72 of this chapter, to each individual, partnership, corporation, or other entity licensed pursuant to the regulations in this chapter to possess, use, and/or transfer within the United States source material, byproduct material, special nuclear material, and/or spent fuel, or to construct, manufacture, possess, own, operate and/or transfer within the United States, any production or utilization facility or independent spent fuel storage installation, and to each director (see § 21.3(f)) and responsible officer (see § 21.3(j)) of such a licensee. The regulations in this part apply also to each individual, corporation, partnership or other entity doing business within the United States, and each director and responsible officer of such organization, that constructs (see § 21.3(c)) a production or utilization facility licensed for manufacture, construction or operation (see § 21.3(h)) pursuant to Part 50 of this chapter or an independent spent fuel storage installation for the storage of spent fuel licensed pursuant to Part 72 of this chapter, or supplies (see § 21.3(l)) basic components (see § 21.3(a)) for a facility or activity licensed, other than for export, under Parts 30, 40, 50, 60, 70, 71, or 72 of this chapter. Nothing in these regulations should be deemed to preclude either an individual or a manufacturer/supplier of a commercial grade item (see § 21.3(a-1)) not subject to the regulations in this part from reporting to the Commission a known or suspected defect or failure to comply and, as authorized by law, the identity of anyone so reporting will be withheld from disclosure.[1]

46 FR 58281

§ 21.3 Definitions.

As used in this part.

(a)(1) "Basic component," when applied to nuclear power reactors means a plant structure, system, component or part thereof necessary to assure (i) the integrity of the reactor coolant pressure boundary, (ii) the capability to shut down the reactor and maintain it in a safe shutdown condition, or (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to those referred to in § 100.11 of this chapter.

(2) "Basic component," when applied to other facilities and when applied to other activities licensed pursuant to Parts 30, 40, 50, 60, 70, 71, or 72 of this chapter, means a component, structure, system, or part thereof that is directly procured by the licensee of a facility or activity subject to the regulations in this part and in which a defect (see § 21.3(d)) or failure to comply with any applicable regulation in this chapter, order, or license issued by the Commission could create a substantial safety hazard (see § 21.3(k)).

(3) In all cases "basic component" includes design, inspection, testing, or consulting services important to safety that are associated with the component hardware, whether these services are performed by the component supplier or others.

[1] NRC Regional Offices will accept collect telephone calls from individuals who wish to speak to NRC representatives concerning nuclear safety-related problems. The location and telephone numbers (for nights and holidays as well as regular hours) are listed below:

Region		
I	(Philadelphia)	(215) 337-5000
II	(Atlanta)	(404) 221-4503
III	(Chicago)	(312) 932-2500
IV	(Dallas)	(817) 465-8100
V	(San Francisco)	(415) 943-3700

(4) A commercial grade item is not a part of a basic component until after dedication (see § 21.3(o-1)).

(a-1) "Commercial grade item" means an item that is (1) not subject to design or specification requirements that are unique to facilities or activities licensed pursuant to Parts 30, 40, 50, 60, 70, 71, or 72 of this chapter and (2) used in applications other than facilities or activities licensed pursuant to Parts 30, 40, 50, 60, 70, 71, or 72 of this chapter and (3) to be ordered from the manufacturer/supplier on the basis of specifications set forth in the manufacturer's published product description (for example a catalog). [46 FR 58281]

(b) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

(c) "Constructing" or "construction" means the design, manufacture, fabrication, placement, erection, installation, modification, inspection, or testing of a facility or activity which is subject to the regulations in this part and consulting services related to the facility or activity that are important to safety. [42 FR 28891]

(c-1) "Dedication" of a commercial grade item occurs after receipt when that item is designated for use as a basic component. [43 FR 46621]

(d) "Defect" means:

(1) A deviation (see § 21.3(e)) in a basic component delivered to a purchaser for use in a facility or an activity subject to the regulations in this part if, on the basis of an evaluation (see § 21.3(g)), the deviation could create a substantial safety hazard; or [42 FR 36803]

(2) The installation, use, or operation of a basic component containing a defect as defined in paragraph (d)(1) of this section; or

(3) A deviation in a portion of a facility subject to the construction permit or manufacturing licensing requirements of Part 50 of this chapter provided the deviation could, on the basis of an evaluation, create a substantial safety hazard and the portion of the facility containing the deviation has been offered to the purchaser for acceptance; or [42 FR 28891]

(4) A condition or circumstance involving a basic component that could contribute to the exceeding of a safety limit, as defined in the technical specifications of a license for operation issued pursuant to Part 50 of this chapter.

(e) "Deviation" means a departure from the technical requirements included in a procurement document (see § 21.3(i)).

(f) "Director" means an individual, appointed or elected according to law, who is authorized to manage and direct the affairs of a corporation, partnership or other entity. In the case of an individual proprietorship, "director" means the individual.

(g) "Evaluation" means the process accomplished by or for a licensee to determine whether a particular deviation could create a substantial safety hazard. [42 FR 28891]

(h) "Operating" or "operation" means the operation of a facility or the conduct of a licensed activity which is subject to the regulations in this part and consulting services related to operations that are important to safety.

(i) "Procurement document" means a contract that defines the requirements which facilities or basic components must meet in order to be considered acceptable by the purchaser.

(j) "Responsible officer" means the president, vice-president or other individual in the organization of a corporation, partnership, or other entity who is vested with executive authority over activities subject to this part. [42 FR 28891]

(k) "Substantial safety hazard" means a loss of safety function to the extent that there is a major reduction in the degree of protection provided to public health and safety for any facility or activity licensed, other than for export, pursuant to Parts 30, 40, 50, 60, 70, 71, or 72 of this chapter. [46 FR 58281]

(l) "Supplying" or "supplies" means contractually responsible for a basic component used or to be used in a facility or activity which is subject to the regulations in this part.

§ 21.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 21.5 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, or to the Director of a Regional Office at the address specified in Appendix D of Part 20 of this chapter. Communications and reports also may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C.; at 7920 Norfolk Avenue, Bethesda, Md.; or at a Regional Office at the location specified in Appendix D of Part 20 of this chapter.

§ 21.6 Posting requirements.

(a) Each individual, partnership, corporation or other entity subject to the regulations in this part, shall post current copies of the following documents in a conspicuous position on any premises, within the United States where the activities subject to this part are conducted (1) the regulations in this part, (2) Section 206 of the Energy Reorganization Act of 1974, and (3) procedures adopted pursuant to the regulations in this part.

(b) If posting of the regulations in this part or the procedures adopted pursuant to the regulations in this part is not practicable, the licensee or firm subject to the regulations in this part may, in addition to posting section 206, post a notice which describes the regulations/procedures, including the name of the individual to whom reports may be made, and states where they may be examined.

(c) The effective date of this section has been deferred until January 6, 1978. [42 FR 28891]

42 FR 28891

§ 21.7 Exemptions.

The Commission may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

43 FR 48621

Suppliers of commercial grade items are exempt from the provisions of this part to the extent that they supply commercial grade items.

NOTIFICATION

42 FR 28891

§ 21.21 Notification of failure to comply or existence of a defect.

(a) Each individual, corporation, partnership or other entity subject to the regulations in this part shall adopt appropriate procedures to:

(1) Provide for: (i) Evaluating deviations or (ii) informing the licensee or purchaser of the deviation in order that the licensee or purchaser may cause the deviation to be evaluated unless the deviation has been corrected; and

(2) Assure that a director or responsible officer is informed if the construction or operation of a facility, or activity, or a basic component supplied for such facility or activity:

(i) Fails to comply with the Atomic Energy Act of 1954, as amended, or any applicable rule, regulation, order or license of the Commission relating to a substantial safety hazard, or

(ii) Contains a defect. The effective date of this paragraph has been deferred until January 6, 1978.

45 FR 58281

(b)(1) A director or responsible officer subject to the regulations of this part or a designated person shall notify the Commission when he obtains information reasonably indicating a failure to comply or a defect affecting (i) the construction or operation of a facility or an activity within the United States that is subject to the licensing requirements under Parts 30, 40, 50, 60, 70, 71, or 72 of this chapter and that is within his organization's responsibility or (ii) a basic component that is within his organization's responsibility and is supplied for a facility or an activity within the United States that is subject to the licensing requirements under Parts 30, 40, 50, 60, 70, 71, or 72 of this chapter. The above notification is not required if such individual has actual knowledge that the Commission has been adequately informed of such defect or such failure to comply.

42 FR 28891

(2) Initial notification required by this paragraph shall be made within two days following receipt of the information. Notification shall be made to the Director, Office of Inspection and Enforcement, or to the Director of a Regional Office. If initial notification is by means other than written communication, a written report shall be submitted to the appropriate Office within 5 days after the information is obtained. Three copies of each report shall be submitted to the Director, Office of Inspection and Enforcement.

(3) The written report required by this paragraph shall include, but need not be limited to, the following information, to the extent known:

(i) Name and address of the individual or individuals informing the Commission.

(ii) Identification of the facility, the activity, or the basic component supplied for such facility or such activity within the United States which fails to comply or contains a defect.

(iii) Identification of the firm constructing the facility or supplying the basic component which fails to comply or contains a defect.

(iv) Nature of the defect or failure to comply and the safety hazard which is created or could be created by such defect or failure to comply.

(v) The date on which the information of such defect or failure to comply was obtained.

(vi) In the case of a basic component which contains a defect or fails to comply, the number and location of all such components in use at, supplied for, or being supplied for one or more facilities or activities subject to the regulations in this part.

(vii) The corrective action which has been, is being, or will be taken; the name of the individual or organization responsible for the action; and the length of time that has been or will be taken to complete the action.

(viii) Any advice related to the defect or failure to comply about the facility, activity, or basic component that has been, is being, or will be given to purchasers or licensees.

(4) The director or responsible officer may authorize an individual to provide the notification required by this paragraph, provided that, this shall not relieve the director or responsible officer of his or her responsibility under this paragraph.

(c) Individuals subject to paragraph (b) of this section may be required by the Commission to supply additional information related to the defect or failure to comply.

PROCUREMENT DOCUMENTS

§ 21.31 Procurement documents.

Each individual, corporation, partnership or other entity subject to the regulations in this part shall assure that each procurement document for a facility, or a basic component issued by him, her or it on or after January 6, 1978 specifies, when applicable, that the provisions of 10 CFR Part 21 apply.

INSPECTIONS, RECORDS

§ 21.41 Inspections.

Each individual, corporation, partnership or other entity subject to the regulations in this part shall permit duly authorized representatives of the Commission, to inspect its records, premises, activities, and basic components as necessary to effectuate the purposes of this part.

§ 21.51 Maintenance of records.

(a) Each licensee of a facility or activity subject to the regulations in this part shall maintain such records in connection with the licensed facility or activity as may be required to assure compliance with the regulations in this part.

42 FR 28891

(b) Each individual, corporation, partnership, or other entity subject to the regulations in this part shall prepare records in connection with the designs, manufacture, fabrication, placement, erection, installation, modification, inspection, or testing of any facility, basic component supplied for any licensed facility or to be used in any licensed activity sufficient to assure compliance with the regulations in this part. After delivery of the facility or component and prior to the destruction of the records relating to evaluations (see § 21.3(g)) or notifications to the Commission (see § 21.21), such records shall be offered to the purchaser of the facility or component. If such purchaser determines any such records:

(1) Are not related to the creation of a substantial safety hazard, he may authorize such records to be destroyed, or

(2) Are related to the creation of a substantial safety hazard, he shall cause such records to be offered to the organization to which he supplies basic components or for which he constructs a facility or activity.

If such purchaser is unable to make the determination as required above

42 FR 28891

then the responsibility for making the determination shall be transferred to the individual, corporation, partnership, or other entity subject to the regulations in this part that issued the procurement document to the purchaser. In the event that the determination cannot be made at that level then the responsibility shall be transferred in a similar manner to another individual, corporation, partnership, or other entity subject to the regulations in this part, until, if necessary, the licensee shall make the determination.

(c) Records that are prepared only for the purpose of assuring compliance with the regulations in this part and are not related to evaluations or notifications to the Commission may be destroyed after delivery of the facility or component.

(d) The effective date of the section has been deferred until January 6, 1978.

ENFORCEMENT

46 FR 13202

§ 21.61 Failure to notify.

Any director or responsible officer subject to the regulations in this part who knowingly and consciously fails to provide the notice required by § 21.21 shall be subject to a civil penalty equal to the amount provided by section 234 of the Atomic Energy Act of 1954, as amended.

NOTE.—The reporting and record keeping requirements contained in this part have been approved by the General Accounting Office under B-180225 (RO 446).

PART 34 LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHIC OPERATIONS

Sec.

Authority: Secs. 81, 161, 182, 183, 68 Stat. 935, 948, 953, 954, as amended; 42 U.S.C. 2111, 2201, 2232, 2233. For the purposes of sec. 223, 68 Stat. 958, as amended, 42 U.S.C. 2273, §§ 34.11(d), 34.25(c), 34.26, 34.27, 34.28(b), 34.29(c), 34.31(c), 34.33(b), 34.33(e), and 34.43(c) issued under sec. 161o, 68 Stat. 950, as amended, 42 U.S.C. 2201(o), unless otherwise noted.

§ 34.1 Purpose and scope.

This part prescribes requirements for the issuance of licenses for the use of sealed sources containing byproduct material and radiation safety requirements for persons using such sealed sources in radiography. The provisions and requirements of this part are in addition to, and not in substitution for, other requirements of this chapter. In particular, the provisions of Part 30 of this chapter apply to applications and licenses subject to this part. Nothing in this part shall apply to uses of byproduct material for medical diagnosis or therapy.

30 FR 8185

§ 34.2 Definitions.

As used in this part:

(a) "Radiography" means the examination of the structure of materials by nondestructive methods, utilizing sealed sources of byproduct materials;

(b) "Radiographer" means any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic operations and who is responsible to the licensee for assuring compliance with the requirements of the Commission's regulations and the conditions of the license;

(c) "Radiographer's assistant" means any individual who, under the personal supervision of a radiographer, uses radiographic exposure devices, sealed sources or related handling tools, or radiation survey instruments in radiography;

(d) "Radiographic exposure device" means any instrument containing a sealed source fastened or contained therein, in which the sealed source or shielding thereof may be moved, or otherwise changed, from a shielded to unshielded position for purposes of making a radiographic exposure;

(e) "Sealed source" means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material;

(f) "Storage container" means a device in which sealed sources are transported or stored.

30 FR 8185

(g) "Source changer" means a device designed and used for replacement of sealed sources in radiographic exposure devices, including those also used for transporting and storage of sealed sources;

(h) "Permanent radiographic installation" means a shielded installation or structure designed or intended for radiography and in which radiography is regularly performed.

44 FR 50805

§ 34.3 Applications for specific licenses.

Applications for specific licenses for use of sealed sources in radiography shall be filed on Form NRC-313R, "Application for Byproduct Material License—Use of Sealed Sources in Radiography."

30 FR 8185

Subpart A—Specific Licensing Requirements

§ 34.11 Issuance of specific licenses for use of sealed sources in radiography.

An application for a specific license for use of sealed sources in radiography will be approved if:

(a) The applicant satisfies the general requirements specified in §30.33 of this chapter;

(b) The applicant will have an adequate program for training radiographers and radiographers' assistants and submits to the Commission a schedule or de-

scription of such program which specifies the:

(1) Initial training;

(2) Periodic training;

(3) On-the-job training;

(4) Means to be used by the licensee to determine the radiographer's knowledge and understandin.. of and ability to comply with Commission regulations and licensing requirements, and the operating and emergency procedures of the applicant; and

(5) Means to be used by the licensee to determine the radiographer's assistant's knowledge and understanding of and ability to comply with the operating and emergency procedures of the applicant;

(c) The applicant has established and submits to the Commission satisfactory written operating and emergency procedures as described in §34.32;

(d) The applicant will have an internal inspection system adequate to assure that Commission regulations, Commission license provisions, and the applicant's operating and emergency procedures are followed by radiographers and radiographers' assistants; the inspection system shall include the performance of internal inspections at intervals not to exceed three months and the retention of records of such inspections for two years;

(e) The applicant submits a description of its over-all organizational structure pertaining to the radiography program, including specified delegations of authority and responsibility for operation of the program; and

(f) The applicant who desires to conduct his own leak tests has established adequate procedures to be followed in leak testing sealed sources, for possible leakage and contamination and submits to the Commission a description of such procedures including:

(1) Instrumentation to be used,

(2) Method of performing test, e.g., points on equipment to be smeared and method of taking smear, and

(3) Pertinent experience of the person who will perform the test.

Subpart B—Radiation Safety Requirements

EQUIPMENT CONTROL

§ 34.21 Limits on levels of radiation for radiographic exposure devices and storage containers.

Radiographic exposure devices measuring less than four (4) inches from the sealed source storage position to any exterior surface of the device shall have no radiation level in excess of 50 milliroentgens per hour at six (6) inches from any exterior surface of the device. Radiographic exposure devices measuring a minimum of four (4) inches from the sealed source storage position to any exterior surface of the device, and all storage containers for sealed sources or for radiographic exposure devices, shall have no radiation level in excess of 200 milliroentgens per hour at any exterior surface, and ten (10) milliroentgens per hour at one meter from any exterior surface. The radiation levels specified are with the sealed source in the shielded (i.e., "off") position.

§ 34.22 Locking of radiographic exposure devices, storage containers, and source changers.

(a) Each radiographic exposure device shall have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. The exposure device or its container shall be kept locked when not under the direct surveillance of a radiographer or a radiographer's assistant or as otherwise may be authorized in § 34.41. In addition, during radiographic operations the sealed source assembly shall be secured in the shielded position each time the source is returned to that position.

(b) Each sealed source storage container and source changer shall have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. Storage containers and source changers shall be kept locked when containing sealed sources except when under the direct surveillance of a radiographer or a radiographer's assistant.

§ 34.23 Storage precautions.

Locked radiographic exposure devices and storage containers shall be physically secured to prevent tampering or removal by unauthorized personnel.

§ 34.24 Radiation survey instruments.

The licensee shall maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys as required by this part and Part 20 of this chapter.

Each radiation survey instrument shall be calibrated at intervals not to exceed three months and after each instrument servicing and a record shall be maintained of the results of each instrument calibration and date thereof for two years after the date of calibration.

Instrumentation required by this section shall have a range such that two milliroentgens per hour through one roentgen per hour can be measured.

§ 34.25 Leak testing, repair, tagging, opening, modification and replacement of sealed sources.

(a) The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing, repair, tagging, opening or any other modification of any sealed source shall be performed only by persons specifically authorized by the Commission to do so.

(b) Each sealed source shall be tested for leakage at intervals not to exceed 6 months. In the absence of a certificate from a transferor that a test has been made within the 6 months prior to the transfer, the sealed source shall not be put into use until tested.

(c) The leak test shall be capable of detecting the presence of 0.005 microcurie of removable contamination on the sealed source. An acceptable leak test for sealed sources in the possession of a radiography licensee would be to test at the nearest accessible point to the sealed source storage position, or other appropriate measuring point, by a procedure to be approved pursuant to §34.11(f).

[30 FR 8185]

Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Commission for six months after the next required leak test is performed or until the sealed source is transferred or disposed of.

[41 FR 18300]

(d) Any test conducted pursuant to paragraphs (b) and (c) of this section which reveals the presence of 0.005 microcurie or more of removable radioactive material shall be considered evidence that the sealed source is leaking. The licensee shall immediately withdraw the equipment involved from use and shall cause it to be decontaminated and repaired or to be disposed of, in accordance with Commission regulations. A report shall be filed, within 5 days of the test, with the Director of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall be sent to the Director of the appropriate Nuclear Regulatory Commission's Inspection and Enforcement Regional Office listed in Appendix D of Part 20 of this chapter "Standards for Protection Against Radiation."

[30 FR 8185]

(e) A sealed source which is not fastened to or contained in a radiographic exposure device shall have permanently attached to it a durable tag at least one (1) inch square bearing the prescribed radiation caution symbol in conventional colors, magenta or purple on a yellow background, and at least the instructions: "Danger—Radioactive Material—Do Not Handle—Notify Civil Authorities if Found."

§ 34.26 Quarterly inventory.

Each licensee shall conduct a quarterly physical inventory to account for all sealed sources received and possessed under his license. The records of the inventories shall be maintained for two years from the date of the inventory for inspection by the Commission, and shall include the quantities and kinds of byproduct material, location of sealed sources, and the date of the inventory.

[41 FR 18300]

§ 34.27 Utilization logs.

Each licensee shall maintain current logs, which shall be kept available for two years from the date of the recorded event, for inspection by the Commission, at the address specified in the license, showing for each sealed source the following information:

[30 FR 8185]

(a) A description (or make and model number) of the radiographic exposure device or storage container in which the sealed source is located;

(b) The identity of the radiographer to whom assigned; and

(c) The plant or site where used and dates of use.

[41 FR 50805]

§ 34.28 Inspection and maintenance of radiographic exposure devices, storage containers, and source changers.

(a) The licensee shall check for obvious defects in radiographic exposure devices, storage containers, and source changers prior to use each day the equipment is used.

(b) The licensee shall conduct a program for inspection and maintenance of radiographic exposure devices, storage containers, and source changers at intervals not to exceed three months or prior to the first use thereafter to assure proper functioning of components important to safety. Records of these inspections and maintenance shall be kept for two years.

§ 34.29 Permanent radiographic installations.

(a) Permanent radiographic installations having high radiation area entrance controls of the types described in § 20.203(c) (2)(ii), (2)(iii), or (4) shall also meet the following special requirement.

(b) Each entrance that is used for personnel access to the high radiation area in a permanent radiographic installation to which this section applies shall have both visible and audible warning signals to warn of the presence of radiation. The visible signal shall be actuated by radiation whenever the source is exposed. The audible signal shall be actuated when an attempt is made to enter the installation while the source is exposed.

(c) The alarm system shall be tested at intervals not to exceed three months or prior to the first use thereafter of the source in the installation. Records of the tests shall be kept for two years.

PERSONAL RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHERS AND RADIOGRAPHERS' ASSISTANTS

§ 34.31 Training.

(a) The licensee shall not permit any individual to act as a radiographer until such individual:

(1) Has been instructed in the subjects outlined in Appendix A of this part;

(2) Has received copies of and instruction in NRC regulations contained in this part and in the applicable sections of Parts 19 and 20 of this chapter, NRC license(s) under which the radiographer will perform radiography, and the licensee's operating and emergency procedures;

(3) Has demonstrated competence to use the licensee's radiographic exposure devices, sealed sources, related handling tools, and survey instruments; and

(4) Has demonstrated understanding of the instructions in this paragraph (a) by successful completion of a written test and a field examination on the subjects covered.

[41 FR 50805]

(b) The licensee shall not permit any individual to act as a radiographer's assistant until such individual:

(1) Has received copies of and instruction in the licensee's operating and emergency procedures;

(2) Has demonstrated competence to use, under the personal supervision of the radiographer, the radiographic exposure devices, sealed sources, related handling tools, and radiation survey instruments that the assistant will use; and

(3) Has demonstrated understanding of the instructions in this paragraph (b) by successfully completing a written or oral test and a field examination on the subjects covered.

(c) Records of the above training, including copies of written tests and dates of oral tests and field examinations, shall be maintained for three years.

§ 34.32 Operating and emergency procedures.

The licensee's operating and emergency procedures shall include instructions in at least the following:

(a) The handling and use of licensed sealed sources and radiographic exposure devices to be employed such that no person is likely to be exposed to radiation doses in excess of the limits established in Part 20 of this chapter "Standards for Protection Against Radiation";

(b) Methods and occasions for conducting radiation surveys;

(c) Methods for controlling access to radiographic areas;

(d) Methods and occasions for locking and securing radiographic exposure devices, storage containers and sealed sources;

(e) Personnel monitoring and the use of personnel monitoring equipment;

(f) Transporting sealed sources to field locations, including packing of radiographic exposure devices and storage containers in the vehicles, posting of vehicles and control of the sealed sources during transportation;

(g) Minimizing exposure of persons in the event of an accident;

(h) The procedure for notifying proper persons in the event of an accident; and

(i) Maintenance of records.

(j) The inspection and maintenance of radiographic exposure devices and storage containers.

(k) Steps that must be taken immediately by radiography personnel in the event a pocket dosimeter is found to be off-scale.

(l) The procedure(s) for identifying and reporting defects and noncompliance, as required by Part 21 of this chapter.

§ 34.33 Personnel monitoring.

(a) The licensee shall not permit any individual to act as a radiographer or a radiographer's assistant unless, at all times during radiographic operations, each such individual wears a direct reading pocket dosimeter and either a film badge or a thermoluminescent dosimeter (TLD). Pocket dosimeters shall have a range from zero to at least 200 milliroentgens and shall be recharged at the start of each shift. Each film badge and TLD shall be assigned to and worn by only one individual.

(b) Pocket dosimeters shall be read and exposures recorded daily.

(c) Pocket dosimeters shall be checked at periods not to exceed one year for correct response to radiation. Acceptable dosimeters shall read within plus or minus 30 percent of the true radiation exposure.

(d) If an individual's pocket dosimeter is discharged beyond its range, his film badge or TLD shall be immediately sent for processing.

(e) Reports received from the film badge or TLD processor shall be kept for inspection until the Commission authorizes their disposal. Records of daily pocket dosimeter readings shall be kept for two years.

PRECAUTIONARY PROCEDURES IN RADIOGRAPHIC OPERATIONS

§ 34.41 Security.

During each radiographic operation the radiographer or radiographer's assistant shall maintain a direct surveillance of the operation to protect against unauthorized entry into a high radiation area, as defined in Part 20 of this chapter, except (a) where the high radiation area is equipped with a control device or an alarm system as described in §20.203(c)(2) of this chapter, or (b) where the high radiation area is locked to protect against unauthorized or accidental entry.

§ 34.42 Posting.

Notwithstanding any provisions in §20.204(c) of this chapter, areas in which radiography is being performed shall be conspicuously posted as required by §20.203(b) and (c)(1) of this chapter.

§ 34.43 Radiation surveys.

(a) At least one calibrated and operable radiation survey instrument shall be available at the location of radiographic operations whenever radiographic operations are being performed.

(b) A survey with a radiation survey instrument shall be made after each radiographic exposure to determine that the sealed source has been returned to its shielded position. The entire circumference of the radiographic exposure device shall be surveyed. If the radiographic exposure device has a source guide tube, the survey shall include the guide tube.

(c) A record of the survey required in paragraph (b) shall be maintained for two years when the survey is the last survey prior to locking the radiographic exposure device and ending direct surveillance of the operation.

§ 34.44 Supervision of radiographers' assistants.

Whenever a radiographer's assistant uses radiographic exposure devices, uses sealed sources or related source handling tools, or conducts radiation surveys required by § 34.43(b) to determine that the sealed source has returned to the shielded position after an exposure, he shall be under the personal supervision of a radiographer. The personal supervision shall include (a) the radiographer's personal presence at the site where the sealed sources are being used, (b) the ability of the radiographer to give immediate assistance if required, and (c) the radiographer's watching the assistant's performance of the operations referred to in this section.

EXEMPTIONS

§ 34.51 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

Appendix A

I. Fundamentals of Radiation Safety

A. Characteristics of gamma radiation.
B. Units of radiation dose (mrem) and quantity of radioactivity (curie).
C. Hazards of exposure to radiation.
D. Levels of radiation from licensed material.
E. Methods of controlling radiation dose:
1. Working time.
2. Working distances.
3. Shielding.

II. Radiation Detection Instrumentation To Be Used

A. Use of radiation survey instruments:
1. Operation.
2. Calibration.
3. Limitations.
B. Survey techniques.
C. Use of personnel monitoring equipment:
1. Film badges and thermoluminescent dosimeters (TLD's).
2. Pocket dosimeters.

III. Radiographic Equipment To Be Used

A. Remote handling equipment.
B. Radiographic exposure devices.
C. Storage containers.

IV. Inspection and Maintenance Performed by the Radiographers

V. Case Histories of Radiography Accidents

NOTE.—The reporting and record keeping requirements contained in this part have been approved by the General Accounting Office under B-180225 (R0052), (R0335).

CHAPTER THREE

BY-PRODUCT MATERIAL LICENSES

I. UNITED STATES NUCLEAR REGULATORY COMMISSION

NRC Form 374
(3-83)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE

Amendment No. 2

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 40 and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	
1. Ultra Technology, Inc. 2. Pouch #340122 Prudhoe Bay, Alaska 99734	In accordance with application dated January 3, 1985 3. License number 50-23363-01 is amended in its entirety to read as follows: 4. Expiration date May 31, 1989 5. Docket or Reference No. 030-20969

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
A. Iridium 192	A. Sealed sources (Technical Operations Model A-424-9)	A. Not to exceed 100 curies per source
B. Iridium 192	B. Sealed sources (Gulf Nuclear Model RT-15)	B Not to exceed 100 curies per source
C. Iridium 192	C. Sealed sources (Industrial Nuclear Model 4)	C. Not to exceed 100 curies per source
D. Iridium 192	D. Sealed sources (Technical Operations Model A-58101-8)	D. Not to exceed 100 curies per source
E. Iridium 192	E. Sealed sources (Gamma Industries Model GP)	E. Not to exceed 100 curies per source
F. Iridium 192	F. Sealed sources (Gamma Industries Model A-2A)	F. Not to exceed 100 curies per source
G. Iridium 192	G. Sealed sources (Gamma Industries Model T-3-T)	G. Not to exceed 100 curies per source
H. Iridium 192	H. Sealed sources (Gamma Industries Model GP)	H. Not to exceed 200 curies per source

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MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number
50-23363-01

Docket or Reference number
030-20969

Amendment No. 2

6. BYPRODUCT, SOURCE, AND/OR SPECIAL NUCLEAR MATERIAL	7. CHEMICAL AND/OR PHYSICAL FORM	8. MAXIMUM AMOUNT THAT LICENSEE MAY POSSESS AT ANY ONE TIME UNDER THIS LICENSE
I. Iridium 192	I. Sealed sources (Source Production Models G-1 or G-3)	I. Not to exceed 200 curies per source
J. Iridium 192	J. Sealed sources (Source Production Model G-36)	J. Not to exceed 150 curies per source
K. Cobalt 60	K. Sealed sources (Technical Operations Model A-424-14)	K. Not to exceed 100 curies per source
L. Cobalt 60	L. Sealed sources (Gamma Industries Model A-7-A)	L. Not to exceed 50 curies per source
M. Cobalt 60	M. Sealed sources (Gamma Industries Model A-5-A)	M. Not to exceed 100 curies per source

9. Authorized use

A. For use in Technical Operations Model 660 exposure devices for industrial radiography and in Technical Operations Model 650 source changers for storage and replacement of sources.

B. For use in Technical Operations Model 660 exposure devices for industrial radiography and Gulf Nuclear Model U-110B source changers for storage and replacement of sources.

C. For use in Technical Operations Model 660 exposure devices for industrial radiography and Industrial Nuclear Model 50 source changes for storage and replacement of sources.

D. For use in Technical Operations Model 616 exposure devices for industrial radiography.

E. For use in Gamma Industries Model Pipeliner exposure devices for industrial radiography.

F. For use in Gamma Industries Model Century SA exposure devices for industrial radiography and in Gamma Industries Model C-10 source changers for storage and replacement of sources.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number
50-23363-01

Docket or Reference number
030-20969

Amendment No. 2

(continued)

G. For use in Technical Operations Model 660 exposure devices for industrial radiograpy and in Gamma Industries Model C-10 source changers for storage and replacement of sources.

H. For use in Gamma Industries Model 201 exposure devices for industrial radiography.

I. For use in Source Protection and Equipment Model 2T exposure devices for industrial radiography and in Source Production and Equipment Model C-1 source changers for storage and replacement of sources.

J. For use in Source Production and Equipment Model Check Model II exposure devices for industrial radiography.

K. For use in Technical Operations Model 680 exposure devices for industrial radiography.

L. For use in Gamma Industries Model 750A exposure devices for industrial radiography.

M. For use in Gamma Industries Model 100A exposure devices for industrial radiography.

CONDITIONS

10. Licensed material may be used at temporary job sites near Prudhoe Bay, Alaska, which are based at the ARCO MCC contractors camp approximately 4 miles north of the Deadhorse Airport and at temporary job sites of the licensee anywhere in the United States where the U. S. Nuclear Regulatory Commission maintains jurisdiction for regulating the use of licensed material.

11. The licensee shall comply with the provisions of Title 10, Chapter 1, Code of Federal Regulations, Part 19, "Notices, Instructions and Reports to Workers; Inspections", Part 20, "Standards for Protection Against Radiation", and Part 34, "Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations".

12. Licensed material shall be used by, or under the supervision and in the physical presence of, D.S. Heiken, B.A. Servin, H. Kruschke, B. Vehrs, J. Hanson or individuals who have completed the training program described in application dated January 30, 1984 and letter dated April 23, 1984 and as amended in application with enclosures and letter dated June 7, 1984.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number
50-23363-01

Docket or Reference number
030-20969

Amendment No. 2

CONDITIONS

(continued)

13. The licensee is authorized to receive, possess, and use sealed sources of Iridium 192 or Cobalt 60 where the radioactivity exceeds the maximum amount of radioactivity specified in Item 8 of this license provided:

    A. Such possession does not exceed the quantity per source specified in Item 8 by more than 20% for Iridium 192 or 10% for Cobalt 60;

    B. Records of the licensee show that no more than the maximum amount of radioactivity per source specified in Item 8 of the license was ordered from the supplier or transferor of the byproduct material; and

    C. The levels of radiation for radiographic exposure devices and storage containers do not exceed those specified in Section 34.21, 10 CFR 34.

14. Pursuant to Title 10, Chapter 1, Code of Federal Regulations, Part 40, "Domestic Licensing of Source Material", the licensee is authorized to possess, use, transfer, and import up to 999 kilograms of uranium contained as shielding material in the radiography exposure devices and source changers authorized by this license.

15. The licensee may transport licensed material or deliver licensed material to a carrier for transport in accordance with the provisions of Title 10, Code of Federal Regulations, Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions".

16. Except as specifically provided otherwise by this license, the licensee shall possess and use licensed material described in Items 6, 7, and 8 of this license in accordance with statements, representations, and procedures contained in application dated January 30, 1984; letter dated April 23, 1984; application with enclosures and letter dated June 7, 1984; application with letter dated January 3, 1985, and letters dated January 19, 1985, February 5, 1985 and February 20, 1985. The Nuclear Regulatory Commission's regulations shall govern the licensee's statements in applications or letters, unless the statements are more restrictive than the regulations.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

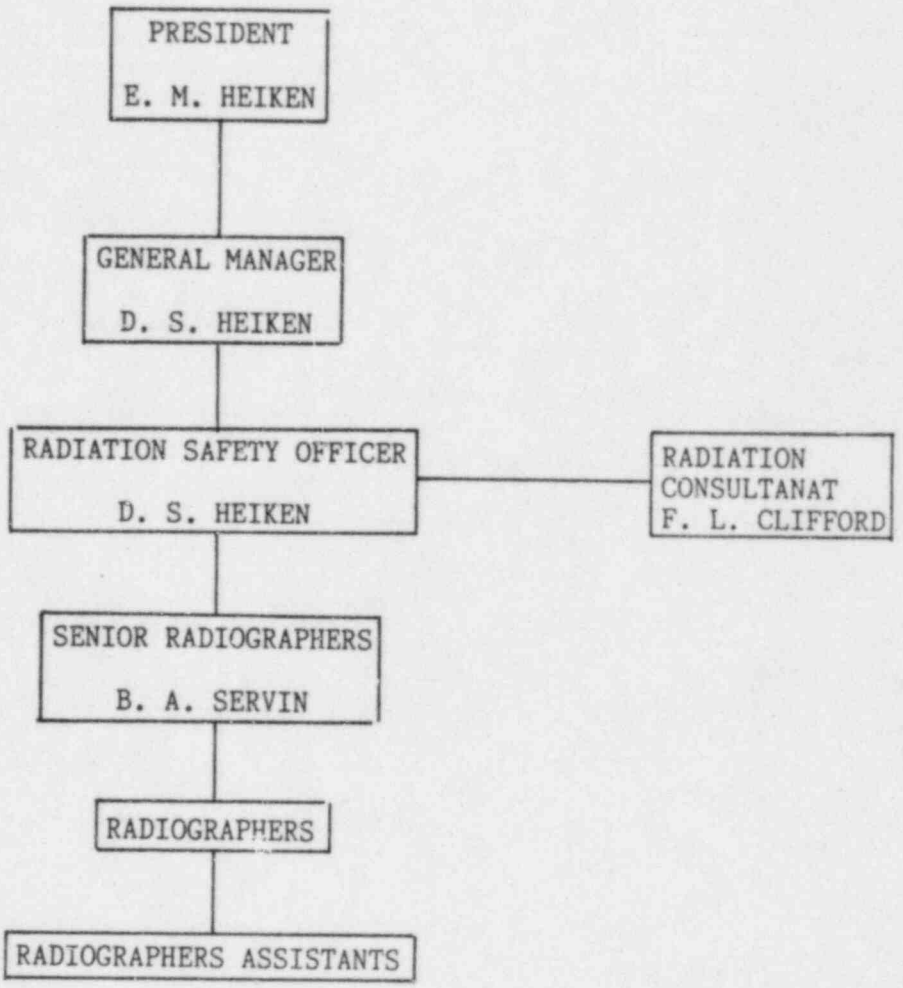
Date FEB 28 1985

By Beth A. Riedlinger
Beth A. Riedlinger
Health Physicist (Licensing)
Nuclear Materials Safety Section
Region V

CHAPTER FOUR

ORGANIZATIONAL STRUCTURE

ORGANIZATIONAL STRUCTURE



CHAPTER FIVE

RADIOGRAPHY OPERATING

AND

EMERGENCY PROCEDURES

RADIATION SAFETY PERSONNEL

1. Radiation Safety Officer

a) That individual who has been delegated the responsibility for the radiation safety program.

2. Senior Radiographer

a) An individual who because of background, experience and training is delegated the responsibility for administering the Radiation Safety Program at various sites where radiography is being conducted.

b) A Senior Radiographer is appointed by the Radiation Safety Officer and reports to him for all matters pertaining to radiation protection.

c) In addition to meeting the requirements of the Company By-product Material License for certification as a Radiographer, this individual must have at least on years experience as a Radiographer with this Company or another qualified Licensee.

3. Responsibility

a) Mr. Donald S. Heiken has been delegated the duties of Radiation Safety Officer.

b) The Radiation Safety Officer will provide for audits of field sites at approximately every 90 days to ensure compliance with regulations and these procedures. Audits will be on an announced and unannounced basis.

c) Any deficiencies noted during these audits will be recorded and reported to the President. Appropriate corrective actions will be taken by management. These actions may be disciplinary, retraining, or such other measures to correct the deficiency and prevent recurrence. Particular note will be made during future audits to assure that these corrective actions have been effective.

5.2 RADIOGRAPHY PERSONNEL

1. "Radiographers" shall have the authority to use and supervise the use of, while in constant attendance at the site, the sealed sources, devices and radiation producing machines for which the company is licensed.

2. "Radiographers Assistants" may, under the personal supervision of a "Radiographer" use the exposure devices, sealed sources, radiation producing machines, related handling tools, or survey instruments in radiography.

3. As personnel become qualified as "Radiographers" or "Qualified Operators", their names and records of qualification will be kept on file for inspection.

5.3 SEALED SOURCES AND DEVICES

1. The Company is licensed to use only the sealed sources and devices designated on its license.

2. Each device containing a sealed source is to be clearly labeled with the radiation caution symbol and the words "CAUTION" or "DANGER RADIOACTIVE MATERIAL". They will also be labeled stating the kind of radioactive material contained, together with the quantity thereof and the date of measurement of that quantity. "Radiographers" are responsible for assuring that equipment in their possession is properly labeled.

5.4 RADIATION SURVEY METERS

1. Calibrated and operable radiation survey meters will be maintained at each jobsite where radiography is being performed.

2. Radiation Survey Meters must have a range of at least 2 mr/hr to 1000 mr/hr.

3. Survey Meters must be calibrated at least once within a 90 day period. A tag attached to the instrument indicates the date calibrated. Meters that do not have this tag attached or that indicate they have not been calibrated within 90 days are not to be used.

5.5 PERSONNEL MONITORING DEVICES

1. Pocket Dosimeters

   a) Dosimeters will be issued to all radiographic personnel and worn at all times during radiographic operations and stored in locations designated by the Radiation Safety Officer.

   b) Dosimeters will be charged prior to the commencement of each work day.

   c)At the completion of each day's operations, dosimeter readings will be recorded on the Daily Dosimeter Record, a copy of which appears on page 5 - 22.

   c) Dosimeters are to be read frequently during radiographic operations. If a dosimeter is found to read "off scale", immediately stop work and notify the Radiation Safety Officer and other emergency personnel. The TLD will be forwarded for processing and the individual will not be allowed to return to work until the magnitude of the exposure is determined.

   d) Dosimeters shall be checked at periods not to exceed one year for correct response to radiation. A tag attached to the dosimeter indicates the date this accuracy check was accomplished. Dosimeters that do not have this tag attached, or that indicate they have not been checked within one year are not to be used.

2. Thermoluminescent Dosimeters

   a) A TLD will be issued to all Radiographic Personnel and worn at all times during radiographic operations, and stored in locations designated by the Radiation Safety Officer.

   b) Personnel will wear only their assigned TLD.

   c) TLD's will be changed on a monthly basis.

   Note 1. TLD's and dosimeters should be worn in approximately the same location, preferably in the shirt or side pants pocket.

5.6 RADIATION SURVEYS

1. All radiation surveys will be conducted in accordance with the procedures contained in this manual.

5.7 RECORDS

1. Utilization Log

   a) Each time a radiographic exposure device is used, the "Radiographer" will make the required entries in the Utilization Log, a copy of which is contained on page 5 - 19 of these procedures.

5.8 SECURITY OF SEALED SOURCES AND EXPOSURE DEVICES

1. All exposure devices and sources will be stored in designated locked facilities. The designated facilities will be steel lockable storage boxes bolted to the floor of a van or within a portable mounted darkroom. The vehicle storage areas will be radiation surveyed to assure that the radiation level 18 inches from any outer surface does not exceed 2.0 mr/hr. Additionally these areas will be posted on all four sides with signs bearing the words "CAUTION (OR DANGER) RADIOACTIVE MATERIAL".

2. Field Operations - See paragraphs 5.11.6.

5.9 RADIOGRAPHIC OPERATIONS

1. Removal of Source from Storage

   a) Each radiographic exposure device will be checked with a radiation survey meter before it is removed from storage. No device will be removed unless the radiation reading is less than 50 mr/hr at six inches from any outer surface.

   b) Each time a source is used, a Daily Inspection Check List will be completed. See pages 5 - 20 & 21.

2. Posting

   a) Calculating for source strength, distance and shielding, rope off and post as follows:

      1. At the perimeter of the "Restricted Area" (2.0 mr/hr), post with signs bearing the words "CAUTION (OR DANGER) RADIATION AREA".

2. At the perimeter of the "High Radiation Area" (100 mr/hr), post with signs bearing the words "CAUTION (OR DANGER) HIGH RADIATION AREA".

b) During exposure, survey the perimeter of the "Restricted Area" using survey meters to assure the calculations are correct. If necessary retract the source, make adjustments to the barriers and repeat the above procedures.

c) BOTH areas must be kept under surveillance by radiography personnel during operations.

d) Specific Instructions for Posting of Pipeline Operations

1) Operations in in Urban Areas (Residential of Business)

Discussion: When radiographic operations must be carried out in highly populated locations, such as the streets and lanes of business and residential neighborhoods, the provisions of 2. (a), (b) and (c) above, are not adequate in many circumstances. It must be remembered that the pipeline right of way is confined to the public street or alley and all pipeline operations including radiography must not trespass on the adjoining property at intensities or total doses greater than permitted by NRC regulations.

The following additional actions are required for radiography operations in Urban areas.

i. The property line edge of the sidewalks, if present or the private property edge of bar ditches on both sides of the street will be designated as the 2 mr/hr line and will be roped (barricaded) and posted. The fence line or apparent property line will be the 2 mr/hr line if operations are carried out in a back lane. The "Radiographer" will ensure that the radiation intensity does not exceed the 2 mr/hr limit by employing the methods described in ii., iii.and iv. below. Access along the street/alley and sidewalk will be restricted by barricades and posted at the calculated distance in 2.a.1 and 2 above.

ii) The lowest practical source strength will be used. i.e. a 20 curie source will be used in preference to a 100 curie source if the longer exposure time of the lower activity source can be tolerated.

iii Collimators which restrict the radiation beam to its minimum useful area will be used. Typically the beam will be confined to the film width along the axis of the pipe and to the interpretable length specified by code in the second dimension.

iv. A 'beam stopper' of area sufficient to contain the emerging beam of radiation described in (iii) above will be placed against the pipe to absorb the total area of emerging radiation. The 'beam stopper' will be composed of sufficient layers of sheet lead to reduce the radiation level at the posted barrier to 2 mr/hr.

v. Although NRC regulations provide for circumstances when the 2 mr/hr barrier reading restriction cannot be complied with and permits a total dose of 2 millirem in any one hour and 100 millirem in any 7 consecutive days, this procedure will not be employed without the specific approval of the Company Safety Officer. Such approval will not be given until the RSO has determined that other methods cannot be used and that the dose specified above will not be exceeded. Written records supporting this dose will be kept on file.

2) Operations in Rural Areas on "Big Inch" Pipelines

Discussion: "Radiographers" and "Radiographers Assistants" must prevent violation of the posted areas described in 2.a.1 & 2 by construction Personnel who may enter the area from within the pipe, or in the case of very large diameter pipelines, may be working on the 'ditch side', of the pipe or in the ditch and are not easily seen from the 'right of way' side of the pipe.

Radiographic personnel will control these areas on all pipelines larger than 16 inches in diameter by:

i. Upon commencement of the work, the Radiation Safety Officer will request a meeting with the 'Chief Inspector', 'Welding Inspector', 'Tie-In or Repair Welding Inspector', 'Spread Boss', 'Welding Foreman', and Tie-In and/or Welding Repair Crew Foreman where an agreement will be reached between the RSO and the aforementioned establishing a written procedure releasing the repaired weldment or weldments to the Radiographic Crew for radiographic inspection. This 'release document' will be signed by the designated 'Contractors Representative, responsible inspector representing the owner and the 'Radiographer'on behalf of the Company. A copy of the 'release document' will accompany the routine inspection reports in a timely manner and will be kept on file with the weld report.

ii. Before commencing radiographic operations, the Radiographer will personally determine that no welder, coating repairman or inspector is working within the pipe. The absence of any vehicle parked near either open end and a release signed as in (i.) above will be accepted as evidence that personnel are not within the pipe.

2. Posting (Cont'd)

d) Specific Instructions for Posting Pipeline Operations (Cont'd)

2) Operations in Rural Areas on "Big Inch Pipelines" (Cont'd)

iii. When open ends are not visible to the "Radiographer" from the radiographic location, i.e. around side bends, sags or overbends; the "Radiographer" will secure a Radiation Warning Sign within the open end of the pipe when the radiography location is within 500 feet of the open end.

iv When the source is in the exposed position, the radiography crew will maintain visual observation of the 'right of way' and 'ditch side" of the pipeline within the areas posted in accordance with 2.a.1 & 2 above. The radiographer will also ensure that no personnel are working in the ditch within the posted area while the source is in the expose position.

v When either pipe end is not visible from the radiography location, the "Radiographer" and "Radiographers Assistant" will maintain a listening watch for sounds characteristic of personnel moving within the pipe. The source will be withdrawn and locked until the source of the unusual sounds emanating from the pipe can be identified.

5.9 RADIOGRAPHIC OPERATIONS Cont'd

3. SPECIFIC INSTRUCTIONS FOR MAKING AN EXPOSURE UTILIZING CRANK OUT TYPE EXPOSURE DEVICES.

a) Locate the exposure device at the desired distance from the specimen to be radiographed.

b) Remove the shipping plug from the device.

c) Attach the source tube sections to the front fitting.

d) Under no circumstances may the total length of the source tube sections exceed 21 feet.

e) It is now necessary to connect the control assembly to the exposure device. This is accomplished as follows.

1. Place the control cable plug near the rear of the exposure device.

2. Remove the rear storage cover.

3. Crank out one or two inches of drive cable by rotating the operating crank in the "expose" direction.

4. Connect the male and female connectors. DOUBLE CHECK TO ASSURE A GOOD CONNECTION.

5. Insert the control cable plug into the control cable connector on the exposure device.

f) Unreel the control cable and extend it to its the maximum possible distance from the exposure device.

g) Unlock the exposure device.

h) Turn the hand crank on the control unit steadily in the "expose" direction until the source is fully extended - THE SOURCE IS NOW EXPOSED.

i) Maintain continuous surveillance of the posted area to guard against unauthorized entry.

j) At the completion of the exposure, turn the hand crank in the "retract" direction until the source is completely shielded within the exposure device.

5.9 RADIOGRAPHIC OPERATIONS Cont'd

3. SPECIFIC INSTRUCTIONS FOR MAKING AN EXPOSURE USING CRANK OUT TYPE EXPOSURE DEVICES. (Cont'd)

k) Approach the device with the survey meter switch in the "ON" position and using the most sensitive meter scale check each surface and the guide tube to determine that the source has returned to the shielded position.

l) Lock the exposure device.

m) If additional exposures are to be conducted, steps (g) through (l) must be repeated.

4. SPECIFIC INSTRUCTIONS FOR SECURING EXPOSURE DEVICES WHEN OPERATIONS ARE COMPLETED.

a) Detach the source tube from the front of the exposure device.

b) Insert the shipping plug.

c) It is now necessary to disconnect the control assembly from the exposure device. This is accomplished as follows:

1. Release the control cable plug.

2. Disconnect the male and female connectors between the drive cable and the exposure device.

3. Insert the storage cover and assure that the exposure device is securely locked.

d) Reel up the control cable.

e) Return the exposure device to storage.

f) Conduct a radiation survey of the exposure device to double check for proper shielding of the source. Enter the results in the Utilization Log.

5.9 RADIOGRAPHIC OPERATIONS Cont'd

5. SPECIFIC INSTRUCTIONS FOR MAKING AN EXPOSURE USING GAMMA INDUSTRIES PIPELINER EXPOSURE DEVICES

a) Locate the exposure device at the desired position on the specimen to radiographed.

b) Remove the dust cap and attach the 5 foot remote cable to the rotor shaft attachment.

c) Extend the remote control in a direction away from the primary radiation beam.

d) Unlock the device.

e) Turn the remote control operating knob in the "expose" direction.

f) Maintain continuous surveillance of the posted areas to guard against unauthorized entry.

g) At the completion of the exposure turn the remote control operating knob in the "retract" direction until the source is completely shielded.

h) Approach the device with the survey meter switch in the "ON" position and using the most sensitive scale check each surface of the device to determine that the source has returned to the shielded position.

i) Lock the device.

j) If additional exposures are required, steps (c) through (i) must be repeated.

6. SPECIFIC INSTRUCTIONS FOR SECURING THE GAMMA INDUSTRIES PIPELINER EXPOSURE DEVICE.

a) Detach the remote control cable from the rotor shaft attachment and replace the dust cap on the device.

b) Return the device to storage.

c) Conduct a radiation survey of the device to double check for proper shielding of the source. Enter the results in the Utilization Log.

5.9 RADIOGRAPHIC OPERATIONS Cont'd

7. SPECIFIC INSTRUCTIONS FOR MAKING AN EXPOSURE USING THE SPEC-CHECK MODEL II EXPOSURE DEVICE.

a) Locate the exposure device at the desired position on the specimen to be radiographed. Securely attach the device.

b) Unlock the device.

c) Expose the source by rotating either of the knurled knobs 180 degrees. The operator should keep his body as far away from the source as possible. Turn the knob nearest to the operator to eliminate reaching across the device. It is important to reach as far as possible when turning on the device to maintain the maximum distance from the source.

d) A high reading on the survey meter will indicate that the source is in the expose position. Move as quickly and as far away from the device as practical.

e) Maintain continuous surveillance of the posted area to guard against unauthorized entry.

f) After the desired exposure time has elapsed, turn the control knob 180 degrees to return the source to the shielded or safe position. Reach as far as possible to maintain maximum distance from the source and perform the operation as quickly as possible.

g) Approach the exposure device with the survey meter switch in the "ON" position and using the most sensitive meter scale, check each surface of the device to determine that the source has returned to the shielded position.

h) Lock the device by depressing the plunger.

i) If additional exposures are required, repeat steps b through h

8. SPECIFIC INSTRUCTIONS FOR SECURING SPEC CHECK MODEL II EXPOSURE DEVICE.

a) Remove the device from the exposure location.

b) Return the device to storage.

c) Conduct a radiation survey of the device to double check for proper shielding of the source. Enter the results in the Utilization Log.

5.9 RADIOGRAPHIC OPERATIONS

13. Review of Important Points:

a) It the source should, for any reason, fail to return to its shielded position in the exposure device, or an emergency arises immediately follow the emergency procedures outlined in this manual.

b) Survey the area during exposures using the survey meter to confirm that restricted area limits are as specified in these procedures. Do not allow anyone in this area.

c) If, while carrying out radiographic operations on a third parties' premises, i.e. the customers premises, unauthorized personnel violate your boundaries, withdraw the source to the shielded position and report the problem to the Radiation Safety Officer immediately who will deal with the matter with the third parties management.

d) Before commencing a radiography operation on a third parties' premises, notify the Plant Superintendent or other representative that the operation will take place. This is a necessary safety practice as well as common courtesy.

e) Do not move any exposure device without safety plugs in their proper position and the device locked.

f) After every exposure, survey the device to insure that the source is back in its safe position.

g) When returning a device to storage, survey the device to determine that the source is still properly shielded and record the results of this survey in the Utilization Log.

h) A survey of the device is required when it is removed from storage and the results are to be recorded in the Utilization Log. All equipment checks called out in these procedures are to be accomplished before leaving the Companies premises and not on the job site.

i) COLLIMATORS ARE TO BE USED AT ALL TIMES to provide maximum radiation protection for radiographic personnel and to reduce exposure to the public. Permission to use 'open sources' will be given by the Radiation Protection Officer, when in his judgement no other practical exposure technique is reasonable.

5.10 EMERGENCY PROCEDURES FOR RADIOGRAPHERS

1. In the event of an emergency such as:

   a) Dropped, lost or damaged source.

   b) Source hung or detached.

   c) Any occasion that could cause exposure to any personnel.

   d) Vehicular accident where it cannot be determined that the source is safely stored.

   e) Fire, flood, hurricane or some other emergency.

2. Reel in and secure the source if possible. if not possible, then proceed as follows.

3. Evaluate the area and set up a restricted area.

4. Act as a communications agent in guarding access to the area.

5. Help notify emergency personnel.

   a) Radiation Safety Officer or designate listed on page 5 - 19.

   b) If for some reason none of the above are available, another individual listed on page 5 - 19 will be notified.

   c) If necessary and by direction of the Radiation Safety Officer or higher authority, the equipment manufacturer will be called for assistance.

6. The Radiation Safety Officer will be notified immediately of any personnel receiving possible high exposure. The Radiographer will note all pertinent data such as the name, distance the individual was from the source, total time exposed, etc.. The Radiation Safety Officer only will make the required reports.

7. Dropped or Lost Sources

   If the source is dropped or otherwise lost from the device, great care should be taken to prevent stepping on it. If the source is not visible, it should be located with a radiation detection instrument and a restricted area set up immediately. Emergency personnel should be notified immediately (listed on page 5 - 17). Recovery will not be attempted by personnel unless they have received previous specific instruction in recovery procedures. In any event, the proposed recovery procedure will be approved by the Radiation Safety Officer before any recovery action is taken.

8. Broken, Crushed or Leaking Source Capsule

If the source appears to be broken, crushed or leaking, the area must immediately be evacuated and set up as a restricted area. A leaking source capsule may be detected by an unusually high radiation level near the device, also, a reading (where there should not be any reading) may be discovered while walking along the Control Cable/Pump Hose or Source Tube/Source Hose. This is positive evidence that solid radioactive material has escaped from the source capsule. All personnel that could possibly have stepped in the contaminated material or have handled control cables, source tubes/hoses must be detained just outside the restricted area until checked for contamination. EMERGENCY PERSONNEL SHALL BE NOTIFIED IMMEDIATELY. A list of Emergency Personnel and their telephone numbers is given on page 5 - 17.

5.11 MOVEMENT OF EXPOSURE DEVICES

1. Devices will be checked, using a survey meter, by a Radiographer prior to removal from any storage area.

2. A Radiographer or a Radiographers Assistant will be in constant attendance during the movement of these devices. Personnel involved will wear TLD's and pocket dosimeters.

3. No device will be moved unless it is locked and all safety plugs are inserted.

4. Portable exposure devices are not to be hand-carried long distances since relatively high radiation levels often exist at the surfaces of these devices. Any transporting vehicle (except a Commercial Carrier) must be personally accompanied by a Radiographer or a Radiographers Assistant.

5. When devices are transported at field locations, a Radiographer or Radiographers Assistant will be in attendance. The device will be securely positioned in a lockable steel 'source box' which is bolted to the vehicle. A radiation survey will be conducted to assure that radiation levels do not exceed 2 mr/hr 18" from any outer surface of the device or in the drivers compartment. Vehicles will be placarded as directed by the Radiation Safety Officer in accordance with Attachment I. The results of this survey will be recorded in the 'Stored Location' column of the Source Utilization Log (Page 5 - 19).

6. When not in use at a field site, the exposure device will be locked in the 'source box' within the transporting vehicle. The keys to the vehicle will be in the possession of the Radiographer at all times a source is contained therein. The vehicle will be posted on all four sides with signs bearing the words "DANGER (OR CAUTION) RADIOACTIVE MATERIALS". These signs will be displayed only when Radioactive Materials are being transported or stored in the vehicle at a field site. A radiation survey will be conducted to assure that radiation levels do not exceed 2 mr/hr at 18" from any outer surface of the vehicle. The results of this survey will be entered in the "stored location" column of the Source Utilization Log (Page 5 - 19).

7. All other radioactive shipments i.e. shipments by commercial carriers will be made in accordance with current DOT regulations.

8. Only Company employees who are Radiographers or Radiographers Assistants may ride in a Company vehicle when the vehicle is transporting a radioactive source. All Company employees will wear TLDs and dosimeters; a functioning survey meter, signs ropes, recovery tongs, cutting tool capable of cutting a control cable, and an emergency source container will be carried in the vehicle to deal with any anticipated emergency.

   Specifically, wives, girl friends or other non-atomic radiation workers are not permitted to ride in a Company vehicle when transporting a radioactive source.

9. The Radiographer must select the most appropriate parking location when a vehicle carrying a radioactive source is parked overnight in an area accessible to the Public such as a hotel/motel parking lot. The Radiographer should arrange with the hotel/motel management for RESERVED PARKING for the vehicle removed as far as possible from the sleeping, public and office areas. The vehicle should be parked on the hotel/motel property and not on a public street or alley.

   Company vehicles carrying radioactive sources MUST NOT park on public streets or alleys in residential neighbourhoods. Off-street parking in residential neighbourhoods is only permitted where access can be controlled i.e. locked behind fences well away from residences.

EMERGENCY TELEPHONE NUMBERS

	Name	Phone Number	
1.	RADIATION SAFETY OFFICER		
	D. Heiken	Office:	403 289 4507
		Home:	403 289 4507
2.	SENIOR RADIOGRAPHER (Alaska)	Office:	907 659 5569
	Bruce Servin	MCC Room	907 659 8233
3.	RADIATION CONSULTANTS		
	Frank L. Clifford	Office	203 442 2909 (24 hours)
4.	Technical Operations	Office:	617 272 2000
5.	Gamma Industries	Office:	504 383 7791
7.	Source Production & Equipment (SPEC)	Office:	504 464 9471

70184

INDUSTRIAL RADIOGRAPHY

DAILY DOSIMETER READINGS

Date: _____

From _____ To _____

Name	Social Security No.	Sun	Mon	Tues	Wed	Thurs	Fri	Sat	Total

Date: _____

From _____ To _____

Name	Social Security No.	Sun	Mon	Tues	Wed	Thurs	Fri	Sat	Total

INDUSTRIAL RADIOGRAPHY

UTILIZATION LOG — SOURCE NO. ______

Date	Isotope	Curies	Model and Serial No. of Device	Time Out	Time In	Location Used	Max. Radiation Level at the Perimeter of Restricted Area	Radiation Survey of Device After Securing (MR/HR)			Stored Location	Responsible Radiographer
								Contact	6 In.	3 Ft.		

RADIOGRAPHY EQUIPMENT DAILY INSPECTION

CRANK OUT TYPE DEVICES

LOCATION: _____ SOURCE # _____ SIGNATURE: _____

DEVICE MFGR: _____ SERIAL # _____ DATE: _____

		SAT	UNSAT
1.	Prior to Use		
	a) Examine operating control for damage.	_____	_____
	b) Turn crank to and fro to assure freedom of movement.	_____	_____
	c) Examine control; cables along their entire length for possible kinks	_____	_____
	d) Assure that all connections are tightened.	_____	_____
	e) Check connector on the drive cable for breaks and bends.	_____	_____
	f) When connecting, pull back on the drive cable to assure some measure of strength.	_____	_____
	g) Assure that the outer drive cable is connected securely to the exposure devices.	_____	_____
	h) Examine the source tube for possible kinks and that connectors of the source tip to tube and tube to device are secure.	_____	_____
	i) Check freedom of movement of the lock on the exposure device.	_____	_____
	j) Overall condition of the equipment.	_____	_____
2.	During Use		
	a) Observe operation of the device.	_____	_____
	b) Perform the required surveys	_____	_____
3.	Any "UNSAT" findings will be reported to the Radiation Safety Officer and the equipment not used until authorized.		

RADIOGRAPHY EQUIPMENT DAILY INSPECTION

SPEC-CHECK MOD II & PIPELINER DEVICES

LOCATION: _____ SOURCE # _____ SIGNATURE: _____

DEVICE MFGR: _____ SERIAL # _____ DATE: _____

		SAT	UNSAT
1.	Prior to Use		
	a) Examine operating controls for damage.	_____	_____
	b) Check freedom of movement of lock.	_____	_____
	c) Assure all connections are tight.	_____	_____
	d) Overall condition of the equipment.	_____	_____
2.	During Use		
	a) Observe operation of the device.	_____	_____
	b) Perform the required surveys	_____	_____

3. Any "UNSAT" findings will be reported to the Radiation Safety Officer and the equipment not used until authorized.

ATTACHMENT A

Description of Radiographic Facilities

A. 1. There are presently no permanent facilities for conducting Isotope Radiography. All operations are conducted at temporary field sites.

2. By-product material will be stored both in-plant and at various field sites in accordance with Procedure 5.8 and 5.11.

ATTACHMENT B

RADIATION DETECTION INSTRUMENTATION

B. 1. RADIATION DETECTION INSTRUMENTS

A. The following radiation survey instruments are utilized by the Company:

MANUFACTURER	MODEL	RADIATION DETECTED	RANGE
Eberline	E-120-G	X or gamma	0 - 1000 mr/hr
Eberline	E-130-G	X or gamma	0 - 1000 mr/hr
Industrial Nuclear	Model 1	X or gamma	0 - 1000 mr/hr
Victoreen	492	X or gamma	0 - 1000 mr/hr
Gamma Industries	250 - B	X or gamma	0 - 1000 mr/hr
Jordan	Radector 3	x or gamma	0 - 100 mr/hr

B. Normally there will be available at least two survey instruments of the types listed above for each exposure device being used.

C. Instrumentation is calibrated at 90 day intervals and after each servicing. These calibrations will be accomplished at one of the following facilities.

CALIBRATION FACILITIES

F.L. Clifford Associates
321 Main Street
Niantic, CT. 06357

Technical Operations
South Street
Burlington, MA. 01803

Industrial Nuclear
1124 Chess Drive
Foster City CA. 94404

Gulf Nuclear
P.O. Box 58866
Houston, TX. 77058

State of Alaska
Dept. of Military Affairs
Div. of Emergency Services
P.O. Box 2267
Palmer AK 99645
(NRC Lic. No.: 50-09056-01)

ATTACHMENT C

PERSONNEL MONITORING

C. 1. PERSONNEL MONITORING DEVICES

A. Dosimeters

1. The following dosimeters are utilized by the Company.

MANUFACTURER	MODEL	RANGE
Victoreen	541	0 - 200 mR
Dosimeter Corp.	862	0 - 200 mR
Landsverk	L-50	0 - 200 mR

2. At least one (1) dosimeter will be available to all radiographic personnel.

3. All dosimeter readings will be recorded on a daily basis.

4. Dosimeters shall be checked at periods not to exceed one year for correct response to radiation. These checks will be conducted at a commercial calibration facility listed in Attachment B.

B. TLD's

1. TLD service will be provided by R. S. Landuaer.

2. Exposure records will be maintained as required by 10 CFR and Agreement State Regulations.

3. A TLD will be available for all radiographic personnel.

4. TLD's will be changed on a monthly basis.

ATTACHMENT D

SOURCE LEAK TESTING

D. 1. SOURCE LEAK TESTING

A. All sealed sources must be leak tested at intervals not to exceed six months. The leak test will be capable of detecting the presence of 0.005 microcuries of removable contamination.

B. It is the responsibility of the Radiation Safety Officer to assure that Leak Tests are done at the required intervals and under his direct supervision.

C. Procedure Utilizing Tech. Ops Mod. 518, Gamma Ind. "Kowipe" or "Drug Store applicator swabs" for Leak Testing Crank Out Type devices.

1. With the exposure device in the "lock" position, remove the front plug.

2. Dampen the swab provided in detergent solution and shake to remove excess solution.

3. Insert the applicator with the swab inside the exposure device front access hole. Rotate "in and out" several times to obtain a representative sample of any radioactive material that might be deposited inside the exposure device.

4. Carefully place the applicator inside the plastic envelope provided. Seal with tape.

5. Thoroughly wash your hands immediately.

6. Place the survey meter on the lowest scale and slowly pass the envelope across the instrument at closest proximity to the detector tube.

7. IF ANY RADIATION LEVEL ABOVE NORMAL BACKGROUND IS NOTED, IMMEDIATELY REMOVE THE SWAB AND THE ASSOCIATED EXPOSURE DEVICE TO THE STORAGE AREA. NOTIFY THE RADIATION SAFETY OFFICER IMMEDIATELY AND DO NOT USE THE EQUIPMENT UNTIL ADVISED.

8. If the survey of the envelope is negative, forward for assay and subsequent report.

D. SOURCE LEAK TESTING Cont'd

D. Procedure Utilizing Tech Ops Mod. 518 or Gamma Ind. "Kowipe" Leak Test of "Pipeliner" or Spec-Check 2-T Exposure Devices.

1. Maintain the exposure device in the "lock" position.

2. Dampen each swab used with the provided detergent solution and shake to remove excess solution.

3. Wipe the following areas:

   a) Rotor shaft attachment.
   b) The joint where the face plate attaches to the bottom of the device.

4. Carefully place the applicator and swab inside the plastic envelope provided. Seal with tape.

5. Thoroughly wash your hands immediately.

6. Place the survey meter on the lowest scale and pass the envelope across the instrument at the closest proximity to the detector tube.

7. IF ANY RADIATION LEVEL ABOVE NORMAL BACKGROUND IS NOTED, IMMEDIATELY REMOVE THE SWAB AND THE ASSOCIATED EXPOSURE DEVICE TO THE STORAGE AREA. NOTIFY THE RADIATION SAFETY OFFICER IMMEDIATELY AND DO NOT USE THE EQUIPMENT UNTIL ADVISED.

8. If the survey of the envelope is negative, forward for assay and subsequent report.

E. Leak tests which reveal the presence of 0.005 microcuries or more of removable contamination will be considered evidence of a possible leaking source and appropriate reports will be submitted by the Radiation Safety Officer and the equipment decontaminated by the vendor.

ATTACHMENT E

TRAINING PROGRAM

70184

TRAINING OUTLINE OF THE

ULTRA TECHNOLOGY INC.

TRAINING PROGRAM (40 hours)

	CHAPTER	Instruction Time
1.	Basic Mathematics	2 hours
2.	Atomic Structure	2 hours
3.	Radioactivity	2 hours
4.	Characteristics of Radiation	2 hours
5.	Unit of Radiation	1 hour
6.	Absorption of Ionizing Radiation	2 hours
7.	Shielding Methods for Gamma Radiation	2 hours
8.	Effects on the Human Body	2 hours
9.	Radiation Safety Standards	2 hours
10.	Survey Instruments	2 hours
11.	Radiation Survey Requirements	2 hours
12.	Personnel Monitoring Instruments	2 hours
13.	Radiographic Exposure Devices	2 hours
14.	Emergency and Remote Handling Equipment Storage Containers	2 hours
15.	Previous Radiation Accidents	2 hours
16.	Emergency Procedures - point by point instruction in the Company Safety Manual and use of Company equipment	9 hours
17.	Records and Reports	2 hours

TRAINING OUTLINE - OPERATING & EMERGENCY
PROCEDURE AND USE OF COMPANY EQUIPMENT

A.	Operating and Emergency Procedures: Sections One through Six	4 hours
B.	Radiation Detection Equipment	1 hour
C.	Exposure Devices	1 hour
D.	Shipping Containers	1 hour
E.	Personnel Monitoring Equipment	1 hour

A. Initial Training

a) Initial Training will be conducted by the Radiation Protection Officer in accordance with the Ultra Technology Inc. training program.

b) Following the above training, personnel will be given an additional 8 hours training in all aspects of the Company Operating and Emergency Procedure and utilizing the Company equipment. This training will be give by the Radiation Safety Officer or a qualified instructor appointed by the Radiation Safety Officer. Personnel will be required to demonstrate a thorough understanding of the Operating and Emergency Procedures and also demonstrate competency in the use of Company equipment. This will be determined by the administration of tests similar to the two final examinations contained on pages E-8 through E- 17 of this procedure. Additionally an "on the job" evaluation will be conducted of the items contained on page E - 7 of this procedure. Personnel successfully completing this phase of training will be designated "Radiographers Assistants" by the Radiation Protection Officer. The Training Outline for this phase of the training is contained on page E - 3.

c) Training courses, equivalent in content to the Ultra Technolgy Inc. Training Program, (formally recognized in a list of approved training programs published by the Nuclear Regulatory Commission or otherwise approved by the Commission), either totally or in part, may be substituted for the Ultra Technology Inc. Training Program.

1. Initial training may be conducted by F. L. Clifford in accordance with the F. L. Clifford training program on file with N.R.C.

2. Initial training may be conducted by instructors of the Hutchinson Area Vocational Institute (Hutchinson, Minn.) in accordance with the Hutchinson Area Vocational Institutes Radiation Safety Training Program on file with N.R.C.

3. Personnel who are graduates of the Anchorage Community College's Weld-263 course will be given credit for Chapters 2 through 7 of the Ultra Technology Inc. Training Program. The Radiation Safety Officer will ensure, either by personal instruction or through delegation to a qualified instructor, that graduates of the Anchorage Community College receive instruction to ensure understanding of the additional Chapters of the Ultra Technology Inc. Training Progam. Personnel who are graduates of Weld-236 will be evaluated as per b) above but will not require additional training as required by b) since this additional training is given in the Ultra Technology Program.

d) In the case of previously qualified personnel who have been trained in accordance with 10 CFR, 34, have at least 6 months experience and qualified as a "Radiographer" by another licensee, the initial training requirements of a) may be waived.

The individual will be trained in accordance with b) above and will be required to attain a passing grade on all examinations. Personnel who do not attain passing grades will be required to attend the entire initial training program.

B. On-The-Job Training

a) Personnel designated as "Radiographers Assistants" will be required to have on-the-job training under the direct supervision of a "Radiographer" who has agreed in writing to act as the "Trainee Supervisor" for a named "Raiographers Assistant".

1. New Trainees: At least three months training during which time at least 80 radiographic exposures will be conducted by the trainee.

2. Previously Qualified Personnel: At least 16 hours training during which time at least 16 radiographic exposures will be conducted.

b) At the completion of on-the-job training, each individual will be evaluated by the Trainee Supervisor and the Radiation Safety Officer. This evaluation will be conducted by observing the trainee's operation for at least 8 hours. During this phase, the trainee will be orally examined in questions similar to those on pages E - 5 through E - 8. Additionally, the trainee will be "on-the-job" evaluated in the items contained on Page E - 4 of this procedure.

Persons who, in the opinion of the Radiation Safety Officer, are thoroughly knowledgeable of the equipment operation, radiation safety, and Operating and Emergency Procedures will be designated as "Radiographers" by the Radiation Safety Officer.

C. Retraining

a) Periodic retraining will be conducted at least every 12 months or whenever changes in the radiography program are made.

b) Retraining will provide instructions in such subjects as amend ments to regulations, changes in equipment, operating procedure revisions and review of subjects contained in the basic training program. Retraining will be conducted by the Radiation Safety Officer or his designate.

D. Records

a) Records of all training will be maintained on file for inspection.

E. General

a) A passing grade of 75 is required on written and oral examinations.

b) All examinations are reviewed with the trainee with particular emphasis on questions missed.

c) Trainees failing to achieve a grade of 75 on any examination will be given another examination within 15 days. Personnel receiving a passing grade will be allowed to continue in the program but personnel receiving a failing grade will be dropped from the program.

d) The tests attached to this procedure are samples of those that will be administered during this training program. Tests will be changed at least every six months so as not to reduce the effectiveness of the test procedure.

NAME _____

		SAT.	UNSAT.
1.	Restricted Area Set Up	_____	_____
2.	Attitude	_____	_____
3.	Survey Meter Usage	_____	_____
4.	Radiation Surveying	_____	_____
5.	Film or TLD Badge Usage	_____	_____
6.	Dosimeter Usage	_____	_____
7.	Familiarization with Emergency procedures	_____	_____
8.	Daily Maintenance Check Procedure	_____	_____
9.	Familiarization and Use of Company Forms	_____	_____
10.	Equipment Operation	_____	_____
11.	Transporting Sources	_____	_____

CERTIFICATION:

A. The above named individual has successfully completed _____ hours of training in the Ultra Technology Inc. Training Program on _____. Additionally, he/she has been evaluated in Items 1 through 11 on _____ _____ and is/is not certified as a "Radiographers Assistant".

Date:_____ _____
Trainee Supervisor

Date:_____ _____
Radiation Safety Officer

B. The above named individual has successfully completed ____ hours of training in the Ultra Technology Inc. Training Program on _____ and _____ months on-the-job training on _____. Additionally, he/she has been evaluated in Items 1 through 11 on _____ and is/is not certified as a Radiographer.

Date:_____ _____
Trainee Supervisor

Date:_____ _____
Radiation Safety Officer

INDUSTRIAL RADIOGRAPHY ORAL EXAMINATION

EXAMINERS KEY

1. Define a curie.

   Answer: A quanity of radioactive material.

2. Explain the difference between 'dose' and 'dose rate'.

   Answer: Dose - total exposure
   Dose rate - exposure per increment of time

3. What is meant by 'chronic exposure'?

   Answer: Exposure over an extended period of time.

4. Whom would you notify in the event the source is lost?

   Answer: Radiation Safety Officer.

5. Must everyone wear dosimeters and TLDs'in a restricted area?

   Answer: Yes.

6. What is the calibration frequency for survey instruments?

   Answer: At least every 90 days and after each servicing.

7. How often is a leak test required?

   Answer: Before the source is put into service and every six months thereafter.

8. When must dosimeter readings be recorded?

   Answer: Daily.

9. Describe in detail the procedure for bringing the survey meter into use and checking the survey meter for proper operation.

   Answer: Assure calibration within 90 days.
   Check battery.
   Determine that the meter is capable of measuring radiation by measuring the surface reading of the exposure device when the source is in the locked position.

10. Describe the correct way to make a survey after an exposure.

    Answer:
    1. Approach the device from the rear.
    2. Check side for normal readings.
    3. Check front for normal readings.
    4. Scan source tube.
    5. Lock device.

11. Describe in detail what areas are posted during radiographic exposure.

    Answer:
    1. High radiation area with "H.R.A." signs.
    2. Restricted area with "Radiation Area" signs.

12. What do you record on the Utilization Log?

    Answer:
    1. Source S/N
    2. Date
    3. Location used
    4. Time out
    5. Time in
    6. Radiation level at perimeter of restricted area
    7. Survey of device prior to storage
    8. Storage location
    9. Responsible Radiographer

13. What level of radiation is allowable at the perimeter of the restricted area?

    Answer: Less than 2 MR/HR

14. You have a 50 curie source of Cobalt 60. What distance is required for Question 13? Assuming no shielding, show your calculations.

    Answer: 602 feet

15. What is the difference between gamma and x-rays?

    Answer: Method of production or origin.

16. What kilovoltage is the radiation of IR-192?

    Answer: Similar to 400 KV.

17. Give the explanation for rem and rad. Can these values be considered equivalent to roentgen for gamma radiation?

Answer: Rem = Roentgen Equiv. Man
Rad = Rad. absorbed dose
Roentgen can be directly converted to rem because quality Factor is 1
For other types of radiation Quality Factor must be considered (i.e. Alpha = 20 R.B.E. etc.)

18 What is the reduction factor of radiation absorbed if the distance from the source is doubled?

Answer: 1/4

19. What is the increase in radiation level using Co 60 from 10' to 5'?

Answer: x4

20. Define the term "half-life". What are the half-lives of Co 60 and Ir-192?

Answer: Time for 1/2 atoms in radioactive material to go through the disintegration process.

Co 60 = 5.2 years
Ir 192 = 74 days

NAME:_____(Print) DATE:_____

SOCIAL SECURITY NUMBER:_____

TYPICAL
INDUSTRIAL RADIOGRAPHY
FINAL EXAM

POINTS

(1) 1. Gamma and x-rays damage tissue by a process called?

Answer: Ionization

(2) 2. What are three ways to reduce personnel exposure?

Answer: a. time
b. distance
c. shielding

(1) 3. Is the Biological Effect on the body the same for one Roentgen of X-radiation as it is for one Roentgen of Gamma Radiation?

Answer: (Yes) No

(2) 4. What is the acute dose normally expected to show blood changes?

Answer: 25 REM to 50 REM

(1) 5. Define the following:
a) Nuclear Radiation
b) Radioactive Contamination

Answer: a) Radiation emitted from nucleus
b) Uncontrolled radioactive material

(1) 6. How many Rem in 750 mrem

Answer: 0.75 rem

(2) 7. What is the radiation level at 1 foot from 10 Curies of Cobalt 60?

Answer: 145 R/hr

70184

POINTS

(2) 8. What is the radiation level at 1 foot from 100 Curies of Iridium 192?

Answer: 590 R/hr

(2) 9. Define a half value layer.

Answer: The amount of shielding material that will reduce the original radiation intensity to 1/2.

(3) 10. How often must Radiation Survey Meters be calibrated?

Answer: every 90 days

(3) 11. Radiation Survey Meters used in Industrial Radiography must have a range of at least:

Answer: 2 mr/hr to 1000 mr/hr

(3) 12. How often must radiographic sources be leak tested? Why

Answer: Every 6 months to check for contamination

(3) 13. Any area accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive a dose in excess of 100 mRem in any one hour, is described in this manual as a _____.

Answer: High Radiation Area

(3) 14. Any area accessible to personnel in which there exists radiation at such levels that a major portion of the body could receive a dose in excess of 5 mRem in any one (1) hour or 100 mRem in any 5 consecutive days is defined as a_____.

Answer: Radiation area

(4) 15. List three (3) precautionary steps that should be taken at the completion of each exposure.

Answer: a. Survey the device
b. Survey the source tube
c. Lock the device

(2) 16. What course of action should you take if your dosimeter were to read 'off scale'?

Answer: Stop work. Notify the Radiation Safety Officer who will have the TLD processed.

POINTS

(3) 17. Pocket dosimeters must have a range from _____ to at least____mr.

Answer: 0 to 200 mr

(3) 18. What is the allowable radiation level for an Atomic Radiation Worker in an "Unrestricted Area"?

Answer: 2 mRems in any one hour
100 mRems in any 7 consecutive days

(2) 19. If NRC form 4 (or equivalent) has not been completed, what is the allowable Quarterly Radiation exposure for a man (20) years of age? (Assume he has never worked in a radiation area.)

Answer: 1.25 Rem

(3) 20. Detail emergency measures you would take in a case where you were unable to retract a source.

Answer: 1. Control access
2. Notify the Radiation Safety Officer

(3) 21. Exposure devices must be labeled with at least the following information:

Answer: 1. Radioactive material symbol
2. Danger, Radioactive Material
3. Type of Isotope
4. Activity of the source
5. Date the activity was measured

(4) 22. What information is required on the Utilization Log?

Answer: 1. Date
2. Device model and serial number
3. Isotope
4. Site utilized
5. Source serial number
6. Radiation level at the perimeter of the restricted area
7. Time out
8. Time in
9. Responsible Radiographers
10. Radiation survey at completion of operations

(3) 23. Constant surveillance is required of areas in excess of ___ mr/hr.

Answer: 2 mr/hr

POINTS

(1) 24. What type of penalty may be imposed for violation of Federal or State regulations?

Answer: Fine, imprisonment or both

(4) 25. How often must sealed sources be inventoried and documented?

Answer: Every three (3) months

(3) 26. What documents must "Radiographers" and "Radiographers Assistants" be supplied by management?

Answer:
1. 10 CFR Parts 19, 20, 21, and 34.
2. Operating and Emergency Procedures
3. License

(3) 27. You have arrived at the radiography job site and find that you have forgotten your TLD. What would be your course of action?

Answer: Do not work. Return for it.

(3) 28. List instances when an exposure device must be radiation surveyed.

Answer:
1. Prior to removal from storage
2. After each exposure
3. After completion of the operation and prior to returning the device to storage.
4. Receipt
5. Shipment

(2) 30. Under what circumstances may a "Radiographers Assistant" operate an exposure device?

Answer: Under the continuous visual surveillance of a Radiographer.

(2) 31. List the half-lives of Cobalt 60 and Iridium 192.

Answer:

Cobalt 60	5.2 years
Iridium 192	74 days

(3) 32. How soon must regulatory agencies be notified of overexposures?

Answer:

+ 3 Rem	30 dayss
+ 5 Rem	24 hours
+25 Rem	immediately

POINTS

(2) 33. What does the term half-life mean?

Answer: The time for 1/2 the atoms in a radioactive material to go through the disintegration process.

(2) 34. Radiographic exposure devices shall have no radiation level in excess of _____ mr/hr on any exterior surface of the device.

Answer: 200 mr/hr

(2) 35. Explain the difference between dose and dose rate.

Answer: Dose is the total dose received
Dose rate is the dose per unit of time. (i.e. mr/hr)

(2) 36. Relative to personnel dosage, what is the effect of shielding?

Answer: More shielding less dose/dosage

(2) 37. How are decayed sources disposed of?

Answer: Returned to vendor.

(2) 38. What markings are required on motor vehicles used for transporting sources with 'Yellow Radioactive-III labels affixed?

Answer: "RADIOACTIVE MATERIAL" on all sides.

(2) 39. When must dosimeter readings be recorded?

Answer: Daily

(2) 40. What action would you take if you suspected an individual had been exposed by a radiographic source?

Answer: Detain, obtain details, notify the Radiation Safety Officer.

(3) 41 What is the allowable radiation level from radiographic exposure devices measuring four (4) inches from the sealed source storage position to any exterior surface of the device and all storage containers for sealed sources or radiographic exposure devices?

Answer: 200 mr/hr at contact
10 mr/hr at 3 feet

(3) 42. Who is the Company Radiation Safety Officer and how would you contact him if necessary?

Answer: The Radiation Safety Officer at the time of examination

TYPICAL RADIOGRAPHY MATH EXAM

NAME _____ DATE _____

1. Given: The dose rate is 100 mr/hr at 8 feet from a source
   Find: The dose rate 1 foot from the source

   Answer: 6400 mr/hr

2. Given: The dose rate is 400 mr/hr at 20 feet from a source
   Find: The dose rate at 30 feet from the source

   Answer: 177.7 mr/hr

3. Given: The dose rate is 70 mr/hr at 6 feet from a source
   Find: The distance at which the dose rate would be 2 mr/hr

   Answer: 35 - 36 feet

4. Given: The dose rate is 2 mr/hr at 20 feet from a source
   Find: the distance at which the dose rate would be 100 mr/hr

   Answer: 3 1/2 feet

5. Given: A half value layer of material is 0.5 inches
   Find: The thickness of material to reduce the radiation level from 128 mr/hr to 2 mr/hr

   Answer: 3 inches

6. Given: A tenth value layer of a material is 2 inches
   Find: The thickness of material to reduce the radiation level from 1 R/hr to 1 mr/hr

   Answer: 6 inches

7. Given: A 2 curie Cobalt 60 source
   Find: The dose rate at 2 feet

   Answer: 7.25 R/hr

8. Given: A 70 curie Iridium 192 source
   Find: The distance at which the dose rate would be 2 mr/hr

   Answer: 454 feet

9. Given: An Iridium 192 source measures 59 R/hr at 1 foot
   Find: The total curies of the source

   Answer: 10 curies

10. Given: A Cobalt 60 source measures 87 R/hr at 1 foot
Find: The total curies of the source

Answer: 6 curies

11. Given: An Iridium 192 source is 100 curies on January 1, 1984
Find: How many curies is it on May 29, 1984 (148 days elapsed)

Answer: 25 curies

12. Given: A Cobalt 60 source is 10 curies on January 1, 1979
Find: How many curies is it on March 1,1984 (62.4 months elapsed)

Answer: 5 curies

13. Given: A 20 curie Iridium 192 source is to be used 20 feet from a welding booth
Find: How thick must a concrete wall be built to prevent the operator from receiving more than 2 mr/hr

The half value layer for concrete is 1.9 inches

Answer: 15.2 inches

14. Given: A man is working in an area with a radiation level of 120 mr/hr
Find: How long would it take for him to receive an exposure of 2 mr

Answer: 1 minute

ATTACHMENT F

INSPECTION AND MAINTENANCE OF

RADIOGRAPHIC EQUIPMENT

70184

F.1 Inspection and Maintenance of Radiographic Equipment.

A. At least once each day, prior to and during use, the responsible radiographer will examine radiographic equipment in use and record the results on the Daily Inspection Check List. A copy of these forms are contained on pages 5-14 and 5-15.

B. At least once each 90 days, the Radiation Safety Officer will perform a detailed inspection of all radiographic equipment and complete the Quarterly Inspection Check List. These forms are contained as part of this procedure.

C. Any unsatisfactory items noted during either of the above inspections will be cause for removal of the equipment from service until the condition is corrected.

D. Any equipment subjected to unusually severe stress will be removed from service and the Radiation Safety Officer notified for appropriate action.

RADIOGRAPHIC EQUIPMENT AND MAINTENANCE RECORD
QUARTERLY INSPECTION CHECK LIST

"Crank-Out" Type Devices

Location_____

Source S/N_____ Date _____:_____

Manufacturer_____ Model _____ Signature
Device S/N_____

			SAT	UNSAT.
1.	a)	Inspect the source connector. The connector should not allow any excessive signs of wear and should be straight. Check flexible cable at the connector for straightness.	_____	_____
	b)	Repair - Do nothing to the source. If the source connector or flexible cable appears worn or faulty in any way, contact the manufacturer.	_____	_____
2.	a)	Inspect the lock for ease of operation. Foreign matter may foul the plunger and make it inoperative.	_____	_____
3.	a)	Inspect the source outlet port by first removing the safety plug. The outlet port should be round and smooth so that it will match the I.D. of the source tube.	_____	_____
4.	a)	Inspect the source tube for crimps, foreign material, ease of connecting and disconnecting from exposure source.	_____	_____
	b)	Preventative Maintenance - Flush source tubes out with a solvent and blow through with compressed air.	_____	_____
5.	a)	Inspect the control conduit and inner core for wear, rusty sections, kinks, etc.	_____	_____

			SAT.	UNSAT.
5.	b)	Preventative Maintenance - Remove the inner core from the control conduit and clean by brushing with a solvent such as varsol, diesel fuel or some other solvent that will not dry out. This is done to remove foreign matter that will cause abrasions in the exposure device and gear box drive mechanism. Rusty inner core should be replaced. After the inner core is thoroughly clean, oil with a light oil such as 3-in-1. It is recommended that graphite not be used because it tends to build up causing wear and difficulty in movement.	_____	_____
6.	a)	Inspect the control assembly which consists of the gear box assembly and the crank handle. The bushings in the gear housing and the plate are the most likely places to find wear. When the bushings are worn, they permit the gear to wobble and wear out quickly.	_____	_____
	b)	Preventative Maintenance - apply light oil on the bushings.		
7.	a)	Inspect to assure radiation warning and source identification label is affixed and legible.	_____	_____
	b)	Replace if necessary		
8.	a)	Inspect ease of operation of the device	_____	_____
	b)	Repair - As necessary determined by cause		

RADIOGRAPHIC EQUIPMENT AND MAINTENANCE RECORD
QUARTERLY INSPECTION CHECK LIST

Spec-Check Model II & Pipeliner Devices

Site _____

Source No._____ Date _____

Mfgr._____ Model _____ Serial # _____:_____
Signature

			SAT.	UNSAT.
1.	a)	Inspect control for damage.	_____	_____
	b)	Repair - replace as necessary		
2.	a)	Rotate control knob to and fro to assure freedom of movement	_____	_____
	b)	Repair - If dirty, clean and lubricate with WD-40 - otherwise replace		
3.	a)	Inspect protector for visible damage or loose hardware	_____	_____
	b)	Repair - Tighten or repair as necessary		
4.	a)	Inspect lock for ease of operation	_____	_____
	b)	Repair - Clean and lubricate with WD-40.		
5.	a)	Inspect to assure all radiation warning and source identification labels are affixed and legible.	_____	_____
	b)	Repair - Replace as necessary.		
6.	a)	Inspect ease of operation of the device.	_____	_____
	b)	Repair - as necessary as determined by cause.		

ATTACHMENT G

COMPANY RECORD KEEPING FORMS

RADIOGRAPHIC SOURCE RECORD

SOURCE SERIAL NO:_____ISOTOPE:_____

DATE RECEIVED:_____FROM:_____

STORAGE DATA

DATE: _____MODEL & SERIAL NO. OF DEVICE OR CONTAINER_____

RADIATION LEVEL: CONTACT:_____mr/hr 6":_____mr/hr 3 feet:_____mr/hr

_____
Signature

DATE: _____MODEL & SERIAL NO. OF DEVICE OR CONTAINER_____

RADIATION LEVEL: CONTACT:_____mr/hr 6":_____mr/hr 3 feet:_____mr/hr

_____
Signature

DATE: _____MODEL & SERIAL NO. OF DEVICE OR CONTAINER_____

RADIATION LEVEL: CONTACT:_____mr/hr 6":_____mr/hr 3 feet:_____mr/hr

_____
Signature

LEAK TESTS

DATE:_____RESULTS:_____microcuries Signature:_____

DATE:_____RESULTS:_____microcuries Signature:_____

DATE:_____RESULTS:_____microcuries Signature:_____

DATE:_____RESULTS:_____microcuries Signature:_____

DATE:_____RESULTS:_____microcuries Signature:_____

DISPOSAL DATA

DATE TRANSFERRED _____TO:_____

SHIPPED VIA:_____ SURFACE READINGS_____mr/hr

RADIATION SURVEY METER CALIBRATION AND
MAINTENANCE RECORD

MODEL:_____ MFG. S/N:_____ I.D. _____

LOCATION

DATE	REMARKS	SIGNATURE

INDUSTRIAL RADIOGRAPHY

QUARTERLY INVENTORY OF
BY-PRODUCT MATERIALS

DATE	ISOTOPE	ACTIVITY	SERIAL NO.	DEVICE	LOCATION

INDUSTRIAL RADIOGRAPHY TRAINING RECORD

NAME_____ _____

DATE	REMARKS	SIGNATURE

TLD - DAILY DOSIMETER RECONCILIATION RECORD

NAME: ______________________________

Wearing Period										
TLD Report										
Dosimeter Totals										

Wearing Period										
TLD Report										
Dosimeter Totals										

Wearing Period										
TLD Report										
Dosimeter Totals										

Wearing Period										
TLD Report										
Dosimeter Totals										

ATTACHMENT I

SOURCE CHANGING
RECEIPT AND DISPOSAL OF SOURCES

70184

SOURCE CHANGING, RECEIPT AND DISPOSAL OF SOURCES

A. All source exchanges and shipments will be conducted under the personal supervision of the Radiation Safety Officer or a designated Radiographer who has received instruction in carrying out source exchanges and who has consented in writing to carry out source exchanges.

1. Only the Industrial Nuclear Model 50, Gulf Nuclear U-110B, Technical Operations Model 650, SPEC Model C-1, or Gamma Industries Model C-10 Iridium 192 shipping containers will be returned to the vendor for source exchange.

2. These step-by step instructions will be followed in detail and in the sequence presented. Particular care must be taken to assure the source is securely locked in the fully shielded position as confirmed by carefully performed radiation surveys. Radiation levels of shipping containers may not exceed the following criteria and be labeled as indicated.

a) Radioactive Material Packages Label Criteria

Label	Dose Rate Limits: At Any Point On Accessible Surface of Package	Dose Rate Limits: At Three Feet From External Surface of Package (Transport Index)
"Radioactive-White I"	0.5 mr/hr	0
"Radioactive-Yellow II"	50.0 mr/hr	1.0 mr/hr
"Radioactive-Yellow III"*	200.0 mr/hr	10.0 mr/hr

*Requires vehicle placarding.

b) Attach two "Radioactive" labels to each shipping container being shipped. The following information must be inserted on these labels.

1. CONTENTS: IRIDIUM 192 OR COBALT 60

2. NO. OF CURIES INSERT TOTAL CURIES OF SHIPMENT

3. TRANSPORT INDEX THIS IS THE mr/hr READING OF THE CONTAINER MEASURED AT A DISTANCE OF 3 FEET AND ROUNDED OFF TO THE NEAREST 1/10 mr/hr.

A. Cont'd.

c) Complete a "Shippers Certificate" form and attach to the freight bill.

B. All incoming sources must be surveyed within 3 hours of receipt and the results of the survey documented on the Radiographic Source Record. Any shipping container, found to have radiation levels in excess of allowable, will be immediately moved to a safe excluded area and the Radiation Safety Officer notified.

C. Source Exchange Utilizing Technical Operations Model 650 Source Exchange

1. Establish and post restricted areas as outlined in Chapter 5, Paragraph 5.9.2 of these procedures.

2. Locate the source changer and projector so as to avoid sharp bends in the source tube and control housing.

3. Set up the projector as for an exposure as outlined in Chapter 5. Paragraph 5.9.3 of these procedures.

4. Remove the cover from the source exchanger by breaking the seal wire and removing the bolts.

5. Remove the source holddown cap by breaking the seal wire and unbolting.

   CAUTION: When the source holddown cap is removed, the source connector is exposed. Care must be taken to ensure that the source is not dislodged when handling the changer.

6. Connect one end of the guide tube extension to the projector and the other end to the fitting above the EMPTY chamber in the source changer.

7. Close and latch the source guided.

8. Standing at the projector controls crank the source from the projector to the source changer.

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

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

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

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

C. Source Exchange Utilizing Technical Operations Model 650 Source Exchange Cont'd.

13. Close and latch the source guides.

14. Standing at the projector controls, crank the source from the source changer to its storage position in the projector

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

16. Lock the Projector.

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

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

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

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

21. Survey all exterior surfaces of the source exchanger to ensure that the radiation level does not exceed radiation limits of Page I - 2.

22. Measure the radiation level three feet from all exterior surfaces of the source changer and ensure that the radiation level does not exceed the limits of I - 2.

D. Source Exchange Utilizing Gamma Industries Model C-10 and SPEC Model C-1 Source Exchangers.

1. Establish and post restricted areas as outlined in Chapter 5, Paragraph 5.9.2 of these procedures.

2. Locate the source changer and projector so as to avoid sharp bends in the guide tube or control housing.

3. Set the projector as for an exposure as outlined in Chapter 5, Paragraph 5.9.3 of these procedures.

4. Open the lower lock of the shipping container. Remove the safety plug.

D. Source Exchange Utilizing Gamma Industries Model C-10 and SPEC Model C-1 Source Exchangers.

5. Connect one end of the short exposure tube (provided in the shipping barrel) to the lower lock box of the shipping container. Attach the other end of the short exchange tube to the exposure port of the exposure device.

6. Connect the control cable to the pigtail of the old source.

7. Unlock the lockbox of the exposure device.

8. Crank old source from exposure device into shipping container.

9. Survey the area, the shipping container, the exposure device and guide tube to assure the source has been properly transferred.

10. Lock the lower lockbox of the shipping container. Be certain to position the ball on the pigtail directly beneath the lock plunger.

11. Disconnect the source tube from the shipping container.

12. Disconnect the pigtail from the control cable. Replace the safety plug in the lower lockbox of the shipping container.

13. Turn the shipping container around, remove the safety plug from the upper lockbox of the shipping container.

14. Screw the exchange tube into the coupling of the container.

15. Unlock the new source side lockbox on the shipping container.

16. Standing as far away as possible, retract the control cable which will pull the source out of the shipping container and into the exposure device.

17. Survey the area, the exposure device and guide tube.

18. Lock the lockbox on the exposure device.

19. Disconnect the control cable from the pigtail.

20. Unscrew the exchange tube from the exposure device and from the shipping container.

D. Source Exchange Utilizing Gamma Industries Model C-10 and SPEC Model C-1 Source Exchangers. Cont'd.

21. Lock the shipping container. Replace the safety plug in the exposure device and the plunger in the shipping container.

22. Affix the identification plate of the new source to the projector and attach the identification plate of the old source to the source changer.

23. Place the shipping container in the shipping drum.

24. Survey all exterior surfaces of the shipping drum to ensure the radiation level does not exceed the limits of Page I - 2.

25. Measure the radiation level three feet from all exterior surfaces of the shipping drum and ensure that the radiation level does not exceed the limits of Page I - 2.

E. Source Exchange Utilizing the Industrial Nuclear Model 50 Source Changer

1. Establish and post the restricted areas as outlined in Chapter 5, Paragraph 5.9.2. of these procedures.

2. Locate the source changer and projector so as to avoid sharp bends in the source tube and control housing.

3. Set the projector as though making an exposure as outlined in Chapter 5, Paragraph 5.9.3. of these procedures.

4. Remove the source shipping container from the shipping drum.

5. Attach one end of the transfer tube to the projector in the usual manner. Remove the green dust cap from the changer. Remove the adapter plug from the dust cap, attach it to the source changer lock body. Connect the other end of the exposure tube to the adapter plug on the empty side of the source changer. Position the equipment in such a manner as to permit free travel of the source assembly in the tube.

6. Position the drive crank the maximum distance from the camera.

7. Unlock the empty side of the source changer. This will be indicated by the fully extended red indicator on the lock body.

E. Source Exchange Utilizing the Industrial Nuclear Model 50 Source Changer

8. Quickly crank the source out of the projector and into the source changer. Survey the changer to verify the insertion of the source.

9. Secure the source changer lock. The red indicator is fully retracted. Test the pigtail to verify the source is securely held by the closed lock. This may be done by attempting to retract the source after the lock has been closed.

10. Unscrew the adapter coupling connecting the exposure tube and the source changer. Disconnect the source drive cable.

11. Remove the red dust cap on the lock body with the new source tag.

12. Install the red dust cap on the lock body containing the spent source. Remove the spent source nameplate from the projector. Wire seal the spent source nameplate to the dust cap and lock body.

13. Align the isotope projector and exposure tube with the source changer. The exposure tube should be straight and fee from kinks with the end of the drive cable protruding 1/2" from the end of the housing.

14. Connect the new source to the drive cable.

15. Connect the exposure tube and adapter to the source changer lock body.

16. Position the projector drive crank the maximum distance from the projector.

17. Unlock the safety feature securing the new source in the source changer - indicated by a fully extended red indicator.

18. Quickly crank the new source into the projector. Survey the projector to verify the safe position of the source.

19. Lock the projector and replace the adapter and green dust cap. Attach the new source identification plate to the projector.

20. Replace the source changer into the shipping drum.

21. Replace the shipping drum cover and secure the lock bolt with the wire seal provided.

E. Source Exchange Utilizing the Industrial Nuclear Model 50 Source Changer

22. Conduct a radiation survey of the shipping drum to assure the radiation levels do not exceed the limits of Page I - 2.

F. Source Exchange Utilizing Gulf Nuclear Model U-110B Source Changer

1. Establish and post restricted areas as outlined in Chapter 5, Paragraph 5.9.2 of these procedures.

2. Locate the source changer and projector so as to avoid sharp bends in the source tube and control cable housing.

3. Set the projector as for an exposure as outlined in Chapter 5, Paragraph 5.9.3 of these procedures.

4. Remove the exchanger from the drum.

5. Set up the projector for normal operation with the changer tube attached. Attach the end of the tube to the empty side of the source changer. Remove the key.

6. Standing as far away as possible from the projector and source changer, crank the spent source into the source changer. Lock the source in place. Remove the key.

7. The previous operation should be monitored very carefully. Check the projector, changer tube and source changer to see that radiation levels are within limits.

8. Unscrew the coupling connecting the changer tube to the source changer. The connector of the spent source should protrude about 1/2" from the port (radiation levels should be monitored during this operation with a meter placed near the exchanger).

9. Disconnect the source from the drive cable.

10. Remove the safety cap from the new source and install on the spent source.

11. Position the projector with the drive cable protruding about 1/2" beyond the end of the changer tube. Avoid kinks. The tube should be laid out as straight as possible.

12. Connect the new source to the drive cable.

F. Source Exchange Utilizing Gulf Nuclear Model U-110B Source Changer

13. Screw the coupling at the end of the changer tube into the source changer. Unlock the exchanger.

14. Standing as far away as possible from the projector and the source changer, quickly crank the source into the projector. Lock the projector. After the transfer, the operator should immediately monitor the projector, changer tube and source changer to assure that the transfer has been completed safely.

15. After monitoring has demonstrated everything is in order, the changer tube should be unscrewed from the source changer and projector.

16. Remove the metal source identification plate from the source changer and fasten it to the projector.

17. Replace the changer and changer tube in the drum. Prepare the drum for return shipment to Gulf Nuclear, Inc. Conduct a radiation survey of all surfaces of the drum to assure radiation levels do not exceed limits of Page I - 2.

ATTACHMENT H

RESUME AND DUTIES OF
RADIATION SAFETY OFFICER

DUTIES OF THE RADIATION SAFETY OFFICER

1. Maintain control of procurement and disposal of licensed by-product material.
2. Develop and submit up-to-date operating and emergency procedures. Ensure compliance.
3. Maintain the personnel monitoring program.
4. Maintain adequate radiation survey instruments.
5. Maintain adequate storage facilities.
6. Ensure maintenance of exposure devices and associated equipment.
7. Conduct the source leak test program.
8. Maintain the local internal inspection program
9. Conduct quarterly inventories and assure maintenance of the Utilization Logs.
10. Coordinate the radiation survey instrument calibration program.
11. Ensure maintenance of the required records.
12. Assume control and institute corrective action in emergency situations.
13. Investigate incidents and recommend necessary preventative and corrective action.
14. Act in an advisory capacity to radiography personnel.

RESUME RADIATION SAFETY OFFICER

EXPERIENCE

1983 to present — Ultra Technology Inc.
3836 Brighton Drive N. W.

Manager, responsible for establishing the Company and its business client base, control systems and licensing.

8/78 - 11/82 — Hardy Associates (1978) Ltd.
2915 - 21 Street N. E.
Calgary, Alberta

Manager, Metallurgical Division

Responsible for all NDT and Engineering services provided by the Calgary laboratory. In addition, functioned as instructor training NDT technicians. Administered radiation control program and provided safety instruction to employees. Acted as Radiation Safety Officer under the United States Nuclear Commission Radioactive Materials License held by the Company.

0/72 - 8/78 — Self employed consultant

Audited radiographs on behalf of clients. Acted as visiting instructor for Radiation Safety portion of NDT courses provided by the Southern Alberta Institute of Technology.

2/61 - 6/72 — Manager, Calgary Division
North American Inspection Services Ltd.

Responsible for all NDT services provided by employers. Trained technicians in NDT techniques and radiation safety.

6/55 - 2/61 — International Radiography and Inspection Services Ltd.
Edmonton, Alberta

Performed the duties of a senior radiographer, using up to 300 kv x-ray, 50 curies of Iridium 192 and 150 curies of Cobalt 60. Supervised several radiography crews on routine radiography projects. Provided on-the-job safety instruction to junior employees as was the custom of the time.

2/54 - 6/55	Isotope Products of Canada Ltd. Edmonton, Alberta Performed radiographers duties on pipelines, industrial process plants, etc. using up to 150 kv x-ray machines and Iridium 192.
6/52 - 2/54	Industrial X-ray Inc. Seattle, Washington Performed duties on a radiographer on pipelines using x-ray machines.

DUTIES OF A SENIOR RADIOGRAPHER

Because the Company does not maintain a permanent radiographic facility and carries out radiographic operations at field sites only, the large distances involved between the Radiation Safety Officers' office and the site, making daily personal supervision impossible; the following responsibilities of the Radiation Safety Officer are delegated to the Senior Radiographer who is responsible for all Company activities at the field site.

1. The Senior Radiographer is the custodian for all licensed by-product materials held by the Company at a specific field site and as such is delegated responsibility by the Radiation Safety Officer for the following:

   a) Receiving new, high activity by-product material and returning low activity material to the supplier.

   b) Carrying out the surveys and reporting procedures required in Section I of the manual.

   c) Maintaining the daily records of dosimeter readings, source utilization reports, daily equipment inspection reports etc. as required by various paragraphs in this manual.

   d) Ensuring that only calibrated survey instruments and dosimeters are used on thejob site.

   e) Ensuring that the radiation levels at the surface of vehicles carrying or used for storage of by-product materials do not exceed the limits specified in this manual.

   f) Assuming control of instituting corrective action on behalf of the Radiation Safety Officer in emergency situations.

   g) On behalf of the Radiation Safety Officer, ensure compliance with the procedures described in this manual.

2. The Senior Radiographer will appoint a Deputy to act on his behalf during brief absences from the field site. The appointment of a "Deputy" will be contingent upon approval of the Radiation Safety Officer and will be an individual who in the judgement of the Radiation Safety Officer and the Senior Radiographer is qualified by experience, training and attitude to act in this capacity. In the absence of the Senior Radiographer, the appointed "Deputy" will be responsible to the Radiation Safety Officer for all the items listed in 1.a) through g) above.

70184

PERSONAL DATA SHEET

Name: Bruce Anthony Servin

Address: 280 West Davies Street, Eldridge, Iowa 52748

Telephone: (319) 285-8445

PERSONAL:

Born: November 21, 1949

Height: 5'10"

Weight: 160 pounds

Health: Good

Marital Status: Married fifteen years, two children

Military Status: Served two years active duty in the United States Naval Reserve, from September 15, 1968 until September 3, 1970

EDUCATION:

Hutchinson Public High School, Hutchinson, Minnesota; 1963-1967

Hutchinson Area Vocational Technical Institute, Hutchinson, Minnesota. Special Emphasis is placed on Radiation Theory and Radiation. A two year course in Non-Destructive Testing; included, Ultrasonics, Magnetic Particle, Liquid Penetrant, Eddy Current, and Metallurgy. Additional courses included, Technical Mathematics, Basic Welding, Physics, and Management and Industrial Relations. 89% average, 1975-1977.

Curriculum:

Basic Radiography (X-ray) NDT Theory	60 hours	
Basic Radiography (X-ray) NDT Lab	90 hours	
Advanced Radiography (Isotope) NDT Theory	60 hours	330 Total Hours
Advanced Radiography (Isotope) NDT Lab	120 hours	

Metals Engineering Institute. Successfully completed correspondence courses in the following:

Fundamentals of Ferrous Metallurgy, September 27, 1979
Fundamentals of Heat Treatment, March 4, 1980
Welding Inspection and Quality Control, August 1, 1980

American Welding Society. Participated in a one week seminar on Welding Inspection, August 15, 1983

American Welding Society, Certified Welding Inspector. Successfully meet the requirements of the AWS Standard for Qualification and Certification of Welding Inspectors, QCI-83 and Certified by examination on November 12, 1983

WORK EXPERIENCE:

Allied Structural Steel Company, Clinton, Iowa
January 1983 to March 1984, Quality Assurance Supervisor. Supervise three Dimensional and two Non-Destructive Testing Inspectors. Perform Ultrasonic examinations of weldments. Schedule and coordinate Radiographic Inspection activities. Review and interpret radiographic film. Review Inspection Reports. Schedule and/or perform equipment calibrations.

Caterpillar Tractor Company, Davenport, Iowa

February 1979 to May 1979, Metallurgical Engineering. Development of new equipment operational procedures, including a 400 K Tensile Machine and Portable Spectrometer.

June 1979 to January 1980, Quality Assurance. Monitor and evaluate the results of machine tool capability studies using 6 sigma analysis.

February 1980 to May 1981, Quality Assurance. Review blue prints and work orders to determine and procure necessary electronic or manual gaging for use by Inspection and Manufacturing departments. Write Inspection Procedures for the use of this equipment and indoctrinate personnel on the use of the equipment.

June 1981 to June 1982, Quality Assurance. Conduct Quality Audits to determine Plant conformance to the various Manufacturing Practices. Results of these audits were reported to the Department Managers and the Plant Manager.

Pittsburgh-Des Moines Steel Company, Des Moines, Iowa

June 1977 to February 1979, Quality Assurance. Non-Destructive Testing Specialist for the Central Division. Development of inspection procedures, techniques, and methods for Non-Destructive Testing. Central Division Radiation Safety Officer, procure equipment and supplies for the Quality Assurance Department. Train and Certify Quality Assurance Inspectors.

While employed by Pittsburgh-Des Moines Steel Company, I served on the Governor's Advisory Committee on Radiation Safety, and was certified Level III in Radiography, Ultrasonics, Magnetic Particle, and Liquid Penetrant Testing in accordance with the requirements of the American Society for Non-Destructive Testing, SNT-TC-1A.

Minnesota Mining and Manufacturing Company, Hutchinson, Minnesota

September 1970 to August 1975, Production Department. Worked as a Supplyman, Assistant Slitter Operator, and as a Slitter Operator.

REFERENCES:

Mr. Phillip Bruno
Metallurgical Engineering
Supervisor
Caterpillar Tractor Company
Davenport, Iowa

Mr. Russel Fritz
Quality Assurance Supervisor
Caterpillar Tractor Company
Davenport, Iowa

Hutchinson Area Vocational Technical Institute

Certifies That

BRUCE ANTHONY SERVIN

has satisfactorily completed the prescribed course of study in

NONDESTRUCTIVE TESTING

as approved by the State Board of Vocational Education
and in recognition thereof is awarded this

Degree

of Occupational Proficiency

with all its rights and privileges in witness whereof our signatures are hereunto affixed

Given at Hutchinson, Minnesota this 12th day of November 1979

Superintendent

Chairman, Board of Education

Director, Vocational Technical

Clerk, Board of Education

Revision 1 H - 9

ATTACHMENT J

INTERNAL AUDIT PROGRAM

J. 1. Auditing

A. At least four (4) audits will be conducted at each site annually on an announced and unannounced basis. They will be at approximately 90 day intervals, but in order not to set a pattern the time span will be varied occasionally.

B. Audits will be conducted by the Radiation Safety Officer.

2. CORRECTIVE ACTION

A. Corrective action on adverse audit findings shall be recommended to management by the Radiation Safety Officer. To accomplish the corrective action, the following steps shall be taken.

1. The Radiation Safety Officer shall evaluate audit findings and determine the cause.

2. The Radiation Safety Officer shall determine those actions necessary to correct the audit findings and prevent recurrence. Possible actions to correct audit deficiencies and prevent recurrence may include:

a) Evaluation to determine the intent of the findings and the effect on related areas.

b) Correct or update associated items to the extent possible.

c) Determine responsibility.

d) Take action with responsible individual(s) to prevent recurrence. Possible actions may include but are not limited to:

1. Complete retraining

2. Partial retraining

3. Reprimand

4. Suspension from the radiography program

5. Dismissal

3. The Radiation Safety Officer shall follow-up to assure all required actions are completed in a timely manner.

4. Audits will be recorded on the Radiation Protection Audit Report (Page J - 3 of 3).

RADIATION PROTECTION AUDIT REPORT

Date_____Location_____Responsible Radiographer_____

Radiographic _____

Personnel _____

1. Records

	SAT	UNSAT
a. Radiographic Source Records	____	____
b. Survey Meter Calibration	____	____
c. Quarterly Inventories	____	____
d. Training Records	____	____
e. Daily Inspection Check List	____	____
f. Quarterly Inspection Check List	____	____
g. Daily Dosimeter Records	____	____
h. TLD Records	____	____

2. OPERATIONS

a. Area Posting	____	____
b. TLD and Dosimeter Usage	____	____
c. Area Radiation Surveys	____	____
d. Exposure Device Surveys	____	____
e. Storage Area Posting	____	____
f. Document Posting	____	____
g. Familiarity of personnel with Radiation Safety Manual Requirements	____	____

3. COMMENTS

_____
Signature

ATTACHMENT K

SHIPPING CONTAINER QUALITY
ASSURANCE REQUIREMENTS

SHIPPING CONTAINER QUALITY ASSURANCE REQUIREMENTS

1. SCOPE

This Quality Assurance Program is limited to fulfilling the requirements of the Atomic Energy Control Board for shipping containers used by the Company to transport sealed radioactive sources. Design and fabrication of shipping containers shall not be conducted under this program.

2. ORGANIZATION

The final responsibility for this Quality Assurance Program rests with the Company whose organizational structure is included in our Radiation Safety Manual.

The Radiation Safety Officer is responsible for overall administration of the program, training and certification, document control and auditing.

3. QUALITY ASSURANCE PROGRAM

This Quality Assurance Program although limited in scope, is conducted in accordance with the Companies Quality Assurance policies. For this program, this requires all procedures necessary for the safe use and control of shipping containers be written and defined by the Radiation Safety Manual and that only properly trained, competent personnel shall conduct the defined operations, inspections or tests. Also, the Radiation Safety Officer shall assure that all shipping containers are designed and manufactured in accordance with the Atomic Energy Control Board Regulations by Certification from the manufacturer.

4. DOCUMENT CONTROL

All documents pertaining to the radiation safety program are controlled by the Radiation Safety Officer and are included in our Radiation Safety Manual. This manual is distributed to all Company employees involved in working with radiative materials. Distribution of the manual and revisions are controlled in a positive manner by return transmittal form.

5. HANDLING, STORAGE AND SHIPPING

All operations involving the handling, storage and shipping of packages of sealed sources will be done in accordance with our Radiation Safety Manual. No shipments will be made unless all test, certifications, acceptance and final inspections have been completed.

6. INSPECTION, TEST AND OPERATING STATUS

The Radiation Safety Officer shall assure all radiographic personnel conduct inspections and test as follows:

a) Receipt Inspection: The following inspections shall be conducted at receipt.

1. Survey
2. Visual inspection for correct marking and damage
3. Manufacturers documentation

The survey results will be recorded on the shipping papers

b) In-process Inspection and Tests: The following inspections and tests shall be conducted as required.

1. Leak tests
2. Visual inspection and survey when damage is suspected
3. Daily and monthly inspections and maintenance

c) Final Inspection: The following inspections shall be conducted immediately prior to shipping equipment off site.

1. Survey
2. Proper labeling
3. Proper preparation for shipping (bolts tightened, seals in place, source identification tag attached etc.
4. Shipping papers are complete and in order (shipping certification, bill of lading etc.)

7. NONCONFORMANCE

On discovery of a nonconformance, the container will immediately be surveyed. If the radiation level exceeds 200 mr/hr at the surface or 10 mr/hr at three feet, a restricted area shall be established and the Radiation Safety Officer notified. He shall direct the resolution of the nonconformance. Surveillance of the restricted area shall be maintained until the nonconformance is resolved. If the survey meets the above levels, the equipment shall be moved to a locked secure area. The Radiation Safety Officer shall be notified of the nonconformance and he shall provide resolution.

8. QUALITY ASSURANCE RECORDS

All shipping container records will be maintained along with the other required radiation safety documents. All records are reviewed quarterly as part of the internal audit program.

9. AUDITS

Audit of this Quality Assurance Program will be conducted on a Quarterly Schedule along with the Radiation Safety Program audits defined in the Radiation Safety Manual.

SHIPPING CONTAINER
QUALITY ASSURANCE CHECK LIST

	SAT	UNSAT
1. Receipt Inspections		
a) Are radiation surveys conducted on receipt?	____	____
b) Are surveys conducted within allowable time limits?	____	____
c) Are visual inspections conducted upon receipt?	____	____
d) Are current "Certificates of Compliance" on file?	____	____
e) Have received sources been leak tested within six months?	____	____
f) Were leak tests within allowable limits?	____	____
2. In Process Inspections and Tests		
a) Leak tests conducted within last six months?	____	____
b) Daily and quarterly maintenance inspections conducted?	____	____
c) Inspections conducted when damage is suspected?	____	____
3. Inspection Prior to Shipment		
a) Radiation Surveys conducted	____	____
b) Surveys within allowable limits?	____	____
c) Proper 'Radioactive' labels affixed?	____	____
d) Properly prepared for shipment (bolts tightened, seals in place, source I.D. tag attached etc.?	____	____
e) Shippers certificates properly prepared?	____	____
f) Bills of lading properly prepared?	____	____
4. Notices of receipt received from consignee?	____	____

Date:_____ Auditor:_____

Approval_____
Radiation Safety Officer

TRAINING OUTLINE - OPERATING & EMERGENCY
PROCEDURE AND USE OF COMPANY EQUIPMENT

(Applicable to those individuals previously
qualified under another license)

A.	Operating and Emergency Procedures: Sections One through Six	4 hours
B.	Radiation Detection Equipment	1 hour
C.	Exposure Devices	1 hour
D.	Shipping Containers	1 hour
E.	Personnel Monitoring Equipment	1 hour

70184

TRAINING OUTLINE OF THE

ULTRA TECHNOLOGY INC.

TRAINING PROGRAM (40 hours)

	CHAPTER	Instruction Time
1.	Basic Mathematics	2 hours
2.	Atomic Structure	2 hours
3.	Radioactivity	2 hours
4.	Characteristics of Radiation	2 hours
5.	Unit of Radiation	1 hour
6.	Absorption of Ionizing Radiation	2 hours
7.	Shielding Methods for Gamma Radiation	2 hours
8.	Effects on the Human Body	2 hours
9.	Radiation Safety Standards	2 hours
10.	Survey Instruments	2 hours
11.	Radiation Survey Requirements	2 hours
12.	Personnel Monitoring Instruments	2 hours
13.	Radiographic Exposure Devices	2 hours
14.	Emergency and Remote Handling Equipment Storage Containers	2 hours
15.	Previous Radiation Accidents	2 hours
16.	Emergency Procedures - point by point instruction in the Company Safety Manual and use of Company equipment	9 hours
17.	Records and Reports	2 hours

CHAPTER I

BASIC MATHEMATICS

BASIC MATHEMATICS

The following is a review of elementary mathematics necessary for solving problems presented in this course. It is confined to practical applications of basic equations.

EQUATIONS

A simple equation can be expressed mathematically as

$$I = E/R$$

In this equation if the values of "E" and "R" are known, the value of "I" can be found.

Example

Given "E" is 120 volts and "R" is 20 ohms,

what is the value for "I"?

Solution

$$I = \frac{120 \text{ volts}}{20 \text{ ohms}}$$

$$I = 6 \text{ amperes}$$

In the following equation

$$y = 2x$$

there is no sign in front of the "2" to indicate if the value is a positive "+" or negative "-" value. In the absence of any sign in front of a number or letter representing an unknown value, the value is assumed to be positive. Thus the above equation is understood to mean

$$y = +2x$$

if the value of 2 was negative, the equation is

$$y = -2x$$

When a factor or expression is transferred from one side of an equation to the other side of the equal sign its sign must be changed. A plus or positive sign on one side of the equation must become a minus or negative sign when the number or expression is moved to the other side of the equals sign. Similarly, if a number or expression is multiplied on one side of the equals sign, it must be divided when transferred to the other side of the equals sign and vice versa.

Examples

a) $x + 5 = 12$

$x = 12 - 5$

$x = 7$

b) $x - 4 = 10$

$x = 10 + 4$

$X = 14$

c) $4x = 20$

$x = \frac{20}{4}$

$x = 5$

d) $\frac{x}{4} = 12$

$x = 3$

The relationship of radiation intensity to distance is given by the following equation

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

where I_2 = new intensity

I_1 = original intensity

d_2 = new distance

d_1 = original distance

An equation of this type has 3 knows and one unknown. However it is more complicated than the original equation because two of our factors are exponential expressions (i.e. they are taken to the 2 nd power or squared).

To solve this type of equation, move all the unknowns to the left of the equals sign and all the knowns to the right of the equals sign. For example, if d is known the equation is written in the form

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

(show cross multiplication)

Example

Given the original intensity and distance as 100 mr/hr and 2 feet, what will the intensity be at 4 feet?

$$I = 2^2 / 2^2 \times 100$$

$$I = 25 \text{ mr/hr}$$

This shows that doubling the distance reduces the intensity by 1/4.

When the radiation intensity (level) is to be altered by changing the distance, the equation is changed from

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

to

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

Example

Given - original intensity and distance are 300 mr/hr and 2 feet, at what distance will the new intensity be 3 mr/hr?

$$d = \sqrt{2 \times \frac{300}{3}}$$

$$d = \sqrt{400}$$

$$d = 20 \text{ feet}$$

This relationship of intensity to distance is known as the INVERSE-SQUARE LAW and is a very important fundamental formula in Radiation Protection.

70184

Further complication of the simple original equation occurs where the unknown is an exponent. An example -

In barrier thickness calculations an equation of the following type is used and may be in the following form.

$$2^n = R$$

where n = number of half value layers H.V/L.)

and R = the reduction factor

The H.V.L. or half-value layer denotes the thickness of any given material that will reduce the radiation intensity to 1/2 its original value and "R" or reduction Factor is numerically equal to the RATIO of original intensity to the 'desired' intensity.

Example

If the original intensity is 80 mr/hr and is to be reduced to 10 mr/hr, how many H.V.L.'s are required?

Solution

Since $R = I_o / I$

$= 80/10$

$= 8$

and $2^n = 8$

$n = 3 \quad (2 \times 2 \times 2 = 8)$

However, when n cannot be solved this easily by inspection logarithms are necessary.

Exponents or Powers of Ten

The powers of ten or exponents (engineers shorthand) is a simple way of expressing very large or very small numbers. For example, 136,000,000 can be written as 1.3×10^{8} and 0.00032 may be written as 3.2×10^{-4}.

The Laws of Exponents must be used when using powers of ten. That is, in multiplication the exponents are added and in division exponents are subtracted. Like exponents in a numerator and denominator may be cancelled. Also, it should be noted that powers of ten, may be transferred at will from the denominator to the numerator, and vice versa, if the sign of the exponent is changed when the transfer is made.

Examples

a) $10^{3} \times 10^{6} = 10^{3+6} = 10^{9}$

b) $\dfrac{10^{7}}{10^{4}} = 10^{7-4} = 10^{3}$

c) $\dfrac{10^{5}}{10^{5}} = 1$

d) $\dfrac{6 \times 10^{2}}{2 \times 10^{-4}} = 3 \times 10^{2} \times 10^{4} = 3 \times 10^{6}$

FINDING THE SQUARE ROOT OF A NUMBER

In the following example the work is carried out to find the square root of 23,668,225.

Mark of the digits in pairs, beginning at the right.

```
              4  8  6  5
            _____________
            23 66 82 25
             16
  8  8   |  7 66
            7 04
 96  6   |    62 82
              57 96
972  5   |     4 86 25
               4 86 25
               -------
                     0
```

The first digit (4) of the square root is the largest number whose square is not greater than 23. Square the 4, subtract 16 from23, and bring down the next two digits, 66.

Double the 4 and use the product, 8 as the trial divisor. This indicates that the next figure in the square root is 8. (At first sight you might be inclined to try 9 but you will by trial that it is too large.) Place the 8 in the root at the top and also in the divisor.

Multiply 88 by 8, subtract and bring down the next two digits, 82. Double 48 and use 96 as the trail divisor, etc.

If a number contains a decimal, the procedure for finding the square root does not differ from that of a whole number. However care must be taken to mark of digits in pairs, starting from the decimal point, in both directions.

CHAPTER II

ATOMIC STRUCTURE

ATOMIC STRUCTURE

A. MATTER

1. Elements

All material is composed of a combination of elements or a combination of elements. There are over 100 known elements. Some of the heavier ones are man made and do not occur in nature.

2. Compounds

Materials which are not elements are called compounds (i.e. a compound always is composed of two or more elements).

for example water and salt are compounds

3. The smallest unit of a stable material which has all the characteristics of the compound is its molecule. i.e. every molecule has its own characteristics.

For example water, is a stable molecule composed of the elements hydrogen and oxygen. However, the occurrence of molecules is not limited to compounds; they occur as elements also.

4. Atoms

The smallest unit of any element is an atom of that element.

As above, the water molecule is composed of hydrogen and oxygen atoms.

B. FUNDAMENTAL ATOMIC PARTICLES

All atoms are extremely small but atoms are built from even smaller particles whose symbols and basic properties are as follows:

Particle	Symbol	Relative Mass	Electric Charge
proton	p	1*	+
neutron	n	1	0
electron	e	1/1840	-

C. STRUCTURE

1. Atoms have a central condensed mass called the nucleus.

2. This is made up of neutrons and protons.

3. A number of electrons revolve around this nucleus. The paths of these electrons are called orbits.

4. The simplest atom, that of hydrogen, has a single proton in its nucleus, and has one electron circling about it.

5. Helium, the second simplest atom, has two neutrons and two protons in the nucleus and two electrons in the orbit.

6. The number of protons and neutrons increase with atomic weight.

7. The number of protons (positive charged) must equal the number of orbital electrons (negative charged), which means that the total positive charge of all the protons is balanced by the total negative charge of the electrons.

D. ATOMIC NUMBER

1. The number of protons and hence the number of electrons in an atom determines the overall structure and is characteristic of the element. This is an important quantity and is called ATOMIC NUMBER.

E. MASS WEIGHT OR ATOMIC WEIGHT

1. Nearly all the weight or mass of an atom is due to the neutrons and protons. The contribution of the electrons is negligible. The sum of the numbers of protons and neutrons is called the Mass Number.

F. ISOTOPES

1. A nucleus can contain only a certain number of protons for a given number of protons. When two atoms of an element contain different number of neutrons they will still have the same atomic number but a different mass number. Such atoms are called isotopes.

   For example, the common form of hydrogen has only one proton an no neutron in its nucleus. However other forms of hydrogen exist. The nucleus of an atom called deuterium has an neutron and a proton. Such atoms have Atomic Number 1 but mass number 2. Hydrogen and deuterium are isotopes of the same element. Another form with 2 neutrons in its nucleus is known. What is the atomic number and mass number of this isotope?

70184

F. ISOTOPES Cont'd

2. Many elements have more than one isotope occurring in nature. Unlike hydrogen, they are not given special names but are identified by their mass numbers, for example: Uranium 235 and 238. Both contain 92 protons but Uranium 238 contains 3 more protons than Uranium 235. The symbols for these isotopes are
How many neutrons do these isotopes contain?

CHAPTER III

RADIOACTIVITY

RADIOACTIVITY

Protons are positively charged particles. Particles of similar charge repel each other. When there are a number of protons in an atomic nucleus they should fly apart. This does not happen in a nucleus because of the presence of neutrons. For a given number of protons to exist there has to be present a minimum number of neutrons to provide a binding force resulting from the proton-neutron interaction.

A. ALPHA-ACTIVITY

As the number of protons increases the tendency for them to 'fly apart' increases. In very large atoms this tendency becomes a reality.

However, instead of a proton being thrown out of the nucleus, a package consisting of two protons and two neutrons is emitted and a new atom is created. This process is called radioactive transformation and is one form of radioactivity. This form of radioactivity occurs mostly in very heavy elements such as uranium and radium. The package emitted will be recognized as the nucleus of a helium atom. It is called an alpha particle.

What is the atomic number of the nucleus formed when uranium undergoes alpha transformation.

B. BETA-ACTIVITY

As pointed out in the previous chapter, the nuclei of the atoms of any element can have a different number of neutrons to give rise to isotopes. Such isotopes may be quite stable. On the other hand, if the number of neutrons is too many or fewer than necessary to hold the protons together, the atom will have a tendency to adjust the situation. If the number of neutrons is too many then, one of the excess neutrons is converted to a proton as follows:-

$$n \quad p^{+} + e^{-}$$

This electron is shot out while the proton remains in the nucleus. The resulting atom is called the daughter or decay product of the original atom and has a new atomic number i.e. it has become a new element. The released electron travels at great velocity and is called a beta particle.

C. RADIOACTIVE SERIES

When an unstable atom undergoes radioactive transformation by any of the processes discussed above, the newly formed atom may be of a Stable Variety. On the other hand it may still be too large or have an excess of neutrons and in the latter case it will undergo further transformations until a stable atom is formed. Such a series of reactions gives rise to a series of elements and there are several such series in nature.

D. GAMMA RADIATIONS

When alpha or beta particles have been emitted the newly born nucleus may be in a highly excited or unstable state i.e. it may have excess energy. If this is so, this excess energy is released in the form of radiation. The process is similar to a hot ingot or other hot body cooling down by emitting heat. The radiations emitted by the nucleus are called gamma-rays. These are electromagnetic radiations and are unlike alpha- and beta-rays.

E. PRODUCTION OF RADIOISOTOPES

While alpha-activity occurs mainly in heavy atoms, beta-activity can occur in any atom provided it has excess neutrons. Therefore if neutrons are added to an ordinary atom, it can be expected that the isotope produced is likely to be radioactive. This is one of the more common methods of making an ordinary material radioactive.

A very large number of neutrons are produced by splitting the uranium atom in nuclear reactors. Material placed inside a nuclear reactor becomes radioactive by capturing some of these neutrons. Different materials capture neutrons at different rates, so some become more radioactive than others. Both the commonly used radioisotopes in radiography, Cobalt-60 and Iridium-192 are produced by placing inactive Cobalt and Iridium in the reactor.

F. RADIOACTIVE DECAY

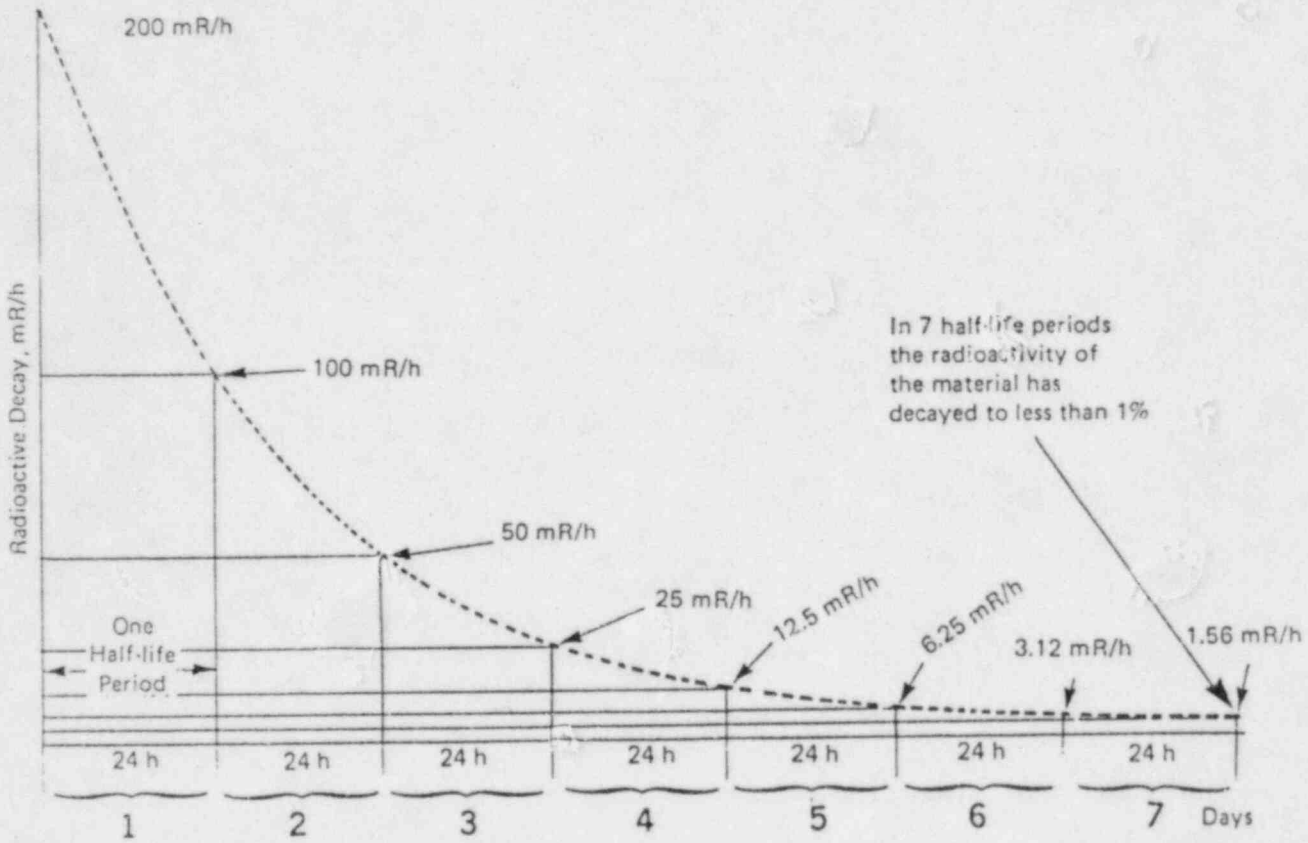
A radioactive atom produced as above will lose an electron and become inactive. Because some atoms undergo this change faster than others, the time required for any given number of radioactive atoms to change to inactive atoms is called the half-life for that isotope.

Assume there are 1000 atoms of radioactive material whose half-life is 10 minutes. After 10 minutes there will be 500 radioactive atoms left and the other 500 atoms will be inactive. After another 10 minutes 250 radioactive atoms remain. This process continues and after 4 half lives there will be 1/16 of the original number of radioactive atoms. This is expressed by the formula:

$$N_2 = \frac{N_1}{2^n}$$

where N is the number of atoms at the beginning, and N_2 the number after n half lives have elapsed.

The half life is a characteristic factor for a radioisotope and cannot be changed by physical or chemical means. The half-life values of radioactive isotopes range from fractions of a second to billions of years.



DECAY OF RADIOACTIVE MATERIAL WITH A 24 h HALF-LIFE

Radioisotope	Half-Life	Energy of Emitted Radiation	
		Beta Particle (MeV)	Gamma Ray (MeV)
$_{55}Cs^{137}$ (Cesium)	30.1 a	1.17 (8%) 0.51 (92%)	0.66
$_{27}CO^{60}$ (Cobalt)	5.3 a	0.32	1.33
$_{77}Ir^{192}$ (Iridium)	74.3 d	0.672	Numerous energies from 0.137 to 1.38

CHAPTER IV

CHARACTERISTICS OF RADIATION

CHARACTERISTICS OF RADIATION

A. ELECTROMAGNETIC RADIATION

(1) Wave Length

The name, electromagnetic radiation, applies to many kinds of radiation including light and heat radiation. A portion of the electromagnetic spectrum is shown in Fig. 1.

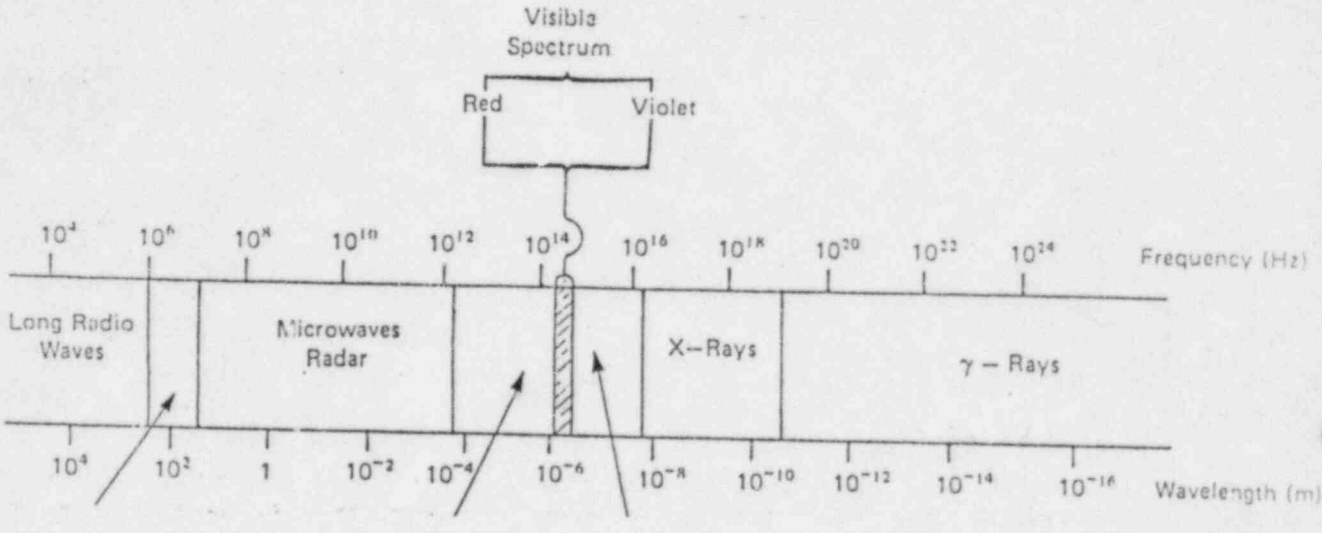


Figure 1. ELECTROMAGNETIC SPECTRUM

Electromagnetic radiations can be visualized to be travelling in the form of waves as shown in Figure 2.

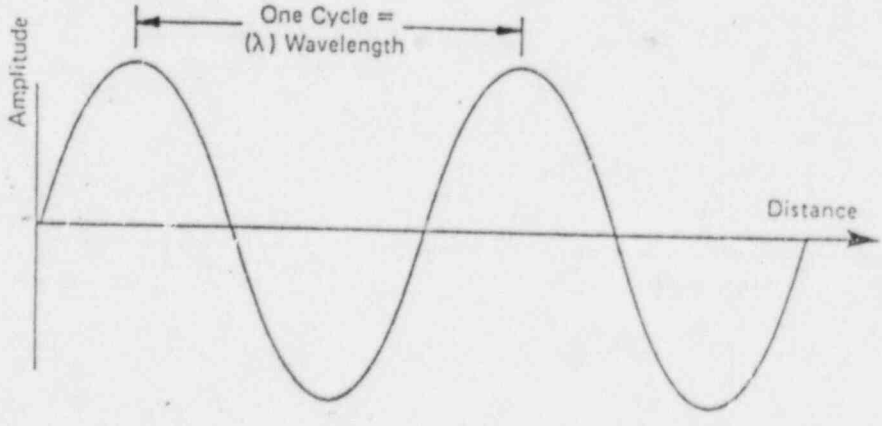


Figure 2. WAVE FORM OF ELECTROMAGNETIC RADIATION

(2) Velocity

All electromagnetic radiation travels at the same speed through a vacuum. This speed is approximately the speed of light i.e 186,000 miles per second.

(3) Frequency

The relationship between wave length and velocity is given by the equation:-

velocity = wave length x frequency

Frequency is the number of waves which go past a point per second.

(4) Energy

The energy of electromagnetic radiation exists in small 'bundles'. The amount of energy "E" in each bundle is directly related to the frequency by the equation

E = h x frequency

where h is a constant for all electromagnetic radiation.

(5) Interaction with Matter

The behavior of electromagnetic radiations is related to their wave lengths. For example, heat rays have a longer wave length than that of visible light. Further, red light has a longer wave length than that of blue light. Radiations with much shorter wave lengths than visible light are x-rays and gamma rays. These are very penetrating.

When light or heat rays strike matter they may be partially reflected or transfer their entire energy in the form of heat. X-rays and gamma rays are different in this respect because they interact with matter in a complicated manner. The net result of this is

(i) knocking off electrons from an atom in the target

ii) production of a secondary x-ray with lower energy than the incident (primary) beam. This results in scattered radiation.

(6) Ionization

When an atom loses an electron it becomes positively charged. This charged atom is called an ion. The electron knocked off is a negative ion. this process of creating an ion pair is called ionization. X- and gamma radiations create ion pairs when the collide with matter and therefore are called ionizing radiations.

B. BETA RADIATIONS

Beta radiations are fast moving electrons. When they pass through matter they knock off electrons, that is they cause ionization. Being particles rather than waves they cannot penetrate very deeply into matter like x- or gamma radiations.

C. ALPHA RADIATIONS

Like beta radiations, alpha radiations also cause ionization. Being very heavy and doubly charged they loose all their energy within a very short distance. Although they have a very short range of penetration they cause intense ionization.

D. PRODUCTION OF X-RAYS

Alpha, beta and gamma rays are all produced as a result of nucleus transformation. X-rays on the other hand are produced by a different method.

If a fast moving electron is suddenly stopped within a heavy target it releases its energy by a variety of means. A small portion is released in the form of x-rays with the majority of the electron's energy producing heat. The energy or the penetrating power of the x-rays increases with the speed of the electron i.e higher voltage-greater penetration. The penetrating power of the x-ray beam is known as the quality.

In x-ray machines the electrons released by a hot filament are speeded up by a high voltage and are made to hit a target made of a heavy metal such as tungsten. The quality of the x-ray produced is depended upon the magnitude of the high voltage used. The quantity or intensity of the beam on the other hand is related to the number of electrons which hit the target. A measure of this is tube current.

CHAPTER V

UNITS OF RADIATION

70184

UNITS USED FOR RADIATION WORK

When working with radiation it is necessary to understand the various units used for measuring different quantities and to understand the inter-relationships which exist. Definitions of units are given in the Glossary of Technical Terms. The more important definitions are discussed below.

A. UNITS FOR MEASURING RADIOACTIVITY

If equal weights of two different radioactive materials are taken, the one with the shortest half-life will give out more radiation than the other. From this it is seen that the weight of a radioactive material does not give direct measure of the amount of radioactivity. Radioactive units are therefore expressed in terms of the number of atoms that undergo radioactive transformations in a unit of time.

The accepted unit is the Curie. A curie of radioactive material is that quantity in which 3.7 x 10 to the tenth power atoms disintegrate per second (d.p.s.). A smaller unit is the millicurie which is equal to 3 x 10 to the seventh power d.p.s.

B. UNITS FOR MEASURING ENERGY OF RADIATION

While the curie gives information about the number of disintegrations it does not indicate the energy of the radiations being emitted. The unit used for this purpose is the electron volt abbreviated ev. One electron volt is equal to the energy gained by an electron in passing through a potential difference of one volt. Because the charge on the electron is very small, the electron volt represents a very tiny amount of energy. The energies of radiations used in isotope radiography are expressed in million electron volts as abbreviated Mev.

The energy of x-radiation is expressed in terms kvp. This is an abbreviation of kilovoltage peak and refers to the peak potential of the high voltages in the x-ray machine. It is not a direct measure of the energy of the radiation but since energy and tube voltage are related, it gives an indication of the quality of the radiation.

C . UNITS FOR MEASURING RADIATION DOSE

1. The Roentgen

The most important characteristic of alpha, beta, gamma and x-rays is their ability to ionize. We therefore measure the intensities of these radiations in terms of the degree of ionization produced in matter.

The unit chosen is called the Roentgen (R). This unit applies primarily to x- and gamma radiations.

A Roentgen is that quantity of x- or gamma radiation which when passing through air, at normal temperature and pressure, creates 2.08 x 10 to the ninth power ion pairs per cubic centimeter of air.

This is equivalent to the deposition of 83 ergs of energy per gram of air or 93 ergs if the radiations pass through human tissue (An erg is a scientific unit).

2. RAD

Since the Roentgen is not easily applicable to all systems, a new unit of absorbed dose is used when considering radiation damage in living tissue. The unit called the RAD is equal to that amount of ionizing radiation which imparts 100 erg/gram of energy. It is seen that the Roentgen and RAD are really not very different in value.

3. RBE

BRE stands for Relative Biological Effectiveness.

Different ionizing radiations can cause different amounts of biological damage for the same RAD dose delivered. Examples of this are alpha-radiations and fast neutrons both of which cause more damage than commonly used x- and gamma radiations. The RBE for x- and gamma radiations used in radiography is equal to 1.

4. REM

The REM is an abbreviation of Roentgen Equivalent Man and is related to RAD by the equation

$$REM = RAD \times RBE$$

Since the RBE for x- and gamma radiations is one, the REM and the RAD dose are the same. For expressing radiation doses the correct unit is the REM. A smaller unit is the milliREM (mrem) = REM/1000.

Since the Roentgen and the RAD are not very different, in many occasions the symbol R is used instead of REM and Mr instead of MREM.

D. RELATIONSHIP BETWEEN RADIATION DOSE AND SOURCE STRENGTH

The radiation dose at any given point from a radioactive source depends on (a) the source strength and (b) the energy of the radiations emitted. Unless the radiation from two different isotopes are very nearly identical, the radiation dose from equal quantities of each at the same distance is likely to be quite different. The radiation dose from 1 curie of different isotopes at various distances have been calculated for most industrial important isotopes and are available in handbooks and Table 1 below.

Radioisotope	Dose Rate R/hr/curie at 1 foot
Co 60	14.4
Cs 137	4.2
Ir 192	5.9
Ra 226	9.0

CHAPTER VI

ABSORPTION OF X- AND GAMMA RADIATIONS

ABSORPTION OF X- AND GAMMA RAY RADIATIONS

The practical aspects of radiation protection involves a knowledge of how various radiations behave as the are absorbed in matter, the selection of shielding materials and techniques which provide the best protection.

Absorption of Radiation

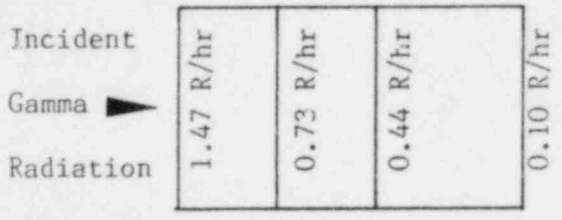
Gamma and x-rays behave in an identical manner. They are absorbed best by high density materials. the absorption of these radiations in shielding materials varies with:

(i) The energy of the incident radiation

(ii) The atomic number of the shielding material

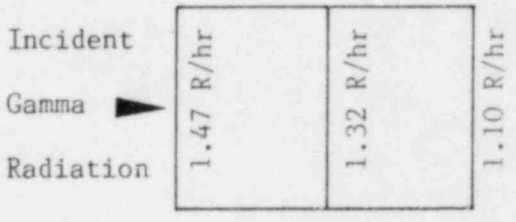
The three effects which take place in absorption are known as Photo-electric, Compton and Pair Production.

When a beam of gamma rays passes through a slab of shielding material, its intensity decreases as it penetrates the material. Consider an actual case involving a 1 curie Cobalt 60 source. Such a source produces 1.47 R/hr at 1 yard. If slabs of lead and concrete are used to shield the gamma radiation, the intensity at different points in the slabs are shown in Figure's 1 and 2.



LEAD

Figure 1.



CONCRETE

Figure 2.

It is to be noted how much more effective lead is at shielding than concrete. The reason is lead is more dense. Iron can be used but, it is not as good an absorber as lead although it is much better than concrete.

The types of materials most suited for shielding against gamma and x-rays are listed in their order of effectiveness. It was observed in f Figures 1 and 2 that it required 0.5" of lead to reduce the radiation dose to half its initial value. (This is true for Cobalt 60 only). Using this half value equivalent thickness for materials concept, one can select a material based on values shown in Figure 3.

	Isotope	
Shielding Material	Co 60	Ir 192
Uranium	0.35"	
Lead	0.49"	0.19"
Iron	0.87"	0.50"
Concrete	2.7 "	1.9 "

Figure 3. Half Value Layers of Common Shielding Materials

It is important to understand what materials provide the best shielding for gamma rays. In general, the heavier, denser ones are best.

ALPHA PARTICLE ABSORPTION

Although the energy of an alpha particle is usually high, its penetrating power is low. There is no danger of radiation external to the body since they are easily stopped.

Alpha particles have a limited range in air or any gas and although they are highly ionizing, their range in air is less than 3 centimeters. A severe hazard arises if they enter the body, i.e. through the mouth. Extreme local damage can be caused.

BETA PARTICLES

Beta particles are electrons released from an atom at various energies. The energies may range from 18 Kev for tritium to 4.81 Mev for chlorine 38.

Beta particles are absorbed in matter by loss of energy through the ionization of atoms within the absorber and conversion of part of the energy to x-rays (bremsstrahlung). The average distance a 3 Mev beta particle travels in air is 10 meters (33 feet). Materials of low atomic number such as plastics, wood and aluminum are used for beta shielding since these materials give rise to the least x-radiation.

SCATTERED RADIATION

Although we have to shield against primary gamma rays in industrial radiography, we are also concerned with scattered radiation from the primary or direct beam. Materials with high density or high atomic number are commonly used for the absorption of gamma rays but these also often create the most scatter radiation for example, tungsten, lead, uranium and steel. This effect is very much in evidence at the gamma energies in the Cobalt 60 and Iridium 192 range.

The total effect of scatter is to increase the dose in a particular area and so its presence and methods of shedding against scatter should be known/ This is particularly important when gamma sources are exposed in a room or an enclosed area.

Since scattered radiation is of comparatively low energy, thin sheets of lead are often very effective in shielding against it.

CHAPTER VII

SHIELDING METHODS FOR X- AND GAMMA RADIATION

SHIELDING METHODS FOR X-AND GAMMA RADIATION

Shielding plays a vital role in the protection against all types of radiation. It enables us to approach a gamma emitting source of high intensity without damage to the body. It is necessary to be able to use protective shielding for all types of operations with gamma sources without undue restriction. The various shielding materials have been discussed previously and methods are given now which will enable us to calculate how much shielding is required in any situation.

Half-Value Layer

A simple method of calculating the thickness or amount of the effective of the effective shielding may be employed by using the half-value thickness method. In this method, the thickness of absorber required to reduce radiation of a particular energy to one half of its original value is used to calculate the effect of the given thickness of shielding on the gamma field.

Most gamma fields are composed of a spectrum of energies. Thus when half-value calculations are carried out beyond four or five half-value layers, only the harder gammas are left, with the result that the true half-value layer becomes greater than the value of the first layers.

Tenth-Value Layer

The tenth value layer, similar to the half-value layer, is the thickness of shielding required to reduce the intensity of radiation to one-tenth its original value. Where the HVL and TVL values of a substance are not known a value for an element with slightly higher atomic number may be used. Table 1 shows the TVL and HVL for lead, iron and concrete for the four common isotopes.

Table 1

Table of Approximate TVL & HVL for Shielding

(thickness in inches)

Source	Lead		Iron		Concrete	
	TVL	HVL	TVL	HVL	TVL	HVL
Co 60	1.62	0.49	2.90	0.87	9.0	2.7
Ra 226	1.85	0.56	3.03	0.91	9.6	2.9
Cs 137	0.84	0.25	2.25	0.68	7.1	2.1
Ir 192	0.64	0.19		0.50	6.2	1.9

The dose rate emerging from a shielding material may be calculated as follows:-

The formula used is

$$\frac{Ao}{2^{n}} = Ap$$

where Ao is the original activity
Ap is the final activity
n is the number of HVL

Calculate the dose from a 1 curie Co-60 source at one meter with the beam passing through 2" of lead. Given that i curie of Co. 60 produces a radiation dose of 1.23 R/hr at 1 meter.

HVL (Table 1) = 0.5" of lead

The number of half-value layers therefore is $\frac{2}{0.5} = 4$

Substituting in the formula

$$\frac{Ao}{2^{n}} = Ap \qquad \frac{1.23}{2^{4}} = \frac{1.23}{2 \times 2 \times 2} = \frac{1.23}{16}$$

$$= 0.08 \text{ R/hr}$$

Inverse Square Law

The intensity of gamma radiation decreases in proportion to the square of the distance from the source. The following formula may be used to calculate radiation fields at different distances from the source.

$$\frac{I^{A}}{I^{B}} = \left(\frac{D^{B}}{D^{A}}\right)^{2}$$

where I^{A} is the intensity at distance A

I^{B} is the intensity at distance B

D^{A} is the distance from the source to point A

D^{B} is the distance from the source to pcint B

70184

Example 1.

Find the intensity of the radiation from a gamma source at 20 feet if the reading taken at 2 feet is 600 mr/hr.

By transposing terms the formula becomes

$$I^B = I^A \left(\frac{D^A}{D^B} \right) 2$$

where $I^A = 600$ mr/hr

$D^A = 2$ feet

$D^B = 20$ feet

$$I = 600 \times \frac{2}{20}^2$$

$$= 6 \text{ mr/hr}$$

Example 2.

Find the radiation from a point gamma source at 10 feet if a reading taken at 20 feet is 100 R/hr.

We are given $I^A = 100$ R/hr

$D^A = 20$ feet

$D^B = 10$ feet

then $I^B = 100 \times \frac{20}{10}^2$

$= 400$ R/hr

Relationship between Dose Rate and Activity

The value of dose rate per curie at a unit distance for a gamma emitting radioisotope have been calculated separately. This information is very important when determining the dose rate from a radiography source of known activity. Table 2 lists values of gamma intensities at 1 yard an 1 meter for various sealed radioisotopes.

Table 2

Calculated Gamma Radiation Levels

for one Curie

Isotope	1 curie at 1 yard R/hr	1 curie at one meter R/hr
Ir 192	0.71	0.59
Co 60	1.47	1.23
Cs 137	0.36	0.30
Ra 226	1.005	0.84

Radioactive Decay

When calculating dose rates from gamma emitting sources, the decay in the activity of the source must be considered. For example, if a Cobalt 60 source with an initial activity of 10 curies has been in a radiography device for 2 years its activity will have decayed to 7.7 curies or about three quarters of its original value. Radioisotopes decay at different rates, and the decay rate cannot be changed by any known means. This decay rate is expressed as the half life of an isotope.

Half Life

A half life is the period of time for one half of a given number of radioactive atoms present to decay. The half lives of some of the common radioisotopes are listed:

Cobalt 60	5.24 years
Cesium 137	30 years
Radium 226	1622 years
Uranium 238	4.51×10^9 years
Iridium 192	74. days

The following example illustrates how half life is important in determining dose rate.

Example

What dose rate is obtained at 3 yards from an Iridium 192 source originally of 10 curies activity and known to be 370 days old.

Since the half life is 74 days, the number of half lives is

$$\frac{370}{74} = 5$$

applying the formula

$$\frac{Ao}{2^n} = Ap \qquad \frac{10}{2^5} = \frac{10}{2 \times 2 \times 2 \times 2 \times 2} = 312 \text{ mc}$$

Table 2 indicates that the intensity of 1 curie of Ir 192 at 1 yard is 0.61 R/hr, thus at 3 yards this will be

$$I = 0.61 \times \frac{1}{3} = \frac{0.61}{9} = 0.068 \text{ R/hr}$$

But since the activity is now only 312 mc the dose will be

$$\frac{0.312}{1.0} \times 0.068 = 0.021 \text{ R/hr or } 21 \text{ mr/hr}$$

The aim of the radiographer and all personnel working with radioactive sources should be to reduce the exposure to a minimum. This can always be done by suitable choice of the three factors of shielding, distance and working time.

CHAPTER VIII

EFFECT OF IONIZING RADIATION ON THE HUMAN BODY

EFFECT OF IONIZING RADIATION ON THE HUMAN BODY

Over-exposure to ionizing radiation can result in two types of injuries.

1. Somatic Effects - injury to the individual exposed.

   (a) Local effects

   (i) erythema (reddening of the skin)
   (ii) epilation (loss of hair)
   (iii) bone necrosis (destruction and death of bones)
   (iv) cataracts (opaque spots in the pupil of the eye)

   (b) Systemetic Effects

   (i) leucopenia (decrease in the number of white blood cells)

   (ii) sterility

   (iii) cancer, e.g. leukemia

   (iv) shortening of life span

2. Genetic Effects - damage to the genes (heredity determiners) increases the number of mutations (altered characteristics of the offspring) in the future generations; however this damage is not apparent to the person exposed.

   The production of a mutation is a chance occurrence and it is possible that any amount of radiation, no matter how small the dose, can produce a damaged gene. Of course an increase in the radiation dose also means the greater are the chances of mutations occurring.

A. SINGLE EXPOSURES

The dose required to kill one individual is not a good measure of the lethal dose to others because of individual differences. Therefore scientists have derived a term called LD/50 or the so-called median lethal dose. This is the dose required to kill 50 percent of the subjects exposed. The LD/50 for penetrating external radiation e.g. gamma rays is about 500 rads delivered to the total body within a 24 hour period or less.

Both the amount of the body exposed and the time period over which the exposure is received are very important.

The effect of 1000 rads of x-ray delivered to the total body is by no means the same as 1000 rads delivered to a small portion of the body, as for example, in radiation therapy where dose rates as high as 2000 rads or more may

be used for treatment of a specific area and the patient not only survives but recovers. This effect may be compared to the chances of survival after a third degree burn of the total body and a third degree burn of only the palm of one hand.

Similarly the time element is important. The ability of the body to withstand abuse is increased if the same amount of abuse given to the body is spread over a longer period of time. For example, some people can drink, without any apparent injury, an ounce or two of whiskey each day over an extended period of time. If, however, the same person attempts to drink three month's quota of whiskey all in one sitting, they very likely will die of alcoholic poisoning because their body has not been given enough time to recover from the poison.

Figure 1.

Effects of External Radiation

(Total Body Exposure Within 24 Hours)

500 rads - half die

200 to 250 rads 1st death

100 rads - nausea, fatigue etc.

50 rads - slight temporary blood changes

25 rads - no detectable effects

In practice the figures quoted above are seldom received in peacetime operations unless there is a gross violation of Safety Regulations.

B. CONTINUOUS EXPOSURE

We all receive a certain amount of this type of exposure to radiation from natural sources. In addition atomic energy workers will be exposed to small amounts of radiation as part of their work. The minimum possible exposure is always the desired goal, but for practical purposes, maximum permissible limits have been set by the United States Nuclear Regulatory Commission. (These will be dealt with in the next chapter).

If these Regulations are followed, little undesirable effect from radiation is to be expected.

CHAPTER IX

RADIATION SAFETY STANDARDS

RADIATION SAFETY STANDARDS

A. BASIS AND PHILOSOPHY

Safety practices have been set by international and national authorities defining the maximum permissible radiation dose (MPD) which a worker can receive in a given period of time.

The MPD is the dose which experts say will cause negligible harm. If it is exceeded it does not mean that harm will follow: but there is an extra risk that is judged undesirable.

The MDP is set a very long way below the point that would produce radiation sickness or any other observable effect. It is necessary to set them extremely low because of the risk of long term hazards such as leukemia, cancer and genetic damage.

The long term hazards of radiation depend on the sum total of all radiation exposure received throughout life. In other words radiation exposures are cumulative in their effect, like lead poisoning or cigarette smoking. Which is to say that the cigarettes smoked today probably will not harm you but it is the total number you have smoked of the years that count.

The MPD, roughly speaking, is about 50 times higher than the "natural background" dose; that is the radiation everyone receives from cosmic rays, natural radioactivity etc. in the environment.

The MPD for members of the general population is (1/10) one tenth the dose allowed a radiation worker. The reason for this is that the general public includes children and other especially sensitive individuals.

The different tissues and organs of the body differ in their sensitivity to radiation; therefore different MPD's have been set for different organs. These can be used when appropriate, but expert knowledge is needed. For example, special MPD for skin doses is set but is applicable only if the radiation is of a type that does not penetrate much below the skin.

When radioactive material gets into the body it can cause internal exposure. Both internal and external exposures must be taken into account in considering the MPD.

It is important to distinguish carefully between the "dose rate" at a given instant, such as is measured by a survey instrument, and total dose over a period of time. The MPD refers to the latter.

The TLD monitoring report is the best way of assessing external exposures in relation to the MPD because it gives the total dose over the periods of time to which the MPD refers; that is, annually, quarterly and "lifetime". The MPD is always calculated as being in addition to the natural background and medical x-ray doses.

B. INTERNATIONAL STANDARDS

The recommendations of the International Commission on Radiological Protection (ICRP) are generally accepted throughout the world. There are detailed and too complicated for discussion in this material.

C. UNITED STATES NUCLEAR REGULATORY COMMISSION

A body of law, the Atomic Energy Act of 1954, authorizing the United States Nuclear Regulatory Commission and its Regulations provides the standards framework for the United States. The specific reference here is made to Title 10. Chapter 1. Code of Federal Regulations - Energy, Part 19, 20, 21 and 34. The portions of these documents relevant to industrial radiography are discussed in detail elsewhere in this material.

TABLE 1

MAXIMUM PERMISSIBLE DOSE

(REMS Per Calendar Quarter)

whole body, head and trunk, active blood forming organs, lens of the eyes or the gonads	1.25 REM
hands and forearms,. feet and ankles	18.75 REM
skin of whole body	7.5 REM

a whole body dose which exceeds the above may be permitted provided -

1. During any calendar quarter the total occupational dose does not exceed 3 REM.

2. The dose to the whole body when added to the accumulated occupational dose to the whole body shall not exceed 5(N-18) REMS where "N" equals the individuals age in years.

3. The licensee has determined the individuals prior occupational dose as per 20.102.

CHAPTER X

SURVEY INSTRUMENTS

70184

SURVEY INSTRUMENTS

A. General:

1. Ionizing radiations, unlike light or heat, cannot be detected by our normal senses. Consequently it has been necessary to develop instruments which will detect and measure the various types of radiation emitted from radioactive materials.

2. Principles of Operation

Ionization of materials in which radiation is absorbed is the most important principle of radiation detection.

3. Methods of Ionization Detection

Although there are various methods of detecting ionization employed in survey instruments; only Geiger Mueller (G.M.) tube and "ion chamber" instruments will be discussed since most survey instruments used in industrial radiography use either technology.

To measure a quantity of radiation requires knowledge of the amount of ionization produced in a known volume of air (or specified gas). Also the ions ionized by radiation move around in a haphazard manner and will eventually recombine if not influenced by other forces. When Gieger Mueller tubes and ion chambers are switched on an electrical field is established in the confined volume of gas by the two oppositely charged surfaces (electrodes). In this situation the negative ions will move to the negative electrode (cathode), while the positive ions will move to the negative electrode (cathode). This results in a flow of current as a short pulse. The number of pulses or flow of current is a measure of radiation and is read off as a radiation rate on the instrument's meter.

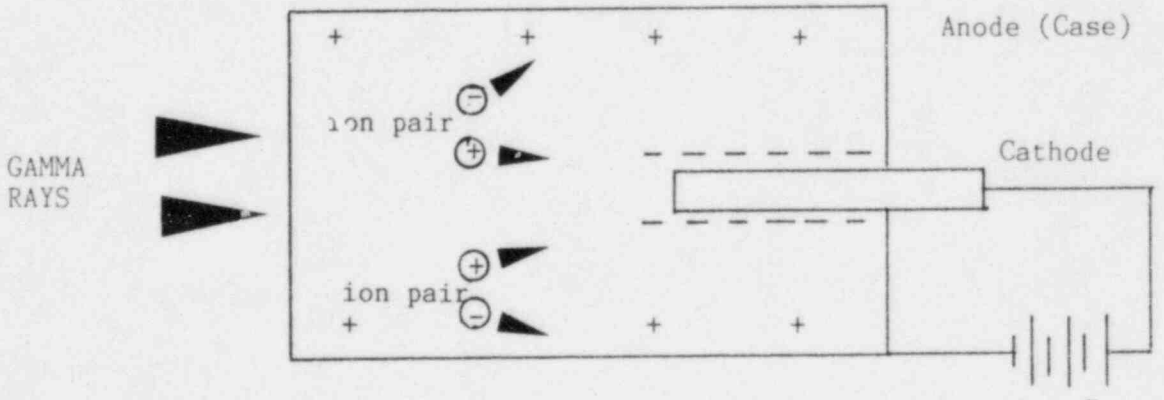


Figure 1. General Arrangement of Geiger Mueller and "Ion" Chambers

5. (a) IONIZATION CHAMBER INSTRUMENTS

The ion chamber consists of an enclosed volume of air or gas having a central electrode in the chamber maintained at an electrical potential in relation to the chamber wall. The wall is the cathode and the central electrode is the anode. This type of instrument is generally used to measure relatively high levels of radiation since the type remains sensitive at high levels.

(b) THE GEIGER MUELLER INSTRUMENT

The G.M. tube consists of a gas-filled tube similar in form to the ion chamber. However the ions created by the radiation are accelerated by a much higher electrical potential applied to the electrodes. This causes secondary ion pairs resulting from collisions with gas molecules within the tube; and as a result, this type of instrument is very sensitive at low radiation levels. However the tube can become overloaded in high fields of radiation. When this happens the meter needle will tend to return to the zero mark on the scale. THIS IS A VERY FALSE INDICATION. The Radiographer should know which type of instrument he is using and any operating peculiarities of the instrument for this reason.

THE SATURATED METER TRAP (Meters that Saturate)

Normally, a rise in the radiation level will be observed as the source is retracted toward the device and the meter reading should fall to zero when the source is in its safe position. However the source may not be completely withdrawn but the device provides sufficient shielding toward the control to lead the Radiographer to believe the source is in the safe position because the survey meter is reading zero. Should the Radiographer approach the device without carefully monitoring his meter as he moves toward the device, he may suddenly emerge from the shadow of the device's shielding; the meter will saturate and may fall to zero without being observed. Should this occur as described, the Radiographer is indeed in a very high radiation field. If it is possible to lock the device without the source in the safe position the Radiographer may proceed forward to the exposure location to remove or change film without being aware of his situation. The Radiographer may suddenly observe a very high meter reading gradually reducing in intensity as he continues forward. This occurs because the meter unsaturates but is still located in a very high radiation field and as the Radiographer moves forward, the field decreases in intensity. If the Radiographer is not observant, he may well proceed to change film or otherwise remain in a very high radiation area for an extended time, unlock the device and walk back to the control position without being aware that the source was unsafe.

Because this scenario has occurred many times resulting in serious overexposures to Radiographers and Assistants, Federal regulations and the Company Safety Manual requires that the survey meter be carried forward in one's hand and observed as the exposure device is approached.

Since meters which do not saturate will read off-scale on very high radiation, the Radiographer can determine if the instruments he is using are a type that will saturate. Place the instrument near the delivery tube at the front of the device and where the meter dial is clearly visible from the control. Crank out the source. The meter dial should "peg out" at the top of the scale and stay "pegged out" on meters which do not saturate. If the meter "pegs" and drops back to zero or near zero within a second or two the meter has saturated. Withdraw the source into the device. This procedure should not be attempted without a backup meter at hand because a saturated meter would not indicate the high radiation field if the source hangs up outside the device.

THE BATTERY CHECK TRAP

Radiographers should realize that a battery check in the "green" does not insure that a meter is capable of detecting and measuring radiation. The detector tube may be broken or the instrument otherwise unserviceable but the battery will check as satisfactory.

The Radiographer can insure that he has a functioning survey meter if he follows Federal regulations and the Company Safety Manual. A survey of the device is required before removing the device from storage. A survey meter is also required at hand when attaching the controls and exposure tube to the device. A survey of all sides of the device is required before locking it after each exposure also. Radiography devices always have a small surface radiation which is detectable by each and every survey described above; and with all survey meters used in industrial radiography. When any of these surveys are made and the meter registers the device's surface field, the radiographer can be satisfied that the instrument is at least capable of detecting radiation. He has no assurance that the instrument is in calibration however.

If the battery check is satisfactory but there is no surface reading from the device, the instrument is unserviceable.

Radiation Surveys Under Arctic Conditions

Radiographers and Radiographers Assistants must be aware that the useful life of the batteries commonly used in survey meters is substantially reduced in the Arctic temperatures. In fact they freeze after a short time and are totally useless when frozen.

Radiographers must take extraordinary precautions to ensure that batteries do not freeze. This is not too difficult in our operation even in Arctic conditions. Our exposure times always permit the crew to return to warmth of the vehicle and the meter should be accompany the crew and be placed in the full blast of air from the heater.

CALIBRATION

Purpose

Radiation instruments are calibrated to ensure that the instrument is giving accurate information.

Method

A convenient procedure for calibration is to utilize the inverse square law. The dose rate from a source of known strength at various distances can be calculated and compared with readings on the survey meter. The calculated readings should be approximately the same after calibration of the instrument.

Calibration Procedure

NRC regulations require that an approved calibration procedure be established by the licensee if the licensee wishes to calibrate his survey instruments 'in house'. Third party calibration procedures must also be approved by NRC and the Company providing calibration service must be named on the licensee. Ultra Technology Inc. sends its survey instruments to those companies shown on Page B - 2 of 2 of the Operations Manual.

NRC regulations also require recalibration of survey instruments at intervals not greater than 90 days. It is managements responsibility to ensure that only 'legal' survey instruments are used in radiography operations.

Maintenance And Care

The survey instrument is a delicate instrument and must be treated accordingly at all times. It can prevent unnecessary exposure to the radiographer only when in proper working condition, and if used correctly.

Before use, the survey meter should be checked by the radiographer to ensure that -

(a) The calibration certificate is current.

(b) The instrument is capable of detecting Radiation

(c) The batteries are not weak.

(d) There are no physical defects.

CONFIRMATION OF CALIBRATION IN THE FIELD

Should the radiographer have only one survey instrument available and during operations have reason to question of his only meter (because it was dropped or other reason), he may test the accuracy of the instrument as follows

1. A survey of the projector is required to determine the radiation level 6" from the surface of the device before it is removed from storage. This number is available from the 'Stored Location" column of the Utilization Log (Page 5 - 17 of 19 in our Operating Procedures Manual). If the Radiographer again determines the 6" from the surface reading, (obtained with the source retracted), is a close match to the logged number it is safe to assume the meter is still in calibration.

2. Regulations also require a barrier at the 2 mr/hr level or lower. Although in practice, for convenience, barriers may be erected at lower radiation levels, the Radiographer should have at least one point on the barrier where the radiation level is known. If he returns to that point and the meter reading is unchanged, he can be assured his meter is in calibration.

3. Although not as dependable as the procedures in 1. and 2. above a the following procedure can be employed. With the source in the expose position, and knowledge of the source strength (from the decay chart which accompanies the source) and the distance from the exposed position to the control, the radiographer can calculate the approximate dose rate at the control and compare the calculated and the actual reading. The meter may be used if the readings are within 10%, but the meter should be checked for agreement with another calibrated meter before the next shift.

Before leaving the discussion of survey instruments it should be pointed out that there are two distinct types of instruments.

1. Dose Rate Meters

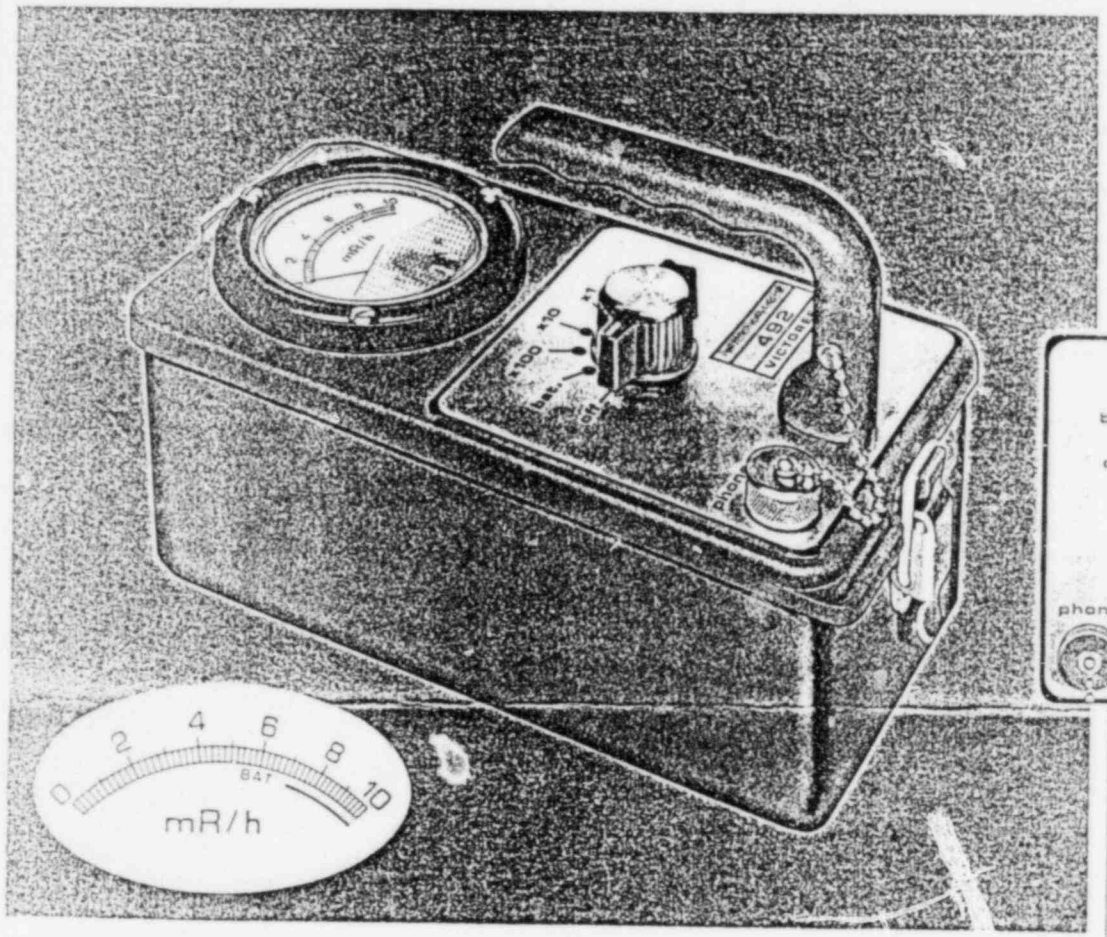
Dose rate meters produce a current when ionization occurs which is read after amplification, on a microammeter whose scale is calibrated in suitable units e.g. mr/hr. The majority of meters used for surveying in industrial radiography are this type.

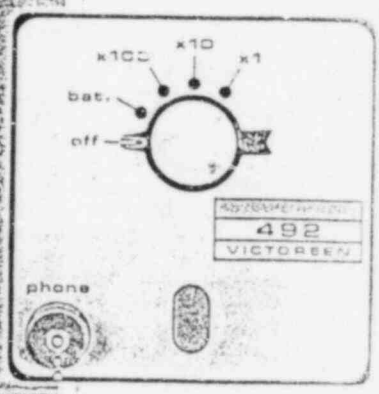
2. Integrating Dosimeters

An integrating dosimeter is designed to measure the total amount of radiation received. They are used commonly in industrial radiography but are not used for survey purposes where rate per unit of time is measured. Common pocket dosimeters, film badges and TLD's such as the personal monitoring devices are examples of integrating dosimeters.

RADIOGRAPHIC . . . GM

MODEL 492 / SURVEY METER





- Simple, Lightweight, Rugged Design . . . Ideal for Industrial Radiography.
- Operates on Two Flashlight "D" Cells with Built-In Battery Check.
- Regulated High and Low Voltage Assures Reliable Readings.
- Energy and Temperature Correction . . . Foremost in Victoreen Survey Meters.

Ideal for field survey work, Victoreen's Model 492, completely self-contained Radiographic Survey Meter, is designed to meet 10 C.F.R. 34 regulations. Energy correction is another outstanding feature of this rugged and dependable survey instrument where minimal scatter radiation is encountered. Powered by two standard "D" cells, the lightweight 492 provides a reliable means of making industrial radiographic measurements.

Rugged and Dependable, the 492 G-M Survey Meter Is the Economical Solution for NDT Radiographic Applications. Helps Radiographers Fulfill Requirements of 10 C. F. R. 34 Regulations. Reliable Operation and Aural Signal Assure Positive Identification of Radiation Fluxes Above 70 keV.

SHELLER-GLOBE CORPORATION

VICTOREEN INSTRUMENT DIVISION
10101 WOODLAND AVENUE • CLEVELAND, OHIO 44104

MODEL 192

Radiation Detected: Gamma and X-ray.

Operating Range: 0-10, 0-100 and 0-1,000 mR/hr in three linear ranges.

Accuracy: ±20% of fullscale on all ranges when calibrated with ^{137}Cs.

Detector: Halogen-quenched, internally mounted G-M tube. Shielded with lead foil for energy correction.

Energy Dependence: 70 keV to 1.2 MeV, ±20%. Instrument normally calibrated with ^{137}Cs.

Warmup Time: None

Exposure Rate Limitations: Has been tested to over 1000 R/hr and meter continued to indicate fullscale.

Response Time: 90% of final reading in 10 seconds.

Drift: Utilizes a hard zero, negligible amount due to normal component aging.

Zero Adjust: Uses a hard zero, eliminates need for adjustment.

Environmental Effects:

Temperature Operating Range: -20° to +120°F (-30° to +50°C) with alkaline batteries.

Temperature Dependence: Within ±20% over above temperature range.

Humidity Range: 10 - 95%; less than 5% change at 95% relative humidity over 24 hours.

Power Requirements:
Battery Complement and Life: Two (2) "D" size cells, NEDA Type 13 or 813. 150 hours at 4 hours/day with standard carbon-zinc batteries.

Controls: Five-position rotary switch for power and range functions marked; Off, Battery, X100, X10 and X1. External connector for loudspeaker or earphone output.

Readout: Meter; 3 in. (7.7 cm) scale marked 0-10 in units of mR/hr.

Geotropism: Within ±2% of fullscale.

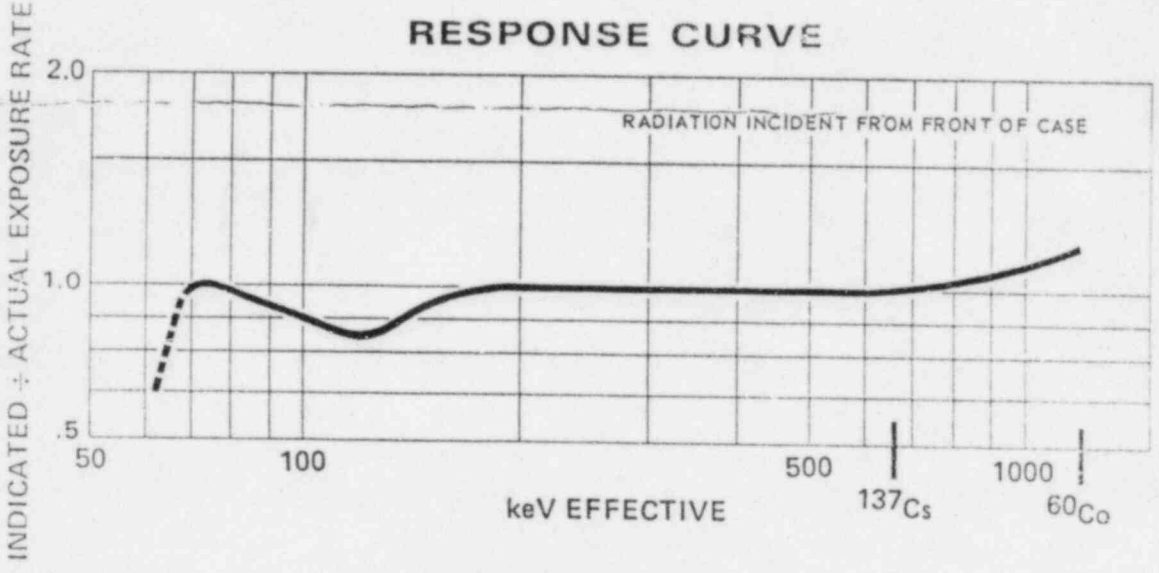
Construction: Splash-proof, shockproof, two-piece all metal case. Cast aluminum top and drawn aluminum bottom with mar-resistant grey matte finish.

Overall Dimensions:
4-1/2 in. (11.4 cm) wide
8-3/4 in. (22.2 cm) long
6-5/8 in. (16.8 cm) high, including handle.

Net Weight: 3.5 pounds (1.6 Kg).

Shipping Weight and Volume: 8 pounds (3.6 Kg), 1.5 cu. ft. (0.042 m^3).

RESPONSE CURVE



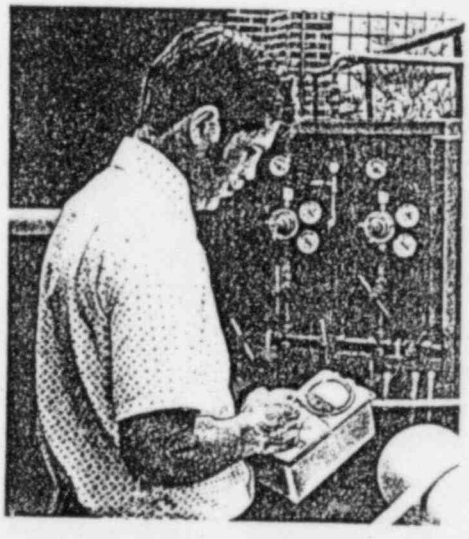


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FIGURE 4. Eberline PNR-4

A. Description: Portable, neutron detecting instrument using a cadmium loaded, polyethylene sphere with BF_3 proportional counter in the center. Energy response roughly parallels tissue rem response. Relatively insensitive to gamma rays.

B. Applications: Used for detection and measurement of neutrons with energies ranging from thermal to approximately 10 MeV. Useful exposure rates are from approximately 1 mrem/hr to 5 rem/hr. Insensitive to gamma rays up to 500 R/hr, depending on certain instrument adjustments. Earphones or speaker device can be attached for detection of low neutron levels.

C. Use Instructions: Scale switching and use of multiplying factors are eliminated by LIN-LOG presentation with two pointers, each covering two "linear" decades; reading is given by pointer that is on scale. Relative rem response vs energy and radiation protection guide (RPG) dose curves are given below in item F. Detector may be detached from rest of instrument for remote monitoring. Requires five standard "D" cells; battery life is about 200 hours. For temperatures below 0°C use alkaline batteries.

D. Specifications:

Detector: Nine-in. diameter, cadmium loaded, polyethylene sphere with a BF_3 proportional counter tube in the center.

Detects: Neutrons from thermal to about 10 MeV in rem/hr.

Ranges: Four "linear" decades with full-scale readings of 5, 50, 500, 5k millirem.

Accuracy: Within ±8% of full scale of decade in which it is reading, exclusive of energy dependence and ±10% directional response.

Response Time: From 12 sec to 0.3 sec, depending on decade.

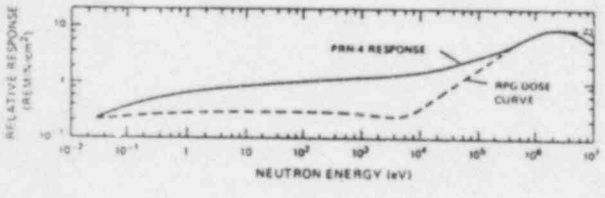
Controls: Switch: Off-On-Batt.

Weight: 8.9 kg.

Dimensions: 24 cm L × 23 cm W × 43 cm H.

E. Calibration: On calibration range to Pu-Be neutrons up to 800 mrem/hr; electronic pulser verifies scale linearity at higher readings. All points must indicate within ±20% of actual levels. Checked for lack of gamma-ray response at 10 R/hr. Routine recalibration scheduled for every three months.

F. Energy Response



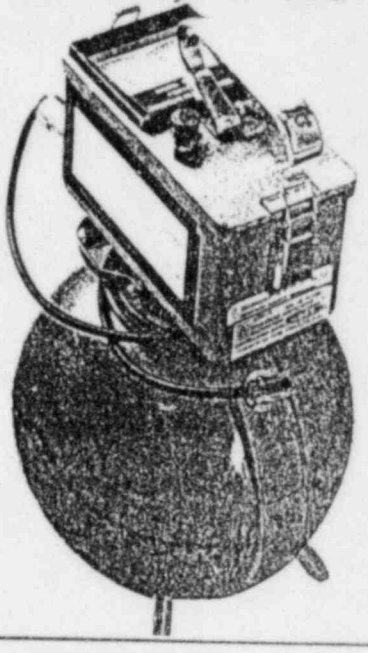


FIGURE 3. Eberline E-112B

A. Description: Sensitive, rugged survey meter using thin-walled, halogen GM tube in a hand probe with a beta discriminating shield. Pulse count-rate circuit does not paralyze in radiation levels up to ten times maximum measurable level. Phone jack provided.

B. Applications: Used for low-level radiation measurements from background up. External probe provides versatility for area and surface monitoring. Movable shield is used to discriminate between beta and gamma radiations. Earphones or speaker device can be attached for fast detection of low-level contamination.

C. Use Instructions: No warm-up time. Gamma-ray energy response is given in item F below. Interpretation of beta-ray response is dependent on source material, distribution, and geometry. Response time of meter can be varied to suit the application. Requires one 67.5 V battery and five 1.34 V mercury cells; approximate battery life is 200 hours. Operation is not reliable in environments below 0°C.

D. Specifications:

Detector: Halogen-filled GM tube with 30 mg/cm² stainless steel wall. Dimensions of probe approximately 3 cm diameter × 16 cm long.

Detects: γ, X-ray—20 keV to several MeV. β-ray—>200 keV.

Ranges: 0-0.2, 0-2, 0-20 mR/hr.

Accuracy: Within ±15% of full scale, exclusive of energy dependence.

Response Time: Controllable between approximately 2 and 10 sec.

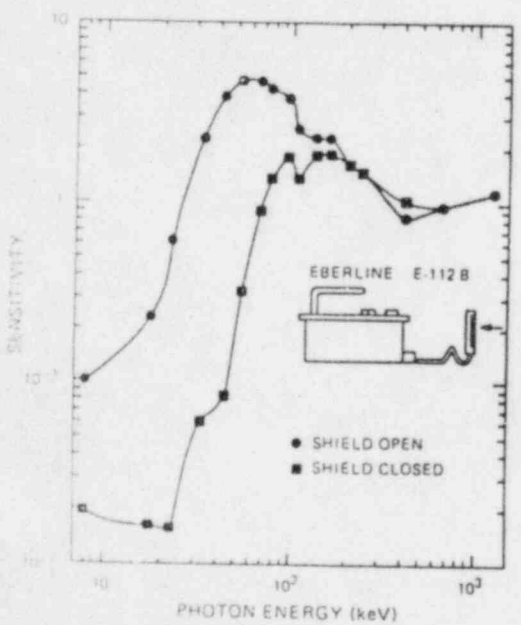
Controls: Switch: power-range. Pot: variable meter response.

Weight: 1.8 kg.

Dimensions: 15 cm L × 7.6 cm W × 16.5 cm H.

E. Calibration: On calibration range to ^{60}Co radiation at four points on scale for each range. All points must indicate within ±20% of actual levels. Routine recalibration scheduled for every six months.

F. Energy Response



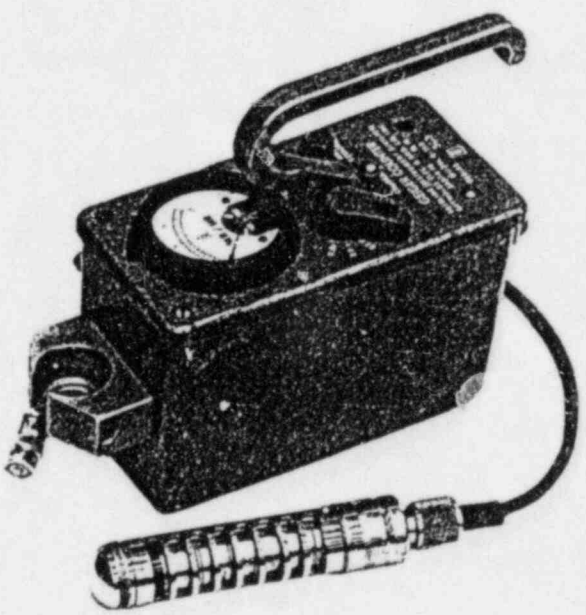


FIGURE 1. Victoreen 440

A. Description: Sensitive, relatively accurate ion chamber survey meter. Nonsealed ion chamber with very thin end window permits measurement of photon, beta, and alpha radiations. Very stable circuit with reasonably long useful battery life.

B. Applications: Used for reliable measurements of photon radiation levels over wide range of energies and to show the presence of energetic beta and alpha radiations.

C. Use Instructions: Warm-up time for most applications is approximately ½ minute; for greatest accuracy allow about 3 minutes. Directional response and effect of end cap are shown in response curves in item F (chart below). Requires four "D" size cells; has approximately 100 hours battery life at four hours operation per day. For temperatures below 0 °C use alkaline batteries.

D. Specifications:

Detector: Unsealed air ionization chamber with 3 mg/cm² end window. End window cap for higher photon energies and for alpha and beta discrimination.

Detects: γ, X-ray—7 keV to several MeV. β-ray—>100 keV. α-ray—>4 MeV.

Ranges: 0-3, 0-10, 0-30, 0-100, 0-300 mR/hr.

Accuracy: Within ±10% of full scale, exclusive of energy dependence.

Response Time: (0-90% of final reading): 20 sec on 0-3 mR/hr. 12.5 sec on all other ranges.

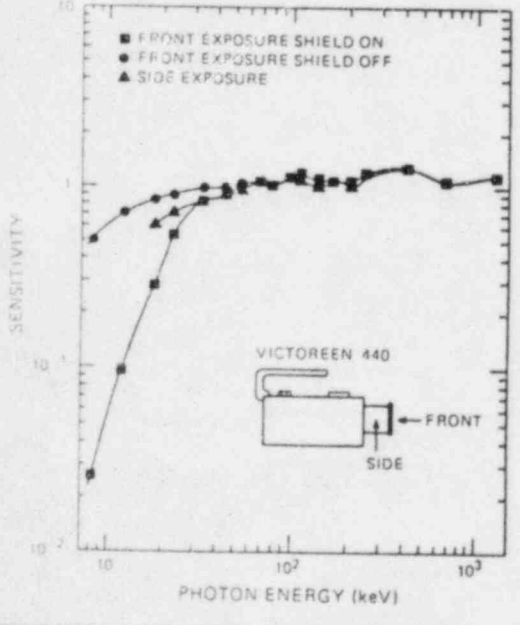
Controls: Single switch: Power-battery check-range. No external zero or calibration.

Weight: 2.26 kg

Dimensions: 25 cm L × 10 cm W × 19 cm H.

E. Calibration: On calibration range to ^{60}Co radiation at four points on scale for each range. All points must indicate within ±20% of actual levels. Routine recalibration scheduled for every six months.

F. Energy Response



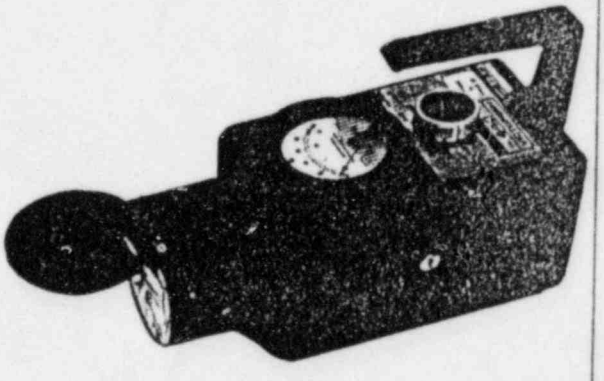


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FIGURE 2. Baird Atomics 904-416 CP; Victoreen 740C

A. Description: "Cutie pie" gun-type survey meter using a nonsealed ion chamber with very thin end window to permit measurement of photon, beta, and alpha radiations.

B. Applications: Used for general monitoring around reactors, accelerators, and X-ray machines. Large-area, thin end window allows meaningful measurements of activities of many isotopes. Removable end cap provides beta discrimination and electron equilibrium for high energy gamma radiation.

C. Use Instructions: Approximately 1 minute warm-up time; zero control allows subsequent drift to be essentially eliminated. Gamma-ray energy response and effect of end cap are shown in item F below. Requires four 22.5 V batteries and one 1.34 V mercury cell; has approximately 200 hours battery life. Unsealed ion chamber uses standard air density correction factors.

D. Specifications:

Detector: Unsealed ion chamber with 0.7 mg/cm² end window. End window cap for higher photon energies and for alpha and beta discrimination.

Detects: γ, X-ray—20 keV to several MeV. β-ray—>40 keV. α-ray—>3.5 MeV.

Ranges: 0–100, 0–1000, 0–10k, 0–100k mR/hr.

Accuracy: Within ±10% of full scale, exclusive of energy dependence.

Response Time: (0-90% of final reading): 3.5–7.5 sec, depending on range.

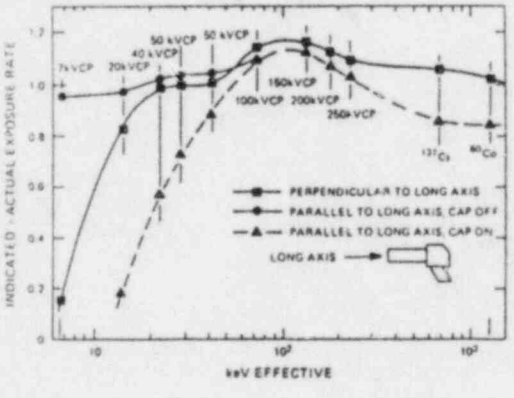
Controls: Rotary switch: Off-Batt-Zero-Range. Rotary zero adjust.

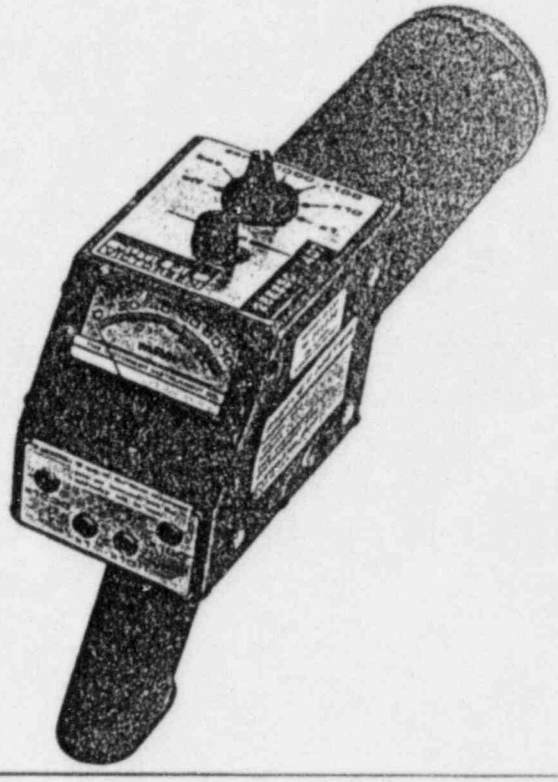
Weight: 3.6 kg

Dimensions: 29 cm L × 8.9 cm W × 22.7 cm H.

E. Calibration: On calibration range to ^{60}Co radiation at four points on scale for each range. All points must indicate within ±20% of actual levels. Routine recalibration scheduled for every three months.

F. Energy Response





CHAPTER XI

RADIATION SURVEY REQUIREMENTS

RADIATION SURVEY REQUIREMENTS

1. In general, a radiation survey is required whenever a source is manipulated or moved. Specifically, a survey must be carried out when

   a) Removing the source and its exposure device from storage. This requirement applies if the source is being removed for a radiographic operation or any other time a source is moved from its designated storage.

      Page 5 - 5 of 19 of the Radiation Safety Manual that the Radiographer carry out this survey to determine that the radiation level 6" form the surface does not exceed 50 mr/hr. This survey is accomplished as follows.

      Determine where the Gieger Mueller or ionization chamber is located within the survey instrument in use. Locate the tube 6" from the surface of the device an a line drawn 90 degrees from the side of the device and note the radiation level is not greater than 50 mr/hr. Maintain this distance as the meter is moved around the sides, ends, top and bottom of the device.

      Record the radiation level in the "stored location" column of the Daily Utilization Log - page 5 - 17 of 19.

   b) A survey of the outside surfaces of the transporting vehicle is required to ensure that no surface reading exceeds 2 mr/hr at 18" from any outer surface or in the drivers compartment. The results of this survey are to be entered in the "stored location column" of the Daily Utilization Log. Note that two entries are required in the same column. Enter both measurements in this column as shown below.

Stored Location
20
2

where 20 is the 6" from the surface reading and
2 is the reading at 18" from the surface of the vehicle

c) Although not specifically defined as a survey, the requirement that a survey meter be in use when the controls and source delivery tubes are assembled and disassembled, in reality is a radiation survey. It is requirement is that that the survey meter be turned on and the meter visible to the Radiographer at all times he is working with an exposure device.

For instance, what could happen if the Radiographer removed the safety plug, removed the rear dust cap, unlocked the device and upon attempting the hook-up requests his Assistant to crank out an inch of control cable. The Assistant complies but drops the crank on a rock in such a way that the handle turns and extends more than the required inch the Radiographer expects. Obviously the source is going to move out of the safe position and subject the Radiographer to a higher than expected radiation field.

Never trust an exposure device with the safety plugs removed. Always approach the device with a survey meter (turned ON) in hand.

d) A radiation survey of the posted "Restricted Area" i.e. the 2 mr/hr level, is required by NRC Regulations and the Company's License.

Note that our license requires that the perimeter of the Restricted Area is determined by calculation using source strength, distance and shielding. The perimeter in not established by cranking out the source and using the survey meter to determine the location of the 2 mr/hr line around the source.

Once the 2 mr/hr perimeter is established and barriers erected, the perimeter radiation level is measured to ensure that the actual radiation field at that point does not exceed legal limits. If it is found that this limit is exceeded, the source is to be withdrawn and the barriers moved or additional shielding provided to obtain this limit.

e) A radiation survey is required when the source is withdrawn at the completion of an exposure. This is a very important survey and must be conducted as follows -

i. With the meter held in front and observing the survey meter, approach the device and determine that the source has withdrawn to its safe position by measuring the the radiation field on the surface of the device. (Just determining that there is not a huge field from an exposed source is not good enough).

ii. Lock the device.

iii. Observing the survey meter proceed to the end of the exposure tube and service the film.

iv. Return to the device, unlock it and return to the controls.

f) A survey must be conducted when the source is placed in the transporting vehicle to ensure that the radiation level 18" from any exterior surface or in the drivers compartment does not exceed 2 mr/hr. If the reading is 2 mr/hr or less enter a 2 beside the 2 entered in the "stored location" column. The result could read 22 or 2/2, but either way the Radiation Safety Officer will know that the required surveys were made and safe levels existed.

g) Should the Company at some future time operate from a fixed location where a storage vault is provided, a survey of the vault, by the Radiographer returning the source to the vault, will be required and recorded.

h) Radiation surveys are required when new sources are received and spent sources returned to the supplier. The required radiation levels for various labels are quite specific and are shown on Page I- 2 of 8 of our Safety Manual. Note that these surveys must be completed within three hours of receipt of the source.

i) Source transfers from the source changer/shipping container to the exposure device must be monitored and the device, changer or shipping container surveyed upon completion of the transfer. A survey of the exposure device is made as described earlier to ensure that the 6" from the surface limits are not exceeded. In the same manner, the surface of the source exchanger is surveyed to assure that the spent source is safely positioned.

j) A radiation survey is required to ensure that the packaging of the spent source complies with the labeling requirements cited in h) above. As explained in Section 2. b).3.. the reading obtained three feet from the surface of the exchanger package is recorded on the shipping documents as the Transport Index.

2. SURVEY METER SCALE SELECTION

For technical reasons, manufacturers provide a three or four position switch to select the appropriate range of radiation levels to be measured. Always select the lowest scale when turning on an instrument before approaching a device containing a source. This should prevent one from entering a high radiation field unexpectedly.

If the meter pegs while measuring a field of radiation select higher scales until you reach a scale which does not read off-scale.

CHAPTER XII

PERSONNEL MONITORING INSTRUMENTS

PERSONNEL MONITORING INSTRUMENTS

Personnel monitoring instruments measure the accumulated radiation dose received by a person. These are different from survey instruments which normally measure the radiation rate only. There are many varieties of personnel dosimeters, the most common and those used by Ultra Technology are the thermoluminescent (TLD) dosimeters and pocket ionization chambers. Film monitors may still be encountered although they are being replaced by TLD's.

FILM MONITORS

The film monitor is a piece of photographic film which looks much like dental film. The film emulsion is of a variety suited for ionizing radiations.

The film when exposed to radiation and subsequently processed shows blackening just like ordinary film exposed to light. The degree of blackening is related to the amount of exposure to radiations.

The situation is somewhat complicated because the degree of blackening is also dependent upon the quality (kv) of the radiation. It is necessary to have some method of determining the quality of radiation we are dealing with.

Most film dosimeters consist of film and a film holder which clips to the clothing. The film holder contains two sets of foils arranged so that the film is sandwiched between them. The foils used are 0.005" of copper and 0.02" of lead.

The degree of penetration through these foils depends upon the quality (kv) of the radiation. It is possible by measuring the ratios of blackening on the various portions of the film (a) without foil, (b) under foil and (c) under lead, to estimate the quality of radiation which exposed the film. Having determined this it is simple to measure the radiation dose. Calibration is carried cut by exposing the film to known amounts and quality of radiation and the measuring the blackening in each area.

THERMOLUMINESCENT DOSIMETERS*

Thermoluminescence is the emission of light from previously irradiated materials after gentle heating. The radiation effect in themolumenescenct (TL) materials is similar to that observed in scintillators, except that light emission does not occur until some heat energy is supplied. Measurement of the light emitted after heating can be correlated to the amount of ionizing energy absorbed by the TL material. Thermoluminescent dosimetry is possible for beta, gamma and neutron radiations, if the appropriate TL material is used.

Lithium fluoride is the most common TL phosphor used in gamma and neutron personnel dosimetry because (a) it is useful over a wide dose range;

has a linear dose response; is nearly dose rate independent; is reusable; has a short readout time; and is nearly equivalent to tissue. Disadvantages include loss of original information and do not provide quality of radiation (kv) information.

TLD readout systems are made up of a sample holder, heating system, light detector, voltage supply, amplifier and a recording instrument (a computer system). The TLD sample is heated and light is emitted over a period of time. The light is converted into an electronic pulse which is then amplified and recorded. A plot of the output signal versus time is equivalent to emitted light versus heat and results in a glow curve. The area under the glow curve is proportional to the absorbed dose.

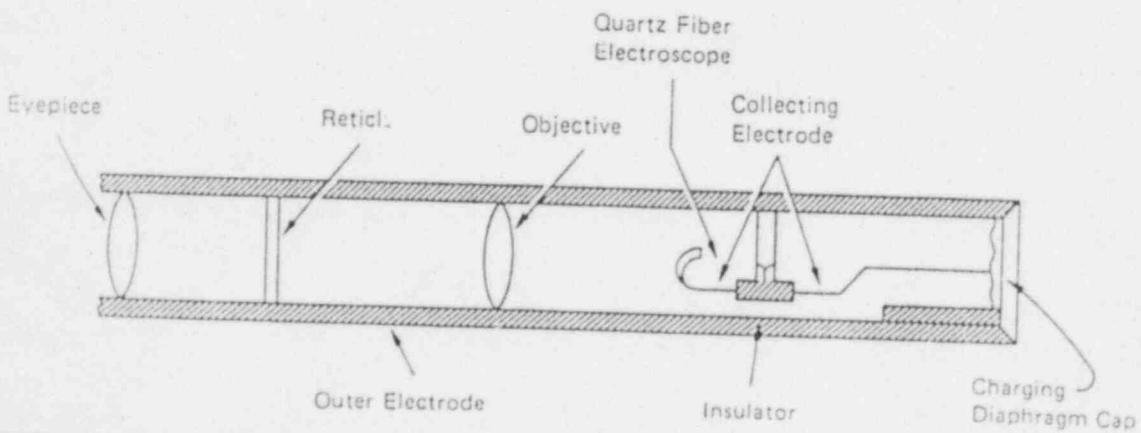
PERSONNEL DOSIMETRY RECORDS

Ultra Technology uses a third party dosimetry service to provide a continuing and timely supply of TLDs. TLDs are returned to the supplier after wearing or at the expiry of the specified wearing period and the accumulated dose read as above. A computer prepared report is returned to the Company which shows the dose the TLD received. The quarterly and annual accumulated doses are reported also if the employee has been monitored by the service for a period of time.

Federal regulations require that the employee be provided with his radiation dose record when he changes employers. If the employee wishes this record to be forwarded to the next employer he must request in writing that the Company supply this information. Otherwise, as soon as the report is available it will routinely be forwarded to the address supplied by the employee.

POCKET DOSIMETERS

Of the other types of personnel dosimeters the self reading Pocket Dosimeter is the most useful. It is usually built to look like a pen and can be carried as such.



A quartz fiber and a wire, each bent into a U and joined at the ends to form a conducting system are located within the barrel of the instrument. A built-in microscope with a transparent scale is focused on the center of the bent quartz fiber.

When an electric charge is applied to the system the quartz fiber is pushed away from the bent wire. This occurs because two bodies with like charges repel each other. The dosimeter is charged in this condition and reads 'zero' on the scale.

A dosimeter is discharged by making the air inside the chamber conducting. This occurs by ionizing the air with radiation and the amount of discharge shows as movement of the quartz fiber. This movement which can be read on the scale is a measure of the amount of radiation which caused the ionization.

This type of dosimeter is an ionization chamber. It has advantages and disadvantages as follows.

Advantages

(a) It is fairly robust and does not need too much maintenance.

(b) It is small and can be clipped on easily to clothing on any part of the body.

(c) It is weatherproof and does not have to be protected from rain or sun.

(d) It can be read at any time and anywhere by the user giving an indication of the dose received immediately after the exposure.

DISADVANTAGES

(a) Pocket dosimeters are very energy dependent but there is no way of finding out the quality of radiation involved in the exposure.

(b) They have very limited range, usually 1 roentgen.

(c) They do not provide a permanent record since they can be charged and discharged at will.

(d) They can give false readings under many circumstances, particularly after being dropped. Also the charge may leak off the electrodes over a short period of time. In field use drift can be confused with an actual dose.

In addition to the above, many special dosimeters have been developed but are not in common use. These include fluorescent glass dosimeters, scintillation dosimeters, chemical dosimeters, calorimetric dosimeters and solid state detectors.

CHAPTER XIII

RADIOGRAPHIC EXPOSURE DEVICES

70184

A. RADIOGRAPHIC EXPOSURE DEVICES

1. The Tech/Ops Model 660

The Tech/Ops Model 660 is the only type of radiographic device presently used by Ultra Technology Inc. A photocopy of the Tech/Ops Operating Manual is included in this chapter.

2. Shipping

Note that Section 2.7 Shipping states that the Model 660 qualifies as a Type B shipping container. This means that an over-pack is not required when transported in a Company vehicle. However, the Companies Radioactive Materials License does require that the projector be carried in a locked storage container which is secured to the vehicle floor.

Although a Type B shipping container can be shipped by commercial carrier 'as is' if the surface radiation readings meet the limits for a "Yellow III" label, the projector should be shipped in a more substantial package which will protect the device from shipping damage.

3. Operation

Section IV of the Tech/Ops Manual describes the proper method of connecting and disconnecting the source delivery tubes and controls. Photographs illustrate the proper procedure for connecting the control cable to the source pig tail and locking the projector. The sequence of operations presented in the Tech/Ops Manual will be altered as follows -

a) Position the projector such that the source delivery tube (guide tube) may be fully extended without sharp radius bends i.e. under 20 inches.

Note that ONLY THREE GUIDE TUBE SECTIONS (INCLUDING THE MASTER) MAY BE CONNECTED TOGETHER. This limit is imposed by the length of return cable in the control system.

b) Lay out the control cable without sharp bends that may restricting the cables freedom of movement to provide the maximum possible distance between the Radiographer or Assistant and the source when it is extended to the exposure position.

c) With the survey meter turned "ON" place it conveniently close to the projector and attach the control cable to the projector as described in the Manual's illustrated sequence.

1. "Unlock the projector with the key provided and turn the connector 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 projector."

2. "Slide the control cable collar back and open the jaws of the control cable connector. This exposes the male position of the swivel connector."

3. "Engage the male and female portions of the swivel connector by depressing the spring-loaded locking pin toward the projector with the thumbnail. Release the locking pin and test that the connecting has been properly made." (A gentle pull is sufficient.)

4. Close the jaws of the control cable connector over the swivel-type connector."

5. "Slide the control cable collar over the connector jaws."

6. Hold the cable connector collar flush against the projector and rotate the selector ring from the CONNECT position to the LOCK position. Keep the projector in the LOCK position until the actual operation is ready to start.

d) Remove the dust caps from the delivery tube, unscrew the storage plug from the projector and attach the delivery tube to the projector when you are ready commence the exposure.

e) Having previously determined the location of the detector tube(s) within the survey meter, place the opposite end of the survey meter ON ALL ACCESSIBLE SURFACES OF THE PROJECTOR and record these readings on paper i.e. right side, left side, front, rear and top.

f) Check to assure that all connections between guide tube sections are securely screwed together, that the guide tube is securely attached to the projector and no severe bends exist in the assembly.

g) Unlock the projector connector and rotate to selector ring to the OPERATE position. The source is NOW FREE TO MOVE.

h) Locate the survey meter (turned ON) conveniently near and visible to the Radiographer at the control.

i) "If the cranking becomes difficult at any time during the next step, reverse the direction of the cranking to return the source to the stored position in the projector." Monitor the projector to ensure that the source has returned to its safe position. The readings should be the same as those of (e) above. Then inspect the guide tube and control cables for excessively short radius bends or dents. If a dent is found replace the guide tube, otherwise repeat the step.

j) "At the control (in a shielded area), rapidly rotate the hand crank COUNTERCLOCKWISE moving the source out of the projector into the guide tubes toward the exposure focal point. Continue to rotate the crank until the source reaches the snout which serves as a mechanical stop for the source. Controls with odometers attached will indicate the total distance the sourcehas travelled (approximately seven feet for one guide tube section, fourteen feet for two sections and twenty one feet for three setions."

k) "At the completion of the exposure,while observing the survey meter, return the source to the safe position in the projector by rapidly turning the crank in a CLOCKWISE direction until the odometer reaches the zero position."

1) While observing the survey meter, approach the projector. Standing at the rear of the projector extend the survey meter over the top of the projector to the front to ensure that the source is not lodged just outside the front of the projector.

m) Repeat the survey conducted in (e) above to ensure that the source is in the safe stored position. The reaadings obtained at this time should closely agree with those obtained in (e). If there is NO MEASURABLE READING, VACATE THE AREA IMMEDIATELY!!! This lack of a radiation reading is positive proof of a survey meter failure.

n) From the safety of the area behind the 2 mr/hr barrier read your personal dosimeter. Your daily recorded dosimeter readings should give you some idea of a normal daily radiation dose; thus if there is a sudden increase in the dose recorded on your dosimeter that exceeds this number, assume the source is unsafe until proven otherwise.

o) Replace the batteries with warm batteries if you are working in below freezing conditions. If possible open the meter case and inspect for a broken ionization or Geiger tube as indicated by broken glass. If it is not possible to open the instrument case, shake it vigorously listening for the sound of broken glass.

p) Replace the batteries with warm batteries if you are working in below freezing conditions. Make certain that the crank cannot be turned any further in the retract (clockwise) direction. Approach the projector from the side with two working survey meters, (one will suffice but extreme caution is required). This will prevent you from suddenly emerging from behind the 'radiation shadow' of the projector into a very high radiation field should the source be lodged near the entrance to the projector. If if the source is unsafe, commence emergency procedures as described in Section 5 of the Operations Manual.

q) "After confirming that the source is in its safe stored position, rotate the connector selector from the OPERATE position to the LOCK position and secure with the projector lock.

WARNING If the projector selector ring cannot be rotated to the LOCK position, the source has not been fully retracted. Check the control odometer reading. It should be at zero. Turn the crank to the full clockwise (retract) direction."

r) To disassemble, unscrew the guide tube from the front of the projector and separate the sections of the guide tube. Replace all dust caps ends to prevent the entry of dirt from entering the tubes and store in a manner which will not subject them to damage. Insert the storage plug into the front of the projector and tighten.

s) Unlock the projector using the key supplied.

t) Rotate the connector selector ring from the LOCK position to the CONNECT position. When the selector ring reaches the CONNECT position, the control cable connector will partially disengage from the projector.

u) Slide the control cable connector collar over the jaws away from the projector.

v) Open the connector jaws and disconnect the swivel-type connector by depressing the spring loaded locking pin towards the projector with the thumbnail and separating the male and female connections.

w) Replace the storage cover in the projector connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the projector. Coil the control cable and store to prevent damage.

MAINTENANCE OF THE TECH/OPS 660 PROJECTOR

1 The Radiographer is required daily to perform the inspection required on the Radiography Equipment Daily Inspection check sheet for Crank-Out Type Devices attached. Should the Company acquire Spec-Check or Pipeliner projectors, the Radiographer will carry out the required daily inspections (attached).

2. The Radiation Safety Officer is required to carry out equipment inspections and preventative maintenance at 90 day intervals as per Attachment F of the Operations Manual. (Attached).

OPERATION and MAINTENANCE MANUAL Model 660 SERIES GAMMA RAY PROJECTION SYSTEMS

TECHNICAL OPERATIONS, INC.
Radiation Products Division
Burlington, Mass. 01803
Phone (800) 225-1383 (toll free)
[in Mass. call (617) 272-2000]

WARRANTY
AND
LIMITATION OF LIABILITY

Technical Operations, Incorporated (hereinafter referred to as *the manufacturer*) warrants its product which it **manufactures** and sells to be free of defects in material and workmanship for a period of 1 year from date of shipment. This warranty shall not apply to any product or parts which have been subjected to misuse, improper installation, repair, alteration, neglect, accident, abnormal conditions of operation, or use in any manner contrary to instructions.

The manufacturer's liability under such warranty shall be limited to replacing or repairing, at its option, any parts found to be defective in such respects, which are returned to it transportation prepaid; or, at its option, to returning the purchase price thereof.

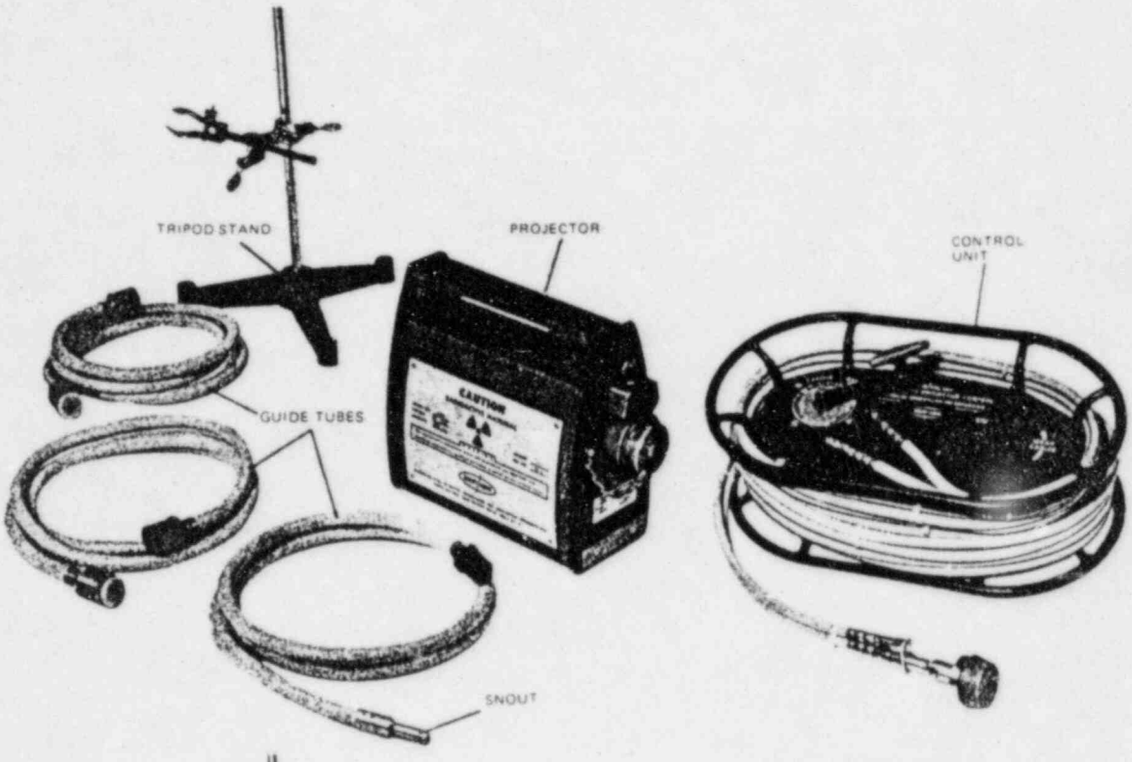
The warranty on other manufacturers' components shall be that of the original manufacturer whose warranty shall be binding.

In no event shall the manufacturer be liable for any incidental or consequential damages, whether or not such damages are alleged to have resulted from the use of such product in accordance with instructions given by or referred to by the manufacturer.

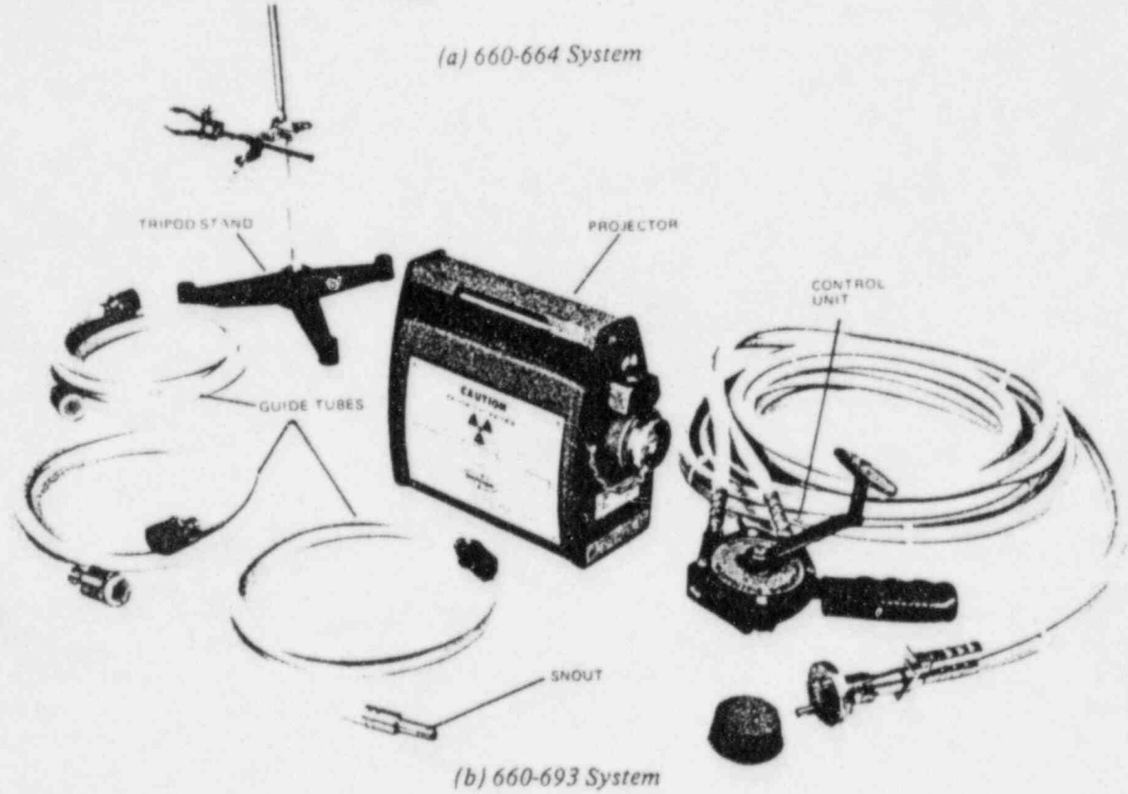
Technical Operations, Incorporated assumes no liability or responsibility for the usage of any radioactive material or device generating penetrative radiation used in connection with this product. The use of such material or generators in any manner other than that prescribed in the Nuclear Regulatory Commissio License or equivalent state license or permitted by any regulation of the Nuclear Regulatory Commission or state regulation may constitute a violation of such license terms.

All other warranties, except those warranties expressly stated herein, including warranties of merchantability or otherwise, are expressly excluded.

TABLE OF CONTENTS



(a) 660-664 System



(b) 660-693 System

Figure 1-1. 660 Series Portable Gamma Ray Projector Systems.

Refer to Section II, Recommended Safety Precautions, before operating or servicing these systems.

SECTION I
GENERAL INFORMATION

1-1. GENERAL

The 660 Series Portable Gamma Ray Projector Systems, shown in Figure 1-1, are used primarily for industrial radiography. The systems operate in similar manner and differ only in the type of control unit supplied.

The portability feature of the system provides both a safe means of transporting the radioactive source and operating flexibility, particularly needed in limited access areas. In use, either system safely positions an Iridium^{192} radioactive source at a predetermined location. The 360° (panoramic) radiation pattern may be used to full advantage, either for multiple specimen work or for circumferential exposure techniques. Optional collimators are available which limit the panoramic pattern to a directional beam. The systems may be used with Iridium^{192} isotope sources up to a maximum of 100 curies. Iridium^{192} sources of other capacities are available, upon request. Basic source information is contained on the nameplate of the source shield (projector).

1-2. SYSTEM SAFETY

The systems provide maximum operator safety. A positive mechanical control of the source and an accurate visual indication of its position are given at all times. In addition, the systems have a fail-safe connection; where:

a. the system cannot be operated (source exposed) unless a secure connection to the control cable is made, and

b. the controls cannot be disconnected unless the source is properly stored in the shield.

1-3. SYSTEM COMPONENTS

All components of the 660-664 and 660-693 Systems are identified in Figure 1-1. Components common to both systems are discussed first. The separate control units are discussed last.

a. Gamma Ray Projector Model 660.

The Gamma Ray Projector, shown in Figure 1-2, can be used in either system. The projector serves as the storage and transport device of the radioactive source assembly. The projector consists of a steel housing which contains approximately 29 pounds of "depleted uranium" shielding material. When the source is properly stored in the projector, the effective shielding properties of the depleted uranium reduce radiation at the projector exterior to a level well below the regulatory mr/hr limits prescribed in applicable NRC regulations.

Figure 1-2 shows both ends of the projector. A special fail-safe connector is located at one end. This connector is used to engage the cable from the control unit. The safety features of the connector were discussed in paragraph 1-2. The control connector contains a three-position selection device – OPERATE, LOCK, and CONNECT. For maximum safety when the projector is disconnected from the control cable and guide tubes, the connector should be in the LOCK position with the attached lock and storage cover engaged and the key removed. All of the connector positions are discussed in detail in Section III, Operation. The guide tube connector is located at the other end of the Projector. Figure 1-2 identifies the connector. Also shown in Figure 1-2 is the storage plug which must be removed before the guide tubes are connected. The storage plug should be used to prevent dirt and dust from entering the projector whenever the projector is not in use.

The total weight of the projector is 44 pounds. The projector is 9½" high, 4¾" wide, and 12¾" long (includes handle and connectors).

b. Guide Tube Assembly.

The guide tube assembly consists of one seven-foot master guide tube and two seven-foot extender guide tubes (see Figure 1-1). The master is

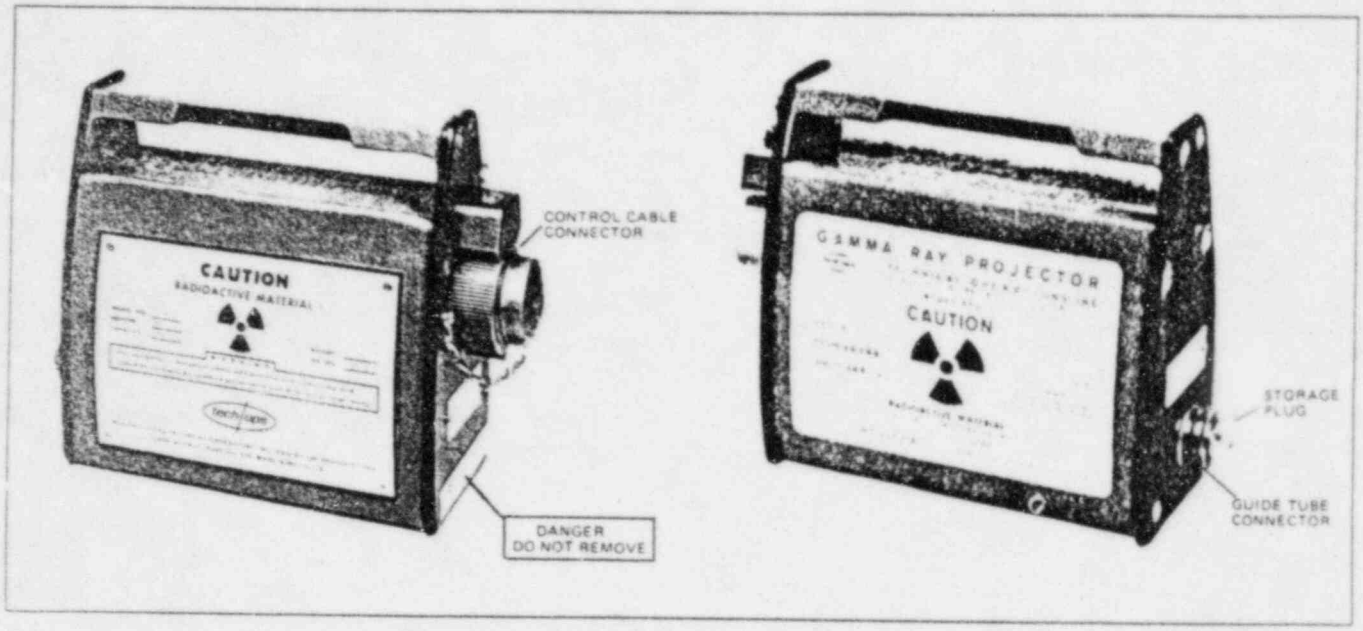


Figure 1-2. Model 660 Gamma Ray Projector.

the guide tube section which contains the snout or source stop at one end. The system should never be operated without the master guide tube attached to the projector. The two extender sections can be used as necessary to lengthen the guide tube to 14 or 21 feet. Both master and extender guide tubes are made from flexible stainless steel tubing with a protective polyvinyl covering. The three guide tube sections weigh approximately five pounds.

CAUTION

NEVER OPERATE THE SYSTEM WITH MORE THAN THREE GUIDE TUBE SECTIONS (MASTER SECTION PLUS TWO EXTENDER SECTIONS– TOTAL GUIDE TUBE LENGTH OF TWENTY ONE FEET).

c. Tripod Stand.

The tripod stand provides a means of securing the snout end of the master guide tube section so that the source can be positioned at the desired focal position. The stand has adjustable clamps which will provide an unlimited degree of positioning flexibility. The weighted tripod base provides a solid foundation for the stand. The tripod stand, complete with clamps, weighs approximately ten pounds.

d. Model 664 Control Unit.

The 664 unit is used with the 660-664 Gamma Ray Projector System. The unit consists of a hand crank, odometer, and 25-foot control cable, and lightweight convenient storage cable reel. In operation, the hand crank controls the movement of the source from the storage position in the projector to the exposure position in the master guide tube. The odometer indicates the distance in feet and inches that the source has been moved from its storage position. The reel provides a convenient storage facility for both the control cable and the three guide tubes. The outer control tubing is similar to the construction of the guide tubes. The inner spiral-wound flexible steel drive cable (the actual controlling element) terminates with the male section of a swivel-type fastener used to securely engage the female section which is attached to the leader cable of the radioactive source assembly. The control tube is terminated at one end by the connecting plug assembly which mates with the fail-safe connector on the projector and at the other end by fittings which attach it to the main frame of the control unit. The 664 control unit with the control cable weighs approximately twenty-two pounds.

e. Model 693 Control Unit.

The 693 unit is used with the 660-693 Gamma Ray Projector System. The basic purpose of the 693 is similar to that of the 664 unit. However, the 693 unit does not have the storage reel and is provided with a pistol grip handle for convenient operation. The 693 control unit with the control cable weighs approximately nineteen pounds.

1-4. RADIOACTIVE SOURCE ASSEMBLY

The radioactive source assembly is the most vital component in the system. It is supplied and must be ordered separately from other system components. The system can operate with various capacity sources up to the maximum 100 curies (+20%). The source is contained in a stainless steel capsule firmly attached to one end of the short leader cable.

The source can easily be changed in the field using a TO-414 or TO-650 Source Changer which also serves as a shipping container.

1-5. SYSTEM OPTIONAL ACCESSORIES

Table 1-1 lists the options available for both projector systems.

Also available is a complete range of radiation survey and personnel monitoring dosimeters.

1-6. PRINCIPLES OF OPERATION

The hand crank on the control unit moves the drive cable through the control tube. The control cable is locked to the encapsulated radioactive source via a short leader. Figure 1-3(a) shows the source in the stored position in the projector (hand cranked fully clockwise – in the full RETRACT position). Figure 1-3(b) shows the source being moved out of the projector and into the guide tubes. This action occurs by rotating the hand crank in the EXPOSE counterclockwise direction. Figure 1-3(c) shows the source reaching the snout which serves as a mechanical stop at the radiographic focal spot. The hand crank will not turn any farther and the odometer in the control unit should indicate a reading which approximates the total length of the combined guide tubes. To return the source to the projector (stored position), the hand crank is turned to the full RETRACT (clockwise) position.

1-7. SPECIFICATIONS

a. Source Data
- Isotope: Iridium ^{192} (A424-9 only)
- Maximum strength: 100 curies (+20%)
- Shielding: Conforms to NRC requirement, title 10 CFR part 34.21

b. Size and Weight
- Projector Size: 4¾ x 9½ x 12¾ inches
- Projector Weight: 44 pounds
- Model 664 Control Unit Size: 6 5/8 x 12 x 21 inches
- Model 664 Control Unit Weight: 22 pounds (with control cable)
- Model 693 Control Unit Weight: 19 pounds (with control cable)
- Guide Tubes: 5 pounds
- Tripod Stand: 10 pounds

c. Operating Specifications
- Maximum distance, projector to control unit: 25 feet
- Distance, projector to exposure position: 7, 14, or 21 feet
- Source position reproducibility: ±1/16 inch

Table 1-1. System Options

MODEL NO.	DESCRIPTION
527	Collimator with stand for directional 60° beam or 360° panoramic 20° wide-band beam
653	Side collimator
654	Front collimator
534	Slide-rule type exposure calculator with leather case
492D	GAMMALARM radiation monitor
492E	GAMMAFLASHER used with 492D GAMMALARM

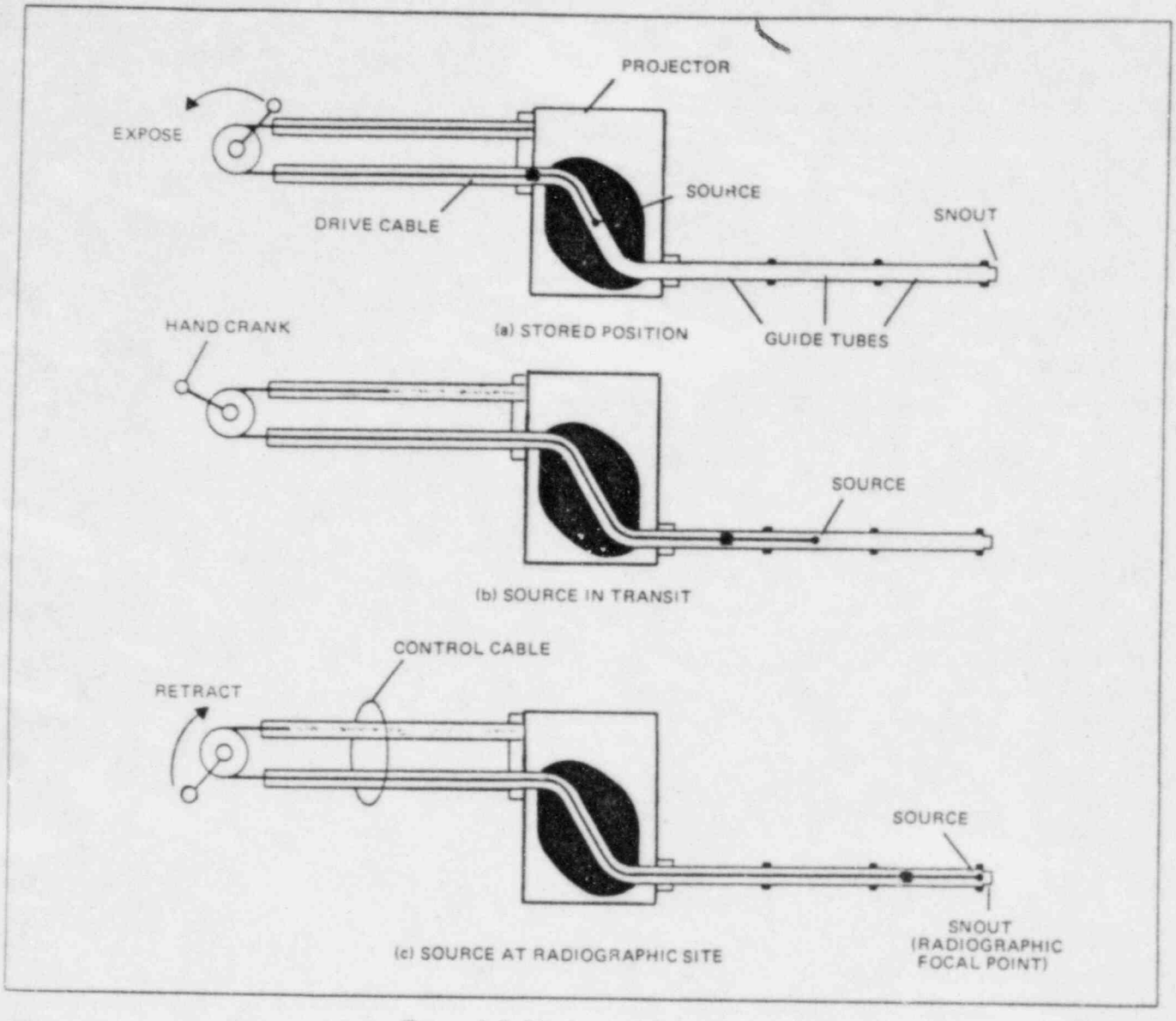


Figure 1-3. Mechanical Schematic.

1-4. RADIOACTIVE SOURCE ASSEMBLY

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   - Maximum strength: 100 curies (+20%)
   - Shielding: Conforms to NRC requirement, title 10 CFR part 34.21

b. Size and Weight
   - Projector Size: 4¾ x 9½ x 12¾ inches
   - Projector Weight: 44 pounds
   - Model 664 Control Unit Size: 6 5/8 x 12 x 21 inches
   - Model 664 Control Unit Weight: 22 pounds (with control cable)
   - Model 693 Control Unit Weight: 19 pounds (with control cable)
   - Guide Tubes: 5 pounds
   - Tripod Stand: 10 pounds

c. Operating Specifications
   - Maximum distance, projector to control unit: 25 feet
   - Distance, projector to exposure position: 7, 14, or 21 feet
   - Source position reproducibility: ±1/16 inch

Table 1-1. System Options

MODEL NO.	DESCRIPTION
527	Collimator with stand for directional 60° beam or 360° panoramic 20° wide-band beam
653	Side collimator
654	Front collimator
534	Slide-rule type exposure calculator with leather case
492D	GAMMALARM radiation monitor
492E	GAMMAFLASHER used with 492D GAMMALARM

SECTION II
RECOMMENDED SAFETY PRECAUTIONS

2-1. GENERAL

The Model 660 Ray Projector is designed to afford operators maximum protection from radiation. However, precautions consistent with accepted isotope handling practices must be observed at all times.

2-2. RADIATION MEASURING INSTRUMENTS

The use of radiation measuring equipment is mandatory; all handling of isotope units should be monitored by proper radiation detectors. The following are recommended:

a. Survey Meters.

Survey meters must be used as a matter of routine to determine the radiation rate per unit time. Technical Operations, Inc. recommends a gamma survey meter of the ionization chamber type, with a full scale range of at least 1000 mr/hr.

b. Film Badges.

Personnel using or working near isotope equipment should wear film badges to provide permanent running records of the radiation dosage received.

c. Pocket Dosimeters.

Technical Operations, Inc. also recommends the use of pocket dosimeters, to allow personnel to determine the exposure received in any given period.

2-3. WORKING DISTANCE

Every precaution should be taken to insure that adequate distance exists between the exposed source and areas accessible to personnel. Surrounding areas should be surveyed – any areas in which readings are excessive should be restricted and posted. (See Code of Federal Regulations, Title 10, Atomic Energy, Part 20.105.) Personnel operating equipment should always work at the maximum possible distance from the source. (The exposure rate varies inversely with the square of the distance from the source.) Always avoid unnecessary or excessive dosages.

2-4. EXPOSURE TIME

Maximum radiation doses to personnel are specified by State and Federal regulations. (See Code of Federal Regulations. Title 10, Atomic Energy, Part 20.101.) Always observe good radiographic techniques to keep doses to a minimum.

2-5. SHIELDING

Wherever possible, the control unit and operating personnel should be positioned behind a shield. Shielding materials commonly used to absorb or stop radiation are concrete, iron, steel, and lead.

2-6. HAND-CARRYING

Hand-carrying should be limited to operations where absolutely necessary. Unnecessary personnel exposures can result from hand-carrying the unit for extended periods. Personnel carrying the unit should always monitor the exposure using a dosimeter or film badge on the part of the body nearest to the source.

2-7. SHIPPING

The Model 660 meets the requirements for a Type B shipping container under the regulations of the U. S. Nuclear Regulatory Commission, the U. S. Department of Transportation and the International Atomic Energy Agency. The container has been assigned USNRC Certificate No. 9033 for domestic shipments and IAEA Certificate No. USA-DOT-RAM-6-70 for international shipments.

Under the terms of USNRC regulations in 10CFR71.12(b), prior to the first shipment of the container, the shipper must register as such with the Transportation Branch, Division of Materials and Fuel Cycle Facility Licensing, USNRC.

In shipment the device must be locked and the storage plug must be inserted and secured with a tamper proof seal.

When shipped with the contained Iridium^{192} the RADIOACTIVE YELLOW III label must be identified with "Iridium^{192}", the number of curies

contained, and the maximum radiation level measured at a distance of three feet from the surface of the container (Transport Index).

When shipped without the Iridium^{192} source, a RADIOACTIVE WHITE I label must be identified with "Depleted Uranium" and "_____ Curies."

These shipping labels are shown in Figure 2-1 and are available from Technical Operations.

(a) With Isotope *(b) Without Isotope*

Figure 2-1. Typical Shipping Labels

SECTION III
UNPACKING AND STORAGE

3-1. INITIAL INSPECTION

If external damage to the shipping containers is evident, ask the carrier's agent to be present when the system is unpacked. Technical Operations, Inc. should be notified immediately if any components were damaged in transit.

WARNING

UNPACK THE SYSTEM ONLY IN AREAS MONITORED WITH APPROPRIATE RADIATION MEASURING EQUIPMENT. SEE SECTION II.

3-2. UNPACKING

Portable Gamma Ray Projector System Components are normally shipped in two cardboard containers. Inspect cartons for external signs of possible damage. Open the cartons and remove the system components.

The components are as follows:

(a) Swivel Clamp
(b) Source Tube Clamp
(c) Tripod Base
(d) Tripod Rod
(e) Control Unit with attached Control Cable
(f) Projector
(g) Three 7-foot Guide Tube Sections

3-3. COMPONENT INSPECTION

Examine all components for damage. Check all items against packing list or Figure 1-1.

3-4. STORAGE

When storing the system between uses, keep the plastic caps, supplied with the system, in place on the three guide tubes. This eliminates dust accumulation within the tubes. During storage the storage plug must be inserted to meet the conditions of 10CFR34.21 and to prevent the entry of foreign material.

SECTION IV
OPERATION

4-1. PREPARATION FOR USE

WARNING

ASSEMBLE THE SYSTEM FOR USE ONLY IN AREAS MONITORED WITH APPROPRIATE RADIATION MEASURING EQUIPMENT. SEE SECTION III.

a. Guide Tube Assembly

1. At the radiographic focal point, position and secure the snout of the master guide tube using the tripod stand and swivel clamps.

2. Remove the plastic dust caps and attach additional extender guide tubes, as necessary, to the master guide tube.

3. Determine the position of the projector (source shield) allowing for maximum possible operating shielding. Assuming appropriate shielding is available, the operator will be approximately twenty-five feet from the projector during actual operation.

4. Lay out the guide tubes as straight as possible directing them toward the projector. Note that the bend radius of the guide tubes should not be under twenty inches. Smaller bend radii may restrict the movement of the control cable.

NOTE

The guide tubes should not be subjected to any undue stress or abuse which could cause restrictions in the tubes.

5. Remove the storage plug from the projector connector and attach the last guide tube to the projector (see Figure 1-2).

CAUTION

NEVER OPERATE THE SYSTEM WITH MORE THAN THREE GUIDE TUBE SECTIONS (INCLUDING THE MASTER).

b. Control Unit.

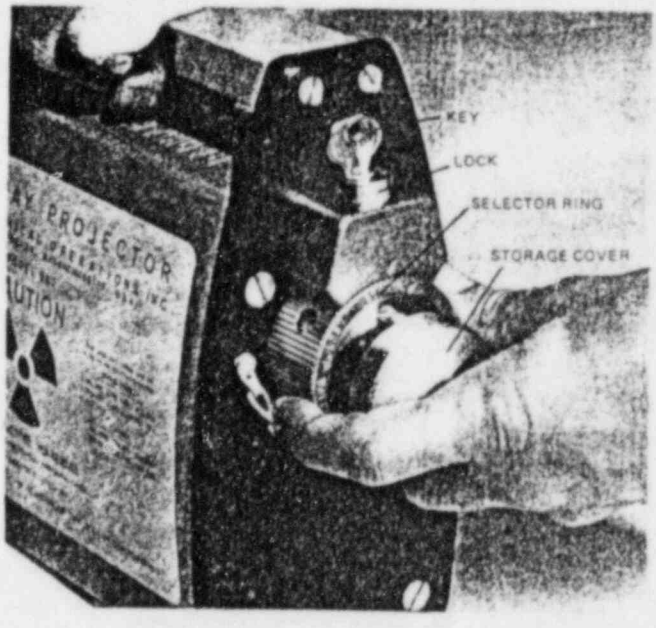
1. Determine the operating site of the control unit. For maximum safety, the operator should be located behind a protective shield.

2. Lay out the control cable as straight as possible directing it toward the projector. Note that the bend radius should not be less than three feet. Smaller bend radii may restrict the movement of the control cable.

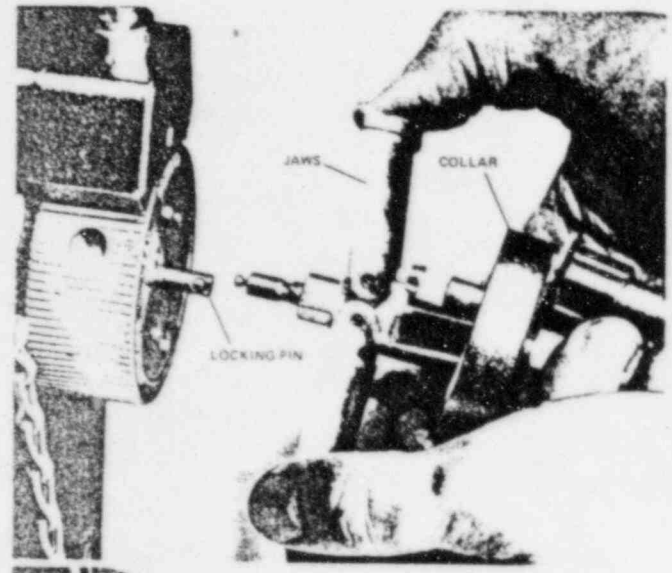
NOTE

The control cable should not be subjected to any undue stress or abuse which could cause restrictions in the cable.

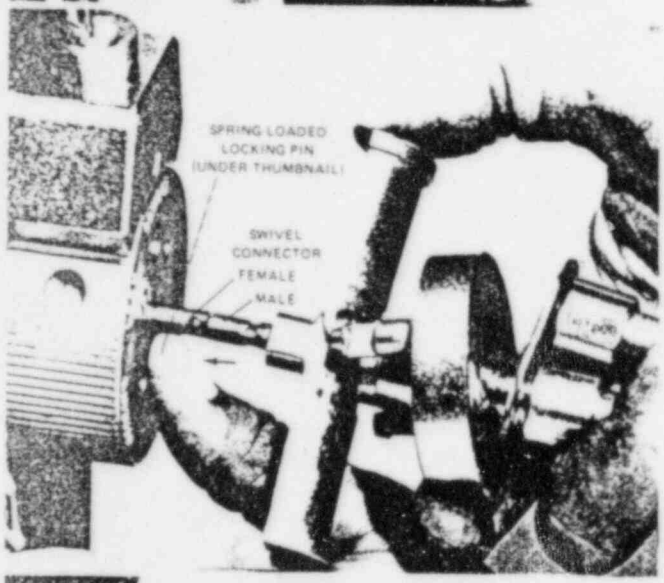
3. Attach the control cable to the projector in accordance with the following illustrated sequence:



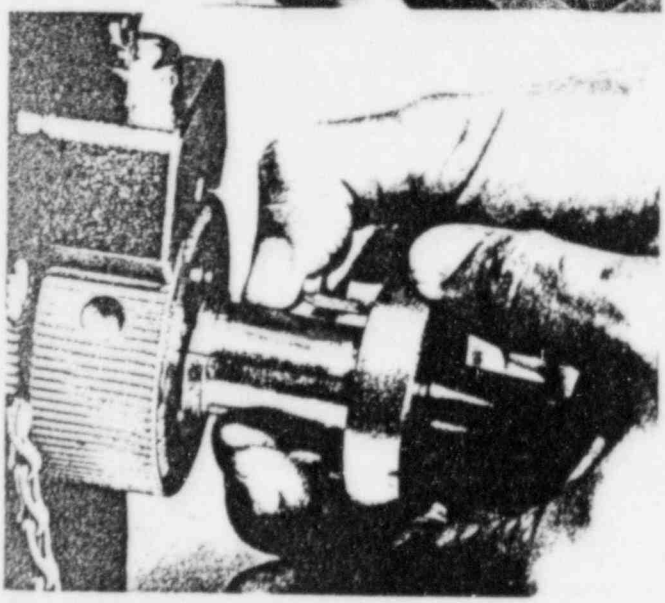
Unlock the projector with the key provided and turn the connector selector ring from the LOCK position to the CONNECT position. When the ring is in the CONNECT position, the storage cover will disengage from the projector as shown.



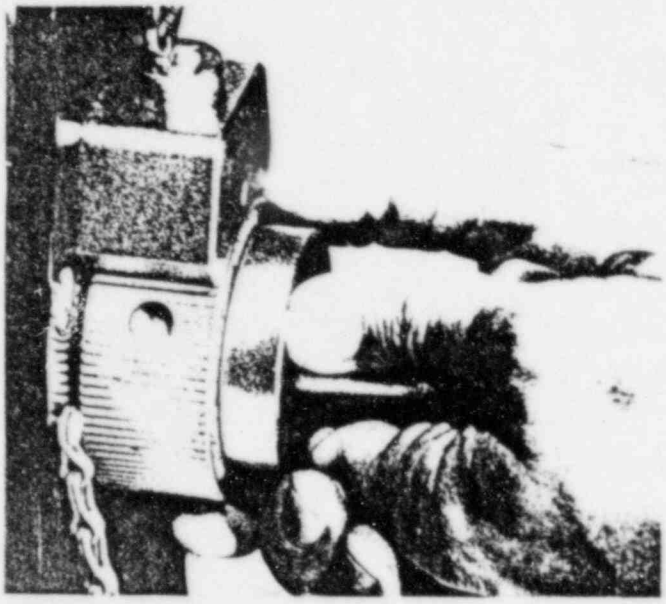
Slide the control cable collar back and open the jaws of the control cable connector. This exposes the male position of the swivel connector as shown.



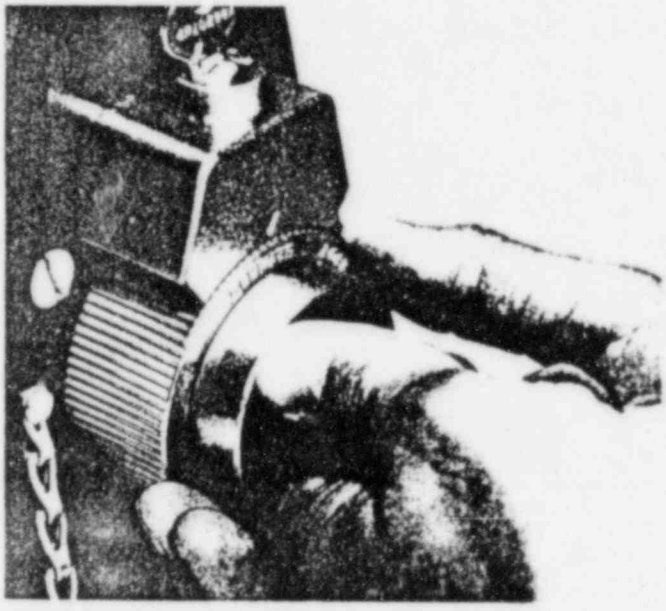
Engage the male and female portions of the swivel connector as shown by depressing the spring-loaded locking pin toward the projector with the thumbnail. Release the locking pin and test that the connection has been properly made.



Close the jaws of the control cable connector over the swivel-type connector.



Slide the control cable collar over the connector jaws.



Hold the control cable collar flush against the projector connector and rotate the selector ring from the CONNECT position to the LOCK position. Keep the projector in the LOCK position until actual operation is ready to start.

4-2. OPERATION

Thoroughly check all cable connections and bend radii and the position of the snout of the master guide tube. (This represents the radiographic focal point of the source.) To operate the system, perform the following:

WARNING

OPERATE THE SYSTEM ONLY IN AREAS MONITORED WITH APPROPRIATE RADIATION MEASURING EQUIPMENT. SEE SECTION II.

a. Unlock the projector connector and rotate the selector ring to the OPERATE position. The source is now free to move.

NOTE

If cranking becomes difficult at any time during the next step, reverse the direction of the cranking to return the source to the stored position in the projector. First monitor the area with a survey meter to insure that the source is properly stored. Then check the control and guide tubes for excessively small bend radii and repeat the step.

b. At the control unit (in a shielded area), rapidly rotate the hand crank in the EXPOSE (counterclockwise) direction to move the source out of the projector and into the guide tubes toward the radiographic focal point. Both the Model 664 and 604 Control Units, shown in Figure 4-1 operate in similar fashion. Continue to rotate the hand crank until the source reaches the snout which serves as a mechanical stop for the source. The odometer reading will indicate the total distance the source traveled (approximately seven feet for one guide tube section, fourteen feet for two sections, and twenty-one feet for three sections).

c. Specimen exposure should be figured from the time that the source reaches the snout or stop.

d. To return the source to the projector, after the desired exposure time has elapsed, rapidly turn the hand crank in the RETRACT (clockwise) direction. Continue to turn the crank until the odometer reading reaches the 000 position. (source properly stored).

CAUTION

AFTER AN EXPOSURE, THE PROJECTOR SHOULD BE THOROUGHLY MONITORED WITH A SURVEY METER BEFORE CONTINUING WITH STEP E.

e. At the projector, rotate the connector selector from the OPERATE position to the LOCK position and secure with the projector lock.

NOTE

If the projector selector ring cannot be rotated to the LOCK position, the source has not been fully retracted. Check the control unit odometer reading. It should be 000. Turn the hand crank to the full clockwise (RETRACT) direction.

4-3. DISASSEMBLY

If the system is to be moved for another exposure or to be stored, the components should be disassembled. Unscrew the guide tube sections from each other and remove the master guide tube from the tripod stand. Place the plastic caps on the tube ends and projector connector to eliminate dust and dirt from entering the tubes. Store the tubes in an area where they will not be subjected to any undue stress or abuse which could cause restrictions. Insert storage plug into position and tighten.

To disconnect the control unit from the projector, perform the following:

a. Unlock the projector using the supplied key.

b. Rotate the connector selector ring from the LOCK position to the CONNECT position. When the selector ring reaches the CONNECT position, the control cable connector will partially disengage from the projector.

c. Slide the control cable connector collar over the jaws away from the projector.

d. Open the connector jaws and disconnect the swivel-type connector by depressing the spring-loaded locking pin towards the projector with the thumbnail and separating the male and female connections.

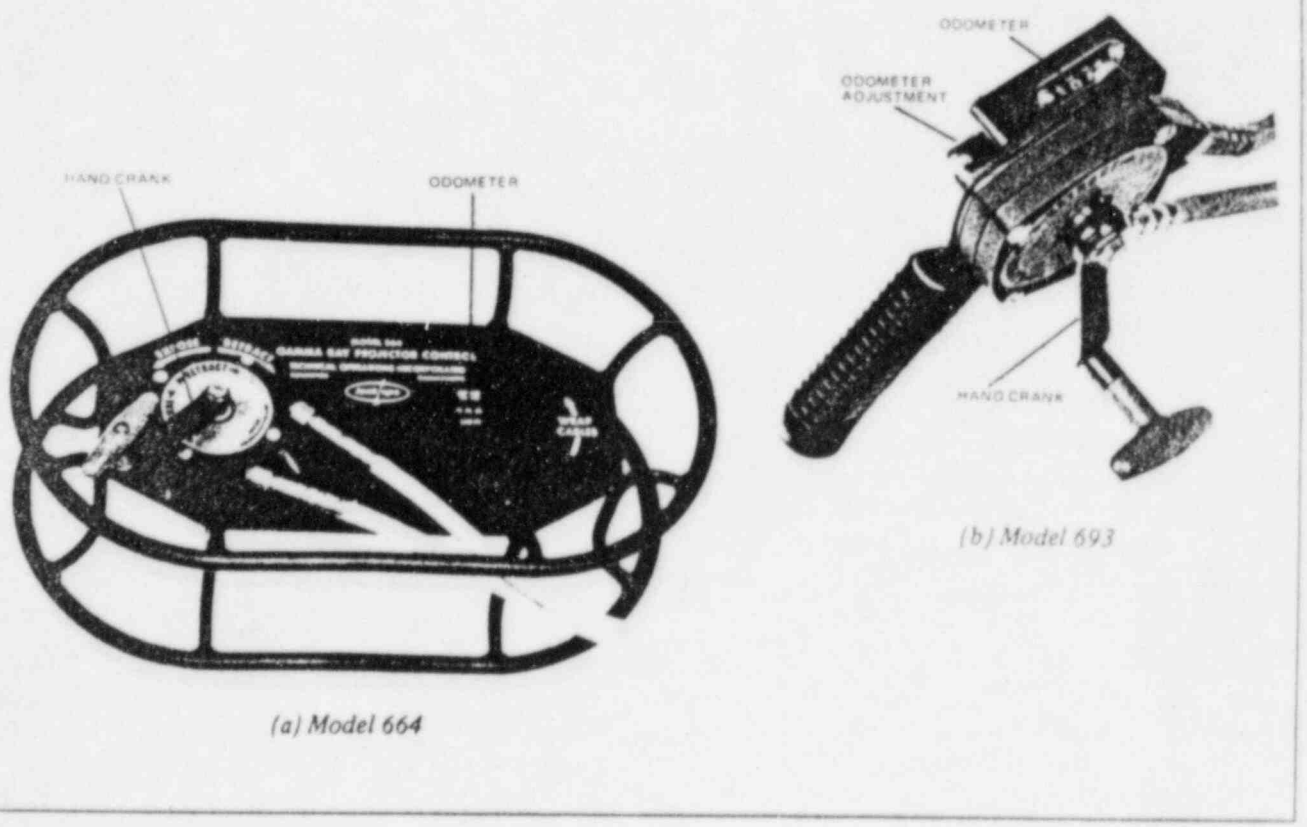
NOTE

If any difficulty is encountered, refer to the illustrated instructions given for making the connection for further assistance.

e. Replace the storage cover in the projector connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the projector.

f. Coil the control cable in the 664 control unit or around the 693 control unit and store the unit in an area where the cable will not be subjected to undue stress or abuse.

g. Disassemble the tripod stand for storage.



(a) Model 664

(b) Model 693

Figure 4-1. Control Units.

SECTION V
MAINTENANCE

5-1. GENERAL

It is imperative that all system components be kept clean. No amount of dirt can be considered negligible. When the system must be operated in a dirty environment, particular care must be exercised to avoid dirt from entering the control or guide tubes. Dirt-clogged cables, tubes, and connectors impede the drive cable movement and could cause jamming.

5-2. CONTROL CABLE

Inspect the control cable regularly for signs of damage. Avoid twisting or bending the cable excessively. Recoil the control cable carefully for storage. Never drag the cable on the floor or ground. Use the protective cover (over the connector) when the control cable is not in use.

5-3. GUIDE TUBES

Inspect the guide tubes regularly for signs of damage. Avoid twisting or bending the tubes excessively. Recoil the guide tubes carefully for storage. Never drag the tubes on the floor or ground. Replace the plastic caps on the guide tubes connectors when not in use.

5-4. CLEANING AND LUBRICATING SYSTEM CABLES

The frequency of cleaning and lubrication depends on the amount and type of use. These procedures should be performed whenever the cranking of the control unit becomes difficult. Perform the following:

1. Disconnect the control cable from the projector.

2. Turn the hand crank in the EXPOSE (counterclockwise) direction until the cable disengages from the drive gear. This becomes apparent because further turning of the hand crank will have no effect on the control cable.

3. Pull the cable free from the control cable housing. Coil the cable (a radius of not less than four inches) and place the cable in a container of degreasing solvent. Do not use water-based cleaning agents. Allow the cable to soak as long as is necessary to remove all accumulated foreign matter.

4. Remove the control cable from the control unit by loosening the two fittings. (Before removing the fittings, label them to facilitate reassembly.)

5. Pour degreasing solvent into the control cable tubing to clean. Continue to flush the tubing until the solvent leaving the hose is free from impurities.

6. Use compressed dry clean air (do not exceed fifteen pounds) to thoroughly dry both the housing and cable. Any remaining solvent could cause permanent damage.

NOTE

Since the drive cable and control tubing has been thoroughly cleaned, care must be exercised to avoid any dust or dirt contamination during the remainder of this procedure.

7. Lightly grease the drive cable with MIL-G-23827A type grease. Other greases may form tars or corrosive compounds when exposed to radiation.

8. Carefully feed the cable into the tubing from the cable end which attaches to the projector.

9. When the cable reaches the control unit fitting, guide the cable into the hand crank housing. Slowly turn the hand crank in the RETRACT (clockwise) direction until the cable engages the crank gear.

10. Reconnect the two fittings which connect the control cable to the control unit.

11. Turn the hand crank in the RETRACT direction until the cable is completely contained in the housing. If the odometer reading is not 000 at

this time, refer to the odometer adjustment procedure given in this section.

To clean the guide tubes, flush them thoroughly with a cleaning solvent (chlorothene or carbon tetrachloride). Dry thoroughly with clean dry compressed air. Replace all plastic dust caps when storing the tubes.

5-5. REPLACING THE CONTROL CABLE

To replace the control cable, refer to the cleaning procedures given in paragraph 5-4.

5-6. ODOMETER ADJUSTMENT

The odometer in both the 664 and 693 control units, has a knob adjustment control. If the hand crank is in its full RETRACT position, the odometer should indicate 000. If not, slowly adjust the control to obtain a 000 reading. The odometer adjustments are located in Figure 6-4 for the 693 control unit and Figure 6-3 for the 664 control unit.

5-7. SOURCE REPLACEMENT

Renewal sources are available from Technical Operations, Inc. for replacement in the field. For instructions, see the procedure supplied with the replacement source.

A dummy source is normally supplied with the system. A clip inside the storage cover of the projector converter is provided for dummy source storage. The dummy source can be used when the radioactive source has been removed (using a source changer) so that the control cable can be disconnected from the projector. Note that the fail-safe feature of the connector requires either a source or a dummy source properly stored in the projector before the control cable can be disengaged.

5-8. CONTROL UNIT REPAIR

Exploded views of both the 664 and 693 control units are given in Section VI (Figures 6-3 and 6-4). If parts must be replaced, use the index numbers of the related illustration as a guide to disassembly and reassembly. The illustrations also include a parts list for ordering replacements.

5-9. GAMMA RAY PROJECTOR

WARNING

THE SOURCE SHIELD PORTION OF THE PROJECTOR IS NOT REPAIRABLE IN THE FIELD. A COVER PLATE HAS BEEN ATTACHED (SEE FIGURE 1-2) TO PREVENT OPENING THE SHIELD WHICH COULD RESULT IN A SERIOUS RADIATION OVEREXPOSURE.

70184

SECTION VI
REPLACEABLE PARTS

6-1. GENERAL

All parts that are replaceable in the field are listed and identified in this section.

6-2. GAMMA RAY PROJECTOR

CAUTION

NEVER DISASSEMBLE THE PROJECTOR IN THE FIELD (SEE PARAGRAPH 5-9).

Refer to Figure 6-1 for component identification.

6-3. TRIPOD STAND

Refer to Figure 6-2 for component identification.

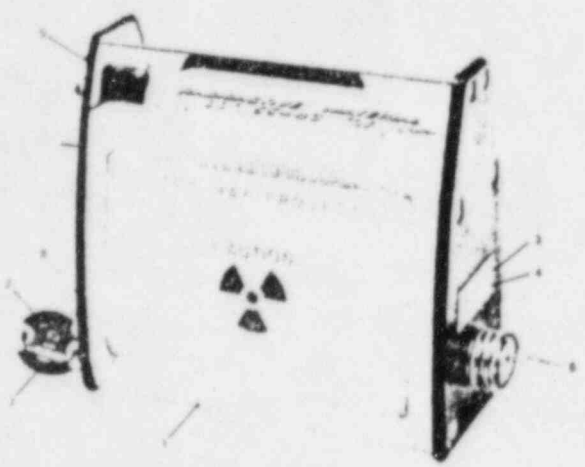
6-4. GUIDE TUBES

The guide tubes are replaced as a complete assembly. Order Part Number B48906 for replacing the master guide tube (with snout) or Part Number B48907 for replacing either of the extension guide tubes.

6-5. CONTROL UNITS

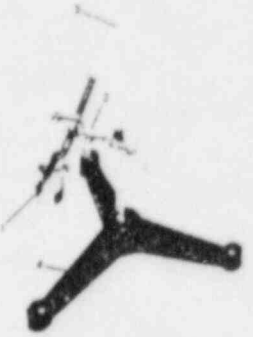
a. Model 664 Control Unit.
Refer to Figure 6-3.

b Model 693 Control Unit.
Refer to Figure 6-4.



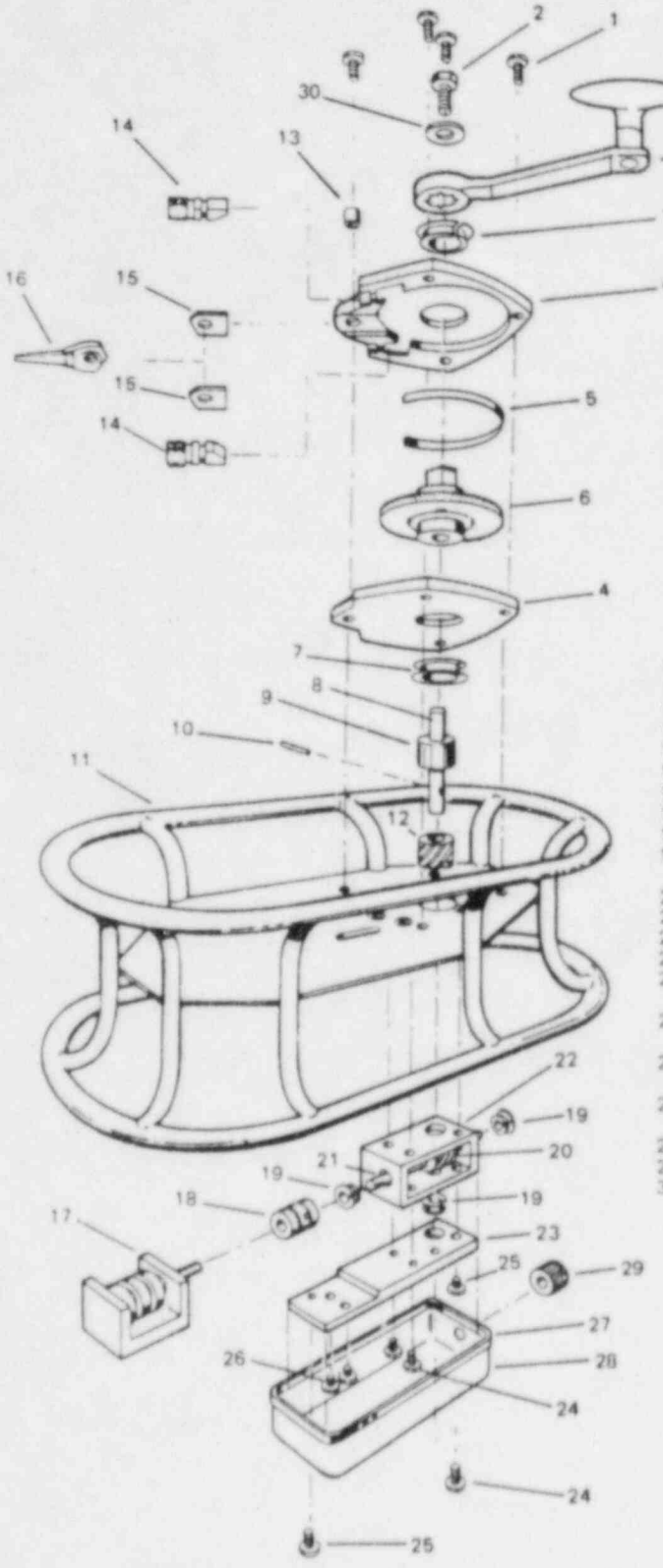
1	D66001	Gamma Ray Projector (complete)
2	B66001-7	Storage Cover
3	–	#6–32 x 3/8 LG Pan Head Screw
4	C66001-10	Nameplate
5	A66001-11	Key
6	A52401-1	Storage plug
7	B66001-20	Dummy Source
8	–	Sash chain, 2¼", steel/copper (NS)

Figure 6-1. Gamma Ray Projector.



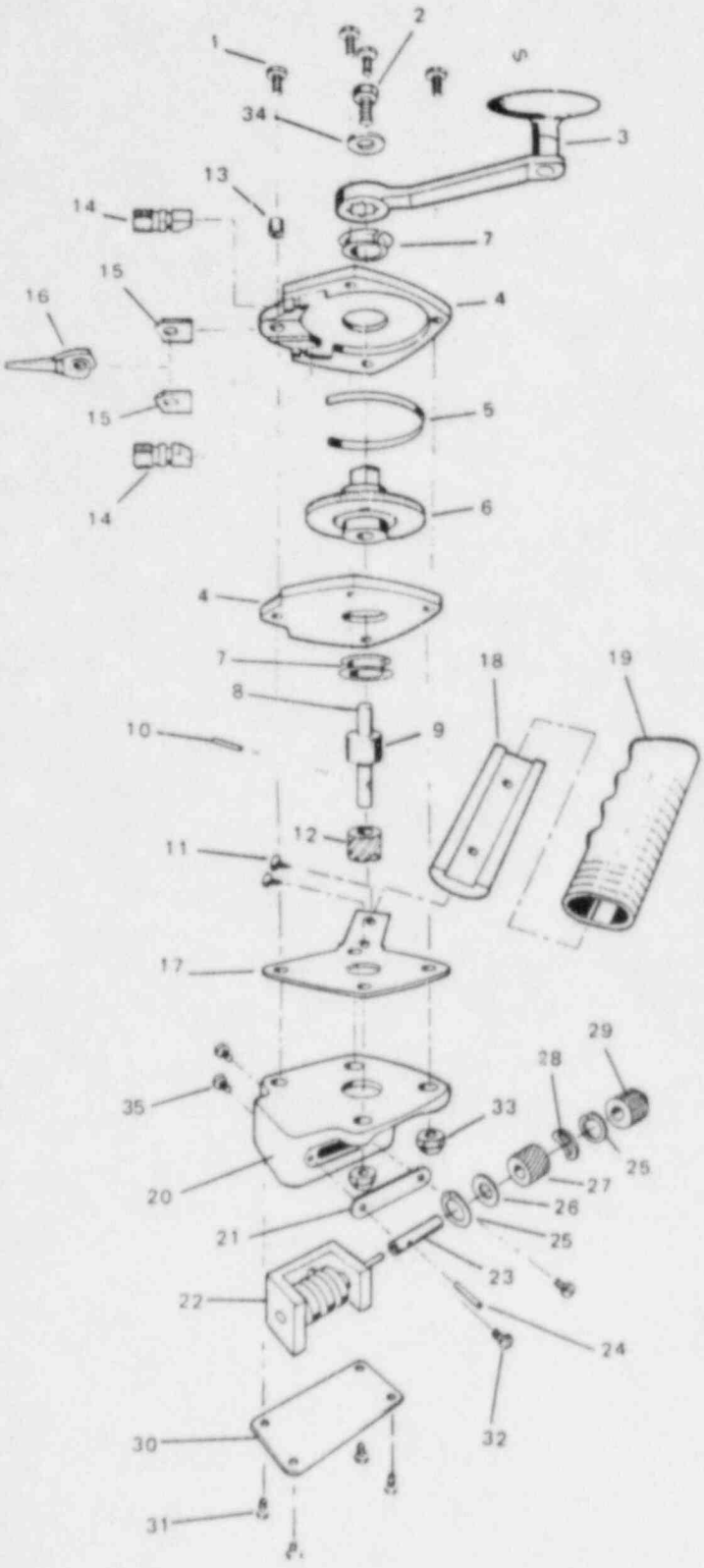
1	40201-7	Burrett clamp
2	40201-8	Clamp holder
3	P/O 40201-9	Aluminum rod, ½ diameter x 32", threaded 3/8 – 16 x 5/8"
4	P/O 40201-9	Tripod base

Figure 6-2. Tripod Stand.



1	——	#10–32 x 1-1/4 Lg. Bind. Hd. Screw and #10–32 Elastic Stop-Nut (4 Each Required)
2	——	5/16–18 x 5/8 Lg. Hex Hd. Bolt (AN 10–5)
3	B68901	Crank Arm Assembly
4	C68900-1	Control Box Housing (2 Req.)
5	A68900-7	Wear Strip
6	C68900-9	Drive Wheel
7	——	Nylon Bearing – Thomson #12L2-FF (2 Req.)
8	A66404-1	Gear Shaft
9	——	Oilite Bearing – Bost. Gear #B48-3
10	——	Dowel Pin – 3/32 Dia. 5/16 Lg.
11	D66402-1	Frame
12	——	Helical Gear – Bost. Gear #H2410L
13	——	Brake Bearing – Bost. Gear #B35–4
14	B68900-2	Cable Adapter (2 Req.)
15	A68900-4	Brake Jaw (2 Req.)
16	A68900-3	Brake Arm
17	——	Odometer – Durant #3Y-8822–R–S–AC
18	A66403-4	Coupling
19	——	Nylon Bearing – Thomson #4L2-FF (3 Req.)
20	——	Helical Gear – Bost. Gear #H2412L
21	A66403-3	Odometer Connecting Shaft
22	B66403-2	Gear Box
23	B66403-1	Mounting Plate
24	——	#8–32 x 3/8 Lg. Bind. Hd. Screw (3 Req.)
25	——	#8–32 x 1/4 Lg. Bind. Hd. Screw (2 Req.)
26	——	#4–40 x 1/4 Lg. Bind. Hd. Screw (2 Req.)
27	——	Rubber Gasket – Green Rubber Co. #GR-121
28	B66403-5	Cover
29	——	Reset Knob – Raytheon #70–1–2
30	——	5/16 Bevel Washer

Figure 6-3 Model 664 Control Unit (Revised July 1974)



1	——	#10–32 x 1-1/4 Lg. Bind. Hd. Screw and #10–32 (4 Each Required)
2	——	5/16–18 x 5/8 Lg. Hex Hd. Bolt (AN 10–5)
3	B68901	Crank Arm Assembly
4	C68900-1	Control Box Housing (2 Req.)
5	A68900-7	Wear Strip
6	C68900-9	Drive Wheel
7	——	Nylon Bearing – Thomson #12L2-FF (2 Req.)
8	A69302-1	Gear Shaft
9	B-48-5	Oilite Bearing – Bost. Gear #B45-3
10	——	Dowel Pin – 3/32 Dia. 5/16 Lg.
11	——	#8 Sheet Metal Screw 5/8 Lg. Flat Head (2 Req.)
12	——	Helical Gear – Bost. Gear #H2410L
13	——	Brake Bearing – Bost. Gear #B35–4
14	B68900-2	Cable Adapter (2 Req.)
15	A68900-4	Brake Jaw (2 Req.)
16	A68900-3	Brake Arm
17	C69201-1	Control Handle
18	B69201-2	Handle Filler
19	——	Handle Grip Hunt-Wilde #FG–1-1/4 Stock #1856
20	C69301-1	Odometer Mount
21	A69301-3	Window
22	——	Counter Durant #3Y-8822–R–AC
23	A69303-1	Odometer Drive Shaft
24	——	Roll Pin, 1/16 Dia. x 1/4 Lg.
25	——	Grip Ring, Tru Arc #5555-25 (1/4 Dia.) (2 Req.)
26	——	Spacer, Pic #88-11 (1/4 Dia. x 1/8 Lg.)
27	——	Helical Gear Boston Gear #H2412L
28	——	Spring Washer, Shakeproof #3502-14-48
29	——	Reset Knob Raytheon #70-1-2
30	A69301-2	Odometer Mount Cover
31	——	8–32 x 3/8 Lg. Bind Hd. Screw (4 Req.)
32	——	4–40 x 3/16 Lg. Bind Hd. Screw (2 Req.)
33	——	10–32 Locknut, Elastic Stop Nut #22 NTM-02 (4 Req.)
34	——	5/16 Bevel Washer
35	——	4–40 x 1/2 LG. RD. HD Screw (2 Req.)

Figure 6-4. Model 693 Control Unit

CHAPTER IV

EMERGENCY AND REMOTE HANDLING EQUIPMENT

STORAGE CONTAINERS

70184

A. REMOTE HANDLING EQUIPMENT

The following remote handling and emergency equipment is supplied with each projector and is to be carried in the vehicle at ALL times.

1. Handling tongs with five foot handle.

2. Cable cutting tool capable of cutting the source guide tube and control cable.

3. Emergency source shield (tunnel)

4. 60 pounds of sand in 10 pound bags

5. Source storage pot.

6. A minimum 2.5 gallon metal bucket with handle capable of being used as an emergency source container.

This emergency and remote handling equipment is provided to assist the Radiographer and Assistant in reducing the field of radiation about an unsafe source during an emergency situation. It is the minimum equipment the Radiation Safety Officer, Senior Radiographer or his designate will need if a source recovery situation exists.

B. AUTHORITY TO USE EMERGENCY EQUIPMENT

SO THAT THERE IS NO MISUNDERSTANDING

A RADIOGRAPHERS ASSISTANT WILL NEVER ATTEMPT TO DEAL WITH AN EMERGENCY. HE WILL ASSIST THE RADIOGRAPHER OR RADIATION SAFETY OFFICER AS REQUIRED.

UNLESS SPECIFICALLY AUTHORIZED BY THE RADIATION SAFETY OFFICER OR HIS DESIGNATE, A RADIOGRAPHER WILL NOT ATTEMPT A SOURCE RECOVERY WHICH REQUIRES REMOVAL OF THE SOURCE FROM THE GUIDE TUBE AND INSERTION INTO AN EMERGENCY CONTAINER.

PROVIDED THAT THE RADIOGRAPHER HAS HAD INSTRUCTION AND PRACTICE IN THE FOLLOWING HE MAY ATTEMPT TO REDUCE THE RADIATION FIELD AS DESCRIBED BELOW. HE IS EXPECTED TO ACT AS FOLLOWS:

At the first indication something is wrong both the Radiographer and Assistant WILL withdraw behind the 2 mr/hr barrier with their survey meters. (You have to have the meter in your hand when you first discover there may be problem; DON'T drop it and run, have the presence of mind to take the meter with you.) DO NOT TOUCH any part of the projector or guide tubes before evacuating.

Once outside the barrier in a safe area there is time to calm down and get one's adrenaline under control. There are very very few emergencies that are life threatening or require immediate response; remember that most of the time a stuck or disconnected source is only a serious problem it is not a disaster.

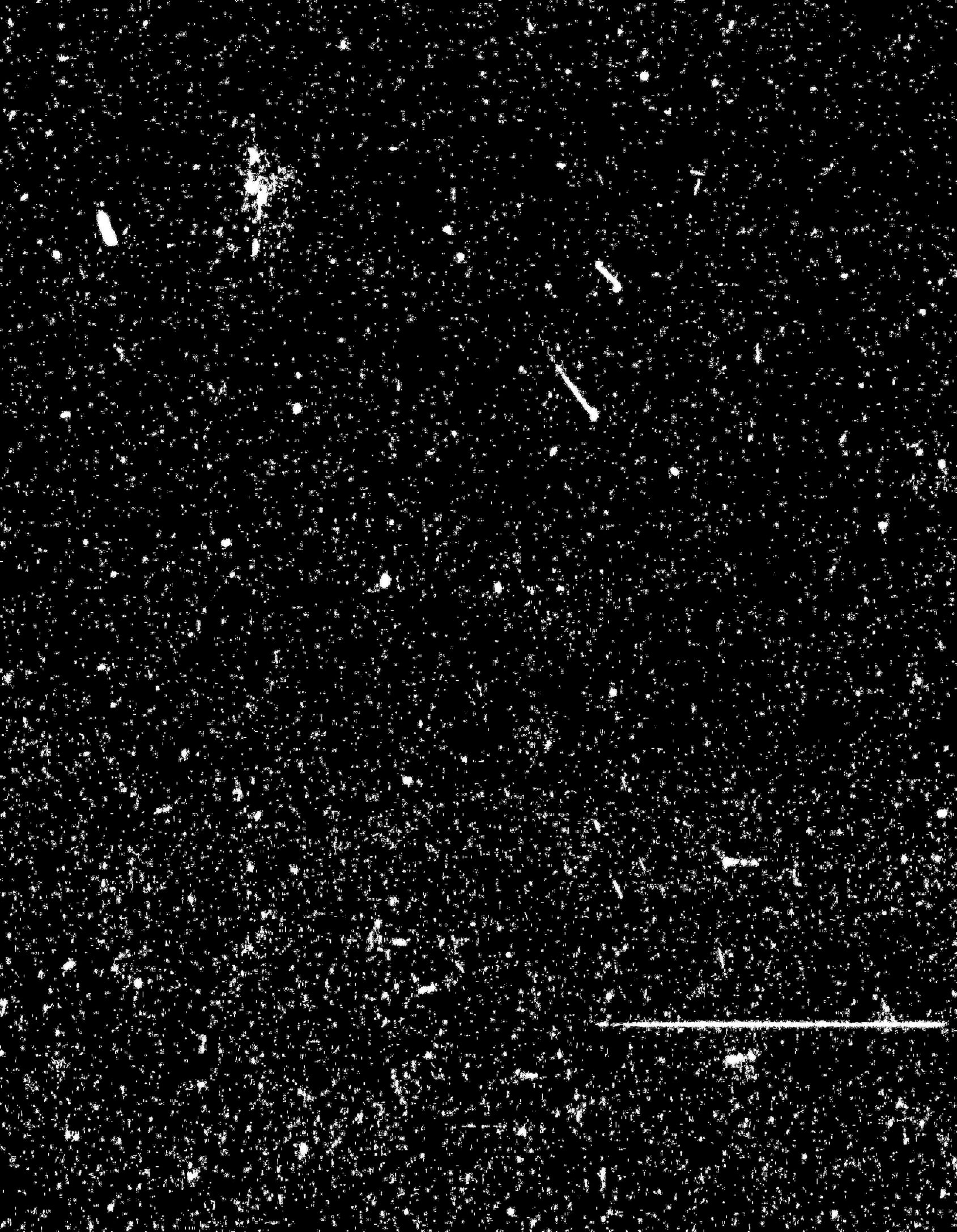
When you have calmed down, try to decide from the events that occurred, is the source disconnected or stuck? Did the survey meter reading jump when source left the collimator shielding? Did the crank get very hard to turn and suddenly release under a lot of pressure? Did you notice the odometer reading where this occurred? If so you would have a good idea if and where a disconnect has occurred. When you have these things firmly in your mind call your supervisor with your problem.

Depending upon the Radiographers experience and state of mind, the Radiation Safety Officer, Senior Radiographer or his designate may authorize an attempt at reducing the radiation level.

Before attempting to reduce the radiation level consider the physical problems, is it muddy, is there danger of slipping and falling in a High Radiation Area, are there obstructions to trip you, are there ladders which must be climbed. If any of these might interfere with you while in close to the source, can the projector safely be pulled by the control to a better location?

The actual location of the source in the guide tube must be determined before any attempt can be made to put some shielding over it to reduce the radiation field. There are at least two methods that can be used to determine the location of the source in the guide tube. If all your actions are planed and carried out swiftly, personal exposure should not exceed the normal dose received at the control crank.

70184



Regardless of your choice of method, record the present reading on your pocket dosimeter, then zero the dosimeter. Later, simply looking at the dosimeter reading will inform you of the dose received without having to subtract any previous dose.

First, establish a line parallel to the guide tube at about a 10 mr/hr level. Observing the survey meter, quickly run this line. One end or the other, or perhaps the middle will have a higher reading indicating the general location of the source.

The second method is more involved and requires precise knowledge of the location of the detector tube in the survey meter. (You may have to open up the instrument to locate the detector tube). Select a location off to the side but near the projector end of the guide tube. Align the flat edge of the source tunnel with the center of the detector tube and from an appropriate distance from the projector (5 to 10 mr/hr level), sight along the flat edge to the projector. Rotate the flat edge of the tunnel toward the exposure end of the guide tube. When the meter reading drops off, the flat surface is approximately pointing at the source. Take up a second position about the same distance to the side but near the exposure end of the guide tube and repeat the procedure. The source will be located very close to the point where the two sight lines intersect the guide tube.

With some knowledge of the source location one can decide on what action can be taken to reduce the radiation field.

C. SHIELDING THE UNSAFE SOURCE

AGAIN, UNLESS YOU HAVE ACTUALLY WITNESSED THE FOLLOWING PROCEDURE AND HAVE PRACTICED IT UNDER SUPERVISION DO NOTHING FURTHER BUT MAINTAIN SURVEILLANCE UNTIL EXPERT HELP ARRIVES.

A Radiographer previously qualified in the following procedures may proceed to drag the source under the source tunnel.

AGAIN, PREPLANNING AND SWIFT EXECUTION OF THE PLAN ARE ESSENTIAL TO MINIMIZE PERSONAL DOSE.

1. Tie a 50 foot length of rope to the handle of the source recovery tunnel. If your first attempt to shield the source fails you can pull the tunnel from the very "hot" area without exposing yourself to this very high radiation field.

2. Establish a reference point off to one side of the projector (but at right angles to the projector) in about a 10 mr/hr field and place a survey meter at that point with its meter visible to the Assistant outside the 2 mr/hr barrier.

3. With both hands on the tool handle, carry the tunnel in front of your body and approach the projector from the control end. (Do not attempt to carry a survey meter with you. All effort should be directed to quickly and accurately placing the tunnel over the guide tube near the front of the projector.) Use whatever shielding that may exist as you approach the projector. (Pressure vessels, piping, concrete walls etc.)

4. Slide the tunnel over the top of the projector and lay it over the source guide tube as close as possible to the front of the projector such that the tube is within the slot in the tunnel. Taking the tool with you, get out of the high radiation area immediately. With survey meter in hand move and at a safe distance, circle the projector noting the radiation levels.

5. If the above survey indicates the source is not within the tunnel, locate a survey meter at the point established in 2. above, then pull the projector backwards toward the control position by pulling on the control cable while the Assistant monitors the source from a safe distance. As the source is withdrawn under the shield, the Assistant should note a drastic drop in radiation field level. Pull no further even though the source may not be centered under the tunnel, you don't want to risk pulling it out the other side of the tunnel. (Should this occur, you have to start over again because you can only pull one way.) Once under the end of the tunnel, the tunnel can be shifted with the tool so that it is centered over the source.

6. A particularly awkward situation would exist if the source logged of disconnected just outside the projectors shielding but inside the source tube screw on connector. Attempting to pull the source under the tunnel might in fact remove it from the tunnel with a marked increase in radiation evident to the Assistant who is monitoring the survey meter located as per 2. above. With a source in this position, the projector's shielding shadow should provide a safe approach from the rear.

70184

6. Confirm the existence of this shadow area with a survey meter and determine its borders. With the tunnel placement tool in hand approach the projector within this radiation shadow, pick up the tunnel with the tool and place the tunnel as close as possible to the front of the projector. It may also be necessary to sandbag the area in front of the projector. If the source has been located elsewhere in the guide tube and contained under the tunnel, the ends of the tunnel should be sandbagged as well.

7. Unless the Radiographer has has further training in source recovery, is capable of completing the recovery and is specifically authorized to proceed by the Radiation Safety Officer, the Radiographer and Assistant Radiographer will secure and maintain visual observation of the site.

8. Although the emergency is not over, with the source and site secured as above, the immediate pressure is off. The Radiation Safety Officer, Senior Radiographer or his designate have the time necessary to plan the recovery to minimize further personal exposures.

C. EMERGENCY SOURCE CONTAINERS

The 'Emergency Pot' is designed to receive the Tech/Ops source and pigtail and provide the shielding of a Type A container. It is not intended for regular source storage or use as a shipping container. Should it be necessary to ship a source for disposal in this container, the Radiation Safety Officer will make the necessary arrangements with the regulatory authorities.

The use of the metal pail as an emergency container should only occur as a last resort measure. Circumstances could occur which require cutting the guide tube and control cable with the condition of the pigtail is such that it cannot be separated from the accompanying section of guide tube - such as might occur after fire. Using the source recovery tunnel for protection as described earlier, the severed guide tube section containing the source can be placed in the bucket. A bed of sand to about one half the depth of the bucket should be prepared before the section of guide tube is placed in the bucket. After placing the the damaged guide tube section and source in the bucket, sand should be shoveled onto the source until the bucket is full. Further sandbagging of the sides will be necessary. With forethought, the bucket would have been placed on a pallet such that the pallet, bucket and auxiliary sandbagging could be moved by forklift to a secure location.

CHAPTER XV

PREVIOUS RADIATION ACCIDENTS

70184

REVIEW OF PUBLISHED RADIATION INCIDENTS

Each employee who works with by-product materials is required to study -

"CASE HISTORIES OF RADIOGRAPHY EVENTS"

Published by the United States Nuclear Commission

When it is possible to do so, a point by point 'post mortem' discussion is held on each case described in the foregoing publication and subsequent releases of similar material.

When new people are added to staff and a group discussion cannot be held, each case is reviewed with the new employee on an individual basis.

Emphasis is placed on breeches of Regulations and the ways and means each Radiographer and Radiographer's Assistant can employee to prevent the same event happening to themselves.