REGULATIONS GOVERNING

THE USE OF

IONIZING RADIATION

Revised

August 1, 1972

BETHLEHEM STEEL CORPORATION
AND
SUBSIDIARY COMPANIES

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1. INTRODUCTION

1.1 This revision reflects the latest changes in Federal and State regulations governing ionizing radiation, including the new standards promulgated under the Occupational Health and Safety Act (OHSA). Interpretations of the regulations of governmental agencies regulating ionizing radiation and of these Regulations can be obtained through the Radiation Control Engineer.

1.2 Purpose

The regulations contained herein are for the purpose of promoting the safe use of ionizing radiation, the protection of personnel from radiation exposure and the general compliance with applicable governmental regulations.

1.3 Scope

These regulations shall apply to the acquisition, possession, utilization, storage and disposal of all ionizing radiation sources and operations related thereto by or on behalf of the Bethlehem Steel Corporation and Subsidiary Companies (hereafter referred to as the Corporation).

Additional regulations relating to radiation protection may be issued regarding specific installations or radiation sources.

2. DEFINITIONS

2.1 Agreement State—Any state with which the Atomic Energy Commission and/or the U. S. Department of Labor has entered into an effective agreement whereby the state has assumed certain licensing and regulatory responsibilities formerly vested in the Atomic Energy Commission and/or the U. S. Department of Labor relative to the possession and use of specified radiation sources.

2.2 Airborne Radioactivity Area—Any room or area in which airborne radioactive materials exist in concentrations in excess of the amounts listed in Appendix B, Table I, Column 1 of Title 10, Code of Federal Regulations, Part 20, **Standards for Protection Against Radiation,** or any room or area in which the average concentrations of airborne radioactive materials, based on the total hours of occupancy, exceed 25 percent of the maximum specified concentrations.

2.3 Collimator—A device such as a cone or diaphragm used to restrict the size and direction of the radiation beam.

2.4 Dead-man Switch—A switch of such design that continuous pressure is required to maintain a closed, energized circuit.

2.5 Dose—The quantity of radiation absorbed by the body or any part of the body. The unit of dose is the REM.

2.6 Exempt Quantity—The quantity of radioactive material that may be possessed and used without specific licensed authorization.

2.7 Exposure—The measure of the ionization produced in air by X or Gamma radiation. For radiation protection purposes the exposure may be considered to be numerically equivalent to the dose.

2.8 External Radiation—Ionizing radiation originating outside of the body.

2.9 Filtration—The application of various materials such as aluminum and copper to reduce the intensity of radiation of ineffective energies in the useful beam.

2.10 High Radiation Area—Any area, accessible to personnel, in which radiation exists such that a major portion of the body could receive a dose, in a period of any one hour, in excess of 100 millirem.

2.11 Half-value Layer—The thickness of any specified material which will reduce a given radiation intensity to one-half the original value.

2.12 Installation—Any room, area or facility in which one or more radiation sources are present. Areas or rooms in which radiation machines are stored in such a manner that the devices are not connected to a power supply and are not generating or liberating

ionizing radiation do not constitute an installation.

2.13 Internal Radiation—Ionizing radiation originating within the body from radioactive materials other than those naturally present in the body.

2.14 Ionizing Radiation—X and Gamma rays, alpha and beta particles, high speed electrons, neutrons, protons and other nuclear particles capable of producing ion pairs, directly or indirectly, as the result of interaction with matter.

Examples of the use or occurrence of ionizing radiation are:

2.14.1 Industrial Radiography.

2.14.2 Medical diagnostic x-rays.

2.14.3 Thickness gages.

2.14.4 Devices to measure the liquid or solid levels in tanks, storage bins or other containment vessels or equipment.

2.14.5 Density gages.

2.14.6 Electrostatic eliminators.

2.14.7 Tracer studies and quality control.

2.14.8 X-ray and electron diffraction, electron microscope equipment and electron probe microanalyzer.

2.14.9 Electronic tubes operating at voltages above 15 kv and those tubes which contain radioisotopes.

2.14.10 Calibration sources.

2.14.11 Control or indicator devices.

2.15 Lead Equivalent—The thickness of lead which affords the same radiation attenuation, under specified conditions, as the material in question.

2.16 Maximum Permissible Accumulated Dose—The maximum dose of radiation which, if accumulated during the life-time of the individual or any major increment thereof, is not expected to produce significant bodily injury.

2.17 Maximum Permissible Dose—The maximum dose of radiation that an individual may receive to his body or any specified part thereof during a stated period of time.

2.18 Non-Occupational Exposure—The exposure of Corporation employees or the general public who are not engaged in or associated with Corporation operations involving the use of radiation sources.

2.19 Occupational Exposure—The exposure of Corporation employees incurred during the performance of work which involves or is directly related to the application or operation of radiation sources.

2.20 Personnel Monitoring—The determination of radiation exposure by means of measuring devices worn by the individual.

2.21 Protective Barrier—Any material such as a shield which is introduced into or present in the path of radiation in a manner such that the radiation intensity at a particular point is reduced to an acceptable level.

2.22 Radiation Area—Any area, accessible to personnel, in which radiation exists at such levels that a major portion of the body could receive a dose in excess of 5 millirems in any one hour or 100 millirems in any 5 consecutive days.

2.23 Radiation Control Engineer—A person in the employ of the Corporation who by training and experience is qualified to evaluate and control radiation exposure and contamination problems associated with the possession and use of radiation sources.

2.24 Radiation Exposure—The absorption of ionizing radiation by the body or any part thereof as a result of the presence of a field of ionizing radiation or the deposition of radioactive materials within the body.

2.25 Radiation Machine—Any device, not containing radioactive materials as the primary source of radiation, which produces radiation when energized.

2.26 Radiation Source—Any radioactive material, or any device which emits radiation when energized.

2.27 Radioactive Material—Any material solid, liquid or gas, that spontaneously emits ionizing radiation.

2.28 Radiographer—A person who performs non-destructive testing which involves the use and application of radiation sources for other than medical purposes or laboratory types of non-destructive testing such as x-ray diffraction analysis.

2.29 Radiographer-in-Charge—The person having the primary supervisory responsibility for radiography at any Corporation facility.

2.30 Rem—The quantity of any type of ionizing radiation which, when absorbed by man, produces an effect equivalent to the absorption by man of one roentgen of x- or gamma radiation.

2.31 Restricted Area—Any area access to which is controlled for the purpose of radiation protection.

2.32 Roentgen—The special unit of exposure. A measure of x- and gamma radiation in air.

2.33 Scattered Radiation—Radiation which has been reflected or deviated in direction as a result of interaction with matter.

2.34 Sealed Source—A quantity of radioactive material encapsulated or otherwise enclosed in such a manner as to prevent the

escape of material under conditions of normal use.

2.35 Shielding—Material used to prevent the passage or reduce the intensity of radiation.

2.36 Stray Radiation—Radiation not serving a useful purpose.

2.37 Survey—Evaluation of the radiation problems incident to the production, use or existence of radioactive materials or other sources of radiation.

3. RADIATION CONTROL RESPONSIBILITY

3.1 The Environmental Quality Control Division of the Industrial Relations Department (hereafter referred to as Environmental Quality Control), acting on behalf of management, has the responsibility to develop and promote the radiation protection program, conduct surveys, prepare rules, regulations and safe operating procedures and to act in the capacity of consultant in matters relating to the use of radiation sources. Some of these responsibilities may be vested in a competent person at certain Corporation facilities.

3.2 Environmental Quality Control has the responsibility of liaison between the Corporation and the Atomic Energy Commission and other governmental agencies regu-

lating radiation sources. This responsibility may be delegated to plant, yard, mine or works personnel by Environmental Quality Control.

3.3 The immediate responsibility for compliance with applicable rules and regulations and the safe use of radiation sources rests with the supervision of the department so involved. Assistance shall be provided by Environmental Quality Control as required. Such responsibility shall include but not necessarily be limited to the following:

3.3.1 The adequate training of personnel in the safe and proper use of radiation sources and equipment and all operating and emergency procedures and rules and regulations related thereto, as required.

3.3.2 The judicious use of personnel radiation monitoring dosimeters as recommended by the Radiation Control Engineer.

3.3.3 The promotion and maintenance of compliance with all applicable rules and regulations pertaining to radiation protection on the part of Corporation employees and outside contractor personnel.

3.3.4 The accountability of all radiation sources regarding security, storage and use.

3.3.5 The reporting of all existing or potential radiation control problems as well as anticipated future radiation applications and

planned acquisitions of new radiation sources to the Radiation Control Engineer.

3.3.6 The scheduling of personnel for required medical examinations in cooperation with the Medical Division of the Industrial Relations Department.

3.4 All personnel working with radiation sources or frequenting restricted areas shall immediately consult the supervisor when there is a question regarding radiation control or protection, performance of equipment, procedure or other such situations.

3.5 In the event of an emergency, such as an accident involving radioactive materials, supervisory personnel shall be notified immediately and shall take prompt action to protect personnel and property, minimize the spread of contamination and restrict the access to the area of concern. The Radiation Control Engineer and the plant fire and patrol chiefs shall be apprised of the situation as soon as possible. Source recovery and decontamination, if necessary, shall be accomplished by or under the supervision of the Radiation Control Engineer.

4. RADIATION SOURCE PROCUREMENT

4.1 All new or unusual uses of radiation sources shall be reviewed with the Radiation

Control Engineer during the period of planning and design.

4.2 The purchase of each radiation source shall be approved by Environmental Quality Control prior to the placement of an order.

5. LICENSING AND REGISTRATION

5.1 The acquisition, possession and use of radioactive materials must be authorized by a license issued by the Atomic Energy Commission, an Agreement State or other State having such jurisdiction and authority. License applications or requests for amendments to existing licenses for all such materials shall be prepared and submitted by Environmental Quality Control.

5.2 Purchase orders for source, byproduct and special nuclear materials or for devices incorporating such materials should not be placed with vendors until the required license has been received, or in the event such is necessary, the order shall be qualified with instructions to defer shipment or delivery until license approval has been received.

5.3 As required by state or local regulations, radiation sources shall be registered with the appropriate agency by Environmental Quality Control or by personnel delegated such responsibility by Environmental Quality Control.

6. MAXIMUM PERMISSIBLE DOSE

Exposure of all personnel to ionizing radiation shall be kept to the lowest practical level. The maximum permissible dose for an individual shall be considered to include all occupational doses from internal and external radiation sources, from all types and energies of radiation, whether delivered simultaneously or successively to the region of interest during the period of measurement. The possession and use of all radiation sources shall be such as to preclude exposures in excess of the following limits.

6.1 External Radiation Exposure (Occupational)

Radiation exposures of personnel engaged in operations involving the use of radiation sources or occupancy of restricted areas shall be limited to not more than:

6.1.1 1.25 Rems to the whole-body, head and trunk, active blood-forming organs, lens of eyes, or gonads during the period of any calendar quarter, except that a maximum exposure of 3 Rems to the whole-body, head and trunk, active blood-forming organs, lens of eyes, or gonads during the period of any calendar quarter shall be permitted provided that the past radiation exposure history of the individual has been properly documented.

6.1.2 5 Rems as a yearly cumulative average for all years in excess of the age of 18.

6.1.3 18.75 Rems to the hands, forearms, feet and ankles during the period of any calendar quarter.

6.1.4 7.5 Rems to the skin of the whole-body during the period of any calendar quarter.

6.2 Internal Radiation Exposure (Occupational)

Internal exposures of personnel engaged in operations involving the use of radiation sources or occupancy of restricted areas shall be controlled in such a manner as to limit the average concentration of radioactive material in air or water to not more than that specified in Appendix B, Table I, Title 10, Code of Federal Regulations, Part 20, **Standards for Protection Against Radiation.** For the purposes of this regulation, concentrations shall be based on an exposure period of 40 hours in any 7 consectutive days.

6.3 External Radiation Exposure (Non-Occupational)

No radiation source shall be used or stored in such a manner as to create in any unrestricted area, radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 2 millirems in any one hour or in excess of 100 millirems in any 7 consecutive days.

Non-occupational external radiation exposures to the whole body, head and trunk,

active blood-forming organs and gonads or lens of the eye originating from Corporation-owned, controlled or contracted radiation sources shall not exceed 0.5 Rem in any one calendar year.

6.4 Internal Radiation Exposures (Non-Occupational)

No radioactive materials shall be used or stored in such a manner as to create in any unrestricted area a concentration in air or water in excess of that specified in Appendix B, Table II, Title 10, Code of Federal Regulations, Part 20, **Standards for Protection Against Radiation.** For the purpose of this regulation, concentrations may be averaged over a period of one year.

Non-occupational internal radiation exposures of individuals resulting from Corporation-owned, controlled or contracted radioactive material shall be regulated by limiting the concentration of such material in air and water in unrestricted areas to not more than that specified above.

7. PERSONNEL MONITORING

7.1 Personnel who (1) enter a high radiation area, or (2) operate or handle radiation sources such that there is a reasonable possibility of receiving a radiation exposure of 300 millirems or greater in any calendar quarter or 500 millirems in any one year or (3) frequent areas where there is a reason-

able possibility of receiving a radiation exposure of 300 millirems or greater in any calendar quarter or 500 millirems or greater in any one year shall be required to wear dosimeter badges. Dosimeter badges shall also be worn in special cases as specified by the Radiation Control Engineer.

7.2 All personnel engaged in industrial radiography employing a radiation source shall wear a pocket dosimeter or pocket chamber if required by applicable governmental regulations in addition to a dosimeter badge. The pocket dosimeter or pocket chamber shall be capable of measuring from zero to at least 200 milliroentgens and shall be read and recorded daily. Should the pocket dosimeter or pocket chamber be discharged beyond its maximum range, the dosimeter badge shall be processed immediately. Records shall be maintained of the exposures recorded by both the dosimeter badge and the pocket dosimeter or pocket chamber.

7.3 Each person shall wear the dosimeter badge (and pocket dosimeter or pocket chamber if such is required) that is specifically assigned to him in such a manner as to accurately reflect his exposure. The loss of any personnel monitoring equipment shall be immediately reported to the supervisor and a proper replacement obtained before re-entering a restricted area.

7.4 Dosimeter badges and exposure evaluation services shall be supplied by Environ-

mental Quality Control. Monitoring periods shall be determined by the Radiation Control Engineer. Following dosimeter processing and evaluation, a record of exposures shall be forwarded to the facility where the personnel monitoring was performed.

8. EXPOSURE RECORDS

8.1 An individual cumulative record of the exposure histories of all personnel monitored for external radiation exposure or subject to exposure to radioactive materials shall be maintained by Environmental Quality Control as required by applicable regulations.

9. SURVEYS AND ENVIRONMENTAL SAMPLING

9.1 Surveys shall be performed by or under the supervision of the Radiation Control Engineer prior to the use of all new radiation sources or after significant modification of existing equipment in order to evaluate associated radiation intensities and operating procedures. Records of all such surveys shall be maintained.

9.2 Environmental sampling to evaluate the concentration of radioactive material in air and water shall be performed by or under the supervision of the Radiation Control Engineer. Records of such evaluations shall be maintained.

10. PHYSICAL EXAMINATIONS

10.1 All employees assigned to departments where personnel monitoring is required shall be given a physical examination before starting such work. The examination shall include the usual history and physical examination and at the discretion of the Medical Director, such hematological tests as may be indicated. In taking the history, inquiry as to significant radiation exposures, including diagnostic and therapeutic procedures shall be made and documented.

For the purposes of these regulations, significant exposures shall include any therapeutic radiation treatment, and diagnostic exposures, particularly diagnostic radioisotopes, fluoroscopic examinations, examinations of the gastrointestinal tract, genitourinary organs, spine and blood forming organs wherein large radiation doses may have been received. Chest x-rays and radiographic examinations of the extremeties need not be included unless the number of such examinations exceeds ten.

10.2 Persons receiving an occupational radiation exposure in excess of 3 rems in any calendar quarter or 5 rems in any year as whole body exposure or exposure to the active blood forming organs, or 3 rems as an acute exposure to an isolated part of the body, may be examined at the discretion of the Medical Director. The Radiation Control

Engineer will notify the Medical Director and appropriate local medical personnel of all such exposures and their significance.

10.3 Persons receiving apparent low exposures from apparatus having highly collimated, high intensity, low energy radiation may be examined at the discretion of the Medical Director. The Radiation Control Engineer will notify the Medical Director and appropriate local medical personnel of all such exposures that he considers significant and the significance of such exposures.

10.4 Every person who is suspected of having ingested, inhaled or otherwise received radioactive materials into his body may also be examined as directed in Regulation 10.1. The Radiation Control Engineer shall notify the Medical Director and appropriate local medical personnel of all such incidents, notify local personnel of the necessary precautions to be taken in handling such persons, determine the need for and the sampling and analytical procedures of biological materials obtained from those persons and advise medical personnel of the results of the analyses.

10.5 Local medical personnel, acting upon the advice of the Medical Director and the Radiation Control Engineer, shall recommend the temporary or permanent removal of any employee from a job which involves possible exposure to radiation or radioactive

materials if, in his judgment, further exposure may jeopardize the employees health. Any person, so removed, shall not be reassigned to radiation work without written authorization from local medical personnel.

10.6 Employees having accumulative occupational radiation exposures in excess of 5 rems for whom notice of intent to terminate employment is known may be given a physical examination as outlined in Regulation 10.1 immediately prior to termination.

10.7 Persons suspected of receiving a radiation exposure in excess of 500 millirems as an acute, non-occupational exposure may be examined at the discretion of the Medical Director. The Radiation Control Engineer will notify the Medical Director and appropriate local medical personnel of all such exposures and the estimated doses that may have been received.

11. ACCOUNTABILITY RECORDS

11.1 An accurate record shall be maintained at each facility where radioactive materials are possessed, stored or used. Such records shall show the amount of radioactive material received, transferred, decayed in storage or use, and released for disposal.

11.2 In addition to the requirements of subsection 11.1, a quarterly inventory of all sealed radiation sources used in industrial

radiography shall be performed by the Radiographer-in-Charge or his designated representative. Documentation of such inventories shall include information as to the quantities, kinds and locations of sealed sources and the date of the inventory.

12. POSTING AND LABELING

Required posting and labeling unless otherwise specified shall bear the standard radiation symbol and appropriate wording in the conventional colors of magenta or purple on a yellow background.

12.1 Radiation Area—All radiation areas shall be conspicuously posted with a sign or signs bearing the words, CAUTION—RADIATION AREA.

12.2 High Radiation Area—All high radiation areas shall be conspicuously posted with a sign or signs bearing the words, CAUTION—HIGH RADIATION AREA.

12.3 Airborne Radioactivity Area—All areas, rooms or enclosures subject to personnel occupancy in which airborne radioactive materials exist in excess of the maximum permissible concentrations shall be conspicuously posted with a sign or signs bearing the words, CAUTION—AIRBORNE RADIOACTIVITY AREA.

12.4 Radiation Machines—All radiation-producing machines shall be posted with a

label bearing the words, CAUTION—THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED. Such a label shall be affixed on the control panel near the switch which energizes the tube. Caution or warning signs shall, in addition to the above label be posted in the vicinity of the radiation-producing tubes if such tubes are significantly remote from the control panel. Such signs may be worded in a manner appropriate to the installation and may be in colors other than those of the conventional radiation warning signs if such is permitted by applicable regulations.

12.5 Containers—All containers in which radioactive materials are stored, transferred or used shall be conspicuously posted with a label bearing the words, CAUTION—RADIOACTIVE MATERIAL. Additional information such as the kind and quantity of the material as well as the date of assay shall also be provided on the label. The container labeling requirement is waived in the case of laboratory glassware during analysis and unenriched naturally occurring radioactive materials.

12.6 "Free Air" Sources—All "Free Air" sources which are not fastened to or contained in a radiographic exposure device shall have a durable tag attached which is at least 1 inch square and bearing the words, DANGER—DO NOT HANDLE. NOTIFY CIVIL AUTHORITIES IF FOUND.

12.7 Additional Posting—All areas or rooms in which radioactive materials are used or stored in amounts exceeding 10 times (100 times in the case of natural uranium and natural thorium) the quantities specified in Appendix C, Title 10, Code of Federal Regulations, Part 20, **Standards for Protection Against Radiation,** shall be conspicuously posted with a sign or signs bearing the words, CAUTION—RADIOACTIVE MATERIALS.

12.8 Notices—Copies of Form AEC-3, **Notice to Employees,** or a similar form as designated by a governmental agency having such jurisdiction shall be posted, if required, in such a manner and in sufficient locations so that all employees who work in restricted areas where a radiation source is present may observe a copy.

12.9 Exemptions From Posting—Areas or rooms are not required to be posted with caution signs because of the presence of a sealed radiation source if the radiation intensity at a distance of 12 inches from the surface of the container does not exceed 5 milliroentgens per hour.

13. INDUSTRIAL RADIOGRAPHY

Industrial Radiography shall be considered to include all nondestructive testing of materials for the examination of certain physical characteristics such as the incidence of

cracks, holes or inclusions by methods or procedures utilizing radiation sources, except that operations, procedures and methods employing radiation sources in laboratory analyses (for example, x-ray diffraction), thickness and coating thickness gages, level indicators or controls, density gages or other similar applications (which are covered in Sections 18 and 19) shall not be classified as industrial radiography.

13.1 Radiographers shall successfully complete the Corporation's radiographer training program unless otherwise exempted by regulation and approved by the Radiation Control Engineer.

13.2 No radiography shall be performed with sealed sources or with X-ray machines unless calibrated and operable survey instrumentation having a range of at least 2 milliroentgens per hour through 1000 milliroentgens per hour is available and used.

13.3 All radiography shall be conducted within a restricted area which shall be enclosed by a permanent fixed barrier or by rope or other temporary means of area definition. Such barriers or restrictions shall be located in a manner to enclose the entire area where radiation levels exceed the limits specified in the radiographic exposure schedule below. The restricted area shall be posted with signs bearing the words, CAUTION—RADIATION AREA. All areas where radiation levels exceed 100 milliroent-

gens per hour shall be posted with conventional radiation warning signs bearing the words, CAUTION—HIGH RADIATION AREA. The duration of radiographic exposures in such areas shall be limited to the time intervals appropriate to the extent of the area restriction as specified in the radiographic exposure schedule below. Whole-body exposures of non-radiography personnel working in unrestricted areas shall not exceed 2 millirems in any one hour, 100 millirems in any seven consecutive days or 500 millirems in any one calendar year.

RADIOGRAPHIC EXPOSURE SCHEDULE

Maximum Radiation Intensity at Area Restriction Barrier (mr/hr)	*Maximum Exposure Time In Any One Hour (minutes)*
20	6
10	12
5	24
2	No Limit

13.4 Except when radiographic radiation sources are used within locked, shielded facilities where the door or doors are equipped with interlocking devices so that the radiation is terminated automatically or an audible alarm is automatically sounded upon opening, X-ray machines when energized and radioisotope sources when not securely

locked in shielded storage containers shall be attended by a radiographer.

13.5 All unlocked doors, roping and other temporary restricted area boundaries shall be under the direct surveillance of a radiographer immediately preceding and during the time that radiographic exposures are in progress.

13.6 When radiography is to be performed in an area other than that in which it is normally done, the plant Patrol and Fire Departments shall be notified as to the location of the proposed radiographic area, the approximate time and duration of the work, the type of the radiation source to be used, the period of time the source will be in the area and the name of the radiographer.

13.7 All radioactive material sources shall be securely locked in their prescribed containers when not attended by a radiographer or when not in use, except as provided in subsection 13.4 above. During periods when such sources are not required for radiography, they shall be stored within locked enclosures or chained or otherwise rigidly secured. Security precautions shall be such as to prevent unauthorized removal. The storage area shall be restricted in a manner that will prevent exposures in excess of 2 millirems in any one hour and shall be conspicuously posted with the required conventional radiation warning signs. X-ray ma-

chines shall be locked in the off position when not in use and secured against unauthorized use or removal.

13.8 The Radiation Control Engineer shall be notified of the anticipated acquisition and arrival of all new radiation sources to be used by the Corporation. He shall inspect and survey such sources to determine associated radiation levels and possible contamination (if a sealed source).

13.9 Radium sources shall be stored in ventilated areas to prevent the accumulation of radon gas.

13.10 All x-ray machines which operate above 150 kv shall have a minimum of one-half millimeter of copper filtration in addition to the tube's inherent filtration unless otherwise specified by the Radiation Control Engineer.

13.11 Where practical, all portable x-ray machines shall be equipped with a cone to collimate the primary beam. The collimator shall have a minimal cross sectional area and be at least 4 inches in length. It should be attached as flush to the x-ray machine as possible. (A gap between the collimator and the machine may allow radiation to be scattered to the sides of the unit.)

13.12 Whenever a remote-controlled source handling device is used, the radiation intensity at the operator's position shall be

measured during the extension of the source to insure that it has not become immobile in the source tube. Following each exposure shot, the device shall be surveyed to insure that the source has been returned to the shielded position before anyone is permitted to enter the restricted area. A similar survey is to be made following each exposure made with an x-ray machine to insure that the radiation exposure has terminated.

13.13 When radiation sources are used outside of a shielded facility, a survey of the radiation levels shall be made immediately upon exposure of the source or the energizing of the radiation producing machine. Roping, barricades or other means of area definition shall be repositioned, if necessary, to properly enclose the restricted area as required in subsection 13.3, above. When a number of similar radiographs is to be made of items of the same materials of construction and thickness, and no change is made in the radiation source such as an increase in the x-ray voltage or current or a change in sealed sources or sealed source strength; area surveys between individual exposures need not be repeated. Spot surveys should, however, be made periodically to confirm adequate restricted area definition. A record shall be made of all such surveys.

13.14 At the termination of radiography employing a sealed source, a radiation survey shall be made to assure that the source

is in the shielded position prior to securing the device and storage container. Records shall be kept of all such surveys.

13.15 Written procedures shall be prepared by the Radiographer-in-Charge which describe the safe handling and operation of each type of radiographic device that is to be used. A copy of each such procedure shall be submitted to the Radiation Control Engineer for review.

13.16 A record shall be maintained of all uses of radiation sources for radiographic purposes. Such records shall include a description of the exposure device or storage container, the identity of the user, the kind and quantity of the radioactive material, the location of and the date of use. An individual utilization log shall be maintained for each such device.

13.17 The Radiation Control Engineer shall periodically review operational procedures, records, utilization logs, inventories and other pertinent information relative to radiographic operations in order to determine general compliance with applicable governmental regulations, license provisions and Corporation operating and emergency procedures.

13.18 The Radiation Control Engineer shall be notified when an outside concern is engaged to provide radiography services at Corporation facilities. Details such as the

name and address of the company, the location of the proposed work, the number and type of radiographs to be made, the kind and quantity of the sources to be used and the dates when such services will be performed shall be provided.

13.19 Environmental Quality Control shall notify the appropriate governmental agency of such proposed outside contractor work as required by applicable regulations.

13.20 All contractors performing radiography for the Corporation shall be given a copy of these regulations and shall govern their operations in accordance therewith as well as all other applicable regulations.

13.21 A minimum of two persons shall attend the radiographic operations performed by an outside contractor. One shall be the radiographer supplied by the contractor. The second person may be either a Corporation employee or a contractor employee who has been instructed in and understands the safe method of returning the radioactive source to an adequately shielded container or how to turn off the radiation producing equipment, should the radiographer become unable to do so.

14. MEDICAL DIAGNOSTIC X-RAY

14.1 Medical radiation for diagnostic purposes shall be applied only under the direction of a physician employed by Bethlehem

Steel Corporation, and only by employees possessing adequate training as described by appropriate governmental agencies. In the absence of a governmental agency regulation determining adequate training, this decision will be made by the Medical Director. The training shall include as a minimum such areas as patient positioning, protection of the patient and the operator, darkroom procedures and radiographic exposure principles.

14.2 Medical X-ray installations shall be designed and shielded in such a manner that significant radiation exposures will not be experienced by personnel frequenting adjacent rooms or areas.

14.3 Only the individuals required for the x-ray procedures shall be permitted in the x-ray room during exposures. Radiation exposures of operating personnel shall be controlled by the use of shielding and protective clothing as necessary to insure against radiation doses in excess of the maximum permissible.

14.4 Access to x-ray rooms shall be restricted during the time when exposures are in progress in order to prevent inadvertent entry and unnecessary exposures.

14.5 Exposure of the patient shall be maintained at as low a level as possible. Shielding shall be used where practical.

14.6 The tube shall be of the diagnostic type.

14.7 For equipment operating at 60 kv and below, the total filtration in the useful beam shall be equivalent to at least 1.5 millimeters of aluminum. This requirement may be assumed to have been met if the half-value-layer is not less than 1.5 millimeters of aluminum at normal operating voltages.

14.8 For equipment operating above 60 kv, the total filtration in the useful beam shall be equivalent to at least 2.5 millimeters of aluminum. This requirement may be assumed to have been met if the half-value-layer is not less than 2.5 millimeters of aluminum at normal operating voltages.

14.9 All new medical diagnostic x-ray equipment shall comply with Federal standards governing new diagnostic equipment. A statement from the installer certifying that the equipment has been manufactured and installed in compliance with Federal "New Equipment Standards" shall be obtained.

14.10 Medical Radiographic Installations.

14.10.1 Diaphragms or cones conforming to Report 33 of the National Council on Radiation Protection shall be provided for collimating the useful beam and shall provide the same degree of protection as is required for the tube housing.

14.10.2 An automatic device shall be provided to terminate the exposure after a preset time or exposure.

14.10.3 The exposure switch shall be of the "dead-man" type and shall be so arranged that it can be manipulated only when the operator is within a shielded area.

14.10.4 The operator's position shall be adequately shielded. The shield shall be provided with a window such that the operator can view the patient.

14.11 Medical Fluoroscopic Installations.

14.11.1 Fluoroscopes shall be so constructed that the entire cross section of the useful beam is attenuated by a primary barrier. Collimators and adjustable diaphragms or shutters shall be provided to restrict the size of the useful beam to less than the area of the barrier. For conventional fluoroscopes, this requirement is met if, when the adjustable diaphragm is open to its fullest extent, an unilluminated margin is left on the fluorescent screen with the screen centered in the beam at a distance of 14 inches from the panel or table top. Installations having image intensified fluoroscopes are to restrict the beam size to the dimensions of the largest size spot film used, but in no case larger than the input phosphor of the intensifier receptor.

14.11.2 Accessory shielding devices such as cones, Buckey slot covers and shielding between the patient and fluoroscopist shall be used as required to reduce the exposure dose rate to not more than 50 millirem per

hour in the area adjacent to the fluoroscopist and his assistants during fluoroscopy.

14.11.3 The target-to-table-panel distance shall not be less than 12 inches.

14.11.4 The tube mounting and the fluoroscopic screen shall be linked together so that during use the fluoroscopic screen always fully intercepts the useful beam.

14.11.5 A manually reset cumulative timing device shall be used which will either indicate elapsed time by an audible signal or turn off the apparatus when the total exposure exceeds a predetermined limit given in one or a series of exposures. The device shall have a maximum range of 5 minutes.

14.11.6 Collimators and adjustable diaphragms or shutters to restrict the size of the useful beam shall provide a minimum of 2.0 millimeters lead equivalent protection for 100 kv, 2.4 millimeters for 125 kv, and 2.7 millimeters for 150 kv.

14.11.7 The exposure rate measured at the panel or table top shall not exceed the values below:

Operating kvp	*Exposure Rate R/ma-min.*
70 or below	2.2
80	3.2
90	4.3
100	5.5
110	6.8
120 and above	8.0

15. EMERGENCY PROCEDURES

15.1 The Patrol, Fire and Safety Departments at all facilities where radioactive materials are used or stored shall be informed of all use or storage locations, kinds and quantities of such materials and the associated contamination and radiation exposure potentials.

15.2 An up-to-date list of the names and office and home telephone numbers of personnel qualified to cope with radiation problems shall be kept on file by the Patrol Department.

15.3 Fire Department personnel shall, in cooperation with the Radiation Control Engineer, plan for combating fires in which radioactive materials are involved. Such planning shall include the evaluation of all possible hazards.

15.4 Rooms or areas in which radioactive materials are stored shall be inspected at least annually by the Fire Department.

15.5 It shall be the responsibility of all personnel to immediately report any emergency involving radioactive materials to the Patrol Department. The Patrol Department shall notify the personnel as listed under the requirement of 15.2.

15.6 Should an emergency occur, radiation sources located in the affected area should be turned off if an x-ray machine,

or returned to the storage container if a radioactive material source, provided such action does not jeopardize the safety of personnel. The area in which an emergency involving radioactive material is located shall be immediately evacuated and only personnel qualified to take remedial action shall be admitted.

15.7 Qualified personnel shall take appropriate steps to confine the radioactive materials, warn other personnel who might be in the area, take immediate measures to decontaminate personnel if such is required, and by the use of available survey instruments, define the boundaries of the area to be restricted. Further corrective action, unless otherwise dictated by the circumstances of the emergency, shall await the arrival or recommendations of the Radiation Control Engineer.

15.8 Personnel present in or frequenting the area in which the emergency occurred shall be surveyed for contamination, and decontaminated if such action is required, prior to leaving the general vicinity of the restricted area.

15.9 All individuals entering the restricted area shall wear personnel monitoring equipment.

15.10 Where there is a possibility of significant airborne radioactive materials, personnel entering such emergency areas shall

wear appropriate respiratory protective equipment. Protective clothing should also be worn if such is available.

15.11 In the event of an accident involving radioactive materials while being transported outside of Corporation property personnel referred to in subsection 15.2 shall be notified immediately. Depending on the type and quantity of material being transported, and the contamination and exposure potential, appropriate state authorities and the Atomic Energy Commission shall be notified regarding the situation. Immediate measures shall be taken to contain the material, to prevent exposure, and to decontaminate if the need for such action is indicated.

16. TRANSPORTATION OF RADIOACTIVE MATERIALS

When radioactive materials are transported over public roadways between different sites by Corporation personnel, the following shall be observed.

16.1 The radioactive material shall be placed in a strong durable container with sufficient shielding to reduce the radiation intensity at the surface of the outer package to not more than 200 milliroentgens per hour and that a distance of one meter to not more than 10 milliroentgens per hour. The container shall meet applicable Federal and

State Department of Transportation specifications.

16.2 The container shall be securely locked and the key shall be retained in the possession of the responsible person accompanying the shipment. The outer shipping container shall incorporate a seal which is not readily breakable and which, while intact, will be evidence that the container has not been illicitly opened.

16.3 The outer container shall bear a conspicuous durable label containing the words, CAUTION—RADIOACTIVE MATERIAL, the standard radiation symbol and colors, the type of radioactive material, the source strength and the date of measurement.

16.4 A properly executed radioactive material label as required by the U. S. Department of Transportation shall be affixed to the outer container.

16.5 The container shall be secured in the transporting vehicle in such a manner that its position will be maintained under conditions normally incident to transportation.

16.6 The vehicle shall be surveyed after loading. Gamma radiation levels on the outer surface of the vehicle shall not exceed 2 milliroentgens per hour. The vehicle shall be placarded with conventional warning signs bearing the word, RADIOACTIVE,

and such other placards as may be required by Federal, State and local regulations.

16.7 A responsible person at the intended destination shall be notified of the departure of the shipment and the estimated time of arrival. Acknowledgement of receipt of the shipment shall be made to the shipper by telephone.

16.8 The driver of the vehicle shall be instructed to notify the responsible person at the shipment origin should unusual delays be encountered enroute.

16.9 In the event of an accident enroute, the responsible person at the shipment origin shall immediately initiate the appropriate measures of Section 15, EMERGENCY PROCEDURES.

16.10 Should the transporting vehicle be overdue and unreported for a period of one hour at its destination, an immediate search shall be initiated.

17. LEAK TESTING

17.1 Sealed radiation sources shall be leak tested prior to initial use and every 6 months thereafter or at intervals otherwise specified by applicable regulations or licenses for the purpose of detecting faulty or damaged containment capsules which permit the escape of radioactive material to the environment.

17.2 Leak tests shall be performed by the Radiation Control Engineer or an authorized representative.

17.3 Analyses of leak test samples shall be performed at the Environmental Quality Control laboratory in Bethlehem, Pennsylvania, or at other facilities where appropriate equipment and qualified personnel are available.

17.4 The sensitivity of analytical procedures shall be such as to be capable of detecting a minimum activity of at least 0.005 microcuries.

17.5 Immediately following sampling, the samples shall be surveyed to determine the radiation levels. Should the radiation level exceed 0.5 milliroentgen per hour at a point in close proximity to the sample, handling shall be such as to minimize exposure and contamination. Final packaging for transmittal to the laboratory shall be such that the radiation levels on the outer surfaces of the container shall not exceed 0.5 milliroentgen per hour.

17.6 Should a leak test reveal the presence of transferrable activity in the amount of 0.005 microcurie or more, the device so tested shall be immediately withdrawn from service and decontaminated, repaired or disposed of in accordance with applicable regulations.

17.7 Leak testing shall be accomplished by one of the following methods depending on the type of device or source.

17.7.1 "Free Air" Sources

"Free Air" sources are those which are not incorporated in remote handling devices or shielded source holders. These sources are handled by the string and pole method, by the threaded pole and source method, or the method employing a magnet which is attached to the end of a pole.

The primary hazard associated with the leak testing of "free air" sources is that of external radiation exposure. The test should be performed as rapidly as possible in a manner which makes maximum use of available shielding such as the source storage container or lead bricks. The person performing the test shall wash his hands thoroughly after completion of the test and handling of the samples.

17.7.1.1 The source shall be removed from the storage container in the approved manner and wiped with a cotton swab. The swab shall then be surveyed for excessive contamination and placed in the accompanying labeled container.

17.7.1.2 After testing, the source shall be returned to the storage container.

17.7.2 Sources Used In Gaging Devices

Gaging devices are constructed in such a

manner that there are only a few areas where the radioactive material can escape to the environment if the source capsule should leak. Sealed radiation sources contained in devices for the measurement of liquid and solid level, density or thickness and other equiment in which the source is permanently mounted in a shielded position are included in this category.

The primary hazard associated with the leak testing of this type of sealed source is the possibility of the contamination of the tester's hands. Hands should be washed thoroughly after the sample has been secured in the container.

17.7.2.1 At the time of the initial leak test, the Radiation Control Engineer shall determine the areas where radioactive materials could leak from the gage. These areas shall be wiped with filter paper or a cotton swab.

17.7.2.2 During subsequent leak tests, the same gage areas shall be wiped with a filter paper or cotton swab. The resulting sample shall be placed in a container and surveyed to determine radiation intensity, if any.

17.7.3 Sources Used in Remote Handling Devices.

Radiographic exposure devices containing sealed radiation sources which are operated by remote means are included in this category. Normally, it is difficult and very dangerous to remove the source from the equip-

ment so that it can be leak tested directly. In lieu of such direct testing, surfaces of the device which make contact with the source capsule shall be tested as an indication of the integrity of the capsule.

The primary hazard associated with the leak testing of this type of device in this manner is the possibility of the contamination of the tester's hands. Hands should be thoroughly washed after the sample has been secured in the container.

17.7.3.1 Immediately prior to leak testing, a radiation survey shall be made to assure that the source is in the shielded position.

17.7.3.2 A surface (or surfaces) of the device which makes contact with the capsule shall be wiped with a cotton swab. The swab shall be surveyed and placed in a sample container.

17.7.4 Special Sources.

Leak testing methods of unique sources or those presenting specialized problems will be devised by the Radiation Control Engineer and performed under his supervision.

17.8 Leak test samples shall be analyzed in the following manner:

17.8.1 Filter Paper and Cotton Swabs

The activity contained on the filter paper or cotton swabs shall be determined by direct counting in an internal gas-flow proportional

counter or other appropriate laboratory counting equipment and shall be considered to constitute that which was transferrable.

17.8.2 Special Methods.

As dictated by the sampling procedures, special analysis will be developed by the Radiation Control Engineer so as to adequately test specialized sources for transferrable contamination.

17.9 Results of the individual leak tests shall be forwarded to the appropriate supervisory personnel having the responsibility for the source. In the event that transferrable activity is observed, its significance and a recommended course of action shall accompany the test results. If the test results indicate a serious problem, the user shall be notified to that effect immediately.

18. GAGING DEVICES

X-ray producing equipment and radioactive materials are used in applications such as detection, measurement, gaging and control. Devices of this type are generally constructed in such a manner and provided with interlocking switches so that operation is, for the most part, inherently safe.

18.1 X-ray Thickness Gages.

X-ray thickness gages as used in steel strip mills usually do not emit significant radiation

to surrounding areas under normal conditions of operation. The possibility of whole-body radiation exposure is minimal because of the small, well-defined radiation beam. The possible exposures of concern are to the lens of the eyes from stray radiation and the accidental exposure of the hands and fingers to the primary beam, particularly during maintenance and manual calibration operations.

18.1.1 During normal operation when the tube is energized, the tube housing, the detector or the area between the tube and detector should not be approached by any part of the body closer than two feet except for laboratory installations where samples are positioned manually. Such sample positioning is to be performed with the aid of remote handling devices.

18.1.2 All maintenance and external calibration shall be performed by personnel who are familiar with the equipment and the correct procedures to be followed.

18.1.3 All maintenance personnel who work on such gages shall wear radiation monitoring devices.

18.1.4 Unless it is necessary for the x-ray tube to be energized, the power supply to the tube shall be positively interrupted by such means as the removal of fuses and locking and tagging switches in the off position during maintenance of the tube enclosure and contents and the detector.

18.1.5 During external calibration, standard samples shall be inserted into the primary radiation beam by means of an extended handle which is at least two feet in length.

18.1.6 X-ray tubes shall not be energized unless installed in a normal manner in the shielded tube enclosure except where adequate external shielding is provided.

18.1.7 All safety features such as shutters and interlocks shall be tested periodically for adequate performance.

18.1.8 The tube housing of all x-ray gages is to contain a warning sign alerting personnel to the existence of an ionizing radiation beam when energized.

18.2 X-ray Coating Thickness Gages

The regulations contained in subsection 18.1, above, shall apply to the operation and maintenance of x-ray coating thickness gages.

18.3 Gages Containing Radioactive Materials.

Gages incorporating radioactive materials have a wide variety of applications. The following pertains to such devices.

18.3.1 The acquisition, possession, use, repair, testing and disposal of radioactive ma-

terial sources shall be compatible with the conditions of the applicable license and regulations.

18.3.2 All such gaging equipment shall be equipped with a durable label which bears the words, CAUTION—RADIOACTIVE MATERIAL, the kind and quantity of the radioactive material contained and the date on which the material was assayed. Such labels or other labels subsequently attached shall not be removed unless authorized by the Radiation Control Engineer.

18.3.3 Installation, repair or relocation of the device containing the radiation source shall be accomplished under the supervision of the Radiation Control Engineer or an authorized representative.

18.3.4 When an installation incorporating such a device is to be inactive for any prolonged period of time, the shield shall be locked in the closed position.

18.3.5 No part of the body shall be placed in the area of the primary radiation beam between the detector and the source housing.

19. X-RAY, ELECTRON DIFFRACTION AND ELECTRON MICROSCOPE TYPE EQUIPMENT

Analytical equipment of this type is usually operated at or below 50 kv with the

exception of electron microscopes which may be operated at voltages in the range of 100 kv. Even though, in general, the voltages are reasonably low, currents in the order of 50 to 100 ma are sometimes employed with minimal beam filtration. The resultant primary beam has an exceedingly high radiation intensity. It is also possible for considerable stray radiation to result from scattering by the target material. The primary area of exposure concern is the hands and fingers from the direct primary beam. The following shall be observed regarding this type of equipment.

19.1 No part of the body shall be placed in the sample chamber while the tube is energized. In those cases where it is necessary to manually position the sample in the area of the primary beam, the x-ray tube shall be de-energized or the primary beam adequately attenuated during such sample positioning. An interlocking device which prevents the entry of any part of the body into the primary beam, or causes the primary beam to be shut off upon entry into its path, shall be provided.

19.2 Shutters, interlocks and other safety devices shall be tested at least once each week to insure proper operation. Such tests shall be performed by the personnel who operate or service such devices.

19.3 Maintenance shall be performed by personnel who are familiar with the equip-

ment, the potential hazards involved and safe procedures.

19.4 Unless otherwise necessary, all maintenance of the x-ray tube, x-ray tube enclosure and contents and the detector, as well as equipment positioned in the area between the tube and the detector shall be performed while the power supply to the tube is positively interrupted by such means as fuse removal or tagging switches in the off position.

19.5 A label bearing the words "CAUTION RADIATION—THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED" shall be placed near any switch which energizes a tube.

19.6 A sign bearing the words "CAUTION—HIGH INTENSITY X-RAY BEAM," shall be placed in the area immediately adjacent to each tube head. The sign shall be so located so that it is clearly visible to any person operating, aligning or adjusting the unit, or handling or changing a sample.

19.7 An indication of the presence of an x-ray beam shall be provided on or immediately adjacent to each tube head, and be so located that it is clearly visible to any person operating, aligning or making adjustments to the apparatus, or changing samples.

19.8 An indication of the status (i.e., open or closed) of beam port shutters shall be pro-

vided, and be so located that they are clearly visible to any person operating, aligning or making adjustments to the apparatus, or changing samples.

19.9 Unused tube ports shall be closed in such a fashion that accidental opening is not possible.

19.10 Surveys shall be performed to insure that operations are conducted safely whenever changes to the physical configuration of the equipment is made.

19.11 No person is to operate this equipment unless instruction is given in the safe operation, radiation hazards concerned with the equipment, the symptoms of an acute localized exposure, and the procedures for reporting an actual or suspected radiation overexposure.

19.12 In cases where the primary x-ray beam is not intercepted by the experimental apparatus under all conditions of operation, protective measures shall be provided, such as auxiliary shielding, to avoid exposure to the residual primary x-ray beam.

20. ELECTRONIC TUBES OPERATING AT HIGH VOLTAGES

X-rays are produced in electronic tubes operated at high voltages. X-rays produced at voltages below 15 kv are probably not sig-

nificant since they are readily absorbed in the tube walls and in the air immediately surrounding the tube. The tubes that should be suspected of emitting significant radiation are the klystrons, magnetrons and thyratrons. Tektronix oscilloscopes are known to emit x-rays in appreciable quantities.

Some electronic tubes are being manufactured which contain radioactive materials as an aid in performance. The amount of such material is small and these tubes will be marked with the magenta radiation symbol and the words, CAUTION—RADIOACTIVE MATERIAL. The potential hazard from these tubes is that of breakage and thus releasing radioactive material which can possibly be inhaled or otherwise enter the body through cuts or breaks in the skin.

Where any of these potential sources of radiation are encountered and there is any doubt as to whether high voltage equipment is emitting x-rays, the Radiation Control Engineer should be consulted.

21. ACCELERATORS

An accelerator shall be any radiation producing machine capable of imparting kinetic energies of 1 Mev or greater to electrons or 0.1 Mev or greater to other particles. They create specialized hazards due to their operation and thus require controls beyond those required for conventional x-ray generators.

21.1 Operators are to be provided and familiar with written operating procedures for normal, bypass and emergency operations.

21.2 Up-to-date diagrams of the accelerator control, safety interlock and warning circuits are to be maintained and available.

21.3 An independent radiation monitoring system shall be provided so that persons entering high radiation areas may be made aware of the existence of a radiation hazard.

21.4 Warning lights wired to the accelerator controls shall be placed inside and at entrances to high radiation areas.

21.5 Tests of all safety and warning devices are to be made prior to beginning the day's operation.

22. TRACER STUDIES FOR RESEARCH AND QUALITY CONTROL

Radioactive tracer techniques involve the introduction of radioactive materials into a chemical or metallurgical process for the investigation of various phenomena such as the degree of wearing or erosion, degree of mixing, rates of reaction and the origin or fate of various materials.

A relatively small quantity of such material is used in tracer studies and, consequently, serious external radiation exposure prob-

lems are usually not involved. Of concern during such operations, however, is the possibility of the spread of contamination and the internal exposure of personnel.

Adequate preparation must be made prior to the use of radioactive materials in this manner. Proper handling techniques, adequate ventilation and material containment equipment and personnel control are several of the problems that must be considered. The Radiation Control Engineer shall be consulted on all such matters. Prior to initiating work on any tracer study, the details of the planned project are to be brought to the attention and approved by the Isotope Committee.

23. INSTRUMENT CALIBRATIONS

All radiation survey instruments shall be calibrated at least every 3 months and after repairs or modifications. The Radiation Control Engineer shall perform or arrange for such calibrations. Records must be kept of all calibrations.

24. STORAGE OF RADIOACTIVE MATERIALS

All radioactive materials, whether in the form of sealed sources or unsealed sources, shall be stored in a manner which will not present a radiation exposure hazard either

internally or externally. The method of storage shall be such as to preclude unauthorized removal.

25. DISPOSAL

The disposal of radioactive materials shall be accomplished only by the return of the material to the original supplier or by other means approved by the Atomic Energy Commission or other governmental agency having such jurisdiction. No disposal or transferral of radioactive materials or radiation producing machines is to be made prior to notification of and approval by the Radiation Control Engineer.