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SUBCHAPTER 21. ANALYTICAL X-RAY INSTALLATIONS

7:28-21.1 Scope

- (a) This subchapter applies to installations using analytical x-ray equipment and establishes requirements for their use.
- (b) The provisions of this subchapter are in addition to, and not in substitution for, the other applicable provisions of this chapter.

7:28-21.2 Definitions

The following words and terms, when used in this subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

□Analytical x-ray equipment□ means any device or combination of devices used to determine the microcopic structure or composition of material utilizing x-rays, including but not limited to x-ray diffraction, x-ray spectroscopy, x-ray fluorescence, or fluorescence x-ray spectroscopy equipment.

□Enclosed beam x-ray system□ means analytical x-ray equipment in which all possible x-ray paths are fully enclosed according to the requirements of N.J.A.C. 7:28-21.5, so that any part of the body cannot enter the enclosure.

□Fail-safe characteristics□ means that all failures of warning and safety systems that can reasonably be anticipated will cause the equipment to fail in a mode such that personnel are safe from exposure to radiation.

□Open beam x-ray system□ means analytical x-ray equipment other than enclosed beam x-ray system.

□Safety interlock□ means a device or system of devices intended to prevent either the generation of x-rays or the emergency of the primary beam from the tube housing.

□X-ray accessory apparatus□ means any portion of an analytical x-ray installation which is external to the x-ray tube housing and into which an x-ray beam is directed for making x-ray measurements or for other uses.

7:28-21.3 General equipment requirements

- (a) No person shall cause, suffer, allow or permit the possession or use of any analytical x-ray equipment unless it is equipped with the following:
 1. A clearly visible label bearing the conventional radiation symbol and the words: □CAUTION: THIS EQUIPMENT PRODUCES X-RAYS WHEN

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ENERGIZED TO BE OPERATED ONLY BY AUTHORIZED PERSONNEL or other words having similar meaning which shall be attached near any switch which energizes an x-ray tube.

2. A clearly visible label bearing the conventional radiation symbol and the words: "CAUTION: HIGH INTENSITY X-RAY BEAM" or other words having similar meaning which shall be located in a conspicuous location near the x-ray tube housing.
 3. A clearly visible warning light with fail-safe characteristics labeled with the words: "X-RAY ON" or other words having similar meaning which shall be located near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized. The provisions of this paragraph shall be effective February 1, 1980.
 4. A clearly visible warning light or indicator with fail-safe characteristics which shall indicate when the x-ray tube is producing x-rays or the port of the radioactive source is open. The warning light or indicator shall be located in a conspicuous position near the x-ray tube, and shall be clearly visible to any person aligning or adjusting the x-ray accessory equipment. The provisions of this paragraph shall be effective February 1, 1980.
 5. A clearly visible label bearing the conventional radiation symbol and the words: "CAUTION: THIS EQUIPMENT CONTAINS RADIOACTIVE MATERIAL" TO BE OPERATED ONLY BY QUALIFIED PERSONNEL or other words having similar meaning which shall be attached to any switch which energizes analytical x-ray equipment which contains a radioactive source.
 6. A clearly visible label which shall be attached to each radiation source housing that contains a radioactive source. The label shall include the following information:
 - i. The conventional radiation symbol; and
 - ii. The type of radioactive material; and
 - iii. The activity in curies or millicuries; and
 - iv. The date of measurement of activity.
- (b) No person shall cause, suffer, allow or permit the possession or use of any analytical x-ray equipment unless such operation is in accordance with the following procedures and within the following dose rates:

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1. Written operating and alignment procedures provided by the manufacturer of the x-ray system, or by the person in charge of use of the system if the radiation source housing and x-ray accessory apparatus are not compatible components supplied by the same manufacturer.
2. Written operating procedures shall be such that a qualified operator following instructions will not receive in any one hour a dose equivalent in excess of 37.5 mrem to the hands and forearms or 2.5 mrem to the whole body, gonads, blood-forming organs or lens of the eye.
3. Alignment procedures shall be such that a qualified worker aware of the radiation hazards will not receive in any one hour a dose equivalent in excess of 37.5 mrem to the hands and forearms or 2.5 mrem to the whole body, gonads, blood-forming organs, or lens of the eye while following these instructions. If either of these dose rates is likely to be exceeded, a definite warning shall be included in the alignment instructions.
4. The dose due to unwanted radiation from components such as high voltage rectifiers shall not exceed 10 mrem in a week in any accessible region 5 cm from the outside surface of the generator cabinet. Where an individual may be in the vicinity of the equipment while it is operating for as long as 40 hours per week, the dose rate shall not exceed 0.25 mrem/hr.
5. The x-ray accessory apparatus shall include a beam trap or other barrier with sufficient shielding so that the dose rate due to the transmitted primary beam does not exceed 0.25 mrem/hr under normal operating conditions. In the presence of scattered radiation this requirement shall be considered met for x-ray tube sources if the inherent shielding of the trap or barrier is at least equivalent to the thickness of lead specified in the following table for the maximum rated anode current and potential. In the case of isotope sources that required barrier thickness shall be determined by a qualified expert. Thickness of lead Required for a Primary Beam Barrier Located 5 cm from the Focal Spot

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Anode Current (ma)	Thickness of lead (mm)		
	50 kVp	70 kVp	100 kVp
20	1.5	5.6	7.7
40	1.6	5.8	7.9
80	1.6	5.9	
160	1.7		

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7:28-21.4 Additional equipment requirements for open beam x-ray systems

- (a) No person shall cause, suffer, allow or permit the possession or use of any open beam analytical x-ray equipment unless it is equipped with the following in addition to the requirements of section 3 of this subchapter:
1. A clearly visible warning light or indicator which shall be located near each individual x-ray tube shutter and shall indicate when the shutter is open.
 2. A suitable barrier to clearly delineate the boundary between the radiation area and the controlled area.
 3. A system barrier surrounding each radiation area with sufficient inherent shielding so that the dose equivalent received by individuals in the surrounding controlled area does not exceed five mrem in any one hour or 100 mrem in any five consecutive days.
 4. A beam shutter for each port of the radiation source housing. Such beam shutter shall be interlocked with the x-ray accessory apparatus coupling, or collimator, in such a way that the port will be open only when the collimator or coupling is in place. Shutters at unused ports shall be secured to prevent casual opening.
 5. A guard or interlock which prevents entry of any part of the body into the primary beam path.
 6. The provisions of paragraphs 3, 4 and 5 of this subsection shall apply to new open beam analytical x-ray equipment after February 1, 1980. Open beam analytical x-ray equipment in use prior to February 1, 1980 shall be exempt from the provisions of paragraphs 3, 4 and 5 unless such equipment is sold, leased, loaned or otherwise transferred from one user to another whether gratuitously or for consideration.
- (b) No person shall cause, suffer, allow or permit the possession or use of any open beam analytical x-ray equipment unless it is operated in accordance with the following procedures and within the following dose rates:
1. The x-ray generator, the control panel and all other parts of the analytical x-ray system, except the x-ray tube housing, shall be so constructed that with all the shutters closed, the stray radiation measured at a distance of five centimeters from its surface is not capable of producing a dose in excess of 0.25 millirem in one hour at any specified tube rating.

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2. The x-ray tube housing shall be so constructed that with all shutters closed, the leakage radiation measured at a distance of 5 centimeters from its surface is not capable of producing a dose in excess of 2.5 millirem in one hour at any specified tube rating.
3. Radiation exposure levels in the vicinity of controls and adjustments of the x-ray accessory apparatus used during routine operation shall not exceed 37.5 mrem/hr to the hands or 2.5 mrem/hr to the whole body, gonads, blood-forming organs, or lens of the eye.

7:28-21.5 Additional equipment requirements for enclosed beam X-ray systems

- (a) No person shall cause, suffer, allow or permit the possession or use of any enclosed beam analytical x-ray equipment unless it is equipped with the following:
 1. A sufficient number of safety interlocks so that the opening of any section of the enclosure during normal operation, or routine alignment, or routine maintenance will prevent either the generation of x-rays or the emergence of the primary beam from any x-ray tube housing port.
 2. A chamber or coupled chambers to enclose the radiation source, sample, detector and analyzing crystal. Any such chamber shall be constructed so that it can not be entered by any part of the body during normal operation. The provisions of this paragraph shall be effective February 1, 1980.
 3. A sample chamber closure which shall be interlocked with either the x-ray tube high voltage supply or with a shutter in the primary beam so that no x-ray beam can enter the sample chamber while it is open. Such interlock shall be of fail-safe design. The provisions of this paragraph shall be effective February 1, 1980.
- (b) No person shall cause, suffer, allow or permit the possession or use of any enclosed beam analytical x-ray equipment unless it is constructed in such manner as to limit the leakage x-rays at a distance of 5 centimeters from any accessible surface during normal operation to less than 0.25 millirem in one hour at any specified tube rating.

7:28-21.6 Operating procedures

- (a) No person shall cause, suffer, allow or permit the possession or use of any analytical x-ray equipment unless it is operated in accordance with the following procedures:

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1. All safety devices, including but not limited to, warning lights, warning indicators, and safety interlocks as required by this subchapter shall be maintained in a fully functional operating condition. These safety devices shall be tested for proper functioning as recommended by the manufacturer or once every six months and records kept of all such testing.
2. All safety devices, including but not limited to, warning lights, warning indicators, and safety interlocks originally provided at the time of the installation of the analytical x-ray equipment, but not otherwise specified by this subchapter, shall be maintained in a fully functional operating condition. An exemption may be made, subject to the approval by the Department, when the operational procedures prohibit the normal functioning of these safety devices. Records of these exemptions shall be kept.
3. In addition to and not in substitution for the applicable requirements of subchapter 7 (Radiation Surveys and Personnel Monitoring) of this chapter, all personnel operating, repairing and aligning analytical x-ray equipment shall be provided with appropriate finger or wrist personnel monitoring equipment. The reported dose equivalent shall be recorded on Form BRP-26, "Current Occupational External Radiation Exposure," or on a clear and legible form containing all the information required on BRP-26. This reported dose equivalent shall be clearly identified as resulting from exposure to analytical x-rays.
4. A radiation survey shall be made before a new installation is placed in routine operation and whenever changes are made that could adversely affect radiation protection, as required by subchapter 7 (Radiation Surveys and Personnel Monitoring). Records shall be maintained showing the results of such surveys as required by subchapter 8 (Records) of this chapter.