DEPARTMENT OF CONSUMER AND INDUSTRY SERVICES

RADIATION SAFETY SECTION

(By authority conferred on the department of public health by section 13521 of Act No. 368 of the Public Acts of 1978, as amended, and section 48 of Act No. 306 of the Public Acts of 1969, as amended, being SS333.13521 and 24.248 of the Michigan Compiled Laws)

PART 7. MEDICAL X-RAY INSTALLATIONS

R 325.5311. Purpose and scope.

Rule 311. (1) This part establishes requirements governing the use of x-radiation in medicine, osteopathy, chiropractic and podiatry.

(2) This part applies to all licensees and registrants who use x- radiation in these healing arts disciplines for the intentional exposure of humans.

(3) In addition to this part all licensees and registrants are subject to parts 1, 4 and 5 and all applicable provisions of the other parts.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

THERAPEUTIC MACHINES OPERATED ABOVE 85 KVP

R 325.5312. X-ray equipment.

Rule 312. (1) The tube housing shall be of the therapeutic type.

(2) Permanent diaphragms or cones used for collimating the useful beam shall afford the same degree of attenuation as is required of the housing.

(3) Adjustable or removable beam-limiting devices shall transmit not more than 5% of the useful beam as determined at the maximum tube potential and with maximum treatment filter.

(4) Filters shall be so mounted as to prevent their movement during the treatment.

(5) The filter slot shall be so constructed that the radiation escaping through it does not produce an exposure rate exceeding 1 R/h at 1 meter, or if the patient is likely to be exposed to radiation escaping from the slot, 30 R/h at 5 centimeters (2 inches) from the external opening.

(6) A removable filter shall be permanently marked with its thickness and material.

(7) A filter indication system shall be used on therapy machines which use changeable filters and are manufactured after the effective date of these rules. It shall indicate, from the control panel, the presence or absence of any filter and it shall be designed to permit easy recognition of the filter in place.

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(8) The x-ray tube shall be so mounted that it cannot turn or slide with respect to the housing aperture. A reproducible means of measuring the focal spot to patient distance shall be provided.

(9) Means to immobilize the tube housing during stationary portal treatment shall be provided.

(10) An easily discernible indicator which shows whether or not x-rays are being produced shall be on the control panel.

(11) On therapeutic machines manufactured after the effective date of these rules beam monitoring devices shall be fixed in the useful beam to indicate any error due to incorrect filter, tube current, or tube potential, unless the device introduces more filtration than is clinically acceptable.

(12) A suitable exposure control device (e.g. an automatic timer, exposure meter or dose meter) shall be provided to terminate the exposure after a preset time interval or preset exposure or dose limit. If a timer is used, it shall permit accurate presetting and determination of exposure times as short as 1 second. Means for the operator to terminate the exposure at any time shall be provided.

(13) Mechanical or electrical stops or both shall be provided to insure that the useful beam is oriented only toward primary barriers.

(14) Interlocks shall be provided so that, when any door to the treatment room is opened, the machine will shut off automatically or the radiation level within the room will be reduced to an average of not more than 2 mR/h and a maximum of 10 mR/h at a distance of 1 meter in any direction from the source. After the shut-off or reduction in exposure rate, it shall be possible to restore the machine to full operation only from the control panel.

(15) The x-ray control circuit shall be so designed that it is not possible to energize the x-ray tube to produce x-rays without resetting the x-ray "ON-OFF" switch at the control panel.

(16) When the relationship between the beam interceptor (when present) and the useful beam is not permanently fixed, mechanical or electrical stops shall be provided to insure that the beam is oriented only toward primary barriers.

(17) X-ray equipment installed after the effective date of these rules shall be installed and used in accord with the appropriate portions of the 1975 national electrical code (NFPA No. 70-1975) reproduced or referenced in rule 359. X-ray equipment installed before the effective date of these rules shall conform with the appropriate national electrical code in effect at the time of installation.

(18) X-ray machines with electron beam extraction capability shall be provided with such additional safety devices as determined necessary and specified in writing by the department to prevent accidental electron beam exposure.

(19) To reduce the electron contamination of high energy treatment beams, shadow trays or other accessories placed in the primary beam shall be placed at a sufficient distance from the patient that the electron contamination contribution to the skin dose is minimal.

(20) X-ray machines capable of producing radioactive material in excess of exempt quantities listed in schedule B of rule 147 unless excluded from the particle accelerator definition in part 1 by design and use shall comply with the applicable requirements of part 11.

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History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5315. Enclosures.

Rule 315. (1) An enclosure shall be a permanent part of the building or equipment. Portable protective barriers shall not be used for permanent installations.

(2) The degree of protection required for an enclosure shall be determined by the workload, use and occupancy factors and the kilovoltage, milliamperage, mechanical movement, and distance factor, and shall be subject to design approval by the department.

(3) All wall, ceiling and floor areas that can be irradiated by the useful beam plus an additional area extending at least 30 centimeters (1 foot) beyond shall be provided with a primary protective barrier.

(4) For equipment capable of operating above 150 kVp the control station shall be outside of the therapy room.

(5) The enclosure shall be so constructed that persons may at all times be able to escape from within.

(6) If the radiation exposure rate within the therapy room is so high that a person who is accidentally in the treatment room when the machine is turned "ON" may receive as much as 1250 mR exposure during the time required to reach an access door, special cut-off or panic buttons shall be required. When pressed, these buttons, operable by open hand at appropriate positions about the treatment room, shall cause the irradiation to be terminated.

(7) Effective means shall be provided to prevent access to the treatment room during exposure. For equipment capable of operating above 150 kVp, each access door to the treatment room shall be provided with a fail-safe interlock. The interlock system shall be so designed that the failure of any 1 component will not jeopardize the safety of the system, (e.g., the use of series connected double switch assemblies at access doors, and dual interlock relays). If an access door is opened when the machine is "ON", the interlock shall cause termination or reduction of exposure as specified in rule 312 (14).

(8) Red warning signal lights, energized only when the useful beam in "ON", shall be located on the control panel and near each entrance to the therapy room. Under conditions as specified in subrule (6) a visible signal shall also be located within the therapy room. Depending upon control panel and door locations, a single warning signal light may be sufficient to comply with this subrule.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5317. Conditions of operation.

Rule 317. (1) An installation shall be operated in compliance with any limitations determined necessary and specified in writing by the department.

(2) The output of the x-ray generator shall be calibrated before use for the treatment of patients for each technique or condition of use. The department shall be informed by telephone or in writing of completion of initial calibration before patient

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treatment is initiated. A written report of this initial calibration only shall be submitted within 30 days to the department. Recalibration shall be required after each tube replacement and after any changes or replacement in the generating apparatus which could effect a change in the x-ray output. Check calibrations shall be made on an annual basis and records of all calibration maintained for not less than 7 years.

(3) X-ray therapy equipment capable of operating above 150 kVp shall not be operated routinely until the radiation safety of the installation has been established by a protection survey conducted in accordance with rule 221. The department shall be informed by telephone or in writing of completion of the initial survey before patient treatment is initiated. A written report of this initial survey shall be submitted within 30 days to the department. All x-ray therapy equipment shall be operated in conformance with recommendations of the protection survey.

(4) Both the control panel and the patient shall be observable during exposure.

(5) When a patient must be held in position for radiation therapy, mechanical supporting or restraining devices should be used. If the patient must be held by an individual, upon approval by the radiologist in charge followed by written notice to the department, that individual shall be provided protection equivalent to 7 half-value layers and he shall be positioned so that no part of his body will be struck by the useful beam and so that his body is as far as possible from the edge of the useful beam. The exposure of any individual used for this purpose shall be monitored and a permanent record maintained. The individual selected for this purpose shall not otherwise be occupationally exposed to ionizing radiation.

(6) With the exception of subrule (5), a person other than the patient shall not be permitted in the treatment room when the tube is operated at potentials exceeding 85 kVp. At potentials of 85 kVp or below, other persons may be permitted in the treatment room by the radiologist in charge if essential to conduct the treatment, but only if they are protected as specified in subrule (5) and their radiation exposure is monitored and permanently recorded.

(7) Personnel monitoring shall be performed in controlled areas for each individual occupationally exposed to ionizing radiation from therapeutic x-ray equipment. Personnel monitoring devices such as film badge dosimeters or thermoluminescent dosimeters shall be permanently assigned to each occupationally exposed individual. This monitoring shall be continuous during employment as a radiation worker.

(8) Personnel exposure records shall be kept on permanent available file at the facility where the exposure occurs.

(9) Monitoring devices used to estimate whole body exposure shall normally be worn on the chest or abdomen. Monitoring of any other body part shall comply with rule 222.

(10) Monitoring devices worn to estimate personnel occupational exposure shall not be worn by the individual when he is exposed as a patient for any medical or dental reason.

(11) Lead, lead rubber, lead foil and similar materials used for limiting the field shall not transmit more than 5% of the useful beam under the conditions at which the machine is operated for therapy. This subrule does not pertain to treatment blocks used to adjust or modify the intended radiation dose to the area of treatment.

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(12) A therapeutic x-ray system shall not be left unattended without locking the apparatus, room or building in some manner which will prevent use of the apparatus by unauthorized persons.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

THERAPEUTIC MACHINES OPERATED AT OR BELOW 85 KVP

R 325.5321. X-ray equipment.

Rule 321. (1) The x-ray equipment shall comply with the general requirements of rule 312 excluding subrules (11), (14) and (16).

(2) Maximum potential shall be mechanically or electronically limited to 85 kVp.

(3) A contact therapy machine shall meet the additional requirement that the leakage radiation at 5 centimeters (2 inches) from the surface of the tube housing shall not exceed 0.1 R/h. As used in this subrule "contact therapy machine" means an x-ray therapy machine designed for source to skin treatment distances of 5 centimeters or less at tube potentials in the range of 20 to 50 kVp.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5322. Enclosures.

Rule 322. An enclosure shall comply with the general requirements of rules 315 (1) and (2).

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5323. Conditions of operation.

Rule 323. (1) Operation shall comply with the general requirements of rule 317.

(2) If the x-ray tube of a contact therapy machine as defined in rule 321 (3) is hand held during irradiation, the operator shall wear protective gloves and a protective apron. When practical, a cap of at least 0.5 millimeter lead equivalence should cover the aperture window of the tube housing of such apparatus when the apparatus is not being used. Because the exposure rate at the surface of the window of contact therapy and beryllium window machines may be more than 10,000 R per minute, extreme precautions are necessary to prevent accidental exposure to the useful beam.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

FIXED RADIOGRAPHIC INSTALLATIONS

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R 325.5325 X-ray equipment.

Rule 325. (1) All x-ray tube housings in fixed radiographic installations shall be of the diagnostic type.

(2) The aluminum equivalent of the total filtration in the useful beam shall not be less than the values shown in Table 1.

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Table 1

Operating kVp	Minimum Total Filter (Inherent plus added)
Below 50 kVp	0.5 mm aluminum
50-70 kVp	1.5 mm aluminum
Above 70 kVp	2.5 mm aluminum

(3) If the filter in the machine is not accessible for examination and the total filtration is not known subrule (2) may be assumed to have been met if the half-value layer is not less than

0.6 mm aluminum at 49 kVp
1.6 mm aluminum at 70 kVp
2.6 mm aluminum at 90 kVp

(4) Under conditions of subrule (3) for tube potentials above 90 kVp subrule (2) may be assumed to have been met if the half-value layer is not less than that specified in table 2.

(5) The half-value layer (HVL) of the useful beam for a given x-ray tube potential shall not be less than the values shown in table 2.

Table 2

Design operating range (Kilovolts peak)	Measured potential (Kilovolts peak)	Half-value layer (milli-meters of aluminum)
Below 50	30	0.3
	40	0.4
	49	0.5
50 to 70	50	1.2
	60	1.3
	70	1.5
Above 70	80	2.3
	90	2.5
	100	2.7
	110	3.0
	120	3.2
	130	3.5
	140	3.8
	150	4.1

(6) If it is necessary to determine the half-value layer at an x-ray tube potential which is not listed in table 2, linear interpolation or extrapolation may be made. Positive means

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shall be provided to insure that at least the minimum filtration needed to achieve these beam quality requirements is in the useful beam during each exposure.

(7) Machines equipped with beryllium window x-ray tubes with removable filters shall contain keyed filter interlock switches in the tube housing and suitable indication on the control panel of the added filter in the useful beam. The total filtration permanently in the useful beam shall not be less than 0.5 millimeter aluminum equivalent and shall be clearly indicated on the tube housing.

(8) Beryllium window x-ray tubes shall not be used routinely for general purpose diagnostic examinations. Such a tube may comprise an x-ray subsystem if needed for special soft tissue technique in accord with subrule (7).

(9) Beam-limiting devices (diaphragms, cones, adjustable collimators), capable of restricting the useful beam to the area radiographically recorded shall be provided to define the beam and shall provide the same degree of attenuation as that required of the tube housing.

(10) Beam-limiting devices shall be calibrated in terms of the size of the projected useful beam at specified source-image distances (SID). This calibration shall be clearly and permanently recorded on the beam-limiting device. Calibration of adjustable beam-limiting devices shall permit reproducible settings.

(11) X-ray systems designed for only 1 image receptor size at a fixed SID shall be provided with means to limit the field at the plane of the image receptor to dimensions no greater than those of the image receptor, and to align the center of the x-ray field with the center of the image receptor to within 2% of the SID. However, for mammography the x-ray field need not be aligned with the center of the image receptor if the x-ray field does not extend beyond the edge of the image receptor.

(12) General purpose radiographic x-ray systems shall be equipped with adjustable beam-limiting devices containing light localizers that define the entire field. Rectangular beam-limiting devices are usually preferable.

(13) The size of the x-ray beam projected by fixed aperture beam-limiting devices, except those used for stereoradiography, shall not exceed the dimensions of the image receptor by more than 2% of the SID when the axis of the x-ray beam is perpendicular to the plane of the image receptor.

(14) The calibrated field size indicator on adjustable beam-limiting devices shall be accurate to within 2% of the SID. The light field shall be aligned with the x-ray field with the same degree of accuracy. The field size projected by automatic adjustable beam-limiting devices shall provide the same precision.

(15) For radiographic procedures resulting in multiple views on a single x-ray film the beam-limiting device shall limit the x-ray field size to the recorded radiographic image size within 2% of the SID. Covering a portion of the radiographic film with radio-opaque material is not a substitute for proper x-ray field limitation. This subrule does not apply to spotfilm devices manufactured before the effective date of these rules.

(16) After the effective date of these rules radiographic x-ray machines used for purposes other than mammography or extremity radiography only shall be capable of operation at not less than an average current of 100 milliamperes (mA) during any radiographic technique used. A machine not capable of sustained operation at not less than an average of 100 mA for the duration of a given technique shall not be used for that technique. As used in this subrule "extremity radiography" means radiography of the

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hand or arm excluding the shaft of the humerus or the foot or leg excluding the shaft of the femur.

(17) A device shall be provided which terminates the exposure at a preset time interval or exposure limit. The operator shall be able to terminate the exposure at any time by discontinuing pressure upon the exposure switch except that during serial radiography means may be provided to permit completion of any single exposure in progress.

(18) The exposure switch, except for those used in conjunction with spot film devices in fluoroscopy, shall be securely fixed so that the operator is required to be behind a fixed shield which will intercept the useful beam and any radiation which has been scattered only once.

(19) When 2 or more x-ray tube heads are operated from a single exposure switch (multiple tube units), there shall be indication at the control panel showing which tube is connected and ready to be energized, and means to prevent energizing more than 1 tube head at the same time unintentionally. Machines designed for simultaneous multiple tube operation shall have positive means for selecting single tube or multiple tube operation.

(20) The control panel shall provide positive visual identification of the production of x-rays whenever the x-ray tube is energized. A milliammeter may comply with this subrule.

(21) On radiographic machines manufactured after the effective date of these rules, a signal audible to the operator shall indicate that the exposure has ended.

(22) The technique factors to be used during an exposure shall be indicated before the exposure begins, except when automatic exposure controls are used, in which case the technique factors which are set before the exposure shall be indicated. On equipment having fixed technique factors, this requirement may be met by permanent markings. Indication of technique factors shall be visible from the operator's position.

(23) X-ray equipment installed after the effective date of these rules shall be installed and used in accord with the appropriate portions of the 1975 national electrical code (NFPA No. 70-1975) reproduced or referenced in rule 359. X-ray equipment installed before the effective date of these rules shall conform with the appropriate national electrical code in effect at the time of installation.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5331. Enclosures.

Rule 331. (1) An enclosure shall be a permanent part of the building or equipment. Portable shields shall not be used for permanent installations.

(2) The degree of protection required for an enclosure shall be determined by the workload, use and occupancy factors and the kilovoltage, milliamperage, mechanical movement and distance factor, and shall be subject to design approval by the department. Recommended shielding appears in rule 357.

(3) Radiographic-room wall and floor areas exposed to the useful beam plus an additional area extending at least 30 centimeters (1 foot) beyond shall be provided with a primary protective barrier where necessary as determined by workload, use, occupancy and distance factors. All vertical primary protective barriers specified in this rule shall extend continuously from the floor to a minimum height of 2.1 meters (7 feet).

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(4) Secondary protective barriers shall be provided in the radiographic room ceiling and in those walls not requiring primary barriers.

(5) Control apparatus for the radiographic equipment shall be shielded by a primary protective barrier which cannot be removed from a protective position between the operator and the radiation source during machine operation.

(6) Movable barriers with electrical interlocks shall not be approved in lieu of compliance with subrule (5).

(7) Exposure switch location and control shield shall be oriented so that, at arm's length from the exposure switch, the operator shall not be exposed to the useful beam, leakage radiation or any radiation scattered only once.

(8) The operator shall be able to see and communicate with the patient from a shielded position at the control panel. When an observation window is provided, it shall be a lead equivalence at least equal to that required of the control barrier and shall be installed so that the attenuation effectiveness of the barrier is not impaired.

(9) At times it may be necessary for personnel to remain within operating room or special procedure installations during radiographic exposures. A primary protective barrier shall be provided for personnel protection under these circumstances unless necessary technique prevents use of such protection. This barrier may be movable if necessary. Movable barriers shall not be permitted in lieu of the provisions of subrules (3) and (5).

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5333. Conditions of operation.

Rule 333. (1) An operator shall properly utilize the beam-limiting devices provided to restrict the useful beam to the smallest area consistent with clinical requirements. Particular care shall be taken to align accurately the x-ray beam with the patient and film.

(2) The operator shall insure the presence of adequate filtration before any radiographic procedure.

(3) Staff personnel routinely working with or around radiation sources shall not be required by the licensee or registrant to hold film or restrain patients during radiography. If such procedure is permitted personnel exposure shall not exceed rule 205 or the procedure shall be prohibited.

(4) When a patient must be held in position for radiography, mechanical supporting or restraining devices shall be available and shall be used unless contraindicated. If the patient must be held by an individual, this individual shall wear protective gloves and a protective apron of 0.5 millimeter minimum lead equivalence and he shall be so positioned that no part of his body will be struck by the useful beam and that his body is as far as possible from the edge of the useful beam.

(5) Only individuals whose presence is necessary shall be permitted in the radiographic room during exposure. Each individual, except the patient, shall be protected by 0.5 millimeter minimum lead equivalent aprons unless protected by an approved primary barrier.

(6) Personnel monitoring shall be performed in controlled areas for each individual occupationally exposed to ionizing radiation from diagnostic x- ray equipment.

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Personnel monitoring devices such as film badge dosimeters or thermoluminescent dosimeters shall be permanently assigned to each occupationally exposed individual. This monitoring shall be continuous during employment as a radiation worker.

(7) Personnel exposure records shall be kept on permanent available file at the facility where the exposure occurs.

(8) Monitoring devices used to estimate whole body exposure shall normally be worn on the chest or abdomen. Monitoring of any other body part shall comply with rule 222.

(9) Monitoring devices worn to estimate personnel occupational exposure shall not be worn by the individual when he is exposed as a patient for any medical or dental reason.

(10) The gonads of children and persons who have not passed the reproductive age shall be protected from the useful beam either by the use of shielding (0.5 mm lead equivalent), collimation, or special gonad shields when this will not interfere with the conditions or objectives of the examination.

(11) Intensifying screens shall be employed to reduce patient exposure except in cases where a noticeable decrease in image definition may reduce the clinical value of the examination. Film and screen speed combinations shall be carefully selected to produce the necessary clinical information with the least exposure to the patient consistent with current clinical judgement.

(12) Film processing materials and techniques shall be those recommended by the x-ray film and processing materials manufacturers unless otherwise tested to insure maximum information content of the developed film. Sight developing in not permitted except under extreme emergency conditions.

Correct temperature control and development time are necessary to minimize radiation dose to the patient.

(13) A radiographic x-ray system shall not be left unattended without locking the apparatus, room or building in some manner which will prevent use of the apparatus by unauthorized persons.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

FIXED FLUOROSCOPIC INSTALLATIONS

R 325.5337. X-ray equipment.

Rule 337. (1) All x-ray tube housings of fixed fluoroscopic installations shall be of the diagnostic type.

(2) The aluminum equivalence of the total filtration permanently in the useful beam shall not be less than 2.5 millimeters aluminum.

(3) Beam quality of fluoroscopic machines manufactured after the effective date of these rules shall comply with the provisions of rules 325 (5) and (6).

(4) The source-patient distance on fluoroscopic machines manufactured before the effective date of these rules should not be less than 45 centimeters (18 inches)

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and shall not be less than 30 centimeters (12 inches). Specific exemption may be granted in writing by the department for special purpose equipment such as heart catheterization machines.

(5) On fluoroscopic machines manufactured after the effective date of these rules, means shall be provided to limit the source-skin distance to not less than 38 centimeters. For image intensified fluoroscopes intended for specific surgical application that would be prohibited at this source- skin distance, provisions may be made for operation at shorter source-skin distances but in no case less than 20 centimeters.

(6) Provision shall be made to intercept the scattered x-rays from the undersurface of the table top and other structures under the fluoroscopic table if the tube is mounted under the table. A cone or shield shall provide the same degree of attenuation as is required of the tube housing.

(7) On fluoroscopic machines manufactured after the effective date of these rules a shielding device of at least 0.25 millimeter lead equivalence for covering the bucky slot during fluoroscopy shall be provided.

(8) On fluoroscopic machines manufactured after the effective date of these rules a shielding device of at least 0.25 millimeter lead equivalence, such as overlapping protective drapes or hinged or sliding panels, shall be used to intercept scattered radiation which would otherwise reach the fluoroscopist and others near the machine.

(9) The equipment shall be so constructed that, under conditions of normal use, the entire cross-section of the useful beam is attenuated by a primary protective barrier, permanently incorporated into the equipment. The exposure shall automatically terminate when the barrier is removed from the useful beam.

(10) On fluoroscopic machines manufactured after the effective date of these rules:

(a) The entire cross section of the useful beam shall be intercepted by the primary protective barrier of the fluoroscopic image assembly at any SID. The fluoroscopic tube shall not produce x-rays unless the barrier is in position to intercept the entire useful beam. The exposure rate due to transmission through the barrier with the attenuation block in the useful beam combined with radiation from the image intensifier, if provided, shall not exceed 2 milliroentgens per hour at 10 centimeters from any accessible surface of the fluoroscopic imaging assembly beyond the plane of the image receptor for each roentgen per minute of entrance exposure rate.

(b) The entrance exposure rate shall be measured in accordance with subrule (20). The exposure rate due to transmission through the primary barrier combined with radiation from the image intensifier shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters. If the source is below the tabletop, the measurement shall be made with the input surface of the fluoroscopic imaging assembly positioned 30 centimeters above the tabletop. If the source is above the tabletop and the SID is variable, the measurement shall be made with the end of the beam-limiting device or spacer as close to the tabletop as it can be placed, if it is not closer than 30 centimeters. Movable grids and compression devices shall be removed

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from the useful beam during the measurement. For all measurements, the attenuation block shall be positioned

in the useful beam 10 centimeters from the point of measurement of the entrance exposure rate and between this point and the input surface of the fluoroscopic imaging assembly.

(11) The lead equivalence of the barrier of conventional fluoroscopes shall be not less than 1.5 millimeters at 100 kVp, 1.8 millimeters at 125 kVp, and 2.0 millimeters at potentials greater than 125 kVp.

(12) A beam-limiting device shall be provided to restrict the size of the useful beam to less than the area of the barrier. The x-ray tube and beam-limiting system shall be linked with the fluorescent screen assembly so that the useful beam at the fluorescent screen is confined within the barrier irrespective of the panel-screen distance. For image intensifiers, the useful beam shall be centered on the input phosphor. It should not exceed the diameter of the input phosphor during fluoroscopy or cine- recording.

Ideally, for spot film radiography with image intensifier equipment, the shutters should automatically open to the required field size before such exposure.

(13) Beam-limiting devices (collimators, adjustable diaphragms or shutters) shall provide the same degree of attenuation as is required of the tube housing.

(14) When the beam-limiting device is opened to its fullest extent, a minimum ¼ inch unilluminated margin shall exist at all edges of the fluorescent screen when the screen is 35 centimeters (14 inches) from the panel surface or table top, or at the fixed screen position in equipment such as an orthodiascope. In equipment used solely for image intensified fluoroscopy, the x-ray beam shall not have dimensions greater than the diameter of the input phosphor.

(15) On fluoroscopic machines manufactured after the effective date of these rules:

(a) The x-ray field produced by nonimage-intensified fluoroscopic equipment shall not extend beyond the entire visible area of the image receptor. Means shall be provided to permit further limitation of the field. The minimum field size at the greatest SID shall be equal to or less than 5 by 5 centimeters.

(b) For image-intensified fluoroscopic equipment the total misalignment of the edges of the x-ray field with the respective edges of the visible area of the image receptor along any dimension of the visually defined field in the plane of the image receptor shall not exceed 3% of the SID.The sum, without regard to sign, of the misalignment along any 2 orthogonal dimensions intersecting at the center of the visible area of the image receptor shall not exceed 4% of the SID. For rectangular x-ray fields used with circular image receptors, the error in alignment shall be determined along the length and width dimensions of the x-ray field which pass through the center of the visible area of the image receptor. Means shall be provided to permit further limitation of the field. The minimum field size, at the greatest SID, shall be equal to or less than 5 by 5 centimeters.

(16) X-ray production in the fluoroscopic mode shall be controlled by a device which requires continuous pressure by the operator for the entire time of any exposure. When recording serial fluoroscopic images, the operator shall be able to terminate the x-ray exposures at any time, but means may be provided to permit completion of any single exposure of the series in progress.

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(17) When the fluoroscope is operated at 80 kVp, the exposure rate at the position where the beam enters the patient shall not exceed 3.2 R/mA-min and should not exceed 2.1 R/mA-min.

(18) The entrance exposure rate at the position where the center of the useful beam enters the patient should be as low as is consistent with the fluoroscopic requirements and shall not normally exceed 10 R/min. With modern equipment, most fluoroscopy can be carried out with entrance exposure rates of less than 5 R/min.

(19) Entrance exposure rate limits for fluoroscopic equipment manufactured after the effective date of these rules shall be as follows:

(a) Machines with automatic exposure rate control shall not be operable at any combination of tube potential and current which will result in an a exposure rate in excess of 10 roentgens per minute at the point where the center of the useful beam enters the patient, except during recording of

fluoroscopic images or when an optional high level control is provided. When so provided, the equipment shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of 5 roentgens per minute at the point where the center of the useful beam enters the patient unless the high level control is activated. Special means of activation of high level controls, such as additional pressure applied continuously by the operator, shall be required to avoid accidental use. A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.

(b) Machines without automatic exposure rate control shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of 5 roentgens per minute at the point where the center of the useful beam enters the patient, except during recording of fluoroscopic images or when a optional high level control is activated.Special means of activation of high level controls, such as additional pressure applied continuously by the operator, shall be provided to avoid accidental use. A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.

(20) Compliance with subrules (18) and (19) shall be determined as follows:

(a) If the source is below the table, the exposure rate shall be measured 1 centimeter above the tabletop or cradle.

(b) If the source is above the table, the exposure rate shall be measured at 30 centimeters above the tabletop with the end of the beam-limiting device or spacer positioned as closely as possible to the point of measurement.

(c) In a C-arm type of fluoroscope, the exposure rate shall be measured 30 centimeters from the input surface of the fluoroscopic imaging assembly.

(21) A cumulative timing device, activated by the fluoroscope exposure switch, shall be provided. It shall indicate the passage of a predetermined period if irradiation either by an audible signal or by temporary interruption of the irradiation when the increment of exposure time exceeds a predetermined limit not exceeding 5 minutes.

(22) On fluoroscopic machines manufactured after the effective date of these rules means shall be provided to present the cumulative on-time of the fluoroscopic tube. The maximum cumulative time of the timing device shall not exceed 5 minutes without resetting. A signal audible to the fluoroscopist shall indicate the completion of any

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preset cumulative on- time. This signal shall continue to sound while x-rays are produced until the timing device is reset.

(23) Devices which indicate the x-ray tube potential and current shall be provided. On image intensified fluoroscopic equipment, these devices should be located in such a manner that the operator may monitor the tube potential and current during fluoroscopy.

(24) X-ray equipment shall be installed and used in accord with article 660 of the national electrical code which is reproduced in rule 359.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5347. Enclosures.

Rule 347. (1) An enclosure shall be a permanent part of the building or equipment. Portable shields shall not be used for permanent installations.

(2) The degree of protection required for an enclosure shall be determined by the workload, use and occupancy factors and the kilovoltage, milliamperage, mechanical movement and distance factor, and shall be subject to design approval by the department. Recommended shielding appears in rule 357.

(3) For conventional fluoroscopy extraneous light that interferes with the fluoroscopic examination shall be eliminated. Dark adaptation normally is not necessary when using image intensifiers.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5348. Conditions of operation.

Rule 348. (1) Each individual present in a fluoroscopic room, except the patient, shall wear a protective apron of at least 0.5 millimeter lead equivalence.

(2) Only individuals whose presence is needed to conduct the examination, to conduct radiation protection surveys or undergoing specific training shall be permitted in the fluoroscopy room during x-ray exposures.

(3) Personnel monitoring shall be performed in controlled areas for each individual occupationally exposed to ionizing radiation from diagnostic x- ray equipment. Personnel monitoring devices, such as film badge dosimeters or thermoluminescent dosimeters, shall be permanently assigned to each

occupationally exposed individual. This monitoring shall be continuous during employment as a radiation worker.

(4) Personnel exposure records shall be kept on permanent available file at the facility where the exposure occurs.

(5) Monitoring devices used to estimate whole body exposure shall normally be worn on the chest or abdomen. Monitoring or any other body part shall comply with rule 222. Since employees involved in fluoroscopic procedures are required to wear protective aprons and may be subjected to non-uniform

radiation fields, a dosimeter assigned to monitor whole body exposure will not necessarily record the dose most representative of exposure to the lens of the eye. To monitor this critical area for which the exposure limit is the same as for whole body,

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active blood-forming organs, or gonads, an auxiliary dosimeter shall be provided in accordance with rule 222.

(6) Monitoring devices worn to estimate personnel occupational exposure shall not be worn by the individual when he is exposed as a patient for any medical or dental reason.

(7) The fluoroscopist's eyes should be sufficiently dark-adapted for the visual task required before commencing conventional fluoroscopy. Under no circumstances shall he attempt to compensate for inadequate adaptation by increasing exposure factors employed or by prolonging the fluoroscopic examination.

(8) Special precautions, consistent with clinical needs, shall be taken to minimize exposure of the gonads of potentially procreative patients and exposure of the embryo or fetus in patients known to be or suspected of being pregnant. Gonadal shielding is advised whenever it will not interfere with the conditions or objectives of the examination.

(9) In cineradiography, special care shall be taken to limit patient exposure when, as is often the case, tube currents and potentials employed are higher than those normally used in fluoroscopy. The exposure rates to which patients are normally subjected shall be determined quarterly and records of the surveys maintained.

(10) A fluoroscopic x-ray system shall not be left unattended without locking the apparatus, room or building in some manner which will prevent use of the apparatus by unauthorized persons.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

MOBILE OR PORTABLE DIAGNOSTIC X-RAY EQUIPMENT

R 325.5351. X-ray equipment.

Rule 351. (1) Radiographic x-ray equipment shall comply with the general requirements of rule 325 excluding subrules (11) and (18).

(2) Fluoroscopic x-ray equipment shall comply with the general requirements of rule 337 excluding subrules (5), (6), (7), (8) and (11).

(3) The radiographic exposure control switch shall be located on the machine where adequate personnel protection is provided to attenuate the direct and scatter radiation, or the length of switch cord shall be such that the operator shall be able to stand at least 1.8 meters (6 feet) from the patient, the x-ray tube, and out of useful beam. A coil type extension switch cord capable of providing more than 1.8 meters (6 feet) of distance protection is recommended.

(4) Hand-held fluoroscopic screens and others not attached to a diagnostic source assembly with stable mounting shall not be used.

(5) Image intensification shall always be provided on mobile fluoroscopic equipment. It shall be impossible to operate mobile fluoroscopic equipment unless the useful beam is intercepted by the image intensifier. Means shall be provided to limit the source-skin distance to not less than 30 centimeters (12 inches). For fluoroscopes intended for specific surgical application that would be prohibited at the source-skin

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distances specified in this subrule, provisions may be made for operation at shorter source- skin distances but in no case less than 20 centimeters.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5352. Shielding.

Rule 352. (1) Portable shielding shall be used by the operator and others in the room when possible, 1.6 millimeter (1/16 inch) lead equivalent.

(2) Mobile or portable diagnostic x-ray equipment used routinely in 1 location shall be considered a fixed installation and shall comply with the general requirements of rules 325 and 331 or rules 337 and 347 or both.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5353. Conditions of operation.

Rule 353. (1) Operation shall comply with the general requirements of rules 333 and 348.

(2) Individuals operating mobile or portable diagnostic x-ray equipment shall wear a protective apron of minimum 0.5 millimeter lead equivalence unless portable shielding is provided as specified in rule 352 (1).

(3) Mobile or portable diagnostic x-ray equipment shall not be used for routine radiography or fluoroscopy in hospitals or private offices of practitioners of the healing arts. This equipment shall only be used when it is medically inadvisable to move a patient to a fixed radiographic or fixed fluoroscopic installation.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

MISCELLANEOUS AND SPECIAL INSTALLATIONS

R 325.5355. General provisions.

Rule 355. (1) Types of x-ray sources and uses not specifically covered by this part and not exempted in rule 182, shall comply with parts 1, 4 and 5.

(2) For the purpose of registering and approving medical x-ray producing equipment and devices not specifically covered by this part (e.g. therapy simulators) the protective design, the workload, the use factor and the occupancy factor shall be considered.

(3) Therapy simulators are considered special installations not specifically covered by this part and shall be subject to specific requirements designated by the department in the form of registration conditions for the protection of public health and safety until these rules

are amended to specifically cover such sources and uses.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

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R 325.5357 Appendix A. Table 1.

Rule 357. Recommended shielding for medical diagnostic x-ray installations.*

	HIGH WORKLOAD HOSPITALS RADIOLOGY OFFICES		MODERATE WORKLOAD CLINICS		LOW WORKLOAD OFFICES	
Anticipated Workload	250-1000 mA-min/wk		15-250 mA-min/wk		0-15 mA-min/wk	
Thickness of shielding material or equivalent protection	Lead† (inches)	Concrete† (inches)	Lead† (inches)	Concrete†† (inches)	Lead† (inches)	Concrete†† (inches)
OPERATOR SHIELDS	1/16 - 1/8	5 - 9	1/16	5	1/16	5
PRIMARY BEAMS						
Walls	1/16 - 1/8	5 - 9	1/16	5	1/16	5
Doors	1/16 - 1/8	- - -	1/16	- - -	1/16	- - -
Floors	3/32 - 1/8	6 ½ - 9	1/16 - 3/32	5 - 6 ½	1/16	5
SECONDARY RADIATION						
Walls	1/16	5	1/32 - 1/16	2 ½ - 5	0 - 1/32	0 - 2 ½
Doors	1/16	5	1/32 - 1/16	- - -	0 - 1/32	0 - 2 ½
Floors	1/16	5	1/32 - 1/16	2 ½ - 5	0 - 1/32	0 - 2 ½
Ceilings	1/16	2.5	1/32	2 ½	0 - 1/32	0 - 2 ½

* This table is provided only as a guideline for optimum shielding protection for a few typical radiographic workloads and conditions encountered in hospital, clinic and office situations. More or less shielding may be required in any specific case depending upon many variable factors. Shielding listed is that generally approved by the division of radiological health.

† Thickness ranging from 1/32-1/8 inch based on commercial lead sheets ranging from 2-8 pounds per square foot nominal weight.

†† Thickness based on concrete density of 2.35 grams per cubic centimeter (147 pounds per cubic foot).

[Note: As a result of Executive Order 2011-4, the authority, powers, duties, functions, and responsibilities of the radiation machine registration, licensing, and compliance program were transferred to the Michigan Department of Licensing and Regulatory Affairs. The reference in these rules to the Division of Radiological Health should now reference the Radiation Safety Section.]

History: 1954 ACS 85, Eff. Dec. 3, 1975.

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R 325.5358 Appendix A. Table 2.

Rule 358. Distances at which shielding may not be required for medical radiographic installations.*

	HIGH WORKLOAD HOSPITALS RADIOLOGY OFFICES	MODERATE WORKLOAD CLINICS	LOW WORKLOAD OFFICES
Anticipated Workload	250-1000 mA-min/wk	15-250 mA-min/wk	0-15 mA-min/wk
	DISTANCE IN FEET FROM X-RAY TUBE TO NEAREST OCCUPIED AREA		
PRIMARY BEAMS			
Area controlled	25 - 200	10 - 50	6 - 25
Area non-controlled	80 - 300	25 - 150	15 - 50
SECONDARY RADIATION			
Area controlled	10 - 25	3 - 15	0 - 10
Area non-controlled	30 - 80	10 - 40	15 - 15

* This table is provided only as a guideline to emphasize the need for protective shielding under most circumstances in typical installations. Distances may vary considerably depending upon many uncontrollable factors. Shielding is the preferred method of radiation protection because it can be precisely calculated and controlled.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

R 325.5359. Appendix B. National Electrical Code

Rule 359. Excerpts from Articles 100, 500, 517 and 660.

ARTICLE 100 - DEFINITIONS

Approved: Acceptable to the authority having jurisdiction.

Approved for the Purpose: Approved for a specific purpose, environment, or application described in a particular Code requirement.

Ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded: Connected to earth or to some conducting body that serves in place of the earth.

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Grounded Conductor: A system or circuit conductor that is intentionally grounded.

Grounding Conductor: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding Conductor Equipment: The conductor used to connect noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor at the service and/or the grounding electrode conductor.

History: 1954 ACS 85, Eff. Dec. 3, 1975.

ARTICLE 500
HAZARDOUS (CLASSIFIED) LOCATIONS

500-4. Class I Locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations shall include those specified in (a) and (b) below.

(a) Class I, Division 1. A Class I, Division 1 location is a location: (1) in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions; or (2) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which breakdown or faulty operation of equipment or processes that might release hazardous concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

ARTICLE 517 - HEALTH CARE FACILITIES

517-2. Definitions.

Anesthetizing Location. Any area in which it is intended to administer any flammable or nonflammable inhalation anesthetic agents in the course of examination or treatment and includes operating rooms, delivery rooms, emergency rooms, anesthetizing rooms, corridors, utility rooms and other areas when used for induction of anesthesia with flammable or nonflammable anesthetizing agents.

Critical Patient Care Area. A section (rooms, wards or portions of wards) designated for the treatment of critically ill patients.

Flammable Anesthetics. Gases or vapors such as fluroxene, cyclopropane, divinyl ether, ethyl chloride, ethyl ether, and ethylene, which may form flammable or explosive mixtures with air, oxygen, or reducing gases such as nitrous oxide.

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Flammable Anesthetizing Location. Any operating room, delivery room, anesthetizing room, corridor, utility room, or any other area if used or intended for the application of flammable anesthetics.

Patient Grounding Point. A jack or terminal bus which serves as the collection point for redundant grounding of electric appliances serving a patient vicinity, and for grounding conductive furniture or nonelectric equipment within reach of a patient or a person who may touch him.

Patient Vicinity. The space with surfaces likely to be contacted by the patient or an attendant who can touch him. This represents a space 6 feet beyond the reach of the patient.

Reference Grounding Point. A terminal bus which is an extension of the equipment grounding bus and is a convenient collection point for grounding all electric appliances, equipment and exposed conductive surfaces in a patient vicinity.

Room Bonding Point. A grounding terminal bus which serves as a collection point for grounding exposed metal or conductive building surfaces in a room.

517-3. Grounding. In locations intended for occupancy by patients at any time, all noncurrent-carrying conductive surfaces of electrical equipment that are subject to personal contact shall be grounded by an insulated copper conductor, sized in accordance with Table 250-95, installed with the circuit conductors supplying these receptacles and equipment.

517-50. General.

(b) Patient Care areas shall be classified into one of the three following categories:

(1) General Care Area. Areas where patients ordinarily have only incidental contact with electrical devices.

(2) Critical Care Area, Controlled. Areas where patients ordinarily are intentionally exposed to electrical devices, and where the governing body requires protection (insulation) of externalized cardiac conductors from contact with conductive surfaces other than those designed for connection to such cardiac conductors.

(3) Critical Care Area, Uncontrolled. Areas where patients ordinarily are intentionally exposed to electrical devices and where the governing body makes no requirements for protection of externalized cardiac conductors from contact with conductive surfaces other than those designed for the purpose.

517-51. Performance.

(a) Any two exposed conductive surfaces in the patient vicinity shall not exceed the following potential differences at frequencies of 1000 Hertz or less measured across a 1000 ohm resistance. Exception: Permanently installed x-ray equipment.

(1) General Care Areas. 500 mv under normal operation.

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(2) Critical Care Areas, Controlled. 100 mv under normal operation.

(3) Critical Care Areas, Uncontrolled. 100 mv under normal operation or under conditions of line-to-ground fault.

(b) Special Requirements. The following requirements in both categories shall not apply to small portable nonelectric devices such as bed pans, chairs, and the like.

(1) General Care Areas. Each patient bed location shall be provided with a minimum of four single or two duplex receptacles, each receptacle shall be grounded by means of an insulated copper conductor sized in accordance with Table 250-95.

(2) Critical Care Areas. Each patient bed location shall be provided with a minimum of six single or three duplex receptacles, and grounded to the reference grounding point by means of an insulated copper equipment grounding conductor. Each patient bed location shall be provided with a patient

grounding point, grounded to the reference grounding point by means of an insulated continuous, stranded copper conductor, not smaller than No.10. All exposed conductive surfaces of portable equipment used in the patient vicinity, including those on double-insulated and nonelectric beds shall be grounded to the reference grounding point. One patient bed location shall not be served by more than one reference grounding point.

(7) The equipment grounding conductor for special purpose receptacles such as the operation of mobile x-ray equipment shall be extended to the reference grounding points for all locations likely to be served from such receptacles. When such a circuit is served from an isolated ungrounded system, the

grounding conductor need not be run with power conductors; however, the equipment grounding terminal of the special purpose receptacle shall be connected to the reference grounding point.

(c) Permanently Installed X-Ray Equipment.

(1) In addition to the grounding requirements of Article 660, permanently installed X-ray systems shall have a patient grounding point as described in

(b) above, located as close as possible to the patient support, and be connected to the metal frame of the patient support by a separate, insulated, continuous, stranded, copper conductor, not smaller than No. 4.

(2) The patient grounding point shall be connected to the ground conductor serving the X-ray equipment by an insulated, stranded, copper conductor not smaller than No. 10.

(3) The permanently installed X-ray system including all equipment powered from the X-ray generator power supply shall not be required to be powered by an isolated system. The equipment grounding conductors associated with the equipment shall have a maximum DC resistance of 0.025 ohms, as measured between the chassis and the patient ground point.

517-60. Anesthetizing Locations Classifications.

(a) Hazardous Location.

(1) Any room or space in which flammable anesthetics or volatile flammable disinfecting agents are stored shall be considered to be a Class I, Division 1 location throughout.

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(2) In a flammable anesthetizing location, the entire area shall be considered to be a Class I, Division 1 location which shall extend upward to a level 5 feet above the floor.

(b) Other Than Hazardous Locations. The term "other than hazardous locations" shall apply to any operating rooms, delivery rooms, anesthesia rooms, corridors, utility rooms, and other areas permanently used for or intended for the exclusive use of nonflammable anesthetizing agents. Confirmation of other than hazardous locations shall be accomplished by a written policy by the hospital administration prohibiting the use of flammable anesthetics and posting of rooms. In such cases, the rooms are excluded from the requirements of Section 517-61, 517-62, 517-63(f) (2), and 517-63(f) (3) as applied to X-ray systems only.

517-61. Wiring and Equipment Within Hazardous Areas.

(a) In hazardous areas referred to in Section 517-60, all fixed wiring and equipment, and all portable equipment, including lamps and other utilization equipment, operating at more than 8 volts between conductors, shall conform to the requirements of Section 501-1 through 501-15 and Sections 501-16(a) and (b) for Class I, Division 1 locations. All such equipment shall be specifically approved for the hazardous atmospheres involved.

(b) Where a box, fitting or enclosure is partially, but not entirely, within a hazardous area, the hazardous area shall be considered to be extended to include the entire box, fitting or enclosure.

(c) Flexible cords, which are or may be used in hazardous areas for connection to portable utilization equipment, including lamps operating at more than 8 volts between conductors, shall be of a type approved for extra-hard usage, shall be of ample length, and shall include an additional conductor for grounding. A storage device for the flexible cord shall be provided, and shall not subject the cord to bending at a radius of less than 3 inches.

(d) Receptacles and attachment plugs in hazardous areas shall be listed for use in Class I, Group C hazardous locations, and shall have provision for the connection of a grounding conductor.

517-62. Wiring and Equipment in Nonhazardous or Above Hazardous Anesthetizing Areas.

(a) Wiring above a hazardous area as referred to in Section 517-60 or in a nonflammable anesthetizing area shall be installed in rigid raceways or shall be Type MI cable, Type ALS cable, Type CS cable, or Type MC cable which employs a continuous, impervious metallic sheath.

(b) Equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, generators, motors, or other equipment having make-and-break or sliding contacts, shall be of the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

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(f) Plugs and receptacles for connection of 250V, 50-ampere and 60-ampere AC medical equipment for use in nonhazardous areas of flammable anesthetic Anesthetizing Locations and in nonflammable Anesthetizing Locations shall be so arranged that the 60-ampere receptacle will accept either the 50- ampere or the 60-ampere plug. 50-ampere receptacles shall be designed so as not to accept the 60-ampere attachment plug. The plugs shall be of the two-pole, 3-wire design with a third contact connecting to the (green or green with yellow stripe) equipment grounding conductor of the electrical system.

517-63. Circuits in Anesthetizing Locations.

(a) Except as provided in Section 517-63(f) and (g), each circuit within, or partially within, an anesthetizing location as referred to in Section 517-60 shall be controlled by a switch having a disconnecting pole in each circuit conductor, and shall be isolated from any distribution system supplying areas other than anesthetizing locations. Such isolation shall be acceptable by means of one or more transformers having no electrical connection between primary and secondary windings, by means of motor- generator sets, or by means of suitable isolated batteries.

(f) Branch circuits supplying only fixed lighting fixtures in nonhazardous areas of anesthetizing locations other than surgical lighting fixtures, or supplying only approved permanently installed X-ray equipment shall be permitted to be supplied by a conventional grounded system, provided: (1) wiring for grounded and ungrounded circuits does not occupy the same raceways: (2) the lighting fixtures and the X-ray equipment (except the enclosed X-ray tube and the metal-enclosed high-voltage leads to the tube) are located at least 8 feet above the floor or outside the anesthetizing location; and (3) switches for the grounded circuits are located outside of the anesthetizing location.

(g) Components of an isolated power center approved for the purpose and its grounded primary feeder shall be permitted to be located in an anesthetizing location provided it is located in an other than hazardous area.

Note 1: For a description of approved permanently installed X-ray equipment, see Sections 3384, 3385, 3432, 3433, 4435, and 4437 of the Inhalation Anesthetics Standard, NFPA No. 56A-1973.

Note 2: Remote-control stations for remote-control switches shall be permitted in the anesthetizing location if the remote-control circuit is energized from the ungrounded distribution system.

517-65. Other Equipment.

(b) X-ray equipment installed or operated in an anesthetizing location as defined in Section 517-2 shall be provided with approved means for preventing accumulation of electrostatic charges. All X-ray control devices, switches, relays, meters, and transformers shall be totally enclosed, and where installed or operated within a hazardous area, shall be approved for Class I, Group C locations. High-voltage wiring shall be effectively insulated from ground and adequately guarded against accidental contact. The entire installation shall comply with Article 660.

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517-66. Grounding. In any anesthetizing area, all metallic raceways, and all noncurrent-carrying conductive portions of fixed or portable equipment including the conductive floor shall be grounded.

Exception: Equipment operating at not more than 8 volts between conductors shall not be required to be grounded.

ARTICLE 660 - X-RAY EQUIPMENT

660-2. Definitions.

Portable: X-ray equipment designed to be hand-carried.

Mobile: X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

Transportable: X-ray equipment to be installed in a vehicle or that may be readily disassembled for transport in a vehicle.

Long-Time Rating: A rating based on an operating interval of five minutes or longer.

Momentary Rating: A rating based on an operating interval that does not exceed five seconds.

660-3. Hazardous Locations. Unless approved for the location, X-ray and related equipment shall not be installed or operated in hazardous locations. See Article 517, Part E.

660-4. Connection to Supply Circuit.

(a) Fixed and Stationary Equipment. Fixed and stationary X-ray equipment shall be connected to the power supply by means of a wiring method meeting the general requirements of this Code.

Exception: Equipment properly supplied by a branch circuit rated at not over 30 amperes shall be permitted to be supplied through a suitable attachment plug cap and hard-service cable or cord.

(b) Portable, Mobile, and Transportable Equipment. Individual branch circuits shall not be required for portable, mobile, and transportable medical X-ray equipment requiring a capacity of not over 60 amperes. Portable and mobile types of X-ray equipment of any capacity shall be supplied through a suitable hard-service cable or cord. Transportable X-ray equipment of any capacity shall be permitted to be connected to its power supply by suitable connections and hard-service cable or cord.

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(c) Over 600-Volt Supply. Circuits and equipment operated on a supply circuit of over 600 volts shall comply with Article 710.

660-5. Disconnecting Means. A disconnecting means of adequate capacity for at least 50 percent of the input required for the momentary rating or 100 percent of the input required for the long-time rating of the X-ray equipment, whichever is greater, shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating shall be permitted to serve as a disconnecting means.

660-9. Minimum Size of Conductors. Sizes No. 18 or 16 fixture wires as specified in Section 725-16 and flexible cords shall be permitted for the control and operating circuits of X-ray and auxiliary equipment where protected by not larger than 20-ampere overcurrent devices.

D. Guarding and Grounding.

660-47. General.

(a) High-Voltage Parts. All high-voltage parts, including X-ray tubes, shall be mounted within grounded enclosures. Air, oil, gas, or other suitable insulating media shall be used to insulate the high voltage from the grounded enclosure. The connection from the high-voltage components shall be made with high-voltage shielded cables.

(b) Low-Voltage Cables. Low-voltage cables connecting to oil-filled units that are not completely sealed, such as transformers, condensers, oil coolers, and high-voltage switches, shall have insulation of the oil- resistance type.

660-48. Grounding.

Noncurrent-carrying metal parts of X-ray and associated equipment (controls, tables, X-ray tube supports, transformer tanks, shielded cables, X-ray tube head, etc.) shall be grounded in the manner specified in Article 250. Portable and mobile equipment shall be provided with an approved grounding-type attachment plug cap. In areas designated as critical care areas, X-ray equipment shall be grounded in the manner prescribed in Section 517-51.

Exception: Battery-operated equipment.

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