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X-RAY AND RADIUM PROTECTION

RECOMMENDATIONS OF INTERNATIONAL CONGRESS OF RADIOLOGY

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X-RAY AND RADIUM PROTECTION

RECOMMENDATIONS OF INTERNATIONAL CONGRESS OF RADIOLOGY

ABSTRACT

The X-ray and radium protection proposals that were adopted by the Second International Congress of Radiology are given in their final form. The section of the 1928 National Electrical Code, dealing with X-ray and high-frequency apparatus is also given. The first set of recommendations are effective until the next congress in 1931.

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The bureau receives many requests for information regarding safety and protection from X rays and radioactive substances. In answering these each case has been considered in itself and, when possible, recommendations have been made. At the Second International Congress of Radiology in Stockholm, 1928, there was adopted the following series of recommendations (not fixed rules) covering such protection and it is intended that from time to time additions or modifications will be made conforming to the advances in the practice and applications of radiology. In connection with these recommendations it should be understood that in the various protection coefficients the minimum values consistent with safety have been given.

The general form of the proposals is that adopted several years ago by the British X Ray and Radium Protection Committee and which in the meantime has been found applicable and quite satisfactory.

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I. RECOMMENDATIONS ADOPTED BY THE SECOND INTERNATIONAL CONGRESS OF RADIOLOGY, JULY, 1928

1. The dangers of overexposure to X rays and radium can be avoided by the provision of adequate protection and suitable working conditions. It is the duty of those in charge of X-ray and radium departments to ensure such conditions for their personnel. The known effects to be guarded against are: (*a*) Injuries to the superficial tissues, (*b*) derangements of internal organs and changes in the blood.

1. WORKING HOURS, ETC.

2. The following working hours, etc., are recommended for whole-time X-ray and radium workers:

(*a*) Not more than seven working hours a day.

(*b*) Not more than five working days a week. The off days to be spent as much as possible out of doors.

(*c*) Not less than one month's holiday a year.

(*d*) Whole-time workers in hospital X-ray and radium departments should not be called upon for other hospital service.

2. GENERAL X-RAY RECOMMENDATIONS

3. X-ray departments should not be situated below ground-floor level.

4. All rooms, including dark rooms, should be provided with windows affording good natural lighting and ready facilities for admitting sunshine and fresh air whenever possible.

5. All rooms should be provided with adequate exhaust ventilation capable of renewing the air of the room not less than ten times an hour. Air inlets and outlets should be arranged to afford crosswise ventilation of the room.

6. All rooms should preferably be decorated in light colors.

7. X-ray rooms should be large enough to permit a convenient layout of the equipment. A minimum floor area of 250 square feet (25 square meters) is recommended for X-ray rooms and 100 square feet (10 square meters) for dark rooms. Ceilings should be not less than 11 feet (3.5 meters) high.

8. A working temperature of about 18° C. (65° F.) is desirable in X-ray rooms.

9. Wherever practicable the X-ray generating apparatus should be placed in a separate room from the X-ray tube.

3. X-RAY PROTECTIVE RECOMMENDATIONS

10. An X-ray operator should on no account expose himself unnecessarily to a direct beam of X rays.

11. An operator should place himself as remote as practicable from the X-ray tube. It should not be possible for a well-rested eye of

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normal acuity to detect in the dark appreciable fluorescence of a screen placed in the permanent position of the operator.

12. The X-ray tube should be surrounded as completely as possible with protective material of adequate lead equivalent.

13. The following lead equivalents are recommended as adequate:

X rays generated by peak voltages	Minimum equivalent thickness of lead
Not exceeding—	*mm*
75 kv	1.0
100 kv	1.5
125 kv	2.0
150 kv	2.5
175 kv	3.0
200 kv	4.0
225 kv	5.0

14. In the case of diagnostic work, the operator should be afforded protection from scattered rays by a screen of a minimum lead equivalent of 2 mm.

15. In the case of X-ray treatment the operator is best stationed completely outside the X-ray room behind a protective wall of a minimum lead equivalent of 2 mm. This figure should be correspondingly increased if the protective value of the X-ray tube inclosure falls short of the values given in paragraph 13. In such event the remaining walls, floor, and ceiling may also be required to provide supplementary protection for adjacent occupants to an extent depending on the circumstances.

16. Screening examinations should be conducted as rapidly as possible with minimum intensities and apertures.

17. The lead glass of fluorescent screens should have the protective values recommended in paragraph 13.

18. In the case of screening stands the fluorescent screen should, if necessary, be provided with a protective "surround" so that adequate protection against direct radiation is afforded for all positions of the screen and diaphragm.

19. Screening stands and couches should provide adequate arrangements for protecting the operator against scattered radiation from the patient.

20. Inspection windows in screens and walls should have protective lead values equivalent to that of the surrounding screen or wall.

21. Efficient safeguards should be adopted to avoid the omission of a metal filter in all X-ray work.

22. Protective gloves, which should be suitably lined with fabric or other material, should have a protective value not less than ½ mm lead throughout both back and front (including fingers and wrist). Protective aprons should have a minimum lead value of ½ mm.

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4. ELECTRICAL PRECAUTIONS IN X-RAY ROOMS

23. The floor covering of the X-ray room should be insulating material, such as wood, rubber, or linoleum.

24. Permanent overhead conductors should be not less than 9 feet (3 m) from the floor. They should consist of stout metal tubing or other coronaless type of conductor. The associated connecting leads should be of coronaless wire kept taut by suitable rheophores.

25. Wherever possible earthed guards should be provided to shield the more adjacent parts of the high-tension system. Unless there are reasons to the contrary, metal parts of the apparatus should be efficiently grounded.

26. The use of quick-acting double-pole circuit breakers is recommended. Overpowered fuses should not be used. If more than one apparatus is operated from a common generator, suitable overhead multiway switches should be provided.

27. Some suitable form of kilovoltmeter should be provided to afford a measure of the voltage operating the X-ray tube.

5. RADIUM PROTECTIVE RECOMMENDATIONS

(A) Radium Salts.—

28. Protection for radium workers is required from the effects of:

(*a*) Beta rays upon the hands;

(*b*) Gamma rays upon the internal organs, vascular and reproductive systems.

29. In order to protect the hands from beta rays, reliance should be placed, in the first place, on distance. The radium should be manipulated with long-handled forceps, preferably made of wood, and should be carried from place to place in long-handled boxes, lined on all sides with about 1 cm of lead. All manipulations should be carried out as rapidly as possible.

30. Radium, when not in use, should be stored in a safe as distant as possible from the personnel. It is recommended that radium tubes or applicators be inserted into separate lead blocks in the safe, giving a thickness of protective wall amounting to 5 cm of lead per 100 mg of radium element.

31. A separate room should be provided for the "make-up" of screened tubes and applicators, and this room should only be occupied during such work.

32. In order to protect the body from the penetrating gamma rays during handling of the radium, a screen of not less than 1 inch thickness of lead should be used, and proximity to the radium should only occur during actual work, and for as short a time as possible.

33. The measurement room should be a separate room, and it should contain the radium only during its actual measurement.

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34. Nurses and attendants should not remain in the same room as patients undergoing radium treatment.

35. All unskilled work or work which can be learned in a short period of time should preferably be carried out by temporary workers, who should be engaged on such work for periods not exceeding six months. This applies especially to nurses and those engaged in "making up" applicators.

36. Discretion should be exercised in transmitting radium salts by post. In the case of small quantities it is recommended that the container should be lined throughout with lead not less than 3 mm thick. It is more satisfactory to transport large quantities by hand in a suitably designed carrying case.

(B) EMANATION.—

37. In the manipulation of emanation, protection against the beta and gamma rays has likewise to be provided.

38. The handling of emanation should be carried out, as far as possible, during its relatively inactive state.

39. The escape of emanation should be very carefully guarded against, and the room in which it is prepared should be provided with an exhaust fan.

40. Where emanation is likely to come in direct contact with the fingers, thin rubber gloves should be worn to avoid contamination of the hands with active deposit. Otherwise, the protective measure recommended for radium salts should be carried out.

41. A separate pumping room should be provided with a connecting tube from the special room in which the radium is stored in solution. The radium in solution should be heavily screened to protect people working in adjacent rooms. This is preferably done by placing the radium in solution in a lead-lined box, the thickness of lead recommended being according to the following table:

Quantity of radium element, in grams	Thickness of lead	
	Inches	*cm*
0.5	6.0	15.0
1.0	6.6	16.5
1.5	6.8	17.0
2.0	7.2	18.0

II. DISCUSSION OF THE RECOMMENDATIONS

The proposals do not specify the use of sheet lead, but state that a certain "lead equivalent" be used. Sheet lead is, however, the safest and most permanent protection, and should be used whenever possible. If protective plasters are used, great care must be taken in their preparation and application in order to insure a uniform

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protective value. Papers by Hunt[1,2] discuss the properties and use of such materials.

In most X-ray departments the lighting is inadequate and the ventilation poor. These are two factors which are very commonly overlooked in the design of X-ray departments and consequently particular attention should be given to paragraphs 4 and 5.

There is frequently also a lack of sufficient auxiliary protective aprons on screening stands and couches, thus exposing the operator to the very soft radiation scattered from the patient's body. This is one of the most common sources of danger to the doctor.

In the edition of 1928, the Electrical Committee of the National Fire Protection Association formulated section 5012 of the National Electrical Code, which bears directly on protection from X-ray equipment. Some measures in this code are covered in the proposals above, but where there is any difference between them, the more stringent should be followed. This section follows.

III. 5012. X-RAY AND HIGH-FREQUENCY APPARATUS

(*a*) Adequate mechanical barriers shall be provided to prevent too close approach to any high-voltage part except the operating tube and its leads, and it is recommended that all other parts be inclosed in a separate room or cabinet. Such barriers may consist of grounded metal or of insulating material, such as glass. High-voltage parts inclosed in a wooden cabinet shall have adequate spacing from the wooden walls. If one side of the high-voltage circuit is grounded, the milliammeter shall be connected in the grounded lead, and need not be guarded. All operating parts, such as spark-gap handles and regulating handles, shall be made of suitable insulating material, and shall be operative from outside of the barriers.

(*b*) Overhead high-voltage stationary conductors shall be not less than 7 feet 6 inches above the floor where the ceiling height permits, and in no case less than 7 feet. The high-voltage leads on tilting tables and fluoroscopes shall be adequately insulated or so surrounded by barriers that inadvertent contact with them is improbable. Tube terminals and high-voltage wires connected thereto should be adequately insulated for a distance of 12 inches from the terminal. Shields for this purpose shall be designed to carry the high-voltage leads away from the patient in a direction at right angles to the long axis of the tube. X-ray tubes used in therapy shall be mounted in a grounded metal inclosure.

(*c*) The low-voltage circuit of a step-up transformer shall contain a manually operable automatic circuit breaker having no exposed live parts. There shall be an additional switch in this circuit, which for diagnostic work shall be one of the following types: (1) A switch with spring or other mechanism to open automatically except while held closed by the operator. (2) A time switch which will automatically open after a definite time for which it has been set.

(*d*) Where more than one piece of apparatus is operated from the same high-voltage source, each shall be provided with a high-voltage switch so as to give independent control.

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[1] F. L. Hunt and M. Temin, Radiology, February, 1927.

[2] F. L. Hunt, Am. J. Roent. and Ra. Th., **14**, p. 524; 1925.

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(*e*) Low-frequency current-carrying parts of machines of the quenched-gap or open-gap type shall be insulated or guarded so that they can not be touched during operation. This applies to all parts except the high-frequency circuit proper which delivers high-frequency current normally for therapeutic purposes.

(*f*) Transformers which are a part of an X-ray or high-frequency apparatus, even though they contain oil, are to be considered and treated as a part of the device, and need not conform to the requirements of section 5005 for power transformers.

(*g*) All tube stands and fluoroscopes shall have their frames, operating handles, and other noncurrent-carrying metal parts of apparatus grounded in conformity with the requirements of article 9. Nonmetallic tables and chairs are recommended, particularly for therapeutic work. Metal or other conducting tables or chairs for supporting patients shall be suitably insulated from ground, and insulating floors, mats, or platforms shall be provided for operators. It is recommended that floors of concrete or other conducting material be completely covered with linoleum, rubber tile, or other insulating material.

IV. DISCUSSION

With the possible advent of new X-ray tubes, such as the "Metalix tube," and new technique, such as high-tension cables, and oil-immersed equipment, many of the problems in protection would be simplified. However, the present type of equipment will undoubtedly be used for some time, and, therefore, proper attention should be given to all new installations as well as existing ones.

In order to continue the work in protection, the Congress has elected a committee of international character which will report any further progress at the Third International Congress of Radiology at Paris in 1931. This committee consists of one representative each from England, France, America, Germany, Sweden, and Italy, and to this committee will be referred any final decisions regarding protection. In this country it is planned to have a small "local" committee which will decide upon recommending any changes or additions arising from experience and advance in the United States. To this committee should be referred any questions or suggestions regarding X-ray protection and, if no settlement can be reached, they will be taken up by the international committee, of which Dr. G. W. C. Kaye and Dr. Stanley Melville are the honorary secretaries. Communications pertaining to the code should be transmitted through Lauriston S. Taylor, Bureau of Standards, the American member on this committee.

WASHINGTON, September 15, 1928.

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