Report of Committee III

on

Protection Against X-Rays up to Energies of 3 MeV and Beta-and Gamma-Rays from Sealed Sources

(1960)

RADIATION PROTECTION

Recommendations of the International Commission on Radiological Protection

ICRP PUBLICATION 3

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on

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PREFACE

THE Report of Committee III on Protection against X-Rays up to Energies of 3 MeV and Beta- and Gamma-Rays from Sealed Sources is the result of the work of the Committee during and after the regular meeting in Geneva in 1956. Since 1956, some members of the Committee have met in New York in 1958, and the report has been reviewed at meetings in Geneva 1958 and Munich 1959. The report indicates the requirements necessary for ensuring adequate protection in the various uses of the radiations to which it relates. In respect of industrial applications, the report is in conformity with the 1958 revision of Chapter XI. Section 2, of the Model Code of Safety Regulations for Industrial Establishments published by the International Labour Office.

The co-operation of the 1958 Publication Committee is gratefully acknowledged. The Committee also greatly appreciates the assistance of Mr. Lars Lorentzon in collecting and preparing the Appendix material and the help of Dr. L.-E. Larsson who assisted the Publication Committee in the Editorial preparation of the report.

The 1956–1959 Membership of the Committee was as follows:

R. G. JAEGER, Chairman	F. GAUWERKY
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Technical Secretary: W. HÜBNER

Also contained in this publication is a reprint of the Recommendations of the International Commission on Radiological Protection (September 9, 1958) (I.C.R.P. Publication 1) together with an addendum which was adopted in July 1959 and which consists largely of explanatory statements and amendments to the 1958 Recommendations. The Report of Committee III is in conformity with both the 1958 Recommendations and the 1959 Amendments.

Chairman Committee III	R. G. JAEGER
Vice-Chairman Committee III	E. E. SMITH

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ON

PROTECTION AGAINST X-RAYS UP TO ENERGIES OF 3 MeV AND BETA- AND GAMMA-RAYS FROM SEALED SOURCES

A. INTRODUCTION

(1) In this report, which is based upon the codes of practice in operation in various countries, the main emphasis has, in accordance with the Commission's policy, been placed on the basic requirements of radiation protection, leaving the expansion of detailed technical requirements to national committees. It has, however, been considered desirable to add an appendix containing certain graphs, tables and examples from which the necessary numerical values for radiation protection can be obtained.

(2) It will be noted that the upper limit for this report has been extended to 3 MeV. This value is regarded by the International Commission on Radiological Units and Measurements (ICRU) as the upper limit of the energy range over which the röntgen should be used. It therefore provides a logical division between the scope of Committees III and IV.

(3) In addition to the revision of the previous report (1 December 1954), sections have been added on the use of sealed beta- and gamma-ray sources, including gamma-ray beam equipment. The sub-section on X-ray analysis equipment has been considerably expanded.

(4) The maximum permissible doses which are recommended for external radiations are given in Section C of ICRP Publication 1 as amended and reprinted on pages 61–84 in this book. For the purposes of this Report, the organ or tissue dose in rads (or rems) is assumed to be numerically equal to the exposure dose in röntgens measured in air.

(5) In view of the increasing use of radiation and of radiation producing equipment, it is now regarded as essential to consider not only radiation workers and patients, but also all other persons in the vicinity. Such persons are considered by the Commission to constitute special groups for whom lower maximum permissible levels have been recommended. These lower levels necessitate increased protection for some radiation installations, particularly those adjacent to living or other accommodation which may be occupied by the same persons for a considerable fraction of the entire week.

(6) It should be stressed that recommendations for the installation and operation of X-ray equipment, or for dealing with radioactive materials, are not in themselves sufficient to guarantee adequate protection. Such protection depends largely on the expert knowledge of the staff and on their co-operation in carrying out the instructions prepared by their supervisor in the interests of radiation protection.

(7) The responsibility of the head of the department for the provision of working conditions in accordance with any regulations, recommendations or codes of practice on radiation protection in operation in his own country has been dealt with in Section D of ICRP Publication 1. He shall also be responsible for ensuring that all instructions and operating conditions specified in the radiation survey report are complied with.

(8) The head of the department shall ensure that adequate medical examinations and radiation monitoring of personnel are carried out, as recommended in Section D of ICRP Publication 1.

(9) It is the duty of the workers, upon the instruction of a qualified expert or responsible supervisor, to follow the recommendations and instructions which have been drawn up in the interests of radiation protection; further, to use the protective devices provided for their welfare, and to bring to the notice of those in charge any defect that has been revealed.

(10) The genetic consequences of the medical uses of ionizing radiations have received much consideration recently and the importance of avoiding unnecessary exposure of patients has been stressed. Attention is therefore drawn to those recommendations which have the purpose of limiting this exposure.

(11) The radiological examination of human beings for non-medical purposes is undesirable and is not recommended. Examples of such examinations are shoe-fitting and anti-crime fluoroscopy.

(12) Further consideration has been given to the emission of X-rays from television equipment, and a reduction in the maximum permissible dose-rate close to the surface of home television sets has been recommended. This revision is required to limit the genetic dose to the population, in view of the widespread use of television. Most of the current types of home television receiver already comply with the new lower limit. Other types of television equipment have also received consideration in this report.

(13) In the previous report, reference was made to the question of introducing a radiation certificate upon which all doses of radiation received by a person from medical exposure to ionizing radiations are recorded. This question has been extensively studied jointly by the ICRP and the ICRU and the conclusion was reached that "the systematic recording and registration of the radiation received by every member of the population is not recommended".*

B. DEFINITIONS

(14) For the purposes of this report the following definitions are given:

Attenuation: decrease in dose rate of radiation in passing through a material.

(1) **Narrow beam attenuation:** attenuation obtained under conditions designed effectively to prevent the inclusion of scattered radiation in the transmitted beam.

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* "Exposure of Man to Ionizing Radiation Arising from Medical Procedures". A report of the ICRP–ICRU, 1957. *Physics in Medicine and Biology*, p. 107, 2, 1957.

(2) **Broad beam attenuation:** attenuation obtained under such conditions that the maximum amount of scattered radiation is included in the transmitted beam.

Collimation: the limiting of a beam of radiation to the required dimensions.

Half-value layer (HVL): the thickness of a specified absorbing material which, when introduced into the path of a beam of radiation, reduces the dose-rate to one-half of its original value.

Ionizing radiation: see **Radiation**

Lead equivalent: the thickness of lead, which, under specified conditions of irradiation, affords the same protection as the material under consideration. The lead equivalent of a substance, such as lead-glass or lead-rubber, which attenuates the radiation essentially by its lead content, is largely independent of the quality of the radiation. The lead equivalent of all other protective materials and also building materials for protective walls (concrete, brick, etc.) and barium protective glass show a dependence on the quality of the radiation.

Occupancy factor: the factor by which the work-load should be multiplied to correct for the degree or type of occupancy of the area in question. This factor may be based in general on the degree of occupancy averaged over a year.

Primary protective barrier: Barrier sufficient to attenuate the useful beam to the required degree.

Protective source housing: enclosure for one or more sealed sources, which limits the leakage radiation to a specified level.

Teletherapy protective source housing: housing so constructed that

(A) With the beam control mechanism in the "OFF" position,
  (a) at 1 metre from the source, in any direction, the maximum dose-rate of the leakage radiation does not exceed 10 mr/h nor does the average dose-rate exceed 2 mr/h, and
  (b) at 5 cm from the housing surface, in any readily accessible position, the respective dose-rates
    (1) do not exceed 10 times the above values in the case of housings for sources with a useful beam dose-rate of more than 100 r/h at 1 metre from the source,
    (2) do not exceed 20 times the above values in the case of housings for sources with a useful beam dose-rate of less than 100 r/h at 1 metre from the source.

(B) With the beam control mechanism in the "ON" position,
  (a) in the case of housings for sources with a useful beam dose-rate of more than 100 r/h at 1 metre from the source,
    (1) the maximum dose-rate of the leakage radiation at a source distance of 1 metre does not exceed either 1 r/h or 0.1 per cent of the useful beam dose rate at 1 metre from the source, whichever is the greater and
    (2) adjustable beam defining diaphragms do not allow the transmission of more than 5 per cent of the useful beam dose-rate.

(b) in the case of housings for sources with a useful beam dose-rate of less than 100 r/h at 1 metre from the source no values are recommended but in the design and use of such housings, consideration shall be given to minimizing the integral dose to the patient from leakage radiation.

Industrial protective source housing: housing so constructed that with the beam control mechanism in the "OFF" position, the dose rate conforms to the requirements of (A, a) and (A, b, 1) of the specification for teletherapy protective source housing. The protection to be afforded in the "ON" position is determined by operational requirements.

Protective tube housing: housing which surrounds the X-ray tube itself, or the tube and other parts of the X-ray apparatus (for example, transformer) and limits the major portion of the radiation emerging from the tube to the "useful beam". Each protective tube housing shall have its type marked upon it.

Diagnostic-type protective tube housing: housing so constructed that at every specified rating of the X-ray tube the leakage radiation at a focal distance of 1 metre does not exceed 100 mr in 1 hour.

Therapeutic-type protective tube housing: housing so constructed that at every specified rating of the X-ray tube the leakage radiation at a focal distance of 1 metre does not exceed 1 röntgen in 1 hour, nor 30 r in 1 hour at any point accessible to the patient at a distance of 5 cm from the surface of the housing or its accessory equipment.

Radiation (ionizing radiation): electromagnetic radiation (X-ray or γ-ray photons or quanta), or corpuscular radiation (α-particles, β-particles, electrons, positrons, protons, neutrons and heavy particles) capable of producing ions.

(1) **Primary radiation:**
   (a) **X-rays:** radiation coming directly from the target of the X-ray tube. Except for the useful beam, the bulk of this radiation is absorbed in the tube housing.
   (b) **β- and γ-rays:** radiation coming directly from the radioactive source.

(2) **Secondary radiation:** radiation, other than the primary radiation, emitted by irradiated matter.

(3) **Scattered radiation:**
   (a) **Side scattered radiation:** radiation which is scattered in directions approximately at right angles to the direction of the primary beam.
   (b) **Back scattered radiation:** radiation which is scattered in directions approximately opposite to the direction of the primary beam.

(4) **Useful beam:** That part of the primary and secondary radiation which passes through the aperture, cone or other device for collimation.

(5) **Leakage radiation:** All radiation, except the useful beam, coming from the tube or source housing.

(6) **Stray radiation:** Radiation other than the useful beam. It includes leakage radiation and secondary radiation.

Sealed source: A discrete amount of radioactive material within a tight, firm and inactive enclosure which effectively prevents the loss of radioactive substance during routine use. In the presence of gaseous radioisotopes (e.g. emanation) a source would be regarded as sealed only if the enclosure is gastight.

Secondary protective barrier: Barrier sufficient to attenuate the stray radiation to the required degree.

Shall: necessary to guarantee adequate protection against radiation.

Should (is recommended): to apply, whenever practicable, in the interests of minimizing dangers.

Specific gamma-ray emission (specific gamma-ray output) of a radioactive nuclide: the product of the exposure dose-rate produced by the unfiltered gamma radiation from a point source and the square of the distance to that source, divided by the activity of the source. Units of specific gamma-ray emission may be, for example,

$$\frac{\text{r m}^2}{\text{c h}}, \quad \frac{\text{r cm}^2}{\text{mc h}}$$

Tenth-value layer (TVL): the thickness of a specified absorbing material which, when introduced into the path of a beam of radiation, reduces the dose-rate to one-tenth of its original value.

Use factor: the fraction of the work-load during which the useful beam is pointed in the direction under consideration.

Work-load: a measure in suitable units of the amount of use of radiation equipment. For the purpose of this report the work-load is expressed in mA · min per week for X-ray sources and röntgens per week at 1 metre for gamma-ray sources.

C. PLANS FOR INSTALLATIONS USING X-RAYS AND SEALED GAMMA-RAY SOURCES*

(15) Plans for new installations using X-rays and sealed gamma-ray sources or for modifications of existing installations involving structural shielding should be reviewed by the appropriate protection organization or a qualified expert before building is commenced.

(16) Protection can be achieved by distance and by protective barriers. Where the cost of protective barriers becomes an important consideration, as, for example, with gamma-ray beam and high-voltage X-ray equipment, the location of the installation with respect to other occupied space may permit economies to be effected. In special cases, the distance involved may be such as to permit the barrier thicknesses to be reduced to zero. These distances, based on various assumed exposure conditions in the direction of the useful beam, are indicated in Figs. 21 and 22 of the Appendix.

(17) Figures 6 to 19 of the Appendix provide basic absorption data for the computation of protective barrier thicknesses. Examples of barrier thicknesses required are given in Tables IV to VII of the Appendix.

(18) In computing the protection required against the useful beam, a qualified expert should consider whether or not to allow for the attenuation provided by the patient, phantom or other removable object.

(19) Protection against stray radiation requires smaller barrier thicknesses than would be necessary for the corresponding useful beam. Accordingly, the amount of

* Sealed beta-ray sources are dealt with in paragraphs (121) to (132).

structural protection required in any instance can be appreciably reduced by using protective tube and source housings and imposing restrictions on the orientation of the useful beam. Data for computing the thicknesses of secondary protective barriers are given in the Appendix.

(20) In the planning of a radiation installation, account should be taken of the expected work-load of the equipment, use factors of the barriers and the occupancy factor of the adjacent areas. Allowance should be made for possible future increases in these factors, such as increase in the output of the machine, modifications in technique and increase in the degree of occupancy of surrounding areas.

(21) There should be no unnecessary openings from the radiation room to occupied space, and where openings are required their size should be limited to what is necessary.

(22) In designing the structural protection, consideration should be given to the possibility of multiple exposure from several different X-ray tubes and other sources of radiation.

(23) In all protective barriers, care should be taken to ensure that the protection is not reduced at joints, nails, bolts, etc. In such places there should be an adequate overlapping of the protective material. Holes in the protective barriers for pipes, conduits, louvres, etc. shall be provided with baffles so that the protection is not impaired.

(24) The final plans of an installation should indicate the type of material and the dimensions of all protective barriers. The positions of all windows, doors, pipes and louvres shall be indicated in so far as they affect the protection requirements. Such plans should have the approval of the appropriate protection organization or a qualified expert.

D. SURVEY AND MONITORING OF INSTALLATIONS USING X-RAYS AND SEALED GAMMA-RAY SOURCES

(25) Routine operation of any installation using X-rays or sealed gamma-ray sources shall be deferred until a radiation survey has been made and the installation found to comply with the recommendations. The survey shall be made by the appropriate protection organization or a qualified expert. A reappraisal of the protection shall be made after every change in an existing installation. Change should here be construed to mean any change that is likely to increase the radiation hazards such as an increase in the work-load, the use factor or the quantum energy of the radiation, or an alteration of the protection of a barrier. The installation should be re-surveyed periodically in order to check that satisfactory conditions still obtain both inside and outside the controlled area.

General Examinations

(26) The completed installation should be compared with plans and specifications previously approved.

(27) If the protection depends on mechanical or electrical restrictions on the orientation of the useful beam, the survey shall include an inspection to see if these restrictions are actually imposed.

(28) All interlocks, warning signals and protective devices such as gloves and aprons, shall be inspected to ensure that they are satisfactory.

(29) The surveyor should study the proposed methods of operation of the equipment and if necessary recommend modifications to minimize radiation hazards. In this connection a study should be made of the personnel monitoring technique.

Area Dose Rate Measurements

(30) In carrying out a radiation survey, it is often useful to make a preliminary investigation by means of a suitable Geiger–Müller, scintillation or ionization instrument. Films or fluorescent screens may be used to localize small defects in the shielding.

(31) Whenever defects are found in the shielding, they shall be eliminated before the installation is put into routine use.

(32) For the final measurements, ionization chambers or other suitable equipment which have a low variation in sensitivity with dose-rate, quality and direction of the radiation should be used.

(33) When required, measurements shall be made outside the controlled area to verify that persons other than the radiation workers are unlikely to receive more than the appropriate maximum permissible dose after allowing for work-load, use factor, occupancy factors and the attenuation afforded by objects in the useful beam.

Report on a Radiation Survey

(34) The results of a survey should be submitted in a formal written report.

(35) The report should include any recommendations required for the modification of the protection, for limitations in operating procedures and for the posting of signs indicating such limitations.

E. RECOMMENDATIONS ON EQUIPMENT AND OPERATING CONDITIONS

X-ray Medical Diagnostic Installations

General Requirements

(36) A diagnostic-type protective tube housing shall be used.

(37) Apertures, cones or shutters which serve to limit the useful beam should afford the same protection as the tube housing.

(38) The permanent total filter should be determined by the highest voltage of the X-ray apparatus. Equipment with a maximum operating potential above 70 kV should have a permanent total filter equivalent to at least 2 mm aluminium. Equipment with a lower maximum operating potential should have a permanent total filter equivalent to at least 1.5 mm aluminium.

(39) A dead-man type of exposure switch should be used where practicable.

(40) The dose-rate outside an X-ray high-tension generator containing rectifying

valves shall not exceed 20 mr in 1 hour at 5 cm from the surface and 2 mr in 1 hour at any readily accessible place in occupied space within a controlled area. Should the generator be situated outside the controlled area, it may be necessary to reduce these dose-rates. See also paragraph (22).

(41) Persons who regularly work in the radiological department should not hold patients during diagnostic examinations. If necessary, children should be held by their parents or by the persons accompanying them. Such persons should be protected, particularly with respect to the gonads and the hands. Motion restricting devices should be used as much as possible and cassettes shall never be held by hand during an exposure.

(42) The dose to the patient, especially the integral and gonad dose should be restricted as much as possible consistent with the clinical requirements: see paragraphs (165) to (177).

(43) No persons shall occupy the X-ray room unnecessarily during irradiation.

Fluoroscopy

(44) Tube, aperture and fluorescent screen should be arranged together in such a manner that, under normal conditions of use, the useful beam cannot fall outside the screen.

(45) The fluorescent screen shall be covered with a protective glass sheet having a lead equivalent of at least 1.5 mm for 100 kV. From 100 to 150 kV an additional lead equivalent of 0.01 mm per kilovolt is required. In arriving at these values the Committee has taken into account the attenuation provided by the patient.

(46) A switch for controlling the X-ray beam should be provided at the fluoroscopic position.

(47) A manually reset cumulative timing device should be provided which will either indicate the total time of irradiation or terminate irradiation when the total time exceeds a previously determined limit.

(48) The focus–skin distance *should* not be less than 45 cm (18 in.) and *shall* not be less than 30 cm (12 in.).

(49) All couches and stands for fluoroscopy should be provided with an adequate arrangement for protecting the operator and the assistants against scattered radiation, particularly from the patient and the underside of the table top. This may take the form of an "apron" which should be not less than 45 cm (18 in.) wide and 45 cm (18 in.) long and should be made of protective material having a lead equivalent of not less than 0.5 mm. It should be attached to the lower edge of the screen holder when the latter is vertical and to the side when the screen is horizontal. A separate protective apron or fixed shield may be attached to the side rail of the couch for use when the screen is horizontal. The apron may consist of several overlapping parts to facilitate palpation.

(50) Image intensifiers should afford protection at least equivalent to 1.5 mm lead for 100 kV. From 100 to 150 kV an additional lead equivalent of 0.01 mm per kilovolt is required.

(51) The so-called "hand fluoroscope" shall not be used.

(52) Notwithstanding that the X-ray equipment conforms in every respect to the requirements of these recommendations, it is usually necessary during fluoroscopy,

to wear protective aprons or coats in order that the maximum permissible doses are not exceeded. In all normal fluoroscopic work the lead equivalent of protective clothing should not be less than 0.25 mm.

(53) Protective gloves having a lead equivalent of not less than 0.25 mm should be worn during each fluoroscopic examination. These should cover the whole hand, including back, palm, fingers and wrist.

(54) Before a fluoroscopic examination is begun the eyes must be sufficiently dark-adapted. In order to work with the lowest possible dose-rate, the adaptation period should be at least ten minutes.

Radiography with Fixed Equipment

(55) The X-ray exposure should be controllable from the control panel only, except in the case of special techniques when it is necessary to control the exposure from the couch or stand. In such special techniques it may be necessary for the personnel to wear protective clothing as specified in paragraphs (52) and (53).

(56) The patient shall be observable from the control panel.

(57) The provision of a light-beam localizer for indicating the cross-section of the useful beam is recommended.

(58) During an exposure, the operator should be adequately protected. This may be achieved where necessary either by providing a shield within the X-ray room or by placing the control panel outside the X-ray room behind an adequately protected wall.

(59) The simultaneous examination of more than one patient in the same room involves unnecessary hazards for both personnel and patients and is not recommended.

Mobile Equipment

(60) All mobile equipment shall be provided with collimating cones or collimating diaphragms and spacer frames, to ensure that the focus–skin distance is not less than 30 cm (12 in.) and that the useful beam is limited to the minimum size required for the examination.

(61) The use of a light-beam localizing device is recommended.

(62) The minimum distance of the operator from the tube and patient should be 1.5 m. The operator shall not stand in the useful beam and shall make certain that it does not irradiate other persons who may be in the vicinity.

(63) Fluoroscopy should not be used unless the requirements of paragraphs (44) to (54) are satisfied.

Photo-Fluorography (Mass Radiography)

(64) A collimator shall restrict the useful beam to the area of the fluorescent screen and the beam should also be limited to the minimum consistent with the clinical requirements. The use of a light-beam localizer is recommended for this purpose.

(65) The equipment shall be so arranged and shielded that all personnel associated with the procedure are adequately protected during routine use without the necessity for protective clothing.

(66) In order to minimize the population dose, consideration shall be given to the protection of persons awaiting examination.

(67) The use of high-speed optical systems, which enable the dose to the patient to be reduced, is recommended.

Dental Radiography

(68) Localizing cones shall be employed with all dental equipment. Such cones shall provide the maximum practicable focus–skin distance and the minimum practicable field size.

(69) A timer shall be provided to terminate the exposure after a preset time.

(70) Installations operating up to 70 kV should be so arranged that the operator can remain at least one metre (70 kV and over—at least 1.5 m) from the tube and patient. Even under these conditions, for more than 30 mA·min per week, protective screens having a lead equivalent of not less than 0.5 mm should be used.

(71) Consideration should be given to the provision of structural shielding in order to protect persons in adjacent areas. This is particularly necessary when more than one dental unit is located in close proximity.

(72) Whenever possible, the film should be fixed in position; otherwise it should be held by the patient or, exceptionally, by a person who is not occupationally exposed to radiation. It should never be held by the dentist or his staff, who should under no circumstances be exposed to the useful beam.

(73) The tube housing should not be held by hand during exposure.

(74) Fluoroscopy with dental equipment is dangerous and shall not be used.

X-ray Therapeutic Installations

General Requirements

(75) A therapeutic-type protective tube housing shall be used.

(76) Permanent diaphragms or cones used for collimating the useful beam shall afford the same degree of protection as the tube housing. Adjustable or removable beam defining diaphragms or cones shall be constructed so as to reduce the integral dose to the patient as much as practicable. In no case shall they transmit more than 5 per cent of the useful beam.

(77) Each accessible filter shall be marked with its thickness and material. A filter indication system should be used which permits easy recognition, from the control panel, of the filtration.

(78) Unless it is possible rapidly to bring the X-ray output to the prescribed value, the tube housing shall be fitted with a shutter, electrically operated from the control panel and of lead equivalent not less than that of the tube housing. The position of the shutter shall be indicated at the control panel.

(79) The equipment shall be provided with an automatic timer to terminate the treatment after a pre-set time.

(80) A transmission monitoring chamber in the useful beam is recommended for observing the constancy of the radiation.

(81) Means shall be provided for observing the patient and should be provided

for oral communication with the patient from the control panel during the treatment.

(82) For installations operating above 100 kV, interlocks shall be provided so that when any door to the treatment room is opened the equipment 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 focal distance of 1 metre and not more than 10 times these values at a distance of 5 cm from the surface of the tube housing. After such a shut-off it shall be possible to restore the machine to full operation only from the control panel. For such installations, only the patient shall be in the treatment room during irradiation.

Special Requirements for Superficial Therapy

(83) Installations for superficial therapy shall comply with the general requirements of paragraphs (75) to (82), except that the operator and other persons may be permitted in the treatment room during irradiation providing they are adequately protected. Interlocks are not normally required at 100 kV or below. Structural shielding may not be required below 50 kV. Where short treatment distances are used and the operating potential is 50 kV or less, the use by the operator of protective clothing as specified in paragraphs (52) and (53) is generally adequate.

(84) An audible or visible signal shall indicate that the tube is in operation.

(85) Only tubes which are intended to be used at 50 kV or less may be held by hand during treatment and this procedure shall only be used when clinically necessary. Such tubes shall be so protected that the permissible doses to the hand and other parts of the body are not exceeded. If the weekly exposure time exceeds 20 minutes the tube housing shall be provided with a hand shield for protection against scattered radiation from the patient. Protective gloves and coats or aprons as specified in paragraphs (52) and (53) shall be worn during this work.

(86) When the inherent filtration is low and the focus–window distance is short, special precautions shall be taken to avoid accidental exposure to the useful beam, brief exposure to which may cause serious injury.

X-ray Installations for Non-Medical Radiography and Fluoroscopy

General Requirements

(87) All areas in which radiation hazards may arise shall be identified by an appropriate and easily recognizable warning sign.

(88) Audible or visible signals shall be provided in the vicinity of installations, to provide warning before and during irradiation.

(89) X-ray tubes shall be provided with protective housings appropriate to the nature of the work, so as to afford adequate protection to personnel. Under normal circumstances, the tube housing should conform at least to the requirements for a therapeutic-type protective tube housing.

Non-Medical Radiography

(90) Whenever practicable, non-medical radiography should be carried out in