



Environment Protection Authority

Radiation Standard 4

Compliance requirements for x-ray protective clothing



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Introduction

In line with the radiological protection principle of optimisation, shielding of persons that are not behind a fixed radiation shield is important to ensure that doses to staff working with ionising radiation are kept as low as reasonably achievable. Poor performance of x-ray protective clothing can cause an unnecessary increase in staff personal dose or be associated with occupational health and safety issues, such as a risk of musculoskeletal injury.

This document aims to contribute to dose optimisation by:

- ensuring that adequate safety measures are provided to protect staff, occupationally exposed workers and the public from radiation exposure when not behind a fixed radiation shield;
- providing practical guidance on the selection, use and maintenance of x-ray protective clothing, thereby:
 - improving the standard of x-ray protective clothing in use,
 - ensuring better monitoring of x-ray protective clothing performance.

This standard for x-ray protective clothing is for the information of the person responsible and all wearers of x-ray protective clothing. Please note that this version no longer includes patient shielding, following the publication of international and national recommendations that patient gonadal and fetal shielding during x-ray based diagnostic imaging is discontinued as a routine practice.

In the event of an amendment to the Act or Regulation, references to the legislation in this document must be deemed to refer to the current legislation. In the event of an inconsistency between the standard and the legislation, the requirements of the legislation prevail to the extent of the inconsistency.

This document sets out the minimum requirements for x-ray protective clothing, which are stated as '**must**' statements. This standard promotes industry best practice in radiation safety for x-ray protective clothing.

The standard was developed by the Radiation Unit of the NSW Environment Protection Authority (EPA) in consultation with the Radiation Advisory Council.

The EPA acknowledges the assistance of Dr Jennifer Diffey and Mr Nick Hille in preparing this edition.

1. Conditions for use

1.1 General

- 1.1.1 The person responsible **must** ensure that all persons (other than the patient) present in the following examination rooms wear x-ray protective clothing if not behind a protective screen during x-ray exposures:
- Radiography (Medical)
 - Radiography (Veterinary)
 - Computed Tomography
 - Any room in which fluoroscopy is performed for x-ray diagnostic, interventional or image-guided procedures.
 - Mobile radiography for people within 2 metre radius of the patient or primary beam.
- 1.1.2 An appropriately qualified person, for example, a consulting radiation expert, a radiation safety officer, a medical physicist, veterinarian or a senior radiographer, **must** be consulted before the purchase of x-ray protective clothing.
- 1.1.3 A safety assessment **must** be undertaken to ensure all persons (other than the patient) wear an x-ray protective apron and other suitable clothing (such as thyroid shields, eyewear or gloves) of appropriate lead equivalence giving consideration to the type of procedure, kVp and position of the person in relation to the x-ray source. Refer to Section 3 of this standard for different types of x-ray protective clothing.
- 1.1.4 Additional protection for the thyroid **must** be worn if provided, by all staff, since the unprotected thyroid can significantly increase effective dose.
- 1.1.5 Eyewear should be worn by staff who are not protected by ceiling-suspended shields or who may exceed dose limits to the lens of the eye. Eyewear should have a specified lead equivalence of not less than 0.5 mm Pb over the entire area of the eye, including any side-shields.
- 1.1.6 Aprons and thyroid shields **must** have a specified radiation attenuation in the front section of not less than 0.35 mm¹ lead equivalence at 50-110 kVp. Closed aprons **must** additionally have a specified lead equivalence in the back section of not less than 0.25 mm Pb at 50-110 kVp .
- 1.1.7 Aprons **must** cover the front of the body from the throat to at least the knees, the entire breastbone and the shoulders. Closed aprons **must** additionally cover the sides of the body from not more than 10 cm below the armpits to the knees and the back down to the knees.

¹ This requirement comes into force from November 2023 for any new protective clothing purchased.

Fastenings **must** be provided to keep aprons closed. Where aprons have two fully overlapping front panels the total of the two panels when correctly worn **must not** be less than 0.35 mm² in lead equivalence at 50-110 kVp.

- 1.1.8 Personal dosimeters, if provided for monitoring effective dose, **must** be worn under the x-ray protective apron. A dosimeter **must not** be worn outside the apron unless it is additional to one worn underneath, and this fact is appropriately reported to the organisation issuing the dosimeter. Dosimeters **must not** be worn in the pocket of an x-ray protective apron unless it provides the equivalent shielding as the front of the protective apron.
- 1.1.9 The manufacturer's recommendations regarding the handling, storage and cleaning of protective clothing should be observed. X-ray protective aprons and thyroid shields **must** be stored either flat or on hangers to prevent the development of cracks in the protective material.
- 1.1.10 Inspection and testing of protective clothing **must** be performed as described in section 2 of this standard when used in the course of medical radiography, veterinary radiography, fluoroscopy and computed tomography procedures.

² This requirement comes into force from November 2023 for any new protective clothing purchased.

2. Inspection and testing requirements

2.1 Identification and markings

2.1.1 All protective clothing should be marked in accordance with Standards Australia / Standards New Zealand, Protective devices against diagnostic medical X-Radiation. Part 3: Protective clothing, eyewear and protective patient shields. AS/NZS IEC 61331.3:2022.

- Markings **must** include:
- Name of manufacturer or supplier
- Size of apron
- Lead equivalence (mm Pb) for front and back section (if applicable)
- X-ray tube voltage (kV) at which the lead equivalence is rated

2.1.2 Each item of protective clothing **must** be identified by the purchaser (facility) with a locally unique identifier that is indelibly marked on the article.

2.1.3 A record **must** be kept that includes the identification number, usual location, date of purchase, lead equivalence, style, testing dates and test results.

2.2 Visual inspection

2.2.1 Each user **must** visually inspect each article of x-ray protective clothing at the time of each use and be confident of its integrity. Clothing **must not** be used if the surface appears cracked or damaged (note that most aprons have a non-shielding protective cover that may appear undamaged even if the shielding material underneath is faulty).

2.2.2 If there is a suspicion that protective clothing is faulty, it **must** be tested by a radiographer, medical physicist, veterinary nurse or other appropriate person such as a radiation safety officer or a consulting radiation expert. Persons undertaking screening **must** have an appropriate radiation licence issued by the Authority.

2.3 Shielding integrity procedures

2.3.1 All new protective clothing (excluding eyewear and gloves) **must** be tested for shielding integrity before use.

2.3.2 Protective clothing (excluding eyewear and gloves) **must** be tested at regular intervals of no more than 12 months, or more frequently if indicated.

2.3.3 Routine shielding assessment of protective clothing **must** be tested by a radiographer, medical physicist, veterinary nurse or other appropriate person such as a radiation safety officer or a consulting radiation expert. Persons undertaking screening **must** have an appropriate radiation licence issued by the Authority.

2.3.4 Testing may be performed using fluoroscopy at approximately 60 kVp (ideally with a floating-top table), which gives good radiographic contrast. Faults or inhomogeneities in shielding

should be easily observed (note that the lead equivalence cannot be measured or verified by this method). Alternatively, testing may be performed using CT scout views (topograms) at the lowest kV setting or radiographs at 60 kVp.

2.3.5 If faults are found, an image of the region **must** be taken for verification and should be kept for five years, and the apron **must** be marked as faulty. The article **must** be immediately removed from use and returned to the radiation safety officer, medical physicist, chief radiographer or another appropriately qualified person. Refer to section 4 of this standard for examples of aprons with shielding defects.

2.3.6 Based on the cost of replacing x-ray protective aprons and the estimated radiation dose received from a defect, it is suggested that x-ray protective aprons be replaced if the total area of defects is greater than those outlined in Table 1. Defects not in proximity of critical organs, or along the seam, in overlapped areas or on the back of the x-ray protective apron should be subject to a less conservative rejection criterion. If the defect is clearly not over a critical organ and is smaller than the rejection criteria then continued use of the x-ray protective apron may continue, provided the location of the defect is clearly marked on the apron and the size, location and date that the defect was identified logged in the accompanying documentation.

Table 1: Replacement criteria, based on defect size and location

Location of defect		Sum of area of defects (mm ²)
Apron	Over a critical organ	46
	Not over critical organs	670
Thyroid shield	Anywhere	13

2.4 Verification of lead equivalence

2.4.1 Measured lead equivalence at 100 kVp should be within $\pm 10\%$ of the specified value when tested in accordance with a traceable method such as AS/NZS IEC 61331.3:2022

3. Different types of protective clothing

The range of available x-ray protective clothing is extensive. In accordance with 1.1.2 and 1.1.3, of this standard clothing **must** be suitable for the person and application, based on risk assessment and discussion with an appropriately qualified person.

Standard apron



Back view



Note that this is not a closed apron since the coverage of the back is limited.

This design may not be suitable for staff working in theatres and angiography suites but is practical for those required to support patients in x-ray rooms (e.g. parents or carers).

Closed wrap-around vest and skirt (has a back panel)



A vest and skirt may provide better weight distribution and comfort than a one-piece apron.

Note that the front panels are considered to overlap completely since all critical organs are covered. The front would need to be specified with at least 0.35 mm Pb in total.

Closed vest (has a back panel)



Note that there is only partial overlap at the front so both panels would need to be specified with at least 0.35 mm Pb.

Protective eyewear



Glasses with a wrap-around style or inclusion of side shields provide protection from scattered radiation in all directions.

Protective glasses can be supplied with prescription lenses; alternatively, a face shield could be worn over normal prescription glasses.

Thyroid shield (collar)



Typically available in a range of sizes and styles with velcro or magnetic closure.

Disposable thyroid shield covers may be used to protect from dirt and perspiration.

Gloves



Available in a gauntlet style, or as lightweight disposable gloves.

May be suitable for some applications but be aware that gauntlet style gloves will limit dexterity and cause radiation exposure factors to increase if placed in the field of view, when working under Automatic Exposure Rate Control; disposable gloves have very low lead equivalence (typically < 0.05 mm Pb) and may give wearers a false sense of security.

Limb shields



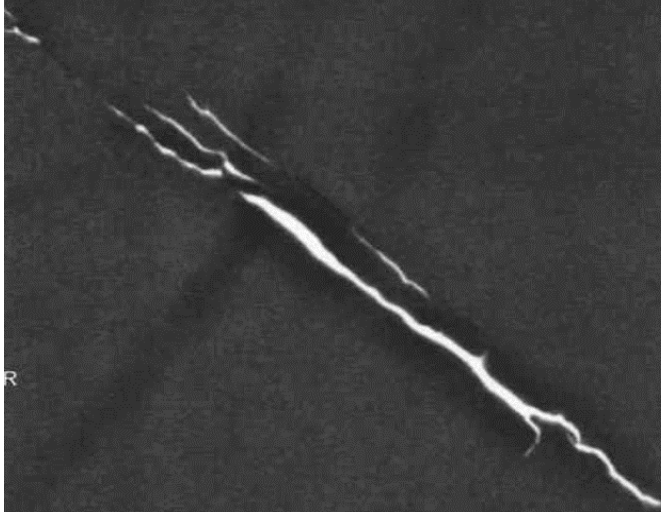
Shin pads may be considered for staff working extensively with an under-couch x-ray tube, although table-side shielding is a preferable alternative. Shin pads and sleeves provide additional shielding for the red bone marrow in the limbs.

4. Examples of aprons with shielding defects

These digital images are of lead composite gowns which were captured from a fixed fluoroscopy unit. The white sections indicate defects. Please note that it is normal to see stitching holes on x-ray images.



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R

EP / Pace
m 25
hA 15
RAO 2° / CAUD 2°

960 x 960
EE 10%
DDO 40%
WW 2600 [W 4096]
WC 2095 [C 2048]

References

AAPM Position Statement on the Use of Patient Gonadal and Fetal Shielding. American Association of Physicists in Medicine.

<https://www.aapm.org/org/policies/details.asp?id=468&type=PP>

ACPSEM endorsement of AAPM Position Statement. Australasian College of Physical Scientists and Engineers in Medicine. <https://www.acpsem.org.au/Latest-News/2019-2020/AAPM-Position-Statement-on-the-Use-of-Patient-Gonadal-and-Fetal-Shielding>

ASMIRT Position Statement: Gonad Shielding. Australian Society of Medical Imaging and Radiation Therapy. https://www.asmirt.org/asmirt_core/wp-content/uploads/2464.pdf

Standards Australia/Standards New Zealand (2022). Protective devices against diagnostic medical X-radiation. Part 1: Determination of attenuation properties of materials. AS/NZS IEC 61331-1:2022.

Standards Australia/Standards New Zealand (2022). Protective devices against diagnostic medical X-radiation. Part 3: Protective clothing, eyewear and protective patient shields. AS/NZS IEC 61331-3:2022.

Australian Radiation Protection and Nuclear Safety Agency (2008). ARPANSA Radiation Protection Series 14.1. Safety Guide: Radiation Protection in Diagnostic and Interventional Radiology

Aprons for protection against X-rays. Australian Radiation Protection and Nuclear Safety Agency. <https://www.arpansa.gov.au/understanding-radiation/radiation-sources/more-radiation-sources/aprons-protection-against-x-rays>

Hiles PA, Hughes H, Arthur D and Martin CJ. Personal Protective Equipment for Diagnostic X-ray Use. Report of a BIR Working Party. British Institute of Radiology. 2016

Jeffries C. Inspection of Lead Aprons: Updated Rejection Criteria. EPSM 2021, Engineering and Physical Sciences in Medicine. Phys Eng Sci Med 45, 315 (2022). <https://doi.org/10.1007/s13246-021-01094-z>

All website addresses correct at the time of printing

Definitions

In this standard:

Act means the *Protection from Harmful Radiation Act 1990*.

Authority means the NSW Environment Protection Authority.

Closed apron means an apron, vest or skirt that additionally covers the back of the body.

EPA means NSW Environment Protection Authority.

Lead equivalence means the thickness of lead causing the same attenuation of a beam of a specified radiation quality as the material under consideration.

Person responsible means as defined in section 6 of the Act.

Protective shield means a protective wall or barrier of radiation attenuation material(s) used to reduce the dose equivalent on the side beyond the radiation source.

Regulation means the Protection from Harmful Radiation Regulation.

Scattered radiation means ionising radiation produced from the interaction of electromagnetic ionising radiation with matter. It has a lower energy than, or different direction from, that of the original incident ionising radiation.

Specified means definitive information stated and documented by the manufacturer relating to the equipment under consideration, in particular the parameters or conditions associated with its use.

Staff means all people employed by an organization or person responsible.

X-ray protective clothing means clothing made of lead rubber or another material that attenuates ionising radiation with the intent to reduce the wearers radiation dose.

Unless otherwise defined, all words in this standard have the same meaning as in the Act and the Regulation.