Shielding verification of medical, veterinary and chiropractic X-ray apparatus using the maximum continuous tube current

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EPA1087/16: This information sheet provides guidance on the use of maximum continuous tube current for shielding verification of medical, veterinary, and chiropractic X-ray apparatus. It should be read in conjunction with the Test Protocol for Shielding of Medical, Veterinary and Chiropractic X-ray Apparatus 2015 (the test protocol).

1 Introduction

Under the *Radiation Protection and Control (Ionising Radiation) Regulations 2015* (the regulations), medical, veterinary, and chiropractic X-ray apparatus are required to be shielded in accordance with regulation 103. Under regulations 103(6) and 103(7) radiation barriers used to shield the apparatus must be able to do so when the apparatus is operated at its maximum rated X-ray tube potential and one-half or one-tenth its maximum continuous tube current depending on the type of occupancy beyond the barrier under test.

The most direct method of verifying compliance with regulations 103(6) and 103(7) is to operate the apparatus at its maximum rated (ie available) X-ray tube potential and a known X-ray tube current and exposure time. Dose measurements of the scattered radiation (or in the case of vertical Bucky units or similar the primary beam) beyond the barrier under test are then performed. The equivalent dose rate, based on the measured dose, can be calculated and compared with the appropriate limit of regulations 103(6) and 103(7).

2 What is maximum continuous tube current

The maximum continuous tube current is the maximum X-ray tube current that an apparatus can be operated at continuously at a specified tube potential before damage to the X-ray tube can occur, typically damage to the anode. This depends on the design of the X-ray tube itself, its housing and the efficiency of the cooling system in extracting thermal energy from the X-ray tube during operation.

Maximum continuous tube current is typically derived from the manufacturer's data – as a specified value, power output data or from cooling curves for a specific X-ray tube and housing combination. Where this data is unavailable, the Environment Protection Authority (EPA) has assumed default values for the maximum continuous tube current. This provides a means of verifying compliance with regulation 103 when appropriate manufacturer's data is unavailable. Please refer to the test protocol for details. To demonstrate the use of maximum continuous tube current a worked example is provided in section 4 of this document.

3 Tolerance and measurement uncertainty

Making an accurate determination of tolerances and uncertainties can be complex, particularly when an evaluation of stacked values is required. A number of methods can be used including the worst case method, the root sum square method and applying uncertainty to measurements as a whole. Using raw measured values without correcting for tolerance or uncertainty is also an option. The application of measurement tolerance and uncertainty is at the discretion of the accredited tester.

4 Example

For this example, the apparatus is a fixed medical apparatus capable of plain radiography. It has a maximum available tube potential of 120 kilovolts peak and a dual focal spot.

No manufacturer's data is available for the maximum continuous tube current.

Configuring the apparatus

1 An appropriate phantom is placed in the beam.

2 The apparatus is configured to:

- a an X-ray tube potential of 120 kilovolts peak
- b an X-ray tube current and exposure time product of 6 milliampere seconds (ie the set mAs)
- c a collimator size of 43 cm by 35 cm
- d a focal spot to phantom distance of 100 cm
- e the broad focal spot.

Determine the maximum continuous X-ray tube current

In the absence of the apparatus manufacturer's data for the maximum continuous tube current, the default maximum continuous tube current, in accordance with Schedule 2 of the test protocol, is 4.5 milliamperes (ie the max continuous mA).

Measuring dose

1 A measurement beyond a barrier under test gave a dose reading of 28 nanogray.

2 An in situ measurement of background radiation indicated a background radiation rate of 2 nanogray per minute is applicable. For the measurement of the wall under test the total measurement time, that is, the time between when the measurement was initiated and terminated, was 2 minutes and 30 seconds. Hence the contribution of the background radiation is 2 x 2.5 = 5 nanogray.

3 Ignoring the tolerances and the general uncertainty of the measurements, the measured dose, when the contribution of background radiation is accounted for, is 28 – 5 = 23 nanogray. This is the measured dose in nGy.

Calculating the equivalent dose rate

1 In the case of a radiation worker continually occupying an area or a member of the public occupying an area for a short time, from Schedule 1 of the test protocol, the equivalent dose rate is given by:

- a equivalent dose rate in µSv/h = 1.80 x (max continuous mA / set mAs) x measured dose in nGy
- b hence, equivalent dose rate in µSv/h = 1.80 x (4.5/6) x 23 = 31.1 µSv/h.

2 In the case of a member of the public occupying an area for other than a short period of time, from Schedule 1 of the test protocol, the equivalent dose rate is given by:

- a equivalent dose rate in µSv/h = 0.36 x (max continuous mA / set mAs) x measured dose in nGy
- b hence, the equivalent dose rate in µSv/h = 0.36 x (4.5/6) x 23 = 6.2 µSv/h.

Verifying compliance

1 In the case of a radiation worker continually occupying an area or a member of the public occupying an area for a short time, the equivalent dose rate in µSv/h, calculated above, exceeds 25 microsieverts per hour.

2 In the case of a member of the public occupying an area for other than a short period of time, the equivalent dose rate in µSv/h, calculated above, exceeds 2.5 microsieverts per hour.

3 The barrier does not comply if the area beyond it is normally occupied.

Disclaimer

This publication is a guide only and does not necessarily provide adequate information in relation to every situation. This publication seeks to explain your possible obligations in a helpful and accessible way. In doing so, however, some detail may not be captured. It is important, therefore, that you seek information from the EPA itself regarding your possible obligations and, where appropriate, that you seek your own legal advice.

Further information

General information

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