SHIELDING REQUIREMENTS FOR DIAGNOSTIC AND THERAPEUTIC X-RAY APPARATUS IN SOUTH AUSTRALIA: REGULATORY REQUIREMENTS, SPECIFICATION AND ASSESSMENT OF X-RAY ROOMS

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ABSTRACT

In South Australia the shielding requirements for diagnostic and therapeutic X-ray apparatus depend on the maxiumum power output of the equipment regardless of workload, usage or occupancy.

The method of calculating the required shielding is discussed and the procedure for assessing the degree of radiation protection of the X-ray room once the apparatus has been installed is outlined.

INTRODUCTION

In South Australia, ionizing radiation is controlled by the Radiation Protection and Control Act, 1982 and its Ionizing Radiation Regulations, 1985. Under the Act, X-ray apparatus must be registered with the South Australian Health Commission. However, the Commission cannot register the apparatus unless it has been constructed, shielded and installed in accordance with the Regulations.

The most widely accepted methodology for the calculation of the radiation shielding is that contained in the NCRP Report No.49. Using the equations in Appendix B of this report, the thickness of the barrier for primary radiation, scattered radiation and leakage radiation can be computed as a function of the distance from the radiation source and the product $L = WUT$, where W, U and T are, respectively, the workload in mA min/week, use factor and occupancy factor.

For new X-ray installations specific information on the value of L may not be available and is usually estimated. An underestimate can lead to inadequate shielding specifications which are expensive to correct after the room has been completed, while overestimates lead to unnecessary costs.

REGULATORY REQUIREMENTS

The Regulations require that diagnostic apparatus be shielded such that:

1. "The air kerma rate:

   (a) 50mm from any wall, door, window, floor or ceiling outside a room, space or enclosure in which the apparatus is installed, being:

      (i) an area continuously occupied by a radiation worker; or
      (ii) a corridor, walkway, lift, stairway, carpark, toilet or other area that is normally occupied by a member of the public for a short time; and

   (b) 50mm from behind a protective screen,

   must not exceed 25 microgray per hour when the apparatus is operated at its maximum rated X-ray tube potential and one half of its maximum continuous tube current at that potential", and

2. "The air kerma rate 50mm from any wall, door, window, floor or ceiling outside a room, space or enclosure in which the apparatus is installed, being an area occupied by a member of the public for other than a short period of time, must not exceed 2.5 microgray per hour when the apparatus is operated at its maximum rated X-ray tube potential and one tenth of its maximum continuous tube current at that potential."

For therapeutic apparatus the shielding requirements are similar to those for diagnostic installations, except that in (2) above one half of the maximum continuous tube current is used instead of one tenth.

The philosophy behind the development of the shielding requirements expressed above was that an X-ray machine should be shielded so that in areas continuously occupied by radiation workers and by members of the public, the air kerma rate should be such that the annual dose limits for radiation workers and general public would not be exceeded when the machine is operated at its maximum capacity. However, calculations of barrier thicknesses indicated that application of this concept was causing overshielding and, therefore, unnecessary costs.

A comparison of the shielding design between the method used in NCRP 49 and that discussed here indicated that overshielding could be prevented if factors of "one half" and "one tenth" of the maximum continuous current at the maximum rated kV were used in the calculation of shielding for radiation workers and members of the general public, respectively. The comparison was made for an existing X-ray room in a large hospital where the workload could be determined accurately. In the calculations made using the NCRP 49 method a weekly exposure of 100 uGy was used for radiation workers. NCRP 49 reports that the cost of shielding for typical diagnostic and therapeutic X-ray installations will only increase approximately 25% if the shielding design for radiation workers is based on a weekly exposure of 100 uGy rather than the maximum design value of 1000 uGy. In other words a tenfold increase in radiation protection could be gained for a 25% increase in cost. An analysis of the shielding materials available locally and their costs indicated that in South Australia for these more stringent shielding conditions the average increase in the cost of X-ray installations is consistent with that mentioned in NCRP 49.

The shielding concept espoused in this work has the advantage that it eliminates contention between the legislative body and the owner of the installation as to whether the equipment has been adequately shielded. It is also consistent with the ALARA principle in which exposure to radiation is as low as practicable without large increases in the cost of shielding.

SHIELDING SPECIFICATIONS

In specifying the structural shielding requirements equations 3c and 6f, Appendix B of NCRP 49, are used where the product WUT is substituted by L calculated as discussed above. It has been found in practice that it is not necessary to consider leakage radiation separately as the shielding requirements calculated for the scattered radiation are also adequate for leakage radiation.

SHIELDING ASSESSMENT

The adequacy of shielding is assessed once the installation is completed using a water phantom with a depth of 200 mm and field area the same as that used in the shielding calculation. A tube voltage as close as practicable to the maximum rated kV of the tube and a charge between 50-200 mAs are used.

A radiation survey is then made with a 100 cm^2 ion chamber. Various critical locations are surveyed, e.g. behind the operator's protective screen, door and joints in wall partitions. The air kerma rate at these locations is then calculated using the appropriate fraction of the maximum continuous current at the kV at which the exposures were made.

SUMMARY

In South Australia the shielding required for diagnostic and therapeutic X-ray equipment depends on the maximum power output of the apparatus only.

The method discussed above has proven to be practical and does not lead to overshielding of X-ray installations and is consistent with the general objective of the ALARA principle incorporated in the legislation. It has also eliminated contention between the legislative body and the owner of the installations over workload, usage and occupancy.

REFERENCES

1. NCRP Report No.49, National Council on Radiation Protection and Measurements, 1976, "Structural Shielding Design and Evaluation for Medical use of X-rays and Gamma Rays of Energies up to 10 MeV" (Bethesda, MD:NCRP)

2. The Radiation Protection and Control Act, No.49 of 1982, South Australia, Assented to 29 April, 1982.

3. The Ionizing Radiation Regulations, No.7 of 1985, Regulations made under the Radiation Protection and Control Act, 1982, See South Australian Government Gazette; 4 April 1985, pp 993-1107.