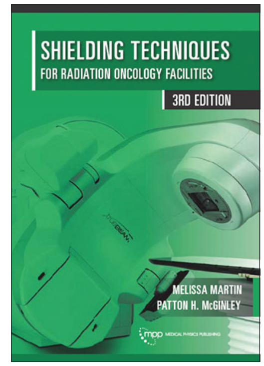
Review of Book Entitled "Shielding Techniques for Radiation Oncology Facilities, 3rd Edition"



Authors: Melissa Martin and Patton H. McGinley
Name and Location of the Publisher: Medical Physics Publishing, 4555, Helgesen Drive Madison, WI 53718, USA 1-800-442-5778, mpp@medicalphysics.org, www.medicalphysics.org
Year of Publication: 2020
Number of Pages of Book: 169
ISBN: 978-1-951134-00-6

Radiation therapy plays a pivotal role in cancer management among other treatment modalities such as surgery and chemotherapy. The exposure of ionizing radiation to the workers and the members of the public above permissible dose limit may lead to adverse health effects. Therefore, room (treatment room) housing radiotherapy equipment should be adequately shielded so that radiation workers and members of the public shall not exceed their allowed dose limits as per regulatory stipulations. In radiation therapy, goal is to deliver maximum dose to the tumor and minimum possible dose to the surrounding health issue/organ. For fulfilling this objective, there has been continuous development of different types of the radiotherapy equipment. It is observed that radiation shielding requirements of the room housing radiotherapy equipment (e.g., 6 MV Accelerator, Tomotherapy, Cyberknife, Halcyon) may vary even for the same photon beam energy, source to point of interest, shielding martials of protective barrier, and allowed dose limit. Many national/international agencies such as IAEA, NCRP, ICRP and IPEM have published various reports on radiation shielding calculation technique for radiotherapy room. P. H. McGinley has been one of the lead researchers in 1990s for radiation shielding in radiation oncology facilities. He has published a book with title "Shielding techniques for radiation oncology facilities" in the year 1998 (first edition) and subsequently published second edition of book in the year 2002. In light of development of advanced radiotherapy equipment (e.g. Tomotherapy, Cyberknife, Halcyon, ViewRay MRIdian System, Elekta Unity, etc.) Melisa Martin and P. H. McGinley revised the 2nd edition and published 3rd edition of the book in the year 2020. Author Melissa Martin is also well known expert in the field of radiation shielding of radiation oncology facilities. This book is intended as a practical guide to the medical physicist/radiation shielding expert for shielding technique of radiotherapy treatment rooms for not only standard radiotherapy equipment but also for advanced and specialized radiotherapy equipment. This book does not cover shielding aspects of Particle Therapy Facility (e.g. Proton Therapy, Carbon Ion Therapy) which could have been included for the sake of completeness.

This book consists of nine chapters in addition to references and Appendix A provided values of some of parameters such as TVLs for head leakage, patient scatter, primary and secondary barriers, neutron leakage, patient scatter fractions etc. used for shielding calculations and Appendix B describing the different types of barrier shielding materials such as concrete, high density concrete, steel, lead, polyethylene and earth. Both Appendices A and B are very much useful in arriving room shielding requirements. In the 2nd edition also, there were nine chapters with same nomenclature but without appendices. However, in 3rd edition, contents are updated in line with current recommendation of national / international reports (e.g. NCRP, IAEA, ISO, IPEM).

Chapter 1

This chapter describes the historical evolution of radiation shielding requirements. Content of this chapter is almost same as that of first chapter of 2nd Edition of the book except some updates based on recent shielding reports (e.g., NCRP report no. 151, 2005, IPEM report 75, 2002, IAEA Safety Series report no 47, 2006, ISO Standard no. 16645, 2016).

Chapter 2

This chapter describes shielding design goals, type of occupancy one could encounter and methods of the calculation of the radiation shielding for the primary and secondary barrier and the width of the primary barrier of the room housing radiotherapy machines. Though this was also there in the previous edition(2nd edition), the current edition includes other aspects as well. Some of them are typical values of occupancy factors for various locations of the room, workload estimation for primary beam and leakage radiation for the medical accelerators with different photon beam energies and their typical values, impact of flattening filter free(FFF) photon beam on the shielding, tapered primary barrier ceiling, obliquity factors, groundshine calculation etc.

Chapter 3

Maze reduces the dose reaching the entrance door of the treatment room. Radiation components reaching the entrance door are primary beam scattered from room surfaces, head leakage photons scattered by room surfaces, and primary beam scattered from the patient. In case no maze is provided then these components of radiations reaching at the entrance door become very high. As a result, heavily shielded door is needed at the entrance of the treatment room for achieving radiation level within the allowed values. Requirements of such heavily shielded door can be avoided if maze wall is designed in the room appropriately. This chapter describes the method of calculating all these components quantitatively for designing maze. Once appropriate maze thickness is arrived, ordinary wooden door could be used. This will help in easy operation of door for efficient emergency handling and increased patient throughput. Above aspect is also covered in chapter 3 of the 2nd edition of the book. However, present edition of the book additionally describes about the calculations of the wall scatter in both the parallel and perpendicular axis of rotation of the accelerator to the maze wall. Technique for the calculation of the shielding for the maze wall with multiple bends is also described.

Chapter 4

Medical electron accelerators normally operating above 10 MeV energy produce beams that are contaminated with neutrons. Such neutrons are termed as photo neutrons. These photo neutrons are produced from various components of accelerator head such as exit window of electron gun, bending magnet, target, flattening filter and collimator. Though some trace elements in the accelerator head may produce neutron even at 6 MV photon beam energy due to their lower threshold value for the nuclear reaction, they are negligible leading to the assumption that the potential above than 10 MV may have contamination with neutron. This chapter describes physics behind production of photons, neutrons, estimation of neutron flux and hence dose, activation of materials, materials effective for neutron shielding etc.

Chapter 5

Maze is used in majority of the radiotherapy treatment rooms due to its advantage in avoiding heavily shielded doors which enables easy operation. This chapter describes on calculations of the neutron and the associated capture gamma radiation at the entrance door of the treatment room of high-energy accelerator based on NCRP-151 recommendations. The calculation techniques described for neutron and capture gamma transmission through a maze, additional bends in the maze, neutron shielding, capture gamma ray shielding, direct shielded doors, additional specialised shielding (jamb) at far and near sides of entrance, neutron and capture gamma radiation at entrance, alternatives to traditional sliding direct-shielded doors, swinging direct-shielded door, swinging direct-shielded door surfaces mounted to wall, recesses and small penetrations, large penetration above maze entrance, neutron and capture gamma passing through shield interior, duct penetration in treatment room with direct-shielded door.

Chapter 6

This chapter describes on photo-neutron production in primary barriers containing metal, calculation of dose through metal and concrete slabs, capture gamma radiation in primary barriers containing metal, extremely thin wall primary barriers of lead and polyethylene containing metal, and laminated ceiling primary barriers. In case of metal layer used in a composite concrete and metal barrier, transmitted neutron dose through such barrier will depends on the location of the metal layer. To address such issue, this chapter describes the method of calculations of neutron dose transmitted through laminated barrier, for example, metal layer in a composite concrete and lead barrier. Further, gamma radiation dose calculations as a result of capture gamma radiation due to neutron in primary barrier containing metal is also explained.

Chapter 7

This chapter includes a variety of general topics. In case of lightly shielding ceiling of treatment room, there would be issue of X-ray and neutron skyshine. This chapter describes calculations method for estimating the X-ray and neutron skyshine. Further, if a multi-storey building is present adjacent to treatment room with lightly shielded ceiling (lesser ceiling shielding for lower individual occupancy over ceiling), in such a scenario scatter directly from the roof must be considered as it will be significantly higher than sky shine. Further, sometimes it is unavoidable to locate treatment room with lightly shielded ceiling inside a building, such as the existing construction. In such a situation scatter from building ceiling needs to be calculated. This chapter describes the calculation methods for such scenarios. When medical accelerator is operated with electron mode for treatment then ozone(O_3) is produced (larger amount as compared to the photon mode) by interaction of electrons with oxygen(O_2) present in the air of the treatment room. Ozone is known to be harmful if concentration of ozone exceeds the recommended limit of 0.1ppm.Chapter 7 describes the equation to be used for calculation of ozone concentration and accordingly ventilation system (number of air exchange) can be provided so that ozone concentration level in the treatment room can be maintained below permissible limit. When medical accelerator is operated above 10 MeV then room air may have radioactive isotopes by photo-neutron nuclear reactions [e.g. $^{14}N(\gamma,n)^{13}N$, $^{16}O(\gamma,n)^{15}O$] and this will impart dose to the radiotherapy staff, particularly the Radiotherapy Technologists. Method of calculation of activity of ^{13}N or ^{15}O per unit air volume produced in the treatment room is described. This chapter includes brief guidance on the methods of the shielding calculations of the specialised radiotherapy equipment such as Cyberknife, Tomotherapy, Halcyon, ViewRay MRIdian System (6MV linear accelerator with MRI imaging system for image guidance), Elekta Unity (7.2 MV linear accelerator combines with MR system for image guidance), RefleXion Therapy System (Integrates 6 MV linear Accelerator with CT and PET imager) and superficial and orthovoltage therapy units. The calculation methods of rooms for housing these specialised advanced radiotherapy equipment were not covered in previous edition of the book (i.e., 2nd Edition). Hence, this edition of book (3rd Edition) will of great use for medical physicist and radiation shielding experts/consultant as a guidance material. However, I feel that authors should have taken anyone of the above radiotherapy equipment as an example and could have given detailed calculations for better understanding.

Chapter 8

This chapter describes the radiation shielding calculations for high dose rate brachytherapy facility, Gamma Knife and GammaPod (Dedicated stereotactic gamma irradiation device developed for the treatment of breast cancer) treatment rooms.

Chapter 9

This chapter describes the process for the development of the shielding design which will provide guidance for Medical Physicists/ radiation shielding expert carrying out radiation shielding calculations and designing the radiotherapy treatment room. This chapter also enumerates the roles of different parties e.g. qualified Medical Physicist, Architect and representative of the facility. This chapter also describes the radiation shielding design evaluation report and recommends that the shielding report should contain i) identification information name and address of medical facility, type of equipment and manufacturer, building and room locations, contact details of the medical physicist who prepared the shielding design evaluation report and issuance date of report; ii) Therapy Equipment characteristics (energy(ies), workload assumption, field size , dose rate etc.); iii) Shielding summary (protected locations, nature of occupancy around the shielded room, design goal, use factor, shielding material, workload etc.); iv) Facility drawing; v) Shielding discussion; vi) Detailed calculations. This chapter also describes the radiation protection survey of equipment and room which includes dose rate calculations from survey measurements (time average dose rate),radiation protection survey report, identification information, therapy equipment characteristics, survey summary, facility drawings, survey calculations, survey discussion, instrumentation calibration certificates. This chapter will be very useful as guidance material for the preparation of shielding report and radiation level measurement.

G. Sahani

Radiological Safety Division, Atomic Energy Regulatory Board, Mumbai Maharashtra, India

Address for correspondence: Dr. G. Sahani, Radiological Safety Division, Atomic Energy Regulatory Board, Niyamak Bhavan, Anushakti Nagar, Mumbai - 400 094, Maharashtra, India. E-mail: gsahani@aerb.gov.in

Access this article online	
Quick Response Code:	Website: www.jmp.org.in
	DOI: 10.4103/jmp.JMP_96_21

How to cite this article: Sahani G. Review of book entitled "shielding techniques for radiation oncology facilities, 3rd edition". J Med Phys 2021;46:228-30.