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ISO/FDIS 24427

Radiological protection — Medical proton accelerators — Requirements and recommendations for shielding design and evaluation

*Radioprotection — Accélérateurs médicaux de protons —
Exigences et recommandations pour la conception et l'évaluation
du blindage*

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Foreword

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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Protons deliver most of their energy at a prescribed, programmable distance inside the body, known as the Bragg Peak. With this feature, proton therapy is used to treat many cancers and is particularly appropriate in situations where treatment options are limited and conventional radiotherapy using photon beam presents unacceptable risks to patients. The use of proton accelerators to administer external beam radiation has been evolving and the proton therapy centres are rising worldwide.

A typical large proton therapy centre consists of an injector, a cyclotron or synchrotron to accelerate the particles, high-energy beam selection and transport system, several treatment rooms (fixed beam and/or gantry) and, occasionally, a research room. Strong secondary radiation, particularly high energy neutrons, is produced at locations where beam losses occur. Such losses may occur in the cyclotron or synchrotron along the beam transport system during acceleration, extraction, energy degradation and transport of the protons to the treatment room, and in the treatment and research nozzles. In addition, the production of proton beam interactions in the patient, beam stop, or dosimetry phantom also results in stray radiation production. As a result, meters-thick barriers are generally used around the entire accelerator system. The radiation shielding of proton therapy centre is quite complex and become one of the key elements to commission a proton therapy centre, in the perspective of both capital and time consumed.

IEC 60601-2-64 relates to the design and the construction of the light ion, including proton, accelerators to ensure the safety of their operation.^[1] Several national^{[2][3]} or international^{[4][5][5]} reports propose recommendations concerning the installation, the commissioning, and the operation of these accelerators, the safety devices, the design and the calculation of protection barriers, the radiological control and monitoring. National standards^{[7][8][9][10]} have been established in certain countries. Moreover, national regulations generally impose rules of protection against radiation, in particular relating to the definition of the controlled area and supervised area and the calculation of shielding.

Considering the developments of proton therapy techniques and of new designs of proton therapy facilities on the one hand, and the variety of guidelines or normative documents on the other hand, it appeared judicious to establish an international standard to be used as a general framework. This document is intended to be complementary to the other international standards (IEC and IAEA).

The following items are discussed in this document:

- shielding design assumption and goals; [ISO/FDIS 24427](https://standards.iteh.ai/catalog/standards/iso/828a05ed-d0d5-427e-a67f-86dbf5113fc8/iso-fdis-24427)
- radiation fields;
- materials for radiation shielding: concrete (ordinary or high density), steels;
- role of stakeholders;
- general formalism for shielding calculations;
- calculation methods;
- radiation survey of the completed installation to ensure national requirements have been met and the shielding design is fit for purpose after installation of the accelerator.

Radiological protection — Medical proton accelerators — Requirements and recommendations for shielding design and evaluation

1 Scope

This document is applicable to the radiation shielding design and evaluation work for medical proton accelerators of proton energies ranging from 70 MeV to 250 MeV, with subsystems such as beam transport system and nozzle components.

The radiation protection recommendations given in this document cover the aspects relating to regulations, shielding design goals and other design criteria, role of the manufacturers, of the radiation protection officer or qualified expert, the medical physicist, the licensee and interactions between them, sources and radiations around a proton accelerator, shielding for accelerators and its subsystems (including shielding materials and transmission values, calculations for various room configurations, duct impact on radiation protection) and the radiological measurements.

FLASH proton therapy is not covered by this document.

NOTE 1 [Annex A](#) provides a list of the most used Monte-Carlo codes for shielding calculation.

NOTE 2 [Annex B](#) provides the analytical methods and the corresponding necessary data for shielding calculation.

NOTE 3 [Annex C](#) provides a set of examples on shielding calculation of barriers, maze and skyshine problems.

NOTE 4 [Annex D](#) provides radiation shielding consideration on special topics.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12749-2, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 2: Radiological protection*

ISO 16645, *Radiological protection — Medical electron accelerators — Requirements and recommendations for shielding design and evaluation*

ISO 80000-10, *Quantities and units — Part 10: Atomic and nuclear physics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12749-2, ISO 16645, ISO 80000-10 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>