ON-LINE EDUCATIONAL MEANS ON RADIOLOGICAL PROTECTION AND ACCELERATOR GENERAL SAFETY POLICY IN RADIOTHERAPY AND INDUSTRIAL STERILIZATION FACILITIES

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Abstract

On-line educational means were developed, which assist training in Radiation Protection and in Accelerator Technology Safety, in Radiotherapy Departments and Industrial Sterilization Facilities. Hypertext and multimedia courseware are gaining importance in University and Professional Education, and may partially release the teaching staff, and offer them more time to concentrate on more substantive tasks, improving their interaction with the individual student. Radiation Protection in Radiotherapy and Industrial Sterilisation Facilities includes several aspects concerning their planning, the hazard-sources, the environmental protection and the general safety. This presentation attempts a methodological approach to the radiation protection policies for Low Energy (up to 50 MeV) and High Current (up to 1kA) Medical and Industrial Electron Accelerator.

1 INTRODUCTION

The purpose of this paper, is to describe on-line educational means, that were developed in order to assist training in Radiation Protection and in Accelerator Technology Safety, in Radiotherapy Departments and Industrial Sterilisation.

Radiation Protection in Radiotherapy and Industrial Sterilisation Facilities includes several aspects concerning their planning, the hazard-sources, the environmental protection and the general safety. This presentation attempts an on-line trainining oriented methodological approach [10][11][12], to the radiation protection policies for Low Energy (up to 50 MeV) and High Current (up to 1kA) Medical and Industrial Electron Accelerator.

2 THE STRUCTURE OF THE COURSE

The developed Hypertext courseware includes presently following topics:

2.1 Radiological Policy and Facility Planning

The Radiological Safety Aspects strongly influencing the site planning are initially dealt with. The accelerator room should usually be in the deepest basement, buried, taking into account the natural features of the ground and of the Hospital or Industrial facility lay-out. Patients or bulky items should be brought into the vault through a radiation protection door [8], frequently moving on rails. Determination in final architectural lay-out of the location, is influenced by the shape and the dimensions of mazes, shafts and penetrations so that safety and functionality are optimised and by the definition of accessibility policy.

The electron and photon interactions with matter, leading also to a photo-neutron component [1][2][4] and the estimation of the associated radiation parameters which are necessary, in order to calculate the apropriate shielding of walls, roof and ceiling, that determines the civil engineering parameters, are also presented. In the present case, including low energy, skyshine contribution to public exposure is negligible.

Other necessary means are described such as radiation monitors, included in the electrical engineering planning in the irradiation areas, interlaced to the interlock system and the control console, as well as, the substantive considerations in the design of the ventilation, cooling and other auxiliary systems, concerning air, water, component, dust activation, and the formation of noxious gases through radiolytic reactions, during the facility operation.

2.2 Radiation Protection Instrumentation

During the facility operation, in several points around it, qualitative and quantitative measurements, should be performed, in order to assure the appropriate function of the entire installation.

Concerning real-time monitoring, the major controls and the corresponding equipment are illustrated, such as beam presence detected by fixed ionisation chambers or equivalent detectors, connected to the Operation Console, electron dose rate or the equivalent beam current measured by twin built-in ionisation chambers and Marcus chambers, X-Ray Dose Rate in Radiotherapy and Material Irradiation, measured by several types of external ionisation chambers, and neutron component monitoring outside the shielding, in control room, door etc. detected by BF3 or LiJ(Eu) detectors, associated with the Bonner Spectrometer.

Concerning professionally exposed personnel, who should be regularly monitored, through personal badge dose-meters, Thermoluminescence (TLD) albedo dose-

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meters and ionisation chamber based pocket and pencil dose-meters, and should be equipped with portable survey meters. The most important of these devices are also demonstrated.

Beyond personnel dosimetry, other systematic measurements of integral dose over some time period that might be necessary, as well as, activation measurements of parts of the equipment, the shielding and other materials and the associated equipment are examined.

Finally, Radiation Protection related Beam Diagnostics and the corresponding beam quality parameters, such as presence of the beam, beam current, alignment, and energy calibration are likewise mentioned.

2.3 Environmental Monitoring Program

The components of an environmental monitoring program, and more specifically, ambient (stray) radiation and background dose-rate measurements, aerosols and water radioactivity measurements, and noxious gases measurements [13] in the accelerator room that should be carried out frequently, are summarised in this section. The associated radiation protection and environmental monitoring laboratory is also described.

2.4 General Safety Requirements

The mechanical hazards presented, in the accelerator facilities under consideration, are related to the planning, the installation and the operation of the irradiation head, the gantry and the table in medical accelerators and the overhead cranes, conveyor belts, and load elevators, in industrial accelerators.

Further hazards are related to the design and the operation of the massive radiation protection doors, and to the cooling water, rain-water drainage or water processing units and pipelines, that in case of malfunction, might result in flood.

Electrical hazards included are concerning high voltage used in the klystron, the vacuum and beam-line monitoring instruments, the short-circuit hazards relative to the high current magnet power-supplies, as well as, the common electrical hazards, encountered in any industrial environment.

Disturbances caused by the high frequency on the accelerators monitoring equipment, such as ionisation chambers, if not properly RF-shielded, and general electromagnetic compatibility questions are also considered in this section.

Closely related to electrical hazards, is the threat of fire and the related fire-protection system of the facility including individual smoke detectors combined to with suitable extinguishers.

Finally, a general accident limitation operational policy, including all the remaining miscellaneous hazards, is also synopsized in this section.

2.5 Radiation Treatment Planning and Administration.

In this part, the Simulation and Localisation systems in Radiotherapy, and their functional relation to and mutual interaction with the Treatment Planning systems are presented. Some special techniques [3][5][6][7], beyond usual Tele- and Brachy-Therapy, such as Irregular and Large Field Irradiation, Stereotactic Irradiation, Radiosurgery, and Intra-Operative Radiation Treatment, combined to the appropriate equipment and the necessary radiation protection procedures, are also outlined.

Biological Treatment Planning in Radiotherapy, considering spatial and temporal dose distribution, forms another topic of interest. Systems that provide the means for the estimation of important biophysical parameters such as the Extrapolated Response Dose (ERD), the Tumor Response Probability (TCP), the Normal Tissue Complication Probability (NTCP) etc. are also examined. Most of them are based on probabilistic algorithms, including the concept of memory dose, and established on experimental data for normal tissue tolerance dose levels to therapeutic irradiation., obtained mainly through cell-series irradiation.

Programs for the patient Irradiation Management performed, including record keeping, fractionation, overlapping of past and present schemata etc. and enabling retrospective data analysis and prospective outcome judgement, are also referred to.

3 HEAVY CHARGED PARTICLES IN RADIATION THERAPY

Several attempts to improve the dose distribution and the biological efficiency in Radiotherapy, by using high-LET radiation are described in this future oriented part of the project.

Experiments carried out with pions have shown, that an increase of biological efficiency of only 20% occurred, in the stopping region of the pions, where the nuclear star reactions are taking place. There are problems to create high pion fluences, and, therefore, the overall treatment time is too long and beyond reason expensive for a routine therapy.

The application of fast neutrons in Radiotherapy, on the other hand, have caused severe late effects. Further, only a limited variety of radioresistant tumors can be treated successfully.

Heavy charged particles [9] are gaining importance in external radiotherapy of deep located tumors, because of the limited angular and lateral scattering and the growth of energy deposition with increasing penetration depth.

In this section of the on-line course, the physical and radiobiological advantages of particle beams due to the beam properties and the high LET effects are presented, as well as, the associated benefits, concerning the overall exposure of the patient.

The on-line control of the beam by PET techniques, the improved dose delivery by magnetic scanning and fast energy variation and the tumor conform treatment planning, when using heavy ion beam scanning, constitute further advantages, both, for the treatment of the patients and the radiological safety policy of the facility, that are also included in the presentation.

The performance of the existing accelerator facilities that develop medical activities and the future aspects of particle therapy are also outlined.

4 ON-LINE EDUCATIONAL MEANS AND TRAINING IN RADIATION PROTECTION

Hypertext and multimedia courseware are gaining importance in University and Continuous Education. Transforming conventional lectures or textbook material into an electronic format, offers limited benefits thus, the structure and the content of a course should be changed in order to take advantage of the technology. HTML-based teaching tools interact both with teachers and students and they may influence our understanding of the scientific subject matter under consideration.

Distance education using Web-based and other emerging technological alternatives promise to reach various groups, offering them continuous education services. These groups may comprise of those who are already engaged in professional work, in our case physicians, nurses, engineers, physicists etc. and of those isolated from such opportunities, due to other social conditions. These groups are not likely to receive the same educational experience as traditional, on-campus students. The concern that technology-based distance education is inferior, is probably not unwarranted. However, the new electronic media may offer a cost-effective way, to enhance formal or professional education alternatives.

A specialized course primarily consists of a mutually interacting group and "digital alternatives", such as email, electronic discussion groups, virtual classrooms etc., are very useful, not only for individuals, but even for Institutions, since they are not able nor willing to create an adequately high academic environment. Presently, it seems likely, that on-line courses, will not develop into a total substitute for in-person education, but rather an appropriate combination of traditional and on-line educational activities will follow.

Finally, on-line instructional material accessed by the students or trainees, may also partially release the teaching staff, and offer them more time to concentrate on more substantive tasks improving their interaction with the individual student or trainee.

The use of accelerator technology in Medicine and associated commercial activities is expected to grow rapidly in the dawn of the 21st Century.

Beyond Radiotherapy, Radiopharmaca production, medical applications of Synchrotron radiation and of free electron LASER are visible, at least in Research and Technological Development activities.

The needs for training in Radiation Protection and in Accelerator Technology Safety, in Medical and Industrial Facilities, will also increase accordingly, and the employment of carefully prepared and frequently updated related on-line educational means seems to be inevitable.

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