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RECENT TRENDS IN PARTICLE ACCELERATOR RADIATION SAFETY*

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ABSTRACT

The use of particle accelerators in both applied and research activities continues to expand. This expansion brings new machines with higher energy and current capabilities and introduces radiation safety problems not commonly encountered before. This paper gives an overview of these increased ionizing radiation hazards along with a discussion of some of the new techniques required in evaluating and/or controlling them. The ORNL Health Physics Information Center aided in a computer search of the literature; hence, a relatively comprehensive reference to publications describing accelerator radiation safety problems and related subjects is included.

Introduction

The proceedings of past Conferences on the Use of Small Accelerators for Teaching and Research had excellent papers summarizing radiation hazards and how to deal with them.[1,2] Each paper contains an excellent bibliography which refers to many relevant papers in the open literature at that time. Rather than attempt to repeat these papers we will review some of the literature which has appeared in print since the last conference with the hope of observing trends that might be developing in radiation safety at particle accelerators.

Trends

A. Availability of Literature

An interesting trend, although not restricted to accelerator safety, is the availability of literature through the use of information centers. The Health Physics Information Center at the Oak Ridge National Laboratory, [illegible] in [illegible] literature [illegible] is an example of what may be available to one seeking information. The primary function of these centers is to aid in the expeditious retrieval of information through the use of computers. A number of centers now exist which specialize in such areas as health physics, shielding, nuclear safety,

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etc. The technically oriented people at these centers analyze information so that it can be more effectively inserted and retrieved. The usefulness of the centers is expanding through the use of telephone networks, cross referencing between centers, and increased participation of users who put information into the centers as well as retrieving it.[3]

B. Manuals

Some of the most helpful newer literature is in the form of textbooks or manuals which give much of the information needed in all phases of an accelerator radiation safety program. The most elaborate of these that we found which relates directly to accelerator health physics, a book by Patterson and Thomas,[4] covers a wide range of subjects. Theory, practice, references and a laboratory manual are included in the book. A manual by Martin[5] covers a lot of material of special interest to people concerned with safety at small accelerators. Two other publications[6,7] cover a large amount of material of practical general interest to the health physicist with a small portion relating directly to accelerators. One of these, edited by Willis and in three volumes, is derived from a Health Physics Society Mid-Year Symposium.

C. Tritium

Control of tritium continues to be a problem at the low energy accelerators and advances in instrumentation and control techniques are of great interest to the accelerator user. There is a plentiful amount of literature relative to tritium and the Proceedings of the 1971 Tritium Symposium in Las Vegas[8] is an excellent source. Also, a recent review article on tritium instrumentation[9] lists 67 references; many of which apply directly to problems encountered by accelerator users. Another article[10] discusses the relative merits of several vacuum systems and includes a discussion of the tritium control problems associated with these systems.

A recent article in the Health Physics Journal[11] describes an interesting technique for detecting and measuring tritium contamination. Pieces of polystyrene are used as smears and then dissolved in toluene or xylene based scintillation mixtures and counted. The method is said to be efficient and economical.

D. Interlock and Safety Equipment

A sizeable fraction of the new literature that we found is concerned with interlock and safety equipment. The trend seems to be toward more elaborate systems which utilize solid state devices, fail-safe circuitry and self-checking circuits. A number of papers describe the systems that are used at large facilities.[12-16] One of the systems[14] utilizes entirely integrated solid state logic in place of electromechanical relays.

One group has developed engineering standards for X-ray and nuclear radiation facilities[17,18] with the goal of improving the level of radiation safety.

An article entitled "Sneak-Circuit Analysis"[19] deals with the problem of circuits that exhibit unplanned modes of operation. The author discusses techniques of dealing with problems such as relay races, sneak grounds and power-supply crossties. Although the paper was the result of research which was done the in the space program, it could be useful for anyone who designs complex safety systems. The NBS Handbook 107[20] includes a list of general requirements for safety systems.

E. Dosimetry

No effort was made to include dosimetry in the literature search made by the information center, but we note an interesting paper entitled Dose vs. Angle and Depth Produced by 20

to 100 MeV Electrons Incident on Thick Targets.[21] This paper contains a considerable amount of data which would be of use to people involved in dosimetry in the fields of radiation medicine, radiation processing or health physics. The data is the result of experiments using 20, 30, and 100 MeV electrons. The data are compared with theory. In addition, the data are compared with data from the literature describing thin target experiments. Another paper, Evaluation of Accidental Exposure to Accelerator Personnel,[22] describes a method of accident dosimetry based on measuring the accident victim's body activation. The technique is said to be capable of detecting exposures as low as one rad within a factor of two.

F . Shielding

Some publications which discuss shielding requirements for accelerator facilities have appeared recently. One such paper[23] describes a basis for establishing shielding requirements based on electrical parameters and use of the accelerator. Another publication of work done at ORNL[24] fixes the half-value thicknesses of ordinary concrete for neutrons from cyclotron targets at approximately 10 cm. In this study thick targets of carbon, aluminum, copper and tantalum were bombarded with beams of protons, deuterons, alpha particles and carbon ions. Measurements were made to determine fast neutron half-value thicknesses of concrete shields for the resultant reactions.

G. Safety Programs

There appears to be a trend toward a more formal safety program at accelerators and elsewhere. (Descriptions of several of these programs were found[25,26,27].) There is often a safety officer appointed. Many installations have safety review committees. Formalization of safety programs is also indicated by the publication of guidelines and regulations. There is a guideline relating to all aspects of radiological safety in the design and operation of particle accelerators.[20] Another guideline relates only to conventional safety problems.[28] Although entitled "Safety Guidelines for High Energy Accelerator Facilities", this guide, as stated in its introduction, may be applied to accelerators of all energies. A publication[29] entitled "State and Federal Control of Health Hazards from Radioactive Materials Other Than Materials Regulated Under the Atomic Energy Act of 1954" might be of interest to some accelerator users since accelerator-produced materials are in this category of "other materials".

H Exposure Reduction

There is a continued emphasis on reducing radiation exposures. Recent regulatory guides, 8.8 and 8.10, issued by the Atomic Energy Commission[30] amplify the text contained in the Code of Federal Regulations[31] which directs licensees to make every reasonable effort to maintain radiation exposures as far below the limits specified as practicable. Not only should facilities be designed and operations be conducted such that radiation exposure limits are not exceeded but every effort should be exerted to maintain them as far below the limits "as practicable". As stated in 8.10, even though current occupational exposure limits provide a very low risk of injury, it is prudent to avoid unnecessary exposure to radiation.

"Practicable" is not defined in numerical terms and it is not intended to be so defined. While releases from nuclear reactors are limited and numerical values are specified, the occupational exposure guide which parallels this As Low As Practicable philosophy is much less specific. The guide states that "practicability is determined by the state of technology and the economics of improvements". It can be said unequivocally that the As Low As Practicable philosophy can be adopted and put into practice only where there is a firm commitment by management to do so.

Conclusions

The trends in accelerator radiation safety, as with trends in other fields of interest, depend upon trends in many diverse areas. Improved availability of literature, better methods for handling tritium, more complete data for dosimetry and shielding work, improved electronic circuits and hardware and improved methods of circuit analysis are examples of the diverse trends which are aiding the field of accelerator safety.

The trend toward more formal safety programs is the result of an increasing backlog of experience and the study of past problems. This trend (which sometimes might seem troublesome) should also aid in producing a safer place to work.

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