RADIOLOGICAL DESIGN CRITERIA

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The design of a structure, whether it is an office building or a nuclear facility, is a systematic process which starts when the structure is scoped by the operating group. This scope includes the purpose to be served by the structure, the number of people to be housed, the space to be included within a dollar limitation, and special equipment or facility requirements. The professional architect or design engineer applies building codes, standards and manuals of good practice, together with his artistic touch, to provide a design that will be functional, legally acceptable and esthetically pleasing. The codes and guides for commercial structures have been well established. These codes, standards and manuals of good practice are continually upgraded to reflect advances in materials and practices used in construction and new requirements in fire protection and safety.

The satisfactory application of the criteria by architects normally will result in a facility which is acceptable to all affected parties. However, this is not true with respect to nuclear facilities. Many nuclear facilities, when complete, are unsatisfactory from a radiation protection point of view. Adequate physical protective features should be achieved in building construction so that supplemental administrative controls may be kept simple and workable. Many nuclear facilities fall short of adequate protective features, thus, remedial and sometimes awkward administrative procedures are required to safely conduct work. The alternative is the costly retrofitting of the facility to meet the physical requirements.

A review of existing standards, handbooks, regulations and reports dealing with radiation protection requirements for a nuclear facility reveal a decided paucity in usable radiological design criteria which can be applied by personnel engaged in the design of nuclear facilities.

There are several problems associated with the approach taken in criteria which do exist. None of them cover the entire subject or facility completely from the standpoint of establishing "codes for design". The regulations concerning the construction of reactors and plutonium facilities in the area of structure and siting provide reasonable guidance, but when it comes to radiation protection capabilities and systems there is little guidance. Some of the existing criteria appear as "Standards" and to an extent do provide general guidance to be followed. These, however, are in narrow areas and do not cover all of the radiation protection requirements.

What is badly needed is a set of criteria or codes covering specific subjects rather than specific facilities. The following are suggested as specific subjects to be considered:

a Functional Requirements of the Facility
b Siting and Access
c Design Exposure Limits
d Layout (People and Materials Flow)
e Ventilation and Effluent Control
f Radiation Protection Facilities and Systems

Identification of functional requirements of the facility should permit the designer, based on kind, form, quantity of radioactive materials to be used and the nature of operation planned, to determine the specific requirements to be adopted from the other functional criteria provided for nuclear facilities. We have adopted three classes of working areas based on toxicity classifications used by K. Z. Morgan, et al., on "Relative Hazard of the Various Isotopes" as modified by degree of dispersibility. In this scheme 1 nCi of high radiotoxicity and 1 μCi of medium radiotoxicity materials were identified as a cutoff below which no special radiation protection requirements are placed on the facility design.

Siting and access criteria, in addition to satisfying regulatory requirements, should include consideration of the effect on surrounding buildings, operations that are sensitive to radiation, and access to special facilities such as railway spurs for the movement of heavy items and waste handling facilities.

The methodology of designing adequate shielding has been well developed. However, no consistent guidance has been provided for the resulting dose rate or accumulated dose that will be permitted outside of the shield. We take a very conservative position for design purpose since a facility is usually stressed well beyond its original design. The following criteria have been adopted for the design of new facilities:

Radiation Zones

Dose rates in excess of 0.5 rem/hr - access controlled by shielding or locked physical barriers

Annual Exposure <0.5 rem (based on annual occupancy)
Weekly Exposure <10 mrem (if annual occupancy not known)

Controlled Zones

Same annual or weekly exposure permitted but no dose rate in excess of 2 mrem/hr

Uncontrolled Zones

Dose rate <0.2 mrem/hr

The control of people and materials flow is an extremely important item. There is always conflict between safety, security, radiation protection and operating requirements. One excellent approach to people and materials flow is to have a central equipment, piping, waste handling corridor bounded by labs on both sides. The people corridors bounding the labs for easy access with offices are located between the corridors and the outside of the building. This satisfies safety requirements for two exits from a lab, permits easy access to utilities for the labs and allows radioactive materials to be transferred without affecting the clean areas of the facility.

Excellent criteria are provided for the filters used in nuclear facilities. However, little guidance is provided on the overall requirements of the ventilation and exhaust system and little or no agreement exists on the number of stages required. (Recently the design for a facility included seven stages of filtration as an example.) As a minimum, we are specifying one absolute filter for any facility designed for unsealed low or medium radiotoxicity materials and two for a facility involving the use of

unsealed high radiotoxicity material. At least one additional filter will be required if the processes planned will disperse the materials involved. We permit the recirculation of room air from Radiation Zones even in plutonium handling areas when two absolute filters are used in series with an air monitor located between the first and second filter. The system must change automatically to single pass if the air monitor indicates the presence of radioactive contamination in excess of 8 MPC hours. More attention is being given to systems carrying radioactive solutions. In one set of requirements sytems containing "high-level" process solutions must be doubly contained with primary system leak detection capability and a means of checking the integrity of the secondary containment. Systems containing "intermediate and low-level" waste solutions should either be doubly contained (preferably when direct buried) with provisions for primary system leak detection and a means of checking the integrity of the secondary containment, or be capable of a routine periodic check to assure system integrity. Systems within buildings or facilities if singly contained, must be accessible for periodic visual inspection.

One of the areas in which the greatest difficulties are encountered is in the exclusion of adequate radiation protection facilities and systems. A lab-office combination is now required for each facility containing Class A ($\geq$ 1 µCi of dispersible high radiotoxicity and $\geq$ 1 mCi medium radiotoxicity materials) or B work stations ($\geq$ minimum cutoff defined earlier) sufficient to accommodate the following:

Class A Work Station

Two monitors for the first 30 radiation workers
One additional monitor for each additional 30 radiation workers

Class B Work Station

Two monitors for the first 50 radiation workers
One additional monitor for each additional 50 radiation workers

General building systems are usually annunciated at one location. We feel it is important that building radiation protection systems such as air monitors and area monitors should be annunciated in the Health Physics lab-office.

Other criteria that should be covered in radiological design considerations include:

Traffic Flow and Air Locks
Decontamination and Maintenance Facilities
Air Monitoring or Sampling System
Individual Laboratory Monitoring Equipment and Facilities
Dosimeter Storage Facilities
Posting Requirements
Personnel Decontamination Facilities
Breathing Air Supply System
Material Transfer Systems
Solid Waste Disposal System

We have attempted to scope specific subjects for which radiological design criteria should be developed to assure that the design and construction of

nuclear facilities are functional rather than requiring costly retrofitting or administrative restrictions. The examples of specific criteria were not presented as those that should be adopted. Rather they were presented to show the degree to which arbitrary decisions should be made. We have found that even if functional radiological design criteria are developed, they are not a substitute health physics representation on the design team.