Barite Concrete Primary Barriers

Medical accelerators used for cancer therapy produce high energy x-rays as well as a low level of neutron radiation. These machines are commonly housed in shielded rooms constructed of ordinary concrete (147 lb/c ft). Other materials such as high density concrete are used when a thinner shield is needed due to space requirements. High density concrete of density 220 to 230 lb/cu ft can be produced by using barite as an aggregate.

In order to calculate the thickness of barite concrete needed for primary radiation barriers the tenth value layer (TVL) is required. The tenth value layer is usually expressed in inches and represents the thickness of shielding material that will reduce the intensity of the radiation by a factor of ten. A primary barrier is the portion of the floor, walls or ceiling that can be struck by the radiation beam. Table 1 presents TVL values for barite concrete of density 230 lb/cu ft based on Radiation Dynamics Ltd technical information data sheet 33/1. The MV (megavoltage) is an indication of the energy of the x-ray beam produced by the accelerator. The MV values shown in Table 1 are those commonly used in radiation therapy and are based on the British Journal of Radiology suppl. 11.

The neutron shielding properties of ordinary concrete and barite concrete are almost identical on a unit thickness bases.

Table 1. TVL values as a function of megavoltage of the x-ray beam for barite concrete of 230 lb/c ft density from Radiation Dynamics.

MV	6	10	15	18
TVL (inch)	7.7	8.9	9.5	9.9

The TVL for a 15 MV x-ray beam was evaluated from dose measurements made outside a 6’0” thick barite concrete barrier and was found to agree within 5% of the value listed in Table 1.

The neutron dose equivalent rate was also measured outside the barrier and was found to be less than 0.05 mrem/hr. For this measurement the accelerator was operated at 600 cGy per minute at the isocenter with the collimator fully opened.

The TVL of barite concrete (230 lb/c ft) is sometime evaluated by multiplying the TVL of ordinary concrete times the density ratio 147 /230 = 0.639. This method overestimates the TVL as can be seen from Table 2. This effect is attributed to the higher atomic number of barium as compared to the atomic number of the components of ordinary concrete.

Table 2. TVL of barite concrete estimated by use of the density ratio, TVL of barite concrete based on data from Radiation Dynamics and TVL of ordinary concrete.

MV	TVL based on the density ratio (inch)	TVL from Radiation Dynamics (inch)	TVL ordinary concrete (inch)
6	8.59	7.7	13.5
10	9.78	8.9	15.3
15	10.8	9.5	17.0
18	11.1	9.9	17.5

Example: 7.5 feet of ordinary concrete is needed for a primary barrier for an 18 MV room. The shield could be fabricated of barite concrete of thickness (7.5')(TVL Rad. Dyn./TVL ordinary conc.) = 7.5' (9.9"/17.5") = 4.24'. So the thickness of the barite shield is 3.26' less than the ordinary concrete shield.

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