



Shielding Against Primary and Leakage X-Rays

Figure 1 taken from Swanson (1979) provides a useful summary of tenth-value layers (TVL) for shielding against primary photons. Values are given for concrete, iron (steel) and lead under broad beam conditions as a function of the electron energy incident on a high-Z target. The TVLs are plotted in units of gm/cm^2 to facilitate comparison to other materials. The smoothed curves are adopted from several sources, taking into account the behavior of both higher and lower energies.

For angles other than on the beam axis, NCRP-51, Appendix E, gives the prescription described in the caption of their Figure E.6. The x-ray spectrum at 90 degrees has approximately 0.6 the maximum energy in the forward direction.

Nelson and LaRiviere (1984) have calculated primary and leakage x-ray spectra for medical accelerators using a Monte Carlo code for 3 energies: 6, 10 and 25 Mev, and 4 angles: 0, 45, 90 and 135 degrees. Broad beam transmission curves generated by the program agreed with existing experimental measurements (Tochilin and LaRiviere, 1979 and LaRiviere, 1984). The above measurements form the basis for the primary and leakage values used by Varian for calculating shielding requirements for x-ray energies from 4 to 24 Mv. These TVL values are summarized for concrete in Table 1. Recommendations have been made to the NCRP to issued updated publications with a more complete treatment of x-ray leakage radiation.

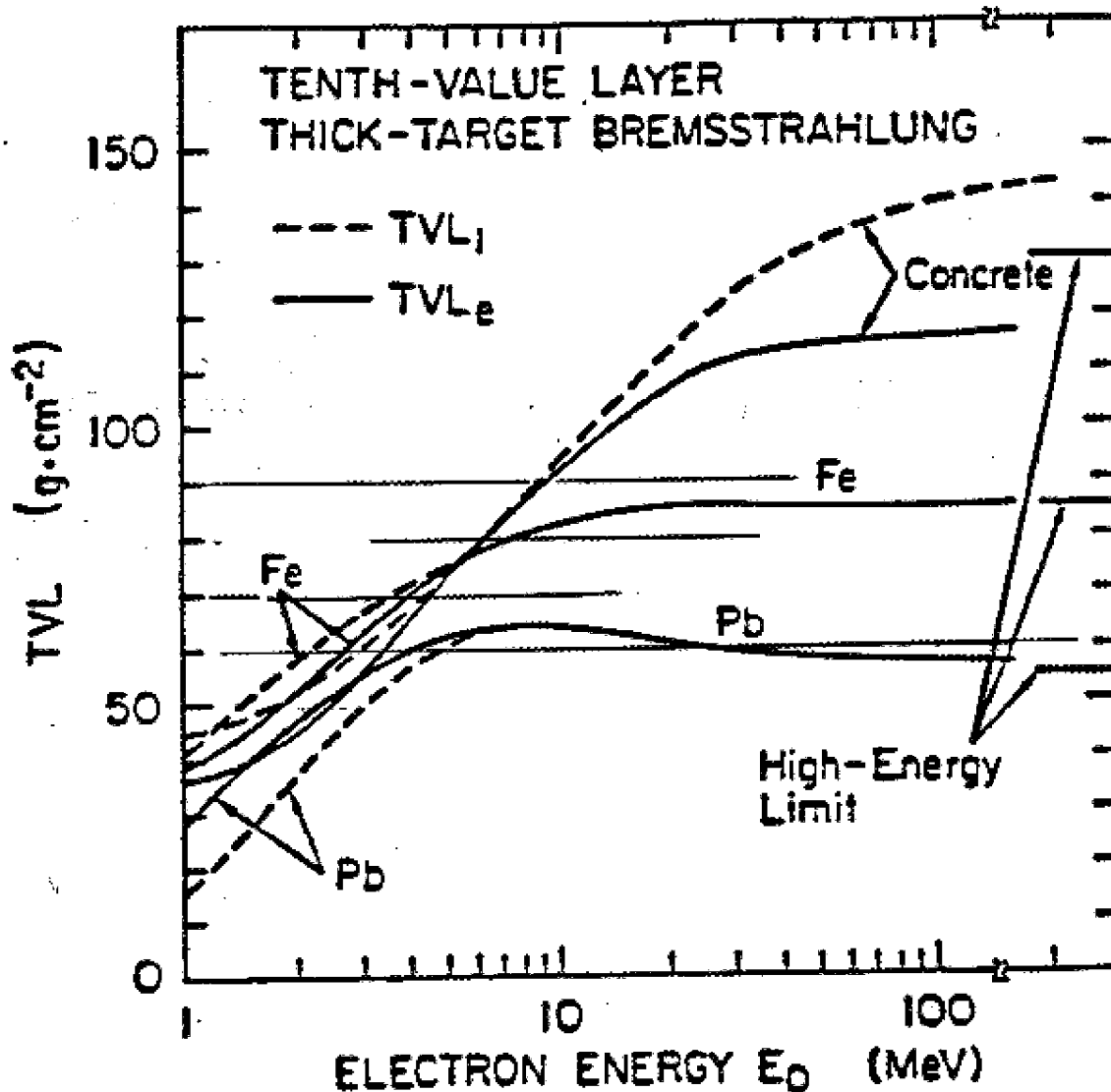
TABLE 1

Typical Broadbeam Tenth-Value Layers
at Characteristic Clinac X-Ray Energies

Material	Primary Beam TVL					
	4 MeV	6 MeV	10 MeV	15 MeV	18 MeV	24 MeV
Concrete (2.35 gm/cc)						
TVL (cm)	29.0	34.3	39.0	43.2	44.5	39.4
TVL (in)	11.4	13.5	15.3	17.0	17.5	18.5
Steel (7.85 gm/cc)						
TVL (cm)	9.1	10.0	10.4	10.8	11.0	11.2
TVL (in)	3.6	3.9	4.1	4.2	4.3	4.4
Lead (11.35 g/cc)						
TVL (cm)	5.3	5.6	5.6	5.6	5.5	5.2
TVL (in)	2.1	2.2	2.2	2.2	2.1	2.0
RATIO: conc/steel	3.2	3.5	3.7	4.0	4.0	4.2
RATIO: conc/lead	5.4	6.2	7.0	7.7	8.0	9.2

Material	Leakage X-Ray TVL*					
	Concrete (2.35 g/cc)					
TVL (cm)	25	28	31	33	33	36
TVL (in)	10	11	12	13	13	14
RATIO: conc/steel	3.0	3.2	3.5	3.7	3.7	4.0
RATIO: conc/lead	5.0	5.5	6.2	7.0	7.0	7.5

*TVL for leakage x-rays will vary with angle. Values at angles greater than 90 degrees will generally be lower than listed.



Values of dose equivalent tenth-value layers for thick-target bremsstrahlung under broad beam conditions at 0° as a function of the energy of electrons incident on a high-Z target. The solid curves show the 'equilibrium' tenth-value layer, TVL_e, and the dashed curves the 'first' tenth-value layer, TVL₁ (from Swanson, 1979).

FIGURE 1

REFERENCES

LaRiviere P.D. (1984); Transmission in Concrete of X-rays from a 24-MV Medical Accelerator, Health Physics, 47, 819.

LaRiviere P.D. and Tochilin E. (1979); Attenuation of Primary and Leakage X-rays in Concrete for X-rays from a 10 MV Accelerator, Health Physics, 36, 387.

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NCRP-51 (1977); Radiation protection guidelines for 0.1-100 MeV particle accelerator facilities, National Council on Radiation Protection and Measurements Report No. 51, U.S. Government Printing Office, Washington.

Swanson W.P. (1979); Radiological safety aspects of the operation of electron linear accelerators, Technical Report Series No. 188, IAEA, Vienna.