QUESTION: ***How do you measure and calculate the lead equivalence of a material? For example, what is the lead equivalence of an old unmarked piece of lead glass used as a viewing window at the control booth in an old x-ray room?***

ANSWER: Essentially, one needs to measure the photon transmission through the lead (Pb) glass and then calculate the thickness (x) using the mathematical model published by Archer, et.al. (1983) To measure transmission, one needs some type of radiation source. Since your question appears to have come from a hospital, an x-ray machine is probably the most likely available source to use. A portable x-ray machine is probably the best to use because one can position it relatively close to the Pb glass window (assuming it is installed in the control room barrier).

One also needs some type of integrating measurement device, such as an ion chamber. Place the integrating ion chamber at a specific distance (let's use 1 meter) from the x-ray tube, set the machine for 100 kVp and a high enough mAs to obtain a total exposure of about 1000 mR.

Now position the portable x-ray machine with the beam pointing toward the Pb glass window. Place the ion chamber on the opposite side of the window, 1 meter from the x-ray source. It is probably best to not place either the x-ray source or ion chamber right against the Pb glass window, but have the window about midway between the two. Using the same techniques as the first measurement (and number of exposures if more than one was used), measure the exposure through the Pb glass. The measurement through the Pb glass divided by the unshielded measurement is the transmission (B) in the equation below. If there is no measurable response on the ion chamber through the Pb glass window, it is necessary to increase the unshielded exposure (either by increasing the mAs or taking multiple exposures) and doing the same for the shielded value until a response is obtained on the shielded side.

The "Archer Equation" for transmission is as follows:

$$x = \frac{1}{\alpha\gamma} \ln\left(\frac{B^{-\gamma} + \frac{\beta}{\alpha}}{1 + \frac{\beta}{\alpha}} \right)$$

The α, β, γ values are fitting parameters for specific energies. For 100 kVp photons, those parameters are $\alpha = 2.50$, $\beta = 15.28$, and $\gamma = 0.7557$. Simply insert the measured transmission (B) into the equation along with the fitting parameters and the result (x) represents the Pb equivalent thickness of the Pb glass.

For example, if the unshielded measured value is 1,000 mR and the shielded value is 1.49, the transmission is 1.49/1,000 or 0.00149. Substituting that value for B into the aforementioned equation and using the 100 kVp fitting parameters results in a thickness (x) of 1.59 mm of Pb (about 1/16").

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Reference

Archer BR, Thornby JI, Bushong SC. Diagnostic x-ray shielding design based on an empirical model of photon attenuation. Health Phys 44(5): 507-517; 1983.