A Comparative Photon Shielding Properties of Protective Window Materials by using EGS5 Code

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Introduction

Radiation protection is a specialised area and important in the radiation and radioactive sources related working environment. Apart from doors and walls, protective windows are installed in a control room near the control panel for viewing. All of them must have the same lead equivalence. It is stated that for general radiographic X-ray systems capable of operating at potentials above 100 kVp, the lead glass observation window required minimum thickness of 1.5 mm lead equivalence while for the size, minimal dimensions of 75 cm of width by 45 cm of height. In this study, lead glass, acrylic glass, plate glass and Pyrex glass are used for radiation shielding materials.

Objectives

The objectives of the Monte Carlo method were to:

- Calculate the glass attenuation coefficient for X-ray of 150 kVp and 59.5 keV
- Calculate the transmitted dose (Sv/inc./cm^2/s) for several glasses

Methods

SIMULATION GEOMETRY MODELLING

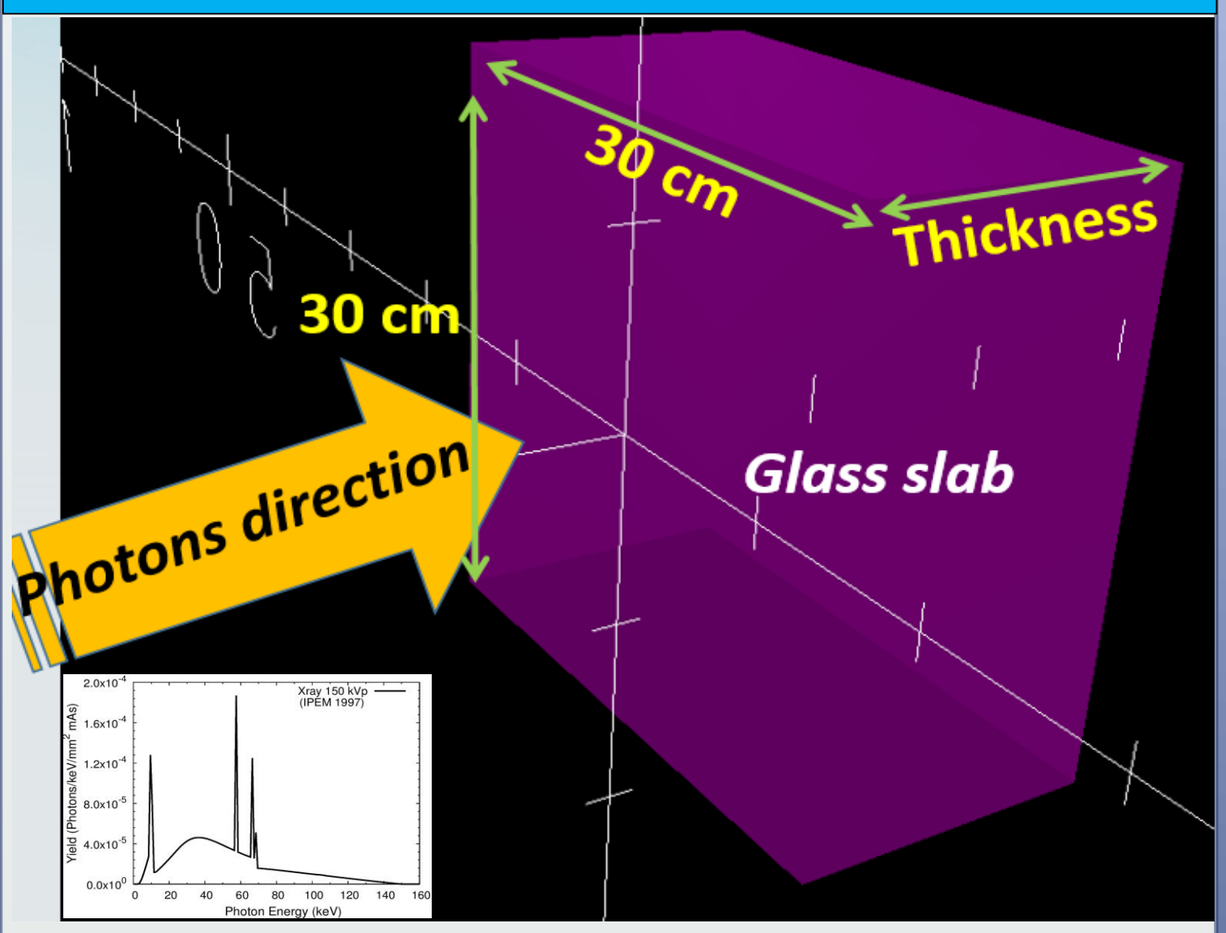

Figure 1. Simulation geometry modelled in EGS-CGview for calculation of photons attenuation.

The glass geometry is modelled as a rectangular shape:

- Front surface of 30 x 30 cm^2
- Various thickness (as variables)
- A pencil beam of photons is directed to the center of the slab
- Fixed distance of 1 m.

Four different glasses studied:

- Lead glass (6.22 g cm-3)
- Plate glass (2.40 g cm-3)
- Pyrex glass (2.23 g cm-3)
- Acrylic glass (1.19 g cm-3)

Results of Photon Attenuation

Table 1. The linear attenuation coefficients values of lead glass, plate glass, Pyrex glass, and acrylic glass obtained by EGS5 and WinXCom for 59.5 keV and 150 kVp

Glass Materials	Linear Attenuation Coefficients, LAC (cm^{-1})		
	59.5 keV		X-ray 150 kVp
	EGS5	XCOM	EGS5
Lead glass	23.82	24.41	18.84
Plate glass	0.72	0.71	0.66
Pyrex glass	0.56	0.54	0.58
Acrylic glass	0.24	0.23	0.28

As for the glass comparison, it could be noted that lead glass had the highest LAC values for both calculated and theoretical values for energy of 59.5 keV while the acrylic glass had the lowest values of linear attenuation coefficients. The LAC results were mainly influenced by the density of material. The plate glass and Pyrex glass LAC values were close to each other with small amount of difference as the density for both glasses were almost similar.

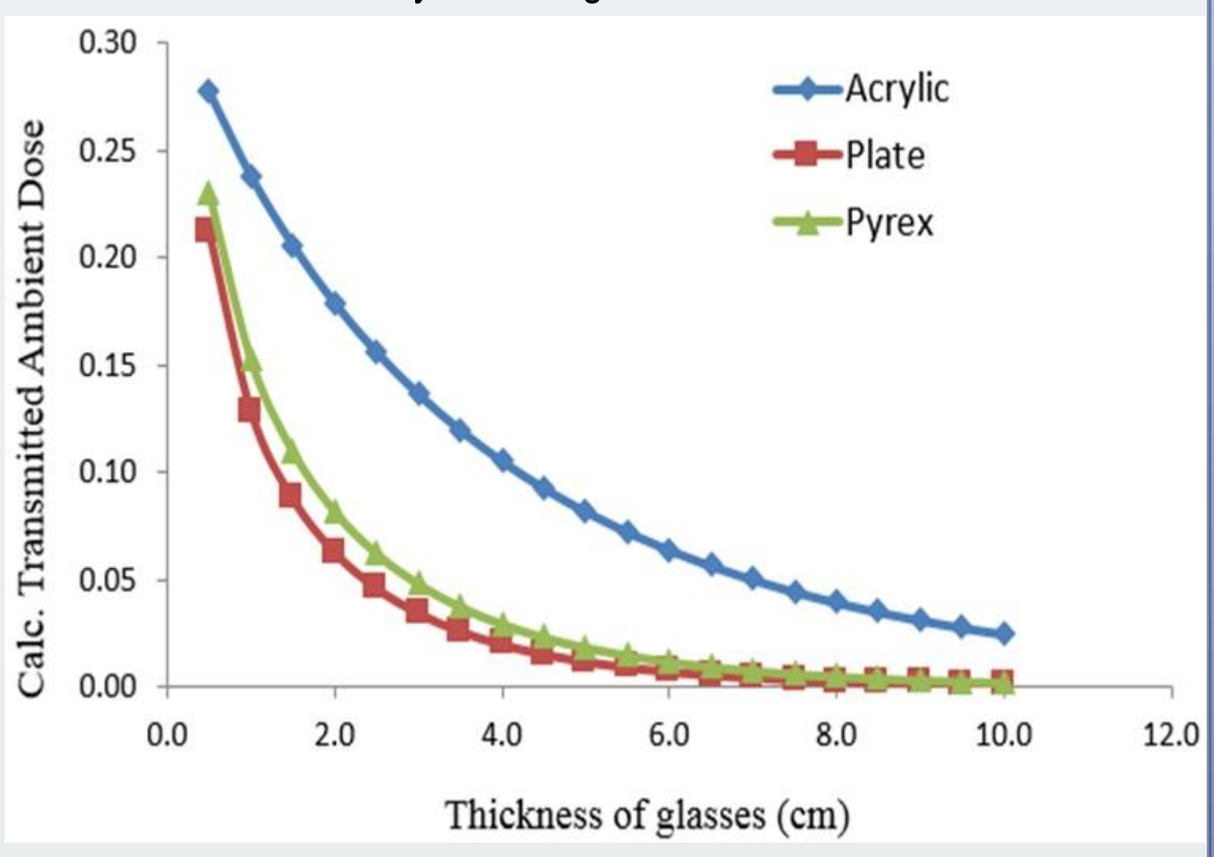

Figure 2: The calculated transmitted dose (Sv/inc./cm^2/s) for several glasses

Among the three glasses excluding lead glass, acrylic glass had the lowest LAC value because of its lowest density of glass. Between plate and Pyrex glass, both had almost similar density. However the LAC value of plate glass was significantly higher more 13.8% than the value for Pyrex glass. It has to be noted that, among the three glasses studied, plate glass contained the high Z element which was Calcium (Ca-20) within 11% in its mixture.

Conclusions

It could be concluded from the graph that, 6 cm plate, 7 cm Pyrex, and more than 10 cm acrylic were needed to have the same output of lead glass at 0.02 cm thickness. A thickness of 0.12 cm lead glass, 4 cm plate, 4.5 cm Pyrex and 9.5 cm acrylic glass were adequate to reduce dose up to 90% of the photons from 150 kVp energy source.

References

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2. H. Hirayama, Y. Namito, A. F. Bielajew, S. J. Wilderman and W. R. Nelson, The EGS5 Code System (2010) SLAC Report number: SLAC-R-730; KEK Report number: 2005-8.

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