Effects of Gas Pressure on the Amount of X-ray Energy Absorbed in the First Wall of an Inertial Confinement Fusion Reactor

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Introduction

Survival of the first wall in an Inertial Confinement Fusion Reactor may require the use of protective methods to reduce the energy flux of ions and photons produced by the fusion microexplosion. Various methods of protection have been proposed previously which include magnetic fields,[1] liquid walls,[2] and gas layers (see for example ref. 3). The object of the present study is to generalize and extend previous investigations[4-5] using gas layers to protect the first wall. This work studies the effect of an inert gas to protect cavity walls from X-rays emitted from the pellet microexplosion. A parameter study is presented here which examines the effect of gas pressure and gas atomic number on the amount of X-ray energy absorbed by the first wall.

Calculation Descriptions

The three gases used for this analysis are helium, neon, and xenon. The code used for this work is T*DAMEN.[6] The spectrum used to describe X-rays is the "Blackbody" which is used when radiation emission is characterized by the temperature of the emitter. The energy dependent absorption cross-sections of the gases used for the calculations are shown in Figure 1. These data are taken from the T*DAMEN code which are taken from the data of Biggs.[7]

Gaseous protection reduces the severity of the response of the first wall to a pulsed-thermonuclear source because it can significantly modify the X-ray spectrum. This modification is, however, extremely sensitive to the initial X-ray spectrum, the gas chosen and the number of gas atoms between the source and the first wall. An example of the modification of an initial 1 keV blackbody spectrum by 7 meters of 0.5 torr neon gas is shown in Figure 2. It should be noted from these data that any single gas can appear

TOTAL X-RAY INTERACTION CROSS SECTIONS

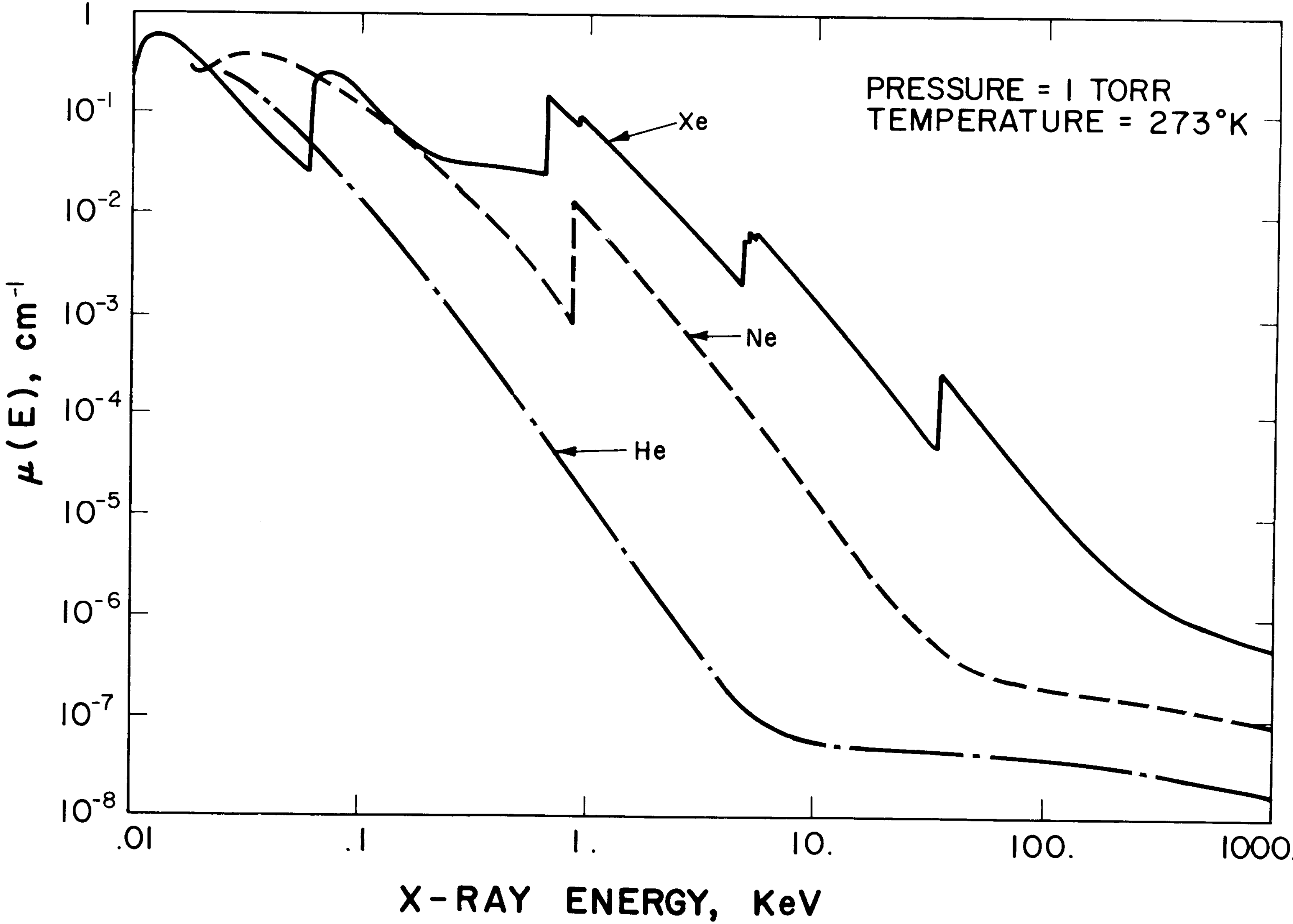


FIGURE 1

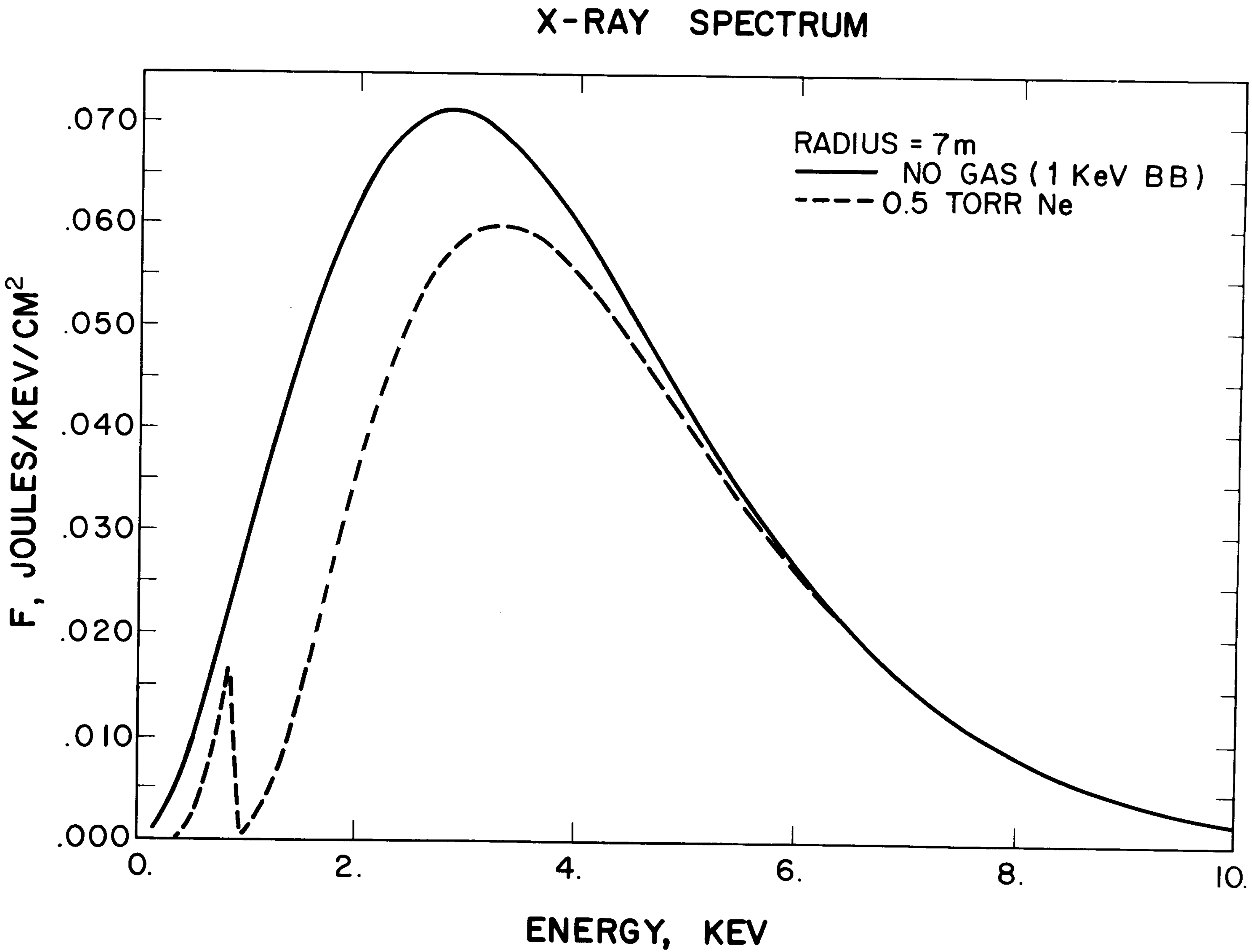

X-RAY SPECTRUM
RADIUS = 7m
NO GAS (1 KeV BB)
0.5 TORR Ne
F, JOULES/KEV/CM2
.070
.060
.050
.040
.030
.020
.010
.000
0.
2.
4.
6.
8.
10.
ENERGY, KEV

FIGURE 2

transparent to radiation near an absorption edge and consequently a mixture of gases may be necessary.

Result of Calculations

The effect of helium gas pressure on the amount of X-ray energy absorbed in the first wall of a 7 meter radius cavity is shown in Figure 3. It can be seen that for X-rays of energy greater than 1 keV, helium gas absorbs very little of this energy and consequently helium does not offer any protection for the first wall even at pressures as high as 100 torr. For soft spectra X-rays with energy less than 1 keV, only high pressures can attenuate X-rays. For example, helium gas at 700 torr-m (100 torr in a meter radius chamber) can attenuate 30% of 0.5 keV spectrum. If the X-ray spectra is softer than 0.1 keV, 700 torr-m of helium can attenuate about 99% of this energy.

Figure 4 shows the effect of neon gas pressure on the amount of X-ray energy that reaches the first wall. Neon at a pressure-distance value of 7.0 torr-m can absorb 50% of 0.5 keV X-ray spectra. In general, neon gas pressures above 25 torr in typical ICF chambers can attenuate most of the X-ray spectra of energy less than 1 keV.

Figure 5 shows the case of xenon gas. For xenon pressure-distance values of 10 torr-m can absorb most of the X-ray energy of spectra less than 1 keV, thus providing full protection of the first wall. For relatively harder spectra of energy 10 keV, 700 torr-m of xenon can still absorb most of this energy.

Figures 6 and 7 show the significant variation in the amount of energy that reaches the first wall with the atomic number of gases used for protection for two different pressure-distance values. For xenon at more than 10 torr-m and for a spectrum of 1 keV X-rays, less than 10% of the

FIGURE 3. EFFECT OF HELIUM GAS PRESSURE ON THE AMOUNT OF X-RAY ENERGY THAT REACHES A FIRST WALL 7 METERS FROM A PELLET

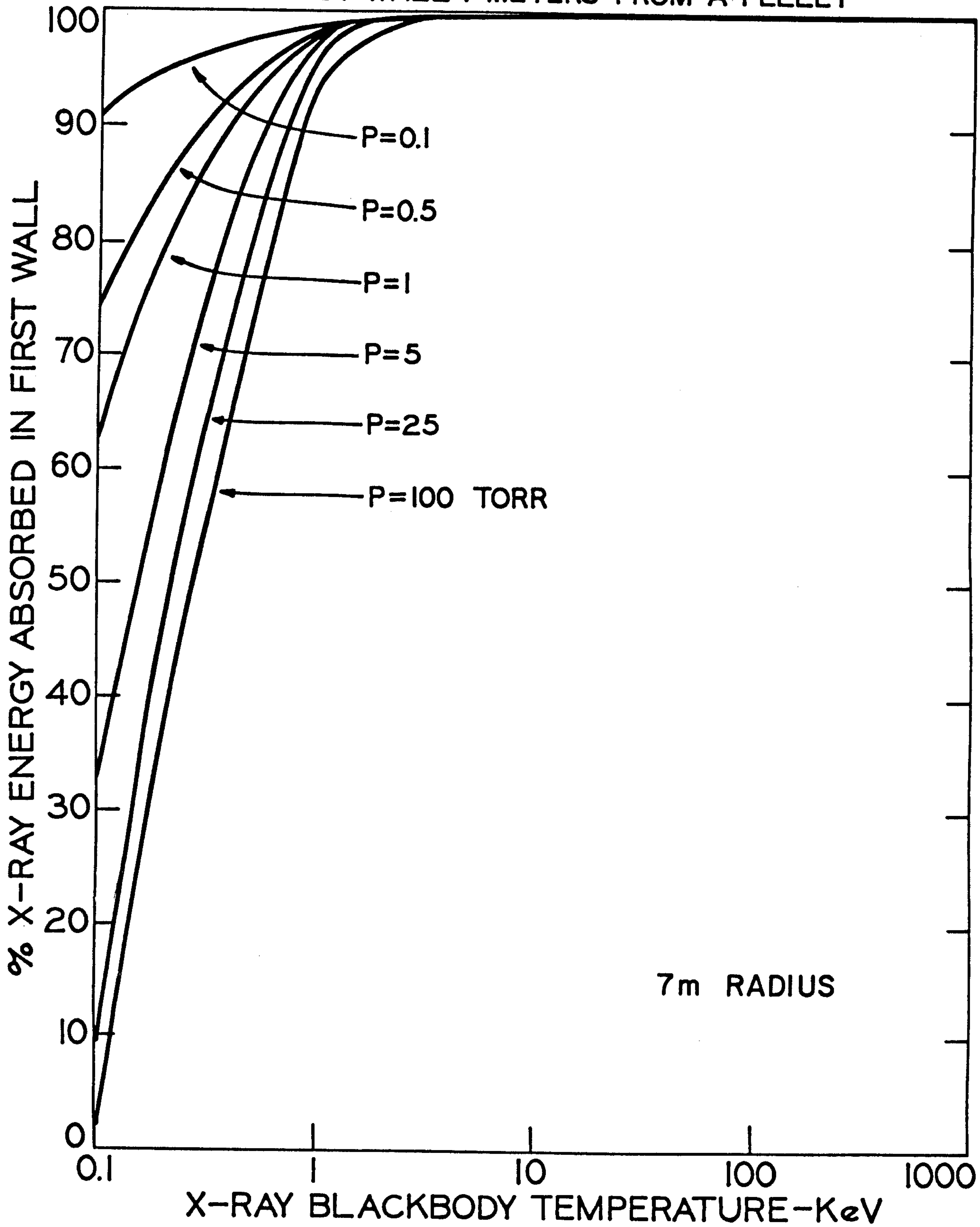


Figure 4. EFFECT OF NEON GAS PRESSURE ON THE AMOUNT OF X-RAY ENERGY THAT REACHES A FIRST WALL 7 METERS FROM A PELLET

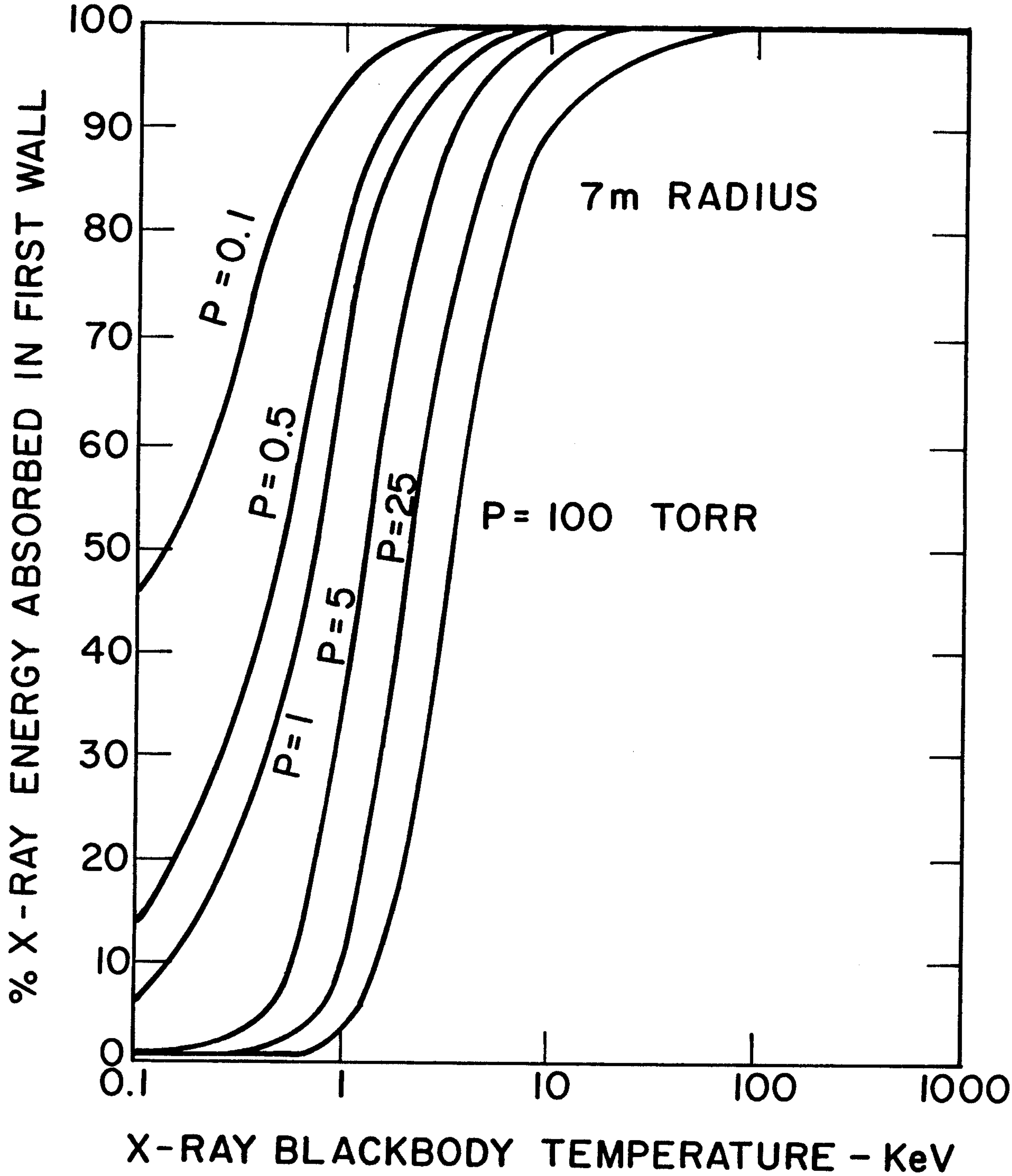


Figure 5. EFFECT OF XENON GAS PRESSURE ON THE AMOUNT OF X-RAY ENERGY THAT REACHES A FIRST WALL 7 METERS FROM A PELLET

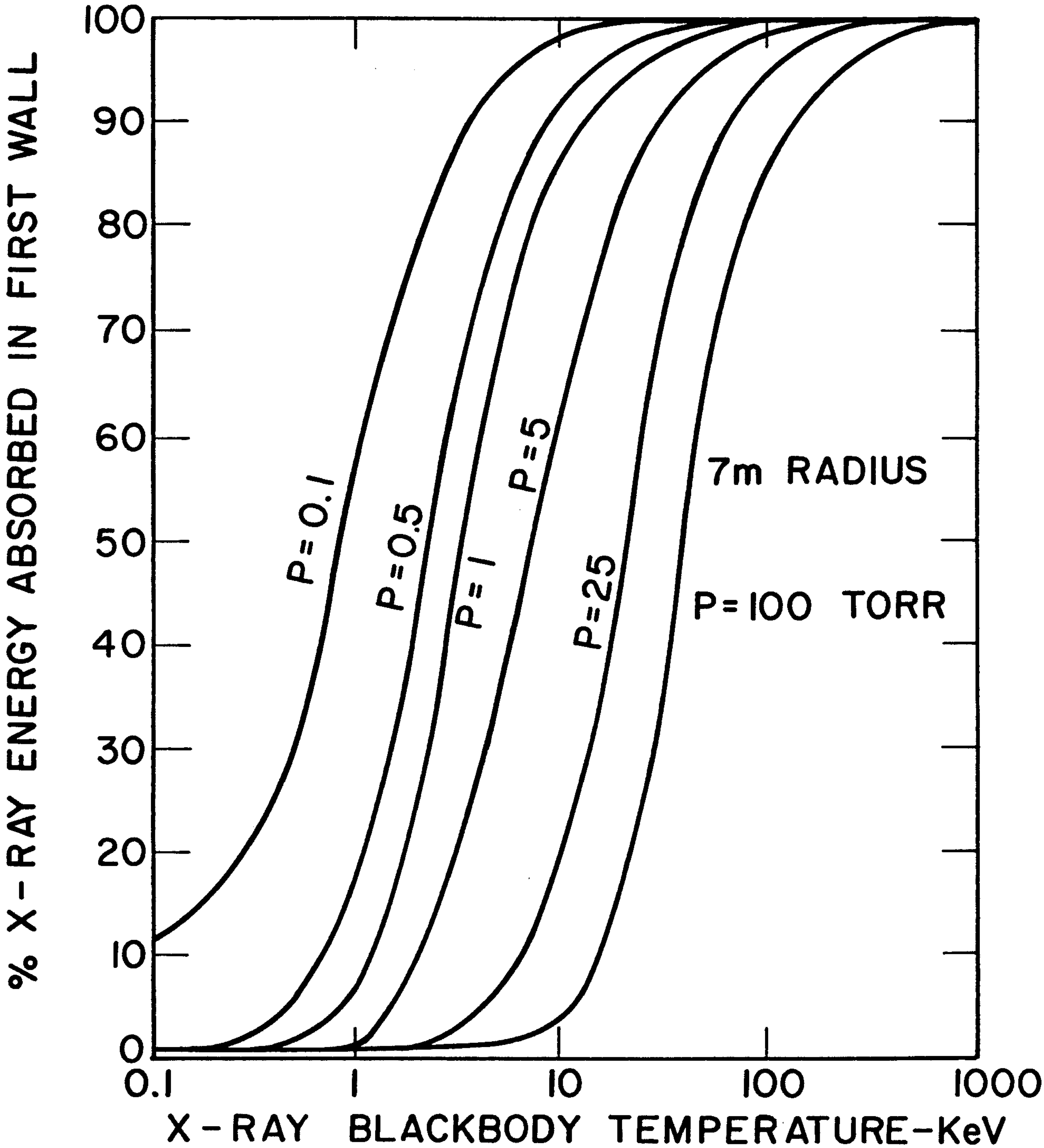


Figure 6. EFFECT OF 7 TORR-METERS OF INERT GAS ON ABSORPTION OF X-RAYS

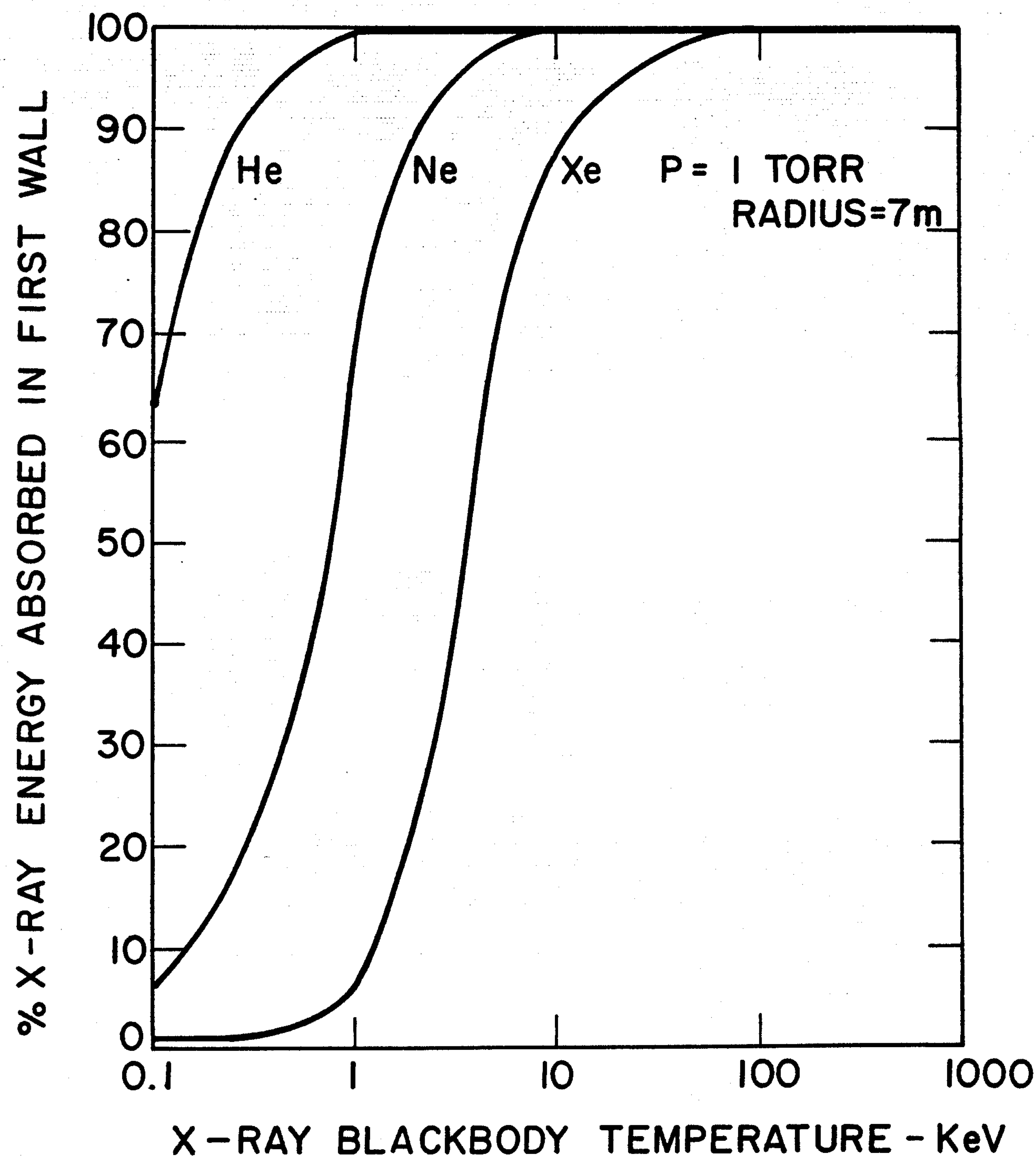
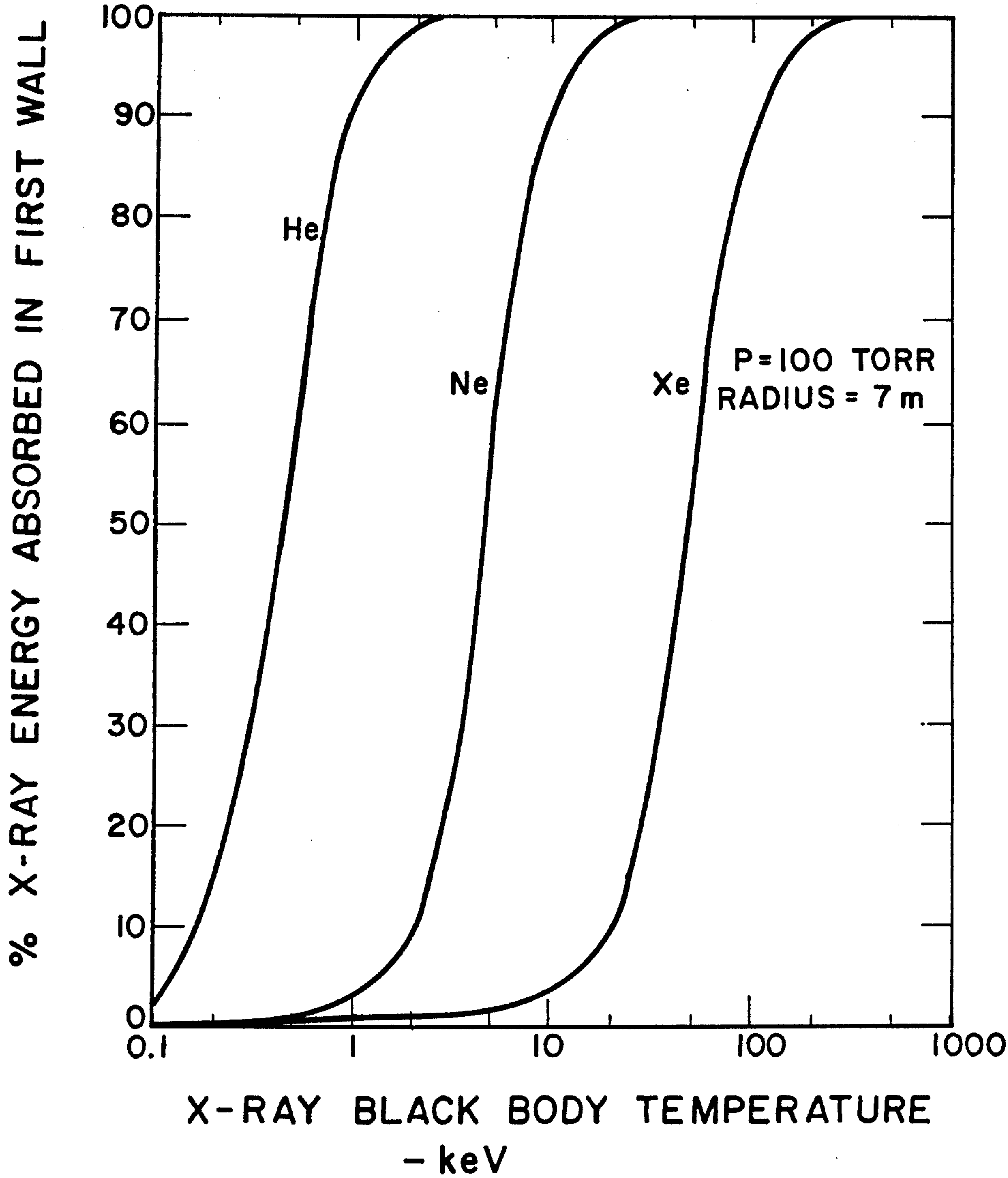


Fig. 7. EFFECT OF 700 torr-meters OF INERT GAS ON ABSORPTION OF X-RAYS



X-ray energy reaches the first wall. In the case of neon, under the same conditions, about $\frac{2}{3}$ of that energy reaches the first wall. In the case of helium, essentially all of the energy reaches the first wall even for as much as 700 torr-m.

Conclusions

This work shows the effect of gas pressure and the atomic number of the gas on the protection of the first wall in a laser fusion reactor. A substantial decrease in the amount of X-ray energy absorbed in the first wall can be achieved. The resultant thermal damage to the first wall can be greatly decreased by the proper choice of gas and gas pressure in the cavity of a Laser or an Ion Beam Fusion Reactor. The data indicate that much greater pressures for the lighter gases will be required to achieve the same result as will heavy gases and in some cases the use of gases lighter than Ne may not be practical.

Acknowledgement

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