γ-radiation is an electromagnetic wave of high energy arising from nuclear interactions. The number and the energy of γ-quanta get reduced when passing through matter because of interactive processes with the atoms.
The intensity absorption of the γ-radiation can be described by an exponential law. The given formula applies to the intensity after passing through a material having the strength x:

$$I(x) = I_0 e^{-\mu x}.$$

Here I_0 is the intensity of the unabsorbed radiation and μ is the material and energy-dependent absorption coefficient.
When logarithm is applied to the absorption law, a linear relationship appears between ln I and x:

$$\ln I(x) = \ln(I_0) - \mu x.$$

The half-value thickness of the material is taken to be as that thickness $x_{1/2}$, at which the intensity of the radiation gets halved. One gets the relationship between the half-value thickness $x_{1/2}$ and the absorption coefficient μ after substituting in the logarithmic absorption law $I(x) = I_0/2$:

$$x_{1/2} = \ln 2/\mu, \text{ or } \mu = \ln 2/x_{1/2}.$$

From the graphical representation of the experimentally found relationship of count rate and the thickness of the material used for absorption, the values for the half-value thickness of different materials can be deduced directly and compared.

Equipment

Support clamp for small case	02043.10	1
Clamp on holder	02164.00	1
Support rod, stainless steel	02030.00	1
Counter tube holder on fix. magnet	09201.00	1
Source holder on fixing magnet	09202.00	1
Plate holder for Demo-board on fix. magnet	09204.00	1
Counter tube Type B	09005.00	1
Geiger-Müller-Counter	13606.99	1
Demo-board for Physics with stand	02150.00	1
Absorption material, Lead	09029.01	1
Absorption material, Iron	09029.02	1
Radioactive sources, set	09047.50	1

Fig. 1: Experimental setup

Set-up and Procedure

See Fig.1

- Set the plate holder on the demo board and completely unscrew its adjusting screw.
- Fix the counter tube in the counter tube holder and adjust it such that its window is positioned above the right edge of the plate holder; remove the protective cap of the counter tube.
- Place the Co-60 source in the source holder and move it upto the left edge of the plate holder.
- Select the measurement time of 100 s and determine the count rate Z (without absorber) once and enter the value in Table 1.
- First fix the lead plate with a thickness of 5 mm in the plate holder and determine the count rate once; repeat the measurement for the plate thicknesses of 10 mm, 15 mm, 20 mm, 25 mm, and 30 mm.
- Repeat the same series of measurements with the iron absorber plates.
- Replace the radiation source in the container, remove the absorber plates from the holder and determine the zero rate Z_0 at least two times; Enter the results in Table 2
- Place the protective cap back on the counter tube.

Fig. 2

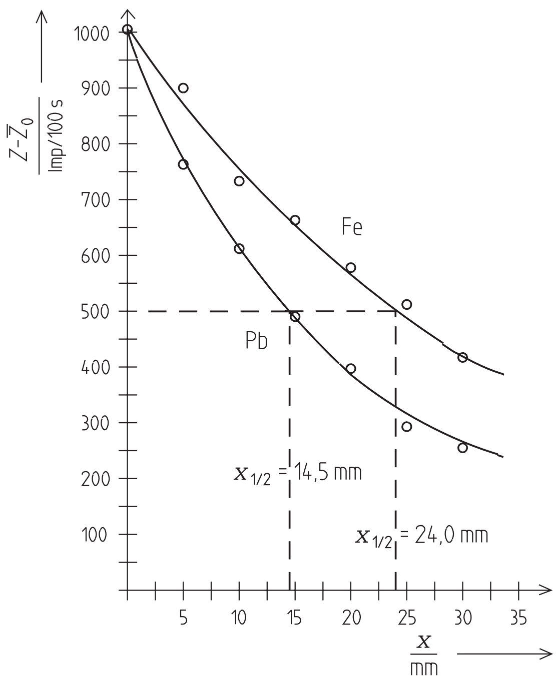


Table 1

	Lead		Iron	
x/mm	Z / Imp/100 s	$Z - \overline{Z}_0$ / Imp/100 s	Z / Imp/100 s	$Z - \overline{Z}_0$ / Imp/100 s
0	1035	1005		
5	793	763	930	900
10	642	612	763	733
15	520	490	693	663
20	427	397	608	578
25	323	293	542	512
30	285	255	447	417

Table 2: Zero rate

Running No.	Z_0 / Imp/100 s
1	28
2	32
$\overline{Z}_0$	30

Evaluation

The mean value of the zero rate is to be deducted from the count rates; the difference $Z - \overline{Z}_0$ are to be entered in the last column of Table 1.

The corrected count rates are to be represented as a function of the absorption thickness x in a coordinate system.

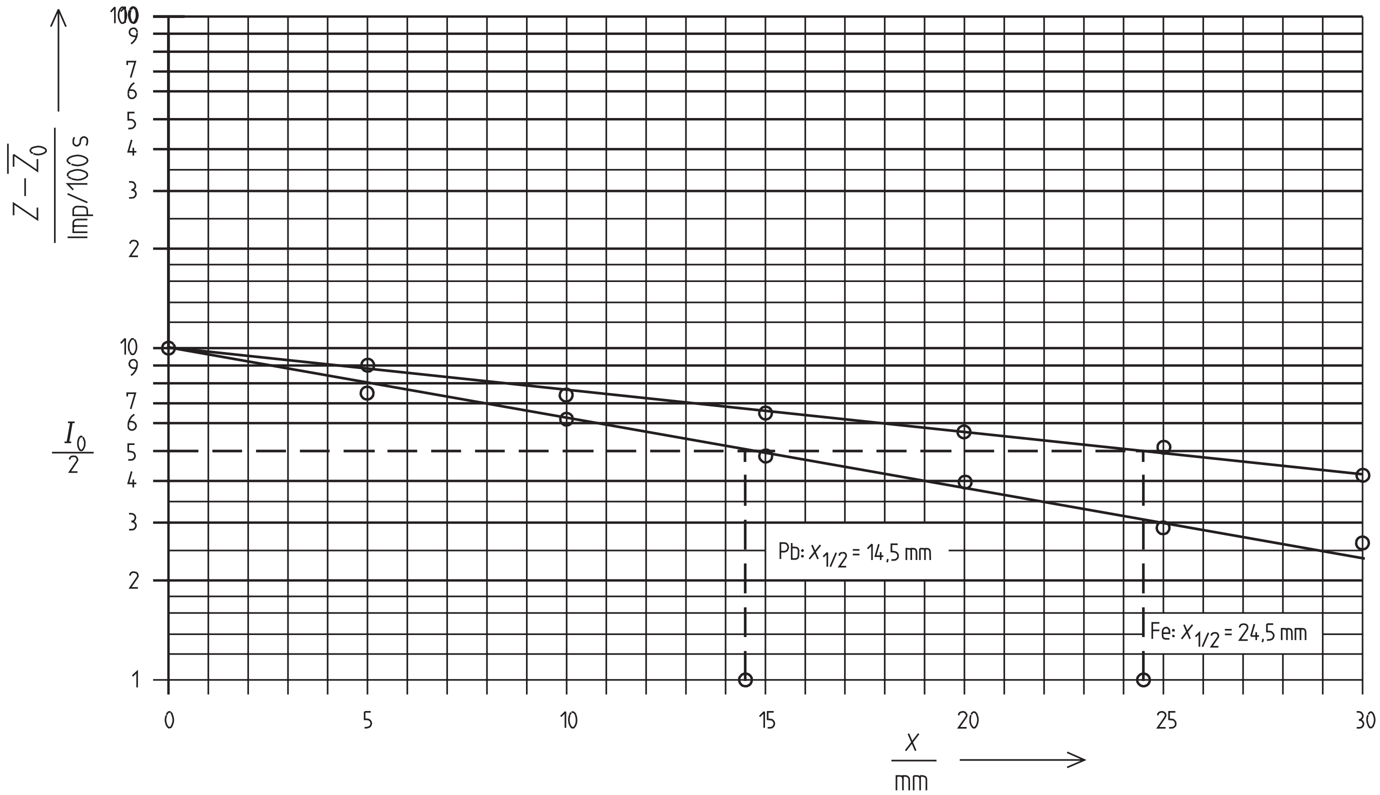
Note: The measured values can also be represented on a simple logarithmically divided coordinate paper and hence the exponential relationship of the absorption law can be proved.

The half-value thickness must be determined from the graphic representations (see Fig. 2, Fig. 3).

In the example, one gets the half-value thickness $x_{1/2}$ = 14.5 mm for lead and $x_{1/2}$ = (24 to 24.5) mm for iron. The tabulated values for the half-value thickness are 13 mm for lead and 23 mm for iron.

The results show, that although the intensity of the γ-radiation cannot be reduced to zero value through absorption, it can still be reduced to 124th part, i.e. to less than 1% after 7 half-value thicknesses and to 1024th part, i.e. to less than 1 per million after 10 half-value thicknesses.

Fig. 3


$\frac{Z - \overline{Z_0}}{\text{Imp/100 s}}$
100
9
7
6
5
4
3
2
10
9
7
6
$\frac{I_0}{2}$
5
4
3
2
1
0
5
10
15
20
25
30
Pb: $x_{1/2}$ = 14,5 mm
Fe: $x_{1/2}$ = 24,5 mm
$\frac{x}{\text{mm}}$

Room for notes