Shielding bricks NEUTROSTOP

Shielding bricks NEUTROSTOP

- **Application:**

– Nuclear reactors
– Radioisotopes
– Fission material
– Radiation in medicine

- **Shield against:**

– Fast neutrons
– Thermal neutrons
– Gamma radiation

Radiation fields are mostly combined of several types of radiation. The fast neutrons, thermal neutrons, primary and secondary gamma radiation are the most important of them. A shielding material is applied to decrease radiation to an acceptable level.

- **Fast neutrons** can be shielded in the most effective way by hydrogen. There is the advantage of the NEUTROSTOP bricks with maximum hydrogen content. Fast neutrons are slowed down by collisions with hydrogen nuclei.
- **Thermal neutrons** can be efficiently shielded using some additional elements in the shielding material – e.g. boron, lithium, or cadmium.
- **The secondary gamma radiation** comes from thermal neutron absorption in hydrogen. This radiation can be minimized by using a shield containing elements like boron or lithium.

- **Technical description**

1) Basic shielding brick shapes:
– H shape (mark H)
– C shape (mark C)
– E shape (mark E)
– Possibility to manufacture special products (by milling)

2) The shielding bricks NEUTROSTOP are manufactured from the three following materials:
– Pure polyethylene (mark 0)
– Polyethylene with addition of boron in amount of 3,5 % (mark 3)
– Polyethylene with addition of boron in amount of 5 % (mark 5)
E.g.: The NEUTROSTOP C0 is the C shaped brick manufactured from pure polyethylene.

- **Pure polyethylene bricks**

Polyethylene is due to its mechanical, physical, and chemical properties very suitable as a shield against neutrons. High purity polyethylene can be produced containing no elements that could be activated by neutrons; the surface of the polyethylene bricks is hydrophobic. The contamination disposition of the surface is low; the decontamination factor of the NEUTROSTOP is very convenient.
Polyethylene as the basic material is characterized from the physical point of view by high content of hydrogen that takes part in the shielding process. Hydrogen concentration in polyethylene is almost the same as its concentration in water; that is why the shielding properties of polyethylene are nearly the same as the properties of water.

- **Polyethylene bricks with addition of boron**

The polyethylene bricks with addition of 3,5 or 5 % of boron are currently produced besides the pure polyethylene ones. Just the bricks containing boron are mostly requested but in case of bulky shield arrangements it is useful to combine them with the cheaper high purity polyethylene bricks to slow down the fast neutrons. The addition of boron brings a drawback that usually does not interfere; the gamma radiation with energy of 478 keV rises from absorption of electrons.
Therefore it is necessary in case of intensive neutron sources to shield this radiation in a common way.

- **Shielding wall construction**

The walls of the C shaped bricks are the simplest arrangement. The H shaped bricks allow in combination with the C shaped ones to construct compact walls and blocks. The new system makes possible even arrangements of hollow units with passing to outside without any additional supporting constructions.
The built-up shielding arrangements can be combined with unequal units using the loose granulated material with addition of boron or particular bricks made by mechanical cutting of pieces manufactured for this purpose.

- **Properties of the NEUTROSTOP shield**

Some modifications can occur when using the NEUTROSTOP owing to high doses of alpha or gamma radiation or to intensive neutron flux. There are three types of these modifications:
– Variance in boron content during neutron irradiation
– Decomposition of polyethylene due to high doses of alpha or gamma radiation
– Decomposition of polyethylene because of heat release at alpha particle braking

It was established that the properties of the NEUTROSTOP shield are constant during continuous five year irradiation by the neutron flux up to about 10^{16} $m^{-2}sec^{-1}$ and its chemical composition does not change. Some depletion in neutron absorbing isotope content and small modifications in mechanical properties of polyethylene occur during irradiation. However these modifications are negligible from the technical point of view.
Their physical and electrical properties correspond to common values of PE and resemble to properties of paraffin, example: energy decrement is 0,9.
Melting point of used PE is 100 °C. The contamination disposition of the NEUTROSTOP was estimated by sample exposition in the 10^{-3} N $Eu(NO_3)_3$ in 1l water solution marked by the isotopes 152 Eu and 154 Eu. The below mentioned contamination was found after calculation the carrier and the isotopes used content:

Polyethylene shield	18 GB q/m^2
Polyethylene shield with addition of boron	29 GB q/m^2
Low-alloy steel	13000 GB q/m^2
Stainless steel 17 246	8,3 GB q/m^2
Stainless steel17 255	2,0 GB q/m^2

The below stated decontamination factors were found by decontamination tests using the 1.10^{-2} N citric acid in 1l water standard solution:

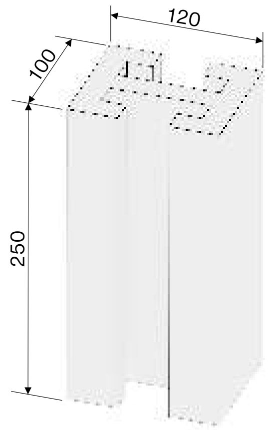
Polyethylene shield	21,1
Polyethylene shield with addition of boron	15,8

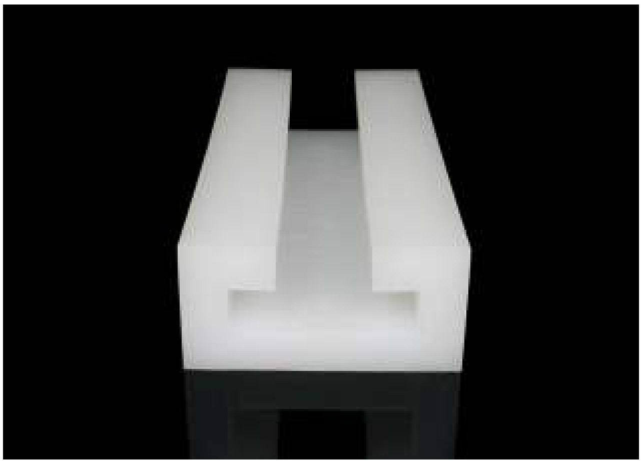
The Metrological institute in Bratislava performed the shielding effect measurement of the NEUTROSTOP bricks using the radionuclide neutron source 239Pu-Be with emission of 2,7.107 s-1, type IBN-26 with the mean spectral energy of 4,4 MeV.

As it follows from the results, the reducing power of the bricks with addition of boron is about 10 times higher than the power of the high purity polyethylene ones.

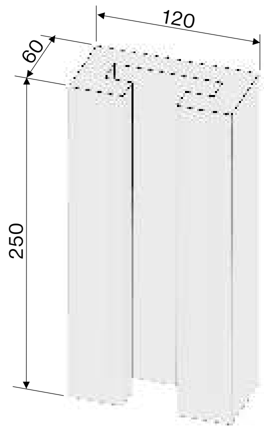
The shielding ability for fast neutrons does not depend on boron content. A polyethylene brick layer with thickness of 44 cm can decrease the neutron flux 100 times and a layer with thickness of 90 cm even 1000 times, as it results from the measurements done.

Shape H

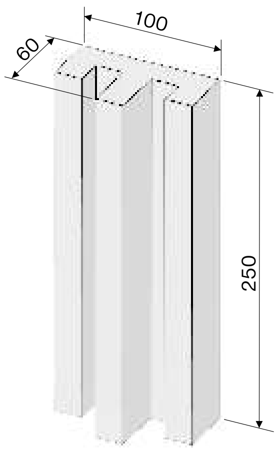




Shape C

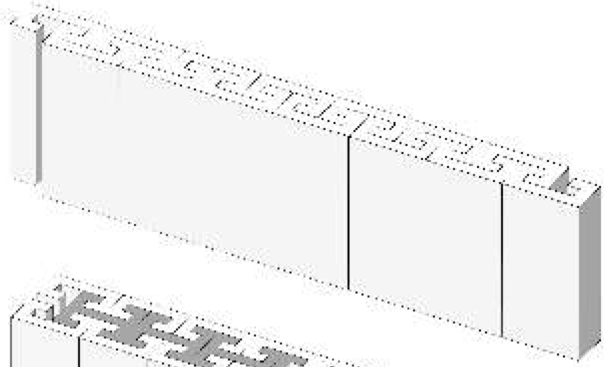


Shape E

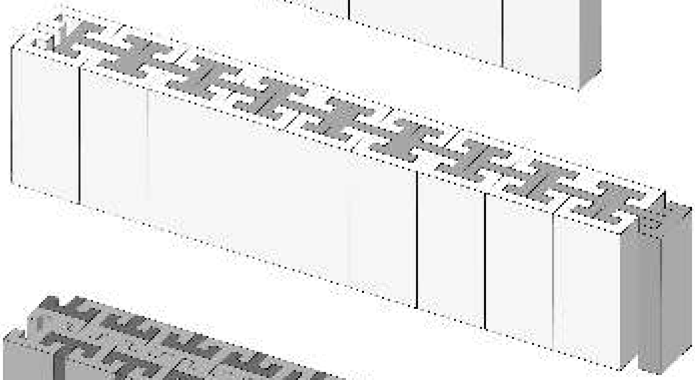


Mounting example

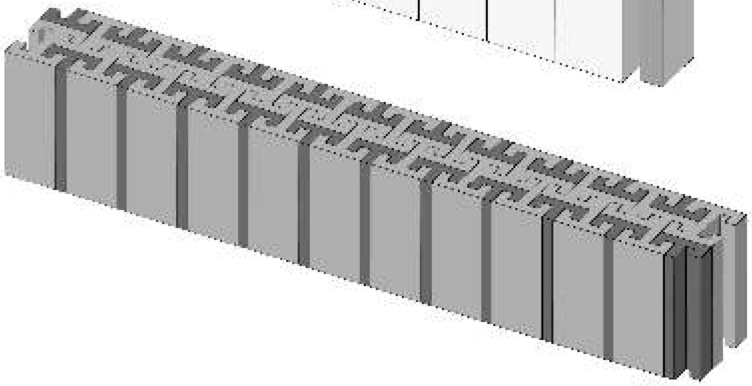
shielding bricks **C**



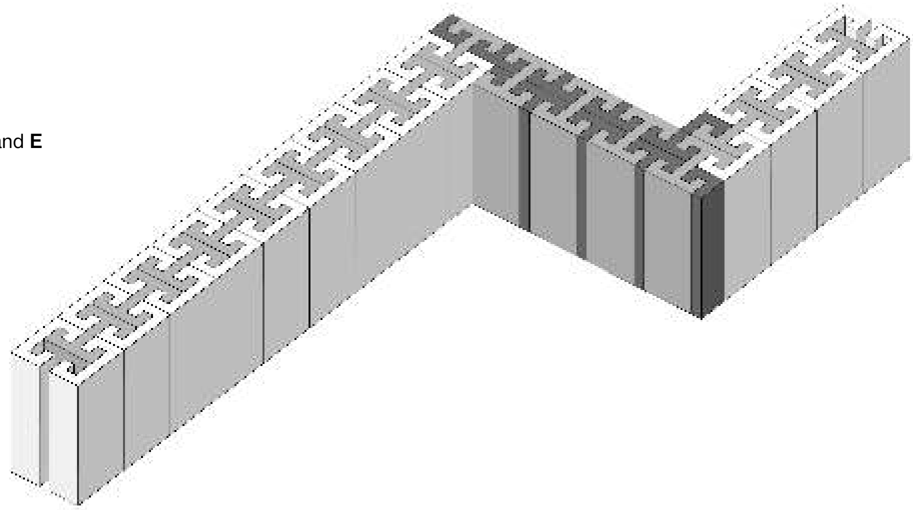
combination of
shielding bricks **H** and **C**



combination of
shielding bricks **H** and **E**



combination of
shielding bricks **C**, **H** and **E**



REFERENCIES:

- AGMECO – MEDICAL ENGINEERING s. r. o. – Turkova 828, 14900 Praha 4 – Chodov, Czech Republic
- CERN – (European Organization for Nuclear Research) – Geneve 23, Switzerland
- Experience EDELWEISS – 90 Rue de Polset, 73500 Modane, France
- EL Malines Depot – Bureau Aankopen, Leuvensesteenweg 30, BE – B-2800 Mechelen, Belgium
- Flerov Laboratory Moscow – Joliot – Curie 6 str., Dubna, Moscow reg., Russia
- Forschunfszentrum Rossendorf, z.Hd.Dr.G.Brauer, Bautzner Landstr. 128, 01328 Dresden, OT Rossendorf, Germany
- Groupe Manoir-Edelweiss (Institut de Physique Nucléaire de Lyon) – Univerité Claude Bernard Lyon I, 4 Rue Enrico Fermi, 69622 Villeurbanne Cedex, France
- International Atomic Energy Agency – Wagramerstrasse 5.P.O.Box 100, A-1400 Vienna, Austria
- Paks Nuclear Power Plant Ltd. – Purchasing Section, H-7031 Paks, P.O.Box: 71, Hungary
- Radioelectronic systems Ltd. – Al. Malinov, Blvd., Sofia, 1715 Bulgaria
- UN Development Programe in Pakistan, P.O.Box 1482, Nilore, Islamabad, Pakistan
- Universität Halle, FB Physik, Friedemann – Bach – Platz 6, 06108 Halle (Saale)/D, Germany

KOPOS KOLÍN a.s.
Havlíčkova 432
280 94 Kolín IV

tel.: +420 321 730 111
fax: +420 321 730 811
e-mail: kopos@kopos.cz

www.kopos.com