KOPOS

SHIELDING BRICKS

NEUTROSTOP

www.kopos.com

SHIELDING MATERIAL

SHAPED BRICKS

Shielding materials are generally used to reduce the intensity of ionizing radiation fields to an acceptable level. The final choice depends on the type of radiation, i.e. whether it is necessary to shield charged alpha and beta particles and electrons, or indirectly ionizing radiation, such as gamma-ray photons, bremsstrahlung photons and neutrons. Of these types of radiation, it is the most difficult to shield neutrons, because their energy spans over more than 10 orders of magnitude, from thermal energy in thousandths of electronvolts (eV) to tens of megaelectronvolts (MeV).

Neutrons can be most effectively shielded with materials containing as much hydrogen as possible. When colliding with hydrogen nuclei, neutrons lose the most energy, and are then slow enough to be captured by hydrogen or other nuclei. When slow neutrons are captured by atomic nuclei, the so-called prompt gamma-ray photons are emitted, usually with a slight delay; these can be more easily shielded using a material with a high atomic number, such as lead. The energy of prompt photons depends on the type of the nuclei: if a slow neutron is captured by a hydrogen nucleus, the prompt photon has an energy of 2.2 MeV; if captured by the nucleus of boron isotope (10B), it has an energy of only 0.5 MeV. If there is a nuclear reaction between a slow neutron and the nucleus of lithium isotope (6Li), an alpha particle will be generated with a negligible range and no photon will be emitted.

THREE SPECIAL MIXTURES

• Special polyethylene mixture without additives - to shield neutrons of all energies.
Thanks to its mechanical, physical and chemical properties, polyethylene is particularly well suited for building even very large shields. Polyethylene can be manufactured with a high degree of purity, so it does not contain neutron-activating elements. The surface of polyethylene products is hydrophobic and can be easily cleaned in case of potential contamination. Surface contaminability is low and decontamination is easy. From a physical point of view, polyethylene as a base material features a high content of hydrogen, which is essential for the shielding process. Hydrogen concentration in polyethylene is almost identical to hydrogen concentration in water, and the shielding capacity of pure polyethylene is therefore similar to that of water.

• Special mixture of polyethylene with an addition of boron - for shielding neutrons of all energies and partial elimination of 2.2 MeVphotons, generated during the capture on hydrogen.
The material contain boron isotope B, which interacts with slow neutrons. The resulting nuclei of isotope Li have excess energy results in an emission of gamma-ray photons with an energy of 0.5 MeV. This value is significantly lower than 2.2 MeV, and therefore these photons can be shielded more easily.
Kopos produces two types of shaped bricks with an addition of boron: with 3.5% and 5% of boron by weight.

• Special mixture of polyethylene with an addition of lithium - for shielding neutrons of all energies and partial elimination of 2.2 MeVphotons, generated during the capture on hydrogen.
The material contains lithium isotope Li, which effectively captures slow electrons and does not emit any gamma radiation. NEUTROSTOP shaped bricks are made with a 10% content of lithium by weight.

TECHNICAL DESCRIPTION

- POLYETHYLENE SHAPED BRICKS WITHOUT ANY ADDITIVES - MARKING C0, E0, H0
- POLYETHYLENE SHAPED BRICKS WITH AN ADDITION OF 3.5% OF BORON BY WEIGHT - MARKING C3, E3, H3
- POLYETHYLENE SHAPED BRICKS WITH AN ADDITION OF5%OF BORON BY WEIGHT - MARKING C5, E5, H5
- POLYETHYLENE SHAPED BRICKS WITH AN ADDITION OF10% OF LITHIUM BY WEIGHT - MARKING C10, E10, H10

Recommendation: shielding structures usually require shaped bricks with an addition of only boron or lithium, but for assemblies of large shielding objects it is advisable to combine shaped bricks with additives with cheaper shaped bricks of pure polyethylene, which are suitably to be placed closer to the source of neutrons.

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.

CUSTOMER ORIENTATION

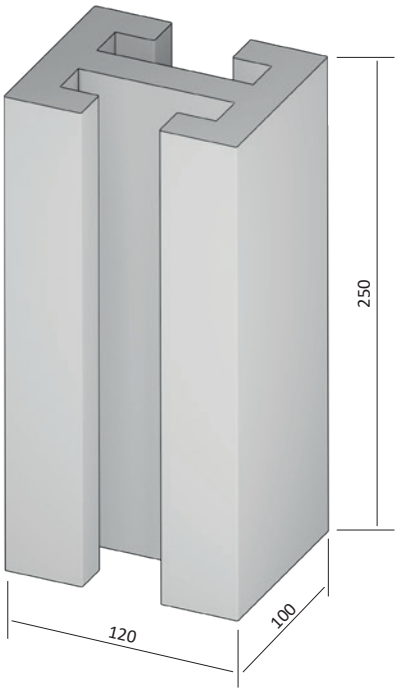
NEUTROSTOP shaped bricks can shield equipment of any size, from a nuclear reactor or a cyclotron to individual radionuclide sources of neutrons. Subject to agreement withKOPOSKOLÍN a.s., an expert opinion can be prepared.

The following data must be provided for a shielding design:
1. value of ambient dose equivalent rate behind the shielding H*(10),
2. neutron emission from the source,
3. neutron energy (spectrum),
4. geometric arrangement of the neutron source and the shielded area.

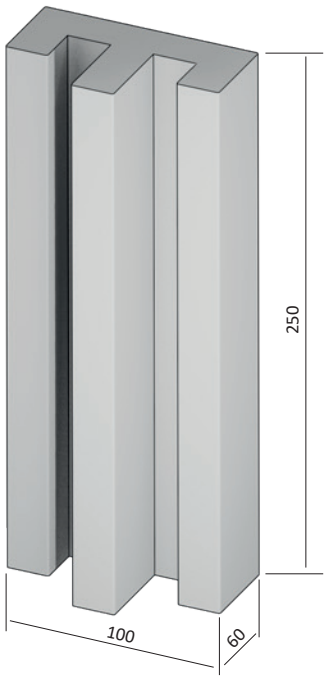
The proposed shielding designs are optimized for the specific project and are not unnecessarily large.
KOPOSKOLÍN a.s. possesses expert opinions from the Inspectorate for Ionizing Radiation of the Czech Metrology Institute.

BASIC SHIELDING BRICK SHAPES

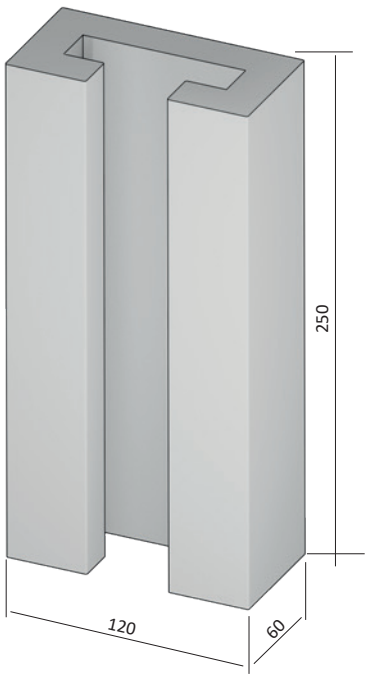
SHAPE **H**



SHAPE **E**



SHAPE **C**



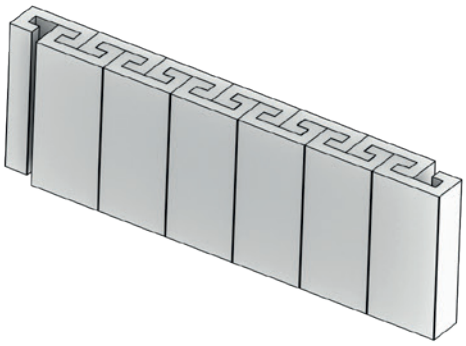
If the customer desires, possibility of special modifications to the shaped bricks, e.g. by cutting for cylindrical shielding designs of particle accelerators.

REFERENCIES

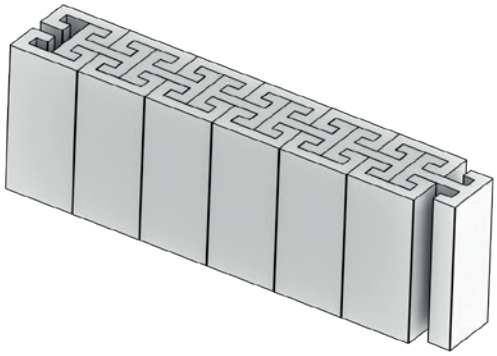
AGMECO – MEDICAL ENGINEERING s. r. o. – Turkova 828, 14900 Praha 4 – Chodov, Czech Republic
CERN – (European Organization for Nuclear Research) – Geneve 23, Switzerland
Experience EDELWEISS – 90 Rue de Polset, 73500 Modane, France
EL Malines Depot – Bureau Aankopen, Leuvensesteenweg 30, BE – B-2800 Mechelen, 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 l, 4 Rue Enrico Fermi, 69622 Villeurbanne Cedex, France
International Atomic Energy Agency – Wagramerstrasse 5.P.O.Box 100, A-1400 Vienna, Austria
P**aks 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

MOUNTING EXAMPLE

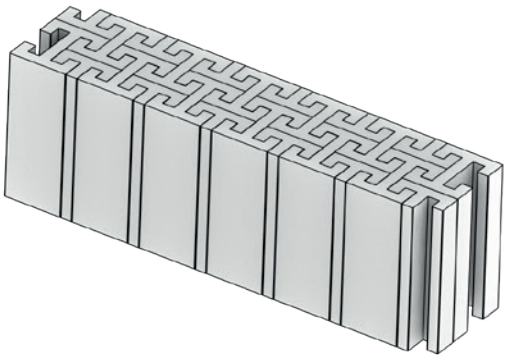
SHIELDING BRICKS **C**



COMBINATION OF SHIELDING BRICKS **C+H**



COMBINATION OF SHIELDING BRICKS **H+E**



COMBINATION OF SHIELDING BRICKS **C+H+E**