EKOR - UNIQUE MATERIAL FOR TRANSPORTATION, CONTAINMENT AND DISPOSAL OF RADIOACTIVE WASTES

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SUMMARY

EKOR - a unique radiation-resistant silicon-organic foam-type elastomer is presented as a new material for transportation, containment, isolation and disposal of radioactive wastes.

EKOR has been developed and full-scale tested by a group of Russian scientists from the Kurchatov Institute, in collaboration with specialists from Euro-Asian Physical Society (EAPS) (President - Prof. S.P.Kapitza) and other organisations. EAPS is a patent holder for EKOR. The sole and exclusive licensee of the patents is Eurotech, Ltd. a US company, with rights to sub-license the patents world-wide.

EKOR maintains structural stability - does not disintegrate and preserves its structural properties under radiation, including α, β and γ rays, with the absorbed dose 10 Grad, transforming finally into foam-ceramics with mechanical compression strength within interval 5-10 kg/cm^2. Material does not inflame and does not burn in the open flame, keeping its initial form and dimensions. It is not toxic under the impact of flame. EKOR has excellent adhesion to concrete, metal, glass without the primer. EKOR has resistance to corrosion caused by acids, alkalis and organic solvents.

Specific unique properties of EKOR which allow to solve the packaging, transportation and storage problems of radioactive materials are treated in this paper.

MAIN CHARACTERISTICS OF EKOR

EKOR material is a frothed silicon-organic elastomer which differs from known elastomers by a row of properties that provide its application in specific areas of industrial activity, particularly when radioactive nuclides are used. Carried out research and testing of EKOR material have shown that it has the following characteristics and parameters:

Density 0.3-0.4 g/cm^3. Material has mostly (60-90 %) closed porosity with pores dimensions within the interval 2-6 mm.

EKOR keeps fully its structure under the impact of gamma-radiation up to absorbed dose 10 Grad, losing only the initial elasticity at the absorbed dose more than 300 Mrad and

transforming finally into a foam-ceramics with mechanical compression strength within interval 6-28 kg/cm^2. EKOR's mechanical compression strength before irradiation is 6.3 kg/cm^2.
Testing was carried out in RSC "Kurchatov Institute" on installations GUT-200 and RHM which allow to vary gamma-radiation dose power within limits from 1.5 R/s to 540 R/s.
Material does not inflame and does not burn under the impact of open flame, keeping its initial form and dimensions. The material keeps its properties at low (up to minus 60 °C) temperatures.

Thermal-physical characteristics of EKOR material are as follows:
- specific heat (within the interval of T=20-250 °C) ~ 0.76-0.97 kJ/kg.°C;
- heat conductivity factor (within the interval of T=30-200 °C) ~ 0.05-0.03 W/m.°C.

There is no material softening at the increase of the temperature. On the basis of obtained data it was stated by calculations that if heat flow with the temperature 900 °C is supplied to hypothetical EKOR sample with thickness 10 cm, temperature 400 °C is reached on the internal sample's surface only after 10 hours. Heating of the surface (up to 300 °C) which EKOR is deposited on will only accelerate solidification process of material. Research was carried out in RSC KI on the installation KS-1 of the Institute of Nuclear Reactors. Method of measurement of heat conductivity factor has been certified, certificate is available.

EKOR is corrosion resistive to decimolar solutions of acids, alkalis and to organic solvents (such as benzine, benzene, hexane, carbon tetrachloride, acetone). Material is nuclear-safe in the system "EKOR - any fissile nuclide". Research was carried out in RSC KI, the method has been certified, certificate is available. EKOR does not become radioactive after long irradiation. Material does not posses sorption properties in relation to radioactive nuclides.
Due to its chemical structure the material is hydrophobic and waterproof. It does not swell in the water, mass loss is absent. EKOR has excellent adhesion to concrete, metal, glass. Break-off from the surface is of cohesion character. Material could be simply utilized after its usage. The final product of utilization is SiO_2 powder.

Emission of radiolysis gases from material under the impact of irradiation is about ten times lower than the one for similar foam-type elastomers. Fire and explosion safety during sealing and conservation could be provided practically for any conditions. Chromatograph "Tsvet" ("Color") and kinetic research stand "KIS" were used for analysis of composition of gaseous radiolysis products.

Density, plasticity, time of foam formation and other properties of basic EKOR material could be varied depending on requirements for concrete application. For example, foam formation time could be changed from several minutes to several hours. Mechanical properties also could be changed through wide range from easily compressible foam-type elastomer to quasi-ceramic light foam (rigid, reinforced). One of EKOR's modification is non-frothed film elastomer, which possesses the same properties.

Material synthesis is simple and is realized on the site of application by mixing preliminarily prepared components. Polymerization proceeds spontaneously and at natural temperature (minus 20 - +60 °C). Synthesis proceeds without absorption and emission of heat.
EKOR material components are inert biologically.

Presently a quasi-industrial installation for EKOR synthesis with effectiveness 25-50 kg/minute has been manufactured. Full-scale production of components for EKOR synthesis is planned to start in the nearest future.
EKOR material was developed in the first place for conservation of premises of Chernobyl NPP 4 block.

It seems to us that block conservation with EKOR material can provide isolation of radioactive materials from surrounding medium, prevent migration of radionuclides within the block and issuing of radioactivity out of block and also prevent the danger of dust ejection as a result of collapse of building constructions. As distinguished from concrete monolith, such conservation will allow to carry out quite simply re-activation of the object and utilization of EKOR material in the future.

It should be stressed that EKOR material synthesis technology allows to fill local hollows, looseness, openings, chinks and other hardly accessible places. In case of necessity, supply of components and material synthesis could be provided by the remote method.

PROCEDURE TO INCORPORATE RADWASTE INTO EKOR

Liquid wastes

Acceptable concentration of acid or alkaline in a solution is not more than 0.1 Moles/l. It seems to us that highly active liquid wastes should be glazed. Wastes with middle and low activity level could be encapsulated into EKOR by means of making holes within material's volume which internal surface should be covered by a film of non-frothed EKOR. The thickness of the film is stipulated by the volume of filled holes and by mass of radioactive wastes solution.

Solid wastes

Wastes in view of salts or powders could be directly incorporated into EKOR volume during the process of its synthesis using additional dosing unit which is a part of EKOR synthesis installation. Maximally acceptable amount of such wastes within EKOR could reach approximately 30% of EKOR mass. Homogeneity of waste distribution in the matrix is stipulated by EKOR synthesis parameters and by properties of wastes themselves for each particular case.

In case of wastes in view of pieces of various materials, layer encapsulation with alternate filling of volumes with EKOR and wastes will seemingly be necessary. The quality of encapsulation will mainly be stipulated by following parameters: granulometric wastes composition, fluidity of initial mass and time of polymerization.

OTHER FIELDS OF APPLICATION FOR EKOR

Investigations of EKOR have shown that it has a wide field of application:

In nuclear industry

- Containment of the objects consisting of radionuclides and nuclear fuel cycle wastes;

- sealing of the worked-out uranium and thorium quarries and their tailings. This will also reduce noncontrolled migration of the uranium and thorium and significantly reduce penetration of radon and thoron gases into the environment. The latter amounts can be reduced to the natural quantities;
- protection of the technical hazardous objects, consisting of radionuclides by dust suppression, protection from the atmospheric acid rains, and thus preventing transfer of radionuclides into the natural conditions media;
- sealing of the structures and buildings containing radionuclides with the goal of preventing proliferation of the latter into the environment with a simultaneous goal of protecting the structural parts from the loss of integrity as a result of accident or reaching the useful life term of the building. Such category of the objects would be: NPP reactor buildings which had an accident, worked out or non-operating buildings of the atomic reactors and radio-chemical plants at the plutonium production facilities, as well as permanently shut-down reactor buildings of NPPs;
- containment of liquid radioactive wastes;
- transportation of radioactive wastes.

In other areas

- sealing of the objects of the chemical industry and isolation of the chemically hazardous substances;
- components of walls and partitions structures of submarines and ships and tankers;
- for collection and isolation of oil spills during accidents in the sea;
- as a protecting material during fire fighting works;
- in the airplane and car manufacturing (seat cushions, etc.);
- transportation of the dusty hazardous materials;
- for isolation of oil- and gas-pipelines to prevent leakage and ignition.

CONCLUSION

As a result of carried out research and testing it could be said that EKOR has a row of following advantages as compared to other stabilizing and conserving materials:

- low specific density (0.3-0.4 g/cm^3) that does not increase significantly object mass and mass of radioactive wastes which are to be reprocessed and concealed;
- the simplicity of synthesis technology and the possibility of its remote organization;
- the flexibility of frothing and polymerization regimes that allows to vary synthesis parameters and properties of final product depending on concrete features of conserved object;
- physical and chemical properties of material (radiation, thermal and water resistance and others) allow to use it for a wide spectrum of radioactive waste products and, for example, for stabilizing of destroyed 4 block of the Chernobyl Nuclear Power Plant for quite a long term (according to estimations - up to 200-300 years) till the elaboration of economical, technological and ecological optimal solution of the problem of its complete liquidation.