PHYSICAL-CHEMICAL STRUCTURE OF VIPRO

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PELF is a manufacturer of rigid expanded PVC in the form of panels of different density.- The technology used in the production of this material is very complex.- For this reason there are only three manufacturers of this product in the world.- This material is used in self-supporting structures of forms of transport, refrigerator trucks, buses, in the naval industry, for the construction of boats up to 40-50 meters in length, in the aeronautical and military industries.- Thanks to the specifics knowledge matured in these last years by PELF in the use of PVC, three years ago, in co-operation with ENEA's TRIGA SERVICE, we thought about the construction of a shielding panel based on PVC with all of those physical characteristics that the current materials of plastic origin (or example polythene) cannot give.-

Reasearch was developed in the two following phases:

1st phase : construction of a PVC panel with the density of approximately 1.000 Kg./c.m. doped with extremely pure Boron using the base formula of rigid expanded PVC

2nd phase : construction of a completely new panel using for the first time in the world in the sector of plastic matters, the formula "in alloy" where the absorbing material Boron or Lead become part

of the chemical link.-

The first phase presented considerable difficulties because we had to obtain a panel with these characteristics:

* perfect homogeneity of the cell structure

* perfect dispersion of the absorbing material

* achieve in an expanded material the density of 1.000 Kg./c.m.

* elevated resistance to temperatures of around 100 ° C.

In order to obtain all of these characteristics it was necessary to resort to an extremely complex form of cross wiring of the PVC.-

The samples of panels subjected to the neutron irradiance test immediately revealed an insufficient resistance liberating atoms of Chlorine.- We attributed this phenomenon to the very complex chemical structure of the material.- Our belief has been confirmed even by the results of the experiments conducted in the USA and in Europe.

Summing up, studies conducted in different parts of the world have emphasized that the polymers, even though equipped with good physical characteristics of resistance to radiation, become extremely fragile when these polymers are treated so as to give them a complex chemical form, necessary in raising the structural characteristics.-

As already mentioned, the only thing left to do was to try for the first time and construct a panel "in alloy" that would overcome the inconveniences presented in the panel experimented in the first phase, in particular that the liberation of chlorine, would occur after the exposure of the material to elevated neutronic radiation, after a very long time, so as to give an absolute guarantee for the use for which it had been foreseen.-

Only a simple and at the same time extremely resistant physical-chemical structure, a determined increase of resistance to temperatures, a considerable increase also of the number of Hydrogen atoms/c.m. could give the hoped for results.-

This is how VIPRO was born.-

<u>The production process is articulated in three phases:</u>

1st Preparation of a controlled viscosity mix composed of Boron or Lead (in variable concentration), PVC with an efficient cross wiring agent and a high temperature of resolution catalyst, as a heat stabilizer Cadium has been used in small quantities.-

2nd Pressing at elevated pressure and at high temperature.- Depending on its use, it is possible to obtain various forms of manufactured goods.-

3rd "Ageing" of the panel achieved at constant medium high temperatures for a determined time.-

It was also necessary to proceed in the removal of possible gasses dissolved in the PVC mass, succeed in controlling in an adequate way the cross wiring reaction of PVC, remarkably exothermic in the main phase, regulate th shrinking of the volume during the pressing of the panels.-

We have noticed that this shrinkage follows a precise equation:

$$\% \text{ shrinkage} = \frac{SG\ p\ -\ SG\ AR}{SG\ p} = X\ 100$$

where SG p = specific gravity of polymer

SG AR = specific gravity of the cross wiring agent

The problem "Emission Chlorine" is that way overcome: imagine a cube in which centre we find the Chlorine; in each edge of this cube we find the Boron. This composite structure is then closed into a bigger cube which has the Hydrogen and the Cadmium in each edge. The neutron collide against the Hydrogen, as a consequence of these collisions they lose energy. Captured by the Boron: only a small part of weakend neutrons collide against Chlorine linkage. The energy that they contain is not sufficient so as to break the link and only doses superior to 2×10^{18} are able to break this link. The increase of Hydrogen atoms per cubic cm. is given by the specific linking agent of PVC.

Up untill this moment we've been talking about PVC, but with this we must not intend ordinary normal plastic, but rather about a resin of PVC that during production is submitted to particular treatments so as to difference it considerably from normal PVC: it would be impossible to construct this "alloy" with the normal resin and neither would be have acheived a distorsion temperature of over 120° celcius.

As absorbers Boron at 99-98 % and Boron carbide for the neutrons have been used; lead for gamma rays. All three of these prime matters must be absolutly free of even the smallest imperfection.

We thank the experts of ENEA's TRIGA SERVICE for their collaboration and at the same time we will continue to improve further in the future the characteristics of VIPRO, because, as a consequence of the work done, we believe that the history of using plastic matters in nuclear energy is susceptible to remarkable development taking in consideration the rapid evolution and the continues technical improvement of the industrial production of polymers.