THE USE OF EKOR™ TO STABILIZE FUEL-CONTAINING MATERIAL AT CHERNOBYL

Paul Childress, EUROTECH, Ltd.

ABSTRACT

One positive result from the accident at Chernobyl is the development of a family of new materials, EKOR™, that isolate radioactive contaminants and prevent their migration. These unique composite polymers were initially developed in Russia and are proving successful in encapsulating a pile of highly radioactive fuel-containing material. EKOR polymers are now being commercialized for application to help solve a broad spectrum of nuclear waste management problems.

BODY

The accident at the Chernobyl Power Station, north of Kiev, Ukraine, in 1986 resulted in tremendous damage and instability in the Unit 4 reactor structure and large quantities of debris within and adjacent to the structure that contain exposed irradiated nuclear fuel. The great majority of exposed fuel and debris were collected into piles of so-called fuel-containing material that dot the floor of the building. The inability of the structure, even after construction of a sarcophagus (or shelter), to prevent environmental migration of radioactive material, either by airborne or ground water mechanisms, is a significant threat to surrounding lands and to the aquifers and tributaries that flow into the Dnieper River. The Dnieper later flows through Kiev on its way to the Black Sea.

Fig. 1 Shelter Roof Showing Exposures that Allow Rain to Enter

Soviet/Ukrainian engineers constructed and maintain a sarcophagus or "Shelter" on Ch-4 with limited international assistance. The Shelter's objectives were to provide limited confinement of the remaining Ch-4 reactor such that the remaining operational reactors could be safely utilized and environmental threats to the local ecology minimized. The Shelter was developed to provide an emergency short-term respite while a long-term solution was found. Funding from the G-7 countries and others was to be marshaled into an efficient international remediation effort that would, if not fully remediate the site, at least make it safe for occupational habitation and remove its threat for off-site environmental hazards. Shortly after the accident Russian scientists embarked on an effort to develop materials that could be used to encapsulate the piles of fuel-containing materials and to prevent airborne or groundwater migration of any radioactive material deposited on the surfaces of the facility and its equipment.

Of particular concern was the exposure to the environment of several piles of once-molten fuel-containing material under the reactor in a section known as the Bubble Pool. The contact doserate of these piles is approximately 1000 R/hr. This area was exposed to water that presented potential danger of criticality and possible migration of radionuclides by airborne and groundwater mechanisms. The encapsulation of these piles was further complicated by a requirement to leave open the potential for removal of the material for safe disposal or reprocessing.

Fig. 2 Pile of Lava-Produced Fuel-Containing Material in Bubble Room Area

Scientists within the Institute of General and Nuclear Physics (a Kurchatov Institute entity) and the Euro-Asian Physical Society (EAPS) set as their goal the development of a geopolymer that would be resistant to damage induced by radiation and harsh chemical environments. This material could then be used to encapsulate radioactive waste or fix the contamination in place to allow safe remediation. Following collapse of the Soviet government and complete loss of federal funding, this research project was nurtured by investors from the American company Eurotech Ltd. The resultant product was a silicon-based geopolymer that had some amazing properties. This material combined with a variety of fillers and crosslinkers to create a family of products known by the generic name EKOR™, a Russian acronym for ecologically safe. EKOR has been previously described in past papers and is patented in the U.S., Russia and other countries. Types of EKOR include Sealer for macroencapsulation, Coating for fixative uses, Matrix (with versions for microencapsulation of dry or wet waste), Grout (for thick sections and aggregate use) and Foam for cavities. Each type has subtypes for specific applications.

The first task requested of EKOR for initial application at Chernobyl was to encapsulate one of the largest piles of fuel-containing material in the Bubble Room. Under the agreement with the Ukrainian Shelter Organization a joint task force was formed. Eurotech's participation was to identify the right form and supply appropriate quantities of EKOR to cover the target pile. The Shelter organization provided the technology for delivery and application of the EKOR on the pile. Objectives of the task force were to test EKOR's behavior in an intense gamma-neutron radiation environment and to develop application techniques using remote methods.

The type of EKOR selected for this task is a sealer with low viscosity. The pile was to be initially covered by a fiberglass net and 10mm spacers to minimize the sealer that would penetrate the debris. After the net was in place the sealer was to be applied by simply pouring over the net until complete coverage was obtained and there was substantial overlap with the concrete floor. In this application the sealer had to be able to fill the crevices and roughness of the net and form an environmental barrier to the atmosphere, adhere to the concrete and extend the barrier to prevent air/water migration, and to maintain this barrier in the high-radiation environment for years. There was no attempt to make the barrier a uniform thickness, only to ensure complete coverage. The final thickness was in the order of 15-25 mm. The project was performed on March 29, 2000.

Fig. 3 Pile of FCM After Encapsulation by EKOR™

The Kurchatov Institute continues to work on development of more efficient robotic delivery carts as shown in Figure 4. Periodically, Shelter personnel have gone back into the Bubble Room to check on the integrity of the barrier. They perform a comprehensive visual examination and physically check the resiliency of the material. As of early February 2001 the material has performed as expected with no loss of integrity. EKOR materials have been tested for up to $10x10^9$ Rads without showing significant degradation in its encapsulation function. This test translates to over a thousand years at the 1000R/hr environment of the pile, so its radiation field was not expected to be a problem.

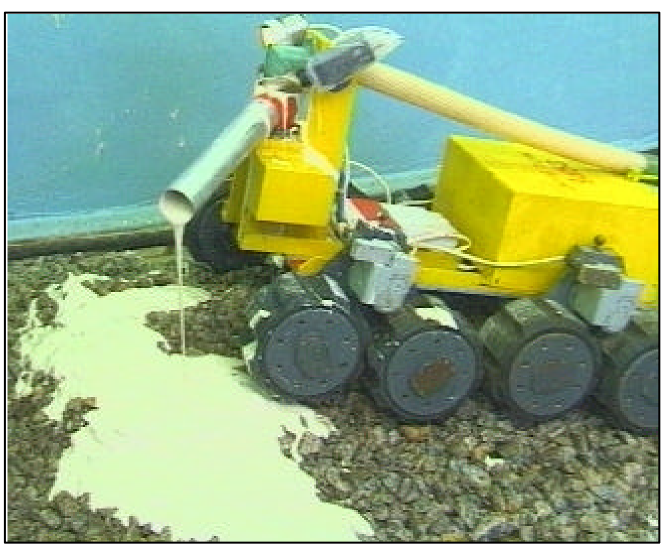

Fig. 4 Robotic Application in Mock-up

In late 2000 the Ukrainian Shelter organization issued a certificate of compliance for EKOR materials. This certificate approves EKOR materials for further applications at the Shelter. Eurotech anticipates that further applications will involve nearly every type of EKOR.

The EKOR used at Chernobyl was produced in Russia. However, Eurotech completed a technology transfer in 2000 that now provides for United States based production. The American forms of EKOR are being tested and the results to date confirm the unique properties of EKOR. Although the uses in the U.S. will not be as drastic as the use at Chernobyl, we believe that EKOR will be an effective tool to help solve many of America's waste management problems.