Paris, 19 July 1999
OLIS : **19-Jul-1999**
Dist. : **19-Jul-1999**

NEA/COM(99)6

SUCCESSFUL INTERNATIONAL EXPERIMENT ON LIMITING CONSEQUENCES OF SEVERE NUCLEAR REACTOR ACCIDENTS

On 6 July 1999 a large-scale test involving the melting of real fuel material of a light water reactor core was successfully carried out as part of the Rasplav project at the Kurchatov Institute in Moscow. This experiment, the last in a series of four, was performed within the framework of the first OECD Nuclear Energy Agency (NEA) sponsored project set up in Russia in the area of nuclear safety. The project addresses overheating of the reactor vessel under severe nuclear accident conditions. It has been designed to ensure that the results generated will be of relevance to the reactors operating in NEA Member countries as well as to Russian-designed pressurised water reactors (VVER). Furthermore, the project is applicable to both current and future reactor designs.

During the test, core material was heated to over 2500C under controlled conditions, and was kept in a steady state at this temperature for about 3 hours. The test vessel was cooled externally in a controlled manner to simulate external cooling of the vessel in a severe accident. All measuring and engineering systems functioned normally during the experiment. The post-test examination will consist of sectioning the solidified material and performing metallographic examination to gain information yielded by the test. Already it is clear that complex physical and chemical phenomena have been observed in the tests to date. All major nuclear safety organisations in OECD countries are actively using the results of the project to further develop computer models which will be used to assess the situation in their power reactors. There will be a conference in Germany at the end of the year 2000 to present the results.

The Rasplav Project brings together 16 NEA Member countries and Russia in the first Agency-sponsored joint nuclear safety project to be carried out in a non-Member country. The participating Russian organisations are the Russian Research Centre 'Kurchatov Institute', the Russian Ministry of Atomic Energy, the Ministry of Science and Technology Policy and the Federal Nuclear and Radiation Safety Authority of Russia. Rasplav is a major international nuclear reactor safety undertaking which started in July 1994, and is now in its second phase, due to end in June 2000. The experimental work is carried out in the Kurchatov Institute, the analytical work is done in the Institute of Nuclear Safety (IBRAE) of the Russian Academy of Sciences, and design work and some testing work is done by other organisations in the Moscow region.

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Rasplav is the latest link in a chain of international projects aimed at refining strategies for maintaining the integrity of reactor pressure vessels in the highly improbable event of a core meltdown. Retaining the integrity of the reactor pressure vessel for such accidents, which are estimated to have a probability of occurrence of less than 1 in l0000 years of reactor operation, will help prevent the release of radioactive material to the environment.

A background note on the Rasplav project is attached.

Annex

BACKGROUND NOTE

Introduction

The Rasplav project is concerned with behaviour of the lower head of the reactor pressure vessel during severe accidents leading to core meltdown. The Rasplav project may be regarded as a successor to the OECD Three Mile Island (TMI) Vessel Investigation Project which was completed in 1993. That project was set up to examine and assess the condition of the actual TMI lower head and thus offered a unique opportunity to study a severe accident in a commercial nuclear power plant. However, in order to better understand and model the complex phenomena taking place during interaction of molten fuel with the reactor vessel lower head, it is also necessary to reproduce this interaction in a controlled environment where the governing parameters can be varied over the range of interest. This is the main aim of the Rasplav project.

Technical background

During a core melt accident, the core debris will relocate to the bottom of the reactor vessel. In the absence of any cooling of this debris, the heat generated would eventually overheat the reactor vessel, which would fail, thereby releasing the corium (molten core material) to the lower containment. There is interest in two aspects of the issue. First, for existing reactors, when external cooling may not be practicable, there is a desire for a better understanding of the phenomena and of the time before the molten fuel penetrates the vessel and discharges to the reactor containment, to assist in the development of severe accident management strategies. Secondly, for future designs where external cooling in severe accidents is being considered at the design stage, and for some existing reactors, there is a need for a better understanding of the complex interactions to demonstrate that cavity flooding is a viable accident management option.

Details of the tests

The Rasplav project uses prototypical materials (real core material components and vessel steel) in large quantities and at temperatures representative of a core meltdown accident. This assists in understanding the chemical reactions, which are very complex, and contributes to understanding the natural convection processes. The design of this main integral test facility is a model of the reactor vessel, filled with 200kg corium, in the form of a slice through the lower head. The corium is electrically heated with graphite induction heaters in the planar side walls, protected from the corium by layers of tantalum and tungsten. The vessel section is cooled by water.

There are supporting smaller scale experiments to study material properties and chemical interactions, and to investigate the technological aspects of the larger Rasplav experiment. These have supplied necessary design information for Rasplav.

The Rasplav programme involves several molten fuel structural experiments. The technical objectives include:

- determining material properties such as emissivity, viscosity, and density to aid predictions of the volume, the composition, and the temperature of the core melt;
- evaluating the interaction of molten core material with the vessel lower head and determining the heat fluxes imparted to the lower head;

- exploring the effect of scaling, in order to assure that the experimental data will be suitable for application to full size vessels.

Measurements made in conducting the experiments include:

- Melt temperature measurements in the Rasplav furnace and in the vessel lower head;
- Heat flux measurements.

The information from Rasplav complements the database obtained from other experiments and projects that provide information related to vessel failure, such as the OECD TMI Vessel Investigation Project, and the European Union sponsored the Melt-Vessel Interaction Project.

The following OECD countries with nuclear power programmes participate: Belgium, Canada, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Republic of Korea, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom and the United States.

The budget is $5 million in total, over a three year period. The second phase of the project started on the 1st of July, 1997.