SECY-97-027

February 3, 1997

FOR: The Commissioners

FROM: Hugh L. Thompson, Jr. /s/
Acting Executive Director for Operations

SUBJECT: NRC PARTICIPATION IN THE OECD/NEA SPONSORED RASPLAV-PHASE II PROJECT AT THE RUSSIAN RESEARCH CENTER (I.V. KURCHATOV INSTITUTE)

PURPOSE:

To inform the Commission of the staff's plans to participate in a follow on RASPLAV project (PHASE II) at the Russian Research Center (I.V. Kurchatov Institute). Also, to inform the Commission of the RASPLAV-PHASE I results and their significance, as well as the objectives of the proposed PHASE II program.

DISCUSSION:

In a memorandum to the Commission, from James M. Taylor, dated April 22, 1994, "Status of the OECD/NEA Sponsorship of the RASPLAV Project at the Russian Research Center (I.V. Kurchatov Institute)", the staff provided the details of technical and financial discussions, including the agreement reached between OECD/NEA and the Russian Research Center, which led in July 1994 to the official initiation of the OECD/NEA sponsored RASPLAV project. The duration of the project agreement was three (3) years and the NRC's financial contribution was $932,000 over that period for phase I, including $110,000 in FY 97 funds. The key objectives of the project are to perform experiments with prototypic materials (i.e., reactor materials under very high temperature), to measure the heat loads to the reactor pressure vessel (RPV) under severe accident conditions (molten pool natural convection), and to assess the effects of materials interactions under these conditions. This information is critical to the issues associated with the retention of a molten core inside the RPV by cooling from the outside. Also, in a memorandum to the Commission, from James M. Taylor, dated October 28, 1996, "Status of OECD RASPLAV Project to Investigate Molten Reactor Fuel-Lower Pressure Vessel Head Interaction," the staff informed the Commission of the progress made in the RASPLAV project, and more specifically, in the RASPLAV integral experiment (RASPLAV-AW-200 experiment) which was successfully performed on October 9, 1996. This large-scale experiment represented a first-of-a-kind (anywhere in the world) in which actual core materials were used at temperatures prototypic of actual severe accident conditions and was the result of extensive development and innovative engineering by the Russian Research Center. In the October 28, 1996 memorandum to the Commission, the staff also summarized the additional experiments which are planned for FY 1997 before the completion of PHASE I of the RASPLAV project in June 1997.

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Based on the results achieved so far, it has been concluded that the main objectives of the RASPLAV project PHASE I have been achieved. In order to further our experience and understanding of the physical phenomena and chemical interaction taking place in high temperature convective corium pools, the member countries participating in the RASPLAV PHASE I project have been exploring and discussing the merits of a follow-up RASPLAV program (i.e., PHASE II). More detailed information regarding the accomplishments of the RASPLAV PHASE I project, their significance to reactor safety, and a summary of the objectives of a follow-up RASPLAV program (i.e., PHASE II), are included in the attached paper prepared by Dr. T.P. Speis and Mr. T. King of the Office of Nuclear Regulatory Research (RES) at the request of OECD/NEA, for appropriate use by member countries participating in the RASPLAV PHASE I project.

Based on the staff's evaluation of the benefits to NRC of a follow-up to the RASPLAV project we plan to express our intention to participate in RASPLAV PHASE II project. Expressions of intent are also being sought from other member countries, and informally all have expressed their intention to participate in PHASE II. In addition, the Department of Energy has informed us of their interest in participating in RASPLAV PHASE II. We are currently discussing terms and conditions of their participation. OECD intends to draft an agreement for PHASE II and present it for signature at the next RASPLAV Management Board (MB) meeting, which is to be held in Paris, on April 8-9, 1997.

RESOURCES:

With the assumption that most western countries plus Japan will participate in PHASE II, it is estimated that NRC's total share of this cost would be approximately $800,000 over a 2.5 year period. The FY 1998 Green Book includes an additional $140,000 in FY 1997, and $320,000 in FY 1998 for PHASE II. FY 1999 funding ($340,000) to complete the Phase II work will be addressed during formulation of the FY 1999 budget.

COORDINATION:

This paper has been coordinated with the Office of the Chief Financial Officer and the Acting CFO has no objections to the resource implications.

I will keep the Commission informed of the status of the RASPLAV PHASE II project following the April RASPLAV MB meeting.

Hugh L. Thompson, Jr.

Acting Executive Director for Operations

Attachment: 1. Paper on "Technical Achievements and Significance of the OECD RASPLAV Project"

ATTACHMENT 1

TECHNICAL ACHIEVEMENTS AND SIGNIFICANCE OF THE OECD RASPLAV PROJECT

BY
THEMIS P. SPEIS
and
THOMAS L. KING

Introduction / Background

July 1994 was the official beginning of the OECD RASPLAV project. The project agreement was ratified by 14 OECD Member countries and called for a series of integral tests with prototypic core materials and with molten salt as well as smaller scale separate effect tests to measure material properties and explore other phenomena of interest. The duration of the project is 3 years. The objectives of the project are to perform confirmatory experiments with prototypic materials (i.e., reactor materials under very high temperature) and with molten salt to measure the heat loads to the reactor pressure vessel (RPV) under severe accident conditions and to assess the effects of materials interactions under these conditions. This information is important to the development of accident management strategies dealing with the retention of a molten core inside the RPV.

To date one large scale (200 kg) integral corium test has been performed along with two smaller scale (12 kg and 40 kg) integral corium tests. Ten integral tests using molten salt and numerous small scale experiments to measure material properties and material interactions have also been conducted. Still to be performed is one additional large scale (200 kg) integral corium test and approximately ten additional integral molten salt tests prior to the expiration date (June 30, 1997) of the agreement. As a result of the success of the first large scale integral corium test, interest has been expressed in extending the project beyond its current expiration date to further enhance our understanding and confidence in working with real reactor materials, including the exploration of additional phenomena (e.g., stratification) and parameters (e.g., corium compositions) not included in the first test series.

Even assuming a successful completion of the remaining experiments, relevant questions which need to be addressed before extending the project are: (a) how well have the general program objectives been met, and (b) what would be the objectives of a follow-up RASPLAV program. First, in terms of the exact number of large-scale (200 kg) tests of corium initially envisioned, the program fell short of its objectives, even though it can be argued that of the total number of 5 tests envisioned, 4 will have been completed by June 30, 1997, although two of them of smaller scale. To a large degree, this was the result of more extensive preparations than originally envisioned, including exploring different heating methods and structural materials, as well as the development of high temperature instrumentation. However, these more extensive preparations resulted in the success of the first large scale test and will help ensure the success of the remaining tests. In addition, an extensive data base of material properties and information related to molten corium technology has been produced. Accordingly, the program has met exceedingly well a number of important objectives associated with the issues of in-vessel retention of a molten core. Among these are:

(1) Experience in handling and working with "real" material at "Relevant" conditions. It is the only way to understand these materials and this has not happened before;

(2) Substantial increase in our understanding of reactor type material interactions and our ability to control these interactions at the "relevant" conditions;

(3) Measurement of materials properties up to the "relevant" conditions;

(4) Determining heat transfer behavior in regimes ranging from conduction, to melting and mixing, to as high a natural convection regime as possible;

(5) Providing additional confidence and perspective regarding the ability for in-vessel retention of a degraded/molten core.

Specific technical achievements of the RASPLAV project and their significance are discussed below.

Technical Achievements

The RASPLAV project has had technical achievements that fall into two broad categories: (1) those associated with the development of a unique test capability, and (2) those associated with conducting experiments and measuring physical properties.

Specifically these achievements can be summarized as follows:

UNIQUE TEST CAPABILITY

- development of a heating technique and of structural materials to contain molten corium at temperatures up to 2800C and establish and maintain natural convection in the molten corium;

- development of instrumentation capable of working for extended periods of time at the test temperature;
- development of test equipment capable of measuring the physical properties (e.g., thermal conductivity, viscosity, etc.) of molten corium;
- development of analytical tools to help in the design of the tests, as well as to predict test results;
- development of a team of people capable of designing, analyzing and conducting such a test program.

EXPERIMENTAL MEASUREMENTS

- physical property measurements of various molten corium compositions (C-22, C-50, C-100);
- material interaction tests between molten corium and various structural materials;
- heat transfer rate to the RPV test wall (as a function of angle) under natural convection conditions using molten corium of uniform composition (C-22). One test has been run and a second test is planned for April 1997;
- heat transfer rate to the RPV test wall (as a function of angle) under natural convection with crust formation on the boundary using molten salt that can be compared with and used to extend the range of the test data from the corium experiments;
- post test examination of the 200 kg corium test.

Significance

The technical achievements have major significance for reducing uncertainties and confirming the validity of using ex-vessel flooding as a means of retaining a molten reactor core in the RPV. The technical achievements also have advanced the state-of-the-art in experimental capability to conduct and control experiments with real materials under prototypical conditions (e.g., high temperatures). As such, the RASPLAV facilities and experiments are first of a kind unique facilities that have provided and continue to provide data that cover the range of conditions (corium composition, temperature, etc.) of interest. This will allow, with high confidence, safety decisions on the viability of retaining molten core material in the RPV. The significance of the technical achievements includes:

- obtaining heat transfer data based on measurements with real materials at high temperatures;
- experience in working with real materials so as to uncover any new phenomena that may not have been uncovered in previous experiments with simulant materials;
- experience in working with real materials so as to determine the extent, if any, of chemical interactions between corium and the RPV. Such chemical interactions can only be obtained with real materials;
- direct comparison of the heat transfer rate obtained from corium experiments with that obtained from salt experiments, so as to extrapolate data to full size reactor conditions.

In addition, actual material properties data have been measured which will improve the capability to analyze a full scale reactor. Facilities and a team of dedicated experimentalists and analysts have been assembled with the capability to explore the range of conditions of interest so that all remaining open questions can be addressed. A recent report on the RASPLAV project (RP-TR-24) provides more detail on the specific accomplishments to date and additional background on the project.

The limited amount of results so far are in broad agreement with simulant experiments and have not revealed any new phenomena. However, they do not cover important aspects such as stratification which cannot be represented in simulant experiments. The success of the initial simple experiments, together with the development of successful melt technology, provides a good basis for moving on to more complex experiments involving, for instance, melt stratification.

Objectives of a Followup RASPLAV Program

The objectives of any followup RASPLAV program should be to further our experience and understanding in working with real materials, focusing on:

- the effects of different corium compositions;
- the potential for and effects of material stratification;
- the effects of variations in boundary conditions (e.g., top surface heat removal)

In addition, obtaining data at reactor scale Rayleigh Numbers ($\sim 10^{16}$) using molten salt should be pursued so as to fully utilize the simulant capability (e.g., crust) and to avoid the need to extrapolate data. Therefore, a followon RASPLAV program can build upon and take full advantage of capabilities developed in the initial phase to fully explore the phenomena of interest and provide relevant information to address the remaining uncertainties associated with in-vessel retention of a degraded core.