Sandia National Laboratories
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February 19, 1981

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FEB 27 1981
U.S. NUCLEAR REGULATORY COMMISSION

Mr. Richard Sherry
U. S. Nuclear Regulatory Commission
Fuel Behavior Research Branch
Division of Reactor Safety Research
MS 1130 SS
Washington, DC 20555

Dear Rick:

Enclosed are the status reports for the month of December for t·e core melt programs.

Sincerely,

Marshall

M. Berman, Supervisor
Reactor Safety Studies
Division 4441

MB:4441:pr

Enclosure

I. Steam Explosions

During the last week of November and the first week of December, a series of meetings were held in the Federal Republic of Germany at Kernforschungzentrum, Karlsruhe; the Annual KfK Colloquium, the German-American Information Exchange Meeting, and the OECD-CSNI Vapor Explosion Specialists Meeting. A discussion topic at each of these meetings was the steam explosion research being conducted at Sandia. Marshall Berman, along with Richard Sherry of NRC, presented a summary of the Sandia steam explosion research accomplishments at the Annual Colloquium.

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The paper was well received at the FRG-US information exchange meeting. More detailed presentations were made by Mike Corradini and Dennis Mitchell concerning steam explosion modelling and the first Fully Instrumented Test Series (FITSA). The discussions following the presentations indicated that the German researchers were interested in continued large scale experiments using prototypic reactor simulants (e.g., Corrium-A). If these tests indicate lower explosion conversion ratios, and further analysis could explain this, this would be further evidence of the unlikelihood of containment failure due directly to steam explosions.

The following week at the CSNI meeting, presentations were made by Lloyd Nelson and Mike Corradini concerning the single droplet experiments and the analysis of these tests and the FITS tests. Because this meeting also involved reseachers in vapor explosions from the LMFBR community, the discussions centered upon the fundamental mechanisms rather than on the specific reactor system. Our presentations were well received; however, from the discussions, there arose two distinct philosophies on how to conduct future research. The first veiwpoint could be summarized by these statements:

- We need a complete understanding of the rapid fuel fragmentation mechanism to adequately judge if vapor explosions are of significant importance to reactor safety. In the interim, the damage potential from such explosions should be modelled by the Board-Hall steady-state vapor detonation model.

The second viewpoint could be characterized by these statements:

- In the current time frame for LWR and LMFBR safety (next few years) a complete understanding of the fundamental mechanisms for vapor explosions cannot be expected. Therefore, we must rely on experiments (both small and large scale with prototypic materials if possible) with supporting analysis to demonstrate if we can get large conversion ratios from a vapor explosion. This analysis, by its very nature, will be somewhat empirical, because not all the detailed mechanisms are known. As our knowledge grows, if time allows, our empiricism will diminish.

We agree with the second viewpoint because our experiments with supporting anlysis have already been successful in regard to LWR safety issues.

During December, the first fuel-coolant interaction test without a steam explosion (FITS1G) was conducted. Pretest analysis indicated that the pressure rise time in the FITS chamber due to vigorous boiling would be between a few seconds to a minute and the peak pressure would be about 50-60% of the thermodynamic maximum ($\sim$ 0.5 MPa). The actual results indicated a pressure rise time of 20 sec with a peak pressure of 0.34 MPa. Data reduction and further analysis is underway.

Also in December, the trigger energy in the single droplet experiments @ 1.1 MPa was doubled and an excplosion using $FeO_{1.3}$ was induced. This verfies at small scale what Mitchell had observed in FITS test 5A.

II. Core-Concrete Interactions

During this month, we continued the analysis of the code comparison test, CC-2, using CORCON-MOD1. The qualitative trends of the CORCON calculation are identical to those calculated for test CC-1. First, the steel melt and the associated light oxidic melt temperatures fall very rapidly within 200-300 sec, to nearly steady-state values. Following this initial decrease, the predicted temperatures remain essentially constant, suggesting a state of equilibrium between energy deposited in the melt by induction and energy lost from the melt by heat transfer. However, the data exhibit an initial temperature drop that is ~ 50 k greater than that predicted by the code. The experimental temperature data then steadily increase at a rate of ~ 4.6 K/min for CC-2.

The major difference between CC-1 and CC-2 is that the data for CC-2 show a greater pecentage increase in the melt temperature (and, therefore, the melt enthalpy) than in the increased induction power deposited in the melt. This indicates to us that these data sets are somewhat inconsistent. In CC-2, the induction power deposited in the melt, $P_I(t)$ is greater than in CC-1. This would then allow the melt layer to be maintained at a higher bulk temperature and total enthalpy $H(T_{melt})$; this temperature increase would also increase the heat transfer rates from the melt. Therefore, the incremental increase in melt temperature and enthalpy, $\Delta H(T_{melt})$ cannot exceed the incremental increase in deposited induction energy, $\Delta P_I(t)$,

$$\int_o^t \Delta P(t)dt \geqslant \Delta H(T_{melt})\Big|_t$$

But the data for CC-2 show the exact opposite trend. Our current explanation for this observation is that these incremental differences are of the same order of magnitude as the experimental errors. Work is continuing to address this.

CORCON-MOD1 was set up and run on a VAX computer to check for possible numerical problems associated with starter wordlength (the VAX carries 7 figures in single precision while the CDC7600 carries 14). As we had expected, there were some discrepancies, mostly associated with the geometrty package. However, they were small ($< 1\%$) and showed no tendency to accumulate significantly. Therefore, we determined to delay improvements in this package until MOD2.

In the course of this exercise, a few minor bugs were found and corrected. We are now reasonably confident that no difficulties will be encountered in using CORCON-MOD1 on other non-CDC equipment.

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