MASTER

SAND--77-1096C
CONF-771109--36

FIRST IN-CORE MOLTEN FUEL POOL EXPERIMENT*

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If during a LMFBR accident a fuel debris bed is not adequately cooled by overlying sodium and dryout occurs, then the fuel would heat up and melt. Molten fuel pools are of concern due to their potential for ablation of the supporting structure and possible penetration of the reactor vessel.

A number of experimental techniques have been utilized to measure heat flow within simulated molten fuel pools.[1-3] However, heating methods, or materials, only approximately simulated the accident situation in which decay heated oxide fuel contacts structural materials. Experimental information is required on the interaction of volumetrically heated molten fuel pools with supporting structure and on heated fuel crust behavior under the complex melting processes occurring at the boundaries of the pool.

The major goal of the molten fuel pool program has been to develop a versatile experiment in which heat flux and structural ablation could be studied using real materials under typical temperature and heating conditions. This has now been accomplished, using the Annular Core Pulse Reactor (ACPR) to fission heat enriched UO_2. In the first experiment conducted, a small portion of a 0.834 kg UO_2 sample was melted, and temperature data were recorded to above the melting point of the UO_2 using ultrasonic thermometry.[4]

The experiment capsule, shown in Fig. 1, held the granular UO_2 (100 to 1000 μm particle size) in a 3.2 mm thick ThO_2 crucible which, in turn, was surrounded by two tungsten crucibles and low

*This work was supported by the United States Nuclear Regulatory Commission.

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density (960 kg/m^3) ZrO_2 insulation. The capabilities of these materials under the experimental conditions were determined in an out-of-core material compatibility study.[5] The fuel bed was 57 mm in diameter and initially 51 mm in depth. Fuel bed specific power was about 2.4 kW/kg at an ACPR power level of 600 kW. Containment of gases and vapors was provided by a concentric pair of 2.54 mm thick steel vessels surrounding the inner crucibles. Cooling air flow was maintained by an aluminum air flow guide surrounding the outer steel vessel.

System diagnostics included pressure transducers, thermocouples, and ultrasonic thermometers. Tungsten-rhenium thermocouples were used to monitor fuel and crucible temperatures, while chromel-alumel thermocouples were used on the steel vessels. Two ThO_2-sheathed tungsten ultrasonic thermometers were placed near the axial centerline of the fuel bed. Each ultrasonic sensor was designed to measure temperatures over 5 axial zones, each about 10 mm long. During the experiment, the ultrasonic thermometer data were sent to the Data Acquisition and Display System (DADS) computer for real time conversion and display.

Fuel temperature histories were obtained from both ultrasonic thermometers and thermocouples. The ultrasonic thermometer data indicated incipient fuel melting was reached after 16.5 min. at power. Heating of the fuel was terminated approximately one minute later. Thermal neutrons were not specifically filtered in the experiment; therefore, the energy deposition was peaked on the edges of the fuel. However, as predicted by calculations, the ultrasonic thermometers showed that the fuel temperatures were not peaked at the edges, but were approximately 250 K higher at the center.

This experiment demonstrated that volumetrically heated fuel pool studies utilizing fission heated UO_2 are practical within ThO_2

containment and that ultrasonic thermometry has the capability to measure fuel temperatures and temperature gradients through melting of the fuel to provide relative heat fluxes. In future experiments, a larger fraction of the UO_2 sample will be melted, UO_2-steel mixtures will be studied, and additional ultrasonic thermometers will provide radial as well as axial temperature gradients.

References

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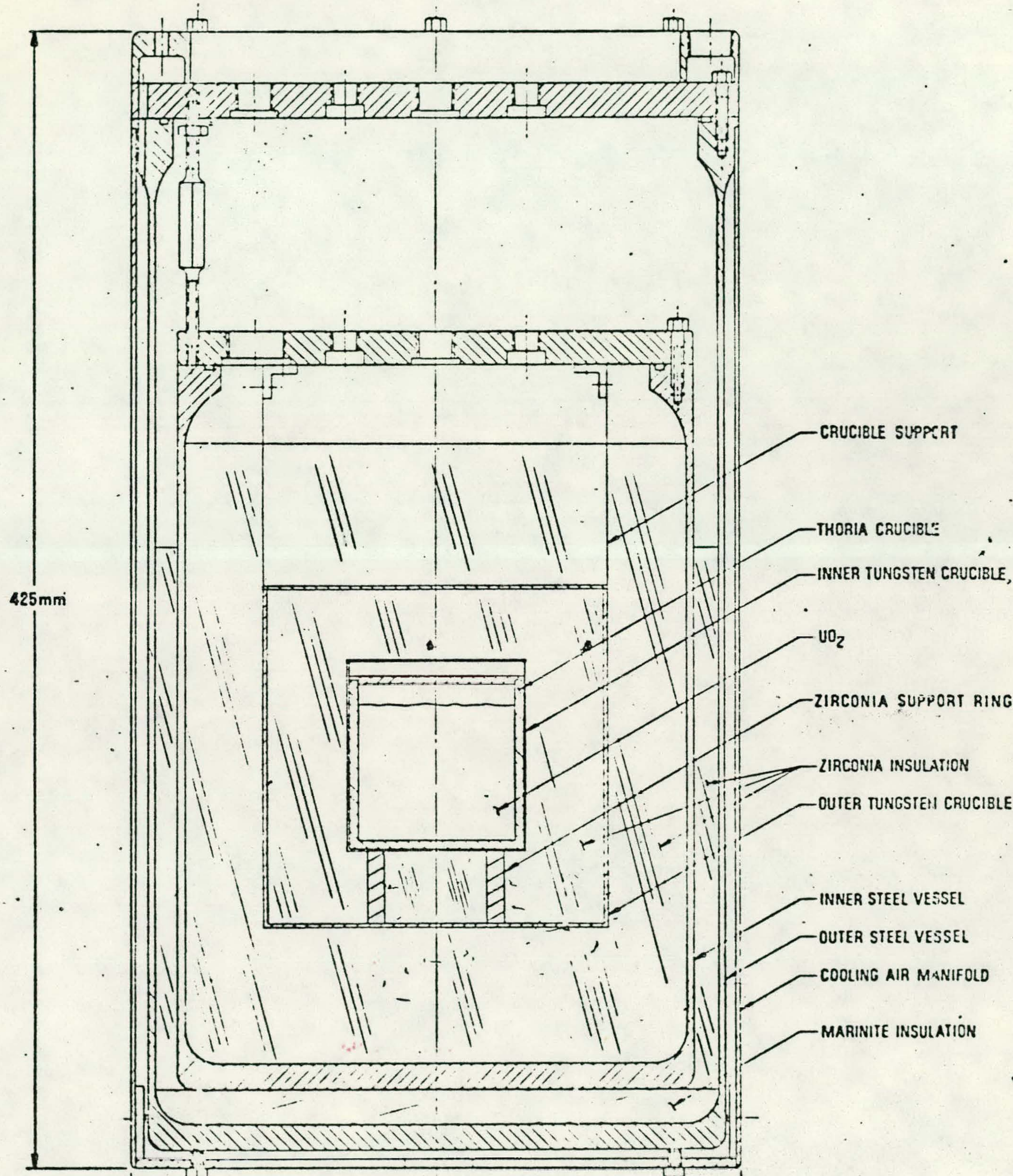
SMALL CAPSULE EXPERIMENT PACKAGE
(FUEL-ONLY EXPERIMENT)



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