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Those on Attached List

Subject: Ninth Monthly Report by NRC Resident Engineer at Kernforschungzentrum, Karsruhe, Germany

Gentlemen:

The enclosed pages (replacement pages 2 and 3) were inadvertently omitted in the typing of the last (ninth) monthly report.

Sincerely,

W. V. Johnston

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Fuel Behavior Research Branch
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(5) T. Dullforce, J. Reynolds, and R. Peckover, "Interface Temperature Criteria and the Spontaneous Triggering of Small-Scale Fuel-Coolant Reactions". The authors considered temperature interaction zones for low melting fuel simulants to determine the temperature regimes within which spontaneous triggering might occur. These interaction zones compare well with experiment. The theory was then extrapolated to the UO_2/Na and steel/Na systems to determine the maximum size of the temperature regimes for spontaneous triggering.

(6) H. Goldammer, H. Hohmann, H. Kottowski, and M. Mol, "Simulation of the Thermal Fuel-Coolant Interaction in Laboratory Tests for Water Cooled Reactors". These experiments have been previously reported. In summary: explosions have been repeatably produced in a shock tube (mass up to 150 gram, pressures to 25 bars), but have not yet been produced in a tank facility.

(7) G. Fieg and H. Werle, "Model Experiments on the Thermodynamics of Core Meltdown". These experiments were conducted at KfK to study the behavior of convection cells and melt-front expansion in a soluble bed.

The correlations of Mayinger and Baker were not well confirmed by the convection cell experiments (discrepancy > measurement errors). Further experiments are required to explain the discrepancy.

In the melt-front experiments it has been shown that the radial advance is almost independent of density ratio, whereas the vertical advance is decisively dependent on this ratio. When the density of the bed is lower than that of the melt, conventional convection cell theory is in good agreement with experiments. This is not true, however, when the density of the bed exceeds the density of the melt.

(8) H. Reincke, L. Rinkleff, and R. Schramm, "Heat Transfer between Molten Core Material and Concrete". This paper describes the discrete bubble model, which has been previously reported in this series.

(9) W. Doerr and M. Peehs, "Thermal Properties and Resistance of Reactor Concrete with Respect to Core Meltdown". Effective heat capacity as a function of temperature was measured by a calibrated laser heating method. C_p of silica concrete varied from 0.9 J/g/K at room temperature to 1.88 J/g/K at 1100° C. The thermal diffusivity was also measured as a function of temperature, and from this a thermal conductivity varying from 0.016 W/cm/K at 50° C to 0.011 W/cm/K at 300° C. Silica concrete shows excellent excellent thermal shock resistance.

Tests of silica concrete with heated corium and corium constituents showed that the attack of a prototypical melt on concrete is purely thermal; no chemical or metallurgical reactions occur that might lower the melting point.

The illustrations in this paper are unfortunately very small and not suited for reproduction. Thermal expansion, density, conductivity, heat capacity and diffusivity are given.

(10) K. Hassmann, J. Artnik, M. Peehs, and P. Hosemann, "The Significance of Hydrogen Formation in Hypothetical Core Meltdowns". Following experiments on reactions between metal melts and gases liberated from concrete, the oxidation reactions were modeled. The simplifying assumption of 100% reduction of the liberated gases was made. Reaction kinetics were ignored; their effect should be slight.

Calculations of the attack of a core melt on the reactor base mat indicated that for the first day, H_2 would be added to the containment. Thereafter, only water vapor would be liberated. The exothermic reactions lead to about 50° C increase in temperature after the initial cooling.

Pressure increase in the containment was computed both for continuous burning of the H_2 and for sudden, massive burning. Containment pressures reached 4 bars with continuous burning and 6 bars with massive burning. These pressures are lower than those assumed for bursting of a German PWR containment.

The transactions of Reaktortagung 1978 include 267 papers covering reactor design, safety, fuel cycle, fuels and fuel elements, components, construction and operation, fusion technology, and economics. The publisher is Deutsches Atomforum, E.V., Heussallee 10, 5300 Bonn.

3. Fuel Rod Behavior Research.

The isothermal steam oxidation of Zirkalloy has been experimentally investigated by Leistikow, Schanz, and von Berg /1/ at KfK (IMF). The temperature regime investigated was 700-1300° C. The following equations describe the kinetics of oxygen uptake (τ), growth of the oxide layer (ϕ), α-layer (α), and of the oxide plus α-phase double layer (ξ):

$$\tau = .724\sqrt{t}\ \exp(-10481/T)$$

$$\phi = .280\sqrt{t}\ \exp(-10107/T)$$

$$\alpha = .713\sqrt{t}\ \exp(-10961/T)$$

$$\xi = 1.29\sqrt{t}\ \exp(-11043/T),$$

where t is time (sec), T is temperature (K), and α, ϕ, ξ are in cm.

The results are compared with the Baker-Just approximation in Figure 1 (p.6). It can be seen that the Baker-Just relation is quite conservative, and that this conservatism increases with increasing temperature.

/1/ S. Leistikow, G. Schanz, and H. v. Berg, Kinetik und Morphologie der isothermen Dampf-Oxidation von Zircaloy 4 bei 700-1300° C, KfK 2587, Kernforschungszentrum Karlsruhe GmbH, March, 1978.

4. Forthcoming Events of Interest.

Readers are reminded of the Topical Meeting on Nuclear Power Reactor Safety, to be held at Brussels, Belgium, October 16-19, 1978.

5. Miscellaneous.

By agreement with Dr. W. V. Johnston, the reporting period will in the future be bimonthly. In special circumstances (e.g., when very important results need to be urgently reported), the period will revert to a monthly basis.