LARGE SCALE SODIUM INTERACTIONS

Part 2: Preliminary Test Results for Limestone Concrete*

by

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Any sodium cooled reactor system must consider the interaction of hot sodium with cell liners, and given either a failed liner or a hypothetical core disruptive accident, the interaction of hot sodium with concrete. The data base available for safety assessments involving these interactions is limited, especially for the concrete and failed liner interactions. To better understand what happens when hot sodium comes in contact with concrete, a series of tests is being carried out to investigate sodium concrete reactions under conditions which are similar to actual reactor accident conditions. Tests cover the cases of sodium spills on bare concrete and on cells with defective steel liners. Specific objectives have been to obtain a complete description of the sodium/concrete interaction including heat balance, gas evolution and flow, movement and heat generation of the reaction zone, reaction product formation and the layering or movement of the products.

*Work is supported by the U. S. Nuclear Regulatory Commission.

To meet these objectives, emphasis is being placed on the following measurements:

1. Measurement of the temperature profile of the concrete crucible as well as the temperature of the sodium pool and vapor.
2. Measurement of the quantity and composition of the gases evolved from the sodium concrete reactions as a function of time.
3. Measurement of the penetration rate and total penetration of the reaction zone into the concrete for sodium drops while varying the initial temperature.
4. Identification of the effects of specific engineering features such as the presence of cracks and steel reinforcement on the penetration of sodium into the concrete crucible.
5. Identification of the effects when sodium flows into the vent space between the concrete and its steel liner.

The concrete for this test series meets the current concrete specifications obtained from the Clinch River Breeder Reactor Plant (CRBRP) project and was mixed from raw materials obtained from CRBRP site sources.

Several tests of this series have now been completed. For each test, up to 100 Kg of sodium is first heated to 550C in a separate tank. The sodium is then dumped rapidly (less than 10 seconds) into an instrumented concrete crucible. Fig. 1 shows the approximate locations of the instrumentation transducers. The initial sodium depth in the crucible was 86.36 mm.

Based on the tests completed, the reaction is reasonably quiescent for about 5 minutes. During this time the sodium pool cools to about 450C. Then, the sodium/concrete reaction is sufficiently exothermic to heat the reaction pool to about 800 C (compared to the boiling temperature of sodium of approximately 880C at atmospheric pressure of 83426 N/m^2) in about 10 minutes. The pool temperature remains relatively stable at about 800C for a period of time then cools gradually to ambient.

During a test, reports are heard periodically, followed by the expulsion of gas. It appears that these reports are due to the concrete spalling and the resulting gas from the reaction of the fresh concrete exposed to sodium.

On post test examination the reaction debris consisted of hard, irregularly surfaced material which was difficult to break. The debris appeared to consist of two phases: (1) a light grey material (concrete) and (2) a dark material resembling fused slag. The light grey material was dispersed throughout the black "slag" in layers. The maximum penetration of the reaction into the concrete was about equal to the initial sodium depth in the crucible. Also, in several tests, an annular region of broken-up concrete (without any traces of reaction products) was found underneath the layer of slag-like material. Since there are no reaction products present, it appears that this concrete damage is due to unrelieved thermal stresses present after the sodium-concrete reaction was completed.

Thermal stresses in the crucible during the reaction were strong enough to cause radial cracking of the crucible. These cracks were independent of pre-existing cracks. Slight water leakage from these cracks at the outside edge of the crucible was noted in the oxide layer on the test chamber floor.

In conclusion, several tests have been conducted. Up to 100 Kg of sodium at 550 C has been rapidly dumped into a limestone aggregate concrete creating a sodium pool 86.36 mm deep. The resulting sodium/concrete reaction was sufficiently exothermic to raise the temperature of the reaction pool to about 800C. The erosion of concrete appeared to occur in discrete steps due to spalling. In addition, in the large diameter crucible there appeared to be thermal stress damage to the concrete after the sodium/concrete reaction was completed.

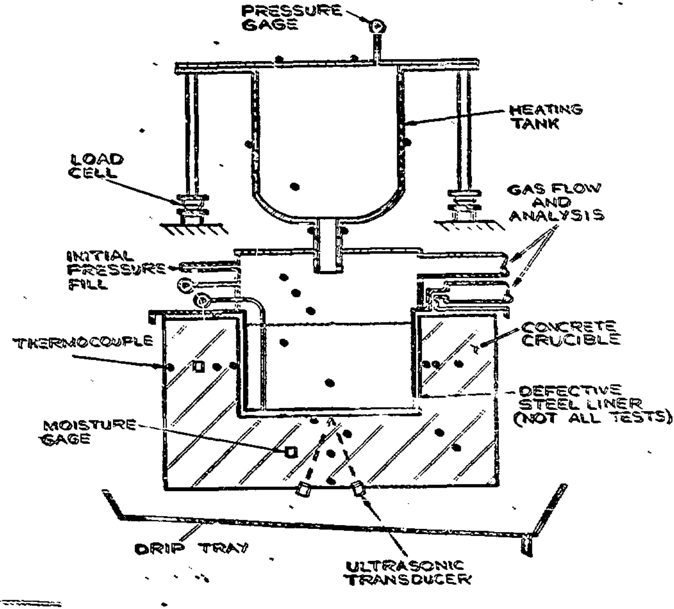

Fig. 1. Test configuration showing the approximate locations of the instrumentation transducers.

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CONF-771107--47

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