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MEMORANDUM FOR: Roger Mattson, Director
Lessons Learned Task Force

FROM: S. Stan Kirslis, Project Manager
Environmental Projects Branch 1, DSE

SUBJECT: TMI INSTRUMENTATION

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In your memorandum of May 31, 1979 you invited the staff to submit ideas for reducing the likelihood of a reactor accident such as occurred at Three Mile Island. The following notions may be useful.

1. Thermocouples Inside the Reactor Core

Voids, whether steam or hydrogen bubbles, could be rapidly detected by a series of thermocouples positioned along the length of a fuel element near the axis of the reactor and extending several feet down into the core. The thermocouples adjacent to voids would read higher temperatures than thermocouples immersed in liquid water (The fuel element near the thermocouples would be the source of heat for the thermocouples).

Besides locating the voids, the measurement of temperatures would warn of the approach to the conditions for hydrogen generation and fuel damage.

2. A Hydrogen Diffuser Tube

This device would be a small diameter closed tube (say 1/4" O.D. and 3/16" I.D.) of stainless steel positioned near the axis of the core adjacent to a fuel element and extending several feet down into the core. The upper end of the tube would be connected to a gas handling manifold to which are attached a vacuum pump, a sensitive pressure gauge and a mass spectrometer designed to measure hydrogen gas.

Hydrogen gas diffuses readily through metals such as stainless steel or nickel, and the rate of diffusion increases exponentially with the metal temperature. The mass spectrometer at normal reactor temperature would give a reading corresponding to the hydrogen level from the radiolysis of water. If the temperature of the tube increased, or if a zircaloy-water reaction generated hydrogen gas, the spectrometer (or pressure gauge) reading would suddenly increase.

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This device would have the virtue of establishing unequivocally whether hydrogen gas was present in the reactor. Of course, this piece of information could also be determined by analyzing the water in the pressurizer.

3. Neutron or Gamma Flux Measurements

If voids form in the core, the shielding value of the displaced water is lost. This loss might be detected by counting instruments inside or outside the core.

4. Dissolution of Hydrogen Gas in the Metal Walls of the Primary System

The thick metal walls of the reactor vessel, the pressurizer, the steam generator, and the associated piping contain hundreds of tons of ferrous metals in which hydrogen gas has an appreciable solubility. The rate of solution of hydrogen in this metal under hydrogen bubble conditions would be of interest for estimating the degree of hydrogen embrittlement of the metal.

There are, of course, many other ways than those suggested above for determining the location and extent of voids in a reactor coolant system. However, those on the Lessons Learned staff with whom I have spoken are aware of these methods, so I will not repeat them here.

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