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August 19, 1983
NRC/TMI-83-053

Docket No. 50-320

Mr. B. K. Kanga
Director, TMI-2
GPU Nuclear
P.O. Box 480
Middletown, PA 17057

Dear Mr. Kanga:

Subject: Response to Core Debris Safety Evaluation Response (SER)

This letter is in response to your addendum to the Underhead Characterization Safety Evaluation in which you propose obtaining core debris samples during the Underhead Characterization Study. Your safety evaluation covering the core sampling was transmitted to this office by GPU letter 4410-83-L-0133, dated July 30, 1983. The NRC staff concurs with your assessment that this data collection is essential in preparing for future reactor vessel defueling activities. The TMIPO staff has reviewed the potential hazards associated with the sampling procedure, as described in your safety evaluation, and we conclude that the sampling task can be performed without undue risk to the workers or to the general public. The potential for a pyrophoric reaction during the core debris sampling was evaluated by the NRC staff. This evaluation (Enclosure 1), concludes that there is little likelihood that pyrophoric zirconium materials are present in the core. Additionally, the evaluation concurred with your assessment that should a pyrophoric event occur during sampling, the reaction and associated heat energy would be contained in the sampling mechanism and no undesirable radiological or safety consequences would result.

The projected occupational exposure for the debris sampling task, 8.4 person-rem, is commensurate with the expected benefit to the accident recovery program. We find after a review of the sampling procedure, that all reasonable measures have been taken to minimize the exposure to workers in accordance with the principles of keeping radiation exposures as low as reasonably achievable (ALARA).

OFFICE ▶							
SURNAME ▶							
DATE ▶							

Based on the enclosed referenced safety evaluation and a review of your procedure for obtaining the core debris samples, we conclude that the proposed operation can be performed safely, without impacting the health and safety of the workers or the general public. Additionally, the environmental impact of this task and sample shipment fall within the scope of conditions previously considered in the PEIS and therefore the staff finds the proposed operation acceptable.

Lake H. Barrett
Deputy Program Director
TMI Program Office

Enclosure:
As Stated

cc w/encl:
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J. Byrne
J. Larson
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ENCLOSURE 1

Evaluation of Pyrophoric Issues Related to TMI-2 Underhead Characterization and Core Sampling

Introduction

By letters dated May 19, 1983 and July 20, 1983, the licensee proposes to carry out an Underhead Characterization Study and a Core Debris Sampling. These operations will expose previously water-covered reactor surfaces and samples of the core debris to containment air. Appreciable amounts of zirconium hydrides might have been formed during the TMI-2 incident.[1,2] In a finely divided form, zirconium hydrides can be pyrophoric. If hydrides are present on reactor surfaces and in the core debris, they might react violently when exposed to containment air during the proposed Underhead Characterization and Core Sampling procedures.

Evaluation

Bulk zirconium metal or zirconium hydride is normally protected from reaction with air, water or hydrogen by a tight impervious surface film of ZrO_2.[2] Even as a powder, the metal or hydride can be handled in air at ordinary temperatures without burning. However, incidents have occurred where finely divided zirconium metal or hydrides ignited spontaneously and burned violently in air.[2]

The large amounts of hydrogen generated during the TMI-2 incident could conceivably have reacted with the hot Zircaloy cladding to produce pyrophoric zirconium hydrides. Pyrophoric zirconium hydrides are formed by the reaction of dry hydrogen gas at 400°C with a Zircaloy surface.[2] During the TMI-2 incident, high pressure steam was also present. At high temperatures, zirconium hydrides react with steam to form zirconium oxide and hydrogen gas.

The presence of steam and the temperature conditions during the accident make it unlikely that significant quantities of zirconium hydride in a pyrophoric condition were produced during the accident. In regions of the reactor core below approximately 400°C, the hydriding reaction would be slow. In regions above approximately 700°C, the hydrides would react with steam. Any hydride formed at intermediate temperatures would be in a narrow band between the uncovered and the cooled regions of the core. In the finely divided condition required for pyrophoricity, this material would be dispersed and mixed with inert components of the core debris. The inert diluents would help to dissipate reaction heat and prevent the development of pyrophoric conditions.

Analysis of solids filtered from the TMI-2 reactor coolant solution and of the thin films scraped from the surfaces of the leadscrews removed from the TMI-2 reactor head indicated the absence of zirconium metal or hydride particles. Over 50% of the particles filtered from the coolant contained stainless steel, Inconel, and Ag-In-Cd control material constituents. Most of the zirconium-containing materials were reaction products with uranium, control materials, or structural materials. Some ZrO_2 particles were identified. A larger proportion of ZrO_2 would have been expected from the reaction of a mixture containing enough zirconium hydride to be pyrophoric.

Similarly, analysis of the thin film scraped from a section of the removed leadscrew showed the presence of some Zr compounds, but the main component was Fe, along with some U, Te, Cu and Ni. The principal form of Zr was identified as an intermetallic oxide of the form $FeZrO_4$. In the analysis of another section of the leadscrew, Zr was formed principally "in an alloyed form with Ag, U or Fe." No free Zr metal nor zirconium hydride was found. Some ZrO_2 particles were identified, but not in the amounts which a pyrophoric mixture would have produced.

These analytical results and the observation of only light deposits on the upper reactor surfaces in the "Quick Look" video tapes indicate a low probability for any significant pyrophoric activity when the reactor coolant level is lowered. As a further precaution, while the upper plenum surface is still covered with water, any debris deposits found will be sampled and tested for pyrophoricity.

The licensee calculated that the specimen holder temperature would be increased by approximately 200°F by the complete oxidation of a one cubic inch sample of core debris containing 10% zirconium metal. We independently verified the calculations and agree that the assumptions and calculational method are conservative and that the burning of this amount of zirconium would not damage the holder, the manipulator tube nor the sample cask. This provides additional assurance that the core debris sampling operations can be carried out safely even in the unlikely event that the debris contains pyrophoric zirconium materials.

Conclusion

Based on the above considerations, we have reasonable assurance that pyrophoric zirconium materials will not be present in the TMI-2 degraded core in sufficient quantities to interfere with the safe execution of the proposed procedures for Underhead Characterization and Core Sampling. Therefore, we conclude that the proposed procedures are acceptable.

References:

1. Memorandum, K. I. Parczewski to P. S. Check, "Formation of Zirconium Hydrides in the TMI-2 Incident" June 6, 1979.

2. Earl K. Gulbransen and K. F. Andrew, "Reaction of Hydrogen with Pre-Oxidized Zircaloy-2 at 300° to 400°C" Journal of the Electrochemical Society 104, 709-712 (1957).