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June 29, 1983
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TMI Program Office
Attn: Mr. L. H. Barrett
Deputy Program Director
US Nuclear Regulatory Commission
c/o Three Mile Island Nuclear Station
Middletown, PA 17057

Dear Sir:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Review of Underhead Characterization SER

Attached find responses to NRC questions forwarded by NRC letter from L. H. Barrett to B. K. Kanga dated June 2, 1983, concerning the Underhead Characterization Safety Evaluation Reports.

If you have any questions, please contact Mr. J. J. Byrne of my staff.

Sincerely,

B K Kanga

B. K. Kanga
Director, TMI-2

BKK/RBS/jep

Attachment

CC: Dr. B. J. Snyder, Program Director - TMI Program Office

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1. Question - Section 2.2, Reactor Coolant Pressure Boundary states that a pressure retaining boundary will no longer be required after the initiation of the underhead characterization. For example, your staff stated that no gasket will be used for the flanged connection between the CRDM vessel flange and manipulator tube flange.

It is our position that cleanup steps such as underhead characterization, should preserve as much system flexibility as practicable to permit optimum response to unexpected conditions. Specifically, we believe it is prudent to take simple steps to allow future reactor coolant system pressurization. This would preferably include the use of a manipulator tube that can be sealed or other less desirable means, e.g., replacement of the manipulator tube with a blind flange. Describe your proposed contingency plans for prompt reclosure capability.

Answer - Following the Underhead Characterization Program activities, the reactor coolant system will remain open to the containment atmosphere in anticipation of head removal. However, means are provided to repressurize the reactor coolant system should it become necessary for some undefined reason.

The method established to return the RCS pressure boundary is to install a blind flange on the CRDM flange of the reactor vessel head. This will require the removal of the manipulator tube from CRDM H-8. The manipulator tube is fabricated of aluminum with a threaded joint at its midpoint to permit installation under the missile shields. Further, the manipulator tube is expected to be bolted to the CRDM flange with three bolts which were not designed as a pressure seal. The aluminum tube may also not be compatible with the reactor coolant chemistry requirements. Its design did not contemplate it being flooded with RCS water. (Note, Question #8.)

2. Question - Section 3.1, (P. 7) you state, "The present general area dose rate on top of the service structure is 50 to 150 mRem/hr. The increase in the general area dose rate on the top of the service structure of less than 20 mRem/hr is relatively small." Based on the above, the potential increases in general area radiation levels resulting from lowering the RCS water level and removing a CRDM are considered acceptable. Measurements will be taken for varying water level conditions to assess the actual conditions with respect to the removed CRDM.

a) Please describe the measurements (other than TLD) that will be taken for varying water level conditions to assess the actual radiation conditions with respect to the removed CRDM.

b) Provide a description of the service structure area radiation monitoring system which was discussed during our meeting on May 25, 1983. Please state the number of channels (monitoring locations) to be used in order to obtain dose rates at various points around the head and service structure.

Answer - Three general areas will be monitored during the process of lowering the RCS water level to Elevation 321'-6".

a. The top of the service structure.

b. Near the CRDM flanges above the center of the reactor vessel head.

c. Adjacent to the reactor vessel head in the vicinity of the top of the reactor vessel closure studs.

Each area will be monitored using an Eberline RMS-2 or RM-16 system with local readout and a continuous strip chart recorder. The local readout will be observable external of the reactor building utilizing the available building TV equipment. The readout will be monitored periodically during draindown.

3. Question - We note that you are in the process of shielding the service structure. Do you intend to undertake the vessel radiation characterization before this shielding is completed? Please describe the considerations of the vessel radiation characterization, and the shielding program.

Answer - The shielding to be provided on the outside of the service structure will be installed for the purpose of providing additional shielding after the control rod drive leadscrews are parked. This shielding is not required for the Underhead Characterization Program. It is anticipated that the leadscrews will not be parked until just prior to lifting the reactor vessel head.

Three locations (note Question #2) will be monitored as the reactor coolant level is lowered. Two of these locations, the top of the service structure and the area between the CRDM housings, will be unaffected by the service structure shielding. If the shielding has been installed prior to lowering the water level provisions will be made to either place the detector inside the lead blanket or remove a suitable portion of the blanket so that the radiation levels indicated on the detector are not affected by the shield.

4. Question - In Section 4.4 (P. 16) you state that "the activities are not expected to increase the airborne activity in the containment atmosphere beyond that assumed in the calculation of releases.... during decontamination activities...."

We find it difficult to relate airborne activities associated with work in the reactor vessel with your previous decontamination activities. Describe your considerations for the potential airborne activity (including alpha emitters) associated with opening the vessel. Describe the air sampling program associated with the vessel characterization study objectives. Describe additional sampling efforts (smears, etc.) required to effectively assess all potential radiation hazards.

Answer - The potential for airborne activity escaping from the underside of the reactor vessel head will be diminished if not eliminated if the small diameter particles under the head remain wetted. The estimated natural draft or "chimney" velocity in the uncontaminated manipulator tube when the head is fully vented is ~ 1.6 ft./sec. The velocity across contaminated surfaces under the head is significantly less. Oxide particulates greater than 100 μm (1×10^{-2} cm) would not be transported up the manipulator tube at the above velocity. Therefore, particulate material that would pose a potential airborne safety problem is restricted to particle sizes that could be transported by natural draft up the manipulator tube.

Surface chemistry studies have shown that the vapor pressure over a convex surface is greater than that over a plane. The pressure differences as a function of surface curvature has been formulated thermodynamically for spherical surfaces. This formulation is called the Kelvin equation, $RT \ln (P/Po) = 2\gamma V/r$. The effect of curvature or water drop radii associated with small drops or capillary surfaces on water vapor partial pressure is generally greater than the equilibrium water vapor partial pressure differences between the reactor building humidity and the underhead reactor vessel humidity. Stated simply, the difference in water vapor partial pressures relative to the humidity in the building and that in the vessel underhead is less than the pressure drop required to cause complete evaporation from small capillary surfaces. Again, as the Kelvin equation indicates, evaporation of wetted surfaces of large diameter particulates occurs more readily than for small particulates. It is shown that as the particle size decreases, the pressure ratio increases. For the particle sizes under consideration, < 100 µm, the liquid meniscus radii associated with wetted particle to particle contact are typically < 1µm. Consequently, it has been determined that the change in equilibrium water vapor to air ratio in the flowing air stream under the head is insufficient to compensate for the partial vapor pressure change required in the small water volume under consideration. Therefore, the small diameter particles under the head will remain wetted.

To better ascertain the radiological airborne potential which may be associated with air flow under the reactor vessel head (see Question #14). The following will be accomplished:

a. A ventable plastic cap will be mounted on the manipulator tube on CRDM H-8. This cap will mount suitable HEPA filters which will permit air flow, but trap suspended particulate. Periodically, these filters will be changed out and analyszed for activity. There are no plans for DOP testing of these filters.

b. A sealed tube on the above cap will be provided which will permit a connection be made to a suitable air sampling apparatus. This apparatus is intended to provide a better quantifiable assessment of the airborne material in the underhead air flow.

No additional sampling program is anticipated to be conducted. Smears of reactor building surfaces will continue to be taken to support the radiation evaluation of the reactor building environment. Routine radiological control air sampling functions and personnel BZA sampling will continue.

5. <u>Question</u> - Section 4.3.2.2, Paragraph 1, provide clarification that an electrically locked out pump is an isolation boundary only when it is the source of driving head.

Answer - Our criteria for double boundary isolation verses pump electrical disconnect is that the pump may be considered an isolation mechanism whenever the pump represents a pressure driving head. Whenever gravitional flow through a pump body has a potential for adding unborated water, a minimum of two isolated boundaries are provided in addition to the pump.

6. Question - Section 4.3.2.2 (a), describe your system for verifying a pressure differential exists including periodicity and any alarms.

Answer - The pressure differential is a combination of water levels in the RCS and in the secondary side of each OTSG in combination with the nitrogen pressures above each. The level instrumentation is discussed in Sections 4.3.2.2 and 4.3.2.3. The following is a tabulation of the frequency of recording this information.

a. "A" OTSG level - once per shift.

b. "B" OTSG level - must be observed at least once every seven (7) days and should be observed daily on days when a routine entry into the containment building is being made.

c. Reactor coolant level - in control room; once per hour.

d. "A" and "B" nitrogen pressure - once per shift.

e. Reactor system nitrogen pressure - no gauge available; however, the nitrogen system is secured and disconnected from the reactor coolant system.

f. No alarms exist on the indications above.

g. The reactor coolant system leak rate calculations are performed once a day.

7. Question - A few of the closed tagged-out valves will need to be operated to support other evolutions. What allowances and special precautions are being taken in this regard?

Answer - Closed tagged-out valves which may be needed to support other evolutions generally fall into three categories:

a. Emergency operations,

b. Surveillance testing, and

c. RCS processing.

Emergency operations, in most instances, entail the addition of boron to the RCS by other than "normal" means. It requires systems normally isolated from the RCS to supply borated water to the RCS. Isolated valves will have to be opened to accomplish this. However, chemistry control and surveillance of the pumped fluid and operation in accordance with approved procedures will insure against a deboration occurrence.

Surveillance testing of all required systems (see Question #12) has been reviewed. All surveillance tests including the activation of pumps and valve cycling may be accomplished without violating the two isolation boundary criteria established to prevent boron dilution in the RCS.

Reactor coolant system processing, which will be necessary periodically while the reactor coolant system is depressurized, will be performed in accordance with presently approved procedures for such operations (see Question #13). These procedures require the sampling of borated water in RCBT "A" prior to pumping into the RCS and was successfully performed in December, 1982.

8. Question - Section 2.2, Reactor Coolant Pressure Boundary. The manipulator tube material is aluminum, whereas most of the RCS is stainless steel. Provide the basis for the compatability of the al minum material considering expected chemistry conditions.

Answer - The manipulator tube was not designed to be a pressure boundary or be in contact with RCS water. (See Answer No. 1.)

9. Question - Section 4.3.2.3, Sampling and Boron Measurements. Describe your location(s) for RCS sample collection and the basis for these samples being representative of core boron concentrations.

Answer - Reactor coolant samples may be taken from at least two locations when the RCS water level is lowered:

a. The reactor vessel via an open CRDM or the manipulator tube.

b. The "A" loop cold leg letdown or sampling lines.

Procedures were established to obtain RCS samples from the reactor vessel via the CRDM during the "Quick Look" program. These will be re-established for the Underhead Surveillance Program. In the long term, a less man-rem intensive method for obtaining RCS samples is required. Coupled with the need to process the RCS fluid periodically, it has been established that representative samples of the reactor vessel fluid may be obtained from the letdown to RCBT "C" provided sufficient time is allowed prior to sampling to flush the entire piping system from the reactor vessel including the cold leg pipe. At the anticipated letdown rate of approximately three gpm, this process will take 8-10 hours. Procedures are being prepared to provide such flushing prior to obtaining a sample from the letdown on a weekly basis. If for some reason such flushing can not be performed on a weekly basis, samples will be taken directly from the reactor vessel as described above.

10. Question - Describe the increased radiation precautions necessary if placing the CRDM on the service structure instead of storage in the canal (polar crane not available).

Answer - If the polar crane is not available, the CRDM housing will be lifted by the under missile shield hoist until the CRDM flange is approximately two (2) feet above the service structure platform. In this position, a clamp will be attached to the leadscrew support tube. The tube will be cut with a saw above the clamp. The CRDM housing will then be moved to either the pendant access hatch on the outer periphery of the service structure or to a storage position near the access ladder to the service structure. Rad Con will determine if any shielding is required around the base of the CRDM while it is stored in this location. After disconnecting the hoist from the CRDM housing, it will be rigged to the leadscrew support tube, the tube will be raised, and a three (3) to four (4) inch piece of tube will be cut off for sample analysis. The leadscrew support tube will then be inserted into a PVC pipe container hanging from the service structure work platform railing.

The PVC tube will then be rigged into a designated storage place at the south end of the fuel canal.

The following radiation guides have been established for CRDM removal under the missile shield:

a. 2 R/hr limit of service structure work area during all operations on the service structure.

b. 50 R/hr hour limit along side an adjacent CRDM at the CRDM flange elevation during CRDM removal.

c. 300 mR/hr maximum on service structure prior to commencement of work.

d. Radiation monitoring will be performed near the work location at all times by Rad Con personnel.

e. A beta shield will be provided for the leadscrew support tube.

f. Care will be exercised to keep workers as far as possible from all radioactive components and debris.

g. A drop cloth will be provided to catch cutting chips and debris.

11. Question - Do you plan to remove more than one CRDM for the detailed underhead characterization (as discussed in Planning Study TPO/TMI-028)? Describe your plan and sequence for additional CRDM removal.

Answer - Our plans are to remove only one CRDM (H-8) from the reactor vessel head to perform the Underhead Surveillance Program. If H-8 can not be removed, another CRDM will be selected, most likely E-9.

12. Question - Describe your plans for meeting Technical Specification Surveillance requirements for those systems affected by the underhead characterization program.

Answer - A review of the Technical Specification Surveillance requirements and methods of performance has shown that double boundary isolation to the RCS may be maintained at all times during surveillance testing. Therefore, all applicable surveillance required by the Tech Specs will be performed during the Underhead Characterization Program.

13. Question - Describe what chemistry/radiochemistry considerations (i.e., turbidity, crud burst, fission products spikes, pH effects) and controls for RCS processing were made recognizing the oxidation conditions within the RCS will change during the underhead characterization.

Answer - A review has been made of RCS data taken during RCS processing and "Quick Look" to ascertain the potential changes that might be encountered during the next scheduled draindown for underhead characterization and future head lift. The changes evaluated were those that might be anticipated upon increasing the dissolved oxygen content, namely:

1. decrease in pH,

2. decrease in water clarity (increased turbidity),

3. slow increase in dissolved radionuclide concentrations (leaching), and

4. rapid increase in radionuclide concentrations (crud burst).

During pre-Quick Look RCS processing, the RCS was exposed to make-up coolant containing considerable quantities of dissolved oxygen. For example, the first batch of RCBT-A water used for make-up contained ~ 2.5 ppm dissolved oxygen compared to a pre-processing concentration of 0.075 ppm in the RCS. As the bleed tanks were maintained under a nitrogen blanket, each successive batch of make-up water contained less dissolved oxygen (e.g., batch 5 D-O_2 ~ 0.4 ppm). This data shows that the RCS experienced a rapid influx of oxygen rich coolant during make-up and letdown operations. During this initial RCS processing effort, several general conclusions were made and reported from sample analyses:

1. The decrease in radiocesium activity in the coolant was consistent with general circulation within the RCS vessel (excluding the pressurizer).

2. The ^{90}Sr concentration decreased only slightly which is consistent with a chemical solubility mechanism (strontium carbonate suggested).

3. The pH and boron did not change.

4. There was a general improvement in water clarity (decrease in turbidity).

5. There was no change in dissolved oxygen concentration in the RCS (oxygen scavenging mechanism occurring).

6. The radionuclide mass balances indicated no appreciable "appearance rate" for cesium radionuclides.

During the Quick Look period (July 15, 1982 to December 13, 1982), the RCS was drained to a level permitting coolant exposure to atmospheric oxygen. Gas samples taken off the high point vents, showed (~ 10%) oxygen content, thereby permitting the coolant to interface with an oxygen-rich atmosphere. Because of the drained down condition, samples were taken directly from the reactor vessel and no routine dissolved gas analysis could be made.

A special sample of the RCS was taken and analyzed for dissolved oxygen at an off-site laboratory and found to be 0.21 ppm. The general conclusions that can be drawn from the RCS samples taken during "Quick Look" were:

1. The radiocesium and ^{90}Sr content in the coolant increased over the time period (appearance rate 0.5-2 Ci/day for ^{137}Cs depending on distributed volume).

2. The pH of the coolant decreased slightly (7.7 to 7.6 in ~ 150 days).

3. The boron concentration did not change.

4. The turbidity increased initially (later samples presumed not representative of solids).

5. The dissolved oxygen content remained low confirming oxygen scavenging.

The effects attributable to coolant stagnation or increased oxygen content during Quick Look would be impossible to separate, however.

With these data and general conclusions, several changes in the RCS chemistry and radiochemistry might be anticipated. First, there might be a slow decrease in coolant pH for long exposures to atmospheric conditions as the oxidation of metals in solution tends to increase the H+ concentrations and the presence of carbonates in the coolant and carbon dioxide in the atmosphere sets up new aqueous equilibria. The daily change anticipated is small and will be monitored during the weekly sampling as a minimum. Second, it is anticipated that the turbidity and dissolved radiocesium concentrations will increase slowly due to oxidation and leaching, but if necessary, the clarity and activity level can be improved by RCS processing in the drained down mode as before (40,000 gallon Batch-6 decreased Cs activity by factor 3). Thirdly, since minimum circulation is present in the reactor vessel during drain down, crud bursts should only occur during water movement and could be handled by processing at ~ 3 gpm in the drained down condition. Lastly, we anticipate that oxygen scavenging will continue to occur. From the leadscrew data, a thick layer (30-100 μ) of reduced iron oxide (Fe_3O_4) probably covers most of the internal surfaces. This and other compounds and metals that make-up the core components provide active chemical sites for increased oxidation. As the maximum dissolved oxygen content contacting these surfaces is ~ 8 ppm, this oxidation should continue to occur for years.

14. Question - Provide supporting data that demonstrates the recirculation rates discussed in Section 4.6 exist.

Answer - A calculation was performed to determine the velocity or "chimney effect" from an open manipulator tube and the volume exchange rate for the reactor head free volume. The following assumptions were made:

a) Manipulator tube is installed on CRDM H-8; inside diameter three inches.

b) Distance from RCS water level to top of manipulator tube - approximately 20 feet.

c) All other CRDM housings vented and partially open to reactor building atmosphere.

d) The temperature profile from liquid surface to top of manipulator tube is a constant gradient.

e) RCS liquid temperature - 110°F.

f) Reactor building air temperature - 85°F.

g) Ideal behavior for the compressible fluid occupying the reactor head and manipulator tube.

h) The ASHRAE Handbook correlation for theoretical draft - Chapter 26 applies.

i) The free volume under the reactor head - 782 cubic feet.

These calculations indicate that approximately nine volume exhanges per day will occur under the reactor vessel head with a velocity in H-8 manipulator tube > one foot per second. (See response to Question 4.)