UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REACTOR VESSEL LOWER HEAD SAMPLING

GPU NUCLEAR CORPORATION

THREE MILE ISLAND NUCLEAR STATION, UNIT NO. 2

DOCKET NO. 50-320

INTRODUCTION

GPU Nuclear Corporation (GPUN), the licensee, submitted for NRC review and approval a Safety Evaluation Report (SER) for sampling the reactor vessel (RV) lower head (reference a). The sampling program includes obtaining metallurgical specimens from the inner surface of the the RV lower head. These samples will be used in an international research program to study core melt/reactor vessel interactions. At the time of the sampling all RV defueling activities will have been completed and the remaining residual fuel will not pose a criticality concern. However, the verification of this safe configuration may not be completed. The NRC staff is proceeding on the assumption that the the amount of fuel necessary for a critical mass could still exist in the reactor vessel.

DESCRIPTION OF REACTOR VESSEL CONDITIONS AND APPARATUS

At the time of the submittal of the SER the TMI-2 core region, hot leg piping, and most of the lower core support assembly had been defueled. When the samples are obtained, defueling will be complete and the lower head will be cleared of debris. Subcriticality is currently assured by borating the moderator (water) in the RV to greater than 4350 ppm B. This will continue during the RV lower head sampling program.

The sample acquisition equipment will include an abrasive wheel saw and a metal disintegration machine (MDM). The abrasive saw will be used to cut incore instrument penetration (IIP) nozzles 2 to 4 inches above the RV lower head surface. The MDM will be used to obtain samples from the RV lower head. It will cut rectangular specimens 3 inches by 6 inches that are triangular in cross section from the RV lower head. The sampling procedure will remove up to 2.5 inches of RV wall material from a total thickness of 5.375 inches. Samples may be taken that include the base of an IIP. The weld at the base of these nozzles currently serves as a portion of the reactor coolant pressure boundary. In these selected locations, after the nozzles are cut the instrument strings will be retracted from the instrument tubes. An expanding plug will be placed through the IIP down into the incore instrument tubing where the tubing penetrates the reactor vessel. The plug will be expanded creating a seal between the outer instrument tube wall and the inside of the 1 inch diameter penetration hole in the reactor vessel. This seal will serve as the reactor coolant pressure boundary when samples form the base of the IIP nozzles are removed.

EVALUATION

The NRC staff evaluated the potential for boron dilution and the possibility of an inadvertent criticality in the reactor vessel, the potential for evolution and collection of combustible gases, and the consequences of load drops and potential leakage through the RV lower head. Issues related to pyrophoricity, fire protection, decay heat, and release of radioactivity fall within the bounds of previous NRC staff analyses (references b, c, d, and e).

The licensee is committed to remain within the safety constraints imposed by the defueling SER and Mode 1 technical specifications throughout the sampling program. These constraints include maintaining boron concentration greater than 4350 ppm. This concentration would keep the entire core subcritical in the most reactive geometry possible during defueling with an adequate safety margin. Except as noted below, all hydraulic fluid used with the sampling equipment will be borated to at least 4350 ppm B.

The MDM system equipment will use non-borated water in the hydraulic system. The maximum potential loss from this system is 2 gallons. The licensee and the NRC staff have previously analyzed localized deboration due to leakage of 2 gallons of non-borated water (references f and g). This analysis involved the most reactive geometry of a full core. Both the licensee and the NRC staff concluded that localized deboration from up to 2 gallons of non-borated water would not pose a criticality hazard. Additional analyses performed during the evaluation of the plasma arc cutting system considered less than a full core but much more fuel and a more reactive geometry than will exist during RV lower head sampling. This conservative analysis used 3 gallons of non-borated water and the results indicated an adequate margin of safety, i.e. greater than 1% delta k with an additional 2.5% delta k uncertainty factor (references h and i).

The licensee has calculated that potential hydrogen evolution will be less than 1 standard cubic foot per minute (scfm). The NRC staff agrees with the licensee's evaluation that the existing defueling work platform off-gas system is adequate to preclude buildup of combustible concentrations of hydrogen. The staff requires that the off-gas system be functional and operating during MDM cutting operations. Any combustion at the cutting head will be localized and self extinguishing due to being submerged under 40 ft. of borated water.

The licensee and the NRC staff have evaluated a wide range of activities including load drops which could cause leakage associated with incore instrument penetrations. These evaluations were associated with RV lower head defueling and previous defueling activities, (references j and k). Leakage through the annular gap between an instrument tube and the reactor vessel wall could

produce a leak of 0.4 gallons per minute (gpm) per penetration. This leakage would result from the case where an incore instrument penetration and its weld are sheared off but the instrument tube remains in the hole in the RV wall. Another set of analyses evaluated the case where an additional unspecified mechanism would force the instrument tube out of the the vessel wall. This would result in a 1 inch diameter hole and a 120 gpm leak. The licensee has safety systems to make up this potential leakage. These systems include gravity feed from the borated water storage tank (BWST) and forced circulation via the reactor building recirculation pumps. The cavity under the reactor vessel contains borated water to preclude criticality in the event that any fuel is flushed down with the leaking water (references j, k, and l).

CONCLUSIONS

The NRC staff has reviewed and evaluated the proposed Reactor Vessel Metallurgical Sampling Activity. We have concluded based on the above evaluations that there is reasonable assurance that the health and safety of the public will not be endangered by this activity. This activity falls within the scope of activities previously considered in the Programmatic Environmental Impact Statement.

REFERENCES

a. GPUN letter 4410-89-L-0085/0480P dated August 18, 1989 from M. B. Roche to NRC with attached Safety Evaluation Report to Remove Metallurgical Samples from the TMI-2 Reactor Vessel.

b. NRC letter, W. D. Travers to F.R. Standerfer, GPUN, "Commencement of Three Mile Island Unit 2 Preliminary Defueling Operations", dated October 29, 1985.

c. NRC letter W. D. Travers to F. R. Standerfer, GPUN, "Safety Evaluation for Early Defueling", dated November 12, 1985.

d. NRC letter W. D. Travers to F. R. Standerfer, GPUN, "Commencement of Bulk Defueling Activities", dated July 24, 1986.

e. NRC memorandum C.E. McCracken to W. D. Travers "TMI-2 Fire Protection Program Evaluation and Proposed Technical Specification Amendment (TAC No. 66697)" dated August 19, 1988.

f. NRC memorandum from R. A. Weller to C. H. Berlinger with attached GPUN Report on Foreign Materials Allowed in the TMI-2 RCS, dated October 16, 1985.

g. NRC memorandum from C. H. Berlinger to R. A. Weller "Review of TMI-2 'Foreign Materials' Criticality Report" dated December 2, 1985.

h. GPUN letter with attachment re "Criticality Safety Assessment for Use of the Plasma Arc Torch to Cut the Lower Core Support Assembly" 4410-87-L-0139-0221P from F. R. Standerfer to NRC, dated November 30, 1987.

i. NRC memorandum re "Review of Criticality from Plasma Arc Torch Operations in TMI-2" from M. W. Hodges to W. D. Travers dated March 1, 1988.

j. GPUN letter, 4410-88-L-0100/0253P, F. R. Standerfer to NRC Document Control Desk, Lower Core Support Assembly and Lower Head Defueling (Revision 1), dated June 27, 1988.

k. NRC letter, J. F. Stolz to M. B. Roche, GPUN, "Three Mile Island Nuclear Station, Unit 2 Lower Core support Assembly and Lower Head Defueling (TAC 67857), dated December 1, 1988.

l. NRC letter J.F. Stolz to M. B. Roche, GPUN, "Three Mile Island Nuclear Station, Unit 2 Lower Core Support Assembly Defueling" (TAC 64632) dated April 1, 1988.

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