POLICY ISSUE
(Information)

April 25, 1990 SECY-90-149

For: The Commissioners

From: James M. Taylor
Executive Director for Operations

Subject: THREE MILE ISLAND UNIT 2 VESSEL INVESTIGATION PROJECT

Purpose: To inform the Commissioners of the successful recovery of specimens from the TMI-2 reactor vessel and the preliminary results from the examination of one of the samples recovered from the vessel. During the sample recovery phase of the project, a total of fifteen vessel samples, fourteen in-core instrument guide tube nozzle stubs, and two guide tube samples were obtained.

Background: On June 27, 1988, an agreement was placed in force, under the auspices of the OECD/NEA, committing the United States and ten foreign countries to a program to investigate the state of the lower head of the Three Mile Island Unit 2 reactor pressure vessel. The agreement is to remain in force until September 30, 1991, and may be renewed. The parties in the agreement will jointly carry out a study to investigate the condition and properties of material extracted from the lower head of the TMI-2 reactor vessel to determine the extent of damage to the lower head during the TMI-2 accident, the thermal input to the vessel, and the margin of structural integrity that remained.

Discussion: The March 29, 1979, accident at the Three Mile Island Unit 2 nuclear power plant resulted in severe damage to the reactor core and a challenge to the integrity of the reactor pressure vessel. The defueling operations at the plant have given qualitative indications of the extent of the damage but have not resulted in quantitative data regarding the extent of the damage to the reactor vessel itself. Molten core material caused severe damage to the core baffle structure and hardware in the lower head region. Flowing melt material damaged various in-core instrument guide tubes

CONTACT:
R. Landry, RES
492-3562

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and their penetration nozzles to an extensive degree. At the same time, other guide tubes and nozzles were undamaged. Material analysis of the vessel steel specimens is expected to indicate the degree of damage that occurred in the accident. The analysis of the entrapped debris particles in the guide tubes and nozzles can also provide indications of the temperatures experienced by the core as well as the temperatures the internals were exposed to.

Sampling Program

The staff of the NRC's Office of Nuclear Regulatory Research developed a plan, with which the foreign participants concurred, to recover representative samples of the TMI-2 reactor vessel lower head, in-core instrument guide tubes, and nozzles. The vessel samples, called "boat samples," are prismatic in shape, measuring 6-1/2 inches in length by 3 inches on their triangular sides, as shown in Figure 1. The lower head samples were cut from the vessel by an electric discharge method rather than by mechanical cutting. The nozzle samples were cut by mechanical sawing using masonry saws. Four of the nozzle stubs that remained after sawing were plugged to prevent leakage after removal of vessel samples containing the nozzle stubs. The guide tubes were also cut by mechanical sawing.

The participants in the program developed a sample recovery priority list based on the known distribution of core melt material following the accident. The priority list was devised to recover samples representative of vessel conditions ranging from undamaged to severely damaged. Examination of the samples would make it possible to map the damage states of the vessel material. The abandoned Midland Nuclear Plant reactor vessel, which is a sister vessel to TMI's in time of manufacture and material, was sampled to provide unirradiated, as-built reference specimens.

The owner of the TMI-2 plant, GPU Nuclear, agreed to make available a thirty-day period for the in-containment sample recovery effort. The thirty-day period was determined to be the maximum allowable impact on the cleanup effort that GPU Nuclear would accept. During that time the removal of the samples was performed by remote control. The vessel and nozzle samples were covered by 40 feet of shielding water in the reactor vessel during the removal operation. The guide tubes that were sectioned had been removed from the core support assembly during the defueling operation and were stored behind the biological shield around the steam generators.

The sample recovery program was predicated on aquisition of a minimum of eight vessel samples. During the in-

containment work window, a total of fifteen vessel samples, four of which contain nozzle stubs, fourteen nozzle sections, and two guide tube sections were recovered. A list of the samples removed is given in Table 1. The locations from which the samples and nozzle sections were removed are shown in Figure 2.

Extensive preparations went into the sample recovery work. Tests were performed under various conditions using several material samples. Hardware was modified throughout the preparation phase. Without the extensive effort put into the preparations, the program could not have succeeded. In evaluating the success of the program, we should not underestimate the contribution, dedication, and skill of the principal contractor for the specimen removal, MPR Associates. MPR designed the cutting equipment delivery system, the tools, and the procedures and provided onsite management of the operations. The electric discharge cutting equipment was designed and operated by the subcontractor, Power Cutting Services, Incorporated. Support with labor and small tool manufacture and modification was provided by GPU Nuclear. The performance of the principal contractor and subcontractors was commendable.

Financial Structure

The total cost estimate for the program is $7,075,000. The share borne by the United States, which includes work-in-kind by EPRI, is $4,192,000. The remainder of the cost, $2,883,000, is shared among the ten foreign participants in proportion to their gross national products. This is the standard OECD formula for funding cooperative projects.

Sample Examinations

Examination of the vessel samples will start with decontamination, photographic and physical documentation, and sectioning into metallographic and metallurgical test specimens by the Argonne National Laboratory. ANL will perform mechanical property measurements on all vessel samples to get as complete an assessment as possible of the material condition of the lower head. Metallographic samples will be sent to the Idaho National Engineering Laboratory for metallographic characterization. The TMI-VIP foreign partners will also receive metallographic and metallurgical test samples for independent studies. Their

results will be combined with the ANL and INEL results. INEL will then have the lead for integrating all test results and analyses obtained from studies by ANL, INEL, and the foreign partners.

Preliminary Results

Room temperature tensile tests have been completed on specimens cut from the Midland reactor vessel archive plate at various orientations to the rolling direction. The tests showed no apparent variations in either the ductility or the strength of the specimens. The staff at the Argonne National Laboratory has concluded that sample orientation will not have an appreciable effect on the mechanical properties of the samples recovered from the TMI-2 lower head.

Media interest was generated on February 9 in the third TMI-2 lower head sample because of a crack that was reported to extend through the vessel base material. The sample location had been selected because of visible surface cracking in the stainless steel cladding. The specimen was sent promptly to the Argonne National Laboratory for metallographic examination. That exam found that the surface crack does not extend through the vessel base material. Rather, the "crack" appears to be a tear in the cladding that stops at the clad base-metal interface. Preliminary metallographic examination shows only layers of iron oxide and some tiny spheres of silver and cadmium in the base of the tear. The examination also reveals that there are a number of additional small surface tears that do not penetrate more than a few mils.

At least one other sample removed has been observed to contain surface "cracks." Examination of those damage sites is expected to provide cross comparison with the sample discussed above.

The indication from the sample recovery phase is that the reactor vessel material is somewhat harder than anticipated. However, initial results show the microstructure of the TMI-2 E-6 sample and the Midland "archive" material are similar, but some differences are now beginning to be seen; work on this issue will continue especially with additional samples. Cutting times in the sample recovery operation were up to two times those experienced with the Midland archive material and in the equipment test operations. In addition, cutting the guide tubes was extremely difficult; the same technique that required 30 minutes to cut a nozzle sample took 12 to 24 hours to cut a smaller guide tube sample. The guide tube and its contents were noted to be much harder

than the nozzles that had been immediately below them in the vessel.

Program Schedule

The present schedule is for shipping the remaining vessel samples to Argonne National Laboratory by the end of April. Because of the high activity levels of the nozzle and guide tube specimens, their shipment schedule will be controlled by the date of the final fuel debris shipment from TMI.

The principal contractor, MPR Associates, is currently preparing a quick-look type report on the sample recovery effort. The final report on the sample recovery phase, which will include all final expenditures and detailed discussions of the work, is due in June.

Examination of the samples will take place over the remainder of Fiscal Year 1990 and Fiscal Year 1991.

James M. Taylor
Executive Director
for Operations

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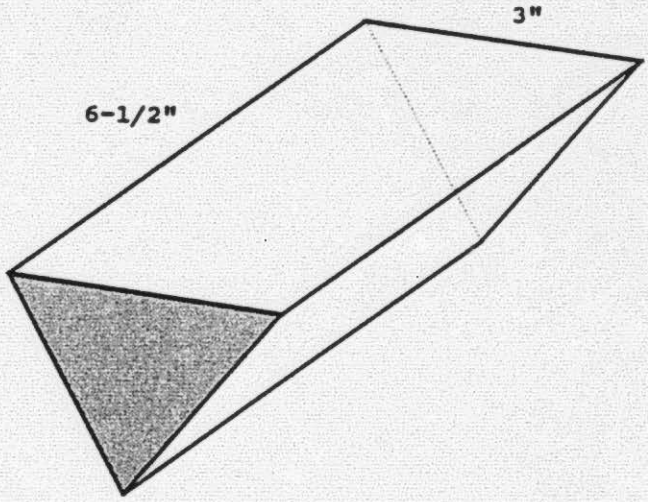

Figure 1
Vessel Sample

Table 1

TMI-2 Vessel Inspection Project

Reactor Vessel Samples Removed

No.	Location	Type	Comments
1	K-7	B	Proof test, central.
2	F-10	B	Proof test, hillside.
3	E-6	B	Crack from E-7 nozzle.
4	G-8	B	Heavy damage.
5	L-9	B	NW sample adjacent to damage.
6	H-4	B	Flow path? Adjacent to damage.
7	E-8	B	Crack area from E-7 nozzle.
8	F-5	B	Adjacent to high damage, pot crack.
9	K-13	B	Undamaged area, control.
10	E-11	N	Lava wall nozzle.
11	H-5	N	Nozzle in heavy damage.
12	H-8	N	Damaged nozzle.
13	M-11	B	Undamaged? Formerly in deep melt.
14	M-8	B	Moderate damage.
15	D-10	N	Lava wall nozzle

B=Base N=Nozzle

Nozzle and Guide Tube Sections Removed

Nozzle Location	Guide Tube
L-11	M-10
H-9	K-5
H-5	
D-10	
K-11	
H-8	
E-11	
L-6	
K-12	
M-10	
M-9	
G-5	
E-7	
R-7	

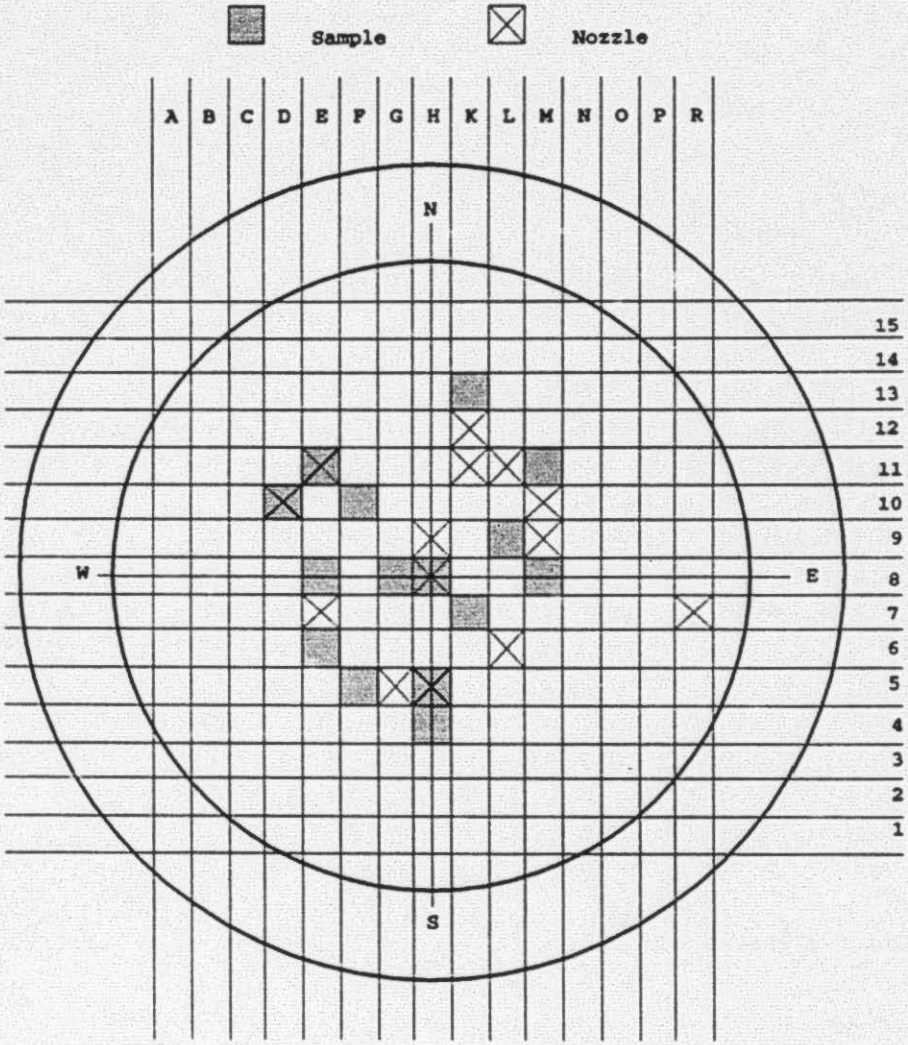

Figure 2
Lower Head Sample Locations