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TMI-2 ACCIDENT EVALUATION PROGRAM SAMPLE ACQUISITION AND EXAMINATION PLAN - EXECUTIVE SUMMARY -

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EG&G Idaho

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1. PURPOSE AND INTENT

The purpose of the TMI-2 Accident Evaluation Program Sample Acquisition and Examination (TMI-2 AEP SA&E) program is to develop and implement a test and inspection plan that completes the current-condition characterization of (a) the TMI-2 equipment that may have been damaged by the core damage events and (b) the TMI-2 core fission product inventory. The characterization program includes both sample acquisitions and examinations and in-situ measurements. Fission product characterization involves locating the fission products as well as determining their chemical form and determining material association.

The intent of the TMI-2 AEP SA&E Plan documentation is to describe the TMI-2 Sample Acquisition and Examination Plan in a manner that provides sufficient information for "stand alone" comprehensiveness. The SA&E Plan description is furnished in two versions, this abridged version (Executive Summary) for external distribution, and a detailed unabridged version primarily for internal use as a reference manual.

2. PROJECT GENESIS

The TMI-2 Sample Acquisition and Examination will be accomplished in accordance with United States Department of Energy contractor business practices. These practices require rigorous project planning, control, and reporting to assure that government-funded research programs are accomplished in a way that maximizes research results and the effective utilization of program resources. The TMI-2 AEP SA&E Plan will provide those assurances.

This Plan is part of the EG&G Idaho, Inc. TMI-2 Programs project which is described in the EG&G Idaho, Inc. TMI-2 Programs Division Master Plan, Revision 4, dated October 31, 1985. Included in this Master Plan is an outline of the EG&G Idaho, Inc. TMI-2 Programs Work Breakdown Structure (WBS). The SA&E program is composed of two (Level 4) elements; Sample Acquisition (WBS No. 751400000) and Sample Examination (WBS No. 755400000). These two elements are within the (Level 2 WBS No. 75B000000) TMI-2 Accident Evaluation Program.

The TMI-2 Accident Evaluation Program will accomplish the Department of Energy's program objectives of understanding the TMI-2 accident, disseminating this knowledge to the nuclear industry, and aiding in the resolution of severe accident and source term issues. The program's work is divided into four elements: (1) Examination Requirements and Systems Evaluation, (2) Sample Acquisition and Examination, (3) Data Reduction and Qualification,[a] and (4) Information and Industry Coordination. The Examination Requirements and Systems Evaluations element is responsible for defining program scope and technical objectives, defining sample acquisition and examination data requirements, determining the accident scenario, and providing a standard problem and applying the research results to aid in the resolution of the severe accident source term issues. The Sample Acquisition and Examination element is responsible for obtaining the samples specified by the Examination Requirements and

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a. Analytical and Experimental Support in Revision 4 of the Master Plan.

Systems Evaluation element from the TMI site, for examination of the samples, and for reporting the examination results. Data Reduction and Qualification is responsible for developing and maintaining the TMI-2 data base and for evaluating and qualifying online instrumentation and recorded data. Information and Industry Coordination is responsible for information transfer, coordination of review and consulting groups, interface with other source term research programs, and coordination of the TMI-2 standard problem exercise.

The tasks within the four work elements are designed to accomplish the following technical objectives:

- Identify and quantify the parameters and processes which controlled the progression of core damage and damage to the lower core support assembly, instrument penetration nozzles and guide tubes, and possibly to the reactor vessel lower head,

- Determine the plant-wide fission product behavior (source term), concentrating on release from the fuel and transport and retention in the primary cooling system,

- Provide a data base that contains the examination (and analysis) results,

- Provide a standard problem of the TMI-2 accident that includes the examination results and against which the severe accident analysis codes and methodologies can be benchmarked,

- Apply the TMI-2 accident evaluation research toward resolution of severe accident source term technical issues.

The Sample Acquisition and Examination element is specifically responsible for the collection of sample materials from the TMI-2 plant, the examination of those samples (to provide the data specified by the Examination Requirements and Systems Evaluation element), the interpretation and reporting of the examination results, and the coordination of examination activities at other laboratories. This program element is also responsible for providing engineering support for the sampling activities and for sample shipment.

3. BACKGROUND AND HISTORY

The TMI-2 AEP SA&E Plan evolved from the requirements set forth in the TMI-2 Accident Evaluation Program[1] document. The program description provides the guidelines for the post-accident core condition and fission product inventory characterization. The SA&E program has been underway since the TMI-2 accident. Examination requirements documents written previously include the GEND Planning Report 001[2] and the TMI-2 Core Examination Plan.[3] The current program description document is an extension of the preceeding examination requirements documents with appropriate additions and changes to account for our enhanced understanding of the TMI-2 accident and the resultant refinements in sample and examination requirements.

The already-completed portion of this SA&E program includes in-situ measurements and sample acquisition and examinations involving private organizations and state and federal agencies. It has provided the post-accident core and fission product end-state data that indicate the following:

a. Large regions of the core exceeded cladding melting (~2200 K), and significant fuel liquefaction by molten zircaloy and some fuel melting occurred with temperatures up to at least 3100 K.

b. Core materials relocated into the reactor vessel lower plenum region from the core, leaving a void in the upper core region equivalent to approximately 26% of the original core volume. Between two and twenty metric tons of core and structural materials now reside in the space between the reactor vessel bottom head and the elliptical flow distributor.

c. Fission product retention in core materials is significant, and the retention of fission products outside the core was primarily in reactor cooling system (RCS) water, water in the basement, and in basement sediment.

Significant consequences resulting from these findings include (a) increased technical interest in the TMI-2 accident because it represents a severe core damage (SCD) event in full-scale and provides evidence of a large inconsistency in the understanding of SCD event offsite radiation release, (b) a reconsideration of the plans and equipment for defueling the TMI-2 reactor, and (c) an expansion in the TMI-2 accident examination plan to determine the consequences of high temperature interactions between core materials and reactor vessel lower plenum structural and pressure boundary components and to determine the release from the fuel of the lower volatility fission products.

4. ASSUMPTIONS

The development of the TMI-2 AEP SA&E Plan included consideration of the following assumptions:

a. The total budget allowance including prior years is $20.6M from the Department of Energy (DOE) and $600K from and administered by the Nuclear Regulatory Commission (NRC).

b. Sample retrieval and in-situ measurements will be accomplished in conjunction with GPU Nuclear's TMI-2 recovery program and with support from the DOE TMI-2 Reactor Evaluation Program in the development of special defueling tools and the collection of defueling-operation-related samples and in-situ measurements.

c. Prioritization of the information needs from the sample acquisition and examination tasks is as shown in Table 1. This prioritization is based on technical needs identified and discussed in the TMI-2 Accident Evaluation Program Document. These are shown in Table 2.

e. The portions of the total budget to be allocated to laboratory examination of samples is: $918K to other DOE laboratories, $1.38M to private domestic laboratories, and 2.9M to EG&G laboratories. In addition, NRC will fund about 600K for other DOE laboratory examinations.

These assumptions, along with the enhanced understanding we have of the TMI-2 accident, were considered in the development of the examination plan described in the following section.

TABLE 1. SUMMARY OF PRIORITIZED SAMPLE ACQUISITION TASKS

1. Central core bore to the lower core support plate, and visual examination.
2. Central core bore to the lower head, and visual examination.
3. Large volume sample from upper debris.
4. Topography of the crust below the debris bed.
5. Mid-radius core bores to the lower plenum (3 bores).
6. Local large volume samples of debris from the core support assembly region.
7. Local large volume samples of the debris resting in the bottom of the reactor vessel.
8. Two intact, part length fuel assemblies from control rod and poison rod locations.
9. Outer radius core bore to the lower core support plate.
10. Basement sludge samples.
11. Concrete samples from containment basement walls.
12. Primary cooling system surface and sediment samples from A and B loop steam generators, pressurizer, hot leg RTD thermowells, and steam generator manway and handhole covers.
13. Samples of the interaction zone between the core materials and lower core support assembly.
14. Samples of the interaction zone between the instrument guide tube structures and core material.
15. Samples of the interaction zone between the reactor vessel lower head surface and the lower core debris materials.
16. Samples of the interaction zone between the core former wall and core.
17. Fission product retention surfaces in upper plenum.
18. Upper plenum leadscrews.
19. Upper end boxes, control rod spiders, and spring from top of core.
20. Fuel rod segments from debris bed.

2. PRIORITIZED LIST OF TMI DATA NEEDS AND SAMPLE ACQUISITION TASKS

Primary Data Needs from TMI-2	Sample Data Acquisition Tasks	Prioritization Criteria: Technical Issue(s)a Priority	Prioritization Criteria: Data Applicability to Issue	Prioritization Criteria: Data Applicability for Establishing Consistent Accident Scenario	Overall Priority of Aquisition Task	Comments
structure of core, core support structures, ument structures, RPV lower head.	a. Video probe data through core bore channels (core and lower plenum).	High	High	High	High	a Video inspections are high priority information needs.
	b. Topography of core and lower plenum regions	High	High	High	High	b. Acoustic characterization of hardpan [illegible] debris bed 1
	c. Acquisition of core bore.	High	High	High	High	c Qualitative data from core boring will provide valuable into damage.
temperature, core and core support materials actions, and core boundary structures.	a. Distinct fuel assembly samples.	High	High	High	High	a. Will provide data on core boundary conditions (radially and poison rod behavior, and fuel degradation.
	b. Core bore samples plus video charcterization to correlate with examination results.	High	High	High	High	b Core bores are primary samples for determining temperat materials, and fission products vs location in the core plenum
	c. Large volume samples of core and lower plenum debris.	High	High	High	High	c. Necessary for extrapolating smaller sample material and product data and for debris bed characterization.
	d. Core former wall samples.	High	Medium	Medium	Medium-High	d. May not be required if intact.
	e Core support assembly samples.	High	High	High	High	e Extent of damage (chemical and thermal interactions) n determined
	f. Instrument structures samples.	High	High	High	High	f. Very important to assess vessel failure modes
	g. Reactor vessel wall samples.	High	Medium	Medium	Medium-High	g May not be required if undamaged
	h. Fuel assembly upper grid and/or end boxes.	High	Medium	Medium	Medium	h. Judged to be important in establishing core boundary
	i. Fuel rod segments from upper core region.	High	Medium	Low	Medium	i. Important for fission product release, local oxidatio

tinued)

Data Needs from TMI-2	Sample Data Acquisition Tasks	Technical Issue(s) Priority[a]	Data Applicability to Issue	Data Applicability for Establishing Consistent Accident Scenario	Overall Priority of Aquisition Tasks	Comments
l Release and Transport						
ission products in core materials.	a. Distinct fuel assemby samples.	High	High	High	High	a. Sufficient examinations are required for characterizing the retai fission products (important high and low volatility species).
	b. Core bore samples.	High	High	High	High	b. Core bore samples are primary sources of data from core and [illegible] plenum
	c. Large volume samples of core and [illegible] plenum debris	High	High	High	High	c. Large volume samples necessary to increase detectability limit fo some important radioisotopes.
ission products on primary stem surfaces.	a. Upper plenum surface samples.	Medium-[c] High	Medium Low	Medium	Medium	a. Surface deposition is important, however, only undissolvable component remains and is [illegible] to be very small. [illegible] data horizontal surfaces [illegible] be used for eva[illegible]ating separate effects experiments.
	b. Primary cooling surface samples o Access covers from steam generators and pressurizer. o Sediment from steam generators and pressurizer. o RTD thermowells.	Medium-High[c]	Low	Medium	Medium	b Surface deposition is important; however, only undissolvable component remains and is [illegible] to be very small Samples from accessable locations will complete RCS inventory Samples inclu A and B loop steam generators, manhole access covers (surface deposits and any accessable sediment), pressurizer, and hot leg thermowells.
ission products in containment	a. Sludge samples.	High[b]	Low[b]	High	High Medium	a Major final fission product repositories are known to be the rea vessel and the containment basement Uncertainty in containment inventory is still large
	b. Basement concrete wall samples	High[b]	Low[b]	High	High-Medium	b. Major final fission product repositories are known to be the rea vessel and the containment basement. Uncertainty in containment inventory is still large.
ssion products in transport side the reactor cooling system ding the containment Basement.	None specified.[e]	High[b]	Low[b]	Medium	L[illegible]	a These examinations and data are primarily for definition of the accident scenario The existing data requires more evaluation integrate the informative into the accident scenario and 2) determine the need for additional samples/data

. (continued)

Primary Data Needs from TMI-2	Sample Data Acquisition Tasks	Prioritization Criteria: Technical Issue(s)[a] Priority	Prioritization Criteria: Data Applicability to Issue	Prioritization Criteria: Data Applicability for Establishing Consistent Accident Scenario	Overall Priority of Aquisition Tasks	Comments
ission product chemical form	a. Fission product chemical form from all core material samples.	High	Medium	Medium	Medium-High	a. Applicability of data obtained to date to fission product form during the accident needs confirmatory evaluation
or system natural convection	a. Upper plenum temperature distribution	Medium	Medium	Low	Medium-Low	a. Reactor system natural convection heating was low in TMI confounding effect of B pump transient will make it diff evaluate natural convection cells in the reactor vessel.
ssel coupling of core degradation, thermal ulics, and fission product deposition	Data acquisition tasks 2a, 2b, 2c, 2d, 2h	High	Medium	Medium	Medium-High	a End-state characterization data will have to be coupled qualified online plant data and reactor systems models t consistent accident scenarios Coupled phenomena can on estimated from code sensitivity calculations.

riority in general applies to the technical issue grouping from Table 9 of the September 1985 draft TMI-2 Accident Evaluation Program document.

on product retention in containment is a very high priority severe accident issue, but primarily for accidents where the core has penetrated the essel and there is significant interaction between the concrete and the molten core, with vaporization or aerosol formation directly into the nt atmosphere. The TMI-2 accident did not progress to that stage.

specific technical issue is rated as medium priority for all severe accidents exce t the interfacing systems LOCA or "V" sequence, for [illegible] it is h.

ng reflects our knowledge that highest concentrations of fission products are probably in the core material and the containment basement. Also, his portion of the fission product pathway has already been sampled.

portion of the fission product transport pathway has been extensively sampled. Additional samples are not requested until a definite need is d.

5. EXAMINATION PLAN DESCRIPTION

The technical background and purpose, previous accomplishments, sample examination plans, product lists and schedules, and resource allocation are described in the TMI-2 AEP SA&E Plan. The plan is divided into four work package categories as follows:

1. Reactor vessel, which includes the reactor vessel, its internal structures, and the core.

2. RCS fission product inventory, which includes the core materials and fission products now residing in the ex-vessel portion of the RCS, including the core flood tanks.

3. Ex-RCS fission product inventory, which includes the core materials and fission products now residing in areas, buildings, and equipment external to the RCS.

4. Program management support, which includes personnel and services to plan, direct, and control the sample acquisition and examination program.

Table 3 is a summary of the in-situ measurements and sample acquisitions and examinations that will satisfy the technical information needs identified the TMI-2 Accident Evaluation Program document and listed in Table 2. Table 3 includes prior year sample acquisitions and examinations and in-situ measurements for completeness. The Sample Acquisition and Examination Plan includes:

1. Acquisition of all samples, distinct components, and in-situ measurements listed in the Future Additional Samples column under Quantity.

TABLE 3. TMI-2 ACCIDENT EVALUATION IN-SITU MEASUREMENTS AND SAMPLE ACQUISITIONS AND EXAMINATIONS

Measurement/Examination Activity	Quantity: Completed Exams	Quantity: Future Additional Samples	Quantity: Proposed Future Exams	Priority[e]	Examiner[a]	Justification/Information
A. Reactor vessel visual examination						Explain accident scenario and support sample selection.
1. Closed circuit television surveys	3 areas[d]	NA	1 area	1	REP/AEP	Determine lower core support structure ablation and approximate location and volume of internal cavities.
2. Periscope survey	0	NA	1 area	4	REP	Improved images of loose debris in core cavity region.
3. Sonar topography survey	1 area	NA	1 area	4	REP/AEP	Core cavity dimensions after loose debris and distinct core component removal.
B. Core bore samples of fused/joined core material						Determine condition and quantity of fused/joined core material under loose debris and between core and reactor vessel head
1. Under loose debris	0	up to 12	3	1, 5, 9	AEP-INEL	
2. Subcore	0	up to 18	5	2, 5, 9	NRC-ANLE[c]	Determine retained fission product concentration and chemical form.
C. Core distinct components						
1. Upper core region						
a. 6-in. fuel rod segments from core cavity periphery	0	6	0	20	--[b]	Determine condition of unrelocated fuel rods in upper core region. In-situ separation of segments. Reduce uncertainty in retained fission product inventory (especially tellurium) from previous grab sample examination.
b. Small grab samples from upper core debris	11	4	0	--		Study interactions between fuel rods and control or burnable poison material and variations in fuel rod damage around the core periphery. Segment separation from fuel assembly remnant will be performed in INEL hot cell.
c. Large grab samples from upper core debris	0	2	1	3		
d. Fuel assembly upper section:						
(1) Fuel rod segments from core cavity periphery fuel assembly remnants	0	25	4	8	AEP-INEL[b]	
(2) Guidetube/burnable poison rod (BPR) segments	0	5	1	8	AEP-INEL[b]	

TABLE 3. (continued)

Measurement/Examination Activity	Quantity: Completed Exams	Quantity: Future Additional Samples	Quantity: Proposed Future Exams	Priority[e]	Examiner[a]	Justification/Information
(3) Guidetube/control rod segments	0	5	1	8	AEP-INEL[b]	
(4) Instr. tube/instr. string segments	0	3	0	19	--[b]	
(5) Instrument tube segments	0	3	0	19	--[b]	
(6) Spacer grids	0	9	0	19	--[b]	
(7) Upper end boxes	0	16	0	19	--[b]	
(8) Holddown springs	0	14	0	19	--[b]	
e. Burnable poison rod spiders	0	6	0	19	--[b]	
f. Control rod spiders	0	7	0	19	--[b]	
g. Axial power shaping rod (APSR) spider surface deposit	0	1	0	19	--[b]	
2. Lower core region						Additional data needed to complete selection.
a. Fuel rod segments	0	TBD	4	TBD	AEP-INEL	
b. Guide tube/BPR segments	0	TBD	1	TBD	AEP-INEL	
c. Guide tube/control rod segments	0	TBD	1	TBD	AEP-INEL	
d. Inst. tube/instr. string segments	0	TBD	0	19	--[b]	May provide information on thermocouple junction relocation.
e. Instrument tube segments	0	TBD	0	19	--[b]	
f. Spacer grids	0	TBD	0	19	--[b]	
g. Lower end boxes	0	TBD	0	19	--[b]	
D. Lower Vessel Debris						
1. Core material samples from lower head region						
a. Small	0	10	10	7	REP-INEL NRC-ANLE	
b. Large		1	1	7	REP-INEL NRC-ANLE	From 2 azimuthal locations via downcomer access.
2. Reactor vessel lower region gamma scans through instrument strings	0	--	-	--	--[b]	Ion-chamber survey of any of 35 unsurveyed core instrument string calibration tubes. Data may be convertible to location of fuel and nonfuel materials.
3. Samples of loose debris in lower core support structure region	0	1	1	6	AEP-INEL	Character of loose debris in lower core support structure region.

TABLE 3. (continued)

Measurement/Examination Activity	Quantity: Completed Exams	Quantity: Future Additional Samples	Quantity: Proposed Future Exams	Priority[e]	Examiner[d]	Justification/Information
E. Reactor vessel internals examinations						
1. Control rod leadscrews	2	7	0	18	--[b]	Fission product transport path, temperature gradient, and reactor vessel natural recirculation routes.
2. Core former wall samples	0	180	4	16	AEP-PL	Data for isotherm maps and materials interactions at core periphery.
3. Leadscrew support tube lower section	1	0	0	Low	AEP-BCL	Characterization of surface deposits in reactor vessel dome region.
4. Core lower support structure plate samples	0	180	6	13	AEP-PL	Data for isotherm maps and materials interactions along core material relocation path. Fission product inventory and materials interactions.
5. Reactor vessel lower head samples	0	180	2	15	AEP-PL	Data for isotherm maps and materials interactions.
6. Lower plenum horizontal surface deposits	0	180	0	17	--[b]	Fission product inventory data.
7. Lower plenum instrument structures	0	180	6	14	AEP-PL	Materials interactions.
F. Reactor coolant system (RCS) characterization						
1. RCS Gamma Scans						Capability to convert data to radionuclide and uranium abundance & location uncertain.
a. A loop steam generator (external)	7	N/A	0	Low	GPUN/AEP	
b. Pressurizer (external)	6	N/A	0	Low	GPUN/AEP	
c. Core flood tank B	9	N/A	0	Low	GPUN/AEP	
d. Steam generator inside	0	N/A	TBD	Low	GPUN/AEP	
e. Pressurizer inside	0	N/A	TBD	Low	GPUN/AEP	
f. Pressurizer surge line	0	N/A	TBD	Low	GPUN/AEP	
g. Decay heat removal line	0	N/A	TBD	Low	GPUN/AEP	
h. Pump volutes	0	N/A	TBD	Low	GPUN/AEP	
i. Hot legs	0	N/A	TBD	Low	GPUN/AEP	
2. RCS adherent surface deposits						Adherent fission product deposits
a. A loop RTD thermowell	1	0	0	12		
b. B loop RTD thermowell	0	1	1	12	AEP-PL	
c. A loop steam generator handhole cover liner	0	1	1	12	AEP-PL	

TABLE 3. (continued)

	Quantity					
Measurement/Examination Activity	Completed Exams	Future Additional Samples	Proposed Future Exams	Priority[e]	Examiner[a]	Justification/Information
d. B loop steam generator manway cover backing plate	0	1	1	12	AEP-PL	
e. Pressurizer manway cover backing plate	0	1	1	12	AEP-PL	
3. RCS sediment						
a. Steam generator tube sheet top loose debris	0	2	2	12	AEP-PL	Character of sediment in both steam generator upper heads.
b. Steam geneator lower head loose debris	0	2	2	12	AEP-PL	GPU Nuclear project. Character of sediment in both steam generator lower heads.
c. Pressurizer sediment	0	1	1	12	AEP-PL	Character of sediment in pressurizer lower head.
G. Ex-reactor-coolant-system characterization						
1. Reactor building						
a. Liquid						Basement liquid has been drained and decontaminated.
(1) Basement 305 ft el.	110 ml	0	0	Low	AEP-INEL	
(2) Basement 325 ft el.	120 ml	0	0	Low	AEP-INEL	
(3) Bottom open stairwell	45 ml	0	0	Low	AEP-INEL/HEDL	
(4) Basement sump pit	200 ml	0	0	Low	AEP-INEL/HEDL	
(5) Reactor coolant drain tank (RCDT)	120 ml	0	0	Low	AEP-INEL/HEDL	
b. Sediment						Sediment includes Suequehanna River silt as well as core fission products and materials.
(1) Basement 305 ft el.	108 g	0	0	10	AEP-INEL	
(2) Basement 325 ft el.	25 g	0	0	10	AEP-INEL	
(3) Bottom open stairwell	1 g	0	0	10	AEP-INEL/HEDL	
(4) Basement sump pit	72 g	0	0	10	AEP-INEL/HEDL	
(5) Reactor coolant drain tank	0.5 mg	0	0	10	AEP-INEL/HEDL	
(6) Basement floor (282 ft el.)						
(a) RCDT discharge area	0	3	3	10	AEP-PL	
(b) Leakage cooler room, RCDT room, inside D-ring, outside D-ring areas	0	10	10	10	AEP-PL	

TABLE 3. (continued)

	Quantity					
Measurement/Examination Activity	Completed Exams	Future Additional Samples	Proposed Future Exams	Priority[e]	Examiner[d]	Justification/Information
(c) Core instrument cable chase	0	2	2	10	AEP-PL	
c. Concrete bores						
(1) Floors: 347 ft el.	8	0	0	Low	GPUN/AEP	
305 ft el.	6	0	0	11	GPUN/AEP	
282 ft el.	0	10	13	11	AEP-PL	GPUN proposal, bore depth not specified, after floor dewatering and desludging.
(2) D-ring walls: 347 ft el	1	0	0	Low	GPUN/AEP	
305 ft el.	2	0	0	11	GPUN/AEP	
flooded region	3	8	3	11	AEP-PL	GPUN proposal, bore depth not specified
(3) 3000 psi (shield) wall (flooded region)	3	8	3	11	AEP-PL	GPUN proposal, bore depth not specified.
(4) Block (elevator/stairwell) walls (flooded region)	3	8	3	11	AEP-PL	GPUN proposal, bore depth not specified.
d. Adherent surface deposits						
(1) Air cooler panels	5	0	0	Low	AEP-INEL	
(2) Basement outer wall steel liner	0	180	180	Low	AEP-PL	Acquisition and examination plan under consideration.
2. Auxiliary and fuel handling buildings						All equipment in the auxiliary and fuel handling buildings has been fully or partially decontaminated by flushing, filter removal, water treatment, and resin removal or treatment.
a. Liquid						
(1) Reactor coolant bleed tank A	125 ml	0	0	Low	AEP-INEL	
(2) Reactor coolant bleed tank B	150 ml	0	0	Low	AEP-INEL	
(3) Reactor coolant bleed tank C	150 ml	0	0	Low	AEP-INEL	
(4) Makeup and purification demineralizer B	40 ml	0	0	Low	AEP-ORNL	
b. Sediment						
(1) Reactor coolant bleed tank A	60 g	0	0	Low	AEP-INEL/HEDL	
(2) Makeup and purification demineralizer A (resin)	10 g	0	0	Low	AEP-ORNL	
(3) Makeup and purification demineralizer B (resin)	40 ml	0	0	Low	AEP-ORNL	
c. Filter housing contents (filter paper, liquid, and collected solids)						

TABLE 3. (continued)

	Quantity					
Measurement/Examination Activity	Completed Exams	Future Additional Samples	Proposed Future Exams	Priority[e]	Examiner[a]	Justification/Information
(1) Makeup and purification system						
(a) Demineralizer prefilters	both	0	0	Low	AEP-INEL/ LANL, NRC-ANLE	
(b) Demineralizer after filters	both	0	0	Low	AEP-INEL/ LANL, NRC-ANLE	
(2) RC pump seal water injection system filters	both	0	0	Low	AEP-INEL/ LANL, NRC-ANLE	

a. Examination responsibility is shown with the funding organization (AEP, REP, NRC, and/or GPUN) shown first (xxx/xxx indicates joint funding and/or performance responsibility), and the sample examination location shown second. Names of funding organizations are abbreviated as follows: Accident Evaluation Program, AEP; Reactor Evaluation Program, REP; Nuclear Regulatory Commission, NRC; GPU Nuclear, GPUN. Names of examination locations are abbreviated as follows: Idaho National Engineering Laboratory, INEL; Argonne National Laboratory-East, ANLE; Battelle Columbus Laboratories, BCL; Hanford Engineering Development Laboratory, HEDL; Oak Ridge National Laboratory, ORNL; Los Alamos National Laboratory, LANL. PL indicates an outside private laboratory is expected to perform the examination.

b. Possible examination by foriegn laboratory, including funding.

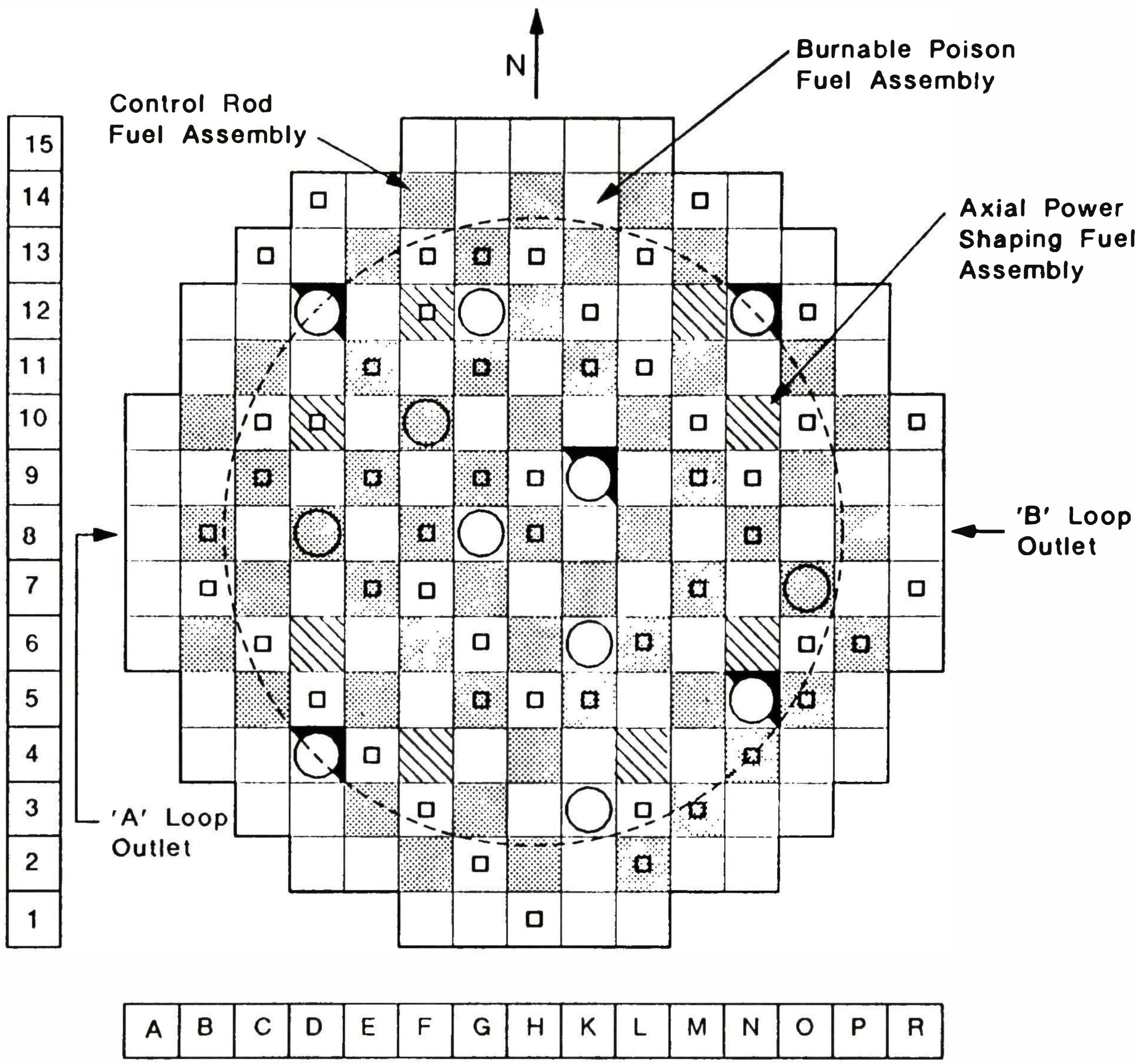
c. Possible examination of two core bores and lower plenum debris by ANL using NRC funding.

d. Completed reactor vessel CCTV surveys include the following areas: all sides of the upper core region cavity, core cavity region loose debris after dislodging core components from plenum assembly, plenum assembly, and accessible areas of the downcomer and reactor vessel bottom head periphery regions.

e. Priority values 1 through 20 are listed in Table 1.

2. Sample examination and in-situ measurement analysis of only those items listed in the Proposed Future Exams column. Only the high priority tasks can be accomplished within the allocated resources. Selection was made using the examination priority list shown in Table 1.

The proposed core bore acquisition and examination plan will provide as much flexibility as possible, since the core bores will be taken from the unexplored region below the core cavity. The core bore acquisition plan is to obtain as many core bore samples as possible using the recommended locations and priorities shown on Figure 1. Each boring location will yield two or three samples (segments); one from the core region and one or two from the region beneath the core, depending on whether or not the lower flow distributor is encountered. The twelve bore locations shown on Figure 1 will provide for radial and azimuthal variations in core damage, characterize the differences between control and burnable poison rod assemblies, and infer location, composition and tensile properties of the core materials. This information will be derived from bore cutting tool data (cutting speed, tool location, cutter material, etc.) obtained during boring operations. Because of funding constraints, the examination plan includes only the segments (3 from the core region, 5 from the region beneath the core) from the three (K9, F10, and N5) high priority locations shown on Figure 1. Medium priority or contingency location segments will be examined if the higher priority location segments cannot be acquired. Examination of these eight core bore samples will yield information on the quantity and the physical and chemical state of fused core materials beneath the loose debris and in the lower plenum. These examinations will also provide data on fission product concentration and chemical form. However, with only three core locations being examined, only the axial and radial variation in these parameters will be determined. Measurement of azimuthal variation would require that more samples be examined.



◯ Recommended Core Bore Location

High Priority	Medium Priority	Contingency
K9	K6	D4
F10	N12	G12
N5	D12	K3
	G8	D7
	D8	

Figure 1. Core bore locations.

Four fuel rod segments, two each from a part-length peripheral control rod assembly and a part-length peripheral burnable poison rod assembly will be examined. One of the fuel rod segments will be obtained from a location near a control rod position and one from a location not near a control rod position. The control rod remnant will also be obtained. Examination of these three (two fuel rods, one control rod) rod segments will help determine the effect of control rod materials on the damage to adjacent fuel rods. The examination of two fuel rods and one burnable poison rod remnant will be structured in a similar manner. Fuel roo segments from a burnable poison rod and a control rod assembly in the lower core region will also be obtained and examined, if possible.

The large debris sample from the debris bed below the upper cavity will help reduce the uncertainty in the retained fission products (especially tellurium) that was measured from the 11 grab samples already examined. Analysis of this large sample will also help determine the homogeniety of the upper debris bed and therefore the applicability of the data from the 11 small samples to the entire debris bed.

Eleven other small debris samples have been obtained from the lower vessel debris bed. Examination of these samples will indicate the fission product retention in a mixture of materials that probably contains more structural material than the upper core debris bed. A large sample of this lower vessel debris will also be obtained and examined to determine homogeniety. Also, a large sample of loose debris will be obtained from the lower core support structure region if possible. The debris examination programs are intended to yield data on the prior peak temperature, materials interactions, and material composition and tensile properties.

In order to determine fission product chemical form and fission product and aerosol interaction with structural materials, samples will be obtained from both the reactor coolant system and the Ex-RCS fission product transport pathways. Samples of high priority in the Ex-RCS are sediment samples and concrete samples from the containment building basement walls and floor. Samples of high priority in the reactor coolant system are adherent surface deposits on the B-loop RTD thermowell, the A-loop steam generator handhole cover liner, the B-loop steam generator manway cover backing plate, and the pressurizer manway cover backing plate. Sediment will be obtained for examination from the steam generator lower head, the top of the steam generator tube sheet, and the bottom of the pressurizer.

The proposed financial plan for the SA&E plan is shown in Table 4, and the companion schedule of activities is shown in Table 5. The list of work package numbers and titles on Table 4 identifies the entire Work Breakdown Structure for the SA&E plan. In brief, the SA&E Plan Work Breakdown Structure provides the following:

1. Acquisition of the samples listed in Table 3 in the Future Additional Samples column. For FY-1986 this includes: as many core bores as possible from up to twelve locations during the 30-days scheduled for core boring, six approximately 6-in. long fuel rod segments, control rod and burnable poison rod spiders, fuel assembly upper end fittings, fuel assembly upper sections, additional core material samples from the loose debris at the floor of the core cavity and from the lower head region; RCS adherent surface deposit samples from a resistance thermal detector (RTD) thermowell, a steam generator handhole cover liner, and from pressurizer and steam generator manway cover backing plates; RCS loose debris samples from the top of the steam generator tube sheets, the steam generator lower plenum, and the pressurizer lower head; and approximately 17 sediment samples from the reactor building basement floor. Acquisition of the remaining samples is planned for FY-1987 and beyond.

2. Examination of the samples listed in the Proposed Future Exams column of Table 3. For FY-1986 this includes initiating the examination of six core bores, four fuel rod segments, one control rod segment, one burnable poison rod segment, nine particles of the reactor vessel lower head debris, two "large"

TABLE 4. TMI-2 AEP SAMPLE ACQUISITION AND EXAMINATION WORK BREAKDOWN STRUCTURE AND FUNDING PLAN

Work Package Number	Description	Funding Plan ($ X 1000) FY-1985	FY 1986	FY-1987	FY-1988	FY-1989	Total
Reactor Vessel SA&E							
7S14202	Reactor vessel internal (acq)	52	81	0	0	0	133
7S14203	RTD thermowells (acq)	7	0	0	0	0	7
7S14204	Lower Head Debris (acq)	70	0	0	0	0	70
7S14205	Fueled rod segments (acq)	107	202	0	0	0	309
7S14206	Stratification (core bore acq)	1679	1723	0	0	0	3402
7S14208	Control rod leadscrew (acq)	16	0	0	0	0	16
7S14212	Discrete core components (acq)	18	199	500	270	0	987
7S54201	Debris bed sample (exam)	411	209	10	0	0	630
7S54202	Reactor vessel internals documentation	52	237	0	0	0	289
7S54205	Fuel rod segments (exam)	7	0	0	0	0	7
7S54206	Stratification sample (exam)	8	1063	1207	190	0	2468
7S54208	Control rod leadscrew (exam)	153	0	0	0	0	153
7S54209	Leadscrew support tube (exam)	62	0	0	0	0	62
7S54212	Core distinct component (exam)	8	144	334	406	0	892
7S54216	Lower vessel debris examination	1	379	0	0	0	380
New	Core former wall examination	0	0	165	0	0	165
New	Core support assembly examination	0	0	0	250	0	250
New	RV instrument penetration examination	0	0	0	0	250	250
New	RV lower head examination	0	0	0	0	165	165
9MA8501	Sample handling equipment	455	369	0	0	0	824
9M78402	Core bore equipment	1710	0	0	0	0	1710
9M78306	Core topography system phase 2	377	170	0	0	0	547
9MA8404	Image Processing	259	0	0	0	0	259
RCS FPI SA&E							
7S1421	RCS gamma scan (acq)	97	105	207	243	0	652
7S5421	RCS FPI sample examination	19	53	443	3	0	518
Ex-RCS FPI SA&E							
7S14213	Equipment/building characterization (acq)	0	105	250	175	0	530
7S54203	Ex-RCS FPI sample examination	8	162	36	249	13	468
SA&E Program Management Support							
7S542PM	Project management	158	493	396	362	0	1409
	Subtotal	5734	5694	3548	2148	428	17552
	Other DOE Labs	115	308	568	75	0	1066
	Costs prior to 1985						1966
	Total						20584

TABLE 5. TMI-2 AEP SAMPLE ACQUISITION AND EXAMINATION PLAN SCHEDULE SUMMARY

Activity Description	Schedule FY-1986	FY-1987	FY-1988	FY-1989
A. Sample Acquisition and In-Situ Measurement Program				
1. Core and subcore bores	X			
2. Six approximately 6-in. long fuel rod segments	XXXX			
3. Small grab samples from upper core debris	X			
4. Large grab samples from upper core debris	X			
5. Fuel assembly upper sections[a]	XXXX			
6. Burnable poison rod spiders	XXXX			
7. Control rod spiders	XXXX			
8. APSR surface deposit	XXXX			
9. Fuel assembly lower sections[b]		XXXXX		
10. Core cavity topography after loose debris removal	X			
11. CCTV of lower core support structure	XX			
12. Core material samples from lower head region: small	X			
large	X			
13. Lower core support structure region loose debris	XX			
14. Control rod leadscrews		XXXXXXXXXX	XXXXXXXX	
15. Core former wall samples		XXXXXX	XXXXXXXXXXXX	
16. Core lower support structure plate samples		XXXX	XXXXXXXXXXXX	
17. Reactor vessel lower head samples			XXXXXXXXXX	
18. Upper plenum horizontal surface deposits			XXXXX	
19. Lower plenum instrument structures			XXXXX	
20. RCS gamma scans[c]	XXXXXXXXX			
21. B-loop RTD thermowell	XXX			
22. A-loop steam generator handhole cover liner	XXX			
23. B-loop steam generator manway cover backing plate	XXX			
24. Pressurizer manway cover backing plate	XXX			
25. Steam generator tube sheet top and lower head loose debris	XXXXXXX			
26. Pressurizer lower head loose debris	XXX			
27. Reactor building basement floor sediment				
o RCDT discharge area	XXXX			
o Leakage cooler room, RCDT room, inside and outside D-rings	XXXXXXXX			
o Core instrument chase	XXXXXXXXX			
28. Reactor building basement concrete bores:				
o Floor		XXXXX		
o D-ring (5000 psi) walls		XXXXXX		
o Shield (3000 psi) walls		XXXXXX		
o Block (elevator and stairwell walls)		XXXXXX		
28. Reactor building basement outer wall steel liner surface	TO BE DETER	MINED		
B. Sample and Data Examination Program				
1. Core region bores	XXXXX	XXXXXXXXXXX		
2. Subcore region bores	XXXXX	XXXXXXXXXXX		
3. Fuel assembly upper sections	XXX			
4. Fuel, control, and burnable poison rod sections (upper core)		XXXXXX		
5. Small grab samples from upper core region	XXXXXXX	XXX		
6. Large grab samples from lower core region	XXXXXXX	XXX		
7. Fuel assembly lower sections			XXXX	
8. Fuel, control, and burnable poison rod sections (lower core)			XXXXXXX	
9. Core material samples from lower head region: small	XXXXXXXXXX			
large	XXXXXXXXXX			
10. Lower core support structure region loose debris		XXXXXXXX	XXXXXXXXXXXX	XXXX
d 11. Core former wall samples		XXXXX	XXXXXXXXXXXX	XXXX
d 12. Core lower support structure plate samples		XXXX	XXXXXXXXXXXX	XXXX
d 13. Reactor vessel lower head samples			XXXXXXX	XXXX
d 14. Lower plenum instrument structures			XXXX	XXXX
d 15. RCS gamma scan data analysis	XXXXXXXXXXXX			
d 16. B-loop RTD thermowell	XXXXXX			
d 17. Steam generator/pressurizer handhole cover/manway liner surfaces		XXXXXXXXXXX		
d 18. Steam generator/pressurizer loose deposits		XXXXXXXXXX	XXX	
d 19. Reactor building basement floor sediment samples	XXXXXXXX	XXXX		
d 20. Reactor building basement concrete bores			XXXXXXXXXXX	XXXX

a. Expected to contain spiders; upper end fittings including holddown springs; spacer grids; and fuel rod, guide tube, control rod, burnable poison rod, and instrument string sections.

b. Assumed to contain lower end boxes; spacer grids; fuel rod, guide tube, control rod, burnable poison rod and instrument string sections; and solidified previously molten core material.

c. Includes steam generator insides, pressurizer inside, pressurizer surge line, decay heat removal line.

d. Examination will be performed by an outside laboratory.

samples of core cavity floor loose debris, the B-loop hot leg RTD thermowell, and approximately 12 reactor building basement sediment samples. Initial examination of the remaining "Proposed" samples is planned for FY-1987 and FY-1988.

The TMI-2 AEP will evaluate the availability of and pursue other resources to examine all the samples listed in the Future Additional Samples column of Table 3. Potential resources include the NRC, OECD/CSNI,[a] and domestic fuel suppliers.

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a. Organization for Economic Cooperation and Development, Committee on the Safety of Nuclear Installations.

6. SUMMARY

The TMI-2 Accident Evaluation Program Sample Acquisition and Examination Plan presents a challenging, high-technology program that addresses the severe core damage accident issues set forth in the TMI-2 Accident Evaluation Program document. The issues addressed include reactor system thermal hydraulics, core damage and damage progression, reactor vessel failure, and fission product release from the fuel and transport and retention within the RCS. The planned examinations include the following:

a. Physical samples from the upper plenum, RCS piping, and vessel internals to determine temperature distribution.

b. Core debris grab samples from the core and lower plenum regions to characterize materials interactions and fission product behavior.

c. Fuel rod segments from the upper and lower portion of intact peripheral assemblies to provide estimates of temperature, fission product retention, and the effects of control and poison rod materials on core damage.

d. Core stratification samples for spatial determination of core damage, material interactions, and relocation of previously molten materials.

e. Lower core support, core instrument support, and lower vessel head area structural component samples to help determine the extent of damage to core boundary material and reactor vessel walls.

f. Ex-vessel and balance-of-plant samples to provide data on fission products, such as chemical form, material associations, and the extent of release from the reactor vessel and transport to the TMI-2 plant.

In addition, the Sample Acquisition and Examination program is designed to (a) be flexible to accommodate new findings, information, and knowledge that may become available from either this examination plan, the GPU Nuclear defueling program, or any SCD research program, (b) be updated annually during the evolution of the TMI-2 Accident Evaluation Program, and (c) be conducted in accordance with DOE contractor business practices for effective accomplishment of government-funded projects.

7. REFERENCES

1. TMI-2 Accident Evaluation Program, EGG Draft, distributed September 24, 1985 under transmittal letter No. JMB-39-85.

2. GEND Planning Report 001, June 1980.

3. Johan O. Carlson, ed., TMI-2 Core Examination Plan, EGG-TMI-6169, July 1984.