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TMI-2 Information And Examination Program Technical Integration Office Annual Report

Technical Integration Office

February 1981

Prepared for the
U.S. Department of Energy
Three Mile Island Operations Office
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Technical Integration Office
Three Mile Island

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EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

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ABSTRACT

This annual progress report includes all activities conducted under the DOE portion of the TMI-2 Information and Examination Program during Fiscal Year 1980, which consists of tasks in the following major areas: instrumentation and electrical equipment survivability; radioactivity and environment; configuration, document control and archives; and reactor core and fuel examination. The report is prepared to provide interested personnel within the nuclear industry with a description of the program activities from its inception through September 30, 1980. This report has been prepared with the intent of stimulating interest in specific program activities to ensure the results of the program provide maximum benefit to the nuclear industry and assist in resolution of specific concerns.

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INTRODUCTION

Background

The TMI Unit 2 accident of March 28, 1979, was and is of great concern to the electric industry, its customers, regulatory and other Government agencies, and the country as a whole. While the accident resulted in only limited radiation exposure to the population surrounding the power plant, extensive damage resulted in the plant itself, with high radiation contamination within the reactor and supporting systems and facilities.

The TMI Unit 2 accident currently presents unique opportunities to accumulate information for the enhancement of nuclear power plant safety and reliability of generic benefit to nuclear power technology. Four organizations, the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), the Electric Power Research Institute (EPRI), and the General Public Utilities Company (GPU) are interested in obtaining this information during the course of TMI-2 cleanup. These organizations, identified by the acronym GEND, have established a TMI-2 Information and Examination Program. A Coordination Agreement was signed to reflect implementation of this program. The Coordination Agreement identifies the objectives and defines, in broad terms, methods to achieve these objectives.

The program presently consists of tasks in seven major areas. Electric Power Research Institute (EPRI) has responsibility for tasks in the areas of decontamination of the primary system, mechanical components survivability, and pressure boundary requalification. These portions of the program will be reported separately by EPRI.

Program Objectives

The TMI Unit 2 accident of March 28, 1979, represented a severe integral test of nuclear plant safety philosophy and safety systems performance. The damage to the reactor core and the subsequent release of fission products to the primary system, containment, and elsewhere in the plant is extensive.

The environmental conditions within the containment and the reactor and auxiliary systems pose technically challenging decontamination and radioactive waste management situations. These circumstances represent opportunities for state-of-the-art advancement not available through normal research, development, and test programs. Consequently, the objective of the program is to obtain significant information and to make it available for the general improvement of light-water reactor plant safety, reliability, regulation, and operation. It is expected that significant information and experience will be obtained during GPU's planned cleanup program, particularly during the stages of plant assessment and decontamination. This information will be used to develop and improve measures for enhancing safety and reliability of nuclear power plants, and to improve the capability to safely recover civilian nuclear power plants from accidents. To achieve these ends, the following tasks are necessary:

- Careful examination and evaluation of the TMI-2 plant and equipment to improve the understanding of the accident itself and the response of the nuclear power plant components, systems, and materials to accidents

- Collection, analysis, and dissemination of information obtained by this program in a manner to improve the reliability and safety of nuclear power plants and improve the ability to safely recover civilian nuclear power plants from future accidents.

The program will be conducted so as not to delay the GPU cleanup schedule. Any applicable information and experience gained during these TMI-2 operations will be integrated into ongoing Government, EPRI, and GPU research and development programs; it will be made available to others engaged in the design, construction, operation, and maintenance of nuclear power plants.

Summary of FY 1980 Accomplishments

Specific information on task descriptions, objectives, accomplishments, and planned future activities appear in the specific task sections of this report. Those accomplishments significant for meeting overall program objectives and highlights of other particularly significant accomplishments are summarized in this section.

Planning Documents. The first necessary element of the program was to establish planning documents and the organizations necessary to implement the required activities. To this end, planning reports were developed and issued in GEND 001, *TMI-2 Information and Examination Program Planning Report.*

Formation and Staffing of the Technical Integration Office. The second necessary element was formation and staffing of the Technical Integration Office (TIO) as provided for in the Coordination Agreement signed by DOE, NRC, EPRI, and GPU. This office was initially staffed in January 1980 with seven full-time employees from EG&G Idaho, Inc. Staffing was increased during the year to 12 persons to meet the expanding program demands. Since the unique nature of the TIO afforded opportunities for participation of various organizations, the staff included two Pennsylvania State University seniors and personnel from Sandia National Laboratory, Exxon Nuclear Idaho Company, Inc., and EG&G Idaho, Inc., temporarily located at TMI. Office facilities are pictured in Figure 1.

During the year, the following were major management accomplishments:

- The *TMI-TIO Program Management Plan*, approved in September 1980, established the formal mechanisms and procedures for the TIO function

- A time and materials contract was signed between EG&G Idaho and GPU in July 1980 to enable the performance of activities at TMI

- The TMI-2 Information and Examination Program *Quality Program Plan* was issued in September 1980

- The *Fiscal Year 1980 Procurement Plan* was prepared and executed when program funding became available.

Instrumentation and Electrical Equipment Survivability. Significant accomplishments in the Instrumentation and Electrical Equipment Survivability portion of the program included:

- Removal of one instrument, a radiation detector, during the second entry into the reactor building

- Procurement of a portable video system for damage assessment documentation and recording significant cleanup program activities

- Procurement of a fixed video system for documentation of the reactor building recovery program activities for the Technical Information and Examination Program

- Performance of in-place examinations of 12 instruments to develop techniques for determining the cause of failure, and development of a data inventory and history folder for each instrument proposed for removal and testing.

Radioactivity and Environment/Dose Reduction Technology. Significant accomplishments in the Radioactivity and Environment and Dose Reduction Technology portion of the program included:

- Taking of early samples from the following:

  Reactor coolant

  - Reactor coolant bleed tank

  - Containment air

  - Hydrogen recombiner piping.

  These samples were all collected early enough that they would not be lost in the ensuing recovery activities.

Figure 1. Technical Integration Office facilities.

- DOE, the Pennsylvania Department of Environmental Resources, the Environmental Protection Agency, and Pennsylvania State University jointly developed and implemented an integrated community radiation monitoring program. Under this program, specially trained residents of communities within a five-mile radius monitored airborne releases with qualified equipment.

- All activities of the reactor building purge that began June 28 were documented for inclusion in a comprehensive report on the sequence of events and results.

- A project was initiated involving the characterization of the highly loaded resins and resin liners used by the EPICOR II system.

Configuration Document Control/Archives. The most significant accomplishment in the Configuration, Document Control, and Archives portion of the program was that all the hardware and software for the Documentation Control Center and the data bank systems was obtained, developed, and fully operational by September 1980. A second major accomplishment was the development and issuance of two Technical Information and Examination Program *Update* newsletters. The second newsletter had a distribution of approximately 3,000 persons associated with the nuclear industry.

Reactor Core and Fuel Examination. Significant accomplishments in the Reactor Core and Fuel Examination portion of the program included:

- Initiation of assessment of the TMI-2 core configuration by photo visual inspection through the reactor vessel head. (This task was well into detailed design by the end of Fiscal Year 1980.)

- Initiation of conceptual development of a can for fuel and debris removed from the TMI-2 core.

- Initiation of development of materials and techniques for in situ encapsulation of core debris.

INSTRUMENTATION AND ELECTRICAL EQUIPMENT SURVIVABILITY

Objectives

The proper function of instrumentation and electrical equipment during an accident is critical for control and operation of the plant to mitigate accident sequences. The TMI Unit 2 accident subjected the equipment to environments that may have been different from those specified in current design standards. Hence, the data that can be obtained from the instrumentation and electrical equipment installed in the TMI-2 containment and auxiliary buildings will be valuable in (a) developing improved and more comprehensive standards for equipment qualification, (b) understanding how equipment designed under existing standards performed, (c) identifying equipment failure modes, (d) selecting approaches for improving equipment design in future nuclear power plant installations, and (e) qualifying data from the TMI-2 accident to enhance understanding of the sequence of events.

The purpose of the Instrumentation and Electrical Equipment Survivability Task is to plan, develop, and execute the orderly recovery of instrumentation and electrical data from the TMI Unit 2 containment and auxiliary buildings.

Approach

An Instrumentation and Electrical Equipment Survivability Planning Group (IEPG) was appointed to develop planning guidance for the orderly recovery of data pertaining to the survivability of instrumentation and electrical equipment contained within the TMI Unit 2 reactor building. This program's purposes include:

1. Identifying failure modes

2. Comparing performance against existing standards

3. Analyzing Class 1E system vulnerability regarding accident management and postaccident monitoring and recovery

4. Recommending revisions to qualification standards, regulatory guides, design guides, and federal regulations

5. Increasing understanding of the TMI-2 accident.

Planning group objectives were:

1. Specifying instrumentation and electrical equipment for in-place testing and/or removal and analysis

2. Defining test objectives and methods for the components selected

3. Defining components/samples for archival storage.

The TIO technical coordinator integrated the planning effort with other persons in agencies and subcontractor organizations including members of the Nuclear Regulatory Commission; Department of Energy; Sandia National Laboratory; Oak Ridge National Laboratory; Electric Power Research Institute; Technology for Energy Corporation; General Public Utilities; Science Applications, Inc; Babcock & Wilcox Co.; and Morefield Communications.

The TIO staff planned and identified the tasks required to complete the stated objectives for performance in Fiscal Year 1980. The accomplishments to date are presented in the following sections.

Significant Accomplishments During FY 1980 in Instrumentation and Electrical Equipment Survivability

Examination Program. Under the joint direction of TIO and a Sandia engineer, 12 instruments were identified for possible inclusion in the Early Equipment Removal Program (EERP). In-place testing was initiated on these devices and one device was removed from the reactor building during the time period from the first to second entry into the reactor building.

Survey Program—As part of an overall survey program of approximately 200 instruments and electrical devices, 12 instruments were selected during Fiscal Year 1980 to survey for the EERP. These devices were tested as defined in Table 1. The Technology for Energy Corporation developed the test procedures, made the measurements, and completed the analysis. Preliminary data from this testing indicated the probable cause of failure for most devices. To verify the effectiveness of the diagnostic method, one of the tested devices was removed from containment and shipped to Sandia National Laboratory for bench testing. Currently, efforts are underway to determine the current status of most of the reactor building equipment by advanced testing techniques from locations such as the cable spreading room. Approximately 200 devices will be selected for this in situ test program, and significant savings in personnel radiation exposure is expected over a program of only removal and bench testings.

Component Removal, Protection, and Examination—As stated in the preceding section, certain devices were selected as candidates for removal during Fiscal Year 1980. One radiation detector, HP-RT-211 (shown in Figure 2) was removed and sent to Sandia for a detailed examination. This device is a Victoreen area survey meter, Model 855, and is composed of a detector module, a readout module, and a remote alarm meter. The detector itself, a Victoreen Model 857-20, is a gamma-ray sensor containing a GM tube and associated counting circuitry. During the in situ testing, the pulse train output indicated proper counting of radiation levels. The lack of correct readout indication was assumed to be caused by a change of the DC bias level, leading to the assumption that the Q6 transistor malfunctioned (see Figure 3). Plans were to install a new detector at the time of removal, but during the removal operation, an apparent change in cable characteristics caused separation of the connector and cable. Sections of this cable were planned for removal for examination on subsequent entries.

The Instrumentation and Electrical Equipment Survivability Program is planning continued participation in the early TMI-2 containment entry program through the end of the fiscal year. The HP-RT-211 cabling, source range preamplifier (NI-AMP-2), and a charge amplifier from the

Table 1. Testing of radiation detector instruments

Instrument Tag Number	Type of Test Performed or Planned	Approved TEC Procedure Number
1. HP-RT-211	1a,b,c,d,e;2a,b,c	TP-101
2. HP-RT-212	1a,b,c,d,e;2a,b,c	TP-102
3. HP-RT-213	1a,b,c,d,e;2a,b,c	TP-103
4. HP-RT-214	1a,b,c,d,e;2a,b,c	TP-104
5. YM-AMP-7023	2a,b,c;1a,b,c,d,e	TP-107
6. YM-AMP-7025[a]	2a,b,c;1a,b,c,d,e	TP-116
7. NI-AMP-2	1a,b,c,d,e;2a,b,c	TP-105
8. IC-10-dPT	1a,b,c,d,e;2a,b,c	TP-111
9. CF1-dPT3	1a,b,c,d,e;2a,b,c	TP-112
10. CF2-LT4	1a,b,c,d,e;2a,b,c	TP-109
11. CF1-PT4	1a,b,c,d,e;2a,b,c	TP-108
12. CF2-LT2	1a,b,c,d,e;2a,b,1	TP-110

Test Description Code

1. *Passive Measurements*—Power to Unit under Test (UUT), On
   a. Recording of output signal—FM recorder
   b. Measurements with digital voltmeter, all active parameters
   c. Waveform observations with photographs—oscilloscope
   d. Wide-band spectrum analysis
   e. Narrow-band spectrum analysis

2. *Active Measurements*—Power to Unit under Test (UUT), Off
   a. Impedance bridge—capacitance and impedance, selected test points
   b. Time domain reflectrometry, all cables to UUT
   c. Resistance measurements, all connection combinations to UUT

a. Unit tested twice prior to and after changeout.

loose parts monitoring system (YM-AMP-7023) are to be removed during the entry on October 16, 1980. Additionally, during that entry, another charge amplifier (YM-AMP-7025) is to be removed and replaced.

Five topical reports based on the examination results and recommendations will be prepared during Fiscal Year 1981:

1. HP-RT-211
2. Cabling
3. Charge amplifiers for loose parts monitoring systems
4. In-systems test program
5. SPND data validation.

The results of the equipment surveys, data inventories, and equipment history surveys will be utilized to develop requirements for future instrument and electrical systems removal and testing.

Plans are to attempt the removal of approximately 32 devices for laboratory examination or

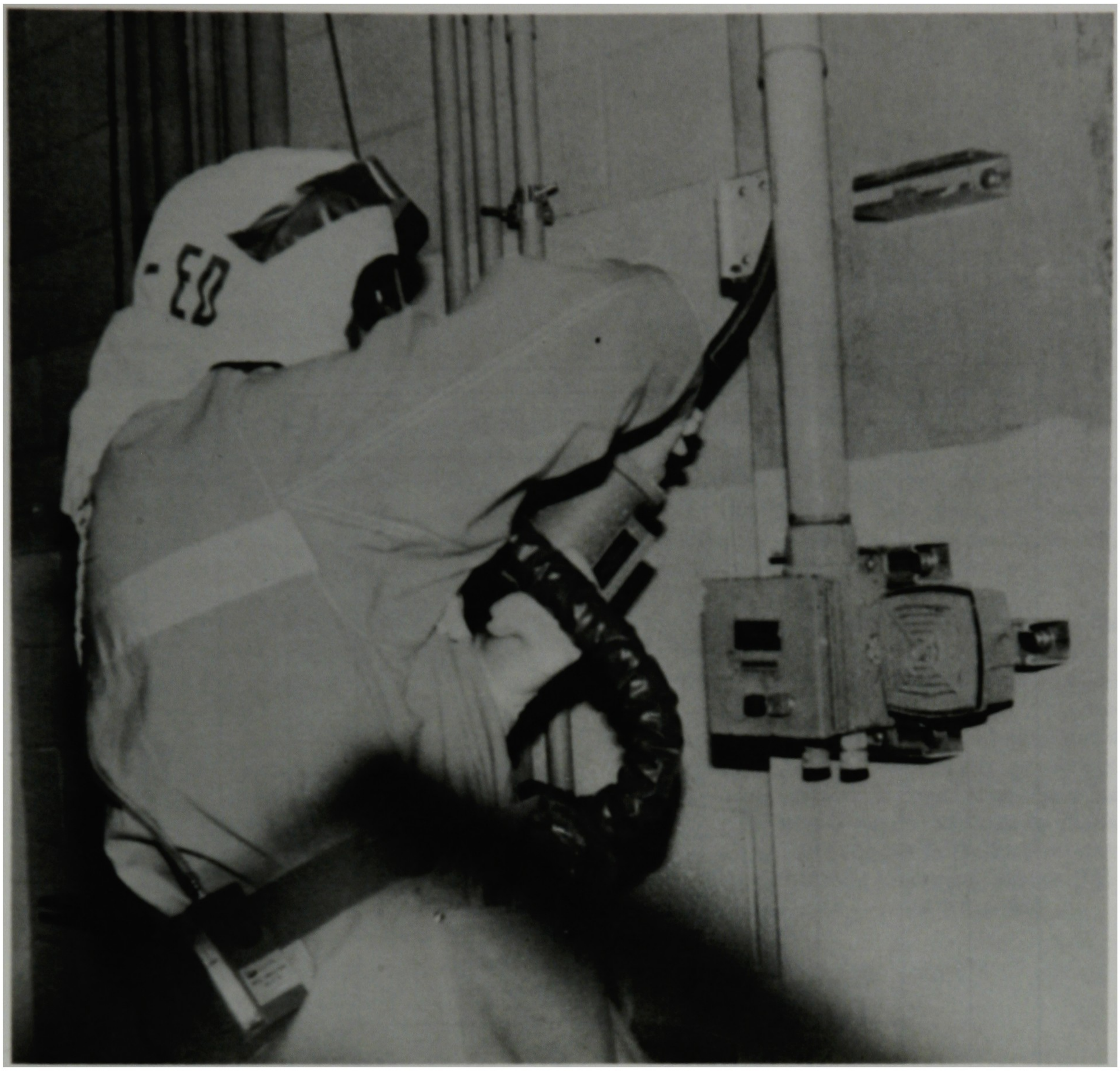

Figure 2. Removal of the HP-RT-211 radiation detector.

extensive onsite testing during the complete program. These would be selected from in-core, ex-core, active, and passive electrical devices or systems. The testing program and test location would be determined after consultation with industry and supplier technical specialists and national laboratory staff scientists.

TV Systems—In support of the investigation of specific devices for removal, and to aid in the location and removal of these devices, a closed-circuit TV system was procured for location inside the reactor building. This system will also allow the TIO to have real-time viewing of the efforts during entries and assist GPU and the TIO in damage assessment. It will reduce the radiation exposure required in information-gathering activities by providing overlapping coverage on the 305- and 347-foot levels.

The system is composed of ten low-light-level TV cameras with each device having a 10-1 zoom lens, heavy duty pan and tilt drive, tripod with a dolly, and and an electronic junction box allowing individual control of all functions. This is accomplished by using a transmitter at each console communicating with its own receiver mounted in the junction box on each tripod. Each junction

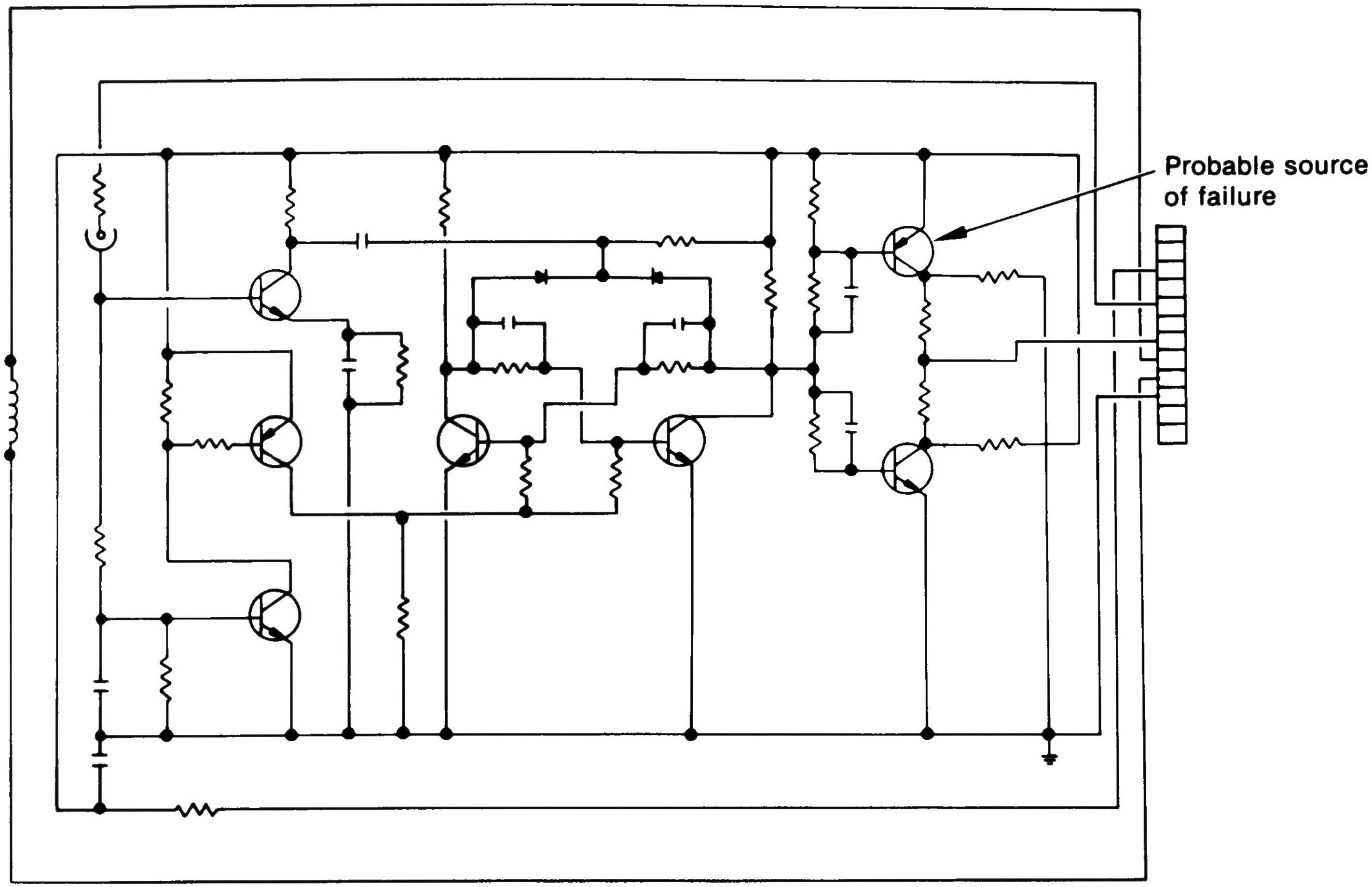

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Figure 3. Detector circuitry diagram showing the location of the Q6 transistor, the probable source of failure.

box has two receivers; the twisted pair is looped through a secondary console to the master console. The system has been accepted by the TIO, but is still undergoing testing. The delivery of all items is scheduled for early Fiscal Year 1981, and installation currently is scheduled for February 1981. Four cameras are to be installed on the 305-foot level and four on the 347-foot level. Two systems are spares. Each console has video taping capability; a video tape editor system was obtained as part of this system although titles, slides, and special effects would require outside assistance.

Portable color TV cameras and a portable night vision black-and-white camera were obtained in addition to portable taping units and portable TV monitors. The intended use of this equipment is for documenting significant cleanup activities and the examination program events. In addition, at least one unit may be mounted on a portable stand, modified for battery operation, and used inside containment for damage assessment in difficult-to-reach locations.

Video tapes produced will be used for (a) training purposes, (b) informing the public and industry of on-site activities, and (c) documenting activities for archive historical files.

System Performance Review

Data Inventory and Analysis – The need for a catalog of the large amounts of data from the various sources became apparent as the data were accumulated to assist in component examinations. The Technology for Energy Corporation (TEC) was contracted to inventory and catalog data taken by GPU during and after the accident; Babcock & Wilcox (B&W) was contracted to inventory and catalog data taken by the B&W organizations at Lynchburg, Virginia. These projects were begun in Fiscal Year 1980 and are due to be completed in early 1981.

Science Applications Incorporated (SAI) was contracted to obtain, catalog, and organize all available information relating to the 97 devices selected as priority 1 by the IEPG planning document. SAI has completed 95% of the planned data acquisition and is sorting the data in preparation for microfiche generation. Upon completion and review of these catalogs early in calendar year 1981, the data will undergo analysis and this analysis will become part of the component or system history file.

System Description and Validation – This activity covers systems analysis of instrumentation in the nuclear steam supply, balance-of-plant, and the plant radiation monitoring systems. The intent is to provide a system matrix that relates each of the safety systems component by component. Identification of nonsafety systems required to effect a cold shutdown at TMI is also planned and will include those component relationships with the safety-related components. To accomplish this, a time-event history is necessary that identifies erroneous data, time-correlated cause and effect, and the fallback to nonsafety-class equipment rationale. During Fiscal Year 1980, information was gathered to help define the scope of this task, and available data were captured for future use.

One system was identified for early analysis, the self-powered neutron detector (SPND) system, as data from that system were being utilized by many groups to predict TMI-2 core damage. To interpret the data taken, it was necessary to segment the system into the data acquisition system and signal generation system. A contract was awarded to B&W to develop a signal simulator to use at TMI-2 to assess performance of the data acquisition system in responding to transient signals. This task will be completed in Fiscal Year 1981.

RADIOACTIVITY AND ENVIRONMENT

Objectives

The Radioactivity and Environment Program included three major activities:

- Fission Product transport and deposition
- Decontamination and personnel dose reduction
- Radiation Monitoring/Information.

The overall purpose of the Fission Product Transport and Deposition activity is the acquisition of data that could significantly improve current understanding of nuclear plant accident environments and the phenomena that contribute to those environments. Data to be acquired will improve current understanding of fission product dispersal mechanisms, aid in the planning for dose reduction during decontamination operations, and provide environmental data necessary to support equipment examination.

Implementation of Decontamination and Personnel Dose Reduction activities includes development of data to evaluate the cost and exposure per unit of work in the areas of decontamination technology and personnel exposure control. These data are needed for estimating decontamination effectiveness and controlling personnel exposures during future cleanup operations. This information will be developed primarily by documenting methods that are used and determining which ones are effective. Evaluation of dosimetry and portable health physics survey instruments in high beta-gamma radiation fields such as at TMI-2 will provide a base to guide needed development to accurately assess personnel exposures.

The objective of the Radiation Monitoring/Information activity was to effectively inform the public in the TMI area of major radiation releases through selective training in conjunction with a citizens-controlled monitoring program.

Approach

Identification of specific goals for each of the three areas was begun early in the organization of the TMI-2 Information and Examination Program. The goals were identified by planning groups who prepared the following planning documents:

- *Fission Product Transport and Deposition.* Early in Fiscal Year 1980, the Technical Working Group for the TMI Information and Examination Program assembled a Fission Product Transport, Dispersal and Environments Characterization Planning Group (the 2.1 Planning Group) from industry, Government, and the national laboratories. This group was tasked with preparing a detailed list of data acquisition tasks to satisfy the previously stated objectives. A task list was issued as a report entitled *Recommended Data Acquisition Tasks at TMI-2 Relating to Fission Product Transport, Deposition, and Environments Characterization.*
- *Decontamination and Personnel Dose Reduction.* Concurrent with the efforts of the 2.1 Planning Group, a Decontamination and Personnel Exposure Control Planning Group (the 2.2 Planning Group) was assembled—also from Government, industry, and the national labratories. This group specified tasks necessary to attain the previously stated objectives in a draft report entitled *Recommended Data Acquisition Tasks at TMI-2 Relating to Decontamination and Personnel Exposure Control.*
- *Radiation Monitoring/Information.* EG&G Idaho, Pennsylvania State University (PSU), and the Pennsylvania Department of Environmental Resources were tasked with preparing a detailed program for a proposed community radiation monitoring program. The program was implemented early in calendar year 1980.

Specific tasks selected for implementation of these programs and specific accomplishments during Fiscal Year 1980 are detailed in the following section.

Significant Accomplishments During FY 1980 in Radiation and Environment

Primary Systems. A task was initiated to acquire information about the identity and concentration of rupture debris, fission products, and activated corrosion products in the primary coolant system. Fission product identities and concentrations are particularly important for completing a core mass balance. Specific tasks to acquire the above information include obtaining the following samples:

- Reactor coolant system (RCS) sludge
- Filters and resin from the reactor coolant purification (letdown cleanup) system
- Reactor coolant system liquid
- Samples from the reactor coolant bleed tanks
- Any sludge or particulates that may be in the bottom of the reactor coolant drain tank.

This information will be used to specify decontamination processes as well as to improve understanding of the accident. The specific activities involved in taking these samples are described in the following paragraphs.

Reactor Coolant System Sludge—An engineering analysis was initiated late in Fiscal Year 1980 to determine the technical approach to obtain samples of RCS sludge as soon as reasonably possible after entry into the containment. Plans are to take two samples, each one containing up to 100 g, from the following locations: the reactor vessel, pressurizer vessel, upper tube sheet and lower portion of the steam generators, a low spot in the piping leading to the steam generators, and a low spot in the return to the reactor vessel. The implementation will ensure that sampling is done at the maximum collection point in each of the above-mentioned areas.

These samples will be analyzed to determine the identity and concentration of rupture debris, fission products, and activated corrosion products in the primary coolant system. Data from this procedure will supply information for model assessment, accident diagnosis, decontamination criteria, and mass balance.

Engineering analysis necessary to take the difficult samples, acquisition of the samples, and the analysis of those samples already taken will be completed during Fiscal Year 1981. The results from these samples will contribute to a core inventory fission product dispersal mass balance of major radionuclides. These data will also be important to the understanding of the course of the accident at TMI-2.

Purification System Samples—During the removal of the MU-F-5A demineralizer prefilter, a smear taken of the housing indicated fuel debris in the housing bottom. A qualitative smear was analyzed, and revealed milligram quantities of fuel. A special vacuum and filter unit was designed and procured for the purpose of retrieving this and debris encountered in other filter housings, for use as samples. These samples will be used to characterize and quantify fuel debris within the primary system.

The ion-exchange resins, filters, and swipes from the inside surfaces of purification filter housings will be obtained and one filter will be analyzed for radionuclide content during Fiscal Year 1981. Remaining samples taken will be archived. The chemical species of particulate and collodial material retained on internals, resins, and filters will be obtained where possible. This information will be vital both for accident analysis and core mass balance since the purification system operated throughout the accident.

Also, engineering analysis will be completed and procedures written to obtain liquid and sludge samples from the primary letdown coolers during Fiscal Year 1981. Material found in the letdown coolers will be accounted for in a fuel mass balance.

Reactor Coolant System Liquid Samples—Reactor coolant samples were taken on a weekly basis and subjected to chemical and radiochemical analyses. Representative results from samples taken at the beginning and end of Fiscal Year 1980 are shown in Table 2.

A portion of the samples taken were sent to the Exxon Nuclear Idaho Company, Inc. (ENICO), for analysis for interlaboratory comparisons. A sample taken by GPU on March 29, 1979, the day after the accident, was shipped and prepared for analysis.

Reactor coolant liquid samples taken before and during Fiscal Year 1980 will be analyzed during Fiscal Year 1981. Sample data will be correlated with analysis results from B&W and detailed in a comprehensive report. This information is important for mass balance considerations and is indicative of the extent of core damage.

Reactor Coolant Bleed Tank Samples—A sample from reactor coolant bleed tank "A" was sent to the Idaho National Engineering Laboratory (INEL) for analysis. Preparations for radiochemical tests are currently underway.

Reactor coolant bleed tank samples taken in Fiscal Year 1980 will be analyzed, correlated with other primary system data, and presented in a report during Fiscal Year 1981. Reactor coolant bleed tank samples are of particular interest because quantities of reactor coolant entered the bleed tanks through the purification system during the accident.

Reactor Coolant Drain Tank Sludge—An engineering analysis was initiated in late Fiscal Year 1980 to determine the best way to obtain samples of any

Table 2. Results of typical coolant system liquid samples

	Units	09/24/79	09/22/80
Boron	ppm	3650	3810
pH	ppm	8.0	7.7
Sodium	ppm	990	1090
Chloride	ppm	3.5	4
Tritium	μCi/g	0.19	0.089
^{134}Cs	μCi/g	14	4.8
^{137}Cs	μCi/g	73	31
^{140}Bs	μCi/g	<0.089	Not detected
^{85}Kr	μCi/g	0.06	0.06
Hydrogen	cm^3/kg	11	15
Nitrogen	cm^3/kg	3	6
Oxygen		Not detected	Not detected
Total gas	cm^3/kg	15	21

sludge or particulates that may be in the bottom of the reactor coolant drain tank. The sludge and debris collected from the tank will be diagnosed to provide information on the form of material released from the system.

The engineering analysis will be completed during Fiscal Year 1981 and procedures written for sampling the reactor coolant drain tank sludge and liquid and vent line inner surfaces. The principal flow pathway for the transport of radioactivity and core debris to the containment during the accident was through the pressure-operated relief valve that allowed discharge into the reactor coolant drain tank.

Fuel Deposition Determination. It is postulated that fuel debris will be dispersed throughout the primary loops and connecting piping. The locations where most of this material will be expected to accumulate can be identified. However, because direct access to many of these locations will be difficult, if at all possible, it will be necessary to develop nondestructive techniques for the location, identification, and assay of fuel debris. Such techniques would contribute greatly to essential aspects of the cleanup operations, and also enable the accumulation of data on postaccident conditions, monitoring effectiveness of debris removal, and dissolution techniques.

During Fiscal Year 1980, an engineering evaluation was initiated to assess and select nondestructive techniques for locating and characterizing fuel debris within the TMI-2 primary system. Another element of this evaluation was to identify developmental work needed for the specialized applications, and to outline a plan for the development program.

A number of nondestructive techniques for locating and characterizing fuel debris within the TMI-2 primary system have been assessed. These techniques are gamma-spectral scanning, neutron counting, acoustics, and infrared.

Any measurement technique must include features that eliminate several obstacles. Since ambient radiation fields at the 305-ft elevation were measured between 300 and 700 MR/hr in August 1980, personnel access will be limited by the radiation field. The reactor coolant pipe walls and insulation constitute a second obstacle to any measurement technique. Access to the primary system pipes will also be a problem. Another access problem is posed by the primary shield wall, which is 4 ft thick. Eight feet of hot leg piping and 16 ft of cold leg piping are embedded in this wall.

Preliminary review of the candidate nondestructive techniques suggests that gamma-spectral scanning and acoustic methods may prove most suitable for determining fuel deposition within the primary system at TMI-2.

A report summarizing the engineering evaluation of nondestructive assay techniques will be completed during Fiscal Year 1981. One or more techniques may be selected for further development by EPRI for their task of decontamination of the primary coolant system.

Reactor Building and Support Systems. This task is to obtain as much information as possible concerning fission products transport, deposition, and plateout in the environment within the reactor building and support systems. Specific areas to be examined and tasks to be performed include:

- Total dose and isotopic measurements of plateout on air coolers and filters. This measurement will assist in the fission product mass balance and accident diagnosis by allowing a determination of the amount of airborne nuclides.

- Determination of (a) quantity and nature of radioactive material in the sump, (b) height and density of flocculent material in the sump, and (c) size and type of solid debris present. This information will be used for mass balance determination, decontamination technique evaluation, and accident diagnosis.

- Determination of chemical and isotopic properties of plateout on internal surfaces of the hydrogen recombiner system. These data will be used to help close the mass balance, as well as to evaluate how well this particular safety system functioned.

- Determination of principal airborne species at different elevations within containment. This task most directly impacts decontamination efforts, but in addition will provide information about the accident and what nuclides are released under loss-of-coolant accident (LOCA) conditions. Sampling as a function of time following a purge should allow the determination of resuspension rates.

Air Cooler Samples/Filter Samples—Initial measurements of exposure rate around the air coolers were made during the first reactor building entries. These measurements did not indicate the presence of large quantities of fission products plated out on the cooling coils. Isotopic measurements have not yet been made but will be performed when reasonable exposures to personnel can be achieved.

Efforts are planned for Fiscal Year 1981 to determine the location and disposition of high efficiency particulate air (HEPA) and charcoal heating and ventilating filters removed after the accident. This will be done primarily through records searches, although interviews with crafts personnel may also be used. Knowledge of radionuclide inventory in these filters is vital for a thorough accounting of all fission products.

Reactor Building Sump Samples—An engineering analysis was begun in Fiscal Year 1980 to determine the appropriate methods to sample the reactor building sump and to inspect it for floating and sunken debris. The study will determine the most practical and economical method for sampling the sump from three levels at each of the locations. Sump samples from three depths were taken early in the year through a penetration just above the water level. The sampling was done under severe constraints and the reported results of analyses done by Babcock and Wilcox (B&W), and Oak Ridge National Laboratory (ORNL) show some disagreement (see Table 3).

During Fiscal Year 1981, the engineering evaluation will be completed to determine the appropriate method of sampling the reactor building sump and inspecting it for floating and sunken debris. The evaluation will determine the method for sampling the sump from three levels at each of three locations. The samples will be used for accident evaluation, mass balance, and determination of any special difficulties associated with purifying the sump water. Considerations will include debris that could clog strainers, or oils that might damage resins.

Hydrogen Recombiner Samples—A file was begun for copies of all analyses performed on the hydrogen recombiner and its inlet and outlet piping. Operation of the hydrogen recombiner during the accident is a subject of intense interest. Plateout in the unit could be an important sink for fission products.

Reactor Building Atmosphere Characterization—An extensive effort was carried out to sample the reactor building atmosphere through the R-626 penetration at the 358-ft level of the reactor

Table 3. Range of reactor building sump samples

	Top		Middle		Bottom	
	B&W	ORNL	B&W	ORNL	B&W	ORNL
^{134}Cs (μCi/g)	30	40	29	40	30	39.6
^{137}Cs (μCi/g)	145	176	144	179	148	174
^{140}La (μCi/g)	0.06	0.09	0.04	0.078	0.10	0.14
^{131}I (μCi/g)	0.06	0.072	<0.5	0.072	<0.5	0.013

building. Specialized equipment, developed for the NRC's Source Term Project, was used to obtain samples for quantification of ^{129}I (both total and iodine species), ^{14}C, ^{3}H, ^{85}Kr, and radionuclide activity of suspended particulates, and for molecular analysis of the atmospheric gaseous components. Analyses of these samples were performed by two different analytical laboratories at the INEL. A summary of the results of these analyses are shown in Table 4.

The report on the containment air samples will be completed during Fiscal Year 1981. This information will be used for resuspension model verification.

Environmental Characterization and Surface Deposition. This activity of the Radioactivity and Environment Program is to determine and document current conditions within the reactor building, including the environmental history of the building since the accident, with particular attention to areas around key pieces of equipment (as defined by the Instrumentation and Electrical Equipment Survivability, and Mechanical Components tasks). Knowing the environment major or important pieces of equipment have been subjected to will make it possible to postulate causes of equipment failure and to determine current design criteria margins.

Any damage to the reactor building itself will be assessed and this information will be used to improve understanding of the accident by localizing areas of high temperature, high pressure, flooding, and caustic sprays. In addition, these data will contribute information about areas where design criteria margins must be increased.

Table 4. Summary of analyses of reactor building atmosphere samples

Nuclide	Concentration ($\mu Ci/cm^3$)
Tritium	$5 \pm 1 \times 10^{-5}$
^{14}C	$4 \pm 0 \times 10^{-7}$
^{55}Fe	$<6 \times 10^{-7}$a
^{58}Co	$<1 \times 10^{-11}$
^{60}Co	$<1 \times 10^{-11}$
^{85}Kr	0.93 ± 0.07
^{89}Sr	$1.1 \pm 0.5 \times 10^{-10}$
^{90}Sr	$2.2 \pm 0.2 \times 10^{-10}$
^{103}Ru	$<2 \times 10^{-9}$
^{106}Ru	$<2 \times 10^{-11}$
Ag-110μ	$<2.5 \times 10^{-11}$
^{129}I	$6 \pm 2 \times 10^{-11}$
^{134}Cs	$0.7 \pm 0.1 \times 10^{-10}$
^{137}Cs	$9.3 \pm 0.3 \times 10^{-10}$
^{235}U	$<5 \times 10^{-12}$
^{238}U	$<2 \times 10^{-11}$
^{238}Pu	$<8 \times 10^{-12}$
^{239}Pu and ^{240}Pu	$<2 \times 10^{-12}$

a. All nuclide concentrations with a < ("less than" symbol) indicate that those nuclides are below the listed instrumentation sensitivity.

Continued estimating and documenting of the extent, as well as the nature and possible causes, of any reactor building damage will result from the early entry program. Reactor building damage will provide information relating to maximum environmental extremes experienced during and subsequent to the accident. The damage assessment will provide information to judge the adequacy of reactor building design criteria and currently engineered structures to survive the design stresses.

The surface desposition task is to determine the composition and distribution of radionuclides deposited inside the containment building, and to determine exposure rates, as well as the isotopic, chemical, and physical properties of deposition. Specific activities include:

- *Radiation mapping*—This will show the effects of equipment layout, geometry, and orientation on contamination deposition, and will provide information that may make future designs more easily decontaminated. Deposition patterns will lead to a better understanding of the accident, as well as providing knowledge about redistribution of nuclides within containment.

- *Containment surface deposition sample analysis*—This will provide information that will relate to the effectiveness of the building spray system accident diagnosis, including the amount of airborne radioactivity; circulation paths, and radionuclide activity balance.

The radiation field inside containment is dominated by shine from the sump, and the radiation maps obtained so far are primarily isopleths about floor penetrations with a general background caused by scatter, rather than a map of deposition patterns.

The first opportunity for direct analysis of surface contamination levels inside the reactor building occurred early in Fiscal Year 1980 when a 9-in. annulus was removed from the stainless steel inner flange of the R-626 penetration. This penetration allowed a video camera and an air sampling probe to be inserted. This annulus or "cookie" (Figure 4) was sent to Oak Ridge National Laboratory for extensive radiological and metallographic analysis and decontamination tests. Initial radiation readings were 80 mr/hr beta-gamma and 6 mr/hr gamma at 2 inches from the surface.

$$\text{Decontamination factors, DF} = \frac{\text{initial activity}}{\text{final activity}}$$

for ^{137}Cs are shown below for various tests. Results for ^{134}Cs were essentially identical.

	DF
Water, 25°C	1.46
Acid, 25°C	7.85
Acid, 80°C	4.58
Dry smear only	1.63
Wet smear only	1.20

An autoradiograph of the contaminated surface (Figure 5) showed uneven contaminant distribution. It is believed that the areas of higher activity corresponded to places on the flange that were "dirty" before the accident. Radiochemical analysis of the contamination is shown below.

Isotope	Ci/cm^2	Total μCi
^{60}Co	6.09×10^{-5}	0.019
^{134}Cs	8.4×10^{-3}	2.68
^{168}Cs	4.0×10^{-2}	12.7
^{89}Sr	1.4×10^{-3}	0.448
^{90}Sr	5.2×10^{-4}	0.166

Metallographic examination of the surface (Figure 6) showed no evidence of physical damage that could be attributed to high temperatures.

Systematic environmental characterization of the reactor building started in July with the first containment entry since the accident. The July entry was confined to the 305-ft. or entry level of the reactor building. Radiation readings were generally between 0.4 and 0.7 R/hr gamma and 1 to 2 Rad/hr beta, except in areas such as open stairwells and drains where streaming from the water in the basement gave gamma exposure rates

Figure 4. Nine-inch annulus or "cookie" from TMI-2 as received.

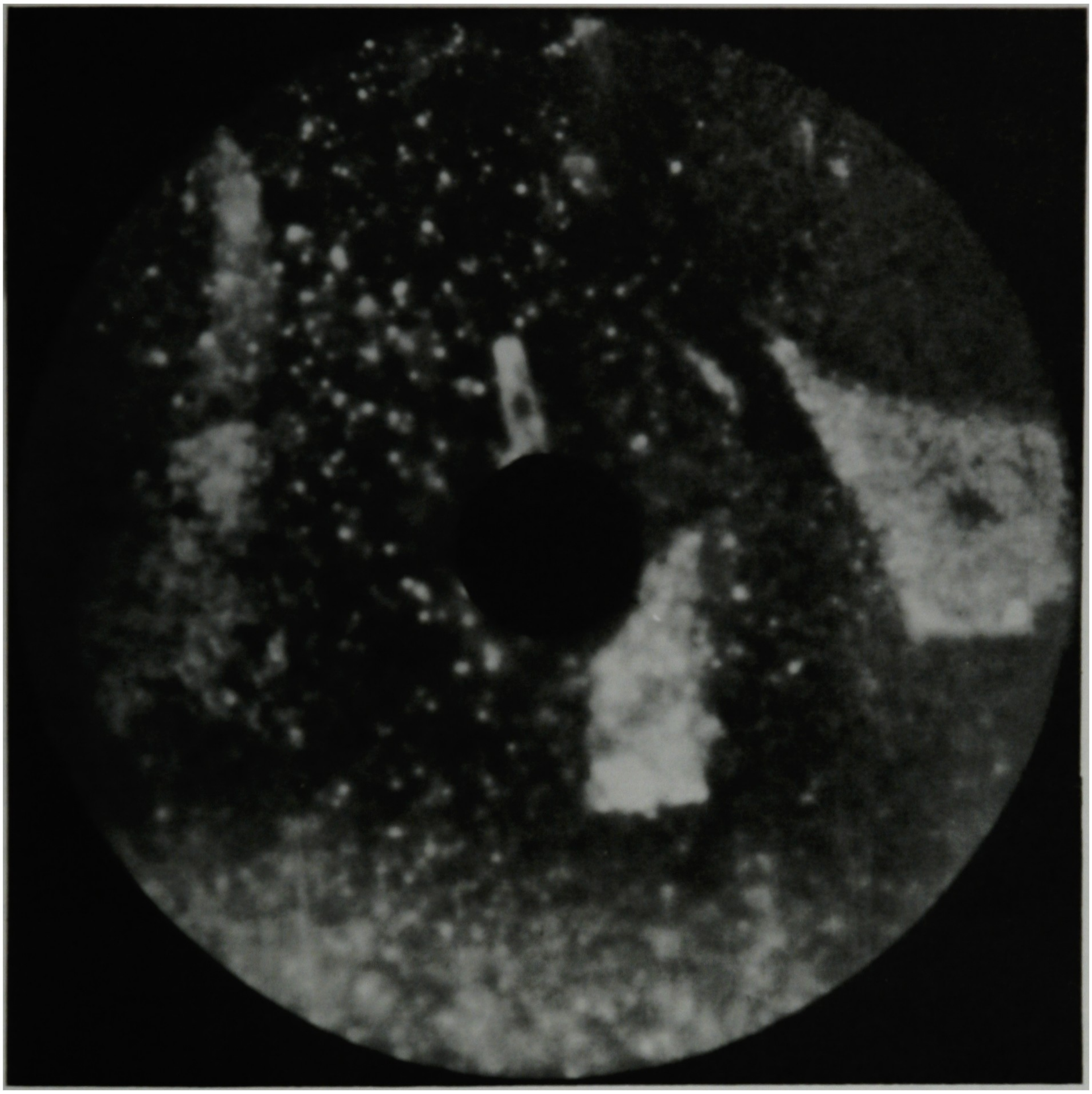


Figure 5. Autoradiograph of the contaminated surface of the 9-inch annulus or "cookie".

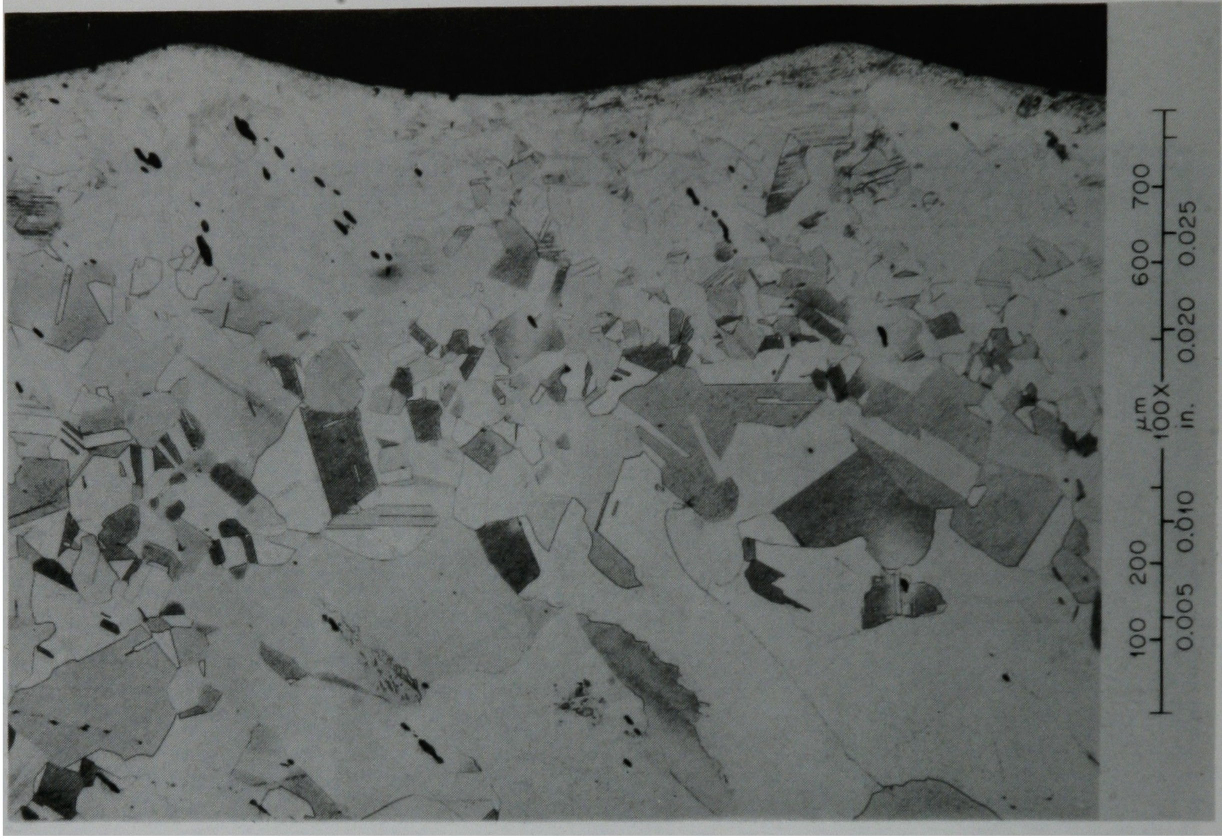


Figure 6. Microstructure of stainless steel "cookie" cross section showing no blast damage.

from 5 to 20 R/hr. ENICO's chemical analysis of swipes taken during the entry showed ^{137}Cs to be the primary contaminant. Photographic documentation showed the building to be in generally good condition (see Figures 7, 8, and 9). The only damage noted was the door to the enclosed stairway, which had been opened with sufficient force to cause bending of the lower half.

The August entry was devoted to determining and documenting conditions on the 347-ft or operating level. Radiation readings were generally lower than on the 305-ft level. The reason for the lower levels is postulated to be the increased distance from the basement water. Exposure rates were generally in the range of 0.1 to 0.4 R/hr gamma. Chemical analysis of the swipes again showed ^{137}Cs to be the predominant contaminant. Photographic documentation was obtained of damage apparently caused by localized high temperatures. This damage included a melted telephone, melted plastic tubing, and charred paper. In addition, several sealed 55-gallon drums had been crushed by a pressure differential caused by either a detonation wave or rapid temperature change. The most significant damage noted was that one of the buss bars that supply power to the polar crane had fallen from the dome onto the 347-ft level. The polar crane is necessary for head removal and must be repaired prior to defueling.

Samples of various surfaces were removed from the reactor building on the second entry for surface deposition analysis. These samples have been temporarily archived for future analysis.

The third entry, planned for October 1980, was to include further radiation surveys on both levels. The results of these entries are being documented in photographs, reports, radiation maps, and transcripts of radio communications and debriefings, all of which are on file with the TIO. No extensive effort on radiation mapping is planned until the high background caused by radiation from the basement is eliminated, thereby allowing the measurement of surface radiation patterns and not shine. Completion of the processing of containment basement water is not expected until Fiscal Year 1982.

Comparison of swipe analyses as performed by GPU, INEL, and SAI (Science Applications, Inc.)

Figure 7. Technicians taking radiation survey measurements at the entry airlock interior—July entry.

are shown in Tables 5 and 6. Figures 10 and 11 show summary radiation survey maps of the 305- and 347-ft levels.

The Radiation and Environment Program will continue to maintain and update an entry file. Entry results will be reviewed, and specific photographs or radiation measurements will be requested as needed to supplement the efforts of GPU.

The Radiation and Environment Program will serve as the coordinator for all requests from and through the TIO for specific tasks relating to reactor building damage assessment.

A new effort to be undertaken in Fiscal Year 1981 involves decontamination. One part of this task is to document the decontamination techniques employed in the auxiliary and fuel handling buildings and the radwaste efforts to date for EPICOR II. This effort is to include (a) man-rem used to perform the decontamination, (b) dollar costs of supplies and equipment, and (c) manhours and efficiency factors needed to perform various types of decontamination.

Another part is to identify state-of-the-art decontamination techniques capable of removing significant amounts of radioisotopes from surfaces similar to the TMI-2 containment.

Effective decontamination techniques must be demonstrated before they can be generally used in the nuclear industry. There are a wide variety of surface conditions and types that will require

Figure 8. GPU technician taking beta survey at the bottom of the reactor coolant pump stand—July entry.

decontamination, including concrete with and without coatings, grillwork, pipes, mirror insulation, and reactor internals. Appropriate decontamination techniques for consideration will include pressure sprays, chemical cleaning, foams, ultrasonic, strippable coatings, electropolishing, and abrasives. Processes must be identified that can do the job. Further, the resultant products must be treatable to an acceptable disposal form. Information gained at TMI on the effectiveness of various decontamination techniques will allow other nuclear facilities to make preparations and modifications before decontamination may be needed.

Dosimetry and Instrumentation. The purpose of this effort is to utilize TMI-2 as a vehicle to accelerate technology development related to dosimetry and instrumentation at TMI. This information is necessary to understand and measure the complex and changing radiation fields encountered during decontamination. Knowledge of measured personnel doses provides for the improved control necessary to ensure adherence to ALARA (As-Low-As-Reasonably-Achievable) principles. Specific tasks to be performed include:

- Evaluation and calibration of existing portable survey instrumentation, and any necessary development of new instrumentation compatible with the radiation environment within the TMI-2 containment.

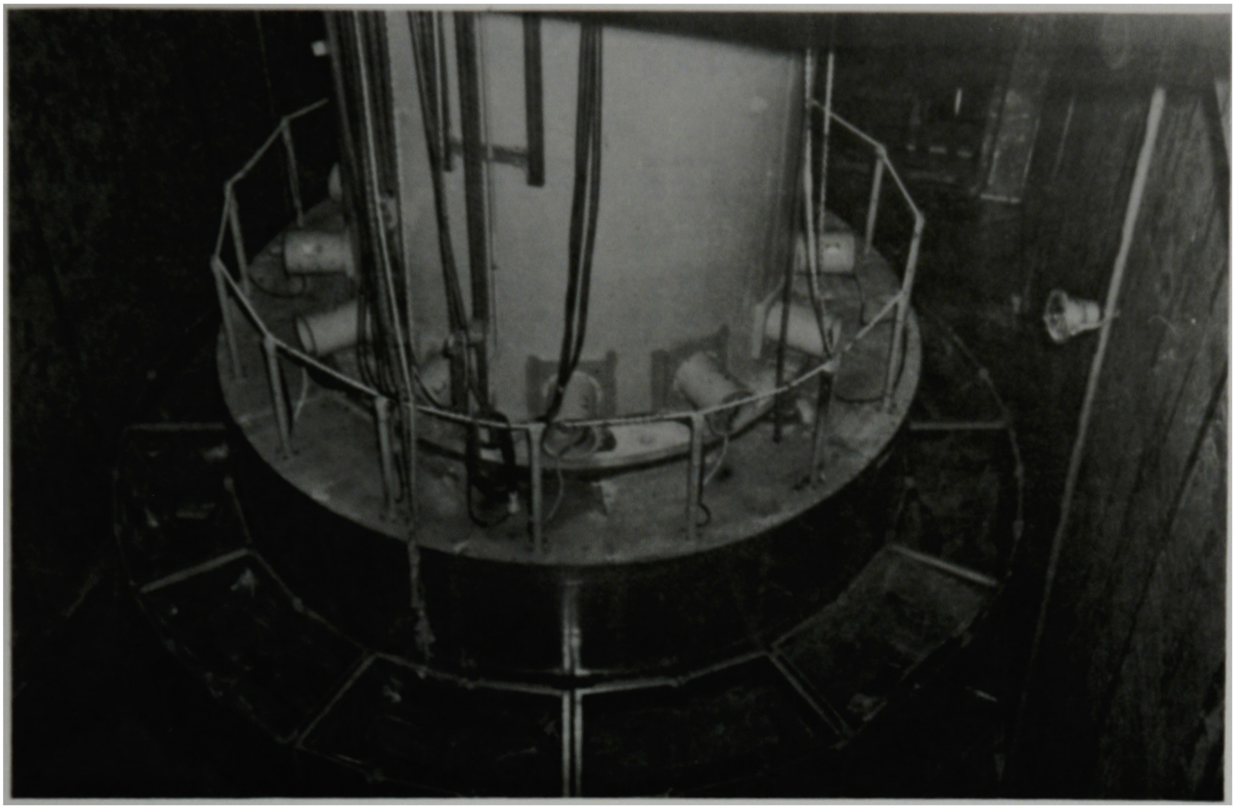


Figure 9. View into the transfer canal—July entry. The shield tanks around the vessel head are dry.

- Review of existing dosimetry, and installation of a state-of-the-art system to provide improved accuracy of beta dose measurements in the high-energy, high-flux beta fields within containment. Typical fields are in the range of 2 to 10 Rad/hr of predominantly 2-MeV beta.

Work on this project was initiated during the closing weeks of Fiscal Year 1980. Initial progress included

- Personnel dosimetry systems in service at various facilities were evaluated for applicability at TMI. Five dosimeters were chosen for specific evaluation on a prototype basis, and implementation as a field system when capability is established (see Figure 12).

- Currently available commercial portable survey instruments were reviewed for beta response. A plan to evaluate, calibrate, and select the most appropriate instruments for reentry has been completed.

Two specific objectives will be addressed during Fiscal Year 1981:

- Identification of a state-of-the-art personnel dosimeter with the specific capability of measuring and recording β and γ dose to personnel, and recommendation for TMI use.

- Calibration and evaluation of commercially available portable survey instruments, and recommendation of the instruments with the best response for TMI use.

Although the nuclear industry has experience in working with high-level beta-gamma fields, beta dosimetry is a generic problem. Specifically, routine commercial nuclear reactor work has not dealt with fields in which the skin or nonpenetrating dose was limiting. In addition, the personnel dosimeters typically were designed to measure dose to the lens of the eyes as the "penetrating" component. The high-level, high-energy, mixed-fission-product contamination

Table 5. Comparison of Entry No. 1 swipe results[a]

	^{134}Cs			^{137}Cs			^{90}Sr			$^{137}Cs/^{90}Sr$	
	GPU	SAI	Exxon	GPU	SAI	Exxon	GPU	SAI	Exxon	SAI	Exxon
46279	3.9 (-4)[b]	4.3 (-4)	4.53 (-4)	2.25 (-3)	3.0 (-3)	2.67 (-3)	NA	1.6 (-4)	1.4 (-4)	16.5	18.9
46280	1.51 (-3)	1.54 (-3)	1.55 (-3)	9.81 (-3)	1.06 (-2)	9.5 (-3)	NA	4.14 (-4)	4.1 (-4)	24	24.3
46281	5.78 (-1)	3.3 (-1)	5.59 (-1)	3.48	3.56	3.16	NA	1.69 (-1)	8.1 (-2)	20.1	42
46282	8.33 (-4)	7.3 (-4)	7.9 (-4)	4.7 (-3)	4.9 (-3)	4.92 (-3)	NA	2.5 (-4)	1.6 (-4)	19.2	30
46283	1.98	2.16	1.78	12	12	10.56	NA	5.82 (-1)	1.9 (-1)	19.8	60.5
46284	2.31 (-3)	2.65 (-3)	2.25 (-3)	1.6 (-2)	1.74 (-2)	1.38 (-2)	NA	1.3 (-3)	2.7 (-4)	12	58
46285	4.7 (-4)	5.4 (-4)	3.8 (-4)	3.12 (-3)	3.7 (-3)	2.43 (-3)	NA	9.8 (-5)	6.5 (-5)	31.4	47.4
46286	6.41 (-5)	5.9 (-5)	3.6 (-5)	3.93 (-4)	2.7 (-4)	3.2 (-4)	NA	1.75 (-5)	2.2 (-5)	18.9	15
46287	3.22 (-3)	2.65 (-3)	2.45 (-3)	2.03 (-2)	1.8 (-2)	1.55 (-2)	NA	4 (-4)	4.3 (-3)	44.75	4.2
46288	4.12	4.4	4.11	25	24.7	24.2	NA	1.73	6.2 (-1)	14.2	39.7

a. All values in μCi/swipe.

b. Example: 3.9 (-4) = 3.9×10^{-4}.

Table 6. Comparison of Entry No. 2 swipe results[a]

	^{137}Cs			^{90}Sr			$^{137}Cs/^{90}Sr$	
Swipe	B&W	Exxon	SAI	Exxon	B&W	SAI	Exxon	SAI
1.	40.7	34.1	33.5	8.2 (-1)	NA	2.63	44	13.7
2.	2.22 (-1)	1.5 (-1)	1.7 (-1)	1.4 (-2)[b]	NA	2.94 (-2)	12.9	6.1
3.	5.1	4.64	4.56	7.5 (-2)	NA	2.4 (-1)	63.6	19.9
4.	5.4	3.83	3.8	1.1 (-1)	NA	1.6 (-1)	39.5	27
5.	4.25	4.06	4.23	3.1 (-1)	NA	4.76 (-1)	13.5	8.8
6.	1.52 (-2)	9.9 (-3)	1.2 (-2)	4.5 (-4)	NA	2.3 (-3)	2755	539
7.	1.91 (-2)	1.66 (-2)	9 (-3)	1.3 (-3)	NA	1.15 (-3)	1146	1 296
8.	5.8	4.7				1.97 (-1)		
9.	2.57 (-1)	2.06 (-1)	2.28 (-1)	5.3 (-2)	NA	5.55 (-2)	43.4	26.6
10.	NA	6.9 (-3)	NA	NA	NA	43		
11.	NA	1.57 (-2)	NA	NA	NA			
12.	1.58	1.23	1.5	1.4 (-1)	NA	9 (-2)		
13.	9.86 (-3)	9.93 (-3)	3.95 (-3)	NA	NA	6.99 (-4)		11 302
14.	3.1 (-2)	2.36 (-2)	2.72 (-8)	NA	NA	3.12 (-3)		875
DF 1.	6.95	4.33	4.69	NA		5.3 (-1)		10
DF 2.	7.15 (-1)	5.14 (-1)	6.54 (-1)	NA		6.98 (-2)		90

a. All values in μCi/swipe.

b. Example: 1.4 (-2) = 1.4×10^{-2}.

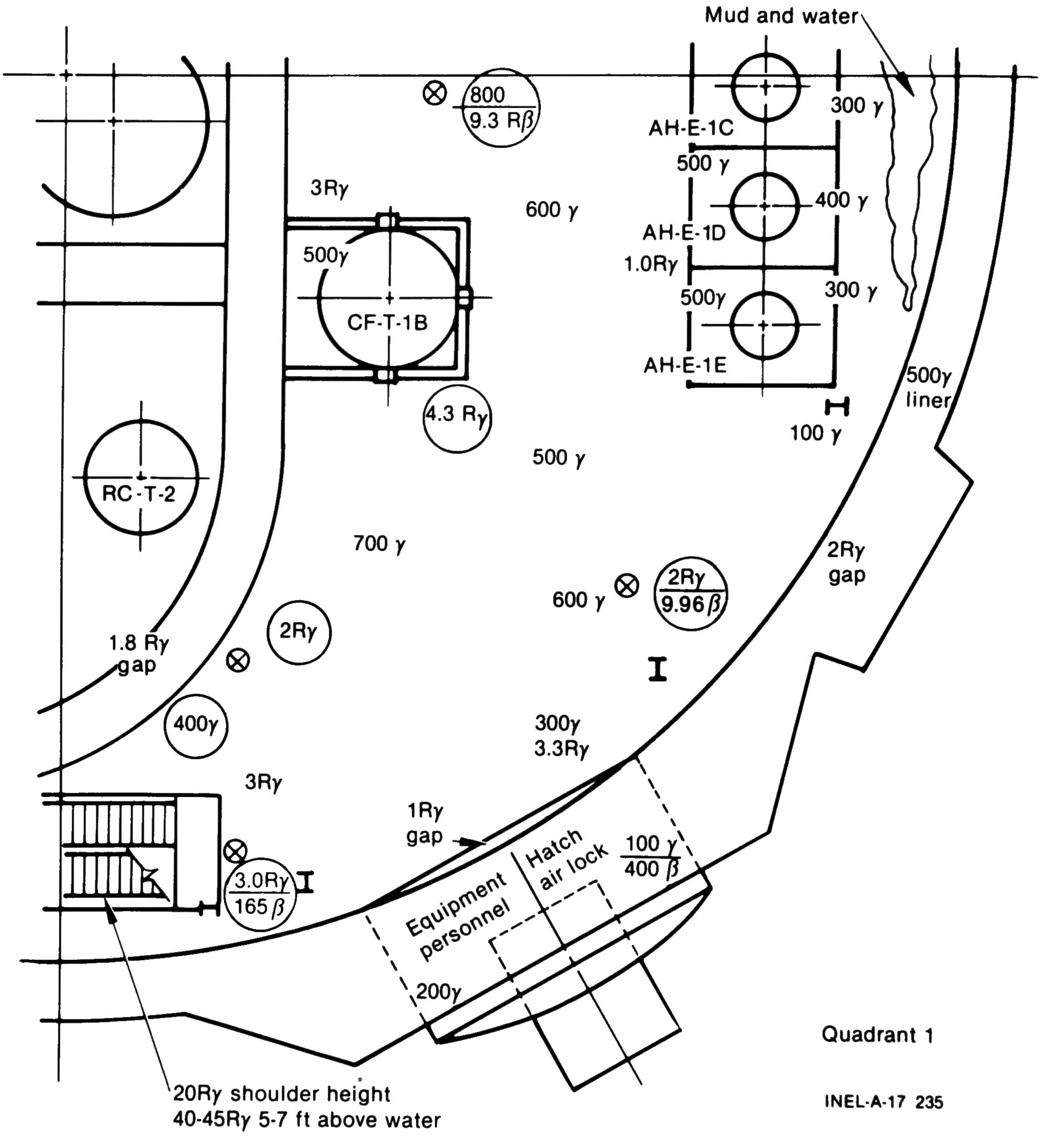
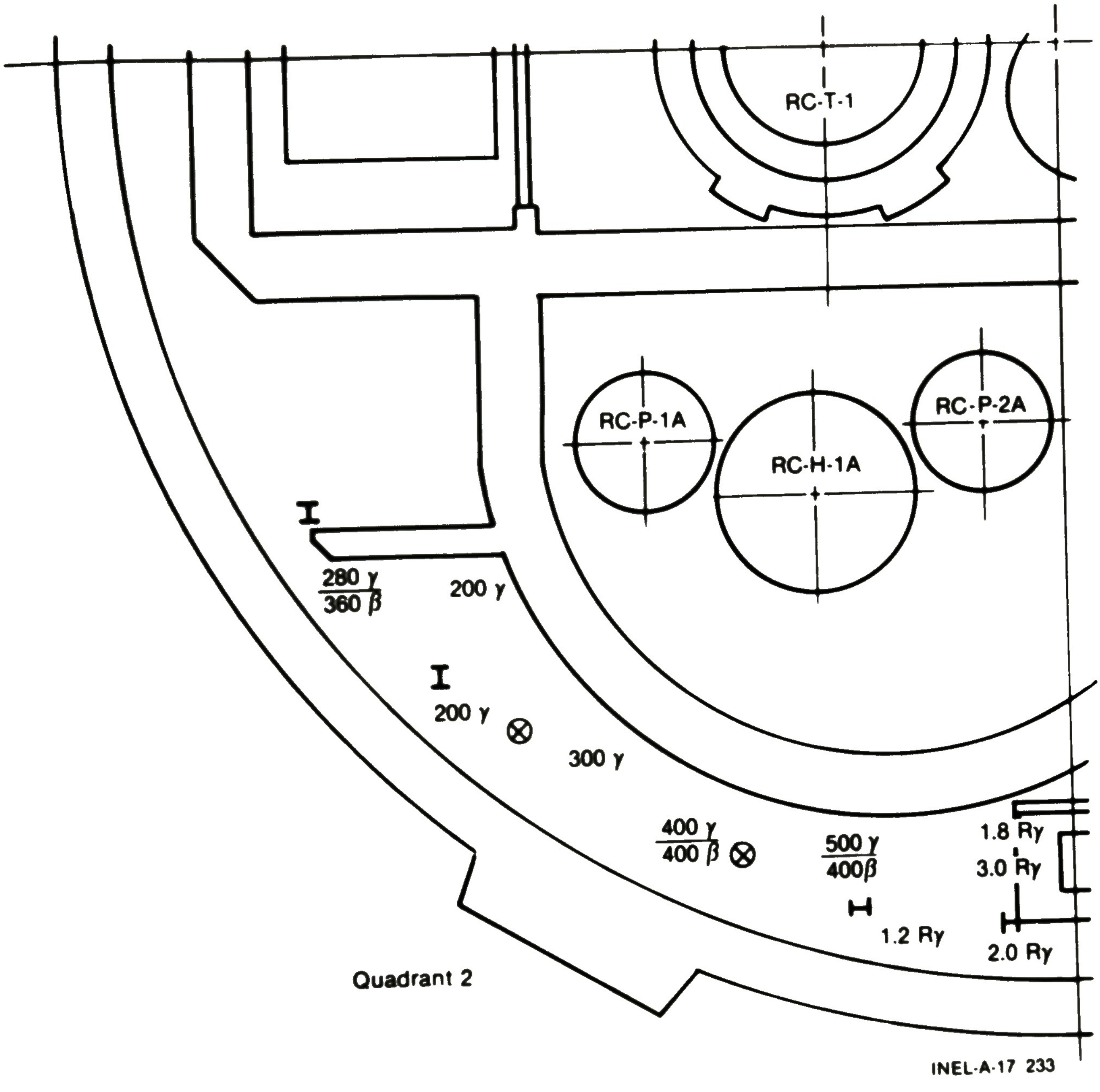


Figure 10. Radiation survey map, 305-ft level.



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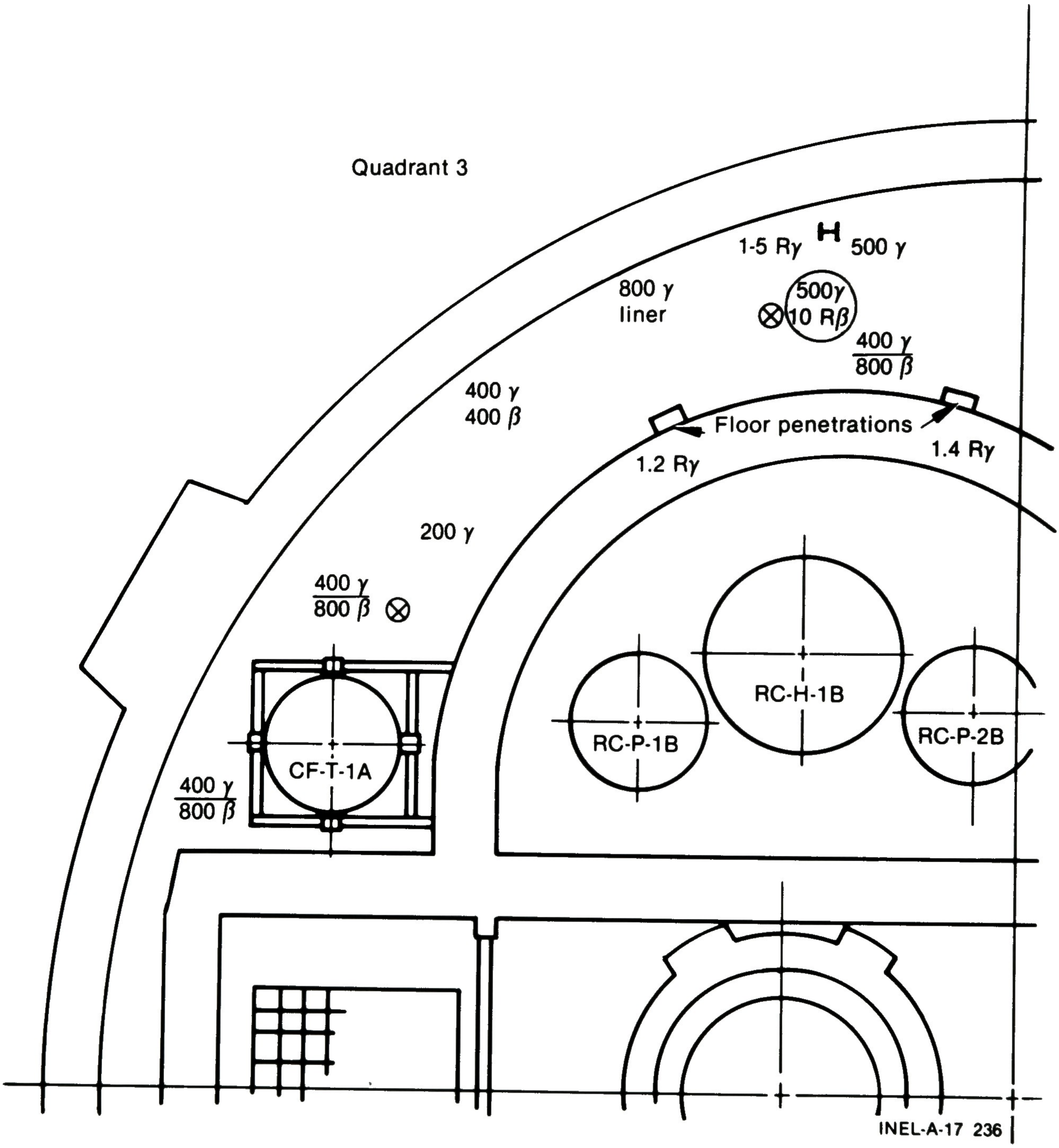

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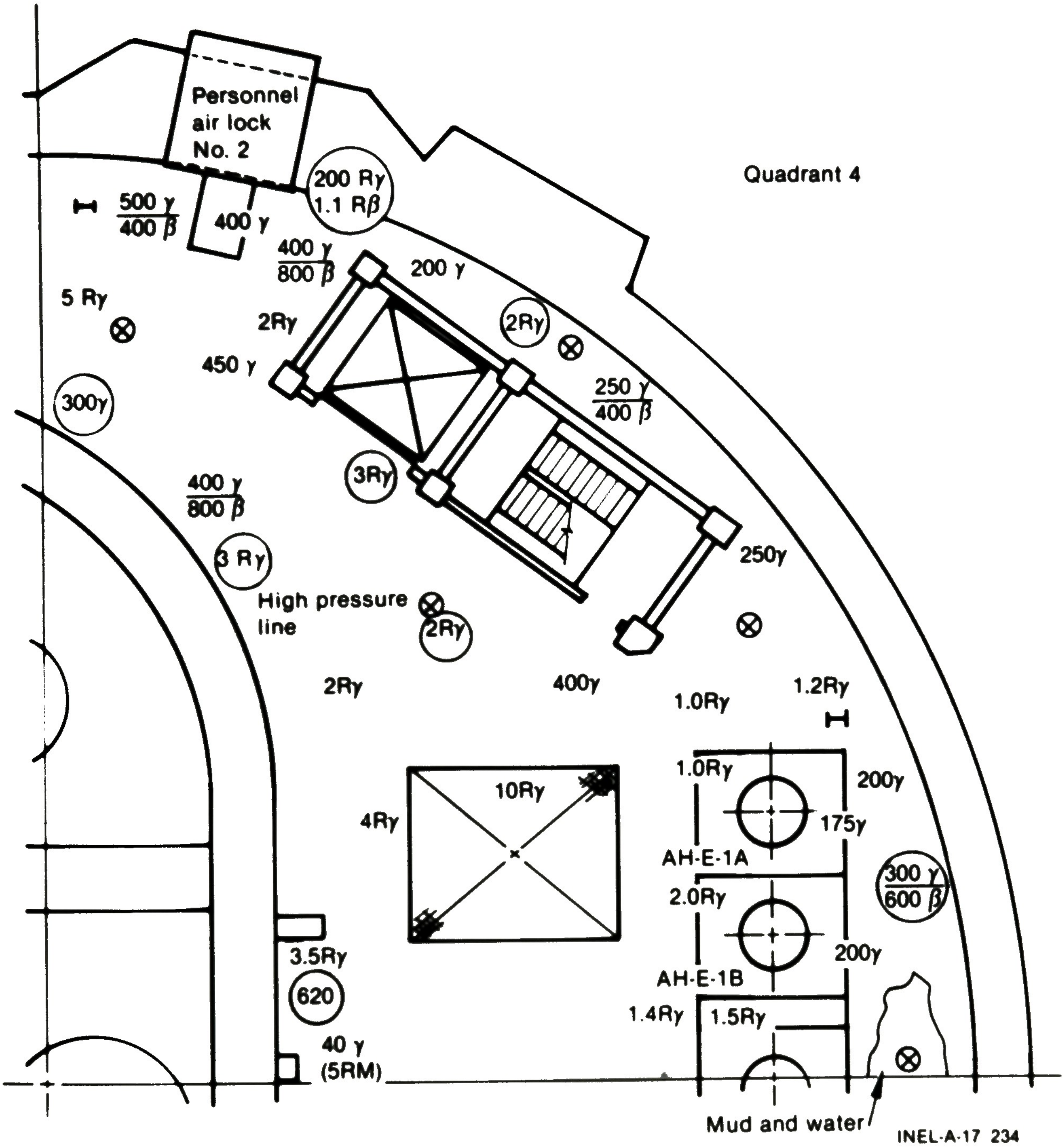

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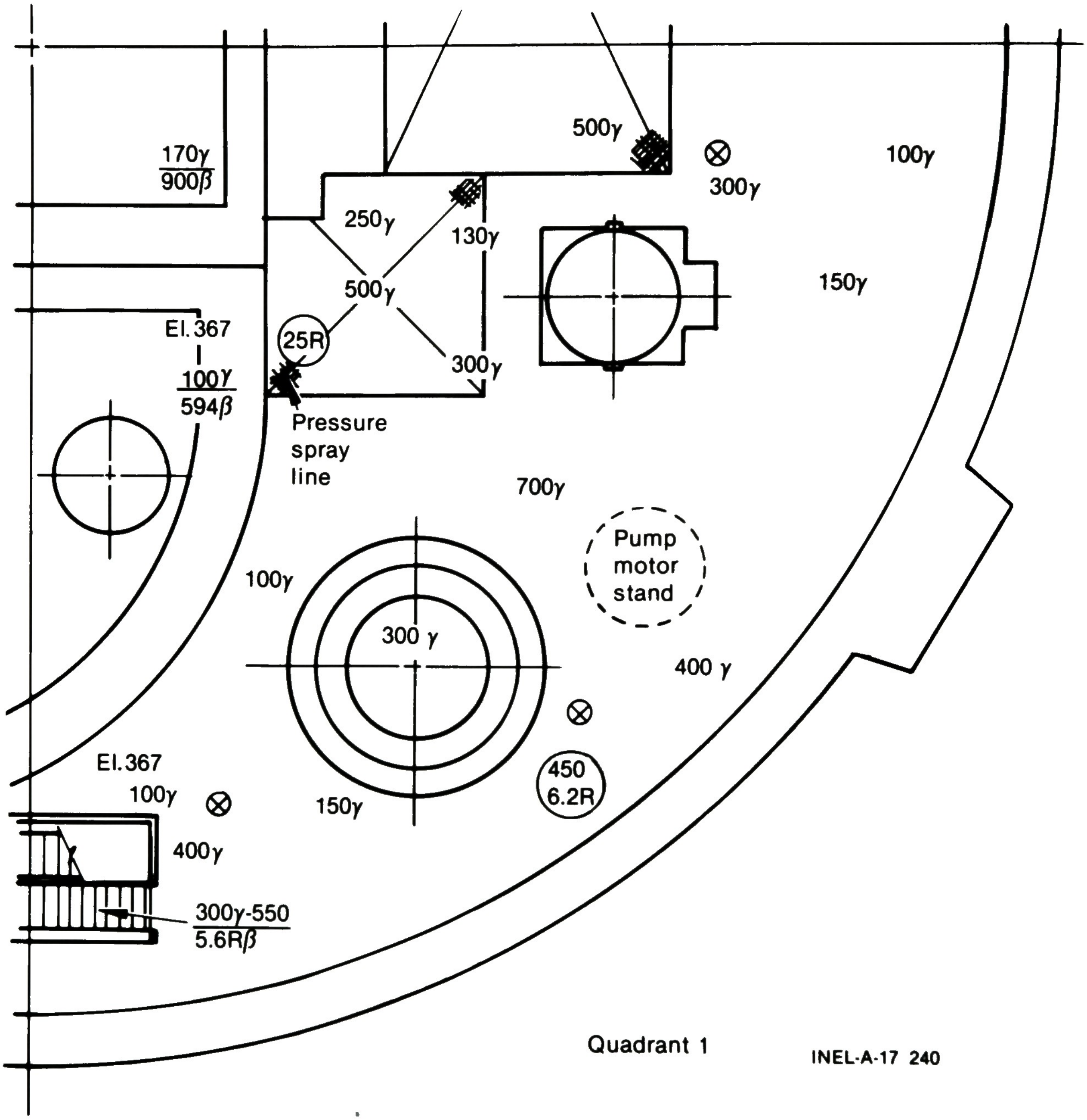
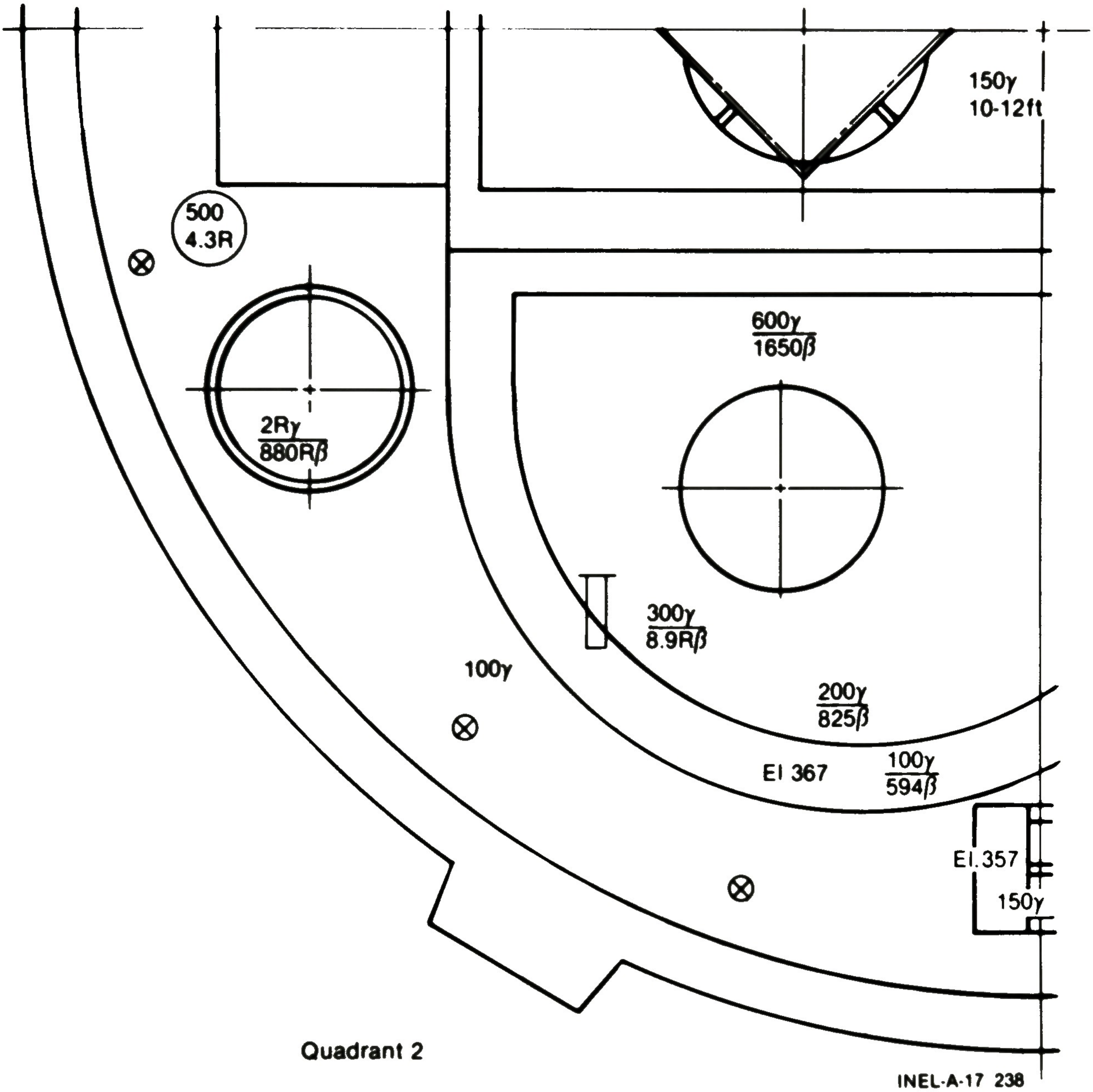


Figure 11. Radiation survey map, 347-ft level.



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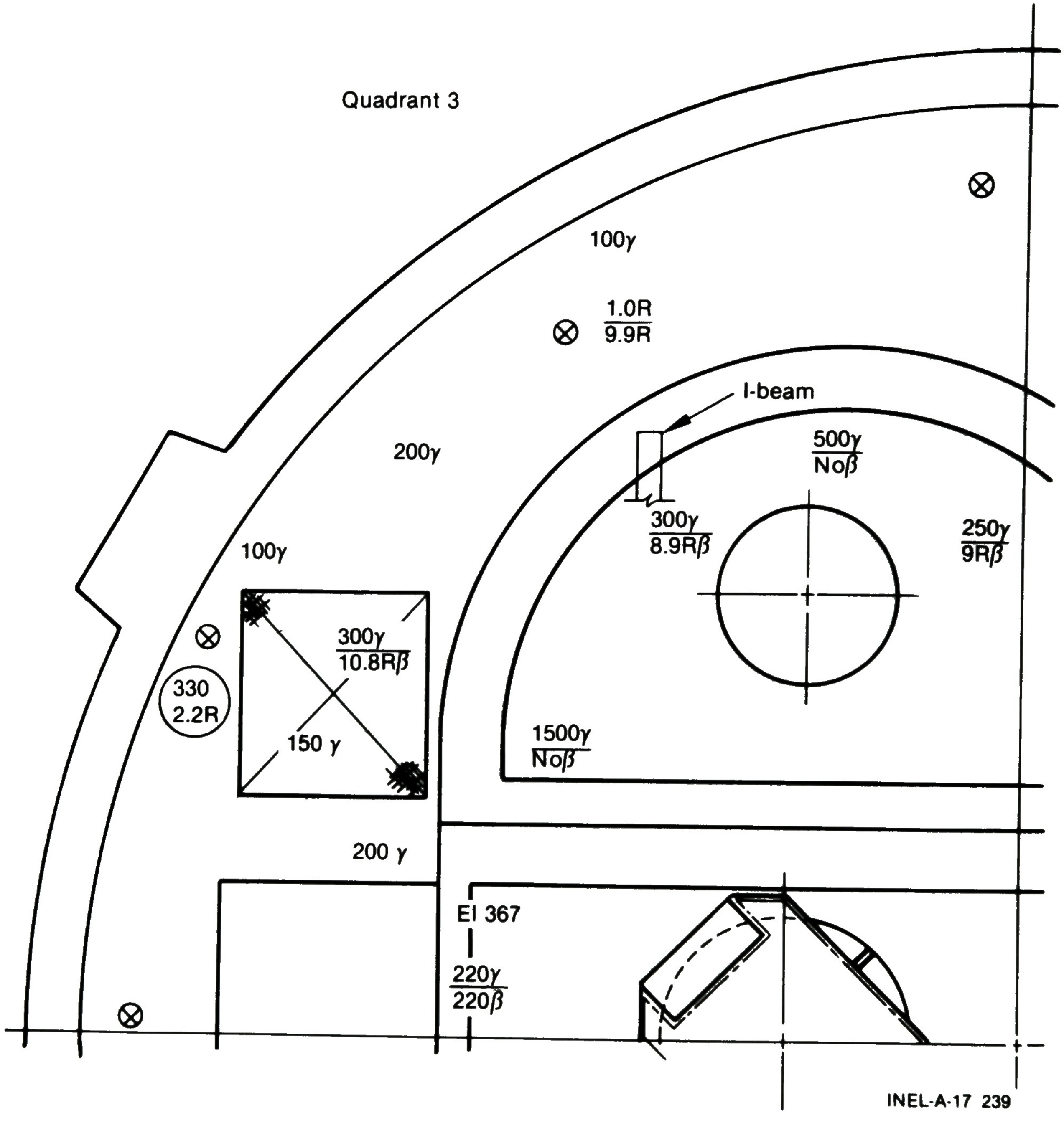

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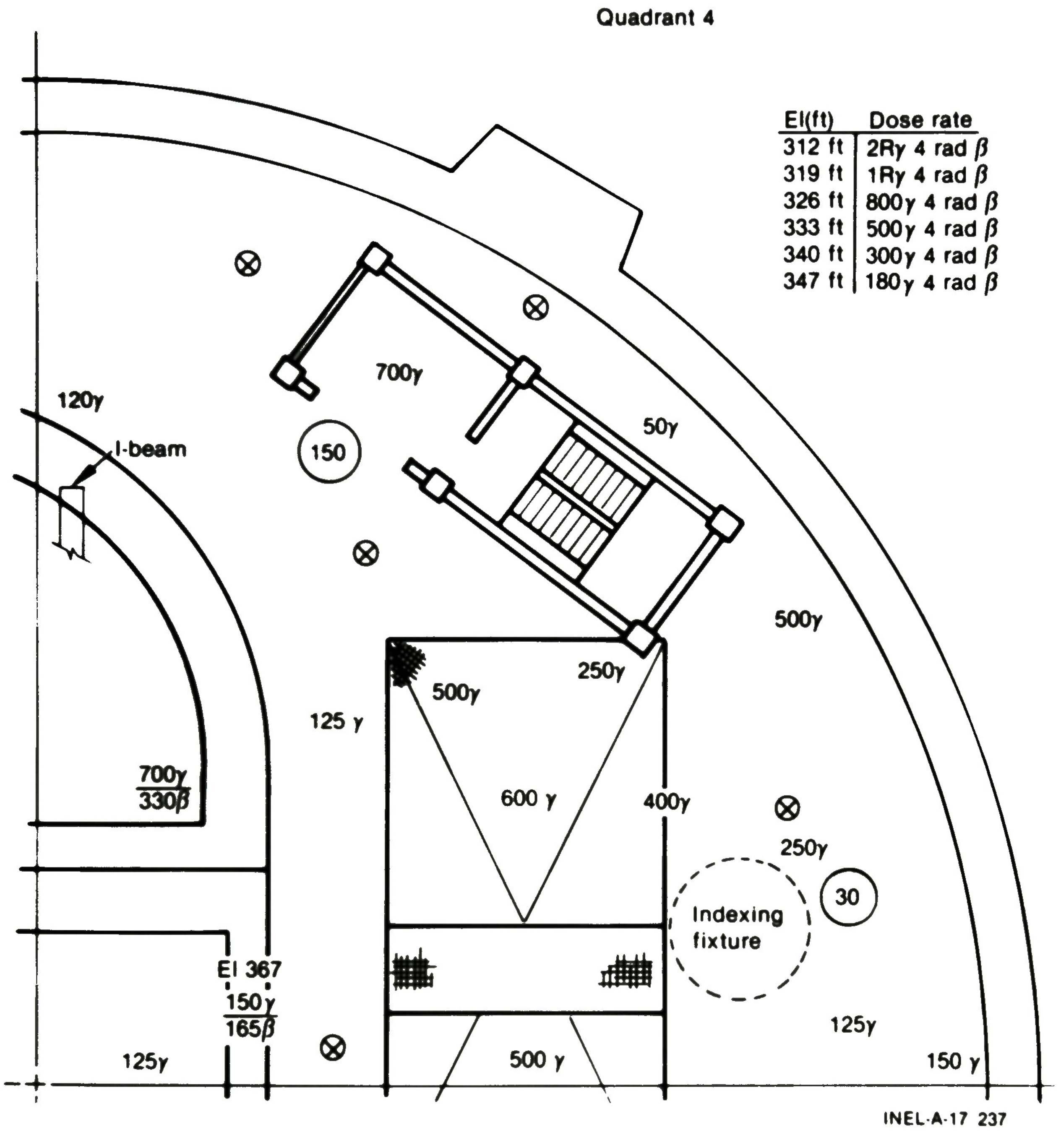

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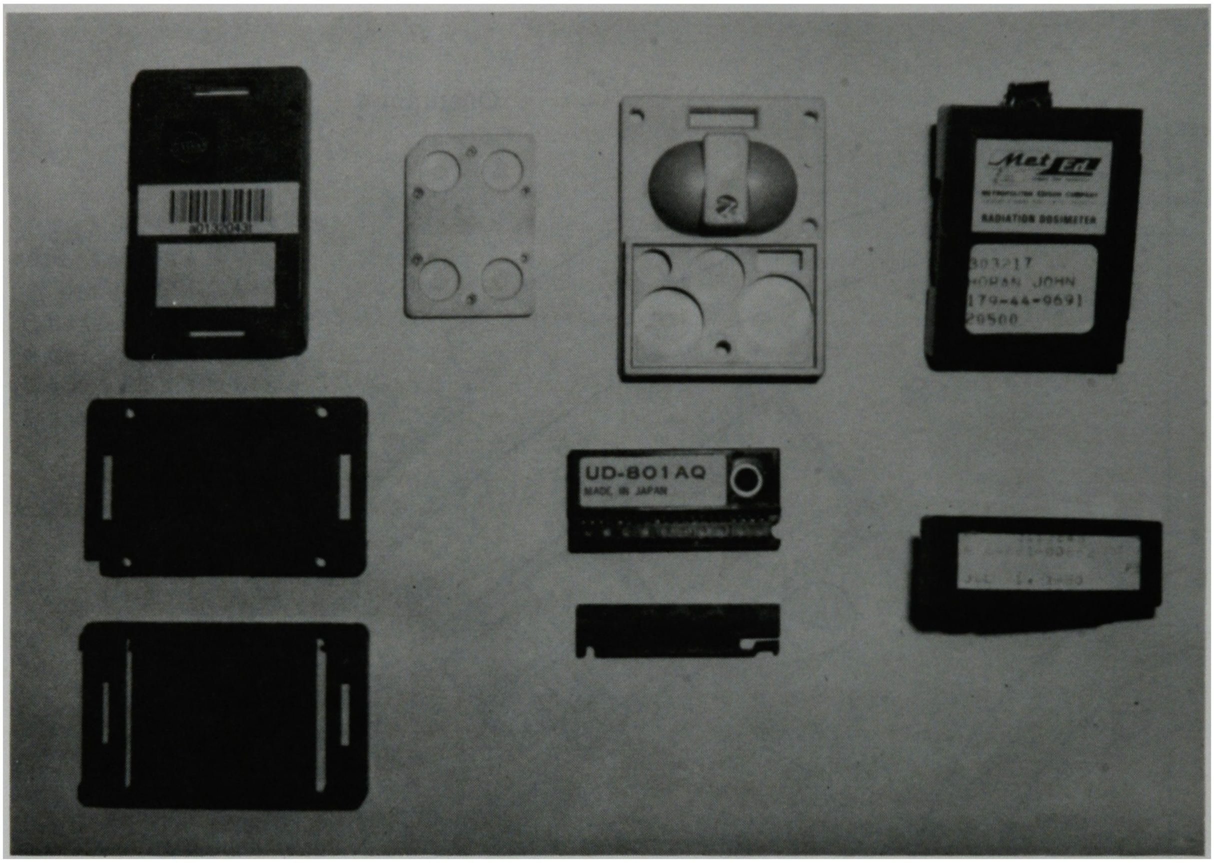

Figure 12. Five different types of dosimeters used during containment entry.

fields at TMI-2 make the standard dosimeter insufficient for adequately defining skin dose, lens-of-the-eye dose, or dose at depths of 1 cm or greater. This project is designed to incorporate recent technology developed in response to DOE chemical processing plant environments (which are closely related to those at TMI-2), to accurately measure both the intensity of the fields and the personnel doses. The project tasks are discussed in the following paragraph.

A short-term effort will transfer technology to the TMI recovery of the state-of-the-art capability currently available in the DOE sector. It is recognized that beta dosimetry and instrumentation require conservatisms and recognition of inefficiencies to ensure that personnel doses are kept within the appropriate limits. This task will coordinate the evaluation, calibration, and placing in service of a state-of-the-art personnel dosimeter for use during TMI-2 recovery operations. Portable survey instruments will be suggested for use in TMI-2 recovery operations. Improved field survey techniques will be developed to allow increased accuracy in predicting personnel dose from field surveys.

Radiation Monitoring/Information Program. The Radiation Monitoring/Information Program was established to provide a citizens' radiation monitoring program and a public information program within the TMI area. This was done by

- Purchasing and installing instrumentation sufficient to support a minimum of 12 air monitoring stations around the TMI facilities at 12 separate communities within a 5-mile radius (Figure 13).
- Educating and qualifying local individuals designated to support and maintain the instrumentation.
- Providing assistance in establishing a pilot program for the Department of Environmental Resources of the State of Pennsylvania.

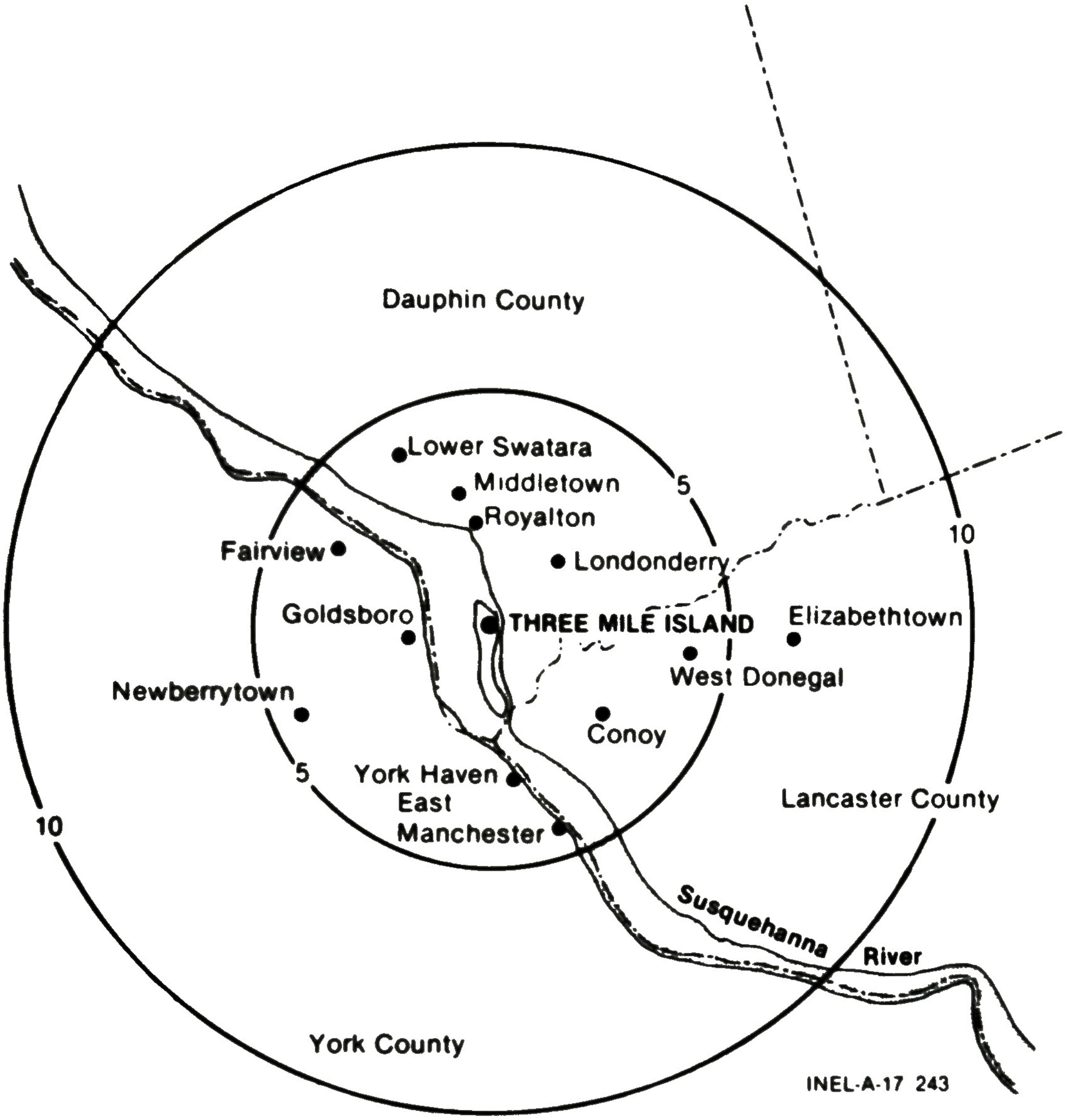

Figure 13. Map showing locations of the 12 air monitoring stations for the Citizens Radiation Monitoring Program.

- Collecting, documenting, and disseminating all information in a final report.

- Assisting the Environmental Protection Agency (EPA) in their monitoring efforts during the TMI Unit-2 containment building purge.

The Citizens Radiation Monitoring Program (CRMP) was designed to provide a credible source of information about radiation levels to citizens in the communities adjacent to TMI. The program represents a unique effort to build citizen confidence in public information. While the President's Commission on the Accident at TMI identified no immediate or expected long-term physical health effects to the citizens from the accident, the potential danger associated with the crisis was substantial, as was the perceived psychological stress that resulted. The psychological stress associated with the accident has been attributed to a lack of credible scientific information on which residents of the area could rely. Such stress was exacerbated by general lack of understanding among the local population as to what radiation is, how to measure it, and what health effects can be expected from exposure to it.

In response to various community requests, the Department of Energy (DOE) convened representatives from seven organizations to explore the feasibility of developing a community monitoring effort around TMI. These organizations were the Pennsylvania Department of Environmental Resources (DER), Pennsylvania State University (PSU), EG&G Idaho (a contractor to DOE), the Environmental Protection Agency (EPA), DOE, the Nuclear Regulatory Commission (NRC), and Metropolitan Edison (Met-Ed).

A decision was made to explore the concept of a citizens' radiation monitoring program with township and county officials of the areas immediately adjacent to TMI. The primary purpose of such a program was to provide a source of accurate and credible information about radiation levels to citizens who live close to the Three Mile Island Nuclear Power Plant. This information would permit citizens to make informed and independent judgments about the safety of radiation levels in their community and to verify radiation levels measured by existing state and federal agencies. The program was to be an independent, routine surveillance program operated by local townships.

To achieve its purpose, six characteristics were designed into the program:

1. *An independent, community-based source of information.* Radiation measurements were made and disseminated by local citizens themselves. Data were not derived from Government agencies or the utility itself, in whom some residents had little trust.

2. *Simple, but technically accurate information.* The instruments were sensitive to radiation levels well below the limits of safe exposure to the public. Of equal importance, the measurements were reported in units that already had public acceptability in the area. This was done to minimize the need for technical conversions, which on occasion confuse even the scientists.

3. *An immediate source of information.* Radiation level measurements were available to any citizen around the clock at a public site in each township.

4. *Education on radiation.* During the three-week training course, the citizen monitors learned enough about radiation and its effects to enable them to interpret the measurements they received in the field and to relate this information to the citizens of their communities.

5. *A forum for dialogue* between scientists, citizens, and Government officials on technical aspects of policy decisions. The dialogue that occurred in the classroom permitted the citizens to air their emotional concerns and to hear alternative explanations against a backdrop of factual information.

6. *A credible source of information,* due primarily to the fact that the citizens themselves made direct measurements of radiation levels and reported their findings directly to their neighbors. The data were not filtered through any other agencies for interpretation or modification. The program operated on the principle, "What you see is what you get!" A second contribution to the program's credibility is the fact that the agencies who sponsored the program had some objectivity in the eyes of the community, since none of them had a direct link with the utility. The sponsoring agencies offered technical expertise on radiation and its effects and served as consultants to the communities in developing their monitoring capability. The program gained credibility as the citizens assumed responsibility for managing the details locally.

The first important step was creation of a process to solicit community input into the design of the program. This was accomplished through meetings with local officials and county commissioners. The officials were asked to nominate four citizens from each township to receive training in radiation monitoring.

Selecting the monitoring equipment to be used in the Citizens Monitoring Program involved evaluating the various monitors for effectiveness in detecting krypton-85 down to minimum permissible concentration levels. Based on extensive testing, the Ludlum Model-2A ratemeter with an

Eberline HP-260 probe and Rustrak recorder was chosen for use as a beta monitor in the Citizens Radiation Monitoring Program. In addition, the Lear Siegler, Inc., Model 131500 ion chamber (LSI) was chosen as a gamma detector. The Ludlum GM sytem was installed in a weather-tight enclosure. The outputs of each instrument were to a strip chart recorder for continuous sampling. The strip chart output allowed convenient identification of intervals by clock time, allowing correlation of observed activity with predicted krypton-85 plume location (see Figure 14).

Designing a system for collecting and disseminating information proved to be one of the most difficult tasks to accomplish.

A system was needed to address a number of specific concerns:

1. Uniform procedures across the 12 townships
2. As little filtering of the data by the citizens or by the technical working groups as possible
3. Rapid verification of the citizens' readings by a technical working group (TWG) made up of representatives from the five organizations (DOE, DER, PSU, EG&G, and EPA) to ensure accurate readings
4. A process by which the TWG could be notified and citizens monitors could receive immediate technical assistance from the TWG in the event that a glitch (abnormal reading) occurred
5. Provisions for initiating equipment maintenance
6. A central location for timely storage, summary, and dissemination of all data
7. Capability for the data to reach multiple outlets simultaneously—including the TWG, EPA, and local townships
8. Reporting of the radiation levels in units that had meaning for the general public.

An overall information collection and dissemination system that met these needs was developed.

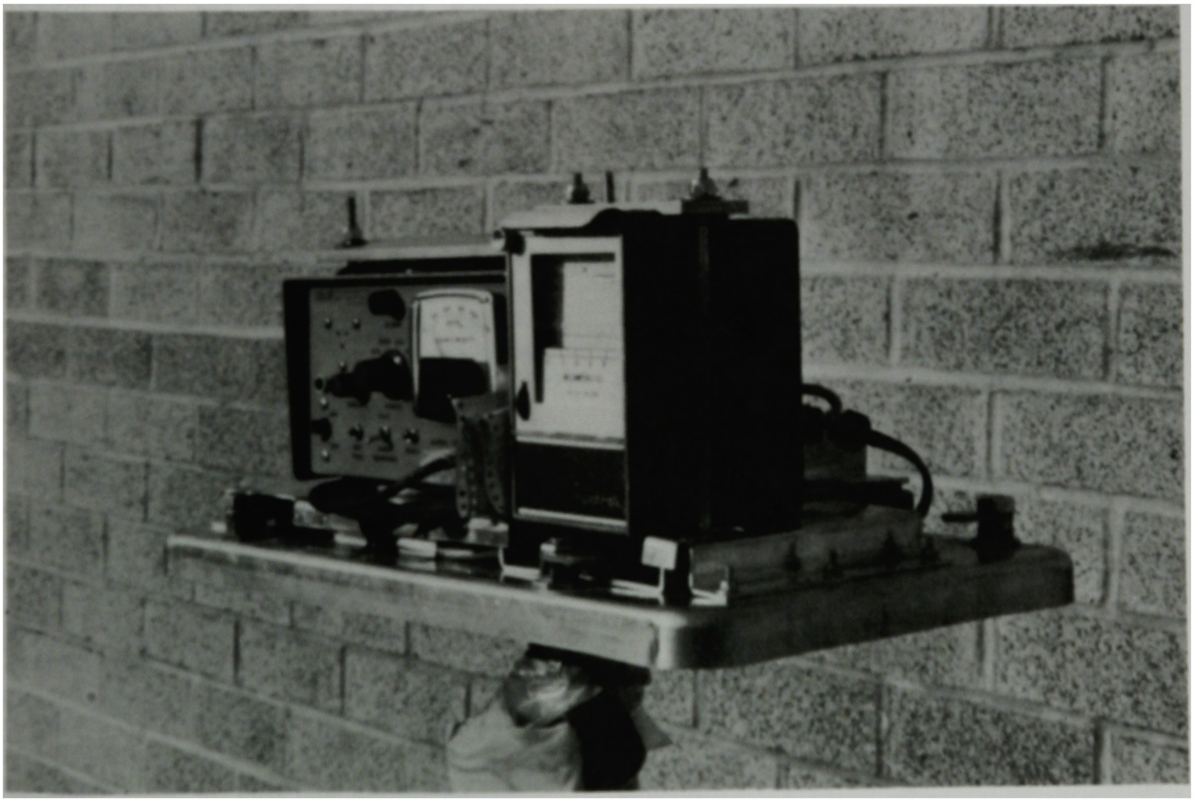

Figure 14. Radiation detector and recorder used in the Citizens Radiation Monitoring Program.

Interviews with local community leaders, the monitors themselves, and state and county officials indicated that the Citizens Monitoring Program was successful in providing a source of credible information to the public at large. A review of the data by EPA, DER, and GPU revealed the monitoring results to be consistent with those obtained by these agencies.

A draft report covering the CRMP was completed and circulated for comments.

During Fiscal Year 1981, the Citizens Radiation Monitoring Program will be maintained at its current level. All monitoring stations will be checked on a regular basis and equipment repaired as needed. The final report of the CRMP will also be issued.

Technology Transfer. The purpose of this effort is to provide for DOE technology transfer to GPU and its subcontractors and others in the radiation and environment areas. Besides general logistic support, specific support tasks include

- Assisting GPU to establish a viable, self-sufficient, and credible analytic high- and low-level radioactive laboratory, which could also be used for TIO samples
- Providing technical support for the Environmental Protection Agency during the purging of krypton-85 from the containment building.

To support the laboratory requirements, the need for the general requirements, laboratory analyses, and anticipated results for each task were defined by describing how the requirements will be implemented in each technical area for the TMI-2 Information and Examination Program (e.g., mass balance, accident diagnosis). Also considered was the possibility of unexpected results and potential impact on each related technical area. Thus, provisions were included to reflect potential schedule modifications in both the technical development and test development areas to meet the program needs.

Functional and operational criteria were developed for the radioactive chemistry laboratory and reviews of conceptual designs and design requirements were performed. When constructed, additional assistance will be provided to ensure the laboratory can produce required results.

Extensive assistance was provided to the Environmental Protection Agency (EPA) in support of their monitoring efforts associated with the June purging of ^{85}Kr from the containment building. Assistance was provided before, during, and after the purge. Before the purge, a report entitled *Monitoring of Controlled Airborne Releases during the Planned TMI-2 Reactor Building Purge* was prepared. This document presents a technical plan for monitoring controlled airborne releases (MOCAR) from the TMI-2 facility during the planned purge of the reactor building atmosphere. This plan defines the objectives of the effort, identifies the methods by which the objectives would be met, and provides for reporting the results and conclusions.

The program plan proposed that a comprehensive, analytical, monitoring effort be carried out by a group with recognized expertise in plant effluents monitoring, environmental monitoring, meteorology, atmospheric transport, and public health. These experts would be drawn from a broad range of research, governmental, and academic organizations.

It was recommended that this program be coordinated through the Environmental Protection Agency (EPA), with the TMI long-term environmental radiation surveillance program, and that it be incorporated as an integral part of the overall federal-state program. The program, as it was actually carried out, closely followed these recommendations. Besides the monitoring program described above, the Citizens Radiation Monitoring Program (CRMP) was functioning during the purge. This effort is described under "Radiation Monitoring/Information Program." Samples of the reactor building atmosphere were taken before, during, and after the purge. This sampling effort is described in the section on the containment building and support systems. Following the purge, the TIO undertook the analysis of the EPA air sample cartridges. The EPA monitoring system consisted of 19 stations distributed in the vicinity of TMI. The sample cartridges consisted of a particulate filter followed by an activated charcoal cartridge for iodine detection. Analysis of the particulate filters was initiated for gamma-emitting nuclides, and the charcoal filters are currently awaiting analysis for ^{129}I by neutron activation.

Before, during, and after the purge, members of the Lawrence Livermore Laboratory staff assisted in determining the location of the vented gas plume through use of the computer code ARAC. The DOE also provided helicopter tracking of the plume for improving radiation monitoring.

Radioactive Waste Handling

The decontamination and cleanup of TMI-2 represents a unique opportunity to develop generic postaccident technology for radioactive waste processing, storage, transportation, and disposal. This technology development should be integrated into ongoing governmental and commercial programs as much as possible to ensure efficiency of funds and maximize technical participation. Also, the development of accident radwaste management information would be useful for subsequent postaccident cleanup; provide a basis for regulatory criteria; and have potential industry-wide application.

The objective of this task is to identify radioactive waste management programs utilizing the experiences from the TMI-2 cleanup to generically enhance the radwaste handling technology of the nuclear industry. Specific topical areas to be investigated include:

- Removal of radioactive contaminants from accident liquids and decontamination solutions
- Immobilization of contaminated ion-exchange media
- Processing, transportation, and disposal of the final waste forms.

At the April 1980 Technical Working Group (TWG) meeting, a Radioactive Waste Handling (Task 3.0) Technical Planning Group (TPG) was established to prepare radwaste program requirements supporting the above goals and common interests of the TI&EP.

The TIO assumed responsibility for the TMI-related Radioactive Waste Handling (RWH) Program. Technical assistance at the TIO was obtained from the INEL and industry consultants representing five companies with specific expertise in radioactive waste management processing, transportation, storage, and disposal. Interfaces were established with DOE, NRC, and GPUSC to coordinate TMI-2 technical information.

The objectives of the radwaste TPG were documented by the development of two lists of technical project opportunities: one addressing long-term objectives that dealt with projects to be undertaken relative to accident radwaste management preparedness; the other a short-term list that dealt with generic waste management activities that could be accomplished in a time consistent with TMI-2 recovery schedules. The significant radioactive waste-handling accomplishments during Fiscal Year 1980 are summarized in the following paragraphs.

Short-term List of Technical Project Opportunities. The purpose of this activity was to develop a short-term program plan based upon candidate descriptions received from involved TPG members representing DOE, NRC, GPUSC, and EPRI. The radwaste projects of the list were to be timely relative to the recovery schedule; preclude utilization of defense waste facilities; exclude the reactor fuel; and provide generic benefits relative to accident waste processing, transportation, and disposal.

This short-term radioactive waste handling program list outlined 18 candidate projects for possible implementation, including specific work scopes, schedules, and estimated costs. The candidate projects addressed the following areas of accident radioactive waste management:

- Interim storage criteria
- Stability and characterization of ion-exchange media from radiation and chemical effects
- Solidification of ion-exchange media, evaporator bottoms, cartridge filters, sludge, and contaminated oil
- High-integrity container development for shipping, storage, and disposal of dewatered ion-exchange media
- Volume-reduction techniques for accident waste combustibles and decontamination liquids
- Development of improved methods for ion-exchange systems.

Implementation of many of these tasks will be considered by the DOE for Fiscal Year 1981.

Resin Characterization. The characterization of organic ion-exchange media (resin) and liner was established in order to

- Identify design and regulatory information relative to the characteristics of resin stability in a radiation environment
- Identify the liner internal containment environment subjected to dewatered spent organic resins for extended time periods, using EPICOR II liners as a test unit
- Provide input to other radwaste tasks.

An EPICOR II liner will be shipped to a laboratory to:

- Determine residual gas pressure after extended periods of liner storage (one year) and chemically analyze gaseous products produced
- Determine resin stability versus time for periods up to two years, in high radiation fields
- Determine liner containment environment and integrity over similar periods of time, thereby providing input into overpack design and regulatory criteria.

Resin samples will be shipped to other laboratories for further processing studies (e.g., elution and vitrification). This information will be available by the summer of 1981.

CONFIGURATION, DOCUMENT CONTROL, AND ARCHIVES

Objective

The enhancement of the nuclear power industry data base depends, in great part, upon the availability of information gathered from the TMI-2 accident.

The accident itself generated unique information on emergency procedures and plant safety. Additional information, gathered and processed during recovery, along with technological advances, will add to the collected data available. As a result of the information gathered both during the accident and in the time to come during recovery and the technology advances, the nuclear community can produce changes in nuclear safety, licensing, and other critical areas.

To obtain and store meaningful information, the Configuration, Document Control, and Archives Section of the TMI-2 Technical Information and Examination Program (TI&EP) was established. The functions of the Configuration, Document Control, and Archives Section include obtaining, storing, and disseminating information gathered.

The implemention of an information records management system is vital to maintaining the integrity and security of the information obtained from the TMI-2 recovery. Also necessary is the archiving of samples and components to be used in future studies and research.

Approach

The objectives of the Configuration, Document Control, and Archives Section were met by:

- Organizing a task planning group and obtaining access to the Nuclear Safety Analysis Center's (NSAC) data base records management system
- Identifying, requisitioning, and installing the necessary equipment to perform information storage and retrieval activities
- Establishing the Document Control Center as the centralized point for the management of all TIO communications and documents
- Preparing the necessary procedures to ensure the proper handling of information and records.

The results of this system will be a well defined, effectively operating Document Control Center capable of capturing, logging, storing, retrieving, and disseminating vital information and reports to the nuclear community.

Significant Configuration Document Control and Archives Accomplishments During FY 1980

Data Bank Users Survey. A survey of the U.S. nuclear industry was performed in May 1980 to determine the following:

- The extent to which data captured by the Technical Information and Examination Program would be requested by the nuclear industry
- The specific types of information that would be requested
- The data retrieval system that would be needed to support these requests for report generation and dissemination.

In July 1980, the telephone data bank user's survey was completed by Southwest Research Institute. Approximately 1,030 organizations in the nuclear community, including colleges, nuclear utilities, architectural engineers, and regulatory agencies were included in the survey.

The results showed that a large percentage (88%) of the sample group was interested in the data. The standard error of the estimate is 7% at the 95% confidence level. Therefore, the demand may range as low as 81% or as high as 95%.

The survey also showed differing levels of demand for various data classes as outlined below and in Figure 15.

1,2. *Instrumentation and electrical equipment survivability*—Performance degradation and failure modes, as a function of temperature, humidity, radiation exposure, and other environmental parameters that exceeded the limits for which these units were designed.

3. *Fission Product transport and deposition: environmental mapping*—Dispersal mechanisms and patterns. Physical and chemical form in which mobilized fission products may be deposited on various surfaces under accident conditions.

4. *Decontamination/dose reduction technology*—Generically useful data on the effectiveness of available decontamination and dose reduction techniques under representative real-life conditions.

5. *Early containment penetration and monitoring*—Remote radiation measurements, air sampling, sump water sampling, and videotaping of the reactor building interior.

6. *Radioactive waste handling*—Waste collection, confinement, consolidation, conversion, packaging, and shipping.

7. *Reactor building damage assessment*—Data, photographic, and/or videotape records of reactor building damage assessment.

8. *Containment sump debris characterization*— The amount and nature of debris (if any) present in the containment sump.

9. *Primary system pressure boundary characterization*—The evaluation of the reactor vessel and head structural and metallurgical conditions, and suitability of the vessel for continued use.

10. *Mechanical component survivability*—The evaluation of possible degrading effects on performance capability or expected service life of various pumps, valves, and other mechanical equipment inside the reactor building.

11. *Criticality control*—Assurance of criticality control in the course of reactor core in-place assessment, fuel removal for examination and disposal, etc.

12. *Core damage assessment and removal*—The conditions of the TMI-2 reactor core important to the reconstruction of the accident, and information related to degraded core configurational features, material interactions, flow characteristics (coolability), etc.

13. *Packaging and shipment of fuel and core components*—Handling, fuel packaging, shipment, and disposal requirements and provisions of accident-degraded reactor core components, including core-removal methods and fuel-sampling techniques.

14. *Fuel experiments and examination*—Behavior of fuel materials, rods, assemblies, etc. under conditions of significant interest.

The survey indicated that a precision search and retrieval system, such as one designed for the Nuclear Safety Analysis Center (NSAC), is appropriate for this program. The survey also determined the following in connection with the Document Control Center:

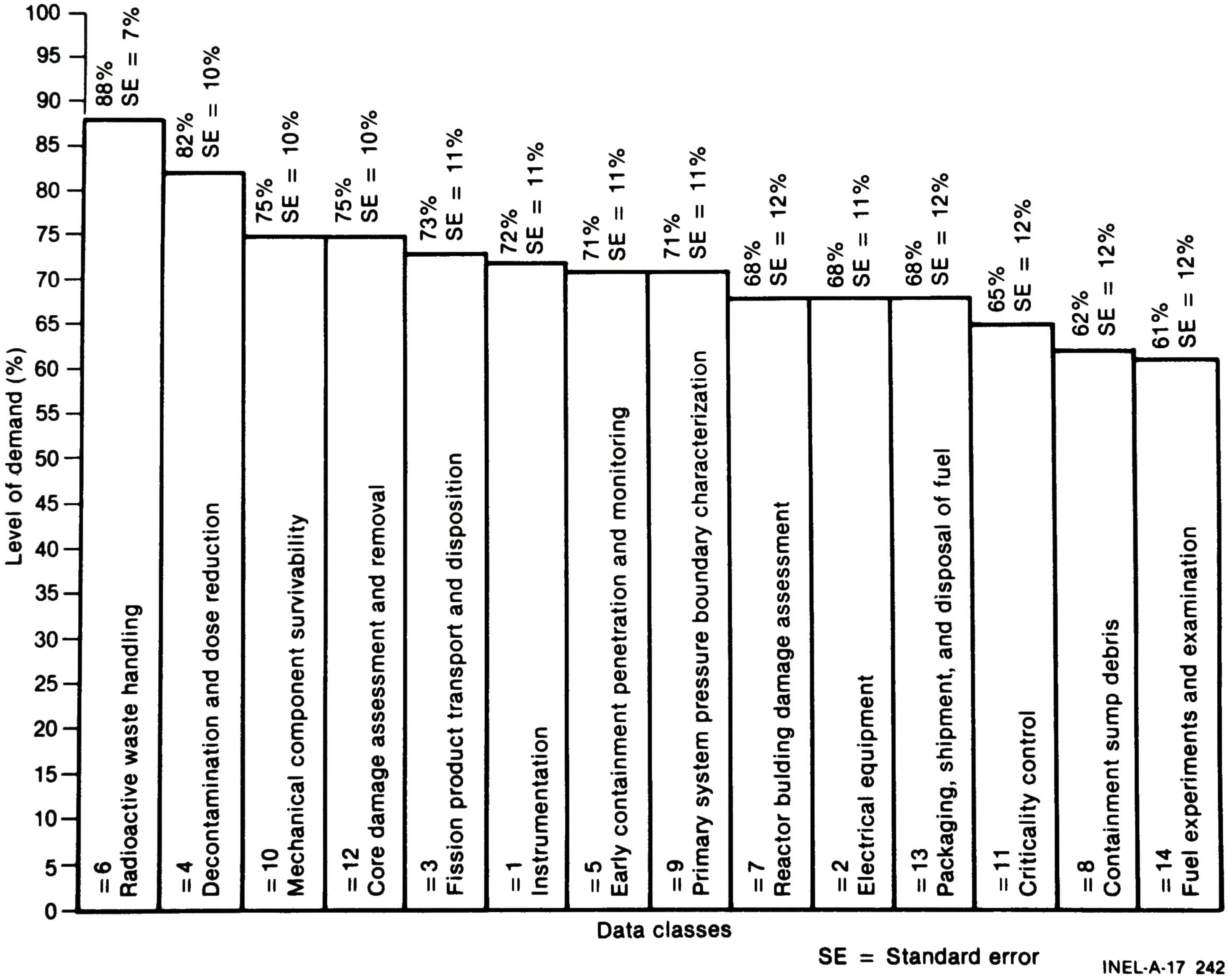

Figure 15. Graph of survey results showing levels of demand for various data classes.

- The data needed to estimate its size
- The personnel required for effective operation
- The necessary equipment
- The form in which the data were to be stored and disseminated.

Document Control Center. The Document Control Center (DCC) was established onsite in a central location (see Figure 16). The DCC provides information processing and document filing and retrieval for technical coordinators and subcontractors.

Telecommunication systems have been established for the Technical Integration Office at Three Mile Island. These systems include a Dimension 400 telephone system, a telefacsimile slow-speed copier and a computerized high-speed copier for transmitting and receiving copies, a computerized teleconferencing system (NOTEPAD), and a computerized data base management system linked to the Zytron computer at EPRI. These systems enable the TIO to effectively communicate with all parties associated with or interested in the work and progress of the TMI-2 Information and Examination Program. The telephone system is used as a primary means of verbal communications with persons involved with the TI&E program, but not located at or near the TIO. The telefacsimile copiers are used to send and receive written communication, reports, memos, drawings, etc. when the regular mail system would be too slow to effect the turnaround time for information. The computer interface with the EG&G computer or several other host systems provides for direct computer usage from the TIO. The computerized teleconferencing system (NOTEPAD) is used for relaying messages and obtaining information with all of the nuclear power generating stations on the system.

The Document Control Center (DCC) has been established and is operational. The DCC activities involve handling information and records in all forms. It is the center for all TIO requests for information from Met Ed/GPU, and for processing of all incoming and outgoing mail. The DCC has implemented functional and detailed procedures to provide guidance and controls in the processing and flow of information in the TMI-2 Information and Examination Program. As a part of these procedures, a specialized sequential indexing file system has been developed and implemented to permit ease in retrieval of communications, data, and the file of final GEND reports.

A computerized information index management system was established. The proper computer interface equipment was procured, installed, and tested. The equipment included: (a) computer terminals (CRTs) with telecommunication interface and the main data base at NSAC and EG&G Idaho; (b) microfilm and microfiche reader/printers; (c) miscellaneous other equipment to support the computer interfaces and microform review and reproduction.

The Document Control Center will be making modifications to existing software and hardware as the need arises. Implementation of equipment to handle drawing requests and computer interfaces will be accomplished in Fiscal Year 1981.

TMI-2 Information and Examination Program Update and GEND Publications. The publishing of the TI&EP *Update*, the TMI-2 Information and Examination Program bulletin, has been initiated and is prepared and distributed as pertinent information becomes available. The *Update* contains technical data in the form of short articles, photos, graphs, charts, and tables that summarize pertinent activities of the TMI-2 Information and Examination Program at Three Mile Island. This information is provided to the nuclear community as an update on the progress of this program and related information being developed during the TMI-2 recovery. The GEND reports are official approved reports of the TMI-2 Information and Examination Program. These reports are issued by the Document Control Center as they become approved for release.

To date, the Technical Integration Office has published two issues of the TI&EP *Update* containing information on atmospheric sample and smear results, the community monitoring program, and the initial entry into the containment. The TIO has also published two GEND reports covering the TMI-2 Information and Examination Program planning reports, and the Hershey Decontamination Meeting highlights. The TI&EP *Update* will continue to be published as information of interest to the nuclear community becomes available. The GEND reports will be published as they are written and approved for release.

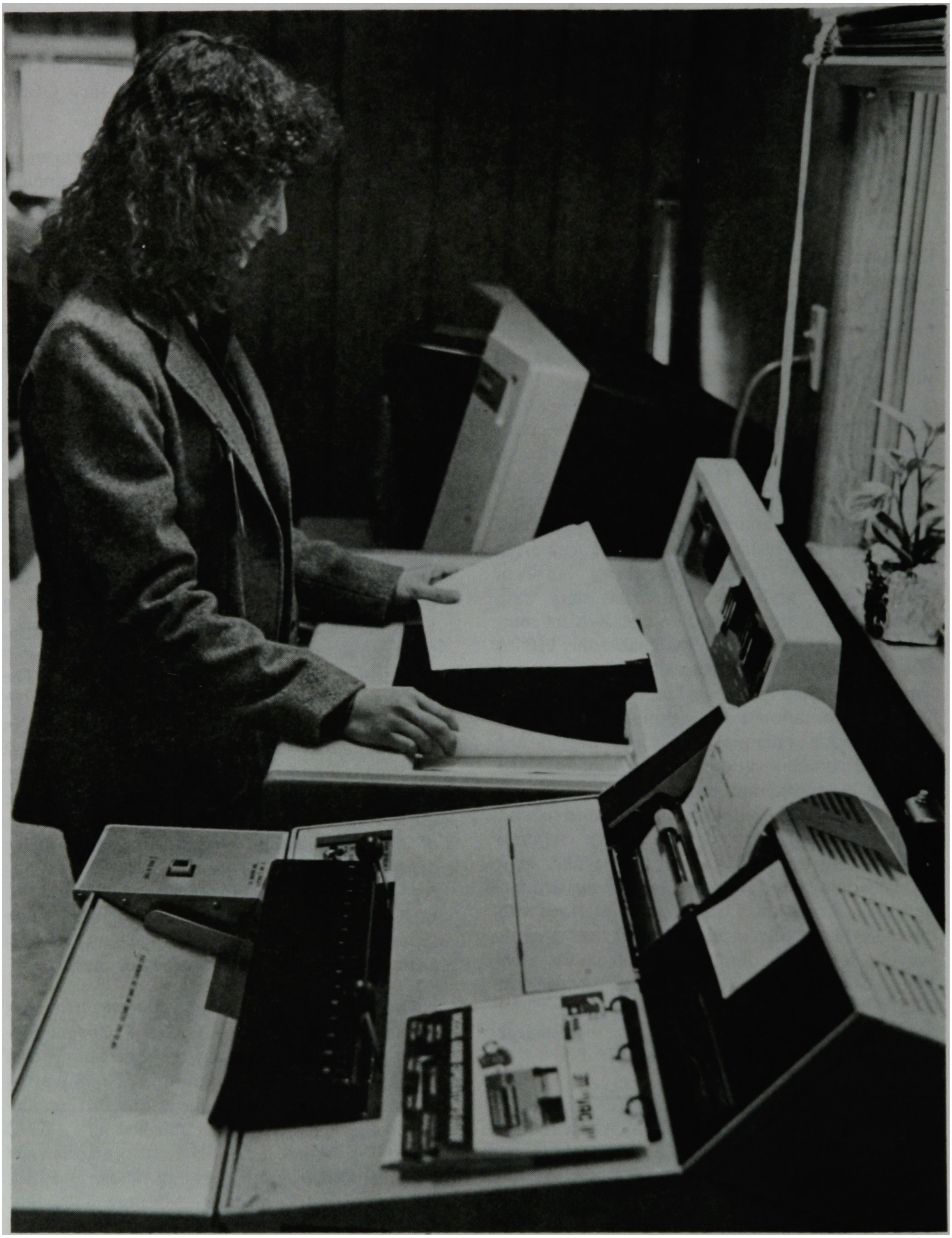

Figure 16. Document Control Center interior.

TMI Nonfuel Archives. A Three Mile Island nonfuel archives requirements document was written to provide the necessary specifications for implementation of an archive storage facility. This facility would provide a means for temporary storage of samples and components taken from the TMI-2 reactor facility so they will be available for examination at a later date.

The TMI-2 nonfuel archives requirements document has been transmitted to DOE headquarters to aid in the selection of the archive facility. When a facility is selected, the TIO will implement the requirements for the management and operation of the facility.

REACTOR CORE AND FUEL EXAMINATION

Objectives

The postaccident condition of the core and reactor vessel internals within TMI-2 represents unique data of significant interest to the scientific/technical community. The basic data, combined with the subsequent reconstruction of the core-damage sequence, constitute unprecedented input for defining future licensing considerations; benchmarking current and future analytical tools; and improving accident-mitigation, safety, and operations in nuclear facilities. The tasks to obtain the data include core damage assessment, recovery of sample materials from the reactor vessel, the development and preservation of data on in-vessel conditions, and the development of special technologies of generic interest to postaccident recovery operations.

Approach

Three planning groups were formed to develop the overall description of what information might be obtained at TMI-2.

The first planning group (7.2) addressed the need for, and potential applications of, the data available within the TMI-2 reactor vessel, and the timing and potential techniques for data acquisition. Recommendations were divided into five major phases, which reflect the recovery sequence for the reactor vessel internals and the opportunities for the early acquisition of data:

1. Before head removal
2. Before plenum removal
3. Before fuel removal
4. During fuel removal
5. After fuel removal.

In addition to the potential techniques, the planning group described the data or information available, its potential use, and the recommended approach for making the data accessible. A final report entitled *Recommendations on TMI-2 Core Damage Examinations* was issued in April 1980.

The second planning group (7.3) evaluated the technical, economic, and institutional factors associated with the alternative approaches to handling and disposal of the TMI-2 fuel. The group also developed recommendations concerning the development of generic technology required to support defueling, packaging, shipping, and storage activities. A report, entitled *Scoping Studies of the Alternative Options for Defueling, Packaging, and Disposal of the TMI-2 Spent Fuel Core*, was prepared by Allied-General Nuclear Services (AGNS) under a DOE-administered contract. The report provides detailed discussions on fuel characteristics, packaging and handling, fuel can design, potential operating procedures and constraints, and logistical considerations for shipping. An evaluation of disposal options, and economic and schedule studies are also presented.

The third planning group (7.4) summarized the sequence of TMI-2 accident events that relate to fuel and core component behavior, and identified the unique data that can be provided by an examination of the core materials. The group also prepared an outline of potential fuel and core component examinations; and guidelines for handling and transporting the selected fuel and core component samples, and for selecting examination and disposal facilities. The Planning Group 7.4 final report entitled *TMI-2 Fuel and Core Components Examinations* was released in October 1980. This report, in conjunction with the Planning Group 7.2 report, provides the basis for planning of those activities related to the preservation, acquisition, and analysis of data from the TMI-2 fuel and core components. The three final reports have been incorporated in the *GEND Planning Report*, GEND-001, released in October 1980.

The TMI-2 Core Examination Program (TCEP) was activated as a functional group within the TIO in May 1980, with a program manager and a staff selected to provide the planning, coordination, and support required to meet the objectives of the TCEP. Communication was established with participating agencies, consultants, and subcontractors including NRC, DOE, GPU, B&W, Bechtel, EPRI, AGNS, Westinghouse/Hanford, ORNL, various private consulting firms, and the members of the 7.2, 7.3 and 7.4 planning groups.

Significant Reactor Core and Fuel Examination Accomplishments During FY 1980

Early Core Damage Assessment through the Reactor Head. Present estimates of the damage within the vessel are based on analysis. It is important to use actual observations to determine the condition of the TMI-2 core and internal components as soon as possible, as this will contribute to meaningful core removal planning. Visual observations and debris sampling inside the vessel will provide early data on

- The relative quantity and distribution of core debris in the plenum assembly
- Thermal distortion or other structural damage in the plenum region and closure head area of the vessel
- The condition of the core, particularly relative to slumping
- The physical condition of those control rod (CR) couplings that cannot be uncoupled normally
- Possible damage to the weldments, and binding of the plenum assembly
- Possible closure head-key binding.

This task will, of necessity, include development of contingency tooling to cut or otherwise remove control rod drive mechanisms (CRDMs) and leadscrews to provide access in the event that normal delatching procedures are not successful. It also includes special operational support items. Systems or devices will be investigated and/or developed to monitor water level under the head, to purge the air space under the head for contamination and exposure control, and to collect samples of the finely divided debris that is expected to be deposited on the plenum structure.

A task order was initiated for the development of techniques and equipment to assess in-vessel conditions via the reactor head. The list of potential techniques for this phase of the examination plan from the Planning Group 7.2 report (then in the draft stage) was reviewed and investigated. A specific approach was determined to be feasible within the environmental, physical, and radiological constraints of TMI-2. This approach, along with supporting equipment items, was conceptually developed and reviewed and has proceeded to the detailed design phase. The task is summarized in the following paragraphs.

Inspection of the interior of the TMI-2 reactor vessel will be made by a camera that can be lowered through a CRDM nozzle. Such a camera will provide a black-and-white 525-line TV image, which will be tape recorded. This task assumes that at least two CRDMs can be successfully uncoupled and the CRD motor tubes removed to provide camera and lighting access. As additional CRDMs are removed, other points of entry will become available. A CRD motor tube that is removed will be replaced by a dummy tube of similar length with an inner diameter matching that of the CRDM nozzle, thereby providing the maximum diametral access to the vessel, and guidance for tooling support. The camera will be lowered directly to the top of the control rod drive spider assembly and to the top of the fuel assembly, assuming no significant damage has occurred in the plenum assembly. With proper guidance, articulating equipment, and lighting, the camera can also observe:

- Adjacent CR guide assemblies (maximum of eight adjacent positions for each entry point)
- The top of the plenum assembly and cover
- Peripheral fuel assemblies and spaces between CR guide assemblies

- The tops of several fuel assemblies and/or the top of the damaged core

- The area between the plenum cylinder and the core support cylinder at the upper core support plate.

The ability to perform the inspections and to remove the reactor vessel (RV) head is dependent upon the removal of CRDMs and leadscrews. In the event that the CRDMs cannot be removed using normal procedures (unlatched from the control rod spiders and lifted free of the CRDM nozzles), contingency procedures and tooling are being developed to augment this operation. These contingency procedures will address

- The removal, by extra-normal means, of any given CRDM assuming that at least some CRDMs can be removed using normal tooling and procedures

- The removal of the first CRDM by extra-normal means assuming that no CRDMs can be removed by conventional means.

In addition to the major subtasks discussed above, other specialized support equipment and/or techniques are included. While comparatively minor, they are incorporated to take advantage of additional data-gathering opportunities and/or to provide suitable protection for inspection personnel. Additional scientific/technical data may be acquired by retrieving one or more swipe samples in the plenum area.

To provide protection for inspection personnel, two related subtasks are included in this work package. The water level must be lowered to prevent flow from the CRDM nozzles area. A means will be developed to monitor the water level under the head. The sensor device will use penetrations provided either by CRDM removal or by opening a thermocouple (TC) nozzle seal. The second system will provide a continuous vacuum purge of the air space under the head when CRDM or TC nozzles are open. The purge system will use a CRDM or TC nozzle as an access penetration, and will provide for negative pressure flow velocity adequate to preclude backstreaming of gases or particulates. Both systems must be coordinated with the actual inspection operations, since the water level will influence where the purge system can be inserted and what the TV cameras and lights can see, especially when inspection of the upper plenum regions is attempted.

Since this inspection task has the highest priority in the TCEP, the effort to prepare the examination and support tooling will proceed as rapidly as possible. Review of the detailed design (Phase II) is scheduled for December 1980, with initiation of fabrication and checkout (Phase III) to begin in January 1981. It is anticipated that the tooling and procedures will be ready in advance of their earliest need date. GPU and its subcontractors are proceeding with identifying and planning for the required in-containment prerequisites for conducting the CRDM removal and through-the-head inspection.

Core Damage Assessment through the Instrument Tubes. This task is intended to provide a preliminary assessment of the condition of the TMI-2 core at the earliest possible date by developing equipment and procedures to make in-core measurements via the calibration tubes in the existing in-core instrument strings. Because of space limitations, the inspection techniques are limited to indirect measurements of parameters related to the distribution of fuel within the reactor's core region.

A task order was initiated for review of the mechanical feasibility of a variety of potential techniques listed in the Planning Group 7.2 report. The techniques were divided by the type of access to be used: the first access route being the in-core calibration tubes located in the center of each instrument string, and the second being the instrument tube that contains the instrument string (this second would necessitate the removal of the instrument string). The techniques included the subtasks described in the following paragraphs.

Subtask 1—Initial Assessment of Damage to the In-Core Calibration Tubes—Useful qualitative data will be gathered during the initial activities of preparing the instrument tube access for subsequent measurements. The in-core calibration tubes (0.093-in.-ID Inconel tubes along the axial centerline of each instrument string for the entire 120-foot length) are normally sealed at their in-core terminus and provide a primary system pressure boundary. Detection of an open or leaking (i.e., railed) condition in any of the insite calibration tubes will give an indication of the extent of core damage.

Subtask 2—Mechanical Access and Thermal Profiles in In-Core Calibration Tubes—Probing of the calibration tubes with thermocouple (TC) wands may potentially provide two additional sets of information without disturbing any in-core conditions. First, a rough map of the axial temperature profile may be generated. Accumulations of radioactive debris around instrument tube locations may provide localized hot spots that can be measured and plotted as a function of the axial position in the tube and the radial position of the calibration tube in the core. Second, the open length of the calibration tube, if less than nominal, can also be plotted as a function of axial and radial position in the core.

Subtask 3—Gamma Radiation Measurements via In-Core Calibration Tubes—It may be feasible to measure and plot the relative strengths of the gamma radiation fields around selected calibration tubes. To accomplish this subtask, wands would be prepared carrying thermoluminescent dosimeter (TLD) arrays. The TLDs may help define accumulations of debris around the instrument tubes by monitoring the relative radiation (chiefly, gamma) field intensity changes as a function of axial position.

Subtask 4—Neutron Flux Measurements via In-Core Calibration Tubes—Standard Indium or Dysprosium flux wires can be inserted into selected in-core calibration tubes. The neutron dose measurements can be used to map localized neutron activity in the areas around the instrument tubes. This subtask would employ the in-core calibration tubes for their original purpose.

Subtask 5—Assessment of Damage to Instrument Strings and Instrument Tubes—The preceding subtasks are performed without displacing or removing any in-core components or debris. At this stage of operations, it would be necessary to remove, or attempt to remove, the instrument strings. On the assumption that some of the instrument strings cannot be totally or even partially removed, observation of certain withdrawal parameters would provide additional data for core damage assessment. The force required, as a function of withdrawal distance, can be recorded. Binding, jamming, and tensile failure of the instrument string can be documented, as can the condition of the active (in-core) portion of successfully withdrawn instrument strings. In addition to providing more data for core damage assessment, these data would be used in evaluating the specific application of the remaining two subtasks.

Subtask 6—Gamma Scanning via In-Core Instrument Tubes—Gamma scanning, using a suitable detector inside those instrument tubes that are now accessible, could provide a more detailed map of the distribution of radioactive materials and debris within the core and in the regions below the core. By selecting discrete energy peaks of selected long-lived isotopes (e.g., ^{137}Cs, ^{134}Cs, ^{60}Co, etc.), it may be possible to differentiate between fuel debris, nonfuel debris, and in-place structural components. Even gross gamma scanning data (as opposed to isotope-specific scanning) may yield results superior to those obtained with TLDs in Subtask 3. Unlike the TLD-based measurements, the gamma scanning detector will not suffer from the masking effects of the radioisotopes present in the Inconel-clad instrument strings, because the instrument strings will have been removed. It appears probable that only a limited number of instrument tubes would be available for scanning because of potential difficulties associated with the removal of the instrument strings.

Subtask 7—Reactivity Measurements via In-Core Instrument Tubes—This subtask would measure reactivity of portions of the core by applying neutron-multiplication techniques using small ^{252}Cf neutron sources and appropriate neutron detectors. The source and detector(s) may be placed in the same instrument tube, in adjacent instrument tubes, or in instrument tubes separated by several feet. Pending availability or development of an appropriate computer code, the results may be used to develop a three-dimensional map of the core as a whole, as opposed to extrapolations of data showing conditions immediately adjacent to the 52 (or less) radial positions. As in Subtask 6, the positions probed will be limited to those locations where the instrument strings can be withdrawn and the instrument tubes are at least partially intact.

Each subtask appears mechanically feasible. However, the technical feasibility of each technique to provide useful information was not verified in Fiscal Year 1980.

Fiscal Year 1981 efforts will concentrate on Subtasks 1 through 4, which can be performed without disturbing the in-core conditions. Evaluations will be performed to assess the capability of each technique to provide the data/information required. Subsequent planning for these subtasks will depend on the results of these technical feasibility evaluations. Subtasks requiring the removal of the instrument strings will be deferred pending (a) the results of the above evaluations, and (b) a consensus on the potential impacts of inadvertently disturbing the present core condition during instrument string removal.

Special Nuclear Materials Accountability. One of the unique problems associated with the accident in TMI-2 is the need to account for the special nuclear materials within the core and primary piping. The requirement, normally handled on a "per-fuel-assembly" basis, necessitates special procedures and approaches when applied to the potentially highly damaged TMI-2 fuel. A specific task was defined to identify methods and procedures that will provide a verifiable special nuclear material balance equating to the preaccident balance. Identification and measurement techniques that apply to the anticipated range of TMI-2 fuel conditions must be delineated.

A subcontract was placed to define identification and measurement techniques for application to the following possible fuel conditions:

- Intact fuel assemblies or rods
- Breached assemblies or rods where loss of fuel from the cladding has occurred
- Severely damaged or dispersed fuel material
- Material that has been vacuumed directly into canisters
- Waste material bearing inseparable fuels material.

The first phase of the subcontract, dealing with definition and concept development, is underway. This phase requires the subcontractor to:

- Evaluate problems associated with identification and quantitative measurement of irradiated and contaminated materials, and to identify possible solutions to these problems or define alternative methods.
- Define a special nuclear material accounting system designed to interface with the identification and measurement system. The integrated system is to provide current inventory data, as well as information on the disposition of TMI fuel.

Phase I of the subcontract will be completed in December 1980. The remaining phases, to be performed at a later date, are:

- *Phase II, Detailed Design*—This is design of an accountability system, including instrumentation, procedural controls, and a computer-based accounting system. The system must be capable of producing periodic reports to governmental licensing agencies and other interested parties.
- *Phase III, Fabrication and Programming*—This is fabrication of all generic accountability system hardware, including instrumentation not provided elsewhere; preparation of all procedural forms, and programming of the computer-based accounting system.

Encapsulation Materials and Techniques. The objective of this task is to develop a means for encapsulating (potting) core materials to be removed from the TMI-2 reactor for future examination at remote-handling facilities. Encapsulation is meant to protect the assemblies and debris and to retain their postaccident dimensional spacing during removal, transportation, and unloading at remote-handling examination facilities.

This task will identify and test candidate encapsulating materials and provide the basis for selecting one or more suitable encapsulants. It also includes the design and fabrication of equipment, and the development of operating procedures for the application and removal of the encapsulating material(s). Full-scale testing of the final encapsulant and equipment will be performed in a suitable (nonirradiated) mockup facility. This project has been divided into five preoperations phases to accommodate the developmental nature. These phases are:

Phase I	Identification and screening of candidate materials
Phase II	Testing of selected candidate materials and preliminary concepts for application and removal

Phase III	Final technical report on Phases I and II
Phase IV	Design and fabrication of application and removal equipment; development of procedures
Phase V	Full-scale testing (nonirradiated).

A Request for Proposal detailing the required performance characteristics and environmental conditions was developed and released. It is anticipated that negotiations on the subcontract will be completed early in Fiscal Year 1981, and work on Phase I will begin. Work on the remaining phases, which will be performed sequentially, will depend on the success of Phase I in identifying suitable candidate materials.

Development of Canisters. This task provides for the development of canister designs and handling techniques for packaging the TMI-2 fuel. Activities within this task include an assessment of the packaging requirements, design of one or more of the specialized canisters, fabrication of prototypes, development of handling techniques, and the testing of the prototypes and procedures. The canisters provide the structural support and material integrity for the movement of fuel once it has been removed from the reactor core.

The task has been developed as a follow-on to the Planning Group 7.3 report. The task will be divided into five phases to be performed sequentially. With the exception of Phase III, a technical report will be prepared and submitted at the conclusion of each phase.

Phase I—Conceptual Development—This phase includes assessment of the environmental conditions (e.g., space constraints, remote handling requirements, etc.), associated with packaging the TMI-2 fuel. Functional criteria will be developed to be used for guidance in subsequent design selection. Alternative canning concepts will be developed to accommodate the various requirements (i.e., debris, partial or complete fuel assemblies, and R&D sampling), and will be evaluated against the criteria. The most promising concepts will be developed as formal conceptual designs.

Phase II—Detailed Design—Selected canister design and handling concepts from Phase I will undergo detailed design and analysis. Uncertainties and assumptions generated during concept development will be resolved as a part of this effort, as will the comments stemming from review of the Phase I technical report.

Phase III—Prototype Fabrication—This includes fabrication of prototypes of the canister design(s) selected following the completion of Phase II, including specialized tooling required to handle or operate the canisters.

Phase IV—Mockup Testing—Handling procedures will be developed. The prototype canister(s), tooling, and handling procedures will be extensively tested in a suitable mockup facility. The tests will include all operating phases (including loading, unloading, and in-pool transport) and applicable design requirements (e.g., flooding/draining or pressurization, sealing, etc.). Testing will not include actual operations involving irradiated material, or exposure of equipment and personnel to radiation sources.

Phase V—Final Report—All work performed in Phases I through IV will be documented in a final comprehensive technical report.

A subcontract has been negotiated with Allied-General Nuclear Services, and Phase I is underway. Phase I of the subcontract will be completed in Fiscal Year 1981 and will be released for review. The other phases will be completed sequentially at a later date.

Borated Water Effects Study. This task has been identified to determine the effects of long-term immersion of TMI-2 core components in postaccident, high-boron-content water. Concerns over these potential effects were addressed in the Planning Group 7.2 report. The objective is to separate, as possible, the effects of accident and postaccident corrosion during fuel examination. The study is well underway, and will be completed in Fiscal Year 1981. To date, no undesirable corrosion effects have been identified.

The results of the study will be released to the GEND participants in a formal report. Should any open questions remain, laboratory-scale tests will be planned, performed, and reported.

Specification of Core Status. The objective of this task is to prepare a specification that will serve as the reference core status description for the design and development of equipment and procedures for core damage assessment, plenum removal, and fuel removal.

Various analytical studies of the TMI-2 accident have been performed to assess the thermal-hydraulic transient and the resulting core damage. This task is not intended as an analytical task to perform an independent assessment, but as a review of the assessments made to date, with the objective of describing the range of core damage assessments. In addition, it would establish a reference description for the different degrees of damage that will have to be considered during development of contingency tooling and procedures for inspection, sample acquisition plenum removal, and defueling of the reactor. These could vary from essentially undamaged fuel assemblies to assemblies that have only 2 to 3 ft of undamaged structure, with the remainder in some specified configuration above the undamaged section.

The release of the report early in Fiscal Year 1981 will complete the task. The report, however, will provide a reference document for a wide variety of current and future TCEP tasks.

CS:LME KMH