U.S.NRC
United States Nuclear Regulatory Commission
*Protecting People and the Environment*

# Three Mile Island Accident of 1979 Knowledge Management Digest

## Overview

NUREG/KM-0001, Revision 1
Office of Nuclear Regulatory Research


Three Mile Island on April 10, 1979, 13 days after the accident

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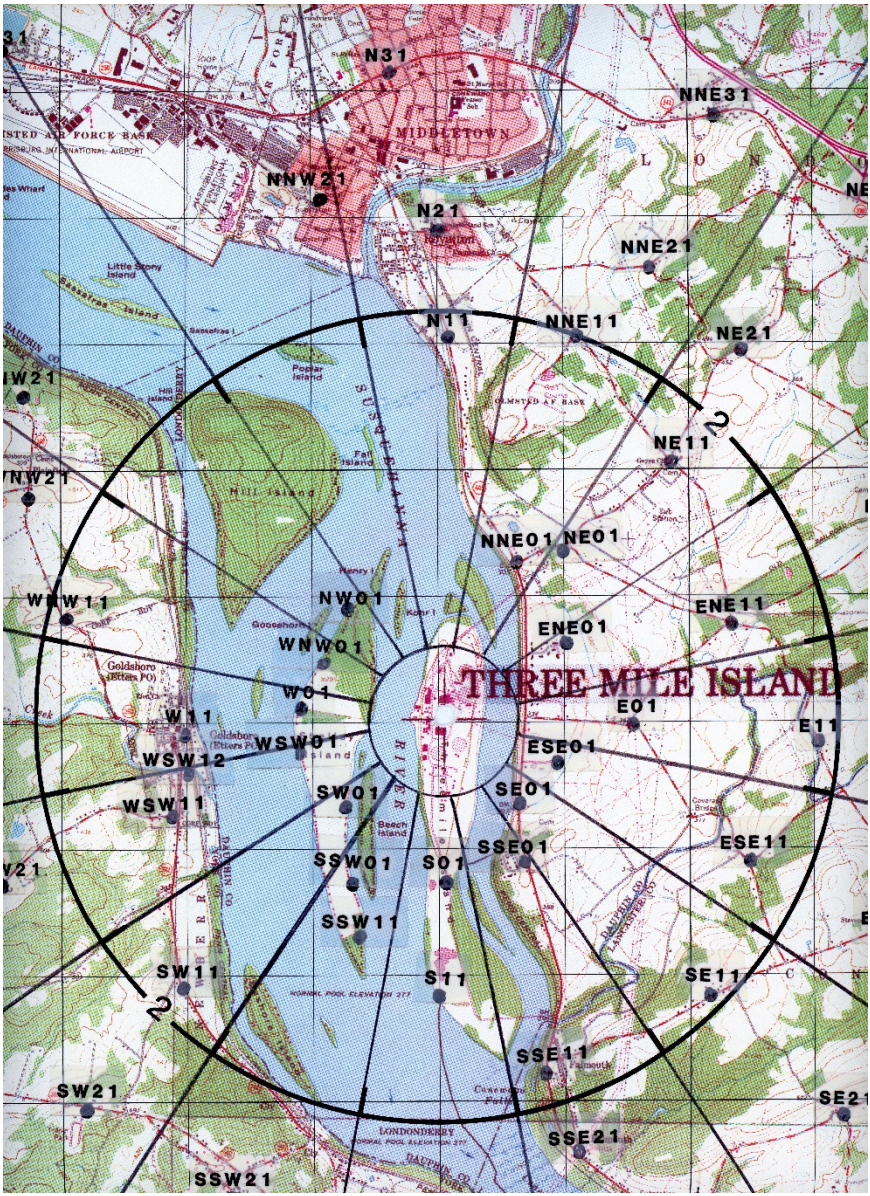
*President Jimmy Carter observes the radiation monitors in the Three Mile Island, Unit 2 control room on April 1, 1979, accompanied by Pennsylvania Governor Richard Thornburgh and the NRC's Harold Denton.*




*Location of dosimetry sites within a 2 mile radius of the Three Mile Island station. NRC deployed thermoluminescent dosimeters at 37 offsite locations on March 31, 1979, and an additional 10 locations the following day. NRC placed portable air samplers around the plant area and observation center and analyzed the results. NRC also placed liquid effluent monitors at the station discharges.*

# Digital Versatile Disc (DVD) Contents

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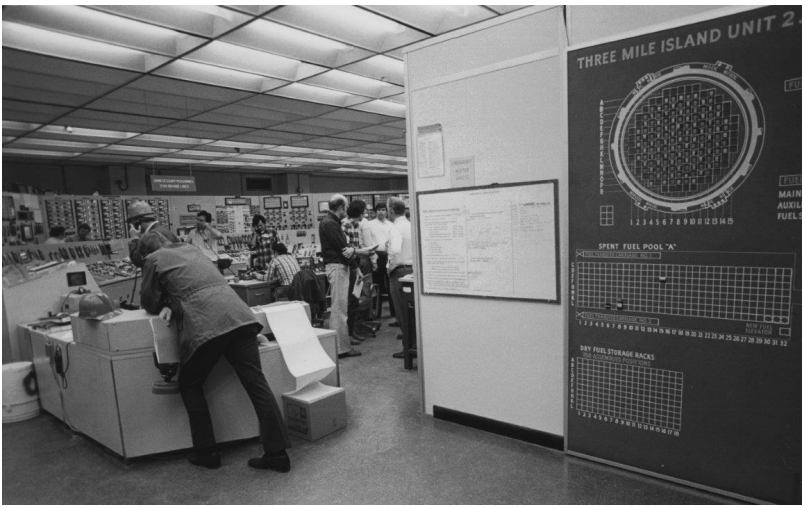


*An aerial view of Three Mile Island looking south. TMI-2 and both of its cooling towers are in the background. Although the island, which is located on the Susquehanna River, is almost three miles long, the island was named from its location three miles downriver from Middletown, PA. (Middletown was founded in 1755 and named from its location halfway between Lancaster and Carlisle, PA.)*

# 1 Introduction

Although it caused no deaths or injuries, the accident at the Three Mile Island, Unit 2 (TMI-2) nuclear power plant was the most serious incident in U.S. commercial nuclear power history. The accident began in the early morning hours of March 28, 1979, at the newly-licensed power plant near Middletown, Pennsylvania, and its effects on nuclear safety and regulation continue to this day. Three Mile Island spurred the U.S. Nuclear Regulatory Commission (NRC) to tighten and heighten its regulatory oversight of the nuclear power industry to ensure the safety of the public and the environment. Investigations and the implementation of lessons learned brought about sweeping changes in the U.S. nuclear industry. These included improvements in emergency response planning, reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations and design. The NRC and the U.S. Department of Energy (DOE) have intensively studied and documented the TMI-2 accident.

This multimedia digest was the first in the NRC's NUREG knowledge management (NUREG/KM) series. One of the missions for NUREG/KMs is to preserve knowledge for future generations of the important historical events and research that have shaped the NRC's regulatory programs. This knowledge management digest and supporting DVD contain the most important documents that the NRC, the licensee, and other government organizations issued following investigations and cleanup of the accident. Although a few key documents have become available electronically, this NUREG/KM marks the first time that the NRC has digitized these historically important documents. On the DVD, the table of contents on the welcome page provides access to these reports.

**About Revision 1.** This revision of NUREG/KM-0001 has evolved into two volumes. This volume presents overviews of the accident: emergency response, investigations, regulatory implications, and accident recovery. This volume includes topics and documents provided on the original DVD with new ones added. Supplement 1 expounds upon the technical details of recovery and cleanup activities: management and oversight, plant stabilization, worker protection, data acquisition and analysis, waste management, decontamination, defueling, and after defueling. The document collections in this supplement are derived from correspondence between the utility and NRC, and from the results of research activities. The accompanying DVDs for both volumes contain about 4,000 documents.

In addition to the large collection of documents, this volume provides three NRC multimedia presentations, "The Accident at Three Mile Island, A Look Back: Preserving the Institutional Memory after 30 Years," "The 35th Anniversary of the Three Mile Island Nuclear Power Plant Accident of 1979: Working at TMI During and Following the Accident," and "Moments in NRC History, Three Mile Island, March 28, 1979."

This NUREG/KM does not fully convey the complete NRC experience in the aftermath of the accident. Other interesting topics for future studies of the TMI-2 accident include: legal lawsuits and actions; court proceedings, including those at the U.S. Supreme Court; Atomic Safety and Licensing Board proceedings; enforcement actions; the utility's financial crisis; interactions with Congress; interactions with Federal, State, and local government agencies; public outreach; the TMI Unit 1 restart; and oversight by the NRC's Advisory Committee for Reactor Safeguards (ACRS).

**How to Use this Digest**. A few suggestions for navigating through this NUREG/KM, and the many documents on the DVD, are provided at the end of this NUREG/KM (see the section on DVD Navigation and Interpretation). The historical documents provided on the DVD are for reference only, and are not official NRC records.

***Shortly after the accident, NRC staff gathers in the NRC office trailer at Three Mile Island. Shown (front-left to right): Thomas Essig, George Smith, Richard Volmer, Frank Congel, Robert Bores (wearing hardhat), and J. Philip Stohr (wearing vest).***

# 2 The Accident

The sequence of certain events—equipment malfunctions, design-related problems, and operator errors—led to a partial meltdown of the TMI-2 reactor core, resulting in a very small offsite release of radioactivity. In an atmosphere of growing uncertainty about the condition of the plant, on the morning of March 30, 1979, Pennsylvania Governor Richard Thornburgh advised people within a 5-mile radius of the plant to stay indoors. He also advised pregnant women and preschool-age children to evacuate the area within a 5-mile radius of TMI. By the close of the weekend of March 30 through April 1, 1979, TMI-2 was determined to be in a stable shutdown condition. On Sunday, April 1, 1979, the President of the United States James Earl "Jimmy" Carter, Jr., First Lady Rosalynn Carter, Governor Thornburgh, and the NRC's Harold Denton visited the damaged unit. Within 2 weeks, the Governor's precautionary advisory to pregnant women and preschool-aged children was lifted.

While the utility and NRC were primarily charged with mitigating the consequences of the accident through plant actions, reducing the effects of offsite radiological releases is the responsibility of State and Federal agencies. The TMI accident initiated an institutional and public response that was unprecedented in the history of nuclear power in the United States. Many organizations participated substantially in the response to this accident, including approximately 24 Federal and 12 State agencies; the military; 27 counties of the Commonwealth of Pennsylvania; innumerable local jurisdictions; public and private organizations; 4 bordering states; and several quasi-Federal organizations. Operational code name "Ivory Purpose" was chosen for the purpose of citing accident support by military and other agencies. These institutions provided many kinds of support services to the utility in evaluating the status of the plant, and in bringing the plant to a safe-shutdown condition. Support was also provided to the state in evaluating the extent of public hazards, preparing for possible evacuation, and considering or preparing for the implementation of other protective actions.

The NRC played an active role as the regulator by responding to the accident. A team began to form at the site with the arrival of the NRC's Region I inspectors during the morning of the first day of the accident, and continued to expand throughout the weekend with the arrival of engineers, scientists, and public affairs specialists from headquarters and other regional offices. The incident response centers, located in the Region I office in King of Prussia, Pennsylvania, and at headquarters in Bethesda, Maryland, were

staffed by NRC incident response teams during the morning of March 28. Other NRC offices, such as State Programs, International Programs, Public Affairs, and Administration, supported the NRC incident response effort. The five commissioners, who provided the general policy that determined the overall course of action that the NRC staff would take in response to incidents, were located at their downtown office on H Street in northwest Washington, DC.

The NRC sponsored a Special Inquiry Group that was tasked with investigating the accident and reporting their findings in NUREG Contractor Report 1250 (NUREG/CR-1250). Volume 1 of that report contains an informative and nontechnical discussion of the accident, including onsite actions and offsite responses. Another good resource on the accident is the main report by the President's Commission on the Accident at Three Mile Island. Additional volumes of both these reports provide technical details of the accident and discussions of emergency actions by the NRC, other Federal agencies, and State and local government offices. The NRC's training manual on reactor safety (NUREG/CR-6042, Section 2.2) provides a technical summary of the accident, as well as an overview of the regulatory implications of the accident (Section 2.3).

The chronology of events can be found in all of the aforementioned documents. Both "Backgrounder", written by the NRC's Office of Public Affairs, and the NRC's 1979 annual report (NUREG-0690), specifically Chapter 2, contain additional nontechnical summaries of the accident;

***Three Mile Island "trailer city" at the visitor center during the accident response (helicopter pad upper left).***

these, and other reports on the accident are provided on the accompanying DVD.

One of many functions of the NRC incident response organization during the accident was to notify appropriate internal offices and external agencies, and keep them and the public informed. Document collections related to the first few weeks of the NRC response effort include the following:

- Preliminary notification (PN) reports, which were used by the NRC Operations Center to communicate daily status of the accident (see DVD folder, Response Preliminary Notices)

- Press releases issued by the NRC public affairs staff (see DVD folder, Press Releases/Conferences)

- Transcripts of press conferences held by NRC emergency managers, and many times, jointly with State executives (see DVD folder, Press Releases/Conferences)

- International cables issued by the NRC international programs staff and used by State Department officials to keep foreign governments informed of the accident (see DVD folder, International Cables)


***NRC's Harold Denton briefs the news media at the NRC press center located at the basketball court in the Middletown Borough Hall.***

During the course of the accident, the NRC commissioners (known collectively as the "Commission"), met frequently to discuss the accident and related matters. Because of their emergency nature, these meetings were not open to the public. At the time of the accident, the five commissioners were John Ahearne, Peter Bradford, Victor Gilinsky, Joseph Hendrie (chairman), and Richard Kennedy. Meetings were recorded and transcripts were prepared in accordance with the Government in the Sunshine Act. These transcripts were later released to the public and used in internal and external investigations of the accident. Notably, the Commission meetings were sometimes held in locations other than where they normally would be, making the creation of complete and high-quality recordings difficult. As such, these transcripts do not represent formal or official Commission statements (see DVD folder, Commission/Operations Center Response).

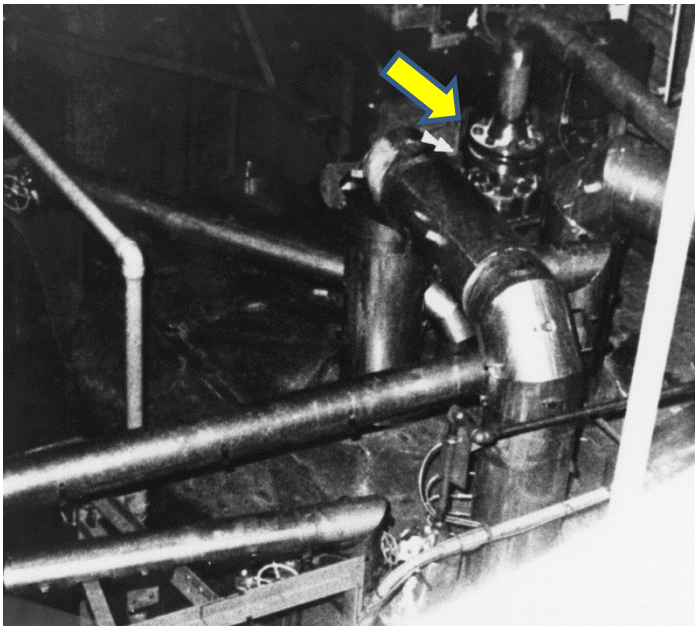
Lessons from investigations of the accident led to vast improvements in how the NRC, nuclear power plant utilities, and Federal and State agencies respond to accidents. Revised NRC rules and guidance mandated utilities to

***The NRC Executive Management Team at the NRC Operations Center located in the East-West Towers Building, Bethesda, Maryland, during the accident response. Shown (left-right): Lee Gossick (team director and Executive Director for Operations), Edson Case (Deputy Director, Office of Nuclear Reactor Regulation), Norman Moseley (Director, Division of Reactor Operations Inspection), John Davis (Acting Director, Office of Inspection and Enforcement), and James Sniezek (Director, Division of Fuel Facilities and Materials Safety Inspection).***

upgrade their overall state of emergency preparedness for a wide range of accidents, including the integration of onsite and offsite emergency preparedness. The newly established Federal Emergency Management Agency (FEMA) consolidated offsite Federal emergency planning and response to radiological accidents. (Although Congress approved the President's Reorganization Plan No. 3 of 1978 that created FEMA on September 16, 1978, the transfer of Federal functions had not been completed at the time of the TMI accident. In the reorganization, each State retained responsibility for protection of its citizens and the NRC retained Federal jurisdiction over plant activities.)

***A new state-of-the-art NRC Operations Center, located in the Fairmont Building (also known as the Maryland National Bank Building) in Bethesda, Maryland, was completed in early 1985 and remained in operation until the NRC consolidated at the current White Flint complex in Rockville, Maryland, during the summer of 1994. This first dedicated use operations center was designed using lessons learned from the TMI-2 accident and human factors principles to ensure seamless flow of information inside and outside the center. Shown is the Executive Team during the Saint Lucie Plant exercise on March 20, 1991. Clockwise: Commissioner Kenneth Rogers (back to camera), Brian Sheron (standing while briefing the team on reactor safety team assessments), Edward Jordon (Director, Office of Analysis and Evaluation of Operational Data), Themis Speis (Deputy Director, Office of Nuclear Regulatory Research), Robert Bernaro (Director, Office of Nuclear Material Safety and Safeguards), Thomas Murley (Director, Office of Nuclear Reactor Regulation), and James Talyor (Executive Director for Operations).***

In 1980, the NRC and FEMA signed memoranda of understanding to further delineate responsibilities regarding emergency planning and activities at NRC-licensed facilities. In the President's Reorganization Plan No. 1 of 1980, the Commission's emergency response functions were transferred to the NRC Chairman for defined emergencies. The Commission approved the revised NRC Incident Response Plan in 1983, which, among numerous improvements, established a site team that takes the agency's lead for larger responses. The Chairman could delegate specific authorities to the site team leader during a defined emergency. The completion of TMI recommendations relating to emergency preparedness and response are summarized in NUREGs 0933 and 1355. Other documents specific to the TMI-2 response, and generic to emergency preparedness for all NRC-licensed activities, are provided on the DVD (see the DVD folders, Other Response and NUREG Reports).



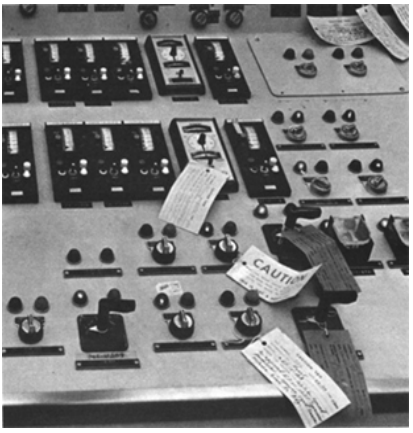
***The pilot-operated relief valve on top of the pressurizer (see arrow) failed to close at the start of the accident. Steam leaked out through the stuck-open valve into the basement of the reactor building at a rate equivalent of some 220 gallons of water per minute, which continued for more than 2 hours and 20 minutes before operators realized that the valve had failed to shut. This was a failure for which the TMI operators had never been trained, and which was not described in their written emergency procedures. This lack of preparation led to a misreading of the symptoms and mistaken responses that would uncover the reactor core.***

# 3 Investigations and Lessons Learned

Two weeks after the accident, the President of the United States, Jimmy Carter, appointed a 12-member Presidential Commission to investigate the accident at Three Mile Island. This group, known as the "Kemeny Commission," conducted a comprehensive investigation of the accident and made recommendations based upon their findings. Their final report was issued to the President on October 30, 1979. Another 10 volumes documented details of their investigation. The NRC published its initial response to the Presidential Commission's recommendations in November 1979 as NUREG-0632 entitled, "NRC Views and Analysis of the Recommendations of the President's Commission on the Accident at Three Mile Island."

The President responded to those reports in his statement on December 7, 1979. By Executive Order 12202 of March 18, 1980, President Carter established the Nuclear Oversight Committee for a short period of time to report to him on the progress of implementing the approved recommendations of the Kemeny Commission. A later report, NUREG-1355, "Status of Recommendations of the President's Commission on the Accident at Three Mile Island—a 10-Year Review," updated the NRC's initial response to include the status of the 44 recommendations made by the Kemeny Commission over a 10-year period.

To help gain comprehensive insight into the accident, the NRC sponsored both internal and external investigations. In mid-June 1979, the NRC asked the independent Special Inquiry Group to perform an investigation under the directorship of the law firm of Rogovin, Stern, and Huge. Most of the people who assisted in the inquiry were drawn from the NRC staff, and




***One highly publicized operating error was the initial failure of emergency feedwater (EFW) flow to the steam generators by two improperly closed EFW block valves. One of these tags obscured one of the block valve indicator lights. The Special Inquiry Group was not able to determine how the block valves were closed; however, they concluded that the 8-minute delay in restoring EFW flow did not directly affect the outcome of the accident. With the pressurizer relief valve stuck open and the high-pressure injection flow throttled, core damage would have occurred anyway.***

carefully screened to avoid any conflicts of interest; a number of technical consultants were also engaged to assist in the inquiry. The Special Inquiry Group provided a thorough analysis and assessment of the causes and implications of the accident. As already noted, the NRC published this work in the four volumes of NUREG/CR-1250, "Three Mile Island, a Report to the Commissioners and to the Public."

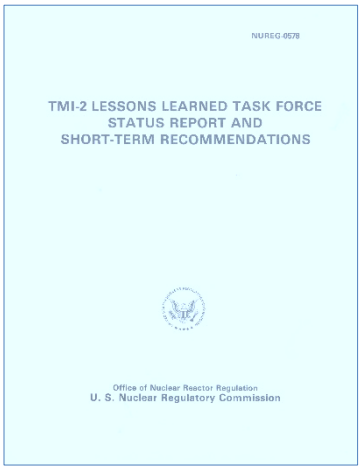
Working internally, the NRC created a Lessons Learned Task Force in May 1979. The NRC task force identified and evaluated safety concerns originating from the TMI-2 accident that required licensing actions at other nuclear power plants. The NRC published the task force's conclusions in NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations," and NUREG-0585, "TMI-2 Lessons Learned Task Force Final Report."

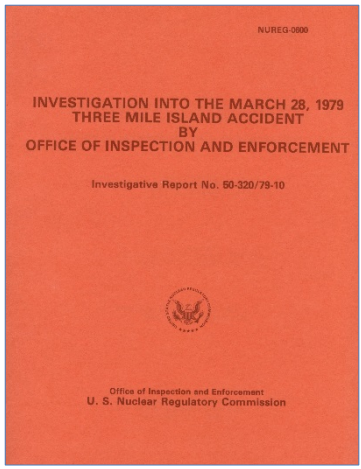
Many other groups, both internal and external to the NRC, also performed separate investigations. These included the U.S. Congress and its General Accounting Office; the Ad Hoc Dose Assessment Group, which comprised various Federal agencies (see NUREG-0558); the NRC's Advisory Committee on Reactor Safeguards; the Bulletins and Orders Task Force of the NRC's Office of Nuclear Reactor Regulation (see NUREG-0645); the NRC's former Office of Inspection and Enforcement's Special Review Group (see NUREG-0616), Task Force on Lessons Learned (see

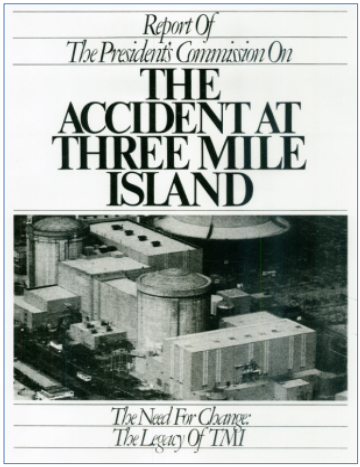
*The NRC Commissioners testifying before the U.S. Senate Subcommittee on Nuclear Regulation for the Committee on Environment and Public Works.*

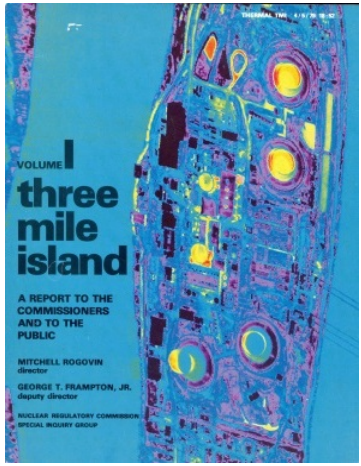
NUREG-0600), and Division of Program Development and Appraisal (who investigated information flow during the accident—see NUREG-0760); the NRC's Siting Task Force, which identified site location requirements for nuclear power plants; the NRC's Emergency Preparedness Task Force; the Staff Panel on the Commission's Determination of an Extraordinary Nuclear Occurrence (see NUREG-0637); the NRC's Office of Nuclear Regulatory Research; and the NRC's former Office of Standards Development.

The DVD provides many of the key investigation reports on TMI (see DVD folders, President's Commission, Rogovin Investigation, NRC Investigations, and Other Investigations). Many of the aforementioned investigation reports are summarized in NRC annual reports, primarily NUREG-0690 (1979) and NUREG-0774 (1980).

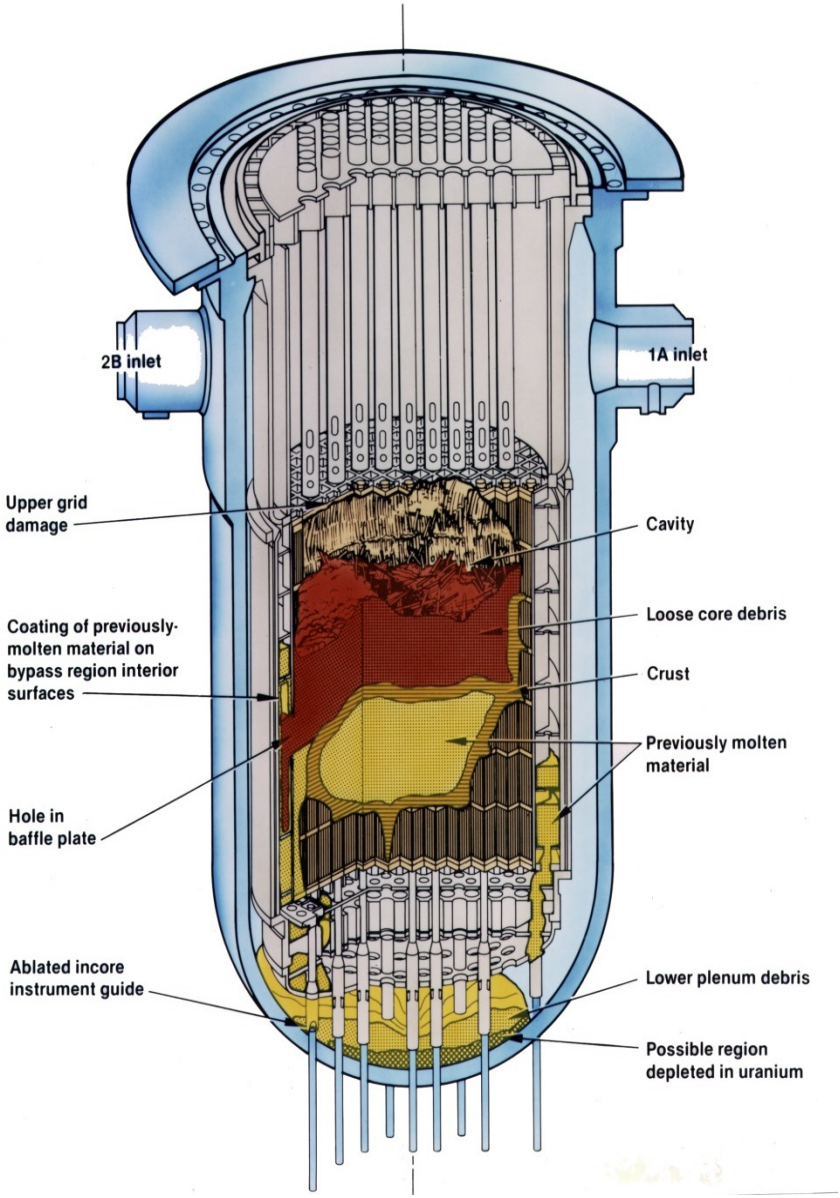


# TMI-2 Core End-State Configuration




*TMI-2 Core End-State Configuration. In 1988, the NRC reported the final state of the damaged TMI-2 reactor core, shown above. The accident was terminated by reflooding of the core. This action did not immediately stop further core melting, but it did prevent the core from melting through the reactor vessel.*

# 4 Regulatory Actions

The NRC implemented a number of regulatory actions resulting from investigations and lessons learned reviews, and completed many more "spinoff" actions in the decades following the accident. The first wave of actions that the NRC approved included orders to individual NRC licensees, and generic communications, such as bulletins and letters; these regulatory tools were implemented in the days and months following the accident.

Once the various investigative groups had documented their findings, the Commission considered the recommendations. The NRC staff consolidated all the recommendations that the Commission approved into NUREG-0737, "TMI Action Plan," published in 1980. The plan included approximately 371 individual requirements. The NRC found that, of these, 13,863 action plan items were applicable when reviewed against each specific licensed nuclear power plant. Some requirements involved changes to the internal NRC organization, processes, and practices.

A few requirements caused the Commission to issue policy statements and specific changes to the NRC's regulations through the rulemaking process. Both of these long-term regulatory tools required extensive internal and external stakeholder involvement, and were completed during the 1980s.

***NRC issued a requirement for nuclear power plants to have a simulation facility appropriate to conduct operator licensing tests. All plants now have a certified plant-referenced simulator that demonstrates anticipated plant responses to normal, transient, and accident conditions. Shown is one control room simulator at the NRC Technical Training Center in Chattanooga, Tennessee, used to train NRC inspectors and technical staff.***

The NRC's training manual on reactor safety, (NUREG/CR-6042, Section 2.3), provided an overview of the regulatory implications of the accident. NUREG-0933, "Resolution of Generic Safety Issues," documented the prioritization and closeout of the TMI Action Plan requirements.

***Generic Communications***. Within 3 days of the accident, the NRC's Office of Inspection and Enforcement started to issue a series of bulletins instructing all operating power plant licensees to take a number of immediate actions to avoid repeating several of the events that occurred during the accident and contributed significantly to its severity (Bulletins 79-05, -05A, -05B, -05C, -06, -06A, -06B, -06C, and -08). The bulletins and resulting evaluations also substantially informed other staff activities, such as those associated with the generic study efforts of the Bulletins and Orders Task Force (NUREG-0645) and the Lessons Learned Task Force (NUREG-0585). The NRC issued other types of generic communications, including generic letters (that transmitted information and usually required action or a response) and information notices (related to issues for which the licensees considered action appropriate). The DVD provides most of the generic communications relevant to TMI-2 (see DVD folder, Generic Communications).

***TMI Action Plan***. Each of the investigating groups organized their recommendations in a different way. These recommendations were collected and transformed into discrete, scheduled tasks in NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident." The report NUREG-0737, "Clarification of TMI Action Plan Requirements," documented the specific items from NUREG-0660 that the Commission approved for implementation at nuclear power plants. In October 1980, the NRC issued NUREG-0737 for implementation in Generic Letter 80-090. This report comprised specific items and included additional information about schedules, applicability, methods of implementation, submittal dates, and clarification of technical positions. The Generic Safety Issues Program prioritized and tracked the TMI Action Plan items detailed in NUREG-0660 and NUREG-0737. NUREG-0933, "Resolution of Generic Safety Issues," documented the closeout of action items.

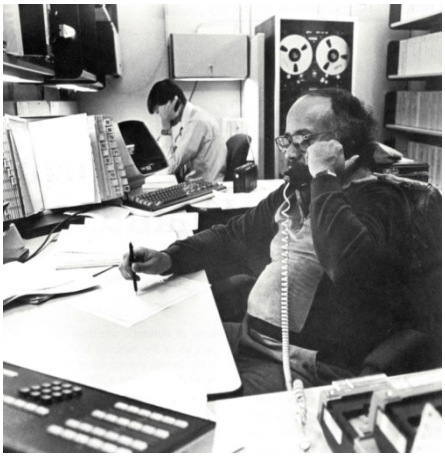
The DVD provides the above NUREGs and other select NUREGs that were associated with the implementation and closeout of TMI Action Items (see DVD folder, NUREG Reports).

***Rulemaking and Regulatory Guides***. In most cases, the NRC implemented the TMI Action Plan items through the review of new licensee applications, and the imposition of confirmatory orders and specific license conditions, rather than through specific changes to the NRC's regulations. In several instances, implementation of the TMI Action Plan resulted in new or modified regulations. These regulations, and a few others that could be considered relevant to the TMI accident, included the following: improved emergency planning requirements in 1980; requirements related to hydrogen control in Mark I and Mark II containments for boiling-water reactors (BWRs) in 1981; improved requirements for operations personnel and staffing at nuclear power plants in 1983; requirements for event reporting in 1983; requirements related to hydrogen control in Mark III containments for BWRs and ice condenser containments for pressurized-water reactors in 1985; improved backfitting process for power reactors in 1985; improved personnel dosimetry processing in 1987; improved requirements for operator licensing in 1987; and mandated participation in the Emergency Response Data System Program in 1991.

***In support of the NRC Special Inquiry Group investigation, a mockup of the TMI-2 control room (above) was constructed by a contractor to study the extent to which factors incorporated within the discipline of human factors engineering (e.g., man-machine interface design, procedures, manning, and training) were influential in causing or contributing to the course of the accident. NRC required all licensees and applicants of new plants to conduct similar detailed reviews to determine if their control rooms provided satisfactory information to allow operators to prevent and cope with accidents.***

In general, a regulatory guide (RG) describes one acceptable method for implementing agency regulations. Regulatory guides are not substitutes for regulations and the NRC does not require that licensees comply with them. Notable regulatory guides that the NRC revised or created during the implementation of the TMI Action Plan include RG 1.8, "Qualification and Training of Personnel for Nuclear Power Plants"; RG 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants"; RG 1.101, "Emergency Planning and Preparedness for Nuclear Power Reactors"; and RG 1.149, "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations." NRC annual reports summarized rulemakings and regulatory guides (see DVD folder, NRC Annual Reports, in Supplement 1 to this NUREG/KM).

***NRC Commission Policy Statements***. Several policy statements that the Commission issued were directly or indirectly related to the TMI Accident. A policy statement is not a regulation and does not impose specific regulatory requirements, but rather, provides the Commission's rationale and motivation for future regulatory positions. Two notable policy statements that continue to have far-reaching regulatory applications include "Severe Reactor Accidents Regarding Future Designs and Existing Plants," issued in 1985 and "Safety Goals for the Operations of Nuclear Power Plants," issued in 1986. The former provided the basis for redirecting NRC research programs and other regulatory programs; the latter provided the basis for backfitting and regulatory analyses, and for the use of probabilistic risk assessment in risk-informed decisions on plant-specific changes to the plant's licensing basis. The DVD contains NRC Commission policy statements relevant to TMI-2 (see DVD folder, Policy Statements).

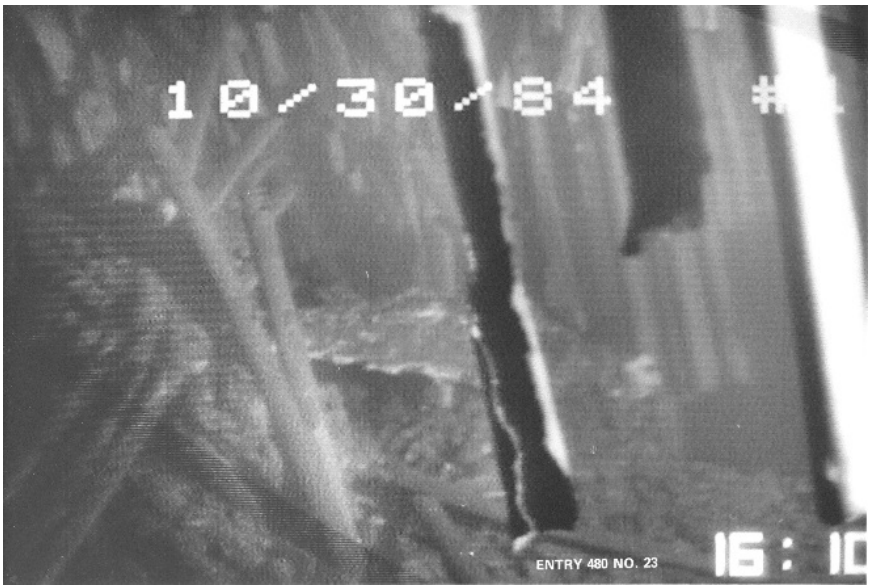


***To facilitate timely NRC responses, more stringent notification requirements were placed on licensees in February 1980 with the publication of 10 CFR 50.72 as an immediately effective rule. The rule required notification from licensees to the NRC Operations Center within one hour of emergencies and certain significant events, via a dedicated direct telephone "Hot Line." Shown is a 1985 photo of operations officers, Chauncey Gould and Raymond Smith (back), at the new Operations Center that opened in February 1985.***

# 5 Research

The NRC's approach to safety changed dramatically after the TMI-2 accident. The agency's emphasis shifted from providing safety by relying on the traditional design-basis approach, to relying on a multi-faceted approach, which emphasized improved operations; human factors considerations in control room and emergency procedures; realistic performance of systems and containments under severe accident conditions; and probabilistic risk assessments to identify generic and plant-specific vulnerabilities. NRC research and development programs also reflected this change.

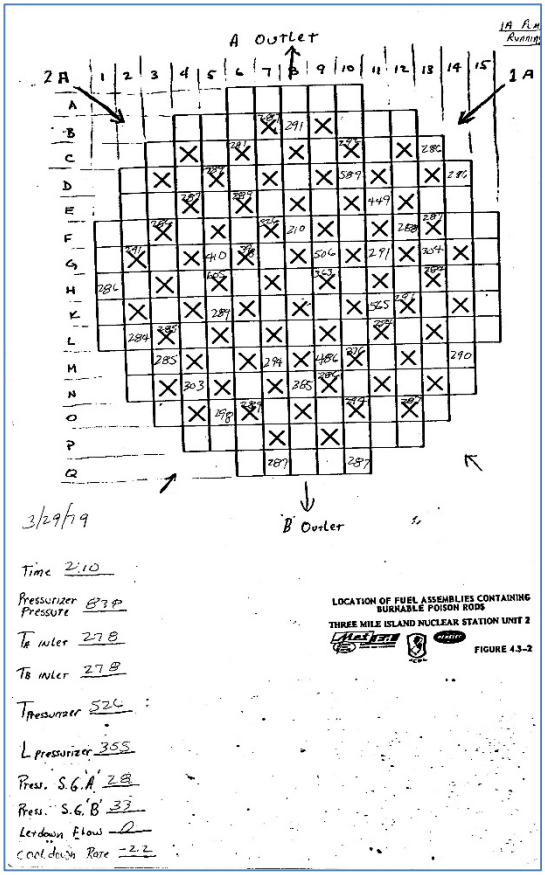
After the accident, the scope and diversity of the NRC's efforts in severe accidents increased substantially. Some examples included allocating additional resources to research and development activities, such as the construction of new experimental facilities; the development of analytical tools; and, in general, the development of the information needed to gain greater insight into severe accident behavior. Since the accident, the NRC, DOE, the U.S. nuclear power industry, and international organizations have developed a large body of information on severe accidents, including their probability; core-melt phenomenology; associated accident sequences; and the effects of severe accidents on plant systems, components, and structures,




*Closed-circuit video inspections of the reactor core revealed a rubble bed approximately 5 feet below the normal location of the top of the fuel assemblies.*

especially those that provide barriers to fission product release to the atmosphere, such as the reactor containment structure.
Shortly after the accident, the DOE also supported an extensive research program, known as the "TMI-2 Accident Evaluation Program," to develop a consistent understanding of the accident. The primary objective of the program was to develop an understanding of core-damage progression in the upper core region; the heatup and the formation and growth of the molten central region of the core; the relocation of approximately 19 metric tons of debris to the lower head; and the release of fission products to the reactor vessel and containment.

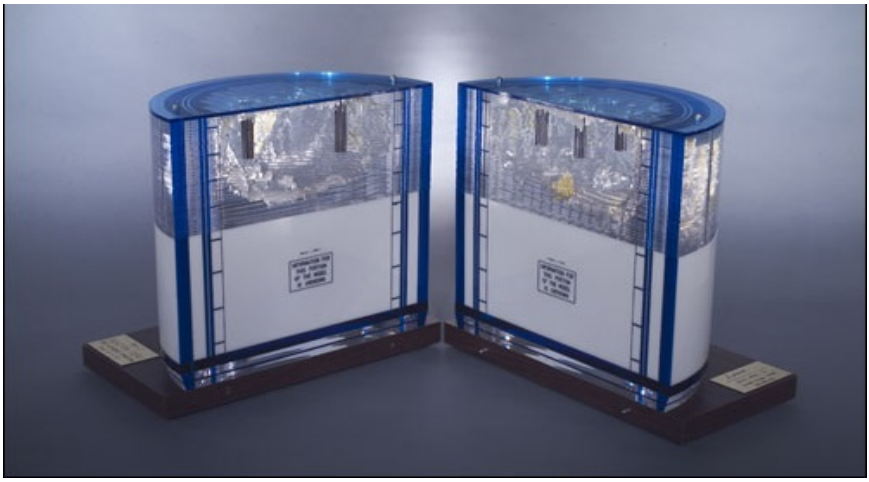
Collaboration between the U.S. Government and nuclear industry organizations also yielded important post-accident research. In 1980, four organizations—the General Public Utilities (GPU), Electric Power Research Institute (EPRI), NRC, and DOE—formed a group known as "GEND," signing a coordination agreement to implement the TMI-2 Information and Examination Program. This program executed research and development




***At left is a page recorded at the NRC Operations Center on the second day of the accident showing temperature readings that were measured by plant technicians with a handheld voltage meter on the wires from reactor core exit thermocouples. These thermocouples were temporary installed to measure coolant temperatures above the reactor fuel in support of startup testing of the new reactor. We now know that many of these temperature readings were measured at newly formed false junctions located in the "liquefied fuel" regions of the core. Today, all pressurized water reactors are required to have redundant, qualified, Class 1E instrumentation for core exit thermocouples, sub-cooling margin monitors, and reactor coolant inventory monitors.***

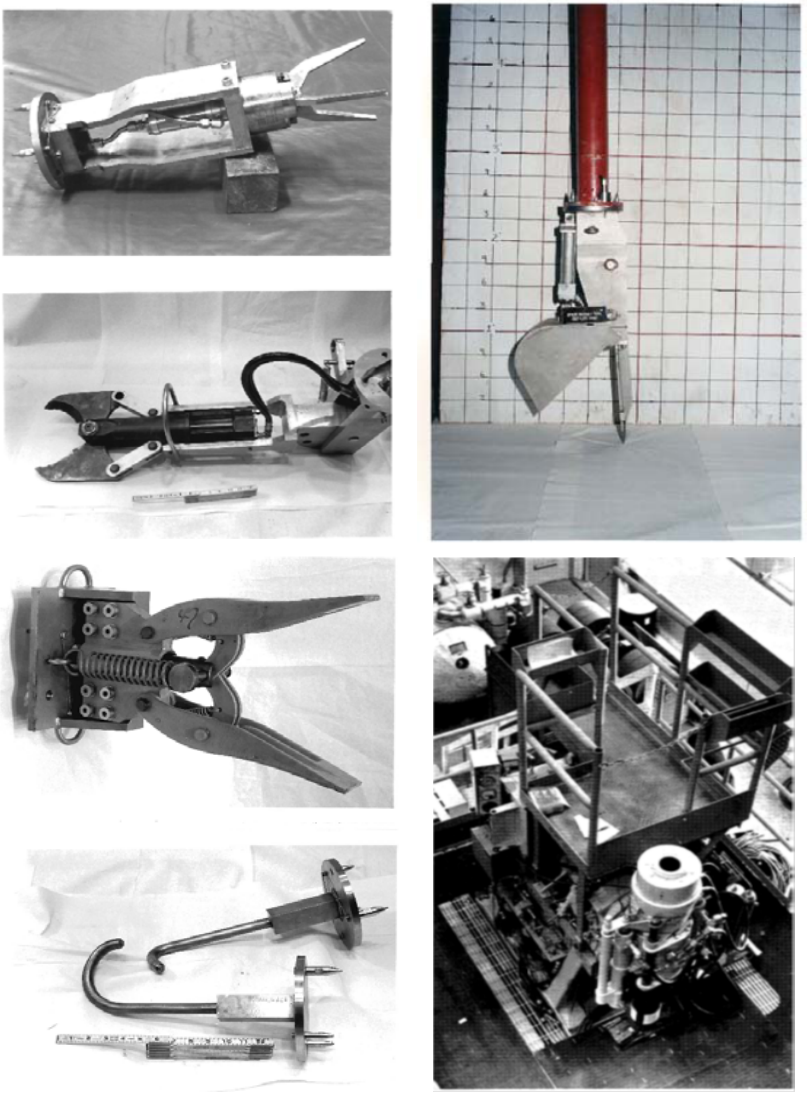
activities relating to the cleanup of TMI-2, and the study of the accident for the enhancement of nuclear power safety and reliability. The group documented the results of this program in a series of approximately 200 GEND and GEND-INF (informal) reports, as well as many other technical reports issued by the NRC, the DOE and its laboratories, EPRI, and GPU.

A cooperation agreement was signed in April 1984 by the DOE and 17 Japan nuclear power organizations for a program of participation in the DOE research and development programs relating to the TMI-2 cleanup. This Japan-U.S. agreement provided information exchanges, Japanese research staff at TMI-2 and DOE national laboratories, and Japanese funding for research and development activities. A total of 43 engineers from 10 electric power companies, 3 reactor vendors, 2 engineering companies, the Nuclear Power Engineering Test Center (currently the Japan Atomic Energy Agency), and the Japan Atomic Energy Research Institute (currently the Nuclear Regulation Authority) worked in almost every area of the TMI-2 cleanup project during the 5-year period.



***In August and September of 1983, the core topography system, designed and built by DOE, was used to develop an ultrasonic profile of the void area in the upper reactor core region. The data and information obtained included the radial and axial extent of the reactor core cavity, the location of supported and unsupported fuel assembly end-fittings, and the location of the core cavity boundary with respect to structurally intact fuel assemblies. The analysis of this data supported upper plenum lift and defueling operations. Shown is the topographic model of the cavity in the upper core region based on this ultrasonic profile. This model is currently located at NRC Headquarters.***

Supplement 1 of the NUREG/KM provides most of the NRC and DOE reports and presentation papers, which documented research and development activities relating to the TMI-2 accident and its unique recovery and cleanup. GEND reports are provided in Supplement 1. NRC annual reports provided summaries of NRC research activities (see DVD-2 folder NRC Annual Reports).



*Numerous manual and hydraulically powered long-handled tools were used to perform a variety of functions, such as pulling, grappling, cutting, scooping, and breaking up the core debris. These tools were used to load debris into fuel canisters positioned underwater in the reactor vessel. Later, a core boring machine (lower right) was used to break apart once liquefied materials.*

# 6 Plant Recovery and Cleanup

By the close of the weekend of March 30 through April 1, 1979, TMI-2 was determined to be in a stable shutdown condition. Within 2 weeks, the Governor's precautionary advisory to pregnant women and preschool-aged children to evacuate the area within a 5-mile radius of TMI was lifted. Within 1 month, the reactor was placed in natural circulation, with decay heat flowing to the condenser and out of the cooling towers. The purging of radioactive krypton gas from the reactor-building atmosphere, followed by the first entry into the reactor building by two utility engineers, was accomplished after the first anniversary of the accident. Shortly before the second anniversary, the reactor was placed in loss-to-ambient cooling mode, in which heat losses are transferred from component and piping surfaces into the reactor building's ambient environment and out through the reactor building's fan coolers.

The reactor vessel head was removed in 1985, while the removal of loose fuel debris from the reactor vessel began later that year, and was completed in 5 years. Workers used numerous manual and hydraulically-powered, long-handled tools to perform a variety of functions, such as pulling, grappling, cutting, scooping, and breaking up the core debris. In 1986, 7 years after the accident, a special core-sampling drilling rig was used to

*The first entry into the reactor building occurred on July 23, 1980 (shown). Heavy-duty outerwear provided protection from high-energy, low-penetration beta radiation.*

reveal the extent of the hard crust layer of the damaged core. Between 1986 and 1990, the DOE shipped the fuel debris by rail to the DOE site at the Idaho National Engineering Laboratory (currently called Idaho National Laboratory), and placed the debris in wet pool storage for study and safekeeping. The evaporation of 2.3 million gallons of slightly-contaminated, accident-generated water at TMI was conducted over a 2- to 3-year period, and completed in 1993.

In late 1993, TMI-2 was placed in NRC-approved, post-defueling, monitored storage, a passive monitored state in which the plant will remain until both units are decommissioned simultaneously. From 2000 to 2001, the fuel debris was moved into NRC-approved aboveground dry storage at a DOE facility to await final disposal.

***NRC Actions at TMI***. The NRC played an active role as the regulator, first by responding to the accident, and then by approving and overseeing recovery activities by the licensee and its contractors. With the arrival of the NRC's Region I inspectors during the first day of the accident, a team began to form and continued to expand throughout the weekend with the arrival of engineers, scientists, and public affairs specialists from headquarters and other regional offices. Early in 1980, the NRC established the TMI Program

***Water level in the reactor building basement reached the first stairwell landing, indicating about 8 feet of water. The submerged demineralizer system or "SDS" was designed and installed to cleanup the 700,000 gallons of highly contaminated basement water. The SDS started operations in September 1981 after NRC approval and completed processing basement water in May 1982.***

Office (TMIPO) within the NRC's Office of Nuclear Reactor Regulation to provide overall direction for the TMI-2 cleanup operations and inspections (see NUREG-0698). About 30 NRC employees staffed the onsite TMIPO office during the first few years. NRC's regulatory responsibilities in recovery operations included reviewing and approving the licensee's proposals for recovery actions, overseeing the licensee's implementation of approved activities, coordinating with other Federal and State government agencies on their activities in the recovery, and informing local officials and the public about the status of the recovery operation.

Important NRC actions during TMI-2 recovery are summarized below and discussed in detail in Supplement 1 to this NUREG/KM.

- issuance of the environmental assessment (NUREG-0591) and Commission order to use the EPICOR II system to decontaminate intermediate-level radioactive accident water in the auxiliary building in October 1979

- creation of the NRC Special Panel on TMI-2 Radiation Protection Program in September 1979 to provide an independent review of the


***Workers perform defueling operations from a shielded defueling work platform, which was located 9 feet above the reactor vessel flange. The platform had a rotating surface with 6-inch steel plates and a diagonal slit for access into the reactor vessel for removing debris.***

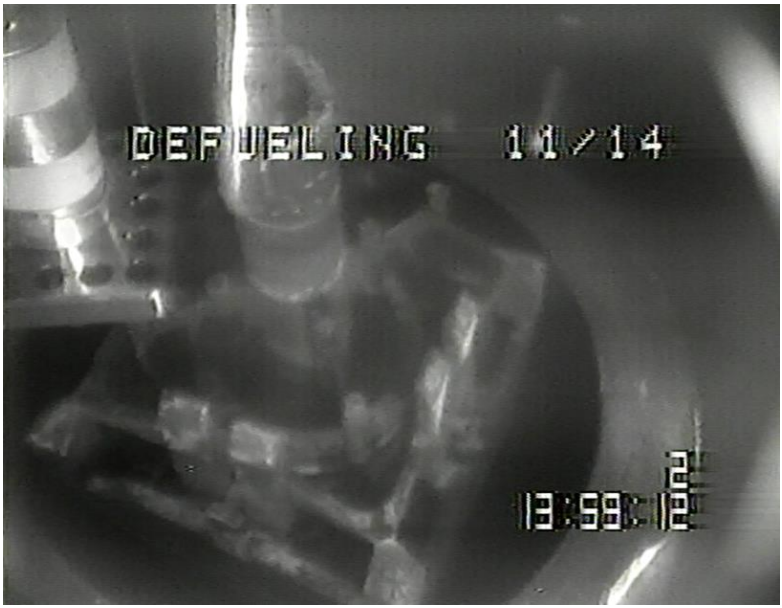
licensee's existing and planned radiation protection program during recovery and cleanup (NUREG-0640)

- issuance of the Commission order to implement the TMI-2 recovery technical specifications in February 1980 (NUREG-0647)

- issuance of a research coordination agreement with the DOE, EPRI, and the licensee in March 1980 to jointly sponsor and participate in the TMI Information and Examination Program, and to obtain valuable information from the accident

- approval by the Commission in April 1980 to allow small radioactive releases for the purpose of data gathering and maintenance operations (SECY-80-175)

- issuance of the environmental assessment (NUREG-0662) and Commission order to purge radioactive krypton gas from the reactor building atmosphere in June 1980




***The first piece of core debris was placed into the defueling canister in November 1985 (shown). The long-handled vice-grip tool was clamped onto an upper end fitting of a partial fuel element. A long-handled tamping tool (upper left) was used to tap the piece into the canister.***

- issuance of the NRC action plan for cleanup operations in July 1980 (NUREG-0698)

- issuance of the draft Programmatic Environmental Impact Statement (NUREG-0683) for public comment in August 1980 and implementation in February 1981

- creation of the public Advisory Panel for the Decontamination of Three Mile Island in November 1980 (see NUREG/CR-6252)

- issuance of the Commission Policy Statement endorsing the Programmatic Environmental Impact Statement in May 1981

- issuance of the safety evaluation report and order to use the submerged demineralizer system to process the highly-contaminated, accident-generated water in the reactor building sump and reactor coolant system in June 1981 (NUREG-0796)


***The NRC issued certificates of compliance to the DOE in April 1986 for casks used to ship fuel debris by rail to the Idaho National Engineering Laboratory (INEL) for research and temporary storage. Each cask contained up to seven defueling canisters. Each rail shipment included up to three cask rail cars. A total of 342 defueling canisters were shipped to INEL in 22 trips between 1986 and 1990.***

- issuance of a March 1982 amendment to the memorandum of understanding with the DOE to accept the entire reactor core and highly-radioactive solid waste for research and long-term storage (see Appendix A to Revision 2 of NUREG-0698)

- approval, in November 1983, of the licensee's safety evaluation for the refurbishment and use of the reactor building polar crane for defueling operations

- issuance of Supplement 1 to the Final Programmatic Environmental Statement (NUREG-0683) on dealing with occupational radiation dose in October 1984

- issuance of certificates of compliance in April 1986 for three shipping casks to be used for shipment of fuel debris to DOE by rail

- issuance of Supplements 2 and 3 to the Final Programmatic Environmental Statement (NUREG-0683) on the final disposal of 2.3 million gallons of slightly-contaminated, accident-generated water in June 1987, and dealing with post-defueling monitored storage and subsequent cleanup in August 1989

- approval in September 1989 to use the evaporator for the final disposal of 2 million gallons of accident-generated water

***TMI-2 Independent Spent Fuel Storage Installation located at DOE's Idaho National Laboratory for interim storage of the TMI-2 core debris.***

- issuance of two amendments to the facility operating license in September and December 1993 to issue a possession-only license and issue technical specifications for post-defueling monitored storage

The NRC Headquarters wrapped up onsite involvement at TMI-2 by the time that the agency terminated the TMI-2 Project Directorate in February 1988. The NRC's TMI resident inspector office took over the inspection program for TMI-2 and a headquarters project directorate assumed responsibility for the technical review and project management functions. In September 1993, the NRC approved "post-defueling monitored storage" at TMI-2 and associated license conditions and technical specifications. The last meeting (78th overall) of the 10-member public Advisory Panel for the Decontamination of Three Mile Island Unit 2 was held in September 1993 (see NUREG/CR-6252 for lessons learned). See Supplement 1 to this NUREG/KM for more documents covering recovery and cleanup activities.

***Timeline***. The timeline feature on the DVD provides a summarized chronology of key recovery milestones and NRC actions. Users may read a short description of many of the actions by clicking on the text of the timeline in the interactive window of the DVD.

**Status Reports**. Several document collections in Supplement 1 to this NUREG/KM provide informative daily, weekly, and annual summaries of TMI-2 recovery and cleanup experiences. These status documents, which are related to topics discussed in all volumes and sections of this NUREG/KM, are provided in the following document collections in Supplement 1:

- NRC TMI Program Office (TMIPO) weekly status reports (see DVD folder TMI Program Office Weekly Status Reports)

- preliminary notification reports—an early notice of an event of possible safety or public interest significance issued by TMIPO or other NRC offices (see DVD folder NRC Preliminary Notifications)

- NRC annual reports to the President of the United States (see DVD folder NRC Annual Reports)

- DOE reports, such as annual and lessons-learned reports, and periodical publications (see DVD folder DOE/National Laboratory Status Reports)

- licensee event reports—a written report of a reportable event submitted by the licensee to the NRC (see DVD folder Licensee Event Reports)

- licensee summary reports required by regulatory requirements (see DVD folder GPU Status Reports)


*NRC's Harold Denton, Governor Richard Thornburgh, President Jimmy Carter, and Rosalynn Carter tour the TMI-2 control room on April 1, 1979.*

# 7 Retrospectives

***30th Anniversary***. For the 30th anniversary of the TMI-2 accident, the NRC's Office of Nuclear Regulatory Research (RES) hosted a special all-day event entitled, "The Accident at Three Mile Island, 30th Anniversary, A Look Back: Preserving the Institutional Memory." The event featured several presentations, including an overview of the accident by Brian Sheron, Director of the NRC's Office of Nuclear Regulatory Research; perspectives from TMI-2 Reactor Operator Edward Frederick; lessons learned from TMI-2 by Gary Holahan, Deputy Director of the NRC's Office of New Reactors, and former member of the TMI-2 Lessons Learned Task Force; and an historical perspective by NRC Historian Samuel Walker.

Following the individual presentations, the NRC hosted a panel discussion titled "Remembering the Accident." The panel included a distinguished group, all of whom made key decisions during the accident: Richard Thornburgh, former Governor of the State of Pennsylvania; Harold Denton, former Director of the NRC's Office of Nuclear Reactor Regulation and the lead Federal onsite manager; and Jessica Mathews, former assistant to President Jimmy Carter.

***A press conference during the early days of the accident with Pennsylvania Governor Richard Thornburgh (right) and the NRC's Harold Denton.***

*In April 1984, a comprehensive video mapping of the upper reactor core region between the plenum and rubble bed was completed. Video snapshots were assembled into a mosaic panoramic view of the rubble bed and core periphery. Videos of the rubble bed showed broken fuel rods scattered around, fuel rod internal springs, intact fuel pellets, control-rod assembly end couplings, and partially intact fuel assemblies around the periphery of the reactor core region. The video also showed unsupported partial fuel assemblies hanging from the underside of the upper plenum grid section which had to be removed before plenum lifting. This map supported planning of defueling operations and eventually the removal of fuel debris.*

***35th Anniversary.*** For the 35th anniversary of the TMI-2 accident, RES hosted a special NRC research seminar event entitled, "The 35th Anniversary of the Three Mile Island Nuclear Power Plant Accident of 1979: Working at TMI During and Following the Accident." The seminar featured a presentation by Mr. Gordon Skillman, a current member of NRC's Advisory Committee on Reactor Safeguards, who was an immediate responder to the TMI-2 accident. As an employee of Babcock and Wilcox during and after the accident, he served for 7 years of the stabilization and cleanup of TMI-2 as recovery support engineering manager and later as the defueling manager.

The presentation covered Mr. Skillman's firsthand experiences while working on technical issues involving plant and reactor core stabilization, accident water cleanup, and early defueling the damaged core. Mr. Skillman shared his personal experiences while living in a nearby community and working closely with people from the utility, many contractors, the NRC, the DOE, national laboratories, and Pennsylvania's and Maryland's environmental agencies.

***Moments in NRC History***. As part of the video series on NRC history, the Office of the Secretary and the Office of Public Affairs prepared a video entitled, "Moments in NRC History, Three Mile Island, March 28, 1979." The video features a short documentary by the NRC's historian, Dr. Thomas Wellock. Dr. Wellock studies nuclear power's history for its relevance to the NRC today and to capture important insights for future generations. This video recounts the plant response during the accident, the emergency response to the accident, improvements to plant safety, and current status of the plant.

The DVD provides a multimedia presentation of these events (see DVD folders, 30th Anniversary Seminar, 35th Anniversary Seminar, and Moments in NRC History).

# Knowledge Management Library for the Three Mile Island Unit 2 Accident of 1979

Search Document Titles Find

- Welcome (Home)
- Timeline
- Photos and Videos
- Response to the Accident
- Investigations and Lessons Learned
- Industry-Wide Regulatory Actions
- Status and Summary Reports
- Licensing Actions
- Management & Oversight
- Plant Stabilization
- Worker Protection
- Data Acquisition and Analyses
- Decontamination
- Waste Management
- Defueling
- After Defueling
- Pre-Accident Plant References
- Document Folder Index

## Welcome to the TMI-2 Knowledge Management Library

**Presented by the Office of Nuclear Regulatory Research**

This library supplements NUREG/KM-0001, "Three Mile Island Accident of 1979 Knowledge Management Digest," with access to over 4,000 digitized documents spanning the period from days after the accident to the end of 1993. The accompanying DVDs contain the most important documents that the NRC, U.S. Department of Energy, the licensee, and other government organizations issued following extensive investigations of the accident, regulatory reviews, and research, as well as during defueling and cleanup. In addition to the large collection of documents, this library also provides several multimedia presentations, including two special NRC events, "The Accident at Three Mile Island—A Look Back: Preserving the Institutional Memory after 30 Years," and "The 35th Anniversary of the Three Mile Island Nuclear Power Plant Accident of 1979: Working at TMI during and Following the Accident."

**Contributors**

**Knowledge** • Harold Denton • Edward Frederick • Gary Holahan • Don Marksberry • Jessica Mathews • Brian Sheron • Gordon Skillman • Governor Richard Thornburgh • J. Samuel Walker • Thomas Wellock

**Management** • Don Marksberry • Felix Gonzalez • Kenneth Hamburger • Anita Aikins-Afful • Theodore Smith • Justin Poole • Robert Norman • Tom Wellock • Andrew Bates • Brian McGrattan • David Aird • Carolyn Siu • Amy Bonaccorso • Tom Kardaras • Mark Henry Salley • The NRC Print Shop and Publications Staff

**Document Collections** • Publications Branch of the NRC's Office of Administration • NRC's Office of the Secretary • U.S. Department of Energy • Idaho National Laboratory • Dickinson College Community Studies Center • The Pennsylvania State University Engineering Library • National Archives and Records Administration • NRC's Agencywide Documents Access and Management System (Public Legacy Library)

Version Date: 5/31/2016

Please "click" the photograph for an introduction from Dr. Thomas Wellock, NRC Historian


"Kemeny Report"
President's Commission


"Rogovin Report"
NRC's Independent Investigation

Programmatic Environmental Impact Statement


NUREG/KM-0001: Overview


NUREG/KM-0001, Supplement: Recovery and Cleanup

# 8 DVD Navigation and Interpretation

This knowledge management guide is an HTML-based collection of information, documents, videos, and photos related to the 1979 accident at the Three Mile Island nuclear power plant. This interactive feature is provided on the DVD to help you navigate through the historical records. Refer to the "Readme" file located on any DVD for viewing instructions.

**Navigation**

- ***Main welcome page***. From the welcome page, you can navigate the different sections of the guide using the blue tabs from the menu on the left side of the page. Each tab is linked to a page that contains one or more subtabs that appear to the right of the tab. Each tab corresponds to a document collection and each subtab links to a folder of documents. This interactive feature will prompt you to load the appropriate DVD to retrieve the document, if necessary. Additionally, there is a photo gallery, interactive timeline, and a document index (green tab). You may also click on the text box on the timeline for a short description.

- ***Document retrieval***. Documents can be accessed from the document page (see figure below) linked to the subtab. Next to each document is a hyperlink which will display the associated document, photo, or video. Because the document collection spans several DVDs, you may be prompted to insert a different DVD as you navigate the guide. A sorting feature is provide on select columns on the document page.

- ***Document searches***. A simple keyword search feature is provided on the welcome page and each document page. A search is applied to a list of all documents on all DVDs in this NUREG/KM. This feature searches words in the file name.

- ***Document lists***. Several convenient lists of documents on the DVD can be viewed from the "Document Folder Index" tab. These lists are also provided in spreadsheet format in the "Common" folder on the DVD (located in the "Documents" folder). A list of more than 25,000 TMI-2 records in the Public Legacy Library is included in the spreadsheet.

- ***Alternative***. Documents are titled and arranged in topical folders on the DVD (located in the "Documents" folder) to provide a usable alternative to the interactive guide. The document can be accessed directly on the DVD using a file explorer.

**Things to Keep in Mind**

- ***Legacy documents***. Many of the documents on the DVD are historical in nature and might contain information that is obsolete or superseded by current regulations and research results. The historical documents provided on the DVD are for historical reference only and are not official NRC records. Please refer to the NRC's public website (http://www.nrc.gov) for current information on regulations, policy statements, regulatory guidelines, regulatory processes, and research results.

- ***Units of measure***. The unit of measure (in English units or the International System of Units) that was used in the original source document was used in this digest. A conversion chart is provided on the back cover.

- ***Abbreviations***. A small set of abbreviations was used throughout this report in order to improve readability: ALARA (as low as reasonably achievable), CFR (*U.S. Code of Federal Regulations*), DOE, DVD, EPRI, GEND, GPU, INEL, NRC, NUREG, NUREG/CR, NUREG/KM, PDMS, and TMI-2. Abbreviations that were less frequently repeated in the report were spelled out at the beginning of each subsection or paragraph that contained them.

- ***Recovery vs. cleanup***. The term "recovery" is used in this NUREG/KM to mean actions taken to keep the plant in a stable condition and to prevent the inadvertent release of radioactivity. The term "cleanup" is used to mean actions taken to decontaminate and defuel the plant and dispose of radioactive waste. These two terms are often used interchangeably for certain actions.

- ***EPRI and GPU documents***. Documents generated by EPRI and GPU are generally not provided on the DVD unless the documents were submitted to the NRC or funded by DOE.

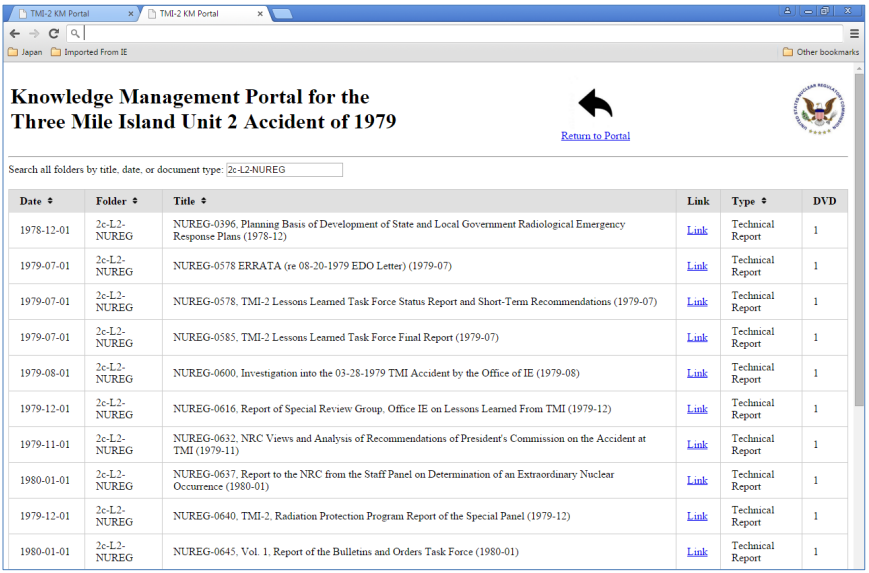
- ***"GPU" and "licensee."*** Unless otherwise noted, the GPU Corporation and its subsidiaries (including GPU Service Corporation, GPU Nuclear Corporation, and Metropolitan Edison Company) are referred to collectively in a historical context as "GPU" or the "licensee" in the text of this NUREG/KM and document filenames.

- ***Document accession number***. Each document and each enclosure of a document that was cataloged in the Agencywide Documents Access and Management System (ADAMS) Public Legacy Library was assigned a unique accession number. This number can be found on the first page of each document. Each enclosure to a transmittal letter was typically assigned its own accession number.

- ***Document filename***. The filenames used on the DVD typically contain the date of the document (generally the date of the transmittal letter); originating organization (e.g., NRC or GPU); document type (e.g., safety evaluation or system description); short title; document revision, if any; and reference date of previous correspondence, if any. Technical reports by the NRC (e.g., NUREGs), DOE, and national laboratories start with the report's identification number, short title, and year and month issued. See examples below.

  (1990-01-18) GPU, Defueling Completion Report, Rev. 3 (re 08-18, 10-09-1989)
  NUREG-0698, Rev. 2, NRC Plan for Cleanup Operations at TMI-2 (1984-03)

- ***Documents, photographs, and diagrams*** in this NUREG/KM and DVD were copied from the best available (surviving) sources. Photographs were generally taken by GPU and DOE contractors.




| Date | Folder | Title | Link | Type | DVD |
|---|---|---|---|---|---|
| 1978-12-01 | 2c-L2-NUREG | NUREG-0396, Planning Basis of Development of State and Local Government Radiological Emergency Response Plans (1978-12) | Link | Technical Report | 1 |
| 1979-07-01 | 2c-L2-NUREG | NUREG-0578 ERRATA (re 08-20-1979 EDO Letter) (1979-07) | Link | Technical Report | 1 |
| 1979-07-01 | 2c-L2-NUREG | NUREG-0578, TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations (1979-07) | Link | Technical Report | 1 |
| 1979-07-01 | 2c-L2-NUREG | NUREG-0585, TMI-2 Lessons Learned Task Force Final Report (1979-07) | Link | Technical Report | 1 |
| 1979-08-01 | 2c-L2-NUREG | NUREG-0600, Investigation into the 03-28-1979 TMI Accident by the Office of IE (1979-08) | Link | Technical Report | 1 |
| 1979-12-01 | 2c-L2-NUREG | NUREG-0616, Report of Special Review Group, Office IE on Lessons Learned From TMI (1979-12) | Link | Technical Report | 1 |
| 1979-11-01 | 2c-L2-NUREG | NUREG-0632, NRC Views and Analysis of Recommendations of President's Commission on the Accident at TMI (1979-11) | Link | Technical Report | 1 |
| 1980-01-01 | 2c-L2-NUREG | NUREG-0637, Report to the NRC from the Staff Panel on Determination of an Extraordinary Nuclear Occurrence (1980-01) | Link | Technical Report | 1 |
| 1979-12-01 | 2c-L2-NUREG | NUREG-0640, TMI-2, Radiation Protection Program Report of the Special Panel (1979-12) | Link | Technical Report | 1 |
| 1980-01-01 | 2c-L2-NUREG | NUREG-0645, Vol. 1, Report of the Bulletins and Orders Task Force (1980-01) | Link | Technical Report | 1 |

***A typical document page listing the contents of a document folder. Columns can be sorted. Keywords in document file names can be searched. The hyperlink directs you to the document, photo, or video.***


***The certificate of appreation given to NRC staff who contributed to the NRC's response to the accident. By the end of the second week, over 200 NRC staff were badged for site access, or about 10 percent of all external responders at TMI. Names of NRC staff who responded to the accident at the TMI site and offsite response centers are discsussed in the Rogovin report (see NUREG/CR-1250, Volume 2, Part III, Appendix III.2).***

# 9 Contributions to the Main Report (NUREG/KM-0001, Overview)

**Knowledge**

Harold Denton
Edward Frederick
Gary Holahan
Don Marksberry
Jessica Mathews
Brian Sheron
Gordon Skillman
Governor Richard Thornburgh
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**Management**

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Robert Norman
David Aird
Ian Gifford
Brian McGrattan
Amy Bonaccorso
Tom Kardaras
Mark Henry Salley
and
The NRC Print Shop and Publications Staff

**Document Collections**

NRC's Agencywide Documents Access and Management System
Publications Branch of the NRC's Office of Administration
NRC's Office of the Secretary
U.S. Department of Energy
Idaho National Laboratory
Dickinson College Community Studies Center
Pennsylvania State University Engineering Library
National Archives and Records Administration

NRC FORM 335 (12-2010) NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

# BIBLIOGRAPHIC DATA SHEET

*(See instructions on the reverse)*

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)
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3. DATE REPORT PUBLISHED
MONTH: June
YEAR: 2016

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5. AUTHOR(S)
Don Marksberry, RES/DRA
Felix Gonzalez, RES/DRA
Kenneth Hamburger, RES/DRA

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7. PERIOD COVERED (Inclusive Dates)
1979-1993

8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)
Division of Risk Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)
Same as 8, above

10. SUPPLEMENTARY NOTES
Prepared in conjunction with several video presentations provided on a DVD. One DVD to this report provided separately.

11. ABSTRACT (200 words or less)
The accident at the Three Mile Island, Unit 2 (TMI-2) nuclear power plant was the most serious incident in U.S. commercial nuclear power history. The safe, expeditious recovery and cleanup of TMI 2, including removal of the fuel from the accident damaged reactor, were necessary for the long term protection of public health and safety and the environment. This knowledge management digest and supporting DVD contain the most important documents that the NRC, the licensee, and other government organizations issued following investigations and cleanup of the accident. The latest revision of NUREG/KM-0001 has evolved into two volumes. The first volume presents overviews of the accident: emergency response, investigations, regulatory implications, and accident recovery. The second volume (Supplement 1) expounds upon the technical details of recovery and cleanup activities: management and oversight, plant stabilization, worker protection, data acquisition and analysis, waste management, decontamination, defueling, and after defueling. The document collections are derived from correspondence between the utility and NRC, and from the results of research activities sponsored by the NRC and DOE. The accompanying DVDs contain over 120,000 pages in over 4,000 documents, over 500 photographs and diagrams, and three NRC video presentations about the accident and recovery activities. A HTML-based interactive feature is provided on the DVD to help you navigate through the historical records.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)
Three Mile Island Unit 2
TMI-2
Knowledge Management
Emergency Response
Reactor Core Damage
Accident Recovery
Accident Cleanup

13. AVAILABILITY STATEMENT
unlimited

14. SECURITY CLASSIFICATION
(This Page)
unclassified
(This Report)
unclassified

15. NUMBER OF PAGES

16. PRICE

# CONVERSIONS

**Radiation Dose**

1 mrem (1 millirem, $10^{-3}$) = *10 microsieverts (10 µSv, $10^{-5}$)

100 mrem = *1 millisievert (1 MSv)

1 rem = *10 mSv

100 rem = *1 Sv

**Radioactive Concentration**

27 picocuries (27 pCi, $2.7 \times 10^{-11}$) = *1 becquerel (1 Bq)

1 millicurie (1 mCi, 0.001) = *37 megabecquerels (37 MBq, $3.7 \times 10^{7}$)

1 curie (1 Ci) = *37 gigabecquerels (37 GBq, $3.7 \times 10^{10}$)

**Radiation Absorbed Energy**

1 roentgen = *0.877 rad = *0.00877 Gy

100 rad = *1 gray (Gy)

**Length**

1 inch (in) = *2.54 centimeters (cm)

1 foot (ft) = 0.3048 meter (m)

**Volume and Weight**

1 gallon (gal) = 3.7854 liters (l)

1 pound (lb) = 0.4536 kilograms (kg)

1 ton (U.S.) = *2000 lb = 907.1847 kg

**Pressure**

1 pound per square inch (psi) = 6.8948 kilopascals (kPa)

1 atmosphere (atm) = *101.325 kPa

**Temperature**

Degrees Celsius (°C) = 5/9 × (°F - 32)

Degrees Fahrenheit (°F) = (9/5 × °C) + 32

* Exact conversion factors

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