The Three Mile Island nuclear power plant near Middletown, Pennsylvania

Three Mile Island accident: A brief history of INL support

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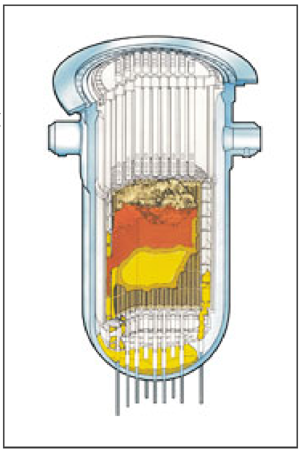
The Three Mile Island nuclear power plant accident March 28, 1979, in Pennsylvania happened 2,200 miles away from the Idaho National Engineering Laboratory (now Idaho National Laboratory) near Idaho Falls, Idaho. But employees and facilities at INL played a key role during the following decade helping the U.S. Department of Energy and the TMI owner GPU Nuclear recover and gain knowledge from the accident, remove the damaged core material, ship it across country and temporarily store it at the Department's Idaho site.

Value of INL expertise and facilities

What put INL in this lead role was its recognized expertise in accident analysis and recovery, and the facilities it had to do the severe accident tests.

Within a day of the accident, the Semiscale Facility was reconfigured to simulate the TMI plant and tests were run to see how a gas bubble could be removed from the system without uncovering the core. (Semiscale was a small test reactor that used an electrically heated core rather than a nuclear heated core. It was located at the Water Reactor Research Test Facility.) Later, Semiscale was used to test systems to better monitor water cooling levels in reactors, a problem that contributed to the TMI accident.

In November 1979, the Loss-of-Fluid-Test facility juggled its test schedule by moving up a series of small-break tests that had been scheduled for 1981. These tests, some duplicating events of the TMI accident, collected data and evaluated the performance of emergency systems during small break accidents at commercial power plants. From a series of tests, INL staff evaluated the effectiveness of systems intended to provide emergency core cooling for light-water reactors in the event of a pipe break accident. The information from this series and later tests helped engineers understand the instrumentation and operations of commercial reactors. It also helped in predicting performance of emergency core cooling systems in large reactors. It provided the Nuclear Regulatory Commission the ability to confirm independently the margins of safety that had been estimated during licensing reviews.



Rendering of hypothesized Unit-2 core damage

INL's Power Burst Facility was used to examine nuclear fuel damage and fission product behavior during a TMI-type severe accident that exposes fuel rods to extremely high temperatures.

INL staffs support office at TMI

Within days of the accident, a number of DOE and INL employees arrived at Harrisburg, Pa., to help GPU assess the accident. This group was the start of the INL's TMI Technical Integration Office and became the DOE focal point for learning from the accident, transferring knowledge gained to the nuclear industry and sponsoring original research into reactor safety issues. At the height of activity, 49 INL employees would staff the TIO. They provided technical advice, assisted in various activities – including entry into the containment building for inspections, visual inspection inside the reactor vessel, sample retrieval from the damaged reactor vessel core and support of many of the projects associated with eventual removal of the damaged spent fuel and core debris to the DOE's Idaho Site.

Hundreds of INL workers stationed in Idaho in scores of organizations contributed to the TMI recovery effort during the 1980s. They helped develop specialized instruments and techniques to examine and recover the damaged core, helped develop and build storage vessels for waste generated during the project, coordinated core debris shipments through 10 states and by two railroad companies, safely moved the material to Idaho, put it into water storage and then dry storage in the 1990s, and performed research on the spent fuel and core debris.

INL, DOE, GPU and numerous U.S. corporations worked to overcome many challenges over the course of the TMI accident recovery effort. These led to development of a number of new examination and waste-handling techniques, new uses for current technologies, use of robotic systems, and a better understanding of nuclear reactors and cores during severe accidents.

Challenges led to innovation and discovery

Tests done at INL and computer model data told engineers what kind of damage to expect in the reactor core. But GPU officials, particularly, didn't expect the core damage to be as extensive as INL engineers predicted. So, actual examination of the damaged core was critical before recovery could be attempted. INL engineers determined that removing a control rod drive could create an opening through which they could take a quick look into the middle of the reactor. They modified a camera, lowered it into the reactor through the opening and got their first look at the rubble bed of core debris and verified the amount of damage. What the camera showed verified what INL had predicted.

Another essential pre-recovery step was to sample the core debris for analysis. Again, INL engineers helped develop tools for retrieving samples and for doing core bores. This included designing in 30 months a device adapted from a commercial drilling machine.

In drilling the cores, it was necessary to develop a drill bit that could bore into ceramics and metal. INL engineers, working with a Salt Lake City company, developed and manufactured a bit that worked on both materials. Ten cores were collected for analysis.

The bore holes gave engineers additional opportunities to use a camera to look into the rubble pile. And, the core boring machine eventually helped engineers remove the damaged core from the reactor vessel.

For an even better picture of what the damaged core debris in the reactor vessel looked like, engineers used a sonar system to collect some 500,000 data points in the core cavity. From these data, they developed a three-dimensional picture of the overall shape of the damaged fuel assemblies and other core features.

Core debris comes to Idaho, Washington

One of the early wastes created during the recovery were the liners from the EPICORE II water treatment system. The EPICORE II system used resins to strip radioactive materials from nearly 500,000 gallons of contaminated water that had gotten into the auxiliary reactor building. The result, however, were 49 radioactively contaminated liners that eventually had to be disposed of. INL developed a gas sampler, vent and purge system to remove potentially combustible gases from the liners to ensure safe shipment to the INL Site. The laboratory also developed a high-integrity container and epoxy stabilizing process that allowed the liners to be disposed of safely. Most of them were sent to a U.S. Ecology facility near Hanford, Wash., although a few were disposed of at INL's Radioactive Waste Management Complex.

Following rail delivery to INL's Central Facilities Area, TMI core debris moved by truck and trailer to specialized examination facilities at Test Area North, 27 miles away.

The TMI core debris was brought to INL for two reasons: It was here that extensive analysis could be done at the Test Area North hot cells. The TMI-2 Accident Evaluation Program helped researchers better understand what had occurred during the accident, understand the core degradation and understand fission product movement. This led to improved severe accident computer codes for the nuclear industry. Also, INL's water storage pool was large enough to hold 344 containers of core debris and spent fuel.

Shipments cross-country to the INL Site began in July 1986 and ended in May 1990. Forty-nine casks were transported by rail through 10 states in 22 shipments. The casks were specifically designed and built for the TMI material by Nuclear Packaging Inc. From design to licensing, the cask project, including the railcars designed to hold them, took 18 months. The shipping campaign required extensive coordination and communication by INL transportation officials with state and local governments in 10 states to alleviate concerns about safety. The shipments were made safely, smoothly and expeditiously.

Arriving by railroad at the Central Facilities Area on the INL desert Site, INL equipment operators used the 200-ton gantry crane to move each shipping cask onto a truck trailer bed for delivery to the Test Area North Hot Shop. The truck and trailer drove into the Hot Shop, the cask lids and shield plugs were removed and the canisters of core debris were transferred by crane into the Hot Shop pool. The empty casks were returned to CFA for transport back to TMI in Pennsylvania for another load.

Workers at CFA and the Hot Shop developed proficiency in these tasks and, with suggestions to improve processes, the unloading at CFA and canister transfers into the Hot Shop pool became efficient operations.

Over the decade of work, DOE's Office of Nuclear Energy managed the TMI research and development program at a cost of about $189 million. About 60 percent of the money was used to develop innovative technologies to examine, disassemble and defuel the damaged core and to dispose of the materials from the accident.

The remainder was used to sponsor detailed technical studies that yielded valuable technical information that was applied to the design and operation of nuclear reactors. Analysis was done of the vessel steel, instrumentation nozzles and relocation of debris within the reactor vessel.

Information obtained included peak reactor core vessel temperatures during the accident, the time that peak temperatures were sustained, the cooling rate, relocated core debris composition and geometry (the form of the cohesive mass beneath the rubble), relocated core material and vessel material interactions, relocated core material and nozzle material interaction, nozzle damage patterns, debris decay heat, relocated core material mass, and the cooling inferred from analysis with input from examinations.

Debris into dry storage

Between 1986 and 1990, Three Mile Island core debris was safely transported to Idaho for examination and temporary storage. Then, for nearly a decade, starting in 1990, 344 containers holding the core debris rested underwater in a storage pool at TAN.

But that was only a temporary resting place.

In 1995, the U.S. Department of Energy, the state of Idaho and the U.S. Navy signed an historic settlement agreement regarding management and disposal of radioactive waste and spent fuel in storage at INL.

One part of that agreement called for the TMI-2 core debris to be removed from water storage to dry storage at INL by June 1, 2001, and shipped out of Idaho by 2035.

This initiated the Three Mile Island-2 Spent Fuel Dry Storage Project.

In the mid-1990s, the Department of Energy contracted with Newport News Shipbuilding for the design and construction of a patented shipping and storage system for the TMI-2 material. The facility was to be the Independent Spent Fuel Storage Installation (ISFSI) and was built at the Idaho Nuclear Technology and Engineering Center. It was licensed by the Nuclear Regulatory Commission in March 1998.

The ISFSI consists of 30 reinforced concrete modules, each 10 feet wide, 15 feet tall, 18 feet deep and weighing 120 tons. The modules were built off site, shipped to INL and put into place onto a concrete pad.

As the ISFSI manufacturing and construction was under way, the containers of core debris were pulled from water storage and dried in a specially-designed drying system at the TAN Hot Shop. Then the containers were placed in dry-shielded canisters. There are 29 canisters and each can hold 12 containers of debris. Once the ISFSI was ready to start accepting canisters, they were trucked one by one to the ISFSI and inserted horizontally into modules. Twenty-nine of the modules hold canisters; one module remains empty as backup storage.

The final canister was loaded into its module two months ahead of the Settlement Agreement deadline. Today, the core debris sits safely in the monitored ISFSI, awaiting final disposal.

Read more about the TMI accident from the Nuclear Energy Institute.

Feature Archive