Transition of TMI-2's successful Operations Culture to TMI-2's successful Decontamination/Disassembly/Defueling (DDD) Culture

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Original TMI 2 Defueling Manager 1985-1986

Introduction

- **TMI 2 Accident occurred over 46 years ago**
- **Overview of GPU, its capability**
- **TMI 2 Accident required GPU to transition to a new work culture**
- **Many of TMI 2's Accident challenges similar to Fukushima Daiichi's, differing in magnitude and complexity**
- **TMI 2's Lessons-Learned may benefit colleagues at Fukushima Daiichi**

Three Mile Island Nuclear Plant – TMI 1 on left, TMI 2 on right - Surrounded by the Susquehanna River – Aerial View (from Northwest to Southeast)

1 Organizational structure and functions of GPU

GPU was Established 1906, began as a holding company

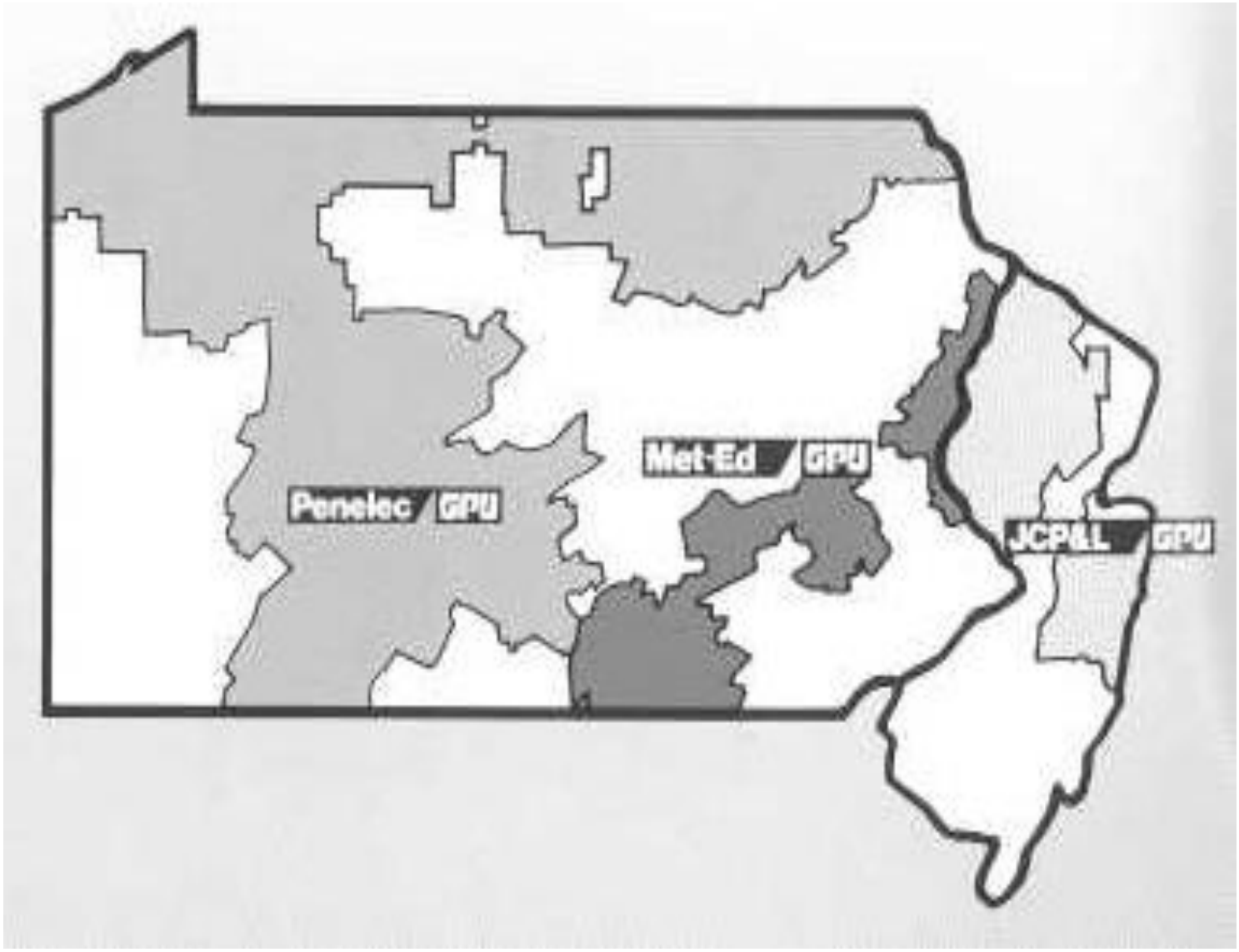
GPU held stock in three smaller operating companies

- **Jersey Central Power & Light (JCP&L)**
- **Pennsylvania Electric (PENELEC) Company**
- **Metropolitan Edison (MetEd) Company**

GPU served a relatively compact geographical area in PA and NJ

By the 1980's GPU employed approximately 14000 workers

GPU Service Areas



1-1 Overall information on GPU

- Began as a regional electricity supplier
- Built and operated numerous coal fired power plants
- Built Oyster Creek Nuclear Power Station
  - Oyster Creek (BWR) was the first "Commercial" (non government subsidized) nuclear power plant in the USA
- Began construction of two PWR nuclear power plants in Pennsylvania the late 1960's and early 1970's at Three Mile Island (TMI) near Middletown, PA
- Completed construction and operated TMI 1 and TMI 2
- Trained reactor operators at the B&W simulator in Lynchburg, Va

TMI 2 Accident, Birth of a new culture

By March 1979 TMI-1 had operated for four successful operating fuel cycles, and was preparing for restart

By March 1979 TMI-2 had completed its successful year-long startup and test period and entered “commercial operation” on January 1, 1979

TMI 2 experienced a Loss of Cooling Accident on March 28, 1979, 0400

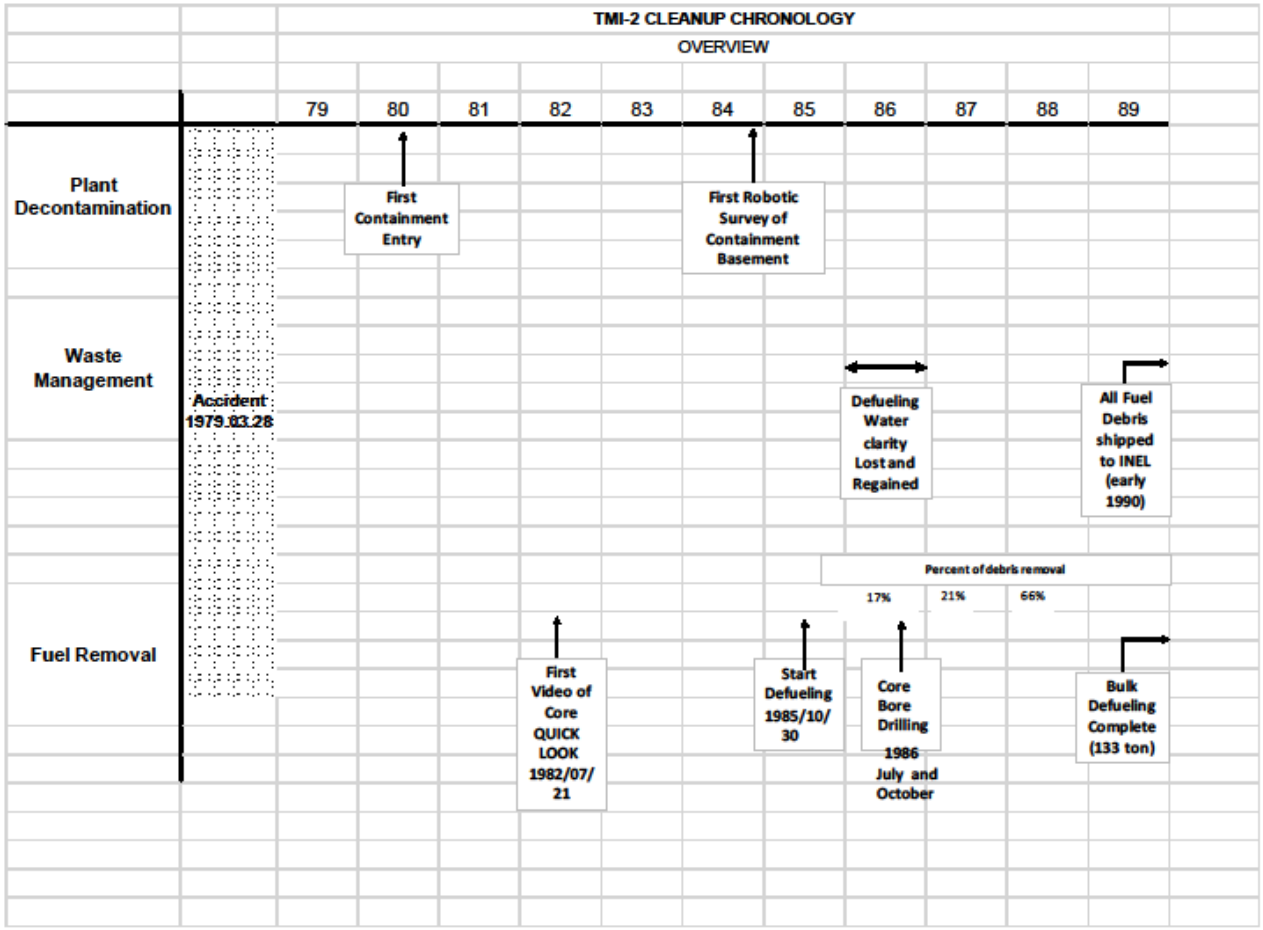
TMI 2 had been in commercial operation for less than 90 days

GPU’s competency to manage and operate a nuclear facility was challenged by the NRC and by numerous other critics

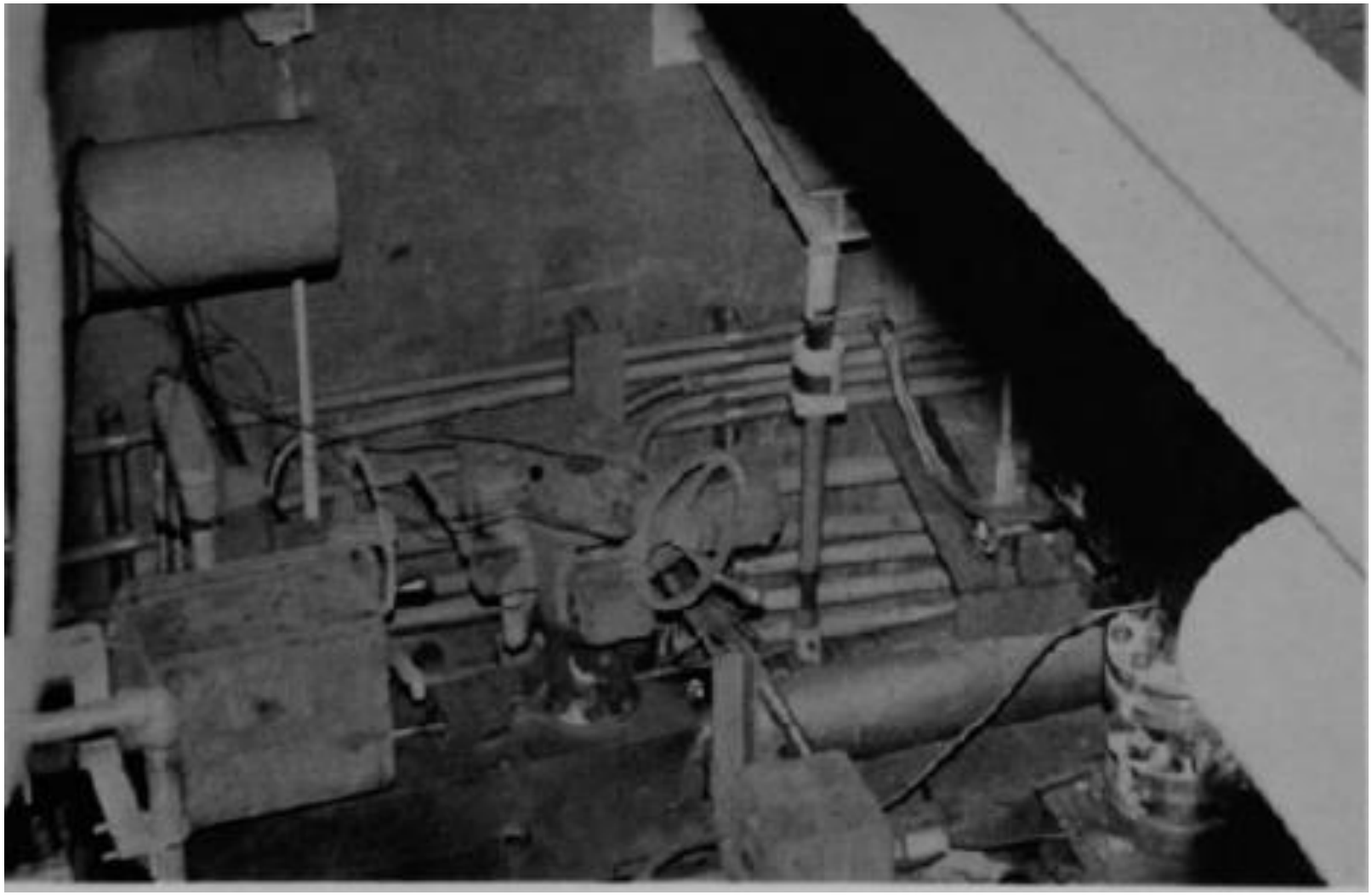
Response to the Accident, and the Cleanup Campaign that followed, provided the foundation for a transition from an Operations-focused culture to a culture where 'respect for nuclear technology‘, including accountability for fine technical detail and rigorous discipline to ensure nuclear safety, was born

GPU’s financial turning point came in November 1985 when the NRC ruled that GPU could return Three Mile Island Unit 1 to operation, ending more than six years of inactivity

Simplified Timeline – TMI 2 Cleanup - Main Events

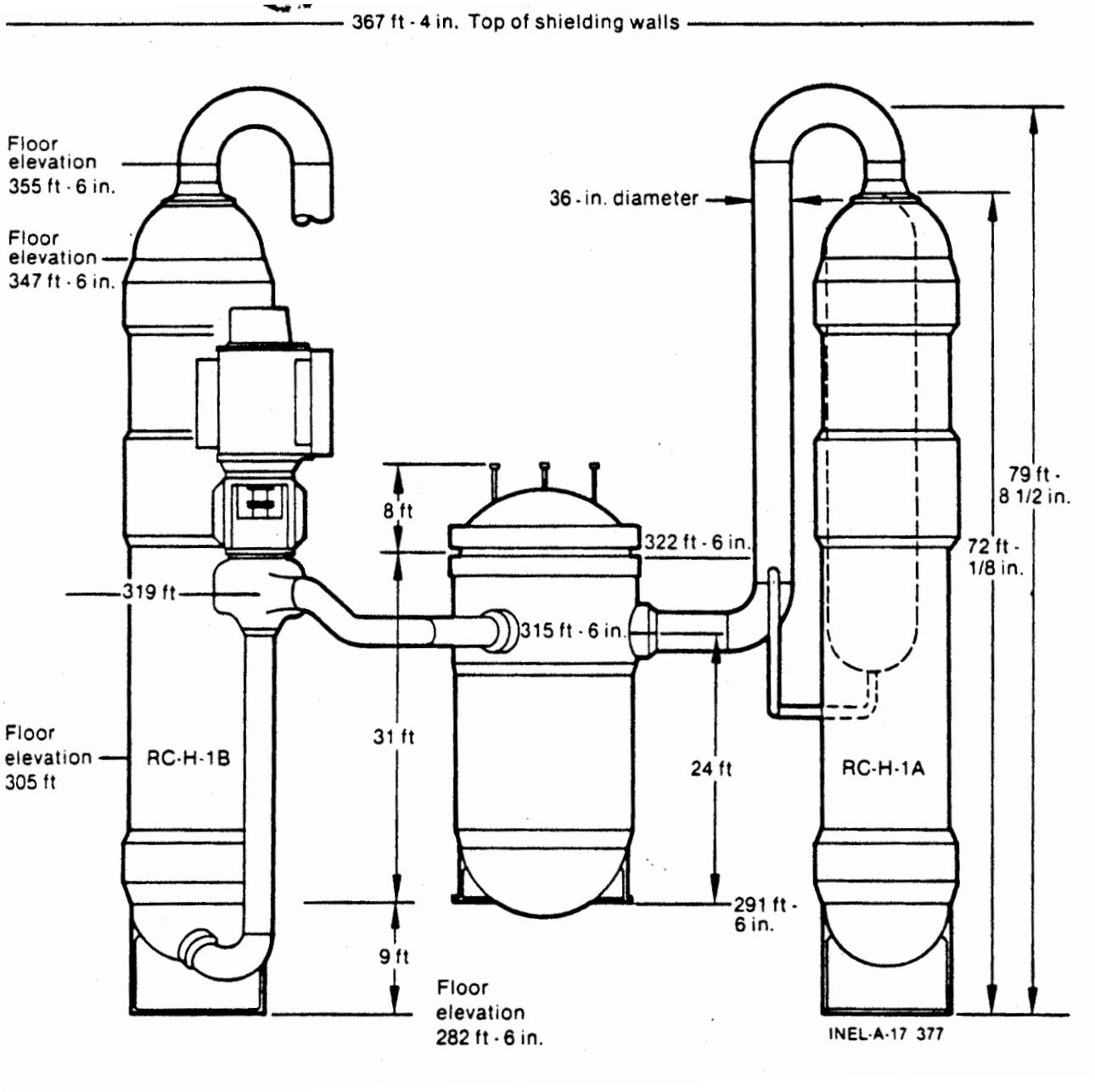


The TMI 2 Accident, Pressurizer Pressure-Operated Relief Valve (PORV) failed to close

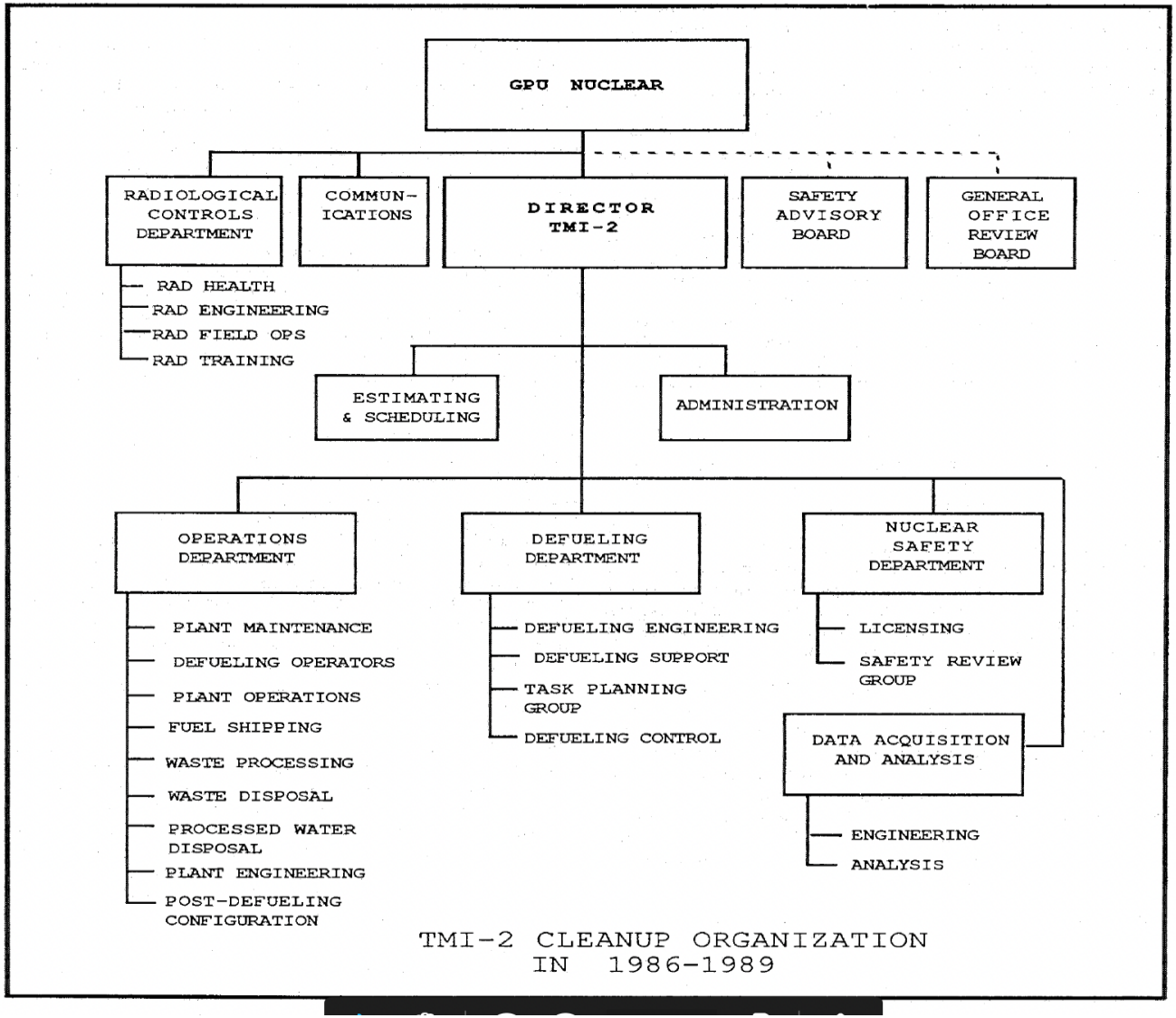


B&W Reactor Coolant System Physical Arrangement

See Reactor Vessel, Piping, OTSGs (Once, Through, Steam, Generators), Surge Line, Pressurizer (in Phantom)



TMI 2 Organization Chart



1-2 Technical ability of GPU

GPU (GPUC) was originally organized to provide technical support to GPU's *fossil plants*; GPU subsidiary GPU Service Corp (GPUSC) provided technical support and managed construction and procurement

GPU utilized Architect Engineers (AE's) for plant design and construction

- **GE was the Architect and Engineer (AE) for Oyster Creek**
- **Gilbert Associates was the AE for TMI 1**
- **United Engineers and Constructors (UE&C) was the AE for TMI 2**

The Architect/Engineer (AE) worked with GPU to conduct site selection, choose reactor type, support construction permitting, choose the construction firm, and ultimately support or conduct construction

1-2 Technical ability of GPU (GPUC)

GPUC ultimately organized a subsidiary, the GPU Nuclear Corporation (GPUNC) and strengthened the Technical Functions organization at Headquarters (Parsippany, NJ) for dedicated nuclear technical support to Oyster Creek and TMI.

GPUNC's technical resources were at two locations:

1) Headquarters location in Parsippany NJ, (Home Office)

Maintained project management of major capital projects and support for longer-range technical products, and specialized support for nuclear and mechanical analyses

2) Two plant sites located at Oyster Creek and Three Mile Island

Incorporated the original Plant Engineering Section that provided immediate and around the clock technical support to the plant.

The TMI 2 accident caused migration of approximately 12 key Parsippany (Home Office personnel, including executive level personnel), to TMI 2, to strengthen the original site-based (Plant Engineering) technical organization at TMI 2

1-2 (Continued) Technical ability of GPU (GPUC)
Establishment of GPU Nuclear Corporation (GPUNC)

- **GPUC recognized the necessity of separating management of the GPU System Fossil Plants from the management of the GPU Nuclear Plants by forming and dedicating an organization specifically skilled in nuclear technology headquartered in Parsippany, New Jersey**

- **GPUC formally established the GPU Nuclear Corporation (GPUNC) on January 1, 1982, three years after the Accident**

- **GPUNC's sole responsibility: Operation, Maintenance, Management and Security of TMI and Oyster Creek**.

GPUNC's Organizational Implementation

Pre-accident	**GPU – Home Office** **Organized Technical Functions as its primary engineering resource** ● **Nuclear Analyses Group** ● **Component Engineering** ● **Once Through Steam Generator Team** ● **Turbine Team** ● **Regulatory Assurance organization** ● **Quality Assurance**
Post - accident	◆ **Approximately a dozen home-office Technical Functions Executive leaders and senior technical personnel moved to the TMI 2 site** ◆ **GPU developed a single (combined) Site Technical Functions organization (Included original Plant Engineering) at TMI 2 that addressed daily and longer term technical issues on site** ◆ **GPU hired personnel from TMI's original architect engineering firms including United Engineers and Constructors (UE&C) and from Gilbert Associates (GA)** ◆ **GPU hired personnel from Combustion Engineering, from Westinghouse, continued cooperation with Babcock and Wilcox, and hired personnel from willing or interested foreign organizations (including Japan), from the National laboratories (Idaho National Engineering Laboratory and Oak Ridge National Laboratory)** ◆ **GPU was a major participant in the formation of GEND, (G) GPUC, (E)EPRI ,(N) Nuclear Regulatory Commission (USNRC), (D) US Department of Energy, to obtain resources from these agencies and the National laboratories including Oak Ridge National Laboratory and the Idaho National Engineering Laboratory,**

GPU in Transition to a new culture From an Operations Culture to a Decontamination/Disassembly/Defueling (DDD) Culture

- **Multiple critical TMI 2 tasks were competing with another important task occurring at the same time (Simultaneously)**
- **Planning and detailed understanding of potential interactions or conflicts between the TMI 2 tasks required high levels of communication, trust between different organizations, and willingness to be flexible so that all of the TMI 2 tasks could be completed safely and successfully**
- **The complexity of planning for each 'next step' required extraordinary preventative or precautionary radiological actions that accounted for the radiological challenges both inside and outside of the Reactor Building, with the most complex challenges inside the reactor vessel**
- **Because of the complexity of the competing TMI 2 tasks, and the focus devoted to each task, the potential for 'Silo'd thinking' was very high**
- **GPU took action to eliminate Silo'd thinking by instituting independent oversight actions (Review Groups SAB, TAAG) and by requiring extensive technical evaluations (Safety Evaluations) for each major task**

The most important concept that guided the culture transition and that guided TMI 2 Defueling :

'Respect for Nuclear Technology'

- **Center of the transition: Unwavering Discipline to respect nuclear technology**

- **Unwavering Discipline: Rigid and consistent compliance and behaviors that respect nuclear safety as most important**

1-3 On-site safety related organizations within GPU and its activities during TMI-2 D&D

- **Classical Industrial Safety (One department shared by TMI1 and 2): Fire Prevention, Fall Prevention, Worker Head Protection, Crane and Lift Management, Ventilation, Breathing Air Quality, and other industrial safety issues**

- **Radiological Controls (Rad Con) - separated TMI 1 Rad Con from TMI 2 Rad Con because of Radiological difference's**

- **Site Protection Force (Security)**

- **TMI 2 Oversight Groups including SAB and TAAG**

  These oversight groups were developed to provide strong and independent oversight capability and to prevent Silo'd thinking.

1-4 - Project Management actions that addressed site safety including the elimination of silo type organizational deficiency (Major Change from Operating Culture to DDD Culture)

- **The GPU Service Corp (GPUSC) was GPU's major Project Management provider, stationed in at Headquarters in Parsippany, NJ, and focused on long range, large capital investment projects for the entire GPU system, including all three generation subsidiaries. GPUSC did not have the capability to adequately focus on the evolving complex problems at TMI 2**

- **At the time of the Accident there was *no* formal on-site dedicated TMI 2 Project Management organization. Instead, within the on-site TMI 2 organization was a "Project Controls" group that was a small procurement organization for procuring local/regional services**

- **The evolving TMI 2 technical challenges required development of an on-site Project Management organization to promptly address the growing TMI 2 plant challenges, included hiring contractors to make "Facility Changes" (plant modifications) while TMI 2 was still in partial operation (decay heat removal). Facility Changes included building shield walls, routing new piping, modifying already-installed equipment, and addressing other significant construction tasks that required significant Project Management capability**

- **The complexity of these competing challenges required Senior Management to develop independent oversight capabilities and to depend on comprehensive Safety Evaluations to prevent Silo'd thinking**

1-4 (Continued) - Project Management actions that addressed site safety including the elimination of silo type organizational deficiency (Major Change from Operating Culture to DDD Culture)
Safety Evaluations

- The Safety Evaluation was prepared in accordance with 10 CFR 50.59 (Facility Changes) and would ultimately be reviewed in detail by oversight groups and sometimes the NRC. Preparation of and review of the Safety Evaluation constituted GPU best tool for avoiding Silo'd thinking.

- The Safety Evaluation Report (SER) was prepared by one or several engineers:
  - The SER Described the task in detail
  - The SER Identified the risks
  - The SER Identified actions to mitigate those risks

- The final work plan for the task, evaluated by the Safety Evaluation, would be integrated into a comprehensive work package that was void of 'Silo'd' thinking.

See on next slide an Example of an SER
Docket No. 50-320
TMI 2 Division Safety Evaluation Report for Early Defueling of the TMI-2 Reactor Vessel

ISSUE DATE

☒ ITS
☐ NSR
☐ NITS

TMI-2

DIVISION

SAFETY EVALUATION REPORT

FOR

Early Defueling of the

TMI-2 Reactor Vessel

COG ENG M.K. Boldt DATE 3/5/85

RTR E.T. Smith DATE 3/5/85

COG ENG MGR. C.L. Rid for R.L. Ride DATE 3/5/85

NO	DATE	REVISIONS	BY	CHECKED	GROUP SUPERVISOR	MGR DESIGN ENGINEERING
2	5/9/85	Revised and Reissued for Use	JCR	R3R	EJS	CLR for RLR
1	4/17/85	Revised and Reissued for Use	JCR	R3R	EJS	CLR for RLR
0	3/5/85	Issued for Use	JCR	R3R	EJS	CLR for RLR
				CHIEF ENGINEER	H/A	

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1-4 (Continued) - Project Management actions that addressed site safety including the elimination of silo type organizational deficiency (Major Change from Operating Culture to DDD Culture)

- The technical workload at TMI 2 increased the demand on the resources required for Project Management
- GPUNC did not have these resources and sought an experienced construction management contractor to work full time at TMI 2
- GPUNC hired the Bechtel Corporation as the construction management contractor
- Bechtel's capability to manage large, complicated projects, including supply of material and supply of construction personnel, was well recognized
- Bechtel effectively managed multiple competing projects at the TMI 2 site.

1-4 (Continued) - Project Management actions that addressed site safety including the elimination of silo type organizational deficiency (Major Change from Operating Culture to DDD Culture)

- **The constantly emerging TMI 2 technical challenges required constant and energetic communication. This communication was sometimes confrontational and stressful, but beneficial**

- **Safety Advisory Board members Dr. James Fletcher (Retired Director of NASA) and Dr. Norman Rasmussen (Chairman, Nuclear Engineering Department, MIT) were highly interested in, and focused on, TMI 2's Defueling.**

- **I (Skillman) enjoyed cordial personal and professional interactions with Drs. Fletcher and Rasmussen. These gentlemen worked with me as advisors on the development of and execution of the TMI 2 defueling process.**

Silo prevention by GPU management

- **Resource competition between multiple active parallel tasks provided opportunity for one work group to presume that their task was more important than a parallel competing task.**

- **Careful planning became necessary including selection of priorities and choosing the optimum 'next task‘ of ‘next step’**

- **GPU Management recognized the potential for competing technical organizations to work in isolation from one another and to form ‘Silos’ that could ignore or not account for important cross - organization, or cross – technology, impacts**

- **GPUNC management took strong action to eliminate Silo‘d thinking**
  - **Convened Independent Oversight Boards**
  - **Required Comprehensive Safety Evaluations**
  - **Conducted highly focused (Critical) Review of Safety Evaluations**

- **The Oversight Boards (TAAG, SAB) provided careful evaluation and challenge of tasks with the intention of providing comprehensive oversight and preventing Silo’d thinking**

Silo prevention by GPU management
Involvement of Oversight Groups: GORB, SAB and TAAG

- **GPU's pre existing GORB (General Office Review Board) remained in place after the TMI 2 accident. GORB was business focused and was experienced in general technical and commercial issues of fossil plants and, to a lesser degree, nuclear plants. It was not experienced in assessing and providing counsel on the enormous radiological challenges accompanying the TMI 2 accident.**

- **GPUC convened two Technically Focused separate and independent groups of consultants:**
  - **SAB - Safety Advisory Board (12 members, all GPU outsiders)**
  - **TAAG - Technical Assistance and Advisory Board – (9 members, all GPU outsiders)**

- **SAB – Safety Advisory Board – Advised GPU and GPUNC Senior Management through four sub-panels - Core Removal Panel, the Source and Waste Identification Panel, the Radiation Hazards Panel and the Externa1 Affairs Panel Chairman: Dr. James Fletcher, retired Director of NASA (National Aeronautics and Space Administration, USA)**

- **TAAG – Technical Assistance and Advisory Group - Advised GPUNC Senior Management in technical aspects of the clean-up activities of TMI-2. Chairman; Retired Director of Westinghouse's Bettis Laboratory**

Silo prevention by GPU management - Important Organizational Actions Frequent Oversight Committee Meetings, Constant challenges - Constant Communication

- **Oversight Committee meetings – TAAG - every ~4 weeks (Monthly) - Attended by Engineers, Managers and Directors, sometimes plant operators if the discussion topic involved them**

- **Oversight Committee meetings – SAB - every ~13 weeks (Quarterly) Attended by GPU and (later) GPUNC Executives and Senior Managers, sometimes contributing Engineer Managers and Engineers**

- **Oversight Committee meetings involved presentation and discussion on the combination of the Technical Plan for the activity and the Safety Evaluation that accompanied the Technical Plan.**

- **Oversight meetings were sometimes contentious, difficult, or stressful**
  - **Main difficult issues involved differences of opinion**
  - **Main challenges generally involved differences in experience levels and differences in technical backgrounds,**

Silo prevention by GPU management - Important Organizational Actions Frequent Oversight Committee Meetings, Constant challenges - Constant Communication (Continued)

- Meetings were sometimes contentious, difficult, or stressful (continued)
  - Plant personnel recognized that they were responsible for the implementation and the outcome of the work that was potentially guided by the oversight committee member's comments.
  - Plant personnel were sometimes unwilling to accept counsel from the oversight committee member.
- This sometimes stressful working relationship resulted in the highly valuable outcome that was the elimination of intellectual silo's, thereby creating successful outcomes both in the cleanup progress and most importantly, providing thoroughness in attention to fine details and assuring nuclear safety by demonstrating respect for nuclear technology

2 Approaches to enhance on-site and working safety during TMI-2 D&D

2-1 On-site preparatory work including occupational exposure reduction (extensive prior decontamination, removal of obstacles on site, and vital sheltering)

Floor Scabbling

Venting of Kr 85 - 58,000 Ci (2.146 e15 Bq)

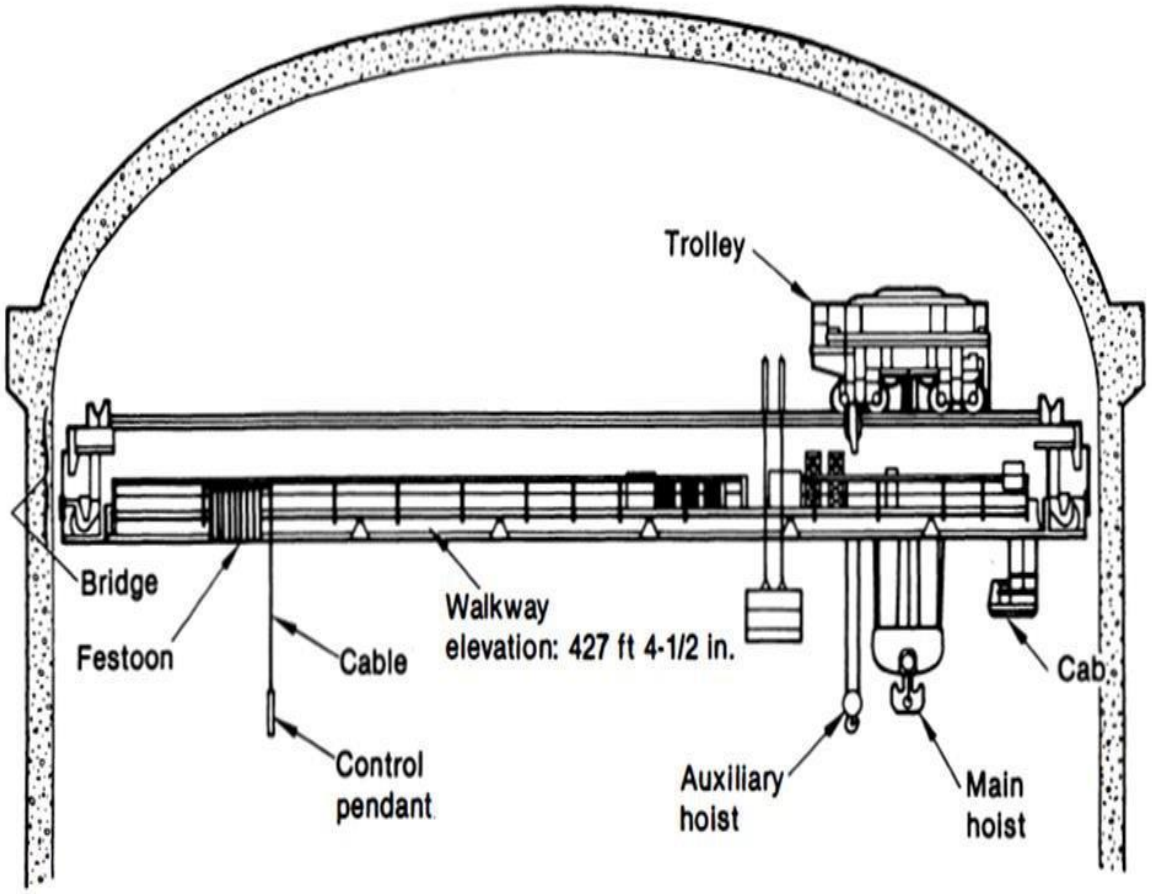
Polar Crane

Quick Look

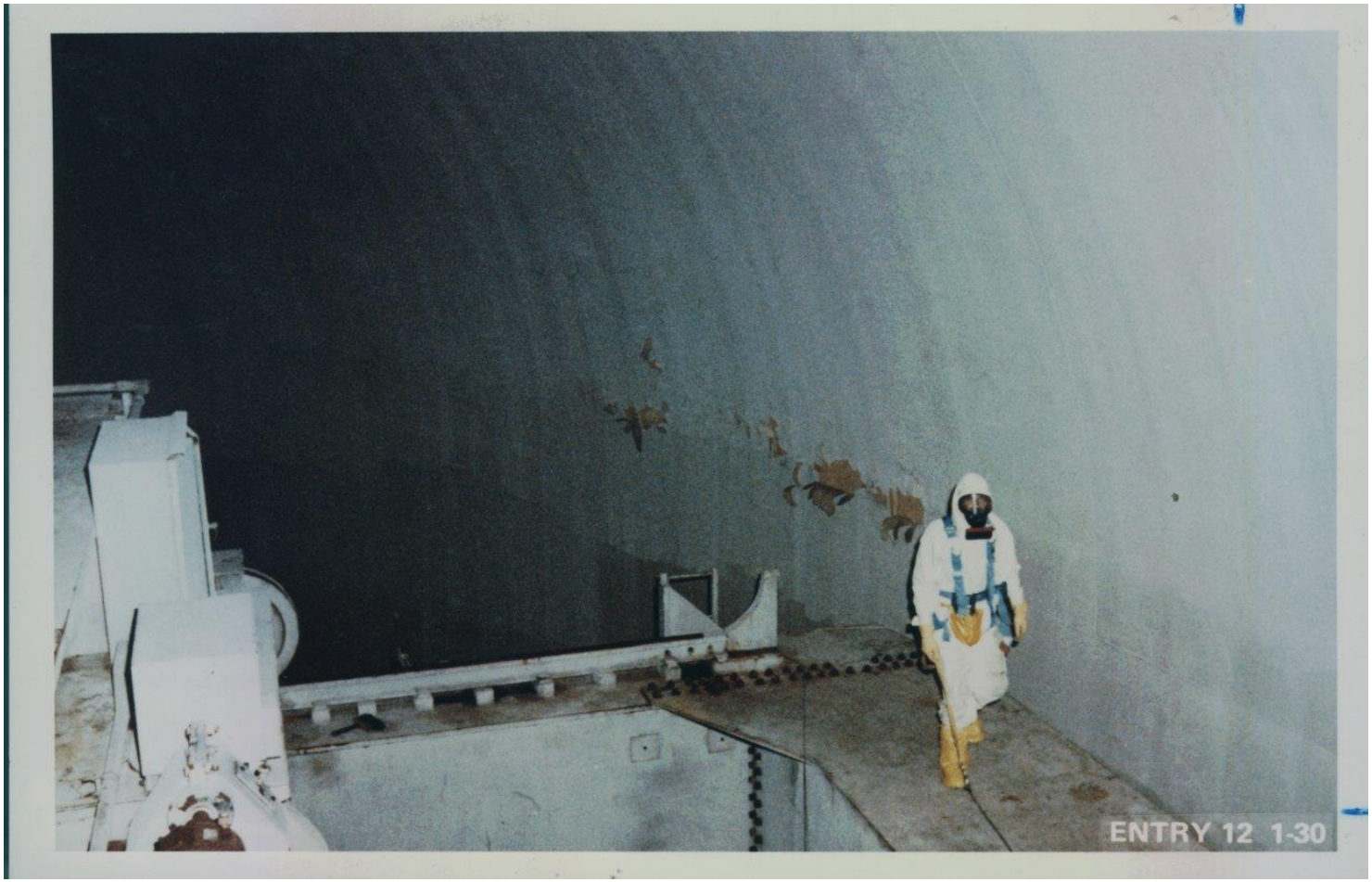
Defueling

Manual Floor Scabbling

Polar Crane Details



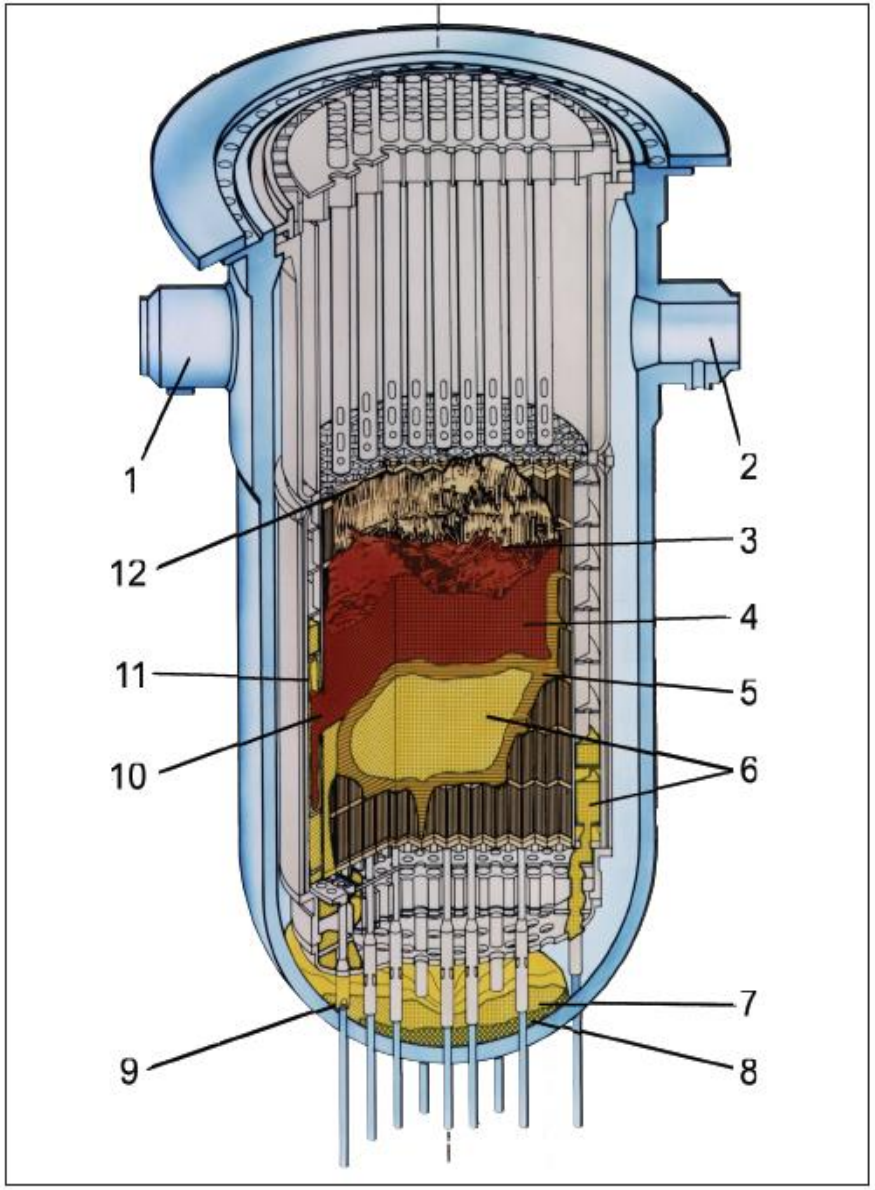
Worker on Bridge of Polar Crane inside Reactor Building



Quick Look on 7-21-1982
Fuel Pins, Spacer Grid, Fuel Pin Upper Spring

TMI-2 Core End-State Configuration

Notes (NUREG/CR-6042):
(1) Cold leg Loop 2B inlet
(2) Cold leg Loop 1A inlet
(3) Cavity
(4) Loose core debris
(5) Crust
(6) Resolidified molten material
(7) Lower plenum debris
(8) Hard layer debris
(9) Damaged in-core instrument guide
(10) Hole in baffle plate
(11) Coating of resolidified molten material on bypass region interior surfaces
(12) Upper grid damage



Wide View of Defueling Team on Rotating Work Platform over the TMI 2 Reactor Vessel, 1985

2-2 Prior identification of risk – GPU's Risk Assessment
Details on Safety Evaluations

- **TEPCO may be using Risk Evaluations, or Risk Assessments, to evaluate Risk for the Fukushima Defueling Program. Those words – Risk, Risk Assessment - were not being used in the early 1980's. GPU used Safety Evaluations to address Risk**

- **TMI 2 was licensed in accordance with 10 CFR 50. Within 10 CFR 50, and in accordance with 10 CFR 50.59, GPU was required to evaluate each 'change to the Facility'. 'Facility' refers to the TMI 2 Plant in the configuration that was licensed by the NRC under 10 CFR 50.**

- **The requirement of 10 CFR 50.59 was (is) for the licensee (GPU) to perform a 'screening evaluation' to determine whether the 'change to the facility' created an "unanalyzed condition" (condition not identified in the operating license)**

- **The TMI 2 organization interpreted "unanalyzed condition" to mean an 'unanalyzed 'risk. Instead performing a simple 'screening evaluation', we developed and used what we called a 'Safety Evaluation' and required it to be a comprehensive evaluation of the 'facility change'.**

2-2 Prior identification of risk – GPU's Risk Assessment
Details on Safety Evaluations (Continued)

- **GPU's Safety Evaluations at TMI 2 provided a written description of the task or activity, its desired outcome, the risks associated with that activity, and actions to reduce or eliminate those risks. Safety Evaluation provided written proof that the risks were thoroughly identified and quantified.**

- **GPU utilized the Safety Evaluation to not only evaluate the simple details of the change, but to exhaustively evaluate all of the elements of the change that involved all impacted areas and organizations. The thoroughness of the Safety Evaluation became a critical tool in preventing Silo'd thinking.**

- **The Safety Evaluation provided the same important function as a Risk Assessment. Safety Evaluations became the foundation for work instructions and procedures. (Review of the TMI 2 KM resource provides access to hundreds of the TMI 2 Safety Evaluations)**

2-2 Prior identification of risk – GPU's Risk Assessment
Details on Safety Evaluations (Continued)

- **The Safety Evaluation provided written confirmation that competing tasks or risks were considered thus reducing the potential for Silo'd thinking**
- **The effort to produce and defend a Safety Evaluation was significant – sometimes requiring hundreds of hours of effort. The resources required to produce and utilize the Safety Evaluation as a Risk Assessment tool was worth the investment**
- **Safety Evaluations were prepared by a GPU employee or employees, or a contractor working on the TMI 2 cleanup program**
- **Safety Evaluations were always reviewed by the TAAG, often reviewed by the NRC, sometimes reviewed by the SAB**
- **The actions to employ the Safety Evaluation supported the DDD Culture by requiring a very high standard for technical accountability**

2-3 Real and practical scheduling based on the actual progress of the work

- **Early accident response, after plant stabilization, was focused on gaining access to areas contaminated by the accident and devising a method to learn core condition**

- **Tasks that were assumed to require one or two days of effort sometimes required weeks of effort. Discovery of new data sometimes required complete rescheduling of the work**

- **While there is often a desire to satisfy upper management or regulators with schedules or plans that align with the regulator's wishes, or upper management's wishes, or thoughts by the politicians, or by local stakeholders, there is danger in complying with these unfounded wishes. Work Scheduling must be based on physical facts, must be based on availability of available resources, and must not be based on unproven assumptions or wishes**

- **The technical challenges that confronted the TMI 2 organization required expertise beyond that available at the site. GPU hired contractors to do some of the work tasks. Bechtel was a major contractor for the TMI 2 Cleanup Campaign.**

2-4 Pursuit of rational interaction with regulator
On site Regulatory issues and decisions

- Day-to-day regulatory issues were addressed by NRC site Residents. These interactions were neutral, objective, and highly focused.
- As described previously in item 1-4 (Slide 19):
  - Each significant work activity that GPU undertook was evaluated prior to work execution utilizing the Safety Evaluation as this written evaluation.
  - Safety Evaluations and, where applicable, accompanying Operating Instructions or Operating Procedures, were made available to the NRC for their review, and were sometimes were formally presented, to the NRC
- The NRC could choose to review or comment on the Safety Evaluation, and usually did.
- The GPU engineer / engineer(s) who prepared the Safety Evaluation was (were) required to provide a written response to each comment from the NRC staff and to successfully resolve the comment
- The site NRC office provided review of most tasks that ***did not*** involve policy decisions

NRC Trailers on TMI site ~ 1980

2-4 (Continued) Pursuit of rational interaction with regulator Policy and Rulemaking Regulatory decisions

Policy and Rulemaking Regulatory decisions

- **Policy and Rulemaking issues regarding TMI 2 were addressed by NRC Headquarters personnel in Rockville, Md.**

- **GPU decisions on Policy or Rulemaking issues regarding TMI 2 required involvement by GPU Executive Management at Headquarters in Parsippany, NJ and usually required Legal Counsel (for Nuclear Law interpretation)**

2-5 Integrated relationship with contractors and local enterprises

Contractors pre accident, local enterprises;

- **Local contractors provided fuel oil, compressed gas, cleaning supplies, common site services**
- **TMI work force was unionized. On site tasks involving labor were completed by the on-site unionized work force**
- **Where specialty labor or special tooling or equipment was required (parking lot paving, paving machine; weld overlays on degraded piping, specialty welding machines), the site would engage local contractors for labor**.

Contractors post accident, local enterprises;

- **GPU hired numerous contractors to supplement the original TMI 2 professional workforce**
- **GPU hired Bechtel who then brought to the site a work management team (Supervisors) and supplemental engineers to support GPU on individual projects**
- **GPU entered into Multi Service Contracts (one Contract, multiple tasks) with other companies for continuing specialty services (B&W, others)**

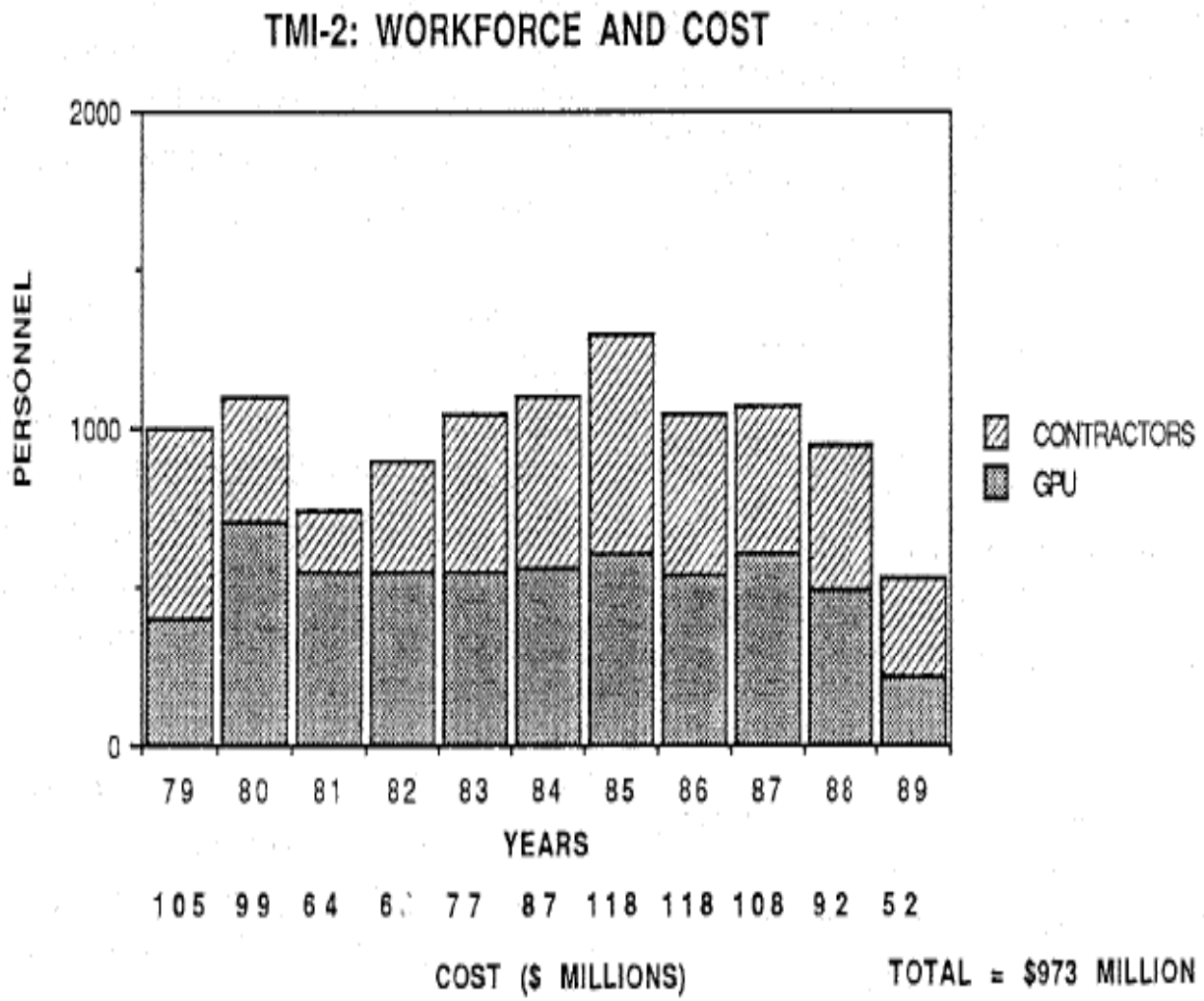
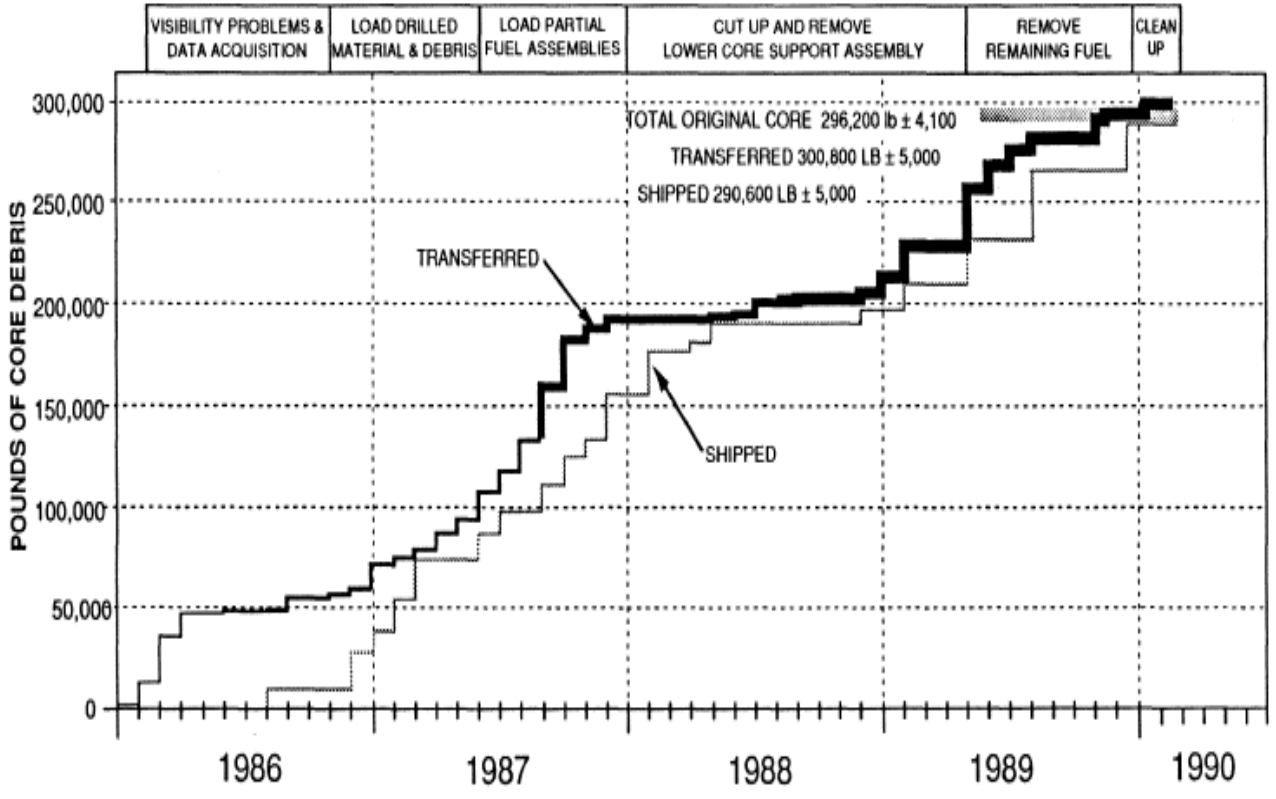


Figure 2-6. TMI-2: Workforce and Costs

TMI-2 Defueling Progress (Defueling Completion Report, GPU 1990)



Conclusion

It took years for GPUNC to transition from the old culture to the new culture, and the transition affected GPUNC at both TMI 1 and TMI 2

- **Critical concepts of the DDD culture, particularly 'Respect for the Technology', became the foundation for GPUNC's new Safety Culture**
- **The transition to the DDD culture was successful because of constant and unwavering Discipline to respect nuclear technology. (Discipline is intended to communicate: "rigid and consistent compliance and behaviors that respect nuclear safety as most important. Politics and finance were secondary considerations.)**
- **Many of the critical concepts of the DDD culture, particularly 'Respect for the Technology', demonstrated by technical thoroughness (Safety Evaluations) and accountability (Challenges by the Oversight Groups), became the foundation for the new GPUNC Safety Culture throughout GPUNC**
- **TMI 2's Defueling Campaign safely and successfully completed in 1990.**
- **By 1990 TMI 1 had returned to power operation at 2568 MWt and was operating in GPUNC's new Safety Culture that had been shaped by TMI 2's DDD Culture.**