Staff Report To
The President's Commission On

THE ACCIDENT AT THREE MILE ISLAND

The Role Of The Managing Utility And Its Suppliers

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REPORT OF
THE OFFICE OF CHIEF COUNSEL

ON

THE ROLE OF THE MANAGING UTILITY AND ITS SUPPLIERS

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SCOPE OF THE INVESTIGATION

In June 1979 a team was formed within the legal staff of the Commission to investigate General Public Utilities Corporation (GPU) -- including its subsidiaries Metropolitan Edison (Met Ed) and General Public Utilities Service Corporation (GPUSC) -- and its two principal suppliers Babcock & Wilcox (B&W) and Burns and Roe.1/

On June 4 a subpoena *duces tecum* was served on GPU.2/ Similar subpoenas were served on B&W on June 4 and on Burns and Roe on June 14.3/ The subpoenas were sweeping in their scope, basically encompassing all documents that had anything to do with the history of TMI-2. They were subsequently narrowed through negotiation to reflect the primary issues pursued in the investigation.

The subpoena power was essential to an effective investigation both in compelling production of documents and taking testimony under oath. Without subpoena power, the legal staff could not have moved with the necessary speed in document production, nor could it have relied on the production of documents unfavorable to the companies being investigated.

Many important points in the investigation were either first identified or substantially clarified through document production. The Dunn memorandum, discussed later in this paper, is a notable example.

The availability of subpoena power also prompted cooperation on a number of occasions where subpoenas did not ultimately have to be issued. In short, the subpoena power was critical to a speedy and effective investigation.

More limited subpoenas were also served on Westinghouse, General Electric, and Combustion Engineering -- all competitors of B&W -- in late June.4/

In response to the subpoenas, the Commission received approximately 100,000 documents. Most, but not all, of those documents were reviewed. Many supplemental requests for documents were made in the course of the investigation, including about 200 requests during depositions.

1/ The team ultimately consisted of three lawyers and two legal assistants. That team received significant support from a number of members of the technical staff.

2/ A copy of the GPU subpoena is attached as Appendix A. The B&W and Burns and Roe subpoenas largely duplicate the GPU subpoena so they have not been appended.

3/ Subpoenas were served under authority granted by Congress to the Commission, S. J. Res. 80 (May 23, 1979).

4/ The Westinghouse subpoena is attached as Appendix B. It reflects the substance of the GE and Combustion subpoenas.

Between June 28 and August 28, nearly 70 depositions 5/ were taken at the offices of the companies being investigated: B&W in Lynchburg, Va.; the utility at Three Mile Island (TMI); and Burns and Roe in Oradell, N.J. All depositions were taken under oath. All witnesses were given an opportunity to read their deposition transcripts and submit corrections.

The raw numbers of documents and depositions are recited more to illustrate what was not done than what was done. The legal staff was limited by the October 25 report deadline and a small staff. It was impossible to ask every question, to depose every potential witness, to review every relevant document. The staff undoubtedly missed certain issues, overlooked certain documents, or failed to depose people who under different circumstances would have been questioned. Others who continue to investigate the accident will have to fill in those gaps, building on what this investigation has done.

Given its limitations of time and personnel, the legal staff focused almost entirely on the events leading up to the accident rather than on the details of the accident itself. It tried to look at the structure of the organizations to see how they acquired, analyzed, and applied information; and to explore their capacity to assess their own management as well as their hardware designs. Even that inquiry is incomplete.

Thus it should be understood that this paper does not reflect a definitive investigation. The legal staff is confident, however, that the themes presented are valid and that the broad picture is accurate.

Although touching frequently on technical issues, this report is not intended to be a technical assessment. Many issues raised here are also discussed in other staff papers on training, the condensate polishers, the pilot-operated relief valve (PORV), quality assurance, and the Nuclear Regulatory Commission (NRC).

Because the staff has investigated only this utility and its suppliers in connection with TMI-2, it draws no conclusions about other utilities or other suppliers in the commercial nuclear industry.

This paper assumes a basic understanding of the operation of a nuclear reactor, including the hardware components of the primary and secondary systems, the flow paths and direction of flow of water in the primary and secondary systems, and basic principles of heat transfer and pressure/temperature relationships.

The reader will find a good explanation of these mechanical aspects of the system in the Commission's report.

5/ A list of all deponents, their employers, and the dates of their depositions is attached as Appendix C.

Among the appendices attached to this paper is an organizational chart of Met Ed which is recommended as an aid in understanding the reporting relationships within the utility. A word on footnotes: all depositions referred to are in the Commission archives. All deposition exhibits are bound, tabbed, and indexed in the archives. Reference to "accession numbers" is to the Commission's computerized numbering system for documents in the archives.

CAST OF CHARACTERS

GPU/MET ED

General Public Utilities Corporation (GPU), a holding company headquartered in Parsippany, N.J., began operations in 1946 as the successor to Associated Gas and Electric Corporation. With assets of $4.6 billion, GPU is the nation's 14th largest publicly owned electric utility.6/

The Metropolitan Edison Company (Met Ed) is one of three operating utilities owned by GPU. The two other operating subsidiaries are Pennsylvania Electric Company (Penelec) headquartered in Johnstown, Pa.,7/ and Jersey Central Power and Light Company (JCPL), headquartered in Morristown, N.J. 8/ Together, the three GPU companies provide electricity to about half the land area of Pennsylvania and New Jersey, 9/ serve more than 1.5 million customers, and jointly own several of GPU's main electric generating facilities.

GPU's fourth operating subsidiary is the GPU Service Corporation (GPUSC), incorporated in May 1971. GPUSC, also headquartered in Parsippany, provides technical assistance and expertise to the three operating utilities. GPUSC grew out of the Nuclear Power Activities Group (NPAG), formed in 1967 "to centralize the technical resources necessary to provide management and oversight on the design and construction of nuclear facilities."10/

William Kuhns, chairman and chief executive officer of GPU, is also chairman and chief executive officer of all four GPU subsidiaries -- GPUSC, Met Ed, JCPL, and Penelec -- a circumstance that creates highly centralized management control in the hands of one person.11/

6/ 1978 GPU Annual Report at 16, Accession #6080794.

7/ Penelec provides electricity to roughly 500,000 people in the northern and western parts of Pennsylvania. 1978 Met Ed Annual Report at 1, Accession #5310049.

8/ JCPL serves about 675,000 customers in New Jersey. 1978 Met Ed Annual Report at 1, Accession #5310049.

9/ The area served by GPU does not include Pittsburgh, Philadelphia or Newark, the three largest cities in the two states.

10/ Arnold deposition at 24. See also Roddis deposition at 917.

11/ Arnold deposition at 22-23.

GPU's generation mix in 1978 was 34 percent nuclear, 57 percent coal, and 9 percent oil.12/ With the entry of TMI-2 into commercial operation on Dec. 30, 1978, the nuclear component in GPU's generation mix reached nearly 40 percent. At that time Walter Creitz, president and chief operating officer of Met Ed, stated that GPU's goal was a balanced generation mix of 50 percent coal and 50 percent nuclear. 13/ This balance was to be achieved with the completion of the Forked River, N.J., nuclear station in the mid-1980s. 14/ Since the TMI-2 accident, the Forked River project has been suspended because of the financial impact of the accident.15/

Met Ed, headquartered in Reading, Pa., provides electricity to about 350,000 customers in the southern and eastern parts of the state. Met Ed's generation mix was 58 percent coal and 38 percent nuclear at the end of 1978. In addition to two nuclear plants at TMI, Met Ed operates the Titus and Portland conventional coal-fired steam plants in Pennsylvania.16/ Met Ed owns 50 percent of both TMI units; JCPL and Penelec each own 25 percent.17/

Three Mile Island is located in the Susquehanna River 10 miles from Harrisburg, Pa. Both units at TMI are nuclear power plants: TMI-1 consists of a Babcock & Wilcox (B&W) pressurizer water reactor and a General Electric turbine with the balance of the plant designed by Gilbert Associates. TMI-2 has a B&W pressurizer water reactor and a Westinghouse turbine with the balance of the plant designed by Burns and Roe.18/

12/ 1978 GPU Annual Report at 16, Accession #6080794.

13/ 1978 Met Ed Annual Report at 2, Accession #5310049. For a general statement of the company's reasons for wanting this balance, see Arnold deposition at 7.

14/ 1978 GPU Annual Report at 13, Accession #6080794.

15/ Hendrickson deposition at 96.

16/ 1978 Met Ed Annual Report at 1, 3, Accession #5310049.

17/ Before the shift of TMI-2 from Oyster Creek, JCPL owned a 50 percent share of the unit and Met Ed and Penelec each owned 25 percent. Herbein deposition at 51.

18/ It should be noted that Gilbert Associates, the TMI-1 architect engineer, was retained by GPU to undertake limited architect engineer functions at TMI-2.

United Engineers & Constructors, Inc., built both units. TMI-1 received its construction permit on May 18, 1968, and its operating license in April 1974 and began commercial operation in September 1974. 19/ TMI-2 received its construction permit on Nov. 4, 1969 and its operating license on Feb. 8, 1978,20/ and began commercial operation Dec. 30, 1978.21/

At the end of 1978 Met Ed's generating capacity was 2,144 megawatts. In 1977 and 1978, Met Ed had operating revenues, net incomes, and assets as follows:

(in thousands)

	1978	1977
Operating Revenues	$310,581	$305,223
Net Income	$ 58,607	$ 58,832
Assets	$1,048,233	$687,606 22/

GPU's operating revenues, net income, and net assets for those years were:

(in thousands)

	1978	1977
Operating Revenues	$1,326,644	$1,252,013
Net Income	$ 138,774	$ 142,779
Net Assets	$3,449,660	$2,682,785 23/

19/ From the time it went commercial in September 1974, until the end of 1978, TMI-1 had a cumulative capacity factor (actual generation divided by maximum theoretical generation) of 76 percent - more than 15 percent above the national average. 1978 Met Ed Annual Report at 3, Accession #5310049.

20/ See Appendix D for chronology of NRC operating license review of TMI-2.

21/ For a discussion of TMI-2's "going commercial," see the "Going Commercial" section in this paper.

22/ 1978 Met Ed Annual Report at 1, 5, 6, Accession #5310049.

23/ 1978 GPU Annual Report at 19-20, Accession #6080794.

At the end of 1978 Met Ed employed 2,784 people. 24/ On March 28, 1979, there were 537 employees assigned to Three Mile Island.25/

The Generation Division of Met Ed, located in Reading, Pa., was responsible for nuclear and non-nuclear plants. The division was headed by John Herbein, vice president for generation, and had five departments: Engineering, Operations, Quality Assurance, Maintenance, and Administration. At the time of the accident, Gary Miller, the station manager for TMI, reported directly to Herbein.

BABCOCK & WILCOX

The Babcock & Wilcox Company, founded in 1867, manufactures and sells specialty-engineered industrial products, including fossil fuel and nuclear power systems. B&W has been involved in nuclear power systems since the beginning of the commercial nuclear industry in the 1950s.

In 1978, B&W merged with and became a division of J. Ray McDermott & Company, Inc. For 1978 and 1977, McDermott's operating revenues, net income, and assets were:

(in thousands)

	1978	1977
Operating Revenues	$1,293,711	$1,223,841
Net Income	$1,159,092	$ 191,642
Assets	$3,182,807	26/

In addition to the two nuclear steam supply systems (NSSSs) at Three Mile Island, B&W supplied the NSSS for:

- Duke Power Company's Oconee -1, -2, and -3;
- Arkansas Power and Light's Unit 1;
- Sacramento Municipal Utility District's Rancho Seco Unit;
- Florida Power Corporation's Crystal River -3; and
- Toledo Edison's Davis-Besse 1.

24/ 1978 Met Ed Annual Report at 1, Accession #5310049.

25/ Letter from Blake (Met Ed) to Gorinson (President's Commission), June 28, 1979.

26/ 1979 J. Ray McDermott Annual Report at 28,32. Fiscal Year 1979 was the first year that McDermott and B&W operated as one company, and therefore the above figures do not reflect B&W's operation results. Id. at 2.

Since Oconee-1, the first of these units to be completed, went on line in 1973, these nine B&W reactors have logged about 30 reactor-years of operation. At the time of the accident, B&W had contracts for 19 additional NSSSs, both in the United States and abroad.27/

B&W is the smallest of four American nuclear steam system suppliers. The others are General Electric, Westinghouse, and Combustion Engineering. While General Electric specializes in boiling water reactors, such as GPU's Oyster Creek-1 station, B&W, Westinghouse, and Combustion Engineering supply only pressurized water reactors (PWRs).

A formal contract for the supply of nuclear equipment and services between B&W and JCPL was executed effective as of Jan. 31, 1967. 28/ The contract set forth the basic scope of services required of B&W as the reactor vendor:

- Supply a chemical shim pressurized water reactor nuclear steam supply system having a base capacity of 2,446 megawatts, and certain auxiliary equipment.

- Assist the utility in obtaining all government authorizations necessary to permit construction and operation of the plant.

- Provide competent personnel to participate in public presentations of technical information.

- Assist the utility in preparing, staffing, and providing a training program.

- Provide the utility with copies of instruction books for installation, operation, and maintenance of equipment furnished by B&W, and provide on-site technical advice and consultation with respect to the NSSS.

- Provide technical assistance for equipment and systems preoperational testing, low-power testing, and NSSS performance testing.

- Provide all reactor internals (except for the fuel assemblies).29/

27/ Information in these paragraphs is taken from G. G. Zipf, "Introductory Remarks" at June 6, 1979, B&W press briefing, at 4-6; B&W Display Booklet at 3, 10; MacMillan deposition exhibit 68A.

28/ Contract, between Babcock & Wilcox and Jersey Central Power & Light, dated effective Jan. 31, 1967. Accession #1008000.

29/ Id. The contract called for delivery at the Oyster Creek, N.J., site. Once the site was changed, the contract was amended to require delivery at TMI-2. See Contract for Nuclear Equipment and Services, Amendment No. 1, accepted November 25, 1970, at 1.

Pursuant to the terms of the contract, as amended, JCPL was required to pay B&W $21,021,761.30/

The equipment delivery dates as spelled out in the contract, as amended, contemplated fuel loading by Dec. 1, 1972.31/

The nuclear steam supply system for TMI-2 was designed and manufactured by B&W's Lynchburg, Va., Nuclear Power Generation Division (NPGD), a part of B&W's Power Generation Group, headquartered in Ohio.32/

The nuclear steam supply system includes the core, the reactor vessel, the steam generators, the pressurizer, the reactor coolant pumps, and a variety of associated equipment in the reactor coolant system of the plant. The equipment supplied by B&W represented roughly 10 percent of the total cost of the TMI-2 plant.33/

The agreement between GPU and B&W for the supply of the TMI-1 reactor included an option for GPU on a second B&W nuclear reactor. That option was exercised in the building of TMI-2. As noted above, B&W's first proposal for the specifics of the TMI-2 plant was effective Jan. 31, 1967.

The NPGD is presently headed by John MacMillan, a vice president of B&W. The Engineering Department and the Customer Services Department (formerly Nuclear Services Department) had primary responsibility for design and construction of the TMI-2 nuclear reactor.

In addition to project managers assigned to the TMI-2 effort, B&W had a site representative, Leland Rogers, located permanently at TMI from 1972 on.

30/ The price term under the original contract was $21 million. The additional $21,761 was caused by the site change to TMI-2. See Contract for Nuclear Equipment and Services, Amendment No. 1, Article IV, at 1.

31/ Pursuant to Article III (A) (1) of the contract, the delivery dates for major items were set forth: pressurizer Jan. 1, 1971; steam generator #1, Feb. 1, 1971;e%reactor vessel March 15, 1971; and steam generator #2, April 15, 1971.

32/ B&W Display Booklet at 2-3; MacMillan deposition exhibit 68A.

33/ Letter from MacMillan (B&W) to Weaver (Committee on Interior and Insular Affairs, U.S. House of Representatives), May 21, 1979.

BURNS AND ROE

Burns and Roe, Inc., was incorporated in 1935 as a consulting engineering firm. 34/ The company currently has approximately 2,400 full-time employees and annual revenues around $100 million. In 1979 Burns and Roe was listed as the 11th largest engineer design-constructor in the country, 35/ and provided engineering consulting services for nuclear, fossil, and hydro-electric power plants. Burns and Roe has had major involvement as architect engineer in the following nuclear power plants:

- Phillipine Nuclear Power Plant;
- Clinch River Breeder Reactor Plant;
- Forked River Nuclear Power Plant;
- WPPSS Nuclear Project No. 2;
- Cooper Nuclear Station;
- Oyster Creek Nuclear Power Station; and
- Handford Electric Generating Project.

The company has been involved, to a lesser degree, in plant or system design and engineering for 61 other nuclear plants.36/

Burns and Roe served as the architect engineer for the TMI-2 project with primary responsibilities for the balance-of-plant design. 37/ Explaining the services generally provided by Burns and Roe as architect-engineer, Tom Hendrickson, assistant to the president, stated:

34/ Burns and Roe began operation as a partnership between Alan Burns and Ralph Roe in 1932. Shortly thereafter Burns left the firm, leaving Roe as sole owner of the company. Today, the company is solely owned by the Roe family. Hendrickson deposition at 81.

35/ Engineering News Report (ENR), "The ENR's largest 50 design-constructors," May 24, 1979, at 90. According to ENR, the ranking is "based on the design-and-construct plus design-only contracts, valued at estimated cost of project." Id. In addition to engineering design, Burns and Roe has the capacity to perform construction management tasks as well. Hendrickson deposition at 52.

36/ Burns and Roe Experience Record (1964-1977), Nuclear Power Experience, at 1-12, Accession #1008010.

37/ Burns and Roe has listed the following scope of service for TMI-2; engineering, design, construction, liaison, model making, quality assurance or quality control, plant test and startup, environmental impact statement, and procurement. Report Burns and Roe Experience Record (1964-1977) at i, Accession #1008010.

> Basically, we will perform as a service to the client anything the client requires and cannot or does not choose to do themselves, with the exception of the actual operation of the power plant or involvement of any kind as a utility.38/

More pointedly, Hendrickson commented during the Commission's investigation that the firm sold its "product by the yard." This mindset in effect triggered a process wherein Burns and Roe would design a particular system, send the design to the client for its review, then make whatever changes (generally minimal) the client wanted.

In March 1967 Burns and Roe was retained by JCPL, one of GPU's three operating utilities, to provide architect engineer services for the planned Oyster Creek-2. 39/ According to Hendrickson, JCPL had been a long standing Burns and Roe client.40/

A formal contract between GPU41/ and Burns and Roe was not executed until Oct. 9, 1975. 42/ The contract set forth the basic scope of services required by Burns and Roe as architect-engineer:

- perform preliminary engineering and site investigation;
- initiate plant licensing and assist in the preparation of the PSAR and Final Safety Analysis Report (FSAR);
- complete detailed engineering and design;
- provide engineering liaison during construction;
- assist in preparation of bid forms and evaluation and delivery requirements;
- establish a quality assurance program;
- contribute to project startup and testing; and
- prepare a spare parts book.43/

38/ Hendrickson deposition at 51.

39/ Caplan deposition at 9.

40/ Hendrickson deposition at 81. Burns and Roe served in the architect engineer's role, as a subcontractor to the General Electric Company, in the design of Oyster Creek-1. In the 1960s Burns and Roe performed studies for JCPL concerning load and future power generation needs. Hendrickson deposition at 82.

41/ The contract was executed by GPU as agent for JCPL, Met Ed and Penelec.

42/ Contract executed between GPU and Burns and Roe, Oct. 9, 1975.

43/ Id. at 312.

The contract, as signed, covered work begun on March 14, 1967. 44/ During the period between March 14, 1967, and Oct. 9, 1975, Burns and Roe performed engineering services pursuant to a work order. The work order for the most part, covered the same scope of service items agreed to in the 1975 contract. 45/ Under the terms of the contract, Burns and Roe was to be compensated on a cost-plus-fixed-fee basis.46/

In total, 8 years elapsed between the issuance of the work order and the signing of the formal contract. As early as Dec. 30, 1969, Burns and Roe expressed to JCPL its concern about not having a formal agreement where the duties and obligations of the respective parties would be completely enumerated. "We believe that completion of a definitive contractual arrangement for Three Mile Island Unit 2 will benefit both our organizations."47/

Asked why the contract had not been signed earlier, Stanley Caplan, formerly Burns and Roe's manager of proposals and contracts, stated: "We had been unable to get a response from Jersey Central to finalize an agreement."48/

While performing its services as the TMI-2 architect engineer, Burns and Roe was organized on a project management basis. Consistent with that structure, technical personnel were added on an as-needed basis to supplement the full-time project staff. 49/ The TMI-2 project was headed by a vice president of operations.

This investigation has focused primarily on Burns and Roe's involvement in three areas: control room design, selection of containment isolation criteria, and the site change from Oyster Creek to Three Mile Island.

44/ Id. at 1.

45/ GPU/Burns and Roe Contract, October 1975; Hendrickson deposition exhibit 3.

46/ Id. at 12.

47/ Letter from Caplan (Burns and Roe) to Williams (JCPL), December 30, 1968; Caplan deposition exhibit 69.

48/ Caplan deposition at 17.

49/ The bulk of all Burns and Roe personnel is assigned to one or more projects.

THE ROLE OF GENERAL PUBLIC UTILITIES SERVICE CORPORATION

NUCLEAR POWER ACTIVITIES GROUP

The design and construction of TMI-2 was the responsibility of General Public Utilities Service Corporation (GPUSC). 50/ Before the formation of GPUSC in 1971, the Nuclear Power Activities Group (NPAG) was responsible for the design and construction of nuclear power plants for the GPU companies.51/

NPAG was a group established within GPU in 1967 "... to try to give the utility more control over the nuclear project, both in terms of cost and scheduling and design features." 52/ The goal "... was to aggregate the company's (GPU's) competence in the nuclear field and ... not attempt to reproduce that same competence over and over in each of the subsidiaries in a complete sort of way." 53/ NPAG was to be responsible for the engineering construction management of the plants and ultimately for the technical backup during operation. 54/ NPAG was not created to operate GPU nuclear power plants. That function was left to the three GPU operating companies. It was the intention at the time NPAG was formed to establish eventually a service corporation.55/

NPAG had several divisions: Project Managers, Fuels, Safety, Consulting Specialists, Inspection and Test, and Administrative. 56/ NPAG's initial personnel came from Penelec, JCPL, and Met Ed and had some nuclear background. By 1969, there were about 20 people in NPAG, several of whom had been recruited from outside.57/ Louis Roddis,

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50/ Herbein deposition at 22; Dieckamp deposition at 36-40; Creitz deposition at 43-52.

51/ Klingaman deposition at 10-13.

52/ Neely deposition at 23. NPAG was a departure from GPU's practice with respect to the design and construction of fossil fuel plants, which had always been left to the operating utilities. Neely deposition at 22-23. Kuhns, who was at that time president of GPU, wrote the charter for NPAG. Neely deposition at 31.

53/ Dieckamp deposition at 11; see also Neely deposition at 8.

54/ Roddis deposition at 14.

55/ Id at 13-14, 117-119.

56/ GPU memorandum, March 18, 1968; Neely deposition exhibit 7.

57/ Roddis deposition at 16-21; Neely deposition at 11-21.

then president of Penelec, was given the additional position of director of NPAG. "It was my feeling that the nuclear plants should be, for all safety matters, under my direct responsibility. [At the time I left NPAG] [t]he only plant then in operation [Oyster Creek-1] was, in fact, under my direct responsibility."58/

Because of its limited personnel, NPAG relied on architect engineer expertise to a greater degree than originally planned.59/

Roddis testified:

> I think we did as good a job as anyone in the industry was doing in that time frame, although I was not satisfied with that job. We were extending ourselves to do a better job.
>
> You simply cannot put organizations together overnight.60/

Notwithstanding these staff shortages, NPAG, according to Ronald Williams,61/ undertook a number of design reviews for TMI-2: (1) the NSSS system (a review function primarily concerned with operation, maintenance, or accessibility of the plant); (2) the steam generators (reviewed largely from an accessibility-handling operations standpoint); (3) the pressurizer (reviewed for ability to handle some of the large equipment, for functional stress requirements, and for satisfaction of all code requirements); and (4) the control rod drive mechanism (reviewed from operator safety perspective, in effect rejected B&W design, eliminating seals and potential leakage paths, and the need for operators to get in and repair the equipment themselves.) 62/ Williams testified that the NPAG review was "more of a mechanically oriented review ... as opposed to a function or systems review."63/

Williams described how the design review was done:

> QUESTION: In the GPU or the Nuclear Power Activites Group design review .. of Burns & Roe or B&W proposed designs, would that ... be done by an acceptance on a component-by-component or system-by-system basis, or would it be done by selective rejection?

58/ Roddis deposition at 23.

59/ Neely deposition at 20-21, 24.

60/ Roddis deposition at 114.

61/ Williams served as a technical specialist within NPAG. He was principally involved in the design review of the TMI-2 NSSS and some activities associated with the balance of plant. Williams deposition at 4.

62/ Williams deposition at 5, 7, and 12.

63/ Id. at 7.

WILLIAMS: In the early days it was almost by exception. There were so few people. We had so few people that we delved into specific areas, and we treated things more by exception. If we liked it, we didn't say anything. If we didn't like it, we let them know about it.

But as time went on, we did develop a much more formalized review procedure, and eventually we ended up receiving, I think, most drawings, we selected which ones we really wanted to review, we received most drawings, most system descriptions, most procedures and things like that, and we reviewed them in a very structured fashion, so that they knew whether we liked it or not. It wasn't a matter of just hearing what we didn't like. We formally approved, or commented on, or agreed with the design that was being developed.64/

Williams added:

And in the early days with a smaller group, we had to be very selective in what we reviewed.

We try to review those things that we felt were most significant in our own judgment at least, and we try to review those things where we felt we may be able to contribute something, that the architect engineer may be lacking, and things like the operability kind of assessment and so forth.65/

The clear intent, from Williams' viewpoint, was to inject into the B&W and Burns and Roe designs the utility's perspective on operation, maintenance, and accessibility.66/

Yet an example where the review of a Burns and Roe design failed to inject Met Ed's perspective on maintenance was cited by TMI's General Office Review Board (GORB).67/ In an October 1977, GORB meeting there

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64/ Id. at 77-78.

65/ Id. at 90.

66/ Id. at 27. Although characterizing Burns and Roe design as typical for architect engineers, Williams indicated that there were a number of design items that lacked the utility perspective, hence requiring design changes. He attributed this lack of perspective to "designers ... not [having] operating [or] utility experience." Id. at 28. Williams discussed utility perspective in terms of: location of equipment, access, adequacy of space for maintenance or repair, etc. He did not discuss it in terms of system or plant philosophy. For an example of a system which has been criticized for poor access, see the Commission staff report on the condensate polishers.

67/ TMI GORB minutes (October 12, 1977); Finfrock deposition exhibit at 3.

was a presentation on TMI-2's readiness for operation: one of the subjects discussed was maintenance. The minutes of that meeting stated:

> Maintenance access is more difficult than at TMI-1 and is expected to result in longer outages with greater man-rem exposures. The staff is identifying these critical areas so that they may be (1) corrected at TMI-2 where possible and (2) avoided at Forked River.68/

Dan Shovlin, TMI's superintendent for maintenance, gave this presentation to the GORB. He testified he had not had input into the design review (he did not begin working for Met Ed until 1973); however, he thought Health Physics did have input into the review of the Burns and Roe design. In late 1978, there was discussion of changes to improve maintenance access. However, Shovlin testified there were no changes made, except introducing a trailer for a change area outside the equipment access hatch.69/

TMI-2's condensate polishing system was originally designed for the Oyster Creek site, a salt water location. The polishers were never modified to reflect the fresh water conditions at TMI.70/ In fact, the NPAG review of the condensate polishing system was minimal, if it occurred at all. Williams testified:

> In an area like condensate polishing -- and this is something that is in every plant that an architect engineer builds -- could very likely be an area that we would have reviewed very lightly, if at all, because of priorities in assessments on our own part of where we felt our people would spend their time best.
>
> I can't assure you that we looked at that very carefully back in 1972 or whenever the basis for the polishing system was established. I suspect it was earlier than '72. In fact, I know it was earlier than '72.71/

Although NPAG continued to provide technical assistance to the TMI-2 design; beginning in 1969 Met Ed took over the administration of

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68/ Id. at 2.

69/ Shovlin deposition at 98-99.

70/ See Commission staff report on Condensate Polishers and the section of this report on condensate polishers.

71/ Williams deposition at 90-91.

the project for some 18 months. 72/ In 1971, the project responsibility was transferred again to GPUSC which was formed from remnants of NPAG, Met Ed, and other utility people. 73/ The shifting in project responsibility from JCPL to NPAG to Met Ed and then to GPUSC further points out a lack of continuity in the management oversight of the design and construction of the TMI-2 facility.

In the spring of 1977, Booz, Allen, and Hamilton completed a management audit for GPU that was ultimately published as a report in May 1978. The report made the following recommendations:

- An evaluation should be made of the authority and responsibility of Met Ed functional officers with respect to GPUSC.74/
- Policies that define the respective roles and responsibilities of GPUSC and Met Ed in the design and construction of new facilities need to be re-evaluated and clarified.75/
- Communications between GPUSC and Met Ed need to be strengthened in project-related areas.76/
- The effectiveness of present systems [maintenance] is reduced by their somewhat limited application and use.77/
- An approach and formal program should be developed to improve the overall effectiveness of the maintenance systems at Met Ed.78/
- There is a wide disparity in the quantity and quality of plant operator procedure documentation and training programs.79/

72/ Report, Review of the Three Mile Island-Unit 2 Construction Project, prepared by Touche Ross & Co., for the New Jersey Department of Public Advocate, October 1978, at A-44. Accession # 6200000. See also letter, Travieso-Diaz (GPU) to Hansel (TMI Commission consultant) Sept. 21, 1979, at 1-30. Accession #1012020.

73/ Id., letter from Travieso-Diaz to Hansel at 1-30.

74/ A Review of Operating Efficiency and Management Effectiveness of Met Ed, Volume Ml, Management Summary; May 1978 at 3-5.

75/ A Review of Operating Efficiency and Management Effectiveness of Met Ed, Volume II, Functional Reports; May 1978 at 3-8.

76/ Id.

77/ Id. at 3-9.

78/ Id.

79/ Id. at 3-10.

- Formal guidelines and minimum standards should be developed to help ensure continued safe, reliable nuclear power plant operations.80/

GPU recognized the merits of the Booz-Allen recommendations and was aware of a need for stronger and deeper engineering capability. 81/ In the spring of 1977, with the recommendations in mind and in the belief that GPU's increasing proportion of capital investment in nuclear power plants warranted commitment of more technical resources, 82/ GPU President Dieckamp and GPU Chairman Kuhns assigned Robert Arnold the task of strengthening GPUSC.83/

At that time Arnold was moving from vice president of Met Ed to a new position as vice president for generation of GPUSC. 84/ He described the situation as it was when he took over in June 1977:

> We had, I think, for a few years prior to June of 1977, been in the stage of consolidation and solidification of what we had within the service corporation and were at the point where it was appropriate to take the next step.
>
> [I]f we look at that time period from 1967 to 1977, we had a number of major construction projects under way, and I think the new company, as it were -- I won't exactly call it a "fledgling" organization, but clearly an organization that was still building its capability, getting itself settled in place, -- had about all it could handle to properly manage the several major construction projects that were under way.
>
> So I see the division at that time between responsibility for operation and design and construction as being a matter of what was the appropriate way to focus those resources that we had available to us in light of the challenges we had and that any merging of them required... a larger in-house engineering capability before that merger would really add anything to the process of managing both design, construction, and operation.

80/ Id.

81/ Arnold deposition at 16-18.

82/ Id. at 12.

83/ Id at 14-15.

84/ Id. at 22.

> The service company wasn't in a position to provide more support than it had been [providing] upon call from the operating companies.85/

Yet the reason for having this separation between design and operating functions was not clear to Met Ed's vice president for generation, John Herbein: "I am not sure I understand completely, but that is the way we are organized."86/

When Arnold moved from vice president of generation at Met Ed to vice president of generation at GPUSC, GPU President Dieckamp charged him with forging a closer link between GPUSC and the operation of GPU's nuclear power plants:

> [T]he issue was a very real one to us. It was one that was emphasized by Herman Dieckamp when I went into the job of the need to couple together the operating plant experience with the plant design and to provide the kind of technical review of what was happening at the plant that was necessary to have the reliability of operation and safety of operation that was necessary.
>
> We ... established a procedure which we had a great deal of difficulty getting executed reliably, so I would not want to take too much credit for what it was, but a policy was set out and it is indicative of what we were putting into place as one of the ways to address this problem.87/

Arnold then listed a number of the mechanisms which he believed had a role at the time of the accident in integrating operating experience into the design review function:

- problem reports for plant upsets aimed at identifying design deficiencies;
- the General Operations Review Board;
- quality assurance;
- the Operations and Maintenance Committee;
- the Management Review Committee;
- licensee event reports;

85/ Id. at 25-26.

86/ Herbein deposition at 22.

87/ Arnold deposition at 68-69.

- a specific charge to the GPUSC director of generation operations, John Bachofer, to be aware of problems at operating plants;

- an outage analysis capability;

- the Commercial Operations Review Board; and

- heavy reliance on "problem reports and the other administrative devices" available to plant operators and others "to flag and correct design problems that were identified during the construction phase."88/

On his arrival at GPUSC, Arnold set out to build within the service company the capacity to do the basic design work for future nuclear power plant construction. That design work had been done outside GPU by Burns and Roe for TMI-2, but Arnold felt that having the design capacity inhouse would help GPU gain better management control over cost escalation, construction schedule delays, and plant availability.89/ "The product, the availability capacity factors, the operating experience of the plants were less than what we had desired and expected," he said.90/

During this process Arnold looked at the organizational approach to the same problems taken by other utilities, namely Duke Power, Baltimore Gas and Electric, and Commonwealth Edison.91/

Although by the spring of 1977 there had been no merger of the GPUSC design/construction function with the Met Ed plant operating function, the possibility of an eventual merger was in the background. 92/ In mid-1977, GPUSC and the three operating utilities began developing "common procedures, common policies that were taking us in the direction of greater coordination of those activities across the four companies 93/

By late 1978, Arnold and Dieckamp were actively discussing a merger of the design, construuction, and operation responsibilities into one organization. 94/ This concept was considered again at the beginning of 1979; however, there was no sense of urgency to implement the reorganization.

88/ Id. at 69-73, 76.

89/ Id. at 12-13.

90/ Id. at 11-12.

91/ Id. at 18.

92/ Dieckamp deposition at 16.

93/ Arnold deposition at 33.

94/ Arnold deposition at 32.

> ... [T]here are these kinds of little [impediments] all the way along to hinder you from doing it, but as I said, I don't think we felt at any point that the structure we had was inadequate or inappropriate. We rather felt that there were ways in which we wanted to improve it as we kept building toward the future.95/

After the accident, GPU filed with the Securities Exchange Commission to consolidate management with respect to all GPU nuclear power plants. In August 1979, a reorganization partially consolidated nuclear operations under Robert Arnold who was given the additional title of senior vice president, Met Ed. The reorganization established a Three Mile Island Generation Group under Arnold integrating GPUSC, Met Ed, and site management for TMI. Gary Miller stated that "[a]s far as Forked River, which was the primary purpose before the 28th, Three Mile Island is now the primary purpose of the organization. We have integrated organization."96/

Discussing the reorganization, Arnold said:

> In the weeks after the accident, a number of things were clear to us, I think. One was that it would be necessary, regardless of what the investigation showed [were the] causes of the accident, for GPU to demonstrate high visibility of the internal resources they had available to bring to bear on Three Mile Island activities and a structure which would insure those resources would, in fact, be applied to Three Mile Island.
>
> It is imperative that we give substance to our position that we have capabilities to proceed ... expeditiously.97/

Following the accident, GPU Chairman Kuhns and GPU President Dieckamp asked Louis Roddis to form and chair a committee98/ to review

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95/ Dieckamp deposition at 20.

96/ Miller deposition at 330.

97/ Arnold deposition at 222-223.

98/ The members of the group included: Dale Myers, former under secretary of the Department of Energy and former manager of the Apollo program for NASA; Paul Soderlind, retired chief pilot of Northwest Airlines; Chalmer Kirbridge, an independent science and energy consultant; David Lanning, professor of nuclear engineering at MIT; Thomas Sheridan, director of the Man-Machine Interface Laboratory at Massachusetts Institute of Technology; John Donlon, a retired Navy captain with background in nuclear submarine training; H. Donnelly, a retired lieutenant general of the Air Force and former operations manager, Atomic Energy Commission, Albuquerque, N.M.; Charles H. Elmendorf, retired assistant vice president of American Telephone & Telegraph Company; William Shoupp, retired vice president of research of Westinghouse Electric; Robert Laney, deputy vice president of Argonne Laboratory and former general manager of the General Dynamics Quinsey Facility.

selection and training and the man-machine interface in light of the accident. 99/ Roddis, currently an energy consultant and consulting engineer, had formerly been president of Penelec and had also headed GPU's Nuclear Power Activities Group when it was formed in the late 1960s.

At the time of the accident, GPUSC was providing the following services for the operating subsidiaries: computer services, certain engineering services, information transfer among the operating subsidiaries, policy guidance, and management of their finances and rate activities. These services could not be performed directly by GPU, the holding company, due to the requirements of the Public Utility Holding Company Act of 1935,100/ which is why the service company had been formed in the first instance.101/ All long-term planning for Met Ed was done by GPUSC.102/

BUDGET

The construction budget for TMI-2 was determined and controlled by NPAG/GPUSC. Met Ed, Penelec, and JCPL each contributed to the construction budget in proportion to their respective holdings in the project (50, 25, 25).

A review of Burns and Roe's board of director minutes 103/ reveals several instances where constraints were imposed on construction because of GPU budgetary and financial problems. For example, in 1976 and 1977 Burns and Roe submitted to GPU estimates of the cost of completing the engineering and design work on the project. 104/ Although agreeing that GPU expressed certain budgetary concerns, Burns and Roe

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99/ Roddis deposition at 40; see also 40-65 for discussion of this issue generally.

100/ 15 USC Sec. 79-792.

101/ Dieckamp deposition at 12-13.

102/ Creitz deposition at 12.

103/ The minutes have been reviewed by Commission counsel but the documents themselves have been withheld by Burns and Roe on grounds of confidentiality.

104/ Cobean deposition exhibit 111. Because of a claim of confidentiality, this document was marked for identification purposes only. The Commission does not have a copy. Warren Cobean, Jr. is vice president of the Project Operations Division, Burns and Roe.

Vice President Warren Cobean was not able to recall the specific causes for the GPU concern. 105/ Cobean indicated that although there may have been budgetary or cash flow problems in GPU, no work required of the project was cancelled: "All we had to do ... was not to start certain operations until the cash flow picture became clear to the client."106/

Leland Rogers, B&W site operations manager for TMI-2, stated that "TMI-2 construction length was affected by economics within [GPU]."107/ According to Rogers, during one 12-month period there was "... almost no erection work going on over in Unit 2, ... because there just wasn't enough construction workers assigned to the site at that time."108/ Rogers noted that the construction delay started when TMI-1 commenced commercial operations, and "GPU's available money for erection work on [TMI-2] was at a fairly low point ..."109/

Former Met Ed President Walter Creitz confirmed that the construction schedule for TMI-2 was in fact delayed due to budgetary constraints.

> It was a difficult period ... 1974 was the time we reduced our work force in some of our areas, and we just felt that we had to restrict our construction expenditures to some degree.
>
> It wasn't that we cut anything out of the project; it was just simply a matter of timing.110/

According to Leland Rogers, the delays in construction did not affect the quality of work, but only the continuity of work. He stated:

105/ Cobean deposition at 136. During 1976 and 1977 GPU expressed concern that Burns and Roe was not sufficiently cost conscious and was generally overly conservative in its engineering and design, thus adding to GPU's construction costs. A number of "examples" were cited, many of which, according to Burns and Roe, were subsequently proven to be invalid. Cobean deposition exhibit 114. Because of a claim of confidentiality, this document was marked for identification purposes only. The Commission does not have a copy.

106/ Id. at 141. According to Cobean, the only instance where there was in fact a delay was the institution of a program to incorporate engineering change memos into drawings. "It did not change the design, the design was there in the engineering memo and in the drawing." Id.

107/ Rogers deposition at 34.

108/ Id.

109/ Id. at 35.

110/ Creitz deposition at 55.

> ... When you stop or significantly slow down a project, it has been my experience that ... it usually takes twice as much time to make up for that delay, just because of getting started again and getting everybody writing their procedures and thinking about the particular work or doing the requirements in that thing.111/

Apart from construction budgets, GPUSC approved the operating budgets each year for Met Ed, Penelec, and JCPL. For example, TMI site management prepared an operating and maintenance budget and a capital budget that was presented first to Met Ed's Generation Division, then to GPUSC functional heads, then to Creitz, and finally to Dieckamp and Kuhns.112/ Creitz did not review the Met Ed budget before review by GPUSC. Dieckamp set down guidelines for Met Ed to follow in preparing its budget.113/

In June 1977, Robert Arnold, who had just moved from Met Ed to become vice president of generation for GPUSC, decided to retain a company named Catalytic to complete the small amount of construction work remaining on TMI-2. Catalytic replaced United Engineers & Constructors, Inc., (UE&C), which had done the bulk of TMI-2 construction.

In discussing why he made this decision, Arnold stated that UE&C was "principally geared to a large construction effort" and thus had little incentive to finish a project that was very near completion.114/

In June 1977, TMI-2 was approximately 95 percent completed; the type of work remaining was "more akin to maintenance work than to major construction effort."115/ Arnold felt that:

> .. we would be much further ahead to bring in a maintenance-type contractor who was a "fresh kid on the block," so to speak, whose incentives were to really finish up that work ... because of what it represented to them in ... additional business.116/

When Catalytic was given the contract to complete construction, it was also given a 2-year maintenance contract. Another reason for the changeover from UE&C to Catalyic was that labor union contracts for

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111/ Rogers deposition at 36.

112/ Arnold deposition at 294-296; Creitz deposition at 29-34.

113/ Herbein deposition at 69-77.

114/ Arnold deposition at 275.

115/ Id.

116/ Id. at 276.

maintenance work with Catalytic were cheaper than the union contracts for new construction with UE&C, even though the work was the same.117/

Arnold indicated that having a smaller organization like Catalytic come in to do the cleanup items at the end of a project was not unusual in the industry.118/ It had in fact been done at TMI-1; the maintenance organization retained in that case had been Crouse Company rather than Catalytic. When Catalytic was retained to complete TMI-2 construction in June 1977, it replaced not only UE&C on TMI-2 but also Crouse as maintenance contractor on TMI-1.119/

117/ Id. at 277.

118/ Id. at 276.

119/ Id. at 277.

SITE CHANGE

On Dec. 23, 1968, GPU President Kuhns announced a decision ". . . to defer construction of Jersey Central Power and Light's Oyster Creek 2 and to build, in its place, for 1973 completion, a second nuclear plant at Metropolitan Edison's Three Mile Island Station."120/ Burns and Roe's notes of the meeting stated that:

> It is a requirement that the minimum possible disturbance be made to the existing design, so as not to detract from the schedule. A design will be used, even though not optimum, provided it is adequate and can save time.121/

Incidental design differences from TMI-1 would be accepted.122/

According to Louis Roddis, then director of GPU's Nuclear Power Activities Group, the decision to change the location of the planned Oyster Creek-2 facility was prompted by labor problems. He stated:

> The problem was related to construction labor difficulties in the central New Jersey area at that time frame which were basically resolved after the Colonial Pipeline cases came to trial and were settled. It was just a very unfavorable labor climate to operate in.123/

James Neely, the Oyster Creek-2 project manager for JCPL during 1968, cited labor union "extortion" as the sole reason for the site change.124/

120/ Planning Meeting Minutes GPU, Dec. 23, 1968; Caplan deposition exhibit 68, at 1. At the meeting in which the change was announced representatives of the following companies were present: GPU, Met Ed, JCPL, Burns and Roe, B&W, Gilbert Associates, and United Engineers & Constructors, Inc.

121/ Burns and Roe Conference note 235, Dec. 26, 1968, at 3; Caplan deposition exhibit 67.

122/ Planning Meeting Minutes GPU, Dec. 23, 1968; Caplan deposition exhibit 68.

123/ Roddis deposition at 81.

124/ Neely deposition at 107. Other deponents stated that certain labor problems prompted the change. Dieckamp deposition at 102; Williams deposition at 16; Arnold deposition at 213; Klingaman deposition at 16-19.

Before the decision was made to change the site, Roddis and Kuhns commissioned an internal study of the economic, political, technical, and engineering factors that would have to be addressed if the site was changed. 125/ The study, which Roddis coordinated,126/ was to serve as a basis for the final decision to change the site.127/

In a November 1968 memorandum to Kuhns'128/ detailing the results of the study, Roddis briefly discussed the consequences of such a change: time (a delay); construction labor (no problem at TMI); cost (annual operating cost of TMI unit would be less); reliability (no difference); operating labor (possible annual $100,000 cost saving at TMI); ocean discharge (problems not overwhelming); site problems at TMI (manageable); constructor (should use same constructor for both TMI units); and public relations (local and state problems at either site were not insurmountable).129/

According to Roddis, a "minimum change" policy evolved from discussions among the major participants, including the two other operating companies involved in the site change process. 130/ "[The policy] seemed to be the best that could be done under the circumstances." 131/ In this regard, James Neely, president of Nuclear Power Consultants, Inc., stated that the idea of having TMI-2 totally redesigned by Gilbert Associates, the TMI-1 architect engineer, was considered and rejected for reasons of cost.132/ Roddis confirmed that a redesign by Gilbert had been considered, but denied that cost was a factor in rejecting that option. 133/ Roddis stated that there were discussions about whether or not to retain Burns and Roe, the Oyster Creek-2 architect engineer, as the TMI-2 architect engineer. According to Roddis, "[t]here was a clear feeling on the part

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125/ Roddis deposition at 85.

126/ Id. at 84.

127/ Id. at 85.

128/ Memorandum Roddis (GPU/NPAG) to Kuhns (GPU), Nov. 19, 1968; Neely deposition exhibit 10.

129/ Id.

130/ Roddis deposition at 89.

131/ Id.

132/ Neely deposition at 59, 61. Neely stated that no study was conducted to substantiate the rejection: " . . . it appeared to be obvious on the face of it that it was not economically feasible to discard the engineering work that had been done . . ." Neely deposition at 63.

133/ Roddis deposition at 90.

of all involved that to change the AE [architect engineer] at this stage would certainly have involved a delay . . . ."134/ Notwithstanding the decision to continue with Burns and Roe after the site change, it is clear that Roddis would have preferred Gilbert as the architect engineer for TMI-2:

> QUESTION: Which one is a better [designed] plant [TMI-1 or TMI-2]?
>
> RODDIS: TMI-1.
>
> QUESTION: Why?
>
> RODDIS: Gilbert is a better design engineer.
>
> would [you] have chosen Gilbert Associates?
>
> RODDIS: [I]f we did not have the time constraints of the delay incident to a complete new design, yes . . . .
>
> QUESTION: When you say that TMI-1 is a better designed plant [what do you mean]?
>
> RODDIS: Well, it has the feel in the plant of having been laid out with somewhat more consideration for the operator. For instance, I was looking, when I was out there a few weeks ago, at the purification system, the water cleanup system, the control panel is much more thoughtfully laid out, and the valve locations are near the things you are trying to control. The same unit in [TMI-2] is put together with much less thought to the operator being able to perform his functions easily 135/

134/ Id. at 93-94. Roddis also said, "For one architect engineer to pick up a design in midstream is a very difficult thing to do, and I am not sure that either of the companies involved would have felt that it was a professional engineering thing to do." Id. at 94.

135/ Roddis at 96-97.

However, at the time of the site change decision, according to Roddis, 75 percent of the engineering and design work required for Oyster Creek-2 had been completed. 136/ Moreover, the bulk of the major plant equipment (hardware items) had been ordered. 137/ In terms of actual dollars spent, Roddis thought the total amounted to $20 million.138/ Neely suggested $10-12 million.139/

In Roddis's view, cost considerations, such as the amount of money already spent on the engineering and design work, were not factors in the minimum change policy decision: "I don't think that entered into the question at all. The only question was one of time and the fact that some two plus years of engineering design had gone into it . . . ."140/ Neely's view was different: "The overall decision to move the plant with minimum changes was based on economic considerations."141/

As noted above, at the time the minimum change policy was adopted it was also determined that an "adequate" design, even though not "optimum," would be used.142/ Roddis explained that optimum ". . . in a form of a design is the least cost or the most efficient . . . ."143/ He felt that the Oyster Creek-2 design was adequate. 144/ Neely said that the use of the word "optimum" or "adequate" in the policy discussions had to do solely with economics.145/ According to Neely:

> You can design somthing that is adequate, or you can design something that is "hell for stout" . . . if you design something that is "hell for stout," you are wasting your money . . . . Optimum was not intended to mean that it was unsafe or that it was inadequate, but optimum from the standpoint of being ideally suited for that particular situation 146/

136/ Roddis deposition at 87.

137/ Id.

138/ Id. at 88.

139/ Neely deposition at 68.

140/ Roddis deposition at 90.

141/ Neely deposition at 72.

142/ See page 31, supra.

143/ Roddis deposition at 92.

144/ Id. at 93.

145/ Neely deposition at 157.

146/ Id. at 58-59.

Neely did suggest, however, that it would have been "ideal" to have duplicate plants at TMI. "It just is generally accepted practice that if you have two plant . . . duplicated on the site, you are in a much better position from the standpoint of overall operability and maintainability than if you have two different plants on the same site."147/

147/ Id. at 58-59.

ROLE OF MET ED IN DESIGN OF TMI-2

Although Met Ed is the primary licensed operator of TMI-2, it had a minimal role in the design of the plant.

As discussed in the previous section of this paper, soon after the site change to TMI-2, Met Ed proposed major control room design changes. However, due in part to the GPU "minimum change" policy, the Met Ed proposal was ultimately dropped.148/

Design questions raised by Met Ed were channeled on field questionaires or problem reports to GPUSC and from there to Burns and Roe or B&W at the discretion of the GPUSC project manager. A Met Ed report on a malfunction in the condensate polishing system in 1977, which closely modeled the initiating event of the March 1979 accident, was never sent to Burns and Roe149/ because of a GPUSC decision that no action was required, even though Burns and Roe was the designer of the system. The GPUSC decision was apparently made without reading the full report.

Operating reality was not adequately linked to design decision-making. GPU President Herman Dieckamp testified:

> I think Met Ed people did, to some degree, participate in the design reviews, even though I am sure that was not as extensive as . . . the operating people say they should have had.150/

Met Ed President Creitz added:

> There were opportunities for general input available during the period of construction, and yet I must admit that sometimes a person might observe a proposed change, and it could be too late; maybe it wasn't identified on the drawing. After it was installed, one might have said, you know, theoretically it makes no difference where you put that particular valve, but from a practical operating standpoint, it would have been a lot better to put it here instead of there. . . . I remember walking through the plant with Gary Miller and/or Jack Herbein, and various things might have been pointed out, like the valve example; this shouldn't be here, it should be here, or we should have done this, or we should have done that. I guess you learn from experience. Perhaps, it is just that man is not capable of putting down on paper the ultimate in what he would like to build. It does take a little practical experience.151/

148/ See the section entitled "Site Change."

149/ GPU Startup Problem Report 2490, Nov. 17, 1977; Miller deposition exhibit 111; see also the section on condensate polishers, infra; Arnold deposition at 72; Frederick deposition at 494.

150/ Dieckamp deposition at 53.

151/ Creitz deposition at 45, 47-48.

Engineering activities, including systems modifications, were handled by Burns and Roe, B&W, or GPUSC engineering with little involvement by Met Ed Generation Engineering. Engineering responsibility only shifted to Met Ed some time after TMI-2 went critical on March 28, 1978; but even then GPUSC continued to exercise some degree of control until the end of 1978.152/

Since the plant staff had minimal contact with Burns and Roe during the design and construction of TMI-2, when Met Ed was considering what architect engineer to retain for technical support after the unit was declared commercial, there was debate about whether Burns and Roe should be retained.153/

One factor that weighted against Burns and Roe was the lack of relationship between Burns and Roe and Met Ed.154/ Richard Klingaman, manager of generation engineering, indicated that Met Ed has a long-standing relationship with Gilbert Associates for its non-nuclear plants. In addition, Gilbert Associates had been the architect engineer for TMI.155/ Klingaman stated: "Speaking for myself, . . . I personally had a leaning towards using Gilbert Associates."156/

Louis Roddis, who served as director of NPAG, had earlier stated a preference for the services of Gilbert Associates. 157/ Despite those reservations Met Ed did ultimately enter into a continuing services contract with Burns and Roe for TMI-2.

152/ After a March 29, 1978, transient at TMI-2, a modification was made **in** the control room to provide some indication of position of the pilot-operated relief valve. This decision was solely GPUSC's. Seelinger deposition at 114-115; Klingaman deposition at 180-181.

153/ Memorandum from Cady (Burns and Roe) to Clowry (Burns and Roe), Aug. 12, 1977, Klingaman deposition exhibit 92.

154/ Other factors entered into this decision. See Klingaman deposition at 127-136.

155/ Id. at 120-138.

156/ Id. at 132.

157/ Roddis desposition at 96.

CONTROL ROOM DESIGN

DESIGN HISTORY

The design of the TMI-2 control room has been evaluated in the Commission staff report on control room design and performance. In this section of the paper, the history of the design as it evolved from the combined desires of Burns and Roe, B&W, GPU, and Met Ed is reviewed.

Howard Stevens, B&W's principal control room design engineer for TMI-2, gave this overview of the industry approach to control room design:

> [T]he utility industry is by nature a very conservative industry particularly where operation of the plant is concerned . . . [and] therefore, tends] to be somewhat slower in response to the state of the art for fear that in adopting the state of the art, they will create a problem in their ability to respond to the network, and so they tend to move slowly, and control room design is one of those areas in which they have traditionally moved slowly, and you will find more control room consoles throughout the utility industry which lean toward the concept that what was used at Three Mile Island, that is, the large pistol-grip switches to operate pumps and somewhat smaller switches to operate valves, simply because that is the way it was done before, and it worked, and with no motivation to change it and a risk involved in changing, they tend to stay with it.158/

158/ Stevens deposition at 31-32.

The design of the TMI-2 control room was the principal responsibility of Burns and Roe,159/ with varying contributions from Met Ed, JCPL,160/ GPU,161/, and B&W.162/

During the period 1967-1972 when the TMI-2 control room was being designed, there was no standard control room design in the industry.163/ The control room design was begun in the summer of 1967 by Edward Gahan, then lead instrumentation engineer for Burns and Roe on the Oyster Creek-2 project. At that time Gahan visited the Oyster Creek-1 plant "to go over the control room, to get the operators' opinions about what they liked and did not like, assistance in the development of criteria for control room layout."164/ The Oyster Creek-1 plant was a General Electric boiling water reactor while the Oyster Creek-2 plant (later TMI-2) was a B&W pressurized water reactor.

According to Gahan, the Oyster Creek operators told him to use compact switches, rather than large ones; use a different wiring access to the panels; be careful to group switches and instruments functionally; and maintain ease of operator access to the panels.165/

159/ Gottilla deposition at 16-17; Stevens deposition at 9, 19.

160/ JCPL's primary involvement was in 1967-1968 when the control room was being designed for Oyster Creek-2. See the design history discussion in the "Control Room Design" section.

161/ GPU's primary involvement in the control room design was principally through its Nuclear Power Activities Group. Roddis deposition at 30; Neely deposition at 45.

162/ Stevens deposition at 19. Documents received by the Commission very late in its investigation made serious allegations about deficiences in the quality control program of Bailey Controls Company during the last year and a half. Bailey is a division of B&W and supplied the control room computer and other equipment for the TMI-2 control room. Although there are no allegations that the original equipment supplied by Bailey during construction of the plant was not subject to adequate quality control, there is a suggestion that parts supplied to TMI-2 in the last year and a half were not adequately inspected. Because the documents were received too late for effective followup, they were transmitted to Victor Stello, director of inspection and enforcement at the NRC, with a request that the NRC follow up with an appropriate investigation. The documents have been accessioned under #1003005.

163/ Stevens deposition at 22; Gahan deposition at 24; Gottilla deposition at 21-22.

164/ Gahan deposition at 19, as corrected by Gahan's errata sheet.

165/ Id. at 36-39

Following that visit, Gahan prepared two alternative design layouts "to give the client his choice of the basic form of the control room, the layout and the panels. . . "166/ The two concepts for control panels that Burns and Roe submitted to JCPL, the Oyster Creek-2 operating company, were: (1) a "low console" version, and (2) a "combination bench board."167/

The low console was basically in the form of a double "U" (like the present TMI-2 control room design) with instruments and controls deemed essential for plant operation in low, waist-high consoles forming the inner "U" and the remainder of the controls mounted on vertical panels in the outer "U."168/ The combination bench board design placed most of the controls on a single set of panels instead of a double set.169/

Burns and Roe presented the two alternative designs to the client, but made no recommendation. 170/ JCPL/GPIJ representatives chose the low console design, 171/ apparently because of complaints and suggestions from the operators at Oyster Creek-1 where a combination bench board design was in use.172/

While designing the control room, Gahan indicated that in addition to client preferences, he considered general practices in the industry:

> Well, we normally keep abreast, if you will, of what the technology is, what type of control panels are being used, what layout features, and so forth. This is part of our ongoing duties, to know these approaches. We review them, pick out what we think -- which have good features, which have bad features, which to avoid.
>
> In other words we try to get the composite set of criteria from this source.173/

Gahan said that he read safety analysis reports (SARs) from other nuclear power plants, including Oyster Creek-1, as a source of "guidance and precedent."174/ Salvatore Gottilla, who succeeded Gahan as lead instru-

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166/ Id. at 19-200.

167/ Id. at 28.

168/ Id. at 29-30.

169/ Id. at 30.

170/ Id. at 30.

171/ Id. at 30, 34.

172/ Id. at 35-37; see also Gottilla deposition at 21-22.

173/ Gahan deposition at 22.

174/ Id.

mentation engineer, added that experience was also important in the sense of knowing basic requirements for the control room.175/ He stated that:

> . . . [W]e did . . . try to logically extend what we had known and done before on control rooms into some improved designs for this plant.176/

B&W had not been involved in TMI-l's control room design and assumed it would not be involved in the design for TMI-2.177/ Then, in early 1968, B&W received a drawing from Burns and Roe indicating that B&W would be responsible for supplying three panels for TMI-2's control room:

- o No. 3 -- Auxiliary Systems;
- o No. 4 -- Reactor Console; and
- o No. 14 -- Control Rods and In-core Monitoring.178/

In November 1968, B&W sent to Burns and Roe the design drawings for its training simulator and for the Rancho Seco control rooml79/ "for your information only should you consider merit in adopting features of this arrangement."180/ A month later B&W recommended that the Sacramento Municipal Utilities District (SMUD) simulator design actually be used for the Oyster Creek-2 control room.

175/ Gottilla deposition at 12-13. Gottilla could not recall any analysis of control room design with respect to its performance in any of the worst case accidents outlined in the Preliminary Safety Analysis Report or the Final Safety Analysis Report. Nor could he recall any discussion about whether the Bailey computer printer designed for utilization in the control room could perform under emergency conditions. Gottilla deposition at 209, 217-218.

176/ Gottilla deposition at 96.

177/ Stevens deposition at 45. According to Stevens, B&W's role in the TMI-1 control room was simply the supply of equipment to be used in the control room. Id. at 5.

178/ Id. at 5.

179/ That design had been developed jointly by B&W; by the Sacramento Municipal Utilities District (SMUD), which owned and operated Rancho Seco; and by Bechtel, an architect engineer. Stevens deposition at 6.

180/ Drawing submittal from B&W to Burns and Roe, Nov. 7, 1968; Stevens deposition exhibit 72. See also, Stevens deposition at 6.

> This is a compact arrangement and does require substitution of miniature . . . push button switches for the gun handle types. The primary advantage would accrue should operators take simulator training and is recommended by B&W Company.181/

Burns and Roe rejected the B&W recommendation for the following reasons:

- B&W had not explained how the simulator would be available for training.

- Formal operator training leading to operator qualification and licensing would be done at the power plant itself and not on t hr tiimi! hors.

- The design was not "general" enough to B&W plants. Differences from plant to plant would prevent B&W from designing a single set of simulator panels representing exactly the control features of each of its plants.

- Items found on actual control room panels, such as annunciators, were not present on the simulator panels.

- Instruments and controls on the B&W design were not of the "heavy duty type consistent with power plant design practice." 182/

In fact, Burns and Roe was wrong that formal training would not be done on the simulator. 183/ The stated reasons for Burns and Roe's rejection of the B&W design did not reflect any real depth of analysis or discussion between B&W and Burns and Roe.

In April 1969 Burns and Roe forwarded designs for panels 3 (Auxiliary Systems) and 4 (Reactor Console) to B&W, stating it was considering adding those panels to B&W's scope of supply and asking B&W for a bid. B&W won the bid and designed the panels; Burns and Roe then used them in concept but not in detail. 184/ B&W found the changes "functionally acceptable" and did not object.185/ In fact, both B&W and Burns and Roe

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181/ Blueprint, Auxiliary Systems Control Panel (B&W), July 23, 1970; Stevens deposition exhibit 83. See also, Stevens deposition at 7.

182/ Memorandum from Gahan Burns and Roe to Gottilla Burns and Roe, Dec. 27, 1978; Gottilla deposition exhibit 11.

183/ Every operator licensed for TMI-2 received training at the B&W simulator.

184/ Stevens deposition at 7-9.

185/ Id. at 9.

personnel generally agreed that in most instances the clients' preferences influenced their course of action. According to Gottilla:

> If we came up with the design and the client wanted to make a change and we disagreed with the design, . . . if the change did not lower the . . . engineering standard, or whatever . . . then there's no question we would adopt the client's way of doing it.186/

Neither Burns and Roe nor B&W consulted with any outside experts in human engineering in the aviation or space industry during the control room panel design process. 187/ In fact, Stevens expressed considerable skepticism about adopting aerospace technology to the utility industry.

When GPU made the decision in December 1968 to change the site of the nuclear plant,188/ it also made the decision to "minimize engineering changes and schedule delay." 189/ With that directive in mind, Gottilla and Gahan made minimal changes to control room design.190/

Then in early 1969, a request came from Met Ed to change the control room design to conform to TMI-1.191/ In a March 1969 meeting at GPU, representatives of Met Ed, GPU, Burns and Roe, and JCPL met to discuss whether to conform the two control rooms.192/

186/ Gottilla deposition at 35, as corrected by Gottilla's errata sheet. Stevens deposition at 9.

187/ Gottilla deposition at 96; Stevens deposition at 27. According to Stevens, aerospace concepts can be applied to power plants only in a very limited way; Stevens said that different philosophies in equipment usage in the aerospace industry (short-term) and the power plant industry (long-term) is but one example of the weakness in the comparison. Stevens deposition at 29.

188/ See the section entitled "Site Change."

189/ Burns and Roe conference note number 235 regarding site change to TMI-2, Dec. 26, 1968; Caplan deposition exhibit 67.

190/ Gottilla deposition at 78-80, 141-142; Gahan deposition at 51-53.

191/ Gottilla deposition at 58-59.

192/ Burns and Roe conference notes 273, March 18, 1969; Gottilla deposition exhibit 20.

Met Ed believed similarity in the control rooms would minimize operator confusion and error and facilitate cross-licensing. Burns and Roe and GPU took the position that having controls nearly but not quite identical could lead to operator error because of confusion over which control room the operator was in. They argued that to avoid such error, adjacent control rooms should be either exactly alike or so dissimilar that the operator was constantly reminded of which control room he was in.193/

Because of the cross-licensing issue, a call was placed to the Atomic Energy Commission (AEC) during the meeting in which an AEC representative confirmed that cross-licensing would be permitted between TMI-1 and TMI-2 even if the control rooms were different.194/

At the close of the meeting it was stated that JCPL and GPU would have the final word on control room design changes and that Burns and Roe should accept no proposed changes from Met Ed without prior approval of either GPU or JCPL.195/ The minimum change policy that had been announced at the Dec. 23, 1968, site change meeting was reemphasized.196/

Although testimony and documents indicate there was further discussion among Burns and Roe, B&W, GPU, Met Ed, and occasionally JCPL in the course of finalizing the control room design, no major changes were made subsequent to the meeting.197/

Shortly after the March 28 accident, legal counsel for Burns and Roe ordered a review of certain Burns and Roe designed systems to assess the firm's legal liability, if any.198/ The review covered the following

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193/ Id. at 2.

194/ Id.

195/ Id.

196/ Burns and Roe conference note 235, Dec. 26, 1968; Caplan deposition exhibit 67.

197/ Telephone conversation from Gottilla Burns and Roe to Bartman (Met Ed), Jan. 13, 1979; Gottilla deposition exhibit 15. Telephone conversation from Burns (JCPL) and Thomas (GPU) to Gottilla Burns and Roe, Jan. 13, 1979; Gottilla deposition exhibit 16. Memo from Williams (GPU) to Bierman and Neely Burns and Roe, March 14, 1969; Gottilla deposition exhibit 18. Conference Note 273 by Gottilla (Burns and Roe), March 18, 1969; Gottilla deposition exhibit 20.

198/ Hendrickson deposition at 101-102.

areas: (1) control room design; (2) containment isolation criteria selection process; (3) design of the containment building; (4) the safety features actuation system; and (5) the condensate demineralization system.199/

According to Tom Hendrickson, assistant to the president of Burns and Roe, the review ordered by counsel was the only review being made of Burns and Roe designed systems involved in the TMI-2 accident.200/ During deposition testimony Burns and Roe counsel instructed Burns and Roe witnesses not to answer questions about the substance of the internal review. 201/ The work product doctrine and the attorney-client privilege were cited as grounds for refusal to answer the questions.202/

DESIGN PERFORMANCE DURING THE ACCIDENT

Although Burns and Roe recognized a conflict between demands for more control room instruments and alarms on the one hand and the danger of overloading operators during an emergency on the other, the problem was never resolved. Gottilla said:

> We were concerned about the large number of alarms.
>
> J. J.
>
> As of late, the sheer numbers are becoming voluminous, and it represents a real problem. I don't know of any power plant design who [sic] has solved this problem.
>
> J.
>
> It's the kind of things [sic] that's endemic in power plant control room design. There is requirement for more and more information, and that requirement comes from the increased complexity of plants, the increased numbers of systems that we put on the plants . . . the requirements of the client . . . and the operators. . . .
>
> J. J. J.
>
> So these increased requirements inexorably lead to increased control room sizes and increased amounts of information.203/

199/ Id. at 103.

200/ Id. at 140.

201/ Id. at 145-149.

202/ Id.

203/ Gottilla deposition at 219, 222-224. See also, id. at 210.

Gottilla noted that there were several attempts by the client or by Burns and Roe to cut down on the number of alarms. Each attempt failed. In fact, more alarms were added.204/

Since the March 28 accident at TMI-2, there has been debate about the impact of the control room alarm system on operator response during the emergency, in particular about whether the alarm system aided the operators in their evaluation of the emergency or caused greater confusion.

Roughly one year before the March 28 accident, Edward Frederick, a TMI-2 control room operator, had written a letter to James Seelinger, TMI-2 superintendent for technical support, stating:

> The alarm system in the control room is so poorly designed that it contributes little in the analysis of a casualty. The other operators and myself have several suggestions on how to improve our alarm system -- perhaps we can discuss them sometime -- preferably before the system as it is causes severe problems.205/

Frederick explained in his deposition why he thought the alarm system was poorly designed and offered suggestions for improvement:

- The size of the printing on the alarm windows was too small to read easily.206/
- Alarms should not be acknowledged and cleared by the same button.207/
- There should be more than one acknowledgement button so that operators would not have to leave duty stations to acknowledge an alarm.208/
- The number of alarms needed to be reduced.209/
- A better method was needed for identifying alarms from remote panels.210/

204/ Id. at 210-211.

205/ Letter from Frederick (Met Ed) to Seelinger (Met Ed), May 3, 1978; Frederick deposition exhibit 17. Scheimann and Faust agreed with the point. Faust deposition at 221-223.

206/ Frederick deposition at 467.

207/ Id. at 469-470.

208/ Id. at 470.

209/ Id. at 471.

210/ Id. at 472.

- There was discussion about installing different audible alarm sounds for different panels in the control room.211/

- Lighting in the control room made it difficult to see some alarms even when flashing.212/

- When bulbs burned out in the alarm windows it was impossible to tell where the alarm was coming from.213/

Other than a brief note from Seelinger, there was no followup with Frederick on his concerns.214/

On March 28, several hundred alarms went off in the first few seconds of the accident.215/ Frederick, the control room operator on duty in the control room at the time of the accident, stated that "there were so many alarms that we had to go to other indications to determine the status of the plant."216/ In addition, Craig Faust, the other control room operator on shift that day, testified that he "would have liked to have thrown away the alarm panel," since "it wasn't giving us any useful information."217/

Besides the number of alarms, the TMI-2 operators had other difficulties with the control room design on March 28.

- One instrument reading that would have provided data to help determine whether the PORV had failed open was the temperature at the discharge point of the reactor coolant drain tank.218/ Yet this instrument was not visible from the main portion of the control room: ". . . you have to walk out around the panel and go behind panels that face the control room to actually read this adjacent panel."219/

211/ Id.

212/ Id. at 473.

213/ Id.

214/ Id. at 474-475.

215/ Frederick May 30, 1979, hearing testimony at 123.

216/ Id. at 176.

217/ Faust May 30, 1979, hearing testimony at 168.

218/ Zewe May 30, 1979, hearing testimony at 131.

219/ Id. at 131-132.

- Faust indicated that a diagram that showed the readings of in-core thermocouple temperatures would have been helpful.220/

- The in-core thermocouple readings went off scale in the control room. While the mere fact that they were off-scale was significant, actual temperature readings would have been considerably more helpful.221/

- The steam generator instrument level was in error during the accident.222/

- The computer alarm printer became inoperable for over an hour.223/

- The PORV position indicator, although functioning as designed, did not give the operator accurate information about the position of the valve.224/

220/ Faust May 30, 1979, hearing testimony at 164.

221/ Id. at 156. See the discussion of in-core thermocouples in the section of this report entitled "Understanding of Core Condition on March 28."

222/ Frederick deposition at 289.

223/ Frederick May 30, 1979, hearing testimony at 121.

224/ See the section of this report entitled "Identifying the Open Pilot-Operated Relief Valve".

CONTAINMENT ISOLATION CRITERIA SELECTION

Because of the release of radioactivity to the environment during the TMI-2 accident, the Commission investigated the criteria for isolating the containment building, since the purpose of containment isolation is to prevent radiation releases to the environment. The Final Safety Analysis Report (FSAR) for TMI-2 states that containment isolation is mandatory upon a high reactor building pressure of 4 pounds per square inch gauge (psig). 225/ The high pressure signal was the only containment isolation criterion in use at TMI-2 at the time of the accident.226/

The investigation, as documented in the Commission staff report on the transport of radioactivity from the TMI-2 core to the environs, found that the radiation release occurred primarily through the reactor coolant make-up/let-down system that is part of the containment isolation system. 227/ However, most of the radiation escaped through the make-up/let-down system after it had been deliberately "unisolated." As a result, the 4 psig criterion for containment isolation was not particularly significant one way or the other in the radiation releases during the TMI-2 accident.228/

Nonetheless, it is an important issue in terms of the thinking that went into the TMI-2 design. Containment did not isolate until almost 4 hours into the accident, 229/ which was substantially after significant radiation had been released into containment. 230/ Other isolation setpoints such as radiation levels or emergency core cooling system (ECCS) actuation would have isolated containment sooner, but were not in use. In a different kind of accident, the absence of the additional setpoints of radiation level or ECCS actuation could have been much more significant.

225/ Final Safety Analysis Report, Three Mile Island Nuclear Station Unit 2, Volume 5, Section 6.2.4, Containment Isolation System.

226/ Id.

227/ Commission staff report, "Transport of Radioactivity from the TMI-2 Core to the Environs," at ES-1.

228/ Id. at 10-1.

229/ Nuclear Safety Analysis Center (EPRI), Analysis of Three Mile Island-Unit 2 Accident, NSAC-1, July 1979, Sequence of Events at 34.

230/ Id., at 1-34. It should be noted that operator action in starting the reactor building ventilation system significantly delayed reaching the 4 psig setpoint, although it is not believed that the delay had a significant impact on the release.

At the time it was adopted, the TMI-2 single setpoint criterion met NRC regulations applicable to the TMI-2 plant.231/ Burns and Roe, B&W, and GPU were all involved in varying degrees in the selection of isolation criteria. One of the issues addressed in the investigation was how the 4 psig setpoint was selected and to what extent additional isolation criteria were considered.

BURNS AND ROE

According to Burns and Roe engineer Samuel Zwickler,232/ Burns and Roe's involvement in the selection of the isolation criteria and setpoint was only indirect.233/

Zwickler said the first step in the isolation criteria selection process was the submission of a proposal by B&W.234/ The B&W proposal stated that reactor building isolation should be actuated by a reactor building pressure of 10 psig.235/ Although Zwickler did not know the reasons that led B&W to propose the 10 psig setpoint,236/ the proposal was made as part of B&W's responsibilities in connection with the nuclear steam supply system. 237/

The next step, said Zwickler, was a review of the TMI-1 emergency core cooling system actuation criteria by the Advisory Committee on Reactor Safeguards (ARCS). In a Jan. 17, 1968, letter from the chairman of the ACRS to the chairman of the Atomic Energy Commission (AEC), the ACRS expressed concern about lack of diversity in the TMI-1 emergency core cooling system (ECCS) functions:

231/ Denton deposition at 159, Stello deposition at 132.

232/ Zwickler was the key Burns and Roe engineer involved in the selection of isolation criteria. According to Zwickler, Burns and Roe coordinated and supervised the preparation of the PSAR and FSAR for all the participants involved in the project.

233/ ECCS initiated at approximately 2 minutes--long before the first radiation release. See Nuclear Safety Analysis Center (EPRI) Sequence of Events, footnote 217, supra.

234/ Proposal No. A5-91, Outline, IC/Protection System, from B&W to Burns and Roe; Zwickler deposition exhibit 76.

235/ Id.

236/ Zwickler deposition at 17-18.

237/ Ward deposition at 13, 23-24. According to Ward, the 10 psig and later 4 psig setpoints were derived from B&W's involvement with the TMI-1 and Oconee plants. Id. at 23.

> The committee recommends that in the interest of diversity, another method different in principle from the one proposed [pressure in containment] should be added to initiate this function. The diversity thus achieved would enhance the probability that this vital function would be initiated in the unlikely event it is needed.238/

Although the ACRS letter addressed the TMl-1 ECCS criteria and recommended diversity for that system, it was, according to Zwickler, a part of the development of the isolation criteria for TMI-2.239/ At that time, the TMI-2 10 psig setpoint was designed to initiate ECCS as well as containment isolation. 240/ Moreover, according to Zwickler, GPU decided to apply whatever was being required by the AEC for TMI-1 to the development of the TMI-2 criteria.241/

The next step in the development of TMI-2 isolation criteria that Zwickler identified was the submission of the Oyster Creek-2 Preliminary Safety Analysis Report (PSAR) in 1968. The PSAR indicated that reactor building isolation would occur on a 4 psig signal in the reactor building, 242/ representing a change from the earlier 10 psig setpoint. The change was explained in PSAR Supplement No. 3, dated Dec. 2, 1968, which was in answer to an AEC question regarding the 4 psig setpoint for ECCS initiation.243/ Referring to the change and B&W's defense of a redundant signal, Zwickler explained that "4 psig [gave] them a reasonable time when the ECCS would be initiated, and since it was there already, it was also being used for containment isolation."244/

238/ Letter from Zabel (ACRS) to Seaborg (AEC), Jan. 1, 1968; Zwickler deposition exhibit 77 at 1-2.

239/ Zwickler deposition at 25.

240/ Id.; Mallay deposition at 41-43. Mallay is a senior engineer at B&W.

241/ Zwickler deposition at 27.

242/ PSAR for Oyster Creek-2, Section 5.2.1; Zwickler deposition exhibit 78. See also section from the PSAR regarding isolation system, March 10, 1969; Beisel deposition exhibit 2.

243/ Zwickler deposition at 30. Letter J. Miller (Met Ed) to P. Nardone (Burns and Roe) June 24, 1969; Zwickler deposition exhibit 79.

244/ Zwickler deposition at 30. In explaining the review process, Zwickler stated, in effect, that (1) GPU would submit to B&W any questions posed by the Atomic Energy Commission (AEC); (2) B&W would prepare a response; and (3) GPU would review the response and submit it in final form to the AEC. Id. at 32.

B&W

There were conflicting views within B&W regarding its role in the isolation criteria selection process.

James Mallay245/ asserted that B&W had a limited role in the selection of the isolation criteria and setpoint. Mallay testified that the containment system was Burns and Roe's responsibility, and that B&W was not involved in the decision-making process.246/

> . . . the only part B&W played in all of this was the supply of certain pressure-temperature relationships as a result of transients occurring inside containment. . . .247/

Yet Edwin Ward248/ and Wilford Beisel249/ acknowledged a more active involvement by B&W in the isolation criteria selection process.

According to Ward, GPU assigned B&W the task of preparing the section of the TMI-2 PSAR relating to containment isolation (section 5). Ward confirmed Zwickler's assertion that certain TMI-1 criteria influenced the course of action with respect to TMI-2.250/ B&W therefore incorporated the 4 psig setpoint into the draft of section 5 of the PSAR which was then circulated to Burns and Roe, GPU, and the consulting firm of Pickard Lowe and Garrick, Inc., for their comment and review.251/

Specifically addressing B&W input, Ward stated:

> The input that we had was largely that of supplying the same recommendations that had currently been going . . . through the

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245/ Mallay is currently the program manager for Brown-Boveri, a subsidiary of B&W. During the period 1971-75, Mallay was manager of licensing for B&W.

246/ Mallay deposition at 42.

247/ Id.

248/ Currently a B&W senior project manager; formerly served as the B&W assistant project manager for TMI-2.

249/ Currently vice president of B&W's Nuclear Equipment Division. Formerly served as B&W's TMI-2 project manager.

250/ Ward deposition at 13. Section 5.2 of the PSAR is entitled "Isolation System."

251/ Ward deposition at 24.

licensing process for TMI-1, namely that the isolation system would be actuated upon a 4 psig building pressure.252/

In fact, at the time of the TMI-2 accident, eight of the nine B&W plants in commercial operation within the United States had the same 4 psig setpoint.253/

Ward said that the issue of multiple criteria for TMI-2 containment isolation was not discussed during the early period of the design process :254/

> It never occurred to me that the system we were using was not satisfactory, and I suppose we may have been considering it satis- factory primarily because it was being approved by the AEC at that time.255/

Ward said that none of the groups participating in the isolation selection process raised doubts about the appropriateness of the criterion adopted.256/

Beisel confirmed Ward's assertion that it was probably B&W that first proposed the 10 psi and 4 psi setpoints for containment isolation. In fact, according the Beisel, the setpoint proposals were based on requirements of the nuclear steam supply system.257/

GPU

James Neely, the first TMI-2 project manager for GPU, said that the NPAG retained outside consultants to help with the design review of

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252/ Id. at 13.

253/ In the PSARs of the eight plants, the following appeared: "Reactor Building isolation occurs on a signal of approximately 4 psig in the Reactor Building." The plants were Oconee 1, 2, 3 (PSAR Vol. 1, Section 5.2.1); TMI-1 (PSAR Vol. 1, Section 5.2.1); TMI-2 (PSAR, Section 5.2.1); Crystal River 1 (PSAR Vol. 2, Section 5.4.1); Crystal River 3 (PSAR Vol. 2, Section 5.2.1); and Rancho Seco (PSAR Vol. 2, Section 5.6.1). The PSAR for the ninth plant, Davis-Besse 1, stated: "Containment isolation occurs on a signal of high pressure in the containment" (PSAR Vol. 2, Section 5.3.1).

254/ Ward deposition at 24.

255/ Id. at 27.

256/ Id. at 28-29.

257/ Beisel deposition at 46.

containment isolation criteria. 258/ Neely said consultants were necessary because the NPAG did not have enough expertise to do the job itself.259/

According to Neely, although the NPAG maintained an oversight role concerning the containment isolation criteria, it was the responsibility of Burns and Roe as architect engineer to select the signals and setpoints for containment isolation.260/ The setpoint selected was not "a major issue."261/

MULTIPLE CRITERIA AND THE NRC'S INVOLVEMENT

Neely indicated that during at least one meeting at GPU, he recommended that multiple isolation criteria be used to trigger containment isolation. 262/ Zwicker stated that he was not aware radiation signals were discussed or considered as a additional isolation criterion.263/ Beisel could not recall any discussions or suggestions of multiple-actuation criteria from any of the participants. 264/ Finally, Ward stated that "[u]ndoubtedly there were discussions and considerations [of multiple actuation criteria]," 265/ but could not recall any specific discussions or correspondence on the subject.266/

258/ Neely deposition at 111-112. Neely recalled that consultants from the firm of Mandell, Panoff and Rockwell (MPR) were retained to give the NPAG assistance in its containment isolation review. As noted elsewhere in this paper, from 1967-1968, the same period during which major design decisions were being made for the Oyster Creek-2 (later TMI-2) site, the NPAG was being formed. Yet it is clear that the NPAG had the lead or coordinating role in making design and engineering decisions for TMI-2 during that period. Memorandum from GPU, March 18, 1969; Neely deposition exhibit 7; memorandum from McElwain (JCPL), April 1, 1968; Neely deposition exhibit 8. See discussion of NPAG in the section of this report entitled "The Role of GPUSC."

259/ Neely deposition at 113.

260/ Id. at 112-114.

261/ Id. at 113.

262/ Id. at 114-120. Neely could not recall when or where the meeting(s) took place, or who was involved; id. at 109-110, 113-114.

263/ Zwickler deposition at 38.

264/ Beisel deposition at 51.

265/ Ward deposition at 26.

266/ Id. Ward said that he had not recommended multiple actuation signals for TMI-2. Id. at 27.

In 1975, the NRC adopted the Standard Review Plan (SRP). The SRP specifies in section 6.2.4, subsection 11.6, that "[T]here should be diversity in the parameters sensed for the initiation of containment isolation."267/

In a memorandum dated June 22, 1976, the NRC staff said that ". B&W plants do not satisfy [the diversity requirements of the SRP]."268/ In noting that B&W plants, in general, did not meet the SRP criterion, it was concluded that ". . . we plan to implement this acceptance criterion on B&W plants beginning with the Green County Nuclear Power Plant and BSAR 205 which is the B&W Standard NSSS design."269/

Although at the time the memorandum was written, TMI-2 was still 2-1/2 years from commercial operation. The SRP requirement of "diverse" signals for containment isolation was never imposed by the NRC on TMI-2.270/

267/ U.S. Nuclear Regulatory Commission, Standard Review Plan, Section 6.2.4, NUREG-75/087, 1975, at 6.2.4.5. See the Commission staff report on the NRC for a more complete discussion of the SRP.

268/ Memorandum from Shapaker (NRC) and Lainas (NRC) to Tedesco (NRC), June 22, 1976. Accession #1017016.

269/ Id.

270/ Final Safety Analysis Report, Three Mile Island Nuclear Station Unit 2, Volume 5, Section 6.2.4, Containment Isolation System. Additional investigation would be necessary to determine what, if any, discussions occurred between the NRC and Met Ed, GPU, B&W, or Burns and Roe on retrofitting the isolation diversity requirements of the SRP to TMI-2.

GPUSC STARTUP AND TEST GROUP

A GPU startup group managed the initial startup and all testing of TMI-2.271/

Procedures for tests required by the FSAR were approved by the Test Working Group (TWG):

> . . . in the balance of the plant and the station operations, there were many procedures and many tests that were carried out that had nothing to do with the primary plant or with the interface of the primary plant as such, and those did not go through TWG, and TWG had no responsibility for them.272/

TWG included representatives from GPU, Met Ed, B&W, and Burns and Roe. B&W and Burns and Roe only approved procedures for systems they had designed. 273/ The TWG process included a preliminary review of a test procedure and then a final review 2 weeks before the test was actually performed.274/

After the tests were performed, TWG would then review the results to determine if further testing was required.275/

Met Ed was granted the NRC operating license for TMI-2.276/ GPUSC startup personnel were not licensed so that they could not directly operate the plant.

> . . . At the time we [Met Ed) are granted the operating license, then although the testing is done under the supervision of the service company test engineers, the plant operators are responsible for all the conditions of the operating license, and as such, are deeply involved with plant operation.277/

271/ Miller deposition at 58.

272/ Rogers deposition at 33.

273/ Id. at 28-30.

274/ Id. at 29-33.

275/ Test Working Group Meeting minutes, Three Mile Island Station, May 7, 1974. Accession #9090028.

276/ JCPL and PENELEC are also named on the operating license.

277/ Herbein deposition at 35.

Prior to TMI-2 receiving its operating license on Feb. 8, 1978, the TMI-2 plant staff devoted its time to drafting procedures and to training.278/ From February 1978, TMI-2 staff took over on a system-by-system basis from GPUSC after testing had been completed on each system.

> On particular systems . . . turnover packages were prepared which not only documented any outstanding deficiencies at the time the system was formally accepted, but contained technical information relative to tests that had been performed of an electrical nature, such as hydrostatic testing and so on. These packages then were reviewed by Plant Engineering in the various technical disciplines, such as Instrument Control and Electrical. Any concerns or comments were reviewed to our mutual agreement prior to formally accepting a system for operation.279/

278/ Id. at 29; see also, Klingaman deposition at 40-42.

279/ Herbein deposition at 33.

GOING COMMERCIAL

"Going commercial" is an elusive concept. This investigation has discovered part of the story of TMI-2's going commercial on Dec. 30, 1978, but many questions remain unanswered.

For instance, the legal staff knows going commercial was not connected with the generation of electricity since TMI-2 first generated electricity on April 21, 1978, and also had been selling electricity for about 2 months before it went commercial. 280/ It also knows that once a plant has been declared commercial it enters the utility's rate base.

Going commercial appears to have been the unilateral decision of the utility, yet it is unclear whether there were threshold requirements imposed by the economic regulatory commissions for a finding by Met Ed that TMI-2 could go commercial.

Although there are apparently rate base consequences and federal tax consequences connected with going commercial, the staff found no objective standard that defines what conditions must be present for a plant to go commercial.

Neither a financial consultant to the Commission, Martin Whitman, nor the legal staff's investigation established decisively a connection between going commercial before the 1978 year end and the accrual of $55.1 million in federal tax benefits.281/

Accordingly, while this section sheds some light on the issue of going commercial it is by no means a complete treatment and further investigation is necessary.

TMI-2 was declared commercial on Dec. 30, 1978, 3 months before the accident. Eight days after the accident, Public Citizen, a Ralph Nader group, published a report, "Death and Taxes: An Investigation of the Initial Operation of Three Mile Island No. 2,"282/ asserting that GPU rushed TMI-2 into commercial operation before its safety was assured to accrue certain tax benefits. That analysis argued that:

- o TMI-2's operating history from March 28, when the unit went critical, to Dec. 30, 1978, when the unit was declared commercial, was ridden with problems.

280/ Met Ed Monthly Operating Report, May 11, 1978. Accession #9100021.

281/ $30.7 million was taken in depreciation and $24.4 million as a investment tax credit by GPU for the 1978 tax year. Letter from Gentieu (GPUSC) to Whitman (Commission consultant), Aug. 30, 1979.

282/ Bancroft, Stulberg, and McIntyre, "Death and Taxes: An Investigation of the Operation of Three Mile Island No. 2," April 5, 1979.

- Federal tax laws allow GPU investment tax credits and depreciation deductions provided TMI-2 was in commercial operation in 1978.

The report questioned whether TMI-2 would have gone commercial in 1978 but for the tax incentives.

There is disagreement whether accrual of tax benefits is specifically tied to the event of going commercial. GPU relies on Revenue Ruling 76-428 which states, in relevant part:

> A nuclear electric generating unit is first placed in service for investment credit and depreciation purposes when the unit is physically and legally placed in the control of the owners by the contractor and is fully operational, even though it is still undergoing testing to eliminate any defects and to demonstrate reliability.

Based on that revenue ruling, GPU argued that by the end of 1978 it had met all the necessary requirements for taking investment tax credits and depreciation, regardless of whether the plant was in so called commercial operation by the end of the year. Therefore, GPU is of the opinion that 1978 for GPU to have taken the $55.1 million in tax benefits, and that the timing of going commercial was irrelevant to the tax issue.283/

Robert McIntyre, one of the authors of "Death and Taxes: An Investigation of the Initial Operation of Three Mile Island No. 2," distinguishes the above revenue ruling from TMI-2's situation. The facts in the revenue ruling were that the unit only had minor testing remaining, was shut down due to a surplus of electricity, and was fully and permanently hooked into the customers' grid; McIntyre, however, pointed out TMI-2 in that it had major testing to do and was not permanently hooked into the grid.

The Commission retained Martin Whitman to review the financial issues associated with TMI-2's going commercial. Whitman's analysis -- a summary of which is attached as Appendix F to this paper284/ -- concludes that GPU's financial condition was sound independent of the $55.1 million in tax benefits that accrued as a result of TMI-2's being declared commercial in 1978. In fact, Whitman's report states that if tax credits and depreciation were not taken in 1979, the penalty for that delay would only be interest on the aggregate tax benefit; the benefit itself would not be lost but rather delayed.

GPU had anticipated declaring TMI-2 commercial prior to Dec. 30, 1978. In March, Met Ed reported to the NRC that TMI-2 would go

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283/ See discussion in report of Martin Whitman (a financial consultant to the Commission) at 45.

284/ Letter from Whitman to Commission, Sept. 18, 1979.

commercial by May 30, 1978.285/ Then in August, Met Ed notified the NRC that the unit would go commercial on Nov. 1, 1978.286/ In October, the date for going commercial was changed to Nov. 26, 1978.287/ In November, Met Ed set the date for commercial operation as Dec. 1, 1978.288/ On Dec. 15, 1978, Met Ed informed the NRC that TMI-2 would be commercial on Dec. 31, 1978.289/ These delays were caused by outages for repairs and startup testing. Burns and Roe's monthly progress reports for June, July, and August 1979 also indicate commercial operation dates earlier than Dec. 30, 1978.290/

Met Ed President Creitz testified that during 1978 he had believed that to use the depreciation allowance in 1978 it would be necessary for TMI-2 to go commercial before the end of the year.291/ But despite that understanding Creitz said he felt no pressure to declare TMI-2 commercial before the end of 1978.292/ Since the accident, GPU has stated that tax benefits were not dependent on TMI-2's going commercial. On the same issue, Gary Miller said:

> It was not indicated to me that the unit had to go commercial in 1978. I always believed in my mind that the company wanted it to go commercial in '78, and I would be less than honest if I said otherwise.
>
> But, I would have had no reservation about the unit not going commercial, no matter what the cost.293/

GPU had also indicated to Burns and Roe its desire to have TMI-2 commercial during 1978, according to Warren Cobean, vice president of Burns and Roe.294/ "They [GPU] made it very clear to all project participants that this objective (commercial operation in 1978] should be made, if at all possible," Cobean said.295/

285/ Met Ed Monthly Operating Report, March 11, 1978. Accession #9100021.

286/ Met Ed Monthly Operating Report, Aug. 10, 1978. Accession #9100021.

287/ Met Ed Monthly Operating Report, Oct. 9, 1978. Accession #9100021.

288/ Met Ed Monthly Operating Report, Nov. 15, 1978. Accession #9100021.

289/ Met Ed Monthly Operating Report, Dec. 15, 1978. Accession #9100021.

290/ Monthly Progress Reports (Burns and Roe), June 1978 - August 1978, January 1978; Cobean deposition exhibits 115-118.

291/ Creitz deposition at 62.

292/ Id. at 63.

293/ Miller deposition at 196, as corrected by Miller's errata sheet.

294/ Cobean deposition at 157-158.

295/ Id. at 158.

To GPU, taking TMI-2 commercial was: (1) an accounting event for Pennsylvania Utility Commission rate purposes and possibly for federal tax purposes; (2) an occasion for a final review of Met Ed's technical and organizational readiness for operation; and (3) the point at which TMI-2 shifted over from the GPUSC construction budget to a Met Ed operating and maintenance budget.

GPU organized the Commercial Operation Review Board to determine whether TMI-2 was ready to be declared commercial. Its membership consisted of corporate management from GPU's four subsidiaries. 296/ There was no regulatory requirement for the establishment of this board. It was apparently a management tool used by the utility at its own initiative. Whether the board's review was designed to place GPU in line for a favorable ruling on taking federal tax benefits in 1978 is a question this investigation cannot answer but which may be worth further inquiry.

It is clear that only when a generating plant is declared commercial can a utility enter that plant into its rate base. When a utility enters a plant into its rate base it begins to recover the capital and operating cost of the plant, plus some margin of profit from its customers. The costs incurred from the construction of TMI-2 only entered Met Ed's rate base once the unit was declared commercial on Dec. 30, 1978.297/ Yet the role, if any, economic regulators -- the Pennsylvania Public Utility Commission (PUC) -- played in determining that TMI-2 was ready to be declared commercial is unknown.

The review board had established certain general criteria to determine TMI-2's technical and organizational readiness. 298/ For instance, the board was to review the TMI-2 staff; the standards of the review, however, were vague and subjective: the staff was to be "sufficient [in number] to support continuous operation, routine maintenance and security. . ."

296/ The board was composed of R. Arnold, GPUSC vice president for generation; J. Bachofer, Jr., GPUSC manager for generation operations; R. Conrad, Penelec vice president for generation; 1. Finfrock, Jr., JCPL vice president for generation; J. Herbein, Met Ed vice president for generation; W. Hirst, GPUSC manager of projects; and R. Wilson, GPUSC manager of engineering.

297/ Dieckamp deposition at 104-106.

298/ Creitz "...was aware of the criteria and not being a generating station type of person or mechanical engineer, I found nothing to be critical of; it seemed like a reasonable approach." Creitz deposition at 60. GPUSC Manual, October 1978; Finfrock deposition exhibit 2.

and "training satisfactorily completed" per Met Ed's plan. The criteria were set out in four single-spaced pages and covered every aspect of plant operation; yet they were all reviewed in a one-day meeting on Oct. 26, 1978. A review of the four-page outline, the format of the meeting, and the time spent suggests that the review was pro forma and that no independent check of the information presented by site management could have been made by the board.

At that meeting the operating company made a presentation covering the subjects specified in the four-page listing of criteria. That presentation included a review of TMI-2's operating history which contained the following:

> On March 28, 1978, TMI-2 went critical. The next day the reactor tripped, the PORV opened, and the emergency core cooling system actuated. On April 8 TMI-2 again went critical. In the next 15 days the reactor tripped four more times, the last trip on April 23 resulting in a 4-month shutdown to replace steam relief valves.299/ Criticality was again achieved on Sept. 17, and 3 days later the reactor tripped again, the sixth trip in about 19 days of critical operation since March 28, 1978.
>
> The reactor tripped **six** additional times before the unit was declared commercial 4 months later. This operating history indicates that TMI-2 experienced 12 accidental reactor trips, 4 that activated ECCS, from the time it first went critical until it was declared commercial .300/ This history has not been compared to startups at other plants to determine whether it is usual or unusual.

James Floyd, supervisor of operations, made the presentation concerning TMI-2's operating readiness to go commercial, telling the board

> I was supervisor of operations for the [TMI-1] Startup and Test Program as well as during the first year of commercial operation. Based on that experience it is my judgment that [TMI-2j can be commercially operated safely and efficiently.301/

299/ See complete discussion of the April 23 transient later in the report.

300/ As of the Oct. 26 meeting of the review board, nine reactor trips had occurred. Three more occurred between that date and Dec. 30. See Appendix E.

301/ GPUSC Manual, October 1978; Finfrock deposition exhibit 2 at 134.

In addition, when Miller and Herbein were shown this operational history, they testified that they did not consider it unusual.302/

A list of action items was prepared as a result of the Oct. 26, 1978, meeting. The items included: insurance certificates, fire inspection deficiency, security system emergency access, test completion and evaluation, water treatment make up system, and NSSS versus turbine generator capability. A subcommittee was established to review the balance of the test program prior to declaring TMI-2 commercial.303/

The subcommittee noted the following items concerning TMI-2's operation: reactor power was limited to 2,690 megawatts since reactor coolant flow instrument reading was low; the ability of the condensate polishing system's deep bed demineralizers to remove sodium was limited; There were unresolved problems with the heater drain pumps and operational and design difficulties with the water treatment system.

It appears that from TMI-2 management perspective, going commercial was simply an accounting term of art. Declaring TMI-2 commercial had no effect on the operation of the plant since prior to Dec. 30, 1978, TMI-2 has been generating and distributing electricity. Gary Miller wanted to ensure that the responsibility for open items that existed prior to declaring the unit commercial was placed with GPUSC since once the unit went commercial it transferred the GPUSC construction budget to Met Ed's operating and maintenance budget.304/

At 11:00 p.m. on Dec. 30, 1978, the last business day of the year, TMI-2 was declared commercial by the subcommittee of the Commercial Operations Review Board. Despite the determination that TMI-2 was technically and organizationally ready to be declared commercial, Gary Miller told a senior level management meeting just 2-1/2 weeks later that there were morale and management problems at TMI-2: "Communication and understanding of our management goals, objectives, and actions taken to achieve them is not understood adequately internally or externally." 305/ Miller made this statement at the Jan. 18, 1979, nuclear plant management review meeting.

302/ Miller deposition at 187-188; Herbein deposition at 44-45. The Commission staff has not analyzed TMI-l's operational history before it was declared commercial, so it cannot state whether TMI-2 history is unusual compared with TMI-1 or, for that matter, any other nuclear power plant.

303/ Report of Review Board for the Determination of Organization Readiness for Placing Three Mile Island Unit 2 into Commercial Operation, Oct. 26, 1978; Miller deposition exhibit 112.

304/ Miller deposition at 190-196; Herbein deposition at 38-41; Creitz deposition at 57-58.

305/ Report -- TMI-2 Nuclear Plant Management Review, Jan. 18, 1978; Finfrock deposition exhibit 11. See complete discussion in the next section on "Site Perception of non-Site Management."

In summary, what the term "going commercial" means is unclear. The following questions are still unanswered:

- What the effect was of having TMI-2 enter Met Ed's rate base.
- What the PUC's role was in declaring TMI-2 commercial.
- Whether TMI-2 had to be declared commercial in 1978 for GPU to accrue certain tax benefits in that year.
- Whether the Commercial Operations Review Board was to be used in support of GPU requesting a tax opinion.

If an inference can be drawn that there was a rush to place TMI-2 on line, it must be drawn from its operating history during all of 1978, not merely the Dec. 30, 1978, event. There is sufficient ambiguity in the Internal Revenue Service (IRS) rulings governing the taking of investment tax credits and depreciation that it is quite possible and even probable that the utility management pushed hard for TMI-2 to be declared commercial by the end of 1978 in order to strengthen its bargaining position with the IRS.

Walter Creitz's and Gary Miller's statements both point in that direction, as do the statements in the monthly operating reports and monthly progress reports cited earlier. However, a final answer would require more investigation.

MANAGEMENT RELATIONSHIPS WITHIN THE UTILITY

GPUSC AND MET ED GENERATION

Both Met Ed and GPUSC had generation divisions. Structurally, the Met Ed vice president for generation reported to the president of Met Ed. In reality, however, a close working relationship existed between Met Ed generation and GPUSC generation senior management levels; such a relationship did not exist at the lower structural levels. The relationship at the top was attributable in part to the fact that GPUSC's vice president for generation, Robert Arnold, had previously been Met Ed's vice president for generation and had a strong working relationship with John Herbein, Met Ed's current vice president for generation.306/

Arnold described his relationship with Herbein:

> [F]rom a generalized view, I would describe my relationship to Jack as typical of a corporate staff functional head to a line functional head, to the equivalent line head in that same functional area.
>
> It was formally promulgated as policy by GPU management that the vice president of generation of the service company was responsible for policy development with regard to operational matters at power plants. . . .307/

Arnold held quarterly staff meetings for the generation divisions of the three operating companies that "primarily focused on technical issues and concerns related to generating plant operations which primarily led to improved efficiency and effectiveness of operation."308/

In addition, Met Ed's president, Walter Creitz, 309/ had no background in nuclear generation. For example, on March 28, Creitz asked George Kunder and Gary Miller ". . . to keep me posted on changes in conditions, I certainly didn't attempt to give any technical instructions. "310/

306/ Arnold deposition at 220; Dieckamp deposition at 67-80.

307/ Arnold deposition at 218-219.

308/ Herbein deposition at 21.

309/ On Aug. 29, 1979, Walter Creitz was relieved of his duties as president of Met Ed, and Dieckamp was made acting president until a search committee finds a replacement. Philadelphia Inquirer, "President of Met Ed Resigns Post," Aug. 30, 1979, at 1.

310/ Creitz deposition at 97.

Further, Creitz has had minimal involvement with the recovery efforts since "Again, this is not my technical background. I have to rely on other people like Jack Herbein and Bob Arnold."311/

Gary Miller also had more substantive interaction with GPU President Dieckamp than with his own Med Ed President Creitz. He contacted Dieckamp once or twice a month in accord with Dieckamp's ". . . policy of staying current on problems in nuclear and the people within the nuclear facility." 312/ In contrast, Miller's contact with Creitz was usually at ceremonial functions. Miller could not recall whether Creitz participated in the Nuclear Plant Management Review Committee meetings313/ although he was sure Creitz would have attended those meetings since presidents of all GPU companies were there.314/

Met Ed, the NRC licensee for TMI-2, had the legal responsibility for the safe operation of the plant.315/ Yet practical control in many ways rested with GPUSC.

GPUSC, MET ED, AND TMI ENGINEERING

One of the divisions within the generation organizations of GPUSC and Met Ed was engineering. There were three separate engineering organizations that provided technical support to TMI-2. TMI-1 and TMI-2 each had a superintendent for technical support with a staff responsible for mechanical, instrumentation and control, electrical, and nuclear disciplines. Met Ed maintained a separate engineering department in Reading, Pa., under the direction of Richard Klingaman, its manager of generation engineering. Finally, GPUSC had an engineering division in Parsippany, N.J.

The site engineers were perceived as "diagnosticians" 316/ in the sense that GPUSC and Met Ed only provided off-site support to TMI when a problem had first been identified by the site engineer. Yet, George Kunder, superintendent for technical support, TMI-2, did not think of

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311/ Id. at 106.

312/ Miller deposition at 201.

313/ The Nuclear Plant Management Review Committee was a committee established by Dieckamp that annually visited each GPU nuclear plant to keep corporate management aware of plant activities.

314/ Miller deposition at 200-202.

315/ Jersey Central Power and Light and Pennsylvania Electric were also listed as licensees on the operating license issued by the NRC, although Met Ed had the primary responsibility for operating the plant.

316/ Arnold deposition at 29.

himself in that way. "I pretty much had the problem areas identified to me by others. . . . basically, I became aware of the problems through various mechanisms and assigned [the problem] to my engineers. . . ."317/ Problems would be identified by operators, maintenance personnel, a vendor, or NRC bulletins and circulars. 318/ At the TMI-2 plan-of-the-day meeting 319/ attended by the unit superintendent and representatives from operations, maintenance, quality assurance, and health physics, Kunder would also be informed of problems.320/

Once a problem was identified, work related to it could be completed by either the site, Reading, GPUSC, or a vendor, depending upon the complexity of the problem. As Klingaman described the relationship, Three Mile Island is ". . . staffed at a level that is not meant to have enough technical support for each and any problem that might occur. Therefore, it is within the purview of the management personnel at the site to request help if a problem exists and they need technical support." 321/ Site personnel would first seek assistance from Reading which was "also staffed with a finite amount of resources and personnel and expertise." 322/ If Reading could not perform the requested task, GPUSC would be contacted; 323/ although it had certain expertise that TMI and Met Ed did not have, it also had limited resources. Klingaman said GPUSC "may or may not have a sufficient amount of talent or the right type of talent for that type of problem and we may have to go outside to contract for that support."324/ Site engineers were responsible for

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317/ Kunder deposition at 28.

318/ Id. at 32.

319/ See the earlier discussion of the role of GPUSC.

320/ Kunder deposition at 27. TMI-2's engineers were organized as follows: one lead electrical engineer with one engineer reporting to him; one lead mechanical engineer with two engineers reporting to him; one lead instrumentation and control engineer with two engineers reporting to him; and one nuclear engineer.

321/ Klingaman deposition at 116.

322/ Id.

323/ For instance, core physics specialists were only located in GPUSC, and GPUSC operated the material and chemical testing laboratory facilities in Reading. Klingaman deposition at 118; Herbein deposition at 24.

324/ Klingaman deposition at 117.

ensuring that any changes in procedures, drawings, the FSAR, or preventive maintenance procedures resulting from modifications were completed, regardless of who did the work.325/

The Met Ed engineering department was responsible for the technical support of all Met Ed generating stations, and for off-site review of engineering changes. 326/ Of the 20 employees assigned to the Met Ed engineering staff, none was a nuclear engineer, 327/ although more than 75 percent of Met Ed's generating capacity was nuclear.

Met Ed engineering was also required to review major changes in safety-related systems in order to make an independent safety analysis of the changes recommended by the plant staff. If Met Ed engineering agreed that a change was minor, there was no need for an independent safety evaluation. That agreement could be secured by telephone.328/

The GPUSC engineering department concentrated most of its efforts on the construction of new power plants. It was also available for support to operating plants. 329/ Where GPUSC did not have the necessary expertise, the architect engineer, a vendor, or a consultant would be used.330/

Though not done in a systematic manner, GPUSC engineering did forward on "an informal basis" analyses of certain problems to Met Ed.

Before the accident, GPUSC engineering had planned to expand its technical support to provide day-to-day service to the operating plants to ensure that experience from the operating plants was applied to new

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325/ As of January 1979, the drawings were not up to date. Logan deposition at 25-26; Kunder deposition at 27-37; Klingaman deposition at 71. Major/Minor Change/Modification Request Form (Met Ed); Shovlin deposition exhibit 30.

326/ Klingaman deposition at 60.

327/ Id. at 90-92.

328/ Id. at 60-83; Kunder deposition at 29-40; Met Ed Generation Procedure 1003. Accession #7180259.

329/ Herbein deposition at 24-27.

330/ Id.; Dieckamp deposition at 67-75.

plants. Dieckamp said his goal was for GPUSC to become more technically self-sufficient and independent from non-GPU engineers and consultants, although he recognized that total independence was impossible.331/

SITE PERCEPTION OF NON-SITE MANAGEMENT

There appears to have been some distance between GPU, Met Ed, and TMI that was more than geographic. At the Jan. 18, 1979, Nuclear Plant Management Review Committee meeting for TMI-2 Gary Miller, station superintendent, expressed his concern that "Communication and understanding of our management goals, objectives, and actions taken to achieve them is not understood adequately internally or externally." His concerns specifically addressed personnel matters. Miller felt that the other divisions did not appreciate the problems of TMI and that they did not feel the same budget and personnel pinch that he did. "There was, in fact, pressure to decrease the staff." 332/ He indicated that TMI lost good employees due to the company's poor personnel policies. Miller also said there was a problem in hiring good people because of salary limitations. Miller indicated that Herbein had agreed to the hiring of more people, specifically engineers, but that paperwork prevented fulfilling these needs.333/

Arnold received a copy of Miller's outline for his speech before the meeting and was sufficiently concerned that he discussed its contents with Dieckamp.334/

> I think that when items that may have this degree of contentiousness in them, as one could read into this memorandum, certainly a more constructive response can be made if there is some thought given ahead of time.335/

Dieckamp said:

> There was the discussion by Gary that related to his concern about the level and energeticness [sic], I guess, of support that he felt he was getting or not getting from the home office staff in terms of acquiring people and the sensitivity to the needs to recognize

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331/ Dieckamp deposition at 18-21. GPUSC had engaged in some activities related to application of past experience. For example, TMI-2 problems were identified for the Forked River Project, Kunder deposition at 123. See memorandum from Hirst (GPU) to Cobean (Burns and Roe), Sept. 16, 1976; Kunder deposition exhibit 88.

332/ Miller deposition at 213.

333/ Id. at 208-233.

334/ Arnold deposition at 300-306.

335/ Id. at 306.

> the kind of extraordinary overtime demands that were routinely placed on the nuclear plant staff, and the inadequate housing facilities -- and let me tell you I have not reviewed that document since the meeting, so you know the meeting is etched in my memory and I think I would have no trouble characterizing it as not having been a typical.336/

Though it had been discussed prior to the Jan. 18 meeting, Gary Miller was made TMI station manager on March 1, 1979, reporting directly to John Herbein, vice president for generation, instead of reporting through the manager for generation operations to Herbein. In explaining the change Met Ed President Creitz said, "I think most of us agree that there were too many levels of supervision or management . . . ."337/ Following the accident there was a reorganization under Arnold that integrated GPUSC, Reading, and site management for TMI, reflecting the kinds of concerns raised by Miller before the accident. Further, the new organization separated the responsibility for operations from the administrative support functions.338/

336/ Dieckamp deposition at 86-87.

337/ Creitz deposition at 81; see also, Dieckamp deposition at 118-119.

338/ Dieckamp deposition at 161.

SITE MANAGEMENT

This section is based on information obtained through interviews of site management; observations of Ronald Eytchison, a member of the Commission's technical staff, during tours of Three Mile Island; and the usual review of documents and depositions.

STRUCTURE

At the time of the accident the TMI station manager reported to the Met Ed vice president for generation; however, the site management was substantially independent from the Reading staff in day-to-day plant operations.339/

TMI-1 and TMI-2 each had a unit superintendent reporting to the station manager. Directly under each unit superintendent was a supervisor of operations and a superintendent for technical support. (These were parallel departments.) There was a shift supervisor who reported to the supervisor of operations. The shift foreman reported to the shift supervisor; the control room operators and the auxiliary operators reported to the shift foreman.340/

MANAGEMENT POLICY

Though TMI Administrative Procedure 1033 provided for the issuance of standing orders that communicated management long-term policy, the procedure was not in use at the time of the accident. Standing orders had been issued at one time by site management, but they were dropped after an NRC inspector suggested that standing orders might be considered a circumvention of the technical specification requirement that procedures be approved by the Plant Operations Review Committee (PORC).341/

Once standing orders were abolished in practice, Miller usually communicated instructions orally, although he sometimes sent memoranda to specific individuals.342/

339/ Before March 1, 1979, Miller reported to Lawrence Lawyer, manager of generation operations, who was responsible for fossil fuel and nuclear generation.

340/ See chart of TMI-2 organization attached as Appendix G.

341/ Miller deposition at 86-88; TMI-2 Technical Specification 6.5.1.

342/ Miller deposition at 91.

Miller received shift turnover notes from shift supervisors each morning. These notes contained plant data from each shift. This procedure was not provided for in writing; rather, it had been established at a shift supervisors' meeting. 343/ Further, the procedure required site management (other than the duty section head) to be notified of abnormal occurrences at the plant was not in writing.344/ Rather, Miller stated:

> I think it has been developed over the years of doing business in a direct contact. I wouldn't want to limit what they contacted me on. It was their judgment, basically, and their judgment was formed through probably five years of experience.345/

Similarly, the unit superintendent did not use standing orders or any other written form to transmit long-term policy to personnel. TMI-2 Superintendent Joseph Logan issued only one standing order prior to March 28, 1979.346/ Further, after standing orders were discontinued, TMI-2 Supervisor of Operations Floyd made no distinction between standing orders and operating memoranda (short-term policy), and kept all such documents in one log in the control room.347/

RESPONSIBILITY FOR TRAINING

Gary Miller stated he had:

> . . . responsibility for a safe and reliable operation of both units I had responsibility for the operations of both units, maintenance of both units, and along with that and corollary to it, it was items like personnel, budgets, some interface with security, chemistry and health physics; the whole gamut, as far as areas that you can think of that would go with an operation this size.348/

343/ Id. at 85-86.

344/ TMI Administrative Procedure 1014 did provide for the notification of the duty section head in an emergency.

345/ Miller deposition at 92; see also, Id. at 88-94.

346/ Logan deposition at 85-86.

347/ Floyd deposition at 80-86.

348/ Miller deposition at 60-61.

Yet Miller did not consider himself responsible for the competence of his operators. He was not involved with the substantive training of operators. 349/ The supervisor of training, though located on the Island, reported to the manager of generation quality assurance in Reading.350/

Logan indicated that he evaluated operators annually. However, this evaluation was for purposes of salary review, rather than operator performance. 351/ Logan, in fact, assumed that Floyd undertook an evaluation of operator performance. But Floyd had not performed such an evaluation either. 352/ Logan viewed the training department as offering a service -- the training of operators. He did not undertake any review of the substance of the operator's training.353/

UNIT SUPERINTENDENT

The unit superintendent had direct responsibility for operating the unit in a safe, reliable, and efficient manner. He was responsible for compliance with the operating license. 354/ TMI-2 Superintendent Logan did not conduct formal inspections of the unit. Though he received reports on the plant, there was no formal reporting system established.355/ In addition Logan was unaware that the supervisor of operations issued operating memoranda. 356/ Operating memoranda contained policy set by the supervisor of operations concerning the operations of the plant.

349/ Id. at 62-71.

350/ Zechman deposition at 37-38. Prior to Sept. 1978, the supervisor of training on the Island reported to Alex Tsiggaris, director of generation training, in Reading. Since Sept. 1978 the position of director of generation training has been vacant. Brown deposition at 36-37.

351/ Logan deposition at 153-156.

352/ Floyd deposition at 88-89. 10 CFR part 55 requires a "systematic observation and evaluation" of employee performance by the utility.

353/ Logan June 26, 1979, interview.

354/ Final Safety Analysis Report, Three Mile Island Nuclear Station Unit 2, Volume 9, Section 13 at 13.1.22.1.2.

355/ Logan June 26, 1979, interview.

356/ Logan deposition at 150.

Logan was aware that certain persons would be notified in the event of a reactor trip or other emergency. Yet he was unaware that the duty section head was the one who would be on call. Although Logan was unit superintendent, he did not compile the list of duty section heads; instead, that list was drawn up by Gary Miller.357/ It is noteworthy that there was no requirement that the duty section head be an engineer or hold an operating license.358/

PLAN-OF-THE-DAY MEETING

Floyd held one-hour plan-of-the-day (POD) meetings each morning.359/ Current plant status, surveillance requirements, maintenance items, and personnel matters were discussed and priorities set. Logan, Floyd's superior, and Rogers, the B&W site representative, attended the PODs.360/ These meetings were generally administrative.

Gary Miller also held a weekly meeting for all department heads that dealt with general administrative matters. Floyd, TMI-2 supervisor of operations, characterized his days as one meeting after another.361/

MAINTENANCE

The TMI-2 supervisor of maintenance adminstered a formal scheduled program for maintenance. 362/ In addition a "field day" was held each Wednesday when each department would clean its assigned area.363/

TMI-2's technical specifications required surveillance tests for certain items, and TMI expanded its preventive maintenance program to include surveillance of items not required by the technical specifications.364/

357/ Id. at 168-169.

358/ Administrative Procedure 1014.

359/ TMI-l's PODs were held three times a week. Floyd deposition at 70-75.

360/ Others attending the PODs included department heads: maintenance, technical support, quality control, health physics, and shift supervisors.

361/ Floyd deposition at 76-80.

362/ It is interesting to note that although there is a site superintendent of maintenance, the unit maintenance supervisors did not report to him. Shovlin deposition at 39-40.

363/ Shovlin deposition at 121-123.

364/ Scheimann deposition at 69-71.

A computer list of surveillance items was provided at the POD meeting forecasting surveillance tests to be performed that day, week, and month. However, the computer was not programmed to provide a historical record of maintenance actually performed. 365/ No one checked what had been done against what was supposed to be done.366/

The shift supervisor scheduled surveillance tests from computer lists. The surveillance items were assigned during each shift by the shift foreman to the control room operators. The control room operators in turn assigned the tests to auxiliary operators. Once the surveillance tests were completed pursuant to a written procedure, the shift foreman checked to see whether the operators had initialed each step of the task.367/ For example, for surveillance of a valve, there was no independent check of the actual valve to see that the task was properly completed. Independent checks were not even performed on a spot basis.368/ If an item disclosed a problem, the shift foreman would complete an exception or deficiency form. After the shift foreman reviewed the checklist for performance of the surveillance, the list was thrown away. This was what happened when the surveillance test on the EFV-12 valves was performed on March 26 -- 2 days before the accident.369/

If an item was found to be outside technical specification limits, a deficiency was noted, and the equipment could not be used until repaired. If the item was not normal, but was within the technical specifications, an "exception" was completed, alerting the maintenance department to the problem. For systems which could not be repaired during operation, repairs were almost always deferred until the next plant shutdown. 370/ This was how the leaking PORV valve at the top of the pressurizer was handled before the accident.371/

Deficiencies and exceptions were reviewed by the shift supervisor. That review consisted only of a review of the paper record of the surveillance. 372/ There were no spot checks of the equipment itself to make sure the surveillance had been performed properly.

365/ Shovlin deposition at 118-120.

366/ Miller deposition at 173-174.

367/ Scheimann deposition at 63-64.

368/ Id. at 71-73.

369/ Cooper May 30, 1979 hearing testimony at 80.

370/ Scheimann deposition at 75-77.

371/ Logan deposition at 167.

372/ Miller deposition at 176; Zewe deposition at 138-142.

On June 11 members of the Commission staff toured the TMI-1 reactor building at TMI and made the following observations about plant maintenance:

- Many valves in the reactor building exhibited packing leaks, as evidenced by large boron accumulations on packing glands and the floor beneath valves. Leaks were also manifested by standing, rusty water on valve bonnets. The core flood isolation valves in the TMI-1 reactor building had several inches of rusty water standing in the bonnets and boron stalactites/stalagmites, several feet in length, hanging from the valves and building up from the floor. Many ferrous components were covered with a layer of rust.

- Oil leaking from the reactor coolant pumps had accumulated on the floor of the reactor building.

- The makeup (HPI) pumps for TMI-1 were observed to have water leaks, as evidenced by rust and boron accumulations, and oil leaks from the speed changes, as evidenced by large quantities of oil in the drip pans.

During the tour by Commission staff of the TMI-1 reactor building on June 11 and a tour of the TMI-1 auxiliary building on August 8, many deficiencies were also noted in radiological control practices. The Commission staff member touring the auxiliary building was not instructed concerning expected radiation levels or contamination areas, nor was his time restricted in certain areas. The staff member observed the following situations in the auxiliary building:

- A waste compacting press was surrounded by a containment tent which had several holes in it. Eight handwritten temporary signs were noted at the entrance. Inside the tent was an assortment of miscellaneous items unrelated to the compacting operation that could become contaminated.

- Tools that were distinctively marked to indicate they were potentially contaminated were noted adrift in uncontrolled areas.

- Contaminated or potentially contaminated equipment was wrapped in clear plastic and stored in various spots in the auxiliary building; these items were neither distinctively marked to indicate they were contaminated nor were they controlled by any administrative procedure.

- A large cage contained hundreds of items that were wrapped in plastic and unmarked. These too were either contaminated or potentially contaminated. The cage door was open, and access was possible by anyone in the auxiliary building. The staff member's escort stated that there is no control system for this radioactive material. When he was asked why there were so many floor polishers stored in the cage he replied that the polishers became contaminated, stored, and forgotten. Rather than decontaminate them, he stated, the company continued to buy new ones.

- Work practices in radiological work areas were deficient. These work areas contained extraneous material that could become contaminated and complicate the radiological problem. An engineer from Gilbert Associates, the TMI-1 architect engineer, wore full anti-contamination clothing and stepped across the barrier from the controlled surface contamination area where he was working into an uncontrolled area in order to retrieve a plan; however, no health physics personnel were present to control his actions.

- Upon frisking out at the auxiliary building control point (exit), the staff member noted that his shoes were contaminated to approximately 200 counts per minute above background. The health physics representative took the shoes, washed the soles, and returned them to the staff member. No one in authority was notified of this incident nor was any record made. No effort was made to determine where the contamination had been picked up.

SHIFT FOREMAN

The shift foreman was responsible for the operation of the plant, specifically the activities of the control room and auxiliary operators. 373/ He was burdened with administrative work that did not allow him to supervise plant operations directly. Frederick Scheimann, a TMI-2 shift foreman, testified that only as time permitted would he tour the plant.374/ A shift foreman's time was spent reviewing the following records and documents:

- Radiological Work Procedures
- Key Log
- Lifted Leads/Jumpers Log
- Temporary Change Log
- Special Operations Forms
- Batch Process Log
- Transient Cycle Log
- Call-Out Work Sheets (overtime)
- Vacation Book
- Absentee Book
- Reportable Occurrences
- Document Review (Weekly Surveillance)
- Out-of-Service Sticker Audit
- Do Not Operate/Caution Tag Log
- Switching and Tagging Book
- Fire System Removal-from-Service Log
- Liquid Transfer Checklist Log

373/ Final Safety Analysis Report, Three Mile Island Nuclear Station Unit 2, Volume 9, Section 13 at 13.1.2.2.1.4.

374/ Scheimann deposition at 80-82.

- Individual Daily Time Report
- Surveillance Reports
- Secondary Logs
- Out Building Logs
- Control Room Logs - Shift and Daily.

The shift foreman gave his turnover notes on the status of the plant to his shift relief. There was no requirement that an itemized check of plant status be made by a shift foreman as he came on shift. The shift foreman checked only the controls in which he was interested.375/

CONTROL ROOM AND AUXILIARY OPERATORS

There were two control room operators (CROs) assigned to each shift. One CR0 was stationed on the control panel, and the other performed "switching and tagging tasks." These assignments would change from shift to shift. The switching and tagging CRO was involved with surveillance procedures and thus was not required to be in the control room.376/ The switching and tagging CRO was also the operator charged to identify a small-break LOCA within two minutes, as required by emergency procedures. 377/ But, because of his other duties it was possible that he would not be in the control room within the allotted time to identify a small break.

When a CRO came on shift he was not required to perform an itemized check of plant status. Edward Frederick, a TMI-2 CRO, testified that he would "walk around [the control room] and read some of the meters that you thought were important . . . ."378/ He discussed with the CRO previously on shift any abnormal occurrences and surveillance procedures that had been completed.379/

The responsibilities of an auxiliary operator (AO) were in the balance of plant. Despite differences between the balance of plant in TMI-1 and TMI-2, AOs were not assigned exclusively to one unit or another. 380/ The FSAR required that auxiliary operators take their direction from control room operators.381/ In practice, however, the

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375/ Id.

376/ Id. at 79; Faust deposition at 117, 122; Frederick deposition at 399-410.

377/ TMI-2 Emergency Procedure, Loss of Reactor Coolant/Reactor Coolant System Pressure, at B, 2.2.2.1; Frederick deposition exhibit 9.

378/ Frederick deposition at 399.

379/ Id. at 399-401.

380/ Faust deposition at 31-32.

381/ Final Safety Analysis Report, Three Mile Island Nuclear Station Unit 2, Volume 9, Section 13 at 13.1.2.2.2.2.

shift foreman also directed an AO.382/ In addition, upon completion of a task the AO did not necessarily report back to the CRO. Craig Faust, a CRO, testified that he was not the AO's "boss," and an A0 might not report back to him if the AO did not like him or did not think it was necessary.383/

Valve and switch lineups were performed by an AO at a frequency established by surveillance procedures. The lineup sheet was reviewed by the shift foreman. 384/ No independent check of valve or switch positions was made by either the shift foreman or another A0. If a valve or switch was found out of position, there was no formal procedure that required reporting the abnormality or at that point checking the entire system.

On March 26 a surveillance test was performed on motor driven pumps that included the emergency feedwater 12 valves. That test required closing both EFV-12 valves-385/ On the morning of March 28 the 12 valves were closed and may never have been opened after the March 26 test.386/ There was no requirement that these valves be checked daily.387/

382/ Faust deposition at 117.

383/ Id. at 118.

384/ Frederick deposition at 404.

385/ Memorandum from J. Miller (Met Ed) to Arnold (Met Ed), April 18, 1979; O'Connor deposition exhibit 3.

386/ Set of handwritten notes by O'Connor (Met Ed) written after the accident, undated; O'Connor deposition exhibit 4. See a fuller discussion of the EFV-12s in a separate report written by the technical staff.

387/ Frederick deposition at 408-410.

REVIEW COMMITTEES

There were four review committees that had oversight functions for TMI-2: the Plant Operations Review Committee (PORC), the General Office Review Board (GORB), the Generation Review Committee (GRC), and the Nuclear Plant Management Review (NPMR).

PORC, required by TMI-2's technical specifications,388/ was an advisory group to the unit superintendent on all safety-related matters.389/ PORC reviewed licensee event reports (LERs) and all changes to procedures and modifications that affected safety and all changes to the technical specifications.

The GORB was established pursuant to TMI-1's technical specifications, and, though it was not required by TMI-2's technical specifications, its review responsibilities included TMI-2.390/ GORB was supposed to perform nuclear safety and radiation protection reviews and make appropriate recommendations to Met Ed President Creitz.391/ However, unlike the PORC members, the GORB members did not have direct line responsibility. They were corporate management personnel from the GPU companies. In addition, representatives from B&W and Pickard, Lowe and Garrick, Inc., (a consulting firm) each sat on the GORB.392/ The intent, said Robert Arnold, was to have an off-site body that would provide a detached review:

388/ Technical Specification 6.5.1.

389/ Its membership included: unit superintendent, unit superintendent for technical support, supervisor of operations, supervisor of maintenance, unit electrical engineer, unit mechanical engineer, unit nuclear engineer, unit instrument and control engineer; and the supervisor of radiation protection and chemistry.

390/ Herbein deposition at 98.

391/ Walter Creitz, Met Ed's former president, did not remember receiving any GORB recommendations concerning TMI-2. Nor did he recall any recommendation by GORB relating to TMI-1. Creitz deposition at 88; memo from Thorpe (GORB) to Creitz (GPU), June 21, 1976; Creitz deposition exhibit 128. Creitz rarely attended GORB meetings. Creitz deposition at 91.

392/ Herbein deposition at 96.

Our feeling was that for what we wanted, the General Office Review Board for us was a group of people with a sufficient management experience, technical background, to sort of sense how the organization was doing, to be perceptive as to where problems were likely to be developing, based on what they were seeing, hearing, much of it indirect in nature, and thereby be able to look for problems, be able to warn the organization of where problems may well develop.393/

GORB's formal responsibilities extended only to TMI-1 but because it was charged with reviewing nuclear safety matters, it extended its oversight to the safety review functions of the TMI-2 PORC. Since that oversight was accomplished by reviewing PORC minutes, and by the occasional attendance of the TMI-2 PORC chairman at GORB meetings, the oversight appears to have been cursory and involved no real independent analysis. 394/ At one point, concerned that a particular individual dominated PORC meetings, GORB sent representatives to attend a PORC meeting to observe how the PORC operated. 395/ The GORB also reviewed internal audits and was kept informed of plant status and emergency drills.396/

The GRC, a committee required by TMI-2 technical specifications, 397/ was an advisory group to John Herbein, Met Ed vice president for generation.398/

393/ Arnold deposition at 80-81.

394/ GORB meeting minutes #28A, Dec. 20, 1977; Finfrock deposition exhibit 3.

395/ Memorandum from Thorpe to GORB members, Aug. 3, 1978; Finfrock deposition exhibit 9. See also Kunder deposition at 83.

396/ GORB meeting minutes 429, Feb. 22, 1978; Finfrock deposition exhibit 5; GORB Review Record Number 286, May 18, 1978; Finfrock deposition exhibit 6.

397/ Technical Specification 6.5.2.

398/ Its members were the manager for generation quality assurance, manager for generation engineering, two individuals from generation engineering, one individual from generation licensing and one from quality assurance, a secretary and the TMI-2 PORC chairman. The manager for generation quality assurance and manager for generation engineering also had to review Change/Modification Request Forms (Met Ed); Shovlin deposition exhibit 39. See also Troffer deposition at 35-40.

> Conceptually, it [GRC] was to provide technical backup for the Island's technical and engineering functions in accordance with our technical specifications. . . . We were to primarily review documentation from the Island for completeness, to see if there were things left undone with respect to licensee event reports, audit finding closeouts, change modifications review. We were to test all these documents with respect to unreviewed safety questions, compliance with tech specs, good engineering practices, safety.399/

Both GORB and GRC reviewed PORC activities. GRC was also responsible for the audit of all TMI-2 activities. Its meetings generally lasted 2 hours and were held at least quarterly during the year following fuel loading and every 6 months thereafter.400/

Finally, Nuclear Plant Management Review was established by GPU President Dieckamp in 1975 to provide a formal mechanism to keep corporate management aware of the activities at each plant and to provide for an exchange between management and site staff. The NPMR, which visited each nuclear power plant once a year for a presentation from the plant staff, was composed of the operating company presidents and generation vice presidents.401/

399/ Charter for GRC by Troffer (Met Ed), Jan. 23, 1979; Troffer deposition exhibit 95.

400/ Id.

401/ Dieckamp deposition at 83-91; Herbein deposition at 99-102; Report-Unit 2 Nuclear Plant Mangement Review (GPU), Jan. 18, 1978; Finfrock deposition exhibit 11.

PROCEDURES

The life of a control room operator at TMI-2 was governed almost entirely by procedures. The procedures were a product of the complexity of the plant, the managerial style of the utility, and the regulatory environment.

When the accident began on March 28, the operators looked to their procedures. In many cases the procedures did not help them. Edward Frederick testified:

> The whole problem we had was trying to figure out which procedure to use. We did not have a procedure to cover these conditions or combination of parameters that we saw.402/

When Richard Zechman, the supervisor of Met Ed's training department, was asked what operators were taught to do in an emergency not covered by procedures, he said:

> ... because of the reliance on the backup systems as taught through the B&W programs, taught at the simulator, considerations outside the scopes [sic] of the procedures just were not discussed. 403/

The operators had a devotion to procedures, said Frederick, in explaining why they had maintained the pressure setpoint on the turbine bypass valve during the accident:

> It is required in the procedure. You can raise the same question, that if I change the setpoint on the bypass valve, you would say, "Why did you change that without an approved procedure?"
>
> I have to follow the procedure in maintaining that setpoint. It is automatically set, and I have to do it.404/

The fact that the operators are instructed to follow procedures, the inability of the operators to recognize which procedures to apply to the accident, and the absence of training in plant fundamentals when procedures fail played a significant role in the accident. This section addresses the issue of procedures in four parts:

402/ Frederick deposition at 271.

403/ Zechman deposition at 254.

404/ Frederick deposition at 287. In fact, Frederick was wrong that the procedure required the pressure setpoint on the turbine bypass to be maintained. Section 3.0 of the procedure for Decay Heat Removal via OTSG permits the setpoint to be changed.

1. The process by which procedures are written, reviewed, approved, and maintained current;

2. Pressurizer level and going solid;

3. Emergency procedure for loss of reactor coolant; and

4. Identifying the open pilot-operated relief valve (PORV).

DRAFTING, REVIEW, AND APPROVAL OF PROCEDURES

Met Ed's Role

Generally there are no standardized sets of procedures that can be "taken off the shelf" as needed for the operation of nuclear power plants. Therefore, new procedures for TMI-2 had to be written during the final phase of construction and startup.

The procedure writing was coordinated and supervised at the site405/ primarily by Gary Miller and James Seelinger, starting about 1974 and continuing to the time of the accident.406/

Procedures generally evolved from first draft to final approval through the following steps:

1. Modification of TMI-1 procedures or original drafting done by Met Ed, B&W, Burns and Roe, or NUS, a Met Ed consultant;407/

2. Review by the Met Ed procedure writing group;408/

3. Review and first approval by PORC;409/

4. "Redline" review by operating departments to see if procedure works in practice;410/

405/ Seelinger deposition at 41, 160.

406/ Miller exercised this responsibility while he was TMI-2 superintendent from 1974 through spring 1977. Seelinger was involved as superintendent of TMI-2 technical support from January 1977 through late 1978. Miller deposition at 18-19; Seelinger deposition at 25.

407/ Seelinger deposition at 25, 31-32.

408/ Id. at 31-32.

409/ Id. at 27.

410/ Id. at 27, 35.

5. Second review and approval by PORC;411/ and

6. Review and approval by the Generation Review Committee.412/

This review schedule was managed by a clerk assigned to the PORC.413/ Decisions about who should be involved at specific steps for specific procedures were made on an ad hoc basis by Seelinger.414/

The Met Ed procedure writing and review staff included about 10 engineers with backgrounds in nuclear, mechanical, electrical, and instrumentation and control engineering. Operations engineers under the supervision of James Floyd were involved where Seelinger thought appropriate.415/ Due to a shortage of in-house engineers, the Met Ed procedure writing group was supplemented by half a dozen of what Gary Miller referred to as "rental" engineers from B&W and NUS, an outside consultant.416/

Initial drafts were written by B&W for many of the primary system operating and emergency procedures, 417/ by Burns and Roe for many of the balance of plant procedures, 418/ by NUS for some surveillance procedures, and by the Met Ed procedure writing group for the remainder.419/

The B&W participation was partly by contract (rental) engineers working at the site, partly by drafting of certain procedures at Lynchburg, Va., and partly through adapting procedures originally supplied by B&W for TMI-1.420/

411/ Id. at 27-28.

412/ Id. at 49.

413/ Id. at 36. Seelinger said that the procedure writing and review process was considerably longer on TMI-1 than on TMI-2 since substantial changes were required along the way because of the adoption of Standard Technical Specifications for TMI-2. Id. at 44-45.

414/ Id. at 32-35.

415/ Id. at 32-34.

416/ Miller deposition at 14-15; Seelinger deposition at 43-44.

417/ Miller deposition at 19-20; Seelinger deposition at 28, 39.

418/ A list of operating procedures (Burns and Roe), undated; Cobean deposition exhibit 57. A list of emergency and surveillance procedures (Burns and Roe), undated; Cobean deposition exhibit 58. A list of operating procedure scopes (Burns and Roe), undated; Cobean deposition exhibit 59.

419/ Seelinger deposition at 31, 40, 43-44.

420/ Id.

B&W engineers were sometimes invited by Seelinger to participate in the PORC review of B&W procedures, although he did not recall B&W's being involved in the review of any emergency procedures. Seelinger did not recall ever including Burns and Roe in the review of Burns and Roe-drafted procedures.421/

The "redline" review was done by whatever department was ultimately intended to use the procedure during plant operations. 422/ Approximately 15 percent to 25 percent of the procedures were returned to PORC as a result of the redline review process with comments and recommendations for change. In those cases the procedure either did not work, did not conform to the plant as it had been built, or was impossible to use as written.423/

During TMI-1 startup in 1974, GORB had reviewed some 60 safety-related operating procedures before fuel was loaded in the reactor.424/ According to Gary Miller, GORB requested the same kind of review for TMI-2 safety procedures although GORB members did not participate personally as they had with TMI-l. The object was to ensure that the review and approval of a procedure was done by someone other than the writer.425/

Except for the final review by the Generation Review Committee, Met Ed personnel at Reading were not involved in the drafting of procedures and were involved in review and approval by happenstance rather than by design.426/

No single individual at TMI reviewed either TMI or other nuclear plant experience for the purpose of incorporating lessons from those experiences into appropriate procedure changes. 427/ Procedure changes could be initiated by anyone. After changes were initiated they had to be reviewed and approved by the PORC, and finally approved by the unit superintendent.

Met Ed Administrative Procedure 1001 required, at a minimum, a review every 2 years of operating and emergency procedures by the supervisor of operations. This review had been completed for TMI-1 but

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421/ Id. at 36-37, 39.

422/ Id. at 35.

423/ Id. at 27.

424/ Letter from Thorpe (GORB) to Creitz (GPU), April 10, 1974. Accession #9090006.

425/ Miller deposition at 34-36.

426/ Seelinger deposition at 48-50.

427/ Brown deposition at 38-39.

had not begun for TMI-2 at the time of the accident. 428/ The review of TMI-1 procedures was not a complete substantive analysis and was only cursory. In fact, Michael Ross, TMI-l's supervisor of operations, indicated he had not reviewed the procedures but only reviewed procedure changes recommended by his staff.429/ "The purpose of the review is to update in case there was a system change made that slipped through the crack, something along those lines."430/

NRC's Role

During the summer of 1977, a team of NRC inspectors conducted an 11-day audit of TMI-2 procedures. At that time, the procedure writing was "quite well along," according to Seelinger, although the redline review was still in its initial phase. An NRC inspector also participated in one PORC meeting devoted to procedure review. 431/ The NRC sent an inspection report on the results of the audit Seelinger recalled being "very pleased that our procedures had stood up so well to a quite extensive audit."432/

The NRC report on the TMI-2 procedure audit433/ indicated that the inspection team reviewed over 150 emergency, operating, administrative, maintenance, and alarm response procedures on a "sampling basis" to ensure that "their technical content was adequate to assure satisfactory performance of intended functions" and that "their format was in accordance with ANSI N18.7 and the licensee's [Met Ed's] administrative controls."434/ No items of noncompliance were found by the NRC team during its inspection435/ nor were discrepancies found as to format or compliance with Met Ed's administrative controls.436/

428/ Seelinger deposition at 65-69.

429/ Ross July 31, 1979, deposition at 43-44.

430/ Id. at 53.

431/ Seelinger deposition at 53-57; see also Miller deposition at 31.

432/ Seelinger deposition at 57.

433/ NRC Office of Inspection and Enforcement Report No. 77-26, August 1977. Accession #7090986.

434/ Id. at 18.

435/ Letter from Brunner (NRC) to Herbein (Met Ed) August 11, 1977 at 1. Accession #1019002.

436/ I&E Report No. 77-26 at 30.

The audit included a review of the following TMI-2 emergency and operating procedures:437/

- reactor trip438/
- loss of reactor coolant/reactor coolant system pressure439/
- pressurizer system failure 440/
- loss of steam generator feed441/
- pressurizer operation442/
- emergency feedwater443/

The audit found no unresolved items with respect to the content of five of the six procedures listed above.444/ In the emergency feedwater procedure it was found that provisions for filling and venting systems were not delineated as required.445/

However, a TMI Commission staff review of the same procedures, which was conducted before the NRC audit report came to the TMI Commission staff's attention, found significant deficiencies in a number of these procedures.446/ For example:

- Reactor Trip. This procedure was found to have "significant deficiencies," in particular the fact that the procedure does not mention determining the cause of a reactor trip and correcting it.447/

437/ Id. at 20, 23, 24.

438/ Emergency Procedure 2202-1.1, Revision 1, June 8, 1977.

439/ Emergency Procedure 2202-2.3, Revision 0, May 23, 1977.

440/ Emergency Procedure 2202-1.5, Revision 0, March 11, 1977.

441/ Emergency Procedure 2202-2.2, Revision 0, February 24, 1977.

442/ Operating Procedure 2103-1.3, Revision 0, May 31, 1977.

443/ Operating Procedure 2104-6.3, Revision 0, April 5, 1977.

444/ I&E Report No. 77-26 at 38-40.

445/ Id. at 39.

446/ Commission Staff Report on Technical Assessment of Operating, Abnormal and Emergency Procedures. The version of the procedure the NRC reviewed in summer 1977 and the version of the same procedures the TMI Commission staff review in Summer 1979 were somewhat different, but almost all of the weaknesses identified in the Commission staff review were present in the 1977 versions of these procedures.

447/ Id.

- Loss of Reactor Coolant/Reactor Coolant System Pressure. This procedure was found so "deficient as to be inadequate" and the Commission analysis concluded that the procedure "may not be adequate to ensure that, in case of a LOCA, the integrity of the core will be maintained."448/

- Pressurizer System Failure. This procedure was found "so deficient as to be inadequate."449/

- Loss of Steam Generator Feed. This procedure was found to have "significant deficiencies."450/

- Pressurizer Operation. This procedure was found "so deficient as to be inadequate," in particular the fact that the requirement in the procedure to control pressurizer level contains no exceptions for emergency conditions.451/

- Emergency Feedwater. This procedure was found to be adequate for its intended purpose, although it was "not rigorous in its terminology," using a variety of terms interchangeably.452/

These general conclusions about deficiencies in the procedures are elaborated in detail in the Commission Staff Report on Technical Assessment of Operating, Abnormal, and Emergency Procedures.

In short, six procedures important in the TMI accident sequence were found by the NRC audit to have "no discrepancies ... with respect to format,"453/ "no items of non-compliance"454/ and only one "unresolved item with respect to content."455/ Nevertheless, two of these procedures were found by the Commission staff to be significantly deficient,

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448/ Id. The "small break LOCA" section of this procedure had not been added at the time the procedure was reviewed by the NRC audit team. However, as set forth in the TMI Commission technical staff analysis of the procedures, the weaknesses in the loss of coolant procedure went far beyond the "small break LOCA" section.

449/ Id.

450/ Id.

451/ Id.

452/ Id.

453/ I&E Report No. 77-26 at 30.

454/ Letter from Brunner (NRC) to Herbein (Met Ed), August 11, 1977, Accession #1019002.

455/ I&E Report No. 77-26 at 30.

three of them were found so deficient as to be inadequate, and one procedure was found to be key accident emergency procedures, and all four were foun deficient or worse.

Of seven other procedures reviewed both by the NRC audit and by the TMI Commission technical staff, six were found by the TMI Commission staff to be adequate and one seriously deficient.456/

The NRC audit report stated that one of the NRC inspectors had expressed concern to Met Ed about errors identified during the procedure review. 457/ Met Ed indicated that it would emphasize "attention to detail"458/ and that its "redline" program should correct any errors.459/

B&W's Role

A June 25, 1974, letter from B&W to Met Ed lists 137 operational procedures and alarm responses as being prepared by B&W for TMI-2.460/ According to Lee Rogers, B&W's TMI site representative, the original contract commitment by B&W to supply a complete set of draft procedures for the TMI-2 Nuclear Steam Supply System (NSSS) was renegotiated in 1975 to an arrangement whereby B&W provided writers to modify the already existing TMI-1 procedures previously supplied by B&W. Rogers indicated that one reason for the modification was a Met Ed effort to save money.461/ However, Gary Miller stated he made the change because the draft procedures being supplied by B&W were "inadequate" and not up to date.462/

456/ The seven procedures were Power Operation, Decay Heat Removal System, Decay Heat Removal via OTSG, Core Flooding System, Reactor Building Spray, Safety Features Actuation System and Turbine Trip.

457/ I&E Report No. 77-26 at 34.

458/ Id.

459/ Id.

460/ This letter was included in Gary Miller's notebook of procedure history (see footnote 452, infra). Accession #9110020. See also October 15, 1974, letter from Gary Miller (Met Ed) to John Barton (GPUSC). Accession #9110019.

461/ Rogers deposition at 61, 69.

462/ Miller deposition at 21-24. During his deposition, Miller produced a looseleaf notebook containing a history of Unit 2 procedure writing that he had maintained. The notebook contained his own notes along with company memoranda and correspondence with B&W. Accession #9110020.

According to Rogers, the role played by B&W, after the contract modification, was that a B&W engineer at TMI would receive a package of materials from Met Ed, presumably including the analagous TMI-1 procedure. The engineer, working as a technical writer, would then draft the TMI-l procedure relying on his own knowledge and experience. 463/ The procedure writing by B&W engineers was not routinely reviewed by B&W engineering in Lynchburg, 464/ or by the B&W Customer Service Department in Lynchburg,465/ and did not necessarily represent the thinking of B&W engineering.466/

Both Rogers and Richard Kosiba, manager of the Customer Services Department at B&W, stressed that the work of the B&W engineers in writing procedures for Met Ed was not the product of B&W engineering thinking as a whole but merely the personal expertise of the particular engineer doing the writing.467/ Rogers said that if B&W technical writers knew that a change needed to be made in a procedure it might be added as a matter of professional pride but there was no obligation to do so.468/ There was some provision for "home office research" to help the B&W procedure writers when they asked for it.469/ When asked whether Met Ed was told that the work product of B&W procedure writers was limited to the knowledge or judgment of one man, Kosiba said he did not know.470/ Yet Kosiba testified that the utilities understood "perfectly" that B&W engineers provided only personal knowledge in procedure writing and not the knowledge of B&W as an organization. 471/ Having described a highly circumscribed role for his procedure writers, Rogers nonetheless painted a picture of Met Ed's believing it had "B&W's technical advise [sic] and expertise in this procedural system."472/

463/ Rogers deposition at 57, 59.

464/ Id. at 58.

465/ Kosiba deposition at 34.

466/ Rogers deposition at 59-60; Kosiba deposition at 37-38.

467/ Rogers deposition at 59-60; Kosiba deposition at 38, 40.

468/ Rogers deposition at 63.

469/ Id. at 66.

470/ Kosiba desposition at 38, 40.

471/ Id. at 40-41.

472/ Rogers deposition at 67-68.

On this point, Gary Miller was asked whether he used B&W engineers for their engineering expertise or simply as technical writers:

> No, it was more a question of engineering expertise, but it was also -- they designed, for instance, the reactor coolant pump seal. I'm picking that because that is one good example. They had the most knowledge of engineering on that in Lynchburg. I needed them to be responsible because I knew I would get a procedure, and if I was to assign that with somebody else, they would still have to go to B&W to get the seal explained. So I thought it would fit best where there was detailed knowledge of the project and engineering expertise to go with it.473/

A handwritten note by Miller dated Jan. 3, 1975, contained in his procedures notebook, indicated "all B&W information -- assumed to have B&W engineering/design Lynchburg blessing."

There was thus a lack of common understanding of B&W's role in the writing of procedures for TMI-2. This was reflected in the poor quality of a number of the key operating and emergency procedures that were applicable during the accident. For a discussion of the technical adequacy of those procedures, see the Commission Staff Report on Technical Assessment of Operating, Abnormal and Emergency Procedures.

Although B&W acknowledged that it was the ultimate source of expertise on the design and operation of its NSSS system474/, its compartmentalized view was illustrated in the following Kosiba testimony:

> QUESTION: Mr. Kosiba, what responsibility does B&W feel it has with respect to those operating and emergency procedures in use at its operating utilities which apply to the NSSS systems, with respect to whether they are [technically] adequate or not?
>
> KOSIBA: At any day, we may not even have the procedures that are in the control room. Therefore, a rigorous answer to your question says that we cannot have responsibility. A substantive answer is that we have over a period of time provided information and continue to provide information, such as the site instructions which followed the Three Mile Island incident. But we do not have the involvement to know that when that information is provided that it is put into the operating procedure and is really being used. That is not part of our role in the business.475/

473/ Miller deposition at 27-28, as corrected by Miller's errata sheet. See also, Seelinger deposition at 156-157.

474/ Kosiba deposition at 12; MacMillan deposition at 5; see also Rogers deposition at 11.

Documents produced by B&W and Met Ed indicate that B&W specifically reviewed, on at least one occasion, the emergency procedure for pressurizer system failure the emergency procedure for loss of reactor coolant/reactor coolant system pressure; and the operating procedure for the pressurizer.476/ The procedures written by B&W engineers were not reviewed by B&W after going through the Met Ed review system. 477/ B&W also originated the limits and precautions for operation of the primary system. Each of the above procedures and the limits and precautions were important in the actions taken by the operators on March 28. They are discussed in detail below.

The B&W training department in Lynchburg used as a basis for training a blend of B&W's own simulator procedures, and the procedures of the utility from which operators came. However, B&W was not on Met Ed's distribution list for procedures revisions at the time of the accident, although it asked to be put on the list shortly thereafter.478/ Although lead instructor Lind said that his instructors tried to point out the differences between B&W simulator procedures used in the training program and the analogous procedures from trainees' home plants, he said that the home procedures weren't always available for such comparison.479/

At the time of the TMI-2 accident, the B&W simulator procedures were being "upgraded" under the direction of B&W lead instructor John Lind.480/ Lind used utility procedures as "guidelines" for the upgrading of the simulator procedures,481/ which meant that procedures for which B&W said it had no responsibility482/ were being used as models for the redrafting of the simulator procedures used in B&W's own training program.

Lind's procedure review was also designed to pick up:

> ... other obvious problems ... like bad wording or something that wasn't put down well on ... paper .... In other words, editorial changes and just bad English, bad structure-type things.483/

476/ Letter with draft revision of OP2103-1.3, Pressurizer Operation, from Rogers (B&W) to Hilbish (Met Ed), March 5, 1976; Rogers deposition exhibit 16; Letter from Rogers (B&W) to Hilbish (Met Ed), Feb. 20, 1976, with draft revision of EP2202-1.3, Loss of Reactor Coolant/RCS Pressure; Rogers deposition exhibit 17.

477/ Rogers deposition at 68.

478/ Lind deposition at 63-64.

479/ Id. at 86-87. See also Elliot deposition at 170-171.

480/ Lind deposition at 90.

481/ Id.

482/ Kosiba deposition at 41-42.

483/ Lind deposition at 90-91.

The B&W engineering department was not involved in the procedure review.484/

PRESSURIZER LEVEL AND GOING SOLID

The impact of procedures on the accident came sharply into focus as one looked at the operators' actions to control water level in the pressurizer. There is general agreement that the following events or perceptions characterized the accident sequence:

1. Control room operators at Three Mile Island and elsewhere were accustomed to inferring water inventory in the reactor vessel from the level of water in the pressurizer.485/

2. This inference was based on experience that if there was water in the pressurizer, the reactor vessel was filled with water.

3. The inference was relied on, at least in part, because there was no direct measure of water level in the reactor vessel at TMI-2.486/

4. Despite rapidly decreasing reactor coolant system (RCS) pressure during the TMI-2 accident, water level in the pressurizer rose to unusually high levels (after an initial drop during the first 60 seconds) and remained high for at least the first 4 hours of the accident.487/

5. At about 2 minutes into the accident, emergency core cooling water flow was initiated by the dropping of RCS pressure from its norm of 2,155 psig to 1,640 psig.488/

6. Believing that high water level in the pressurizer indicated too much water in the RCS, and concerned that the system might "go solid," the operators reduced and all but eliminated the flow of emergency cooling water into the core at about 4-1/2 minutes into the accident.489/

484/ Id. at 91.

485/ Walters July 13, 1979, deposition at 9; Dunn June 30, 1979, deposition at 129; Mallay deposition at 34. See also memo from Walters (B&W) to Kelly (B&W), Nov. 10, 1977; Dunn deposition exhibit 35.

486/ MacMillan testimony before the Committee on Interior and Insular Affairs (Udall Committee), May 24, 1979, at 120.

487/ TMI-2 accident reactimeter data.

488/ Id.

489/ Id., and Frederick deposition at 282-283.

7. In fact, there was never a danger of "going solid," nor was there too much water in the RCS at any time while the PORV was open.

8. Although water level in the pressurizer was high, the core coolant was actually (unknown to the operators) boiling off,490/ gradually uncovering as much as 75 percent of the core by 3 or 4 hours into the accident. 491/

9. Water level in the pressurizer remained high while the core gradually uncovered because steam formed by core boiling had sufficient pressure to force the water level high. This was a phenomenon totally unknown to the operators. 492/

10. Had the flow of emergency cooling water been left untouched by the operators, the core would not have been uncovered, fuel damage would not have occurred, radiation would not have been released, and the transient would have been minor.493/

There has been much said and written characterizing this sequence of events and perceptions as operator error. What was done was exactly the opposite of what was needed. The central issue is: Why did it happen?

To attribute the error solely to the operator is an oversimplification. More importantly, it begs the underlying issue of who supplied and shaped the analytical, procedural, and intellectual tools relied on by the operators and their supervisors in the critical first hours of the accident.

On file in the TMI-2 control room at the time of the accident was a set of B&W limits and precautions for the pressurizer that stated:

1.2-01 Absolute maximum pressurizer at any time the reactor is critical is 385 inches.

NOTE: This water level is the maximum RCS inventory used in the safety analyses for reactor building over-pressure following a LOCA. It is also the maximum level at which the system can accommodate a turbine trip without causing the pressurizer safety valves to open.

490/ Core inventory was boiling away because RCS pressure had dropped below saturation pressure and because the stuck-open PORV was an escape path for the water/steam.

491/ Nuclear Safety Analysis Center (EPRI), Analysis of Three Mile Island - Unit 2 Accident, NSAC-1, July 1979 at Figure CI-3.

492/ Frederick deposition at 268-346; Babcock & Wilcox Nuclear Newsletter, Vol. 6, No. 2, Sept. 1979 at 2, Accession #1008012.

493/ Dunn June 30, 1979, deposition at 203-205.

1.2-04 The pressurizer must not be filled with water to indicate solid water conditions (400 inches) <u>at any time,</u> except as required for system hydrostatic tests.494/

These limits and precautions are derived from the technical specifications and had been taught to the operators in their training both at Met Ed and at B&W.495/

494/ Procedure 2101-1.1, Revision 0, "Pressurizer," Aug. 4, 1977; Dunn deposition exhibit 39; see also Beers deposition at 154-155. Emphasis added in quotation.

495/ Frederick deposition at 149-152, 160; Lind deposition at 111-Illa, 112-113, 116.

The source for the limits and precautions is the TMI-2 Technical Specification, Section 3.4.4, entitled "Pressurizer, Limiting Condition for Operation" (Frederick deposition exhibit 3) which states:

3.4.4 The pressurizer shall be OPERABLE with:

a. A steam bubble.

b. A water volume between 240 and 1330 cubic feet (45 and 385 inches).

<u>APPLICABILITY:</u> MODES 1, 2 and 3.

<u>ACTION:</u> With the pressurizer inoperable, be in at least HOT SHUTDOWN with the control rod drive trip breakers open within 12 hours.

The reference to "Modes 1, 2, and 3" is found at Section 1.4 of the TMI-2 Technical Specifications (Frederick deposition exhibit 4), where modes are defined by reference to Table 1.1 of the Technical Specifications (Frederick deposition exhibit 5) which states in part:

OPERATIONAL MODES

	MODE	REACTIVITY CONDITION, K_{eff}	% RATED THERMAL POWER-	AVERAGE COOLANT TEMPERATURE
1.	POWER OPERATION	> 0.99	> 5%	> 280°F
2.	STARTUP	> 0.99	< 5%	> 280°F
3.	HOT STANDBY	< 0.99	0	> 280°F
4.	HOT SHUTDOWN	< 0.99	0	280°F>T avg >200°F

* Excluding decay heat.

(Footnote continued on next page)

Three months after the accident Norman Elliott, director of the B&W training program, indicated he knew of no exceptions to the B&W limits and precautions for the pressurizer.496/ B&W's lead instructor, John Lind, testified on the same subject:

> QUESTION: ... In any of your training before March of '79, have you ever suggested to the operators that there was an appropriate time to take the plant solid?
>
> LIND: Probably not, because the only circumstances I can think of are compound casualties, which just probably we never got into that specifically. Actually there is almost always an alternative.497/

Lind then talked about the operators' perspective:

> LIND: ... our concern for the [pressurizer] level is based on the specifications, yes, which limits what you can do in levels. That would be one basis. Right off the top of the operator's head you don't want to go above that. The spec says you can't. It is not a good thing to go above.

The effect of the limits and precautions and technical specifications is to lead an operator to attempt to control pressurizer level within the range of "operability" -- between 45 inches and 385 inches -- until system temperature drops below 280°F, a condition not reached during the TMI-2 accident for over a week.

The operating procedure for the pressurizer, which is the operator's most frequent reference document concerning the pressurizer, also contained the same message:

> The pressurizer/RC System must not be filled with coolant to solid condition (400 inches) at any time except as required for system hydrostatic tests (emphasis added). Procedure 2202-1.5, Rev. 1, Pressurizer System Failure, Sept. 29, 1978; Frederick deposition exhibit 8.

That procedure had been reviewed and transmitted to Met Ed by Leland Rogers, B&W's resident engineer at Three Mile Island. Letter from Rogers (B&W) to Hilbish (Met Ed), March 5, 1976, transmitting OP 2103-1.3, Rev. 0, Pressurizer Operation; Rogers deposition exhibit 16.

496/ Elliott deposition at 147.

497/ Lind deposition at 116. On March 28, 1979, there was no alternative to going solid. Assuming the PORV remained open the only way to replace loss of coolant would have been to leave HPI on, despite the appearance of a solid pressurizer. Of course, concern about going solid was only a perception based on high pressurizer level due to steam voiding in the core. In reality the RCS was no where near solid conditions.

There are other considerations which would be discussed. That is not the only concern as far as exceeding that level. It is not just that technical specifications [prohibit it]. There are operational considerations.

QUESTION: In the sense of damage to the system?

LIND: Possible damage.

QUESTION: Pressure spikes?

LIND: Possibility of coming up [on] a code relief and not having re-seat is probably the biggest danger, with filling the plant completely up, then pushing the pressure up to lift the relief up. If that doesn't re-seat, then you have got yourself a problem. You have got a big leak.

QUESTION: You have got a small break LOCA?

LIND: If it fails open, you are talking closer to a large break LOCA than a small break LOCA. That is a big hole.

QUESTION: The operators in your training would have understood that risk and that concern?

LIND: Yes.498/

Lind's statement of reasons for avoiding solid operation in the pressurizer was confirmed and elaborated by James Walters, an engineer in the Customer Service Department at B&W. Walters made the following points:

- Going solid eliminates the steam bubble **in** the pressurizer and thereby eliminates pressure control in the RCS.499/

- Going solid likely involves pressures in the RCS in excess of 2,500 psig, since the setpoint of the code safety valves is 2,500 psig. Because control room gauges record only as high as 2,500 psig, there would be no way of knowing how much higher than 2,500 psig system pressure had actually gone. In that case, a system analysis would have to be done to ensure that the RCS had not been subject to damaging overpressure. That analysis of vessel mechanics would require taking the plant off line for a matter of weeks or months, with a resulting loss of revenue.500/

498/ Lind deposition at 117-118.

499/ Walters July 13, 1979, deposition at 22.

500/ Id. at 19-20.

- Closely allied to the second item was Walters' concern that the code safeties might not discharge water fast enough to handle maximum HPI flow of 1,000 gpm without overpressurizing the RCS.501/

- Going solid raises the possibility of a code safety valve sticking open, creating a substantial break in the system.502/

- In an overcooling transient, going solid is a potential danger.503/

In light of these perceptions and his general knowledge and training during 10 years as a B&W employee, Walters believed that the RCS should never be brought to a solid condition. He also believed that operators generally understood this.504/

It is important to emphasize that Walter's testimony, and that of most others on the "going solid" issue, reflects his personal perceptions. It may be that a technical analysis of Walters' reasons for not going solid would indicate that his (and the operators') concerns about solid operation were unfounded. Regardless of whether Walters, Lind, or the operators were correct or incorrect, their understanding reflected inadequate training in light of the fact that HPI was terminated prematurely with no dissent from anyone present in the control room during the first three hours.

Bert Dunn, B&W's manager of ECCS analysis, was aware of a concern about going solid, specifically that it was not known what would happen to the code safety valves after they lifted under solid conditions.505/ Dunn said that there would be a concern about unnecessarily challenging the relief valves or the piping and tanks downstream of the relief valves.506/

However, Dunn said any such concern would be "inappropriate" in the context of premature termination of HPI leading to possible core damage: "...the circumstances surrounding the need to maintain high pressure injection were far more important than the worry about going solid."507/

501/ Id. at 19.

502/ Id. at 18. His concern is symptomatic of the ambiguity and lack of definition that characterized the "going solid" issue and which almost certainly led to an inadequate understanding by the operators of the relative importance to be placed on avoiding solid conditions.

503/ Id. at 22-23, 26, 27-28.

504/ Id. at 23, 27-28.

505/ Dunn June 30, 1979, deposition at 67, 143.

506/ Id. at 144, 149.

507/ Id. at 66; see also, id. at 149.

Like Elliott, Dunn knew of no exception to the written prohibition on going solid other than his incorrect guess that it applied only during normal operation. 508/ More significant was the fact that Elliott did not know, even 3 months after the accident, what training had been given by his department on going solid or even the B&W attitude toward going solid.509/

Although B&W said after March 28 that going solid was a minor concern compared to core uncovery, no one had instructed operators before the accident how to distinguish when to go solid and when not to go solid.510/ That failure was partly a result of the Dunn memorandum "falling through the crack,"S11/ partly a result of insufficient analysis of the implications of solid operation, 512/ and partly a result of the failure of "bounding analyses" to predict that the core can become uncovered while pressurizer level is high.

According to Dunn, B&W had not specifically analyzed a small-break LOCA at the top of the pressurizer, but it had performed other analyses that "bounded" -- accounted for and explained -- such a break. However, those analyses did not predict the potential for steam formation in the core or the possibility of pressurizer level going high with RCS pressure low. The B&W engineering department only discovered the phenomenon as a result of the Davis-Besse transient of Sept. 24, 1977.513/

"Bounding analyses" are generally designed to predict the outcome of a particular class of events through the use of a single analysis, rather than analyzing each event separately. The bounding analysis approach saves both time and money in nuclear power plant design because of the enormous number of ways in which malfunctions can occur. The **danger in** the use of bounding analyses is that the results are only as

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508/ Id. at 151-154. Bert Dunn had apparently never seen B&W's own pressurizer limits and precautions before his deposition. After being shown the limits on pressurizer level, he assumed they applied only during normal operation because they were contained in an operating procedure. Id. at 150-152. In fact, they also applied during emergency operation to the point of hot shutdown as defined in Table 1.1 of the TMI-2 technical specifications. Table 1.1 of TMI-2 Technical Specifications regarding Pressurizer, Aug. 4, 1977; Dunn deposition exhibit 39.

509/ Elliott deposition at 145-146.

510/ Dunn June 30, 1979, deposition at 147-149; Walters July 13, 1979, deposition at 29-30; Frederick deposition at 372-374; Dieckamp deposition at 60.

511/ Walters hearing testimony at 167; for a full discussion of the Dunn memorandum see the section of this report on the September 24, 1977, Davis-Besse transient -- B&W's role.

512/ Roy deposition at 32-34.

513/ Dunn June 30, 1979, deposition at 130; Roy deposition at 31-33.

good. as the assumptions that go into the analysis. The computer adage -- garbage in, garbage out -- applies here. Accordingly, the evaluation of a bounding analysis must look beyond the result to a detailed scrutiny of the assumptions on which it is based. That scrutiny was apparently missing from the review of B&W's analyses that "bounded" small breaks at the top of the pressurizer. This subject is treated in considerably more detail in Section 5 of the Commission staff report on the Nuclear Regulatory Commission.

The reasons to avoid going solid in the pressurizer were known to the TMI-2 operators and embedded in their intuitive sense of how to handle the plant. Edward Frederick was the operator who throttled back HPI early in the accident because of rising pressurizer level.514/ Frederick believed the reason for pressurizer level control was to maintain a surge capacity in the pressurizer.515/

The limits and precautions, said Frederick, stated that transients without surge capacity were not analyzed in the FSAR, and therefore the operator must avoid operating above 385 inches in the pressurizer.516/

If pressurizer level was outside the technical specification range of 45 inches to 385 inches, the pressurizer was considered not operable, not capable of performing its design function. 517/ Frederick believed water discharge through the code safeties had never been analyzed in the FSAR and was therefore not permitted. 518/ He also believed that a code safety valve might not reseat properly after use,519/ that it might stick open,520/ and that it could not be isolated.521/

514/ Frederick deposition at 345.

515/ Id. at 147.

516/ Id. at 149.

517/ Id. at 158. There are two sizes for the window of the pressurizer level. The TMI-2 pressurizer level had the narrow range window. Dunn July 2, 1979, deposition at 221.

518/ Frederick deposition at 162-163.

519/ Id. at 163-164.

520/ Id. at 165-166.

521/ Id. at 166; see Frederick deposition generally at 139-215 for discussion of the issue of going solid.

Frederick had been told not to exceed the limits and precautions relating to pressurizer level.522/ He believed lack of pressure control in the pressurizer could be dangerous,523/ that the PORV might fail to open,524/ that going solid was fundamentally a safety concern,525/ and that going solid might lead to taking the plant off line for repairs.526/

Faust, Scheimann, and Zewe, the other three licensed operators in the control room at the time of the accident, had been exposed to the same orientation -- control pressurizer level and avoid solid operation.527/ In particular, Zewe pointed out that the positive displacement discharge head of the high pressure injection pumps is 3,100 pounds, while RCS design pressure is 2,750, making it possible to exceed system design pressure by 350 pounds if relief valves were slow to respond.528/

Included in Frederick's training was an understanding that limits and precautions could be set aside in appropriate circumstances to bring the plant to a safe condition. 529/ However, he had never been trained on any specific example of when it might be necessary to exceed pressurizer limits and precautions.530/

Victor Stello, director of the NBC's Office of Inspection and Enforcement, said that he did not believe that operators should use technical specifications as guidance in the event of an accident, but rather that they should follow their emergency procedures.531/ He added:

522/ Id. at 193-194.

523/ Id. at 196.

524/ Id. at 198-199.

525/ Id. at 208.

526/ Id. at 209-211.

527/ Faust deposition at 189-190; Scheimann deposition at 144-153, 207-209; Zewe deposition at 92-95. See also Beers deposition at 109-113; Brown deposition at 81-88; Dieckamp deposition at 60; Floyd deposition at 120-123; Ross deposition at 75-78; Seelinger deposition at 200-213; Zechman deposition at 249-251.

528/ Zewe deposition at 94-15. It should be pointed out that the redundancy in the code safety valves is designed to prevent this from happening.

529/ Frederick deposition at 179-183.

530/ Id. at 183, 205.

531/ Stello Aug. 23, 1979, Commission hearing testimony at 142-143.

> During my stay up at Three Mile Island, there were times that I thought there was undue interest in the technical specifications, rather than dealing -- what were the safety issues that had to be dealt with. I think there is a need to have a clarification on what basis one departs from these technical specifications and clearly follows the procedures. I think it is something that needs work.532/

And yet earlier in his testimony Stello had agreed that utility operators are told to learn the technical specifications and abide by them strictly.533/ Stello thought that the conflict between the requirement in the technical specifications to control pressurizer level and the requirements of the emergency procedure for loss of reactor coolant pressure to add water by means of high pressure injection would have caused operator confusion.534/

Training covering when limits and precautions or technical specifications could be exceeded could and should have been given by B&W at least after the Davis-Besse Sept. 24, 1977, transient. At that time, B&W Training Director Elliott was on the distribution list for Joseph Kelly's memorandum highlighting concern over operator action in terminating high pressure injection at Davis-Besse on Sept. 24, 1977. The memorandum said in part:

> The operator stopped HPI when pressurizer level began to recover, without regard to primary pressure.535/

Elliott did not know whether he received the memorandum. 536/ Nonetheless, B&W Lead Instructor John Lind was told the key facts of the September Davis-Besse transient by Kelly himself. 537/ Yet Lind apparently never connected the early termination of HPI at Davis-Besse to the "never go solid mindset of the operators, an attitude created in substantial part by B&W's own training, procedures, and limits and precautions. 538/ Nor did Lind take any steps to discuss the Davis-Besse transient and its implications in the B&W training program, other than a few random conversations with trainees.539/

532/ Id. at 144-145.

533/ Id. at 135.

534/ Id. at 140-141.

535/ Memorandum from Kelly (B&W) to Distribution (B&W), November 1977; Womack deposition exhibit 24.

536/ Elliott deposition at 68.

537/ Lind deposition at 118-120.

538/ Brown deposition at 86-87; see also footnotes 484 and 485, supra.

539/ Lind deposition at 107-108.

The Met Ed training program emphasized the same procedures, technical specifications, limits and precautions, and general orientation with respect to going solid as the B&W training program.540/

Edward Frederick shut down high pressure injection at 4-1/2 minutes into the accident, despite a rapid and continuing drop in system pressure. In the following section of his deposition transcript, Frederick explained how and why he took that action:

> <u>QUESTION:</u> When you throttled the high pressure injection, you have indicated repeatedly in other testimony the reason that you did that was because of your concern about the pressurizer level, your concern about going solid; is that correct?
>
> <u>FREDERICK:</u> Yes.
>
> <u>QUESTION:</u> And that continues to be your analysis, correct?
>
> <u>FREDERICK:</u> As to why I throttled, yes.
>
> <u>QUESTION:</u> When you throttled it back, that is, the high-pressure injection, I take it that you indicated that you had been looking at and you had considered in the action that you took, not only pressurizer level, but reactor coolant pressure and temperature that you were aware of all three indications at the time you made the decision to throttle?
>
> <u>FREDERICK:</u> I don't specifically remember looking up temperature, though I may have.
>
> <u>QUESTION:</u> But you were aware of pressure?
>
> <u>FREDERICK:</u> Yes.
>
> <u>QUESTION:</u> And pressure was enough to tell you that you had very dramatically conflicting indicators?
>
> <u>FREDERICK:</u> Yes. As the pressurizer approached solid conditions, I realized that the pressure was not reacting as I expected it to. What I was afraid of is after it went off-scale high, it may suddenly increase very rapidly.
>
> <u>QUESTION:</u> What I wanted to ask you was this: When you essentially were there looking at those two factors, pressurizer level and reactor coolant pressure, and saw they were in conflict and then made the decision to essentially rely on and believe your pressurizer level indication, what factors went into that decision? Did you entertain as a possibility at that point the fact that you should ignore pressurizer level and focus on the reactor system pressure?

540/ Beers deposition at 108; Brown deposition at 81-88; see also Zechman deposition at 249-252.

FREDERICK: No, I did not.

QUESTION: Can you explain to me what you brought into that control room that day, in terms of your training and thinking, that led you so surely to acting on the basis of pressurizer level?

FREDERICK: All I can say is I didn't make the assumption that there was a steam void somewhere else, one, because I didn't know that the emergency steam system wasn't operating, and we had no heat sink, and two, because I had never considered the possibility of a steam void before forcing the pressurizer level to go solid.

QUESTION: What did the low reactor coolant pressure suggest to you at the time, or did it suggest anything to you? Obviously high pressure[izer] level was suggesting something fairly specific to you, namely, that you might be approaching solid conditions. That is on the one hand. On the other hand, you had low reactor coolant pressure. Was that suggesting anything else to you at that time?

FREDERICK: No.

QUESTION: But it did not suggest, based on your training and experience and understanding, any conditions or any particular consequences down the road, at least as you stood there in the heat of the emergency?

FREDERICK: No. It was confusing. We had pressurizer level going off-scale high. That was one initial -- while the pressure remained low. That was a confusing piece of information. Several minutes later, we discovered we had no emergency feedwater. That became confusing because the reactor coolant system pressure was low. If we had no heat sink, why was the pressure low, and if we had no pressure, why was the pressurizer level high?

I mean those are three or four confusing indications that don't dictate any particular action.

QUESTION: We talked yesterday about your concern and the basis for your concern about going solid, and you indicated that your concern was essentially a high-pressure transient, a stressing of the system up to the level of 2,750 pounds, is that correct?

FREDERICK: Yes.

QUESTION: That concern, I take it, necessarily involves a concern that the three valves at the top of the pressurizer may not open when they are needed?

FREDERICK: Another phase of our training, beside trying to stay away from safety limits, kind of doesn't allow you to rely on safety systems. In other words, you don't rely on the reactor protection system to trip the reactor; you don't rely on the emergency safeguard system to initiate at 1,600 pounds, and you don't rely on the relief valves to lift at their setpoint, okay? You always watch to see that they are going to fail; you assume you may have to take some action. So, in anticipating a rise in pressure, I naturally assumed that the relief valves may not work, and that is assuming an awful lot of conservatism, but it is just that is what was in my head at the time, if they don't open, I am in trouble, so what do I do.

QUESTION: Is that kind of conservatism, that kind of analytical approach to the problem reflected specifically in your training?

FREDERICK: Yes.541/

After the accident, Met Ed changed the format of some of its procedures to include a purpose statement at the beginning of the procedure, "so that when you are in the procedure you have right in front of you what it is that you are trying to prevent happening."542/

Met Ed Training Instructor Nelson Brown testified that he was told not to go solid during training on the B&W simulator because the simulator was not programmed to go solid.543/

QUESTION: Well, did you understand the "Don't do it" message from B&W to be simply because it screwed up the simulation and, therefore, interrupted the training or that it went to something more fundamental, namely that it wasn't good for the plant?

BROWN: That it wasn't good for the plant -- that was the interpretation that I had.

QUESTION: And how did you get that interpretation? Was there any direct suggestion that something bad would happen to the plant?

BROWN: I don't know if that was the conclusion that I came to or if that was something that somebody said to me. I can't differentiate between the two now.

QUESTION: Do you ever remember having a discussion or a training program which directly addressed the issue of going solid?

BROWN: Nothing other than the review of limits and precautions and textbooks where these maximum numbers were in there.544/

541/ Frederick deposition at 345-350.

542/ Id. at 339; see, for example, Procedure 2202-1.5, Revision 1, "Loss of Pressurizer Level Indication," Sept. 29, 1978; Frederick deposition exhibit 8.

543/ Brown deposition at 86.

544/ Id. at 87.

Members of the control room shift on duty at the time of the accident were interviewed by a GPU team on March 30 and again on April 6 following the accident. 545/ During the interviews Frederick, Faust, Scheimann, and Zewe gave their recollections of what had happened during the accident and of how they had responded as events unfolded.

Since the interviews were taken 2 days and 9 days, respectively, after the accident, they reflect a less studied analysis of the accident than emerged from the Commission depositions in late July. While the facts in the interviews and the depositions are basically the same, the emphasis is different.

For example, in both the interviews and the depositions the operators said they were concerned about pressurizer level going high and the possibility of the reactor going solid. Reasons for the concern about high pressurizer level and solid operation were unarticulated. 546/ But in the depositions, the operators said that their procedures, technical specifications, limits, and precautions and training told them they could not let the pressurizer level remain high or let the plant go solid.547/

The legal staff's reading of the testimony suggests that when the operators acted to control pressurizer level during the accident, they did not have any particular procedure, technical specification, or limit and precaution in mind but were reacting intuitively.

Yet it appears that the net effect of the various procedures, limits and precautions, technical specifications, and training (discussed in more detail above) was to create a belief among the operators that they should control pressurizer level and avoid solid operation. There appears to be no other explanation for why high pressure injection was terminated early in the accident.

Michael Ross, TMI-1 supervisor of operations, probably stated it best in a private recorded discussion with Gary Miller in May 1979:

> One thing on the pressurizer level that I want to make sure you [Gary Miller] fully understand. We've taught our operators, and we

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545/ Frederick March 30, 1979, TMI interview. Accession #1012012; Zewe March 30, 1979, TMI interview. Accession #1012013; Frederick April 6, 1979, TMI interview. Accession #1012014; Faust March 30, 1979, TMI interview. Acession #1012015; Zewe April 6, 1979, TMI interview. Acession #1012016; Faust April 6, 1979, TMI interview. Accession #1012017; Scheimann March 30, 1979, TMI interview. Accession #1012018.

546/ Id.

547/ Frederick deposition at 149, 158, 193-194; Faust deposition at 189-198; Schiemann deposition at 144-153, 207-209; Zewe deposition at 92-95.

have a B&W written caution to never take the plant solid. Unconsciously we have told them all the time. Never take the plant solid.

We unconsciously taught them that, Gary, and I'm sure it was on those guys' minds up there.548/

Faust's March 30 interview indicated his preoccupation with letting the pressurizer go solid:

[W]e had an ES actuation and all we were thinking was that we had to stop -- we were going solid.549/

I knew they had problems. I heard Ed [Frederick] saying that we had a high level on the pressurizer. I knew we had started the pumps and I knew he was shutting one of them off somewhere along there to try to control pressurizer level. I figured we were just jamming a lot of water into the pressurizer.550/

In his April 6 interview Frederick said he had thought the plant was going solid.

Pressurizer level was coming up rapidly. I squeezed back on the 16s [valves controlling the rate of HPI flow] and still couldn't stabilize pressurizer level. We didn't realize at this time that we didn't have emergency feedwater. We thought we were going solid so we turned off one of the HPI pumps on and two valves open instead of two pumps and four valves open.551/

We were trying to figure out why pressurizer levels went up so fast. We have had other trips and pressurizer level [during the accident) just didn't look right. It is what keyed us that something was wrong. We just couldn't put our finger on just what was causing it.

At first I thought that since there was no leak in the primary system, that we were pushing too much water in, but that didn't correlate with reducing plant pressure. We had to keep the high

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548/ Miller tape, May 25, 1979, at 120; Accession #1008013.

549/ Faust March 30, 1979, TMI interview at 5. Accession #1012015.

550/ Id. at 4.

551/ Frederick April 6, 1979, TMI interview at 2. Accession #1012014.

> pressure injection pumps on but I thought if we slowed them down a little bit, until pressurizer level indication returned from off-scale, it would work.

> At first we were afraid to go solid. We were afraid of a pressure spike. We weren't convinced that the pressurizer was solid but we knew we were very high, and I don't think it was until the [reactor coolant] pumps were off that we considered going solid. That's when we talked ourselves into manually indicating high pressure injection.552/

Frederick's testimony indicated he was confused by the pressurizer level being full since the system was not responding as it would if the pressurizer was solid.553/ In fact, he knew it was not solid.554/ He stated:

> The pressurizer went full and we believed it was full. It must have been full of water, but the next confusing thing was the system wasn't reacting as if it was solid. We weren't seeing pressure spikes, so I don't know if anyone concluded that there was steam building someplace else. It was happening so fast, but we knew that we weren't solid.555/

Frederick Scheimann, the shift foreman, was as confused as Frederick about what exactly the pressurizer level was indicating. He said:

> Well, we were suspicious for quite a while about the pressurizer level. I referred to earlier that, when we stopped the injection going into the primary system, the pressurizer level still was going up and up and up and it had actually gone to the point where it was off-scale. We seriously had doubts as to whether that was accurate or not. We had instrumentation people check the reading by going to the computer and it appeared it was as it should have been, the uncompensated level. So once we established level indication

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552/ Id. at 4. The reactor coolant pumps were turned off at 73 and 100 minutes into the accident. Nuclear Safety Analysis Center (EPRI), Analysis of Three Mile Island - Unit 2 Accident, NSAC-1, July 1979, Sequence of Events at 19, 21.

553/ Frederick March 30, 1979, TMI interview at 2. Accession #1012012. In fact the pressurizer only appeared to be solid 4 minutes, minutes 6 to 9. See reactimeter data.

554/ Frederick March 30, 1979, TMI interview at 2. Accession #1012012.

555/ Id.

> on the console we verified that versus what our uncompensated on the computer was and we figured that we were pretty close to being where it should have been. So evidently we really didn't have a problem with the pressurizer level [instrumentation].556/

Thus, having checked the instrumentation the operators knew the pressurizer level indication was accurate. They appeared to be unsure what the high pressurizer level indication meant for at least the first 2 hours and 20 minutes. Zewe stated that:

> [W]e have to leave the pressurizer levels actually high but how else can we get water into it. It took us a good while to look over things and get everything else to say we don't it doesn't seem true. So, then we initiated high pressure injection and stopped the letdown. Because we said that maybe we're actually down and it is just a fake pressurizer level high. Then we and then couple of our people showed up about this time and another shift supervisor. The discharge temperatures of the relief valves, RCRV2 was still higher than the other ones. So we went and shut RCRV2 to block valve for the electromatic and the pressure in the building took a marked drop down.557/

EMERGENCY PROCEDURE FOR LOSS OF REACTOR COOLANT

Guidance on Termination of High Pressure Injection

Although high pressure injection was apparently terminated by the operators because of fear of going solid (see the previous section), B&W Vice President John MacMillan has taken the position in congressional testimony since the accident that:

> ...the operators should not have relied on the single indication of pressurizer level, but, in accordance with the TMI emergency procedure for a loss of primary coolant, they should have considered pressurizer level and primary system pressure ...558/

before throttling back on high pressure injection (HPI).

MacMillan was wrong that the TMI-2 emergency procedures required operators to consider both pressure and pressurizer level.

556/ Scheimann March 30, 1979, TMI interview at 5. Accession #1012018. See also Frederick March 30, 1979, TMI interview at 4. Accession #1012012.

557/ Zewe March 30, 1979, TMI interview at 4. Accession #1012013.

558/ MacMillan, oral statement of the Babcock & Wilcox Company before the Subcommittee on Energy and the Environment of the House Committee on Interior and Insular Affairs (Udall Committee), May 24, 1979. Accession #6270008. See also MacMillan press conference, June 5, 1979; MacMillan deposition exhibit 68 at 33.

While the B&W simulator procedure had such a provision, the TMI-2 procedure did not have such a provision in the section which applied to the accident, despite the fact that B&W had written and reviewed the TMI-2 procedure in 1976.

The procedure in question -- the emergency procedure for loss of reactor coolant/reactor coolant system pressure -- had two main sections. Part A (manual mode) dealt with very small leaks that could be handled by make-up flow. Part B (automatic mode) -- the part of the procedure applied to the TMI-2 accident -- dealt with larger leaks that required high pressure injection to maintain system inventory and pressure.

Part B of the procedure that B&W used in its Lynchburg, Va. simulator provided:

> 5.2.5 If the RC System [sic] and pressurizer level stop decreasing or begin to increase upon initiation of high pressure injection, maintain pressurizer level as close as possible to the normal operating range by varying the number of running makeup pumps.559/

No such proviso appeared in Part B of the Met Ed procedure. A similar proviso appeared in Part A of the Met Ed procedure, 560/ but Part A, by its terms, did not apply to the TMI-2 accident. So MacMillan either failed to check his facts, or was mistaken in his May 29, 1979, testimony before Congress.561/

The Met Ed loss of coolant procedure had been reviewed by B&W in early 1976, and returned to Met Ed under cover of a letter from Leland Rogers, B&W's TMI site representative. In that letter, Rogers made the following comment:

> Attached is the draft revision 0 of EP 2202-1.3, Loss of Reactor Coolant/RCS Pressure, for your review and comment. Please note that this procedure writeup has been modified from the Unit 1 procedure, especially in the area of Part B -- Leak or Rupture of Significant Size Such That Engineered Safety Features Systems are

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559/ B&W Operations Manual for Nuclear Power Plant Simulator, Aug. 14, 1978, OP 1202.6, "Loss of Reactor Coolant/Reactor Coolant System Pressure"; Lind deposition exhibit 59.

560/ TMI-2 Emergency Procedure 2202-1.3, "Loss of Reactor Coolant/Reactor Coolant System Pressure," Section A-3.2.5; Frederick deposition exhibit 9.

561/ It should also be noted here that in a June 5, 1979, press briefing John MacMillan presented a picture of the TMI accident as operator error and knowingly omitted any mention of the Dunn memorandum and B&W's 18 month failure to advise its customers of facts that might have prevented the accident. See section on Davis-Besse September 24, 1977, transient -- B&W's role.

Automatically Initiated. These modifications are aimed at providing the operator with responses to various past accident conditions in order to assure redundant injection flowpaths to the core. Care should be taken in reviewing this procedure to assure understanding in this area.562/

Part B, the part that Rogers referred to in his letter, was applicable to the TMI accident and was applicable at the time of the accident. Although Rogers was concerned about flowpaths to the core, Part B of the procedure he forwarded to Met Ed did not link termination of HPI to both reactor coolant pressure and pressurizer level. In fact there was no instruction for when HPI could be terminated.

Three months after the accident, both B&W training director Elliott and lead instructor Lind referred to the provision of the B&W simulator procedure that is quoted above as providing guidance on when to terminate high pressure injection. 563/ Neither of them appeared to be aware that that provision simply did not exist in the equivalent section of the Met Ed procedure.564/

The discrepancy between the B&W procedure and the Met Ed procedure indicated that neither B&W nor Met Ed cross-checked the B&W simulator training procedures with the Met Ed plant procedures. B&W, as the NSSS vendor and the ultimate expert on the design and operation of that system,565/ apparently failed to make sure that the procedures used by its utilities conformed to its own thinking as reflected in the simulator procedure. B&W's lead instructor Lind testified that the differences between B&W and Met Ed procedures were noted and explained to utility operators during their training at B&W.566/ If the differences were noted and explained, why did the B&W training department not recommend adding the key missing phrase to the Met Ed procedure?

During the Commission investigation, James Taylor, B&W licensing manager, commented informally that up to the time of the accident, 95 percent of industry effort had been devoted to equipment and 5 percent to people. He said he thought it should be closer to 50-50.567/

562/ Letter from Rogers (B&W) to Hilbish (Met Ed), Feb. 20, 1976, attaching TMI-2 EP2202-1.3, "Loss of Reactor Coolant/ RCS Pressure," Feb. 20, 1976, Rev. 0; Rogers deposition exhibit 17.

563/ Elliott deposition at 150-153; Lind deposition at 120-122.

564/ Elliott deposition at 151; Lind deposition at 121.

565/ MacMillan deposition at 14.

566/ Lind deposition at 86.

567/ See also Taylor July 19, 1979, Commission hearing testimony at 199-201.

Two months after the accident, Gary Miller tape recorded a private meeting with James Seelinger, Michael Ross, Ivan Porter, and William Zewe in which they reviewed the procedures used during the accident.568/ In discussing the loss-of-coolant procedure, Zewe, who was shift supervisor during the accident, commented:

> On a small break that actuates emergency safeties, our procedure is pretty poor. Ours is drilled so much at loss of diesel, loss of power, guy run down in the alley, it takes up two pages there. It's really hard to follow if you look at it.
>
> SEELINGER: I read it yesterday and couldn't follow it.569/

Yet Seelinger had approved that very procedure on Oct. 6, 1978, in his capacity as acting TMI-2 superintendent.

Even the proviso linking the concepts of pressurizer level and RCS pressure in Part A of the Met Ed procedure is poorly worded. It says:

> 3.2.5 Caution: Continued operation depends upon the capability to maintain pressurizer level and RCS pressure above the 1,640 psig Safety Injection Actuation setpoint.570/

Continued operation of what? The wording is typical of the turgid and often convoluted language of the Met Ed procedure. What the section means to say is that "high pressure injection should not be terminated or throttled unless RCS pressure can be maintained above 1,640 psig and pressurizer level can be maintained." During his tape recorded review of Part A of the loss of coolant procedure, Miller said:

> The part in caution reads -- what does it read? Continuing operation depends on capability to maintain pressurizer level and RCS pressure.
>
> What is that? Continued operation of the plant?
>
> ZEWE: Yes.571/

Of course, Zewe was wrong. The reference to "continued operation" is to HPI, but the procedure does not say that.

568/ The conversation occurred on May 25, 1979. A copy of the tape was provided to the Commission in September and transcribed. The tape and transcript are in the Commission archives. Accession #1008013.

569/ May 25, 1979, Miller transcript at 14. Accession #1008013.

570/ TMI-2 EP 2202-1.3, footnote 550, supra.

571/ Miller May 25, 1979, transcript at 2-3. Accession #1008013.

The inadequacy of the Met Ed loss-of-coolant procedure, and other procedures as well, illustrated the failure of both Met Ed and B&W to give sufficient attention to the human side of running a reactor. The procedures were not edited for clarity, they were sometimes internally inconsistent, and wording was often poor. The lack of care is of particular concern in an emergency procedure which must be used under conditions of stress.572/

A final confusion in understanding and applying the loss of coolant procedure appears in the transcript of Gary Miller's taped meeting. William Zewe said that when the transient began, the operators manually initiated high pressure injection to control the anticipated shrink in the primary coolant volume. 573/ But at approximately 2 minutes into the accident and after HPI had been started manually, emergency safety features were actuated putting HPI into an automatic mode. Nevertheless, instead of moving at that point to Part B of the procedure that governs automatic initiation of HPI, Zewe stayed in the Part A manual section because he happened to have started HPI manually -- although for a reason unrelated to a LOCA.

The transcript picks up the story:

> ZEWE: Because we mainly started the make-up pumps prior to the initiation, so that's why I said that it was the manual part of the high pressure ejection ....
>
> The caution on the next page is the bad part, as far as I'm concerned. It does specifically state level in pressure under a caution statement.
>
> MILLER: We admitted yesterday that that's a part that we could have followed differently and better, and that is true.574/

So Zewe was in the right part of the procedure for the wrong reason. But even then he did not follow the caution.

A more general analysis of the loss-of-coolant procedure is contained in the Commission Staff Report on Technical Assessment of Operating, Abnormal, and Emergency Procedures. That analysis concludes that the Met Ed loss of coolant procedure "may not be adequate to ensure that, in the case of a LOCA, the integrity of the core will be maintained."575/

572/ In that connection, section 5.2.5 of the B&W simulator procedure omits the word "pressure." Instead of reading "If the RC System and pressurizer level stop decreasing ..." the sentence should read, "If the RC System pressure and pressurizer level stop decreasing ..." Elliott deposition at 150; Lind deposition at 122. John Lind indicated that the omission was a "typo." Lind deposition at 122.

573/ As the water cools, its volume shrinks.

574/ Miller May 25, 1979, transcript at 2-3. Accession #1008013.

575/ Staff Report on Technical Assessment of Operating, Abnormal, and Emergency Procedures.

Applicability of the Loss-of-Coolant Procedure to the March 28, 1979, Accident

Although TMI-2 suffered a LOCA, the emergency procedure for loss-of-reactor coolant was never applied during the crucial early hours because the operators concluded that they had a steam line break in the feedwater system, not a loss-of-reactor coolant. 576/ During a private April 14, 1979, tape-recorded review of the accident by senior plant management (described more fully in the next section entitled "Attention to Experience,") William Zewe said:

> Mehler looked at computer PORV temp readings ... saw RC-RV-2 [PORV] [temperature] still a little high so said shut the block valve. Zewe then said, "S , wasn't generator was RC-RV-2.577/

The loss-of-coolant procedure578/ stated that a loss-of-coolant accident could be distinguished from a steam generator tube leak by the following symptom unique to a LOCA: "Loss-of-coolant inside Rx Building -- particulate iodine gas monitor alarm on MP-R-227 'Reactor Building Air Sample."'

According to Frederick, the operators looked for a particulate, iodine, or gas alarm in containment and did not see one. Therefore, they rejected a LOCA as the explanation of the observed plant symptoms.579/ In fact, a reactor building radiation alarm should have sounded at about 78 minutes into the accident and even before then radiation levels had increased fivefold without an alarm.580/

The Small-Break LOCA

In April 1978, B&W notified the NRC581/ and its utility customers that its previous small-break analysis "had not been based on the worst

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576/ Frederick deposition at 238, 243. See generally id. at 230-245.

577/ Tape recording, Gary Miller et al., review of TMI-2 accident, April 14, 1979, Tape 1. Accession #1008014.

578/ TMI-2 Emergency Procedure 2202-1.3, Loss of Reactor Coolant/Reactor Coolant System Pressure, October 6, 1978; Frederick deposition exhibit 9.

579/ Frederick deposition at 231-233, 237-238.

580/ See EPRI Sequence of Events, footnote 481, supra, at 00:10:23 and 00:29:23.

581/ Letter from Taylor (B&W) to Volgenau (NRC), April 14, 1978, and enclosure "Evaluation of 177 FA Lowered Loop ECCS Concern"; Dunn deposition exhibit 45. This constituted a Part 21 report by B&W to the NRC. B&W followed up with an additional analysis transmitted by letter from Taylor (B&W) to Baer (NRC), April 25, 1978, "Analysis of Small Breaks in the Reactor Coolant Pump Discharge Piping for the B&W Lowered Loop 177 FA Plants," April 24, 1978; Seelinger deposition exhibit 104.

break location."582/ B&W said its analysis now showed the worst break to be at the reactor coolant pump discharge and recommended certain operator actions to deal with such a break.583/

After receiving the B&W analysis, Met Ed wrote to the NRC suggesting changes in its emergency procedures to account for the B&W analysis.584/ However, a reading of the B&W analysis and resulting changes made by Met Ed to its procedure suggests that Met Ed did not fully understand the analysis.

In July 1978, Met Ed forwarded a "proposed permanent solution to [the] small break LOCA concern" to the NRC for approval,585/ which was later withdrawn and replaced by another solution in late November.586/

By the time of the accident, a modification had been made to the TMI-2 Loss-of-Reactor Coolant/Reactor Coolant Pressure procedure that defined a "small-break LOCA response." James Floyd, TMI-2 supervisor of operations, required that there be a "small-break LOCA operator" on each shift and special training was implemented to prepare operators to "carry out the actions required for a small-break LOCA."587/

The problem with the procedure change and the drills was that a highly specialized small-break LOCA concern (one with a failed make-up pump) was described under the generalized heading of "small-break LOCA" without differentiating it from other small-breaks.

As a result, one operator thought that if there was not a loss of one make-up pump a small-break LOCA did not exist.588/ Others saw through the confused terminology in the procedure and recognized that a small-break could exist apart from the loss of a make-up pump.589/

582/ PORC meeting minutes, Meeting 266, May 1-5, 1978. Seelinger deposition exhibit 104 at 1.

583/ Id. at 5.

584/ Letter from Herbein (Met Ed) to Varga (NRC), May 5, 1978; Seelinger deposition exhibit 104.

585/ Letter from Herbein (Met Ed) to Reid and Varga (both NRC), July 24, 1978, with attachment, "Proposed Permanent Solution to Small-Break LOCA Concern (Applicable to TMI-1 and TMI-2)"; Seelinger deposition exhibit 105.

586/ Letter from Herbein (Met Ed) to Reid (NRC), Nov. 21, 1978.

587/ Memorandum from Floyd (Met Ed), to TMI-2 personnel May 10, 1978; Frederick deposition exhibit 14.

588/ Frederick deposition at 214.

589/ Faust deposition at 62, 231; Zewe deposition at 69, 74.

Although B&W told its utility customers that the small-break analysis performed in the spring of 1978 represented the "worst" case, B&W had its own doubts. A Dec. 19, 1978, internal B&W memorandum stated:

> If questioned by the NRC, however, B&W must be in a position to state that the small-break topicals have considered the worst possible conditions: loss-of-off-site power. Our inability to respond conclusively to such an inquiry could result in the NRC derating or shutting down all of B&W's 177 F.A. operating plants (except SMUD) until the issue is resolved. 590/

> The customer should not be informed of the ECCS analysis efforts to examine the pumps running case. It is imperative that B&W be totally prepared to defend an FOAK analysis of this type or to have a planned course of action if results are unacceptable.591/

Due to time constraints the legal staff was unable to depose the author of this Dec. 19, 1978, memorandum. It has no evidence that this information had any effect on the TMI-2 accident. Nonetheless, the content of that memorandum indicated a disturbing attitude of B&W -- namely, the refusal (here intentional) to inform the NRC or its customers of an identified problem.

IDENTIFYING THE OPEN PILOT-OPERATED RELIEF VALVE

The pilot-operated relief valve opened on a rise in the reactor coolant system pressure at 3 seconds into the accident and stuck open at 13 seconds. 592/ It remained continuously open, discharging coolant from the RCS for approximately 2 hours and 20 minutes, at which time the block valve was closed, isolating the PORV and ending the loss-of-coolant.

On March 29, 1978 -- a year before the accident -- the PORV also stuck open. At that time, there was no indication in the control room of PORV position. As a result of that failure, a signal light showing flow of electrical current to a solenoid that opens the PORV was installed in the control room by GPUSC.593/

590/ Memorandum from Cartin (B&W) to Lukin (B&W), Dec. 19, 1978; Womack deposition exhibit 29.

591/ Id.

592/ EPRI Sequence of Events, footnote 481 supra, at 5.

593/ Seelinger deposition at 114. GPUSC made this change and neither Seelinger, who was superintendent of technical support for TMI-2, nor anyone else at Met Ed had a role in the decision or the review leading to the change. Seelinger deposition at 113-115.

When that signal light registered current, the operator could infer that the valve was open since electric current to the solenoid was necessary to maintain the valve open. On the day of the accident, the operators looked at that control room signal light shortly into the accident sequence, saw no indication of power, and assumed that the valve had closed following the initial rise in system pressure.594/

However, the valve had not closed and the signal light reading did not show the actual valve position. The operators then had to disbelieve this control room signal light indication in the analytical process leading to a conclusion that the valve was open.

The operators had an emergency procedure entitled "Pressurizer System Failure" 595/ that they had been trained to use and were familiar with at the time of the accident. Section B of that procedure sets out four symptoms for identifying a leaking or open PORV:

Inoperative Pilot-operated (electromatic) Relief Valve (RC-R-2)

B.1 SYMPTOMS

1. RC System pressure is above 2,255 psig and RC-R2 fails to open.

2. RC System pressure is below 2,205 psig and RC-R2 fails to close.

3. RC-R2 discharge line temperature is above the 200°F alarm. Computer point (402).

4. The RC drain tank pressure and temperature are above normal on the control room radwaste disposal control panel 8A.

Before the accident, there had been a leak from one of the three valves at the top of the pressurizer -- either the PORV or one of the two code safety relief valves -- no one knew which.596/

A simple test for determining which of the three valves was leaking would have been to close the PORV block valve and see if the leak stopped. Such a test was never performed.597/ Frederick explained why:

594/ Zewe May 30, 1979, Commission hearing testimony at 128, 195-196.

595/ TMI-2 Emergency Procedure 2202-1.5, Pressurizer System Failure, Sept. 29, 1978; Frederick deposition exhibit 8.

596/ Frederick deposition at 294. See also Frederick May 30, 1979, hearing testimony at 173; Zewe hearing testimony at 130.

597/ Frederick deposition at 294.

> A valve has been leaking for weeks. We had a leaking relief valve but we weren't doing anything about it. It was either one of the two code safety valves or RC-RV-2 [PORV]. Prior to the accident, we didn't want to cycle the isolation valve (RC-V2) because we were afraid it might stick shut. It sounds like a screwy argument to me. I think they should have shut it anyway to see if they could stop the leaking. I know for weeks we had to process a lot of water and had difficulty keeping boron concentration equalized in the primary system.598/

Other than closing the block valve, the only way to determine the source of the leak would have been to shut down the plant.599/

As a result of the leak, temperature readings in the tailpipe (symptom no. 3 above) had been reading 60-75 °F higher than the usual base line of <u>130°F.600/</u> More importantly, the TMI-2 procedure for pressurizer system failure required closing the PORV block valve if temperatures in the tailpipe exceeded <u>130°-F.601/</u> As a result of the pre-accident leak at the top of the pressurizer, the PORV tailpipe temperatures had been reading in the range of 180° for weeks before the accident,602/ but Met Ed had not followed its own procedure and closed the block valve. Had Met Ed procedures been followed and the block valve closed, there would not have been a loss-of-coolant accident through the PORV.

After the accident, Gary Miller and Bill Zewe talked privately about the failure to close the block valve before the accident:

<u>MILLER:</u> We want to discuss when we would shut that block valve, and looking at the pressurizer system failure procedure ... it says that we would shut it when you had, what, a leaking valve, or inoperable electromatic. Now, how do we authorize operating a valve that's leaking in accordance with our procedures?

L J. J.

We knew the valve was leaking, I thought.

ZEWE: Oh, yes.

598/ Frederick April 6, 1979, TMI staff interview at 4.

599/ Logan deposition at 167.

600/ Zewe hearing testimony at 128.

601/ TMI-2 Emergency Procedure 2202-1.5, Revision 1, June 22, 1977, Pressurizer System Failure, Section A.l(B)(1).; Frederick deposition exhibit 8.

602/ Seelinger deposition at 114.

MILLER: It had nothing to do with this transient ... you have a procedure that says shut the valve when you have a problem with it.

Management-wise, though, we were operating the plant with this valve, known to be leaking, not using this procedure.603/

On March 28 the lifting of the PORV at 3 seconds was an expected event. The operators knew that temperature in the tailpipe would rise as a result of the initial discharge. Thus, when they saw higher temperatures in the tailpipe further into the accident they incorrectly attributed those temperatures to a combination of the higher baseline temperature due to the leak and residual heat from the initial expected discharge through the PORV.604/

Burns and Roe had known about the general problem of leaking PORVs and, in fact, had made some specific design changes to minimize leaks.605/ But Burns and Roe had not recalculated the normal baseline temperature to be expected with various classes of leaks, nor had Met Ed recalculated the baseline temperatures for the particular leak that existed prior to the accident. No one had calculated the heat decay curve on the discharge pipe to show the temperature readings an operator should expect from residual heat as a function of time after discharge as compared with temperature to be expected in a continuing discharge through a failed open valve.606/

The operators said they had expected to see temperatures on the order of 350°F - 400°F in the event of a failed open PORV.607/ In fact, such temperatures are impossible to generate, since the steam passing through the relatively narrow PORV orifice expands rapidly on the discharge side with an accompanying cool-down. No one had ever explained to the operators the cool-down from RCS temperature due to enthalpic expansion through the PORV so that they would know what temperature to look for in the tailpipe. 608/ Nor were the ranges of expected temperatures supplied in the emergency procedure.

603/ May 25, 1979, Miller transcript at 16. Accession #1008013.

604/ Frederick deposition at 299-300; Zewe hearing testimony at 129.

605/ Cobean deposition at 32-36.

606/ Frederick deposition at 300; Cobean deposition at 40.

607/ Frederick hearing testimony at 131; Zewe hearing testimony at 135.

608/ Frederick deposition at 300, 308-311.

Since the leak had been allowed to continue before the accident, temperatures in the discharge tailpipe had routinely hovered in the 180°F range. This desensitized the operators to high temperatures in the tailpipe.

During Frederick's deposition, a mini-sequence of events relating to the four symptoms of a failed-open PORV was presented to him. He was asked which of these events had actually come to his attention. He said that, out of approximately 20 indicators, only the tailpipe temperature symptom had possibly come to his attention during the accident.609/

Zewe received at least two tailpipe temperature readings, but he remembered them as being in the 230°F range when, in fact, data from plant instruments showed they were in the 280 °F range. Zewe dismissed the 230°F readings as not significant.610/

Frederick said that a major problem with the drain tank temperature and pressure readings (symptom no. 4 in the procedure) was that they were out of sight on the back side of the control room panel, and there were no strip chart recorders to show trends of temperature and pressure.611/ He recalled looking once at the drain tank indicators but not seeing anything unusual. He said the only other meaningful symptom of the four listed in the procedure was discharge pipe temperature; however, this was ambiguous because of the prior leak.

On March 28 at approximately 6:00 a.m. a conference call was set up at Gary Miller's request between George Kunder, TMI-2 superintendent for technical support, who was in the TMI-2 control room; Leland Rogers, B&W site representative who was at his home; and John Herbein, Met Ed's vice president for generation, who was in Philadelphia. Kunder gave a plant status description. 612/ During that conference call which ~sted approximately a half-hour, Rogers asked whether the PORV block valve was shut. He testified that Kunder did not know, sent someone to check, and the answer came back, "Yes, the block valve was shut."613/

Brian Mehler, a shift supervisor, testified that when he came into the control room at approximately 5:50 a.m. he saw "... the pressurizer being solid and no pressure in the system, pressure going down. It would indicate to me at that particular time that either the heaters weren't functioning or that we had a leak."614/ Mehler then sent

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609/ Id. at 272-303.

610/ Zewe hearing testimony at 135.

611/ Frederick deposition at 303-306.

612/ Kunder deposition at 144-146; Rogers deposition at 79-83; Miller deposition at 240-241, 250-251; Herbein deposition at 102-103.

613/ Rogers deposition at 84-85; Miller deposition at 243; Kunder deposition at 147-148.

614/ Mehler deposition at 154.

someone to check whether the heaters were functioning and pulled from the computer the tailpipe temperatures for the PORV and the code safeties. When he received the temperature readings, he concluded that the PORV was at least partially open and instructed Scheimann to close the block valve.615/ He testified that he gave this instruction at 6:10 a.m.616/ Mehler did not discuss his decision to shut the block valve with anyone. He also testified that no one told him to close the block valve.617/

Frederick testified that:

> As far as I know the action to close the valve was out of -- somewhat out of desperation. In other words, there seemed to be no other possible cause for the low pressure and it just seemed like something that we could try to see if that would isolate the problem. It is not at all a recommended procedure to isolate a relief valve. It is a last ditch effort.618/

The block valve was probably not shut in response to Rogers' question to Kunder, but rather as a result of Mehler's independent decision. 619/ Nonetheless, it is interesting that B&W's Rogers came so quickly to the conclusion that the PORV might have failed open.620/

The failure to realize that the PORV was stuck open was due to inadequate procedures, instrumentation, and training. Nowhere does the procedure state the fundamental goal: If there is any evidence that the PORV is stuck open, the block valve should be closed. B&W has pointed out that there was little to lose in closing the block valve even on a minimal suspicion that the PORV was open.621/ But if that were true, it was not reflected in the procedure that B&W had helped to write.622/

616/ Id. at 157.

617/ Id. at 160.

618/ Frederick May 30, 1979, hearing testimony at 119.

619/ The block valve was shut at 6:22 a.m. EPRI Sequence of Events, footnote 481, supra. Mehler testified he ordered it shut at 6:10 a.m.; Mehler deposition at 157. The conference call with Rogers was held sometime between 6:00 and 6:15 a.m. Herbein deposition at 104; Miller deposition at 251.

620/ Rogers deposition at 81-89.

621/ MacMillan, Oral Statement of the Babcock & Wilcox Company before the Subcommittee on Energy and the Environment of the House Committee on Interior and Insular Affairs (Udall Committee), May 24, 1979, at 3-4.

622/ Letter from Fisher (Met Ed) to Rogers (B&W); Dec. 30, 1977. Accession #9110020.

B&W omitted from its public statements after the accident its own failure to convey adequate information to its utilities about the history of PORV failures623/, to emphasize training to identify such failures promptly, and to review utility PORV procedures to see whether they were adequate for emergency situations. If, in light of the history of PORV failures, B&W had advised its customers to install direct position indicators on all PORVs, the TMI-2 operators might not have had to guess about whether the PORV was open.624/

623/ See Commission staff report on the PORV; also Zewe deposition at 48-49, 89-90.

624/ Elliott hearing testimony at 319-320.

ATTENTION TO EXPERIENCE

The TMI-2 accident was foreshadowed by events that occurred as much as 5 years earlier. These included:

- a transient at Toledo Edison Davis-Besse-1 plant on Sept. 24, 1977;
- a history of pilot-operated relief valve failures;
- a 1977 analysis by Carlyle Michelson of pressurizer level in relation to reactor coolant pressure;
- a failure in the condensate polishing system at TMI-2 on Oct. 19, 1977; and
- an April 23, 1978, transient at TMI-2 in which the core apparently went into saturation conditions.

Had sufficient attention been paid to any one of these five events or histories, the TMI-2 accident might never have occurred.

To put these five events in perspective, this section looks first at the basic structure for attention to experience at Met Ed and B&W.

MET ED STRUCTURE

Before the accident there was no unique group to which safety concerns were addressed. The only channel available to control room operators at Met Ed for addressing safety concerns was to submit a procedure change request to their supervisor. 625/ For example, when Frederick was not satisfied with the Met Ed response to the April 23, 1978, transient at TMI-2 he wrote a letter to James Seelinger, who was then TMI-2 superintendent for technical support. Raising questions of design, mechanical failure, and operator training, Frederick said that his concerns were "only the tip of the iceberg," concluding, "Let's get together and try to keep this from happening again." 626/

In order to follow operating and safety experiences at othe nuclear plants, Met Ed assigned a technical analyst to each unit superintendent. The analyst's job was to review the information that came routinely to the Island, route the documents to appropriate people for review, and bring significant items to the superintendent's attention.627/

625/ Frederick deposition at 120-125, 459.

626/ Letter from Frederick (Met Ed) to Seelinger (Met Ed), May 3, 1978; Frederick deposition exhibit 17.

627/ Miller testified that there was a technical analyst for each unit -- Miller deposition at 143; yet Seelinger, TMI-1 superintendent, testified that there was only a technical analyst for TMI-1 -- Seelinger deposition at 133.

These technical analysts, however, did not have operating licenses. A nuclear background was not required. There was no requirement that they have any minimum level of expertise. No special training was provided to these technical analysts; nor was any specific direction given to them as to what kind of analysis they were expected to do.628/ Gary Miller said he was burdened with so much paperwork that he had to pass on much of his reading material to the analyst. 629/

Though the limitations of GPUSC's review of operating experiences were recognized, GPU Vice President Arnold testified that there were a number of mechanisms for integrating operating experience into design review. 630/ Despite (or perhaps because of) the number of mechanisms available, no one at GPU or Met Ed devoted full-time, exclusive attention to the review process.

> J don't see any particular advantage to design problems, per se, going through a dedicated group.
>
> We have looked at providing a dedicated group to look for problems. Herman and I talked about putting into place ... a Nuclear Safety Audit Group that would be solely involved with that type of activity.
>
> It is part of the organization structure that we have defined with the change we made last week [August 1979] to establish such a group.631/

Although Arnold expressed reservations a number of times about the relative advantages of a "dedicated" review group, he offered some insight into why GPU has now adopted that approach in its post-accident reorganization:

> Where I come out on the Dedicated Review Group, I guess, is that it is one way of approaching the problem. It doesn't necessarily involve substantial advantages over other ways of approaching it but . . . I think that the operating of nuclear plants involves sufficient exposure to us, as the accident demonstrated, that it is prudent to have the kind of audit function which is set aside and dedicated relative to how our nuclear facilties are being operated, maintained and administered. (emphasis added) 632/

628/ Miller deposition at 145.

629/ Id. at 147.

630/ Arnold deposition at 86-87. See discussion in "The Role of GPUSC," subsection on "Nuclear Power Activities Group," supra.

631/ Arnold deposition at 75-76.

632/ Id. at 76-77.

Nelson Brown, an instructor in the Met Ed training department, was responsible for reviewing and incorporating experiences at other nuclear plants into Met Ed training. He did that by reviewing the following information sources:

- Atomic Energy Clearinghouse documents -- a weekly commercial newsletter including a monthly computer printout of licensee event reports (LERs); the printout includes a brief description of the event and its cause;633/

- "LER Monthly Report on PWR Events" -- an NRC monthly computer printout including reactor status and a brief event and cause description;634/

- "Power Reactor Events" -- a bimonthly NRC newsletter that includes a description of selected transients at nuclear power plants ;635/

- NRC computer printout that extracts LERs relating to personnel error including a brief description of reactor status, the event and the cause.636/

The purpose of his review was to prepare material for a class to discuss LERs from TMI and other plants -- usually a 2-hour session once a year.637/ Brown devoted about one-tenth of his time to reviewing these documents. 638/ He received his own copy of the "LER Monthly Report" directly from the NRC, but the Atomic Energy Clearinghouse report and "Power Reactors" were routed to him through the unit super-intendent, The latter two reports often did not reach him for 2 or 3 months after they had arrived on-site.

633/ Atomic Energy Commission Clearinghouse LER Computer Printout, May 7, 1979, Brown deposition exhibit 79.

634/ LER Monthly Report on PWR Events (NRC), March 2, 1979; Brown deposition exhibit 76.

635/ "Power Reactor Events" (NRC), May 1979; Brown deposition exhibit 78. "Power Reactor Events" was previously titled "Current Events." See "Current Events" (NRC), December 1977; Porter deposition exhibit 2.

636/ LER Monthly Report on Events Involving Personnel Errors (NRC) March 2, 1979; Brown deposition exhibit 77.

637/ See complete discussion in Commission staff report, "Selection, Training, Qualification, Licensing, and Staffing of Three Mile Island Operating Personnel."

638/ Brown deposition at 44.

Even after Brown received these reports, his review often was delayed for several months because of the press of other work.639/ The supervisor of training never indicated to Brown what priority should be assigned to his review of operating experience at other plants.640/

TMI site engineers also received copies of the Atomic Energy Clearinghouse report. After their review they were responsible for initiating any procedural changes they thought necessary. They did not review the complete reports, however, but only those portions brought to their attention by the unit superintendent or the superintendent for technical support. 641/ In reality, it was not the unit superintendent who identified what the engineers should review, but the technical analyst, who did not necessarily have a nuclear background.

Neither Met Ed generation engineering nor GPUSC analyzed operating history at nuclear plants. GPUSC's engineering efforts were basically devoted to design and construction of future plants. 642/ The manager for generation engineering did receive the Atomic Energy Clearinghouse report, but it came to him on a routing slip and took as much as 2 months to reach him.643/ He would read the Clearinghouse report and would sometimes mark a section for someone in his division to review.644/

Nor did any of the standing committees (Plant Operations Review Committee, General Office Review Board, Generation Review Committee, and Nuclear Plant Management Review) serve as an independent body to analyze operating experiences at other nuclear plants. (The role and membership of these committees is described in the "Review Committees" section of this paper.) In January 1979, GORB asked how PORC reviewed TMI-2 LERs to determine whether a trend in the type of reportable occurences was developing. The TMI-2 PORC reviewed LERs for its unit prior to submission to the NRC. GORB minutes noted:

> The PORC maintains a list of LERs and compares the new LER to this list to see if there are similarities. The staff also relies on the experience of the PORC members to recall if the new LER represents a repeat occurrence. The GORB recommended that a more in-depth review of LERs be undertaken at TMI including a review of the LERs listed in the atomic clearinghouse publication.645/

639/ Id. at 25.

640/ Id.

641/ Id. at 40-41.

642/ Dieckamp deposition at 67-75; Arnold deposition at 29-31.

643/ Klingaman deposition at 156-159.

644/ Id.

645/ Draft Minutes, Meeting Number 32 (GORE) Jan. 10, 1979; Finfrock deposition exhibit 10.

Since TMI-1 and TMI-2 each had a separate PORC, a PORC review of its own LERs did not, in and of itself, lead to a knowledge of the other unit's operating experiences.

In June 1978 the GORB became concerned that Met Ed's internal system was not digesting information received about experiences at other plants. This concern was general, not raised in response to any specific event.646/

> The question was raised about whether we needed to develop new techniques for transmitting information, what can we do about the large volume of information that the plant is deluged with, operating people in particular and the industry in general.647/

In response to its concern, the GORB issued Action Item No. 31, raising the following question:

> Are there changes which should be made in the process for acquisition and use of information about incidents at other nuclear plants as one way to forecast and avoid nuclear and radiation safety problems at TMI-1 and TMI-2?648/

Lawrence Lawyer, manager of generation operations, was assigned the responsibility of completing this action item. He and George Kunder prepared a response which listed a variety of information sources but made no attempt to determine how the information was analyzed by Met Ed or indeed whether the information received was adequate.649/

Thus, while they stated that "[t]here is some danger of the above information being buried in the plethora of written communications," they also concluded that "[a] formally organized program to prereview and filter the incoming information and subsequently forward it to the appropriate parties would consume more manpower than would be cost affective [sic]."650/ There was no subsequent action taken by GORB in response to the Lawyer/Kunder memorandum.651/

While the GRC, like the GORB, served an off-site review function, it reviewed TMI-2 LERs only to ensure they met technical specification requirements. GRC did not review LERs from other nuclear power plants.

646/ Lawyer deposition at 60.

647/ Id.

648/ GORB Action Item Number 31, June 15, 1978; Kunder deposition exhibit 87.

649/ Lawyer deposition at 62-63.

650/ GORB Action Item Number 31, June 15, 1978; Kunder deposition exhibit 87.

651/ Lawyer deposition at 64.

The chairman of the PCR and TCN 652/ subcommittee of GRC did review the NRC reports of operating experiences at other nuclear power plants. But he never brought anything from his review of the NRC reports to the full GRC's attention, according to George Troffer, chairman of the GRC and manager of generation quality assurance. 653/ The subcommittee review was not a formal assignment made in the GRC's charter.654/ Troffer stated:

> We received these reports, a thick large number of items, and to do a thorough job of researching applicable to our plant and followup would have been a very considerable effort, and it was one that we never mounted. The reviews were more a chance to see items of interest.655/

Finally, the Nuclear Plant Management Review had no responsibility to review operating experience at either TMI or other nuclear plants.

Herman Dieckamp, president of GPU, spoke generally about Met Ed's and GPU's past attention to experience:

> I think that rightly or wrongly we made the assumption that the suppliers [such as B&W), because of the commonality of seeing supply equipment and their interests, would act as one channel of aggregation of that experience and feedback. We also made the assumption that because of the mechanism of the licensee event reports and the organization structure of the NRC in their bulletins, et cetera, that that would be another channel, and that therefore there was not a need for us to attempt to reproduce that and certainly not in its totality so that we could be self-sufficient or independent of those channels.
>
> Now, going beyond that and having said that, I think one of the critical things we need to do is to make those channels indeed functional and operational.656/

In sum, neither the standing committees nor any particular department was charged with the responsibility of analyzing operating experience. There was no systematic review of experiences at TMI or other nuclear

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652/ PCR stands for procedure change request and TCN stands for temporary change notice. Each was a form for requesting or implementing procedure changes.

653/ Troffer deposition at 41-42.

654/ Id. at 42.

655/ Id. at 43; see generally 41-45.

656/ Dieckamp deposition at 163-165.

power plants. Dieckamp concluded that ". . . to me that is probably one of the most significant learnings of the whole accident is the degree to which the inadequacies of that experience feedback loop . . . significantly contributed to making us and the plant vulnerable to this accident."657/

B&W STRUCTURE

There was no individual or department at B&W charged with the responsibility of analyzing transients that had occurred at B&W plants.658/ James Mallay, a B&W engineering manager, testified that from 1961 to 1969 he had been involved with transient analysis; however, this analysis was "primarily for the purpose of the safety analysis reports submitted to the NRC. They were rarely associated with realistic situations or actual occurrences."659/

Before the accident, B&W often received only abbreviated summaries of licensee event reports, rather than the full text prepared by the reporting utility.

In addition, B&W did not formally incorporate transients from other nuclear plants or even from B&W's own plants into the simulator training.660/ B&W did not always tell the operators whether simulator exercises were real-life incidents or were simply invented scenarios.661/ B&W classroom instruction also never specifically addressed operating experiences at other nuclear plants.662/

Preliminary Safety Concerns

NRC regulations require vendors and licensees to report to the NRC certain classes of events or deficiencies which could create a safety hazard. 663/ The regulations require B&W to have, among other things, a procedure for identifying safety concerns.664/

657/ Id. at 153.

658/ Mallay deposition at 38.

659/ Id. at 36-37.

660/ Lind deposition at 108.

661/ Scheimann deposition at 45.

662/ Faust deposition at 45-46; Zewe deposition at 46-47; Scheimann deposition at 45.

663/ 10 CFR Part 21 and 10 CFR Part 50.55E.

664/ Taylor deposition at 35. Although the PSC procedure antedated the Part 21 requirements, it was modified when Part 21 became effective in January 1978 to reflect the specific requirements of the regulation. Id. at 38.

B&W had such an in-house procedure that relied on a preliminary safety concern (PSC) form.665/ When any employee discovered something that he believed was a potential safety concern, he could complete a PSC form that was sent to the manager of licensing, James Taylor666/ The submission of a PSC to the licensing office was the first step toward a potential report to the NRC. When the PSC reached Taylor's desk he reviewed it and gave it to an assistant who started a review process to determine whether the PSC was reportable to the NRC.667/ That process involved directing the PSC to appropriate engineers for analysis and evaluation, reviewing their findings, and making a decision as to reportability. 668/ The final decision as to whether the PSC identified a "reportable" issue was made by Taylor.669/ According to Taylor:

> The spirit of [the reporting requirement] is to try to give visibility to and provide records for things that could potentially lead to substantial hazards had they not been detected and to provide a system for keeping things from dropping in the crack, to help catch things on paper before they would become a real problem.670/

The B&W procedure implementing the NRC reporting requirements specified no time period within which PSCs had to be analyzed and resolved. 671/ But Taylor said he had an informal target of processing 75 percent of the PSCs within 30 days.672/ For that purpose Taylor's deputy had a chart on the wall of his office which tracked the progress of each PSC.673/

Taylor indicated that he handled the PSCs with some degree of judgment, deciding which ones needed immediate attention and which ones could be handled at a more leisurely pace. ". . .[I]f I see something that is of immediate concern, I will try to precipitate immediate action," he said.674/

665/ Id. at 39.

666/ Id. at 37-38.

667/ Id. at 40.

668/ Id.

669/ Id. at 41.

670/ Id. at 38.

671/ Id. at 47.

672/ Id. at 48.

673/ Id. at 49.

674/ Id. at 42.

An example of how this process actually worked was the handling of the Dunn memorandum, which is explained in detail below.675/ Dunn's memorandum clearly raised a safety concern since it discussed the possibility of "core uncovery and possible fuel damage."676/

At the time Dunn wrote his memorandum he knew of the PSC procedure, knew that Taylor administered the procedure, and knew he could have used the procedure. 677/ Instead Dunn made his concerns known on a routine office memorandum instead of on a PSC form, but he directed it nonetheless to Taylor. Taylor recalled receiving the memorandum but rather than handling Dunn's memorandum as a safety concern, regardless of the form it was written on, he decided it was "a procedural matter" (apparently because it dealt partly with procedures) and forwarded it to the Customer Service Department, 678/ where it was never handled with the kind of procedural safeguards -- deadlines, standardized review process, and requirement for resolution -- that might have prevented it from, to use Taylor's words, "dropping in the crack."

Site Problem Reports

Site problem reports were another B&W mechanism to channel plant experiences to B&W's engineering department in Lynchburg. Site problem reports were used to report malfunctions, unknown operating characteristics, or irregularities in B&W components that might affect the B&W equipment.679/

At TMI-2, site problem reports were initiated by B&W's site representative Leland Rogers and were forwarded to the engineering or other departments at B&W for analysis. Analysis and resolution of site problem reports was by a formal procedure and "flow path" with requirements for the reports to be signed off by appropriate individuals. 680/ Any site problem requiring a response and action by B&W would be handled through a site problem report.681/

675/ See the section on the Davis-Besse Sept. 24, 1977, transient in this paper.

676/ Memo from Dunn (B&W) to Taylor (B&W), Feb. 9, 1979; Womack deposition exhibit 23.

677/ Dunn July 13, 1979, deposition at 10.

678/ Taylor deposition at 55.

679/ Rogers deposition at 20.

680/ Id. at 21.

681/ Id. at 22.

Three site problem reports relating to the PORV were sent from TMI-2 between August 1977 and October 1978.682/ (See "PORV Failure History" later in this section for a discussion of the PORV and the PORV site problem reports.)

B&W Users Group

The B&W Users Group was established by B&W in 1976 to facilitate the exchange of information among the B&W utilities concerning the B&W nuclear steam supply systems, and to transmit recommendations from B&W to the utilities. 683/

The Users Group included representatives of B&W and its utility customers, who exchanged not only ideas but also operating experience and particular problems that may have arisen with a B&W component or system. 684/ Both B&W and the utilities made presentations at the annual Users Group meeting.

B&W Owners Group

The membership of the B&W Owners Group consisted of the utilities owning B&W 177 fuel assembly plants. 685/ The Owners Group was less concerned with operating experiences than the Users Group; its focus was on "potential generic engineering and licensing-related B&W efforts."686/ Met Ed's representative to the Owners Group since early March 1979 had been John Hilbish, supervisor of licensing.687/

The work of the Owners Group was primarily done in its subcommittees, which were formed on an ad hoc basis to deal with issues of concern to the member utilities. 688/ As of early March there were approximately 10 subcommittees, including ones dealing with reactor vessel and materials, the core, asymmetric LOCA loads, and steam generators.689/ After March 28, a subcommittee was formed to consider follow up action in response

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682/ Site problem report #143, Aug. 22, 1977; #183 Rev. 0, April 10, 1978; #195 Rev. 0, Oct. 5, 1978; Rogers deposition exhibits 11-13.

683/ Seelinger deposition at 148.

684/ Herbein deposition at 79.

685/ Fritzen deposition at 62.

686/ Hilbish Aug. 9, 1979, deposition at 32.

687/ Id.

688/ Id. at 32-33.

689/ Id. at 33.

to TMI-2.690/ The frequency of subcommittee meetings varied from 1-6 month intervals.691/

The Owners Group was chartered to operate independently of B&W. The meetings usually lasted 2 days, on only one of which a B&W representative was invited to attend. This was "because the owners feel that there are times when they want . . . to sit down and talk about issues without a B&W representative present."692/

For example, the minutes of a February 1979, meeting of the Owners Group said:

> B&W Responsiveness to Engineers and Licensing Problems. B&W's biggest deficiency in this area was cited as being the coordination of generic or partially generic items between utilities (project and/or service managers). Following the NRC Region III investigation of pressurizer level response to transients, NRC stated they didn't think B&W was being completely open and candid with the owners when items come up. An example cited was the pressurizer level analysis on ANO [Arkansas One) in 1975 which no one knew about until the winter of 1979 during the investigation. It was agreed that this would be brought to B&W's attention during the meeting on 3/7. NRC also complemented the utilities' cooperation on the pressurizer level issue.693/

In addition to the Owners and Users Groups, there was a yearly seminar hosted by B&W at which the utilities' operating experiences were discussed.694/

DAVIS-BESSE, SEPT. 24, 1977, TRANSIENT

The first of the five incidents which foreshadowed the TMI-2 accident occurred in a September 1977 transient at Toledo Edison's Davis-Besse-1 plant. That transient had the following features:

690/ Fritzen deposition at 50.

691/ Id.

692/ Hilbish Aug. 9, 1979, deposition at 34.

693/ Meeting summary, Babcock & Wilcox 177 FA Owners Group for engineering and licensing, Executive Committee Meeting March 6, 1979 at 1. Accession #9030048. These minutes referred to the Feb. 14, 1979, meeting at B&W concerning transients at B&W plants during which pressurizer level indication went off-scale low. See discussion under "Davis-Besse Nov. 29, 1977, Transient" later in this report.

694/ Seelinger deposition at 141-143.

- total loss of feedwater;

- failed open PORV;

- pressurizer level high and reactor coolant pressure low; and

- premature termination of high pressure injection based on pressurizer level alone.

Those events were an almost exact duplication of what would happen 18 months later at Three Mile Island. The significant differences were that the open PORV was identified after 20 minutes at Davis-Besse, but not for 2 hours and 22 minutes at TMI-2 and that Davis-Besse was at 9 percent power, while TMI was at 97 percent power.

The effect of throttling high pressure injection flow was to put the reactor in the potentially dangerous situation of a continuing loss of water through the stuck-open PORN with no water being added to make up for the loss. The operators turned off the extra water flow just when it was needed most because they were focusing on pressurizer level and disregarding low system pressure.

The phenomenon of pressurizer level high with reactor coolant system pressure low had not been predicted and was not known by B&W before the Davis-Besse 1977 transient, although all the necessary information for such a predictive analysis was available to B&W.695/

B&W's Role

The day after the transient, Joseph Kelly of B&W's Plant Integration Unit, a part of the Plant Design Section, was sent to Davis-Besse to investigate what had happened. After 2 or 3 days at the site, he returned to Lynchburg and briefed some 30 B&W employees, including Vice President MacMillan, on the details of the accident. 696/ Bert Dunn, manager of B&W's Emergency Core Cooling System Unit, also part of the Plant Design Section, was present at the briefing. At the end of the meeting Dunn and Kelly began discussing whether operators of B&W plants knew when it was proper manually to interrupt HPI in a loss-of-coolant accident.

Then Kelly learned that on Oct. 23, 1977, the same thing happened again at Davis-Besse. Kelly became more concerned and went to B&W's training department and asked John Lind, the lead instructor, what B&W was teaching utility operators on when to secure HPI. He told Lind what had happened in the two Davis-Besse transients. Lind assured him that the training department was teaching that HPI should not be secured until pressurizer level had stabilized and reactor coolant pressure was

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695/ Dunn June 30, 1979, deposition at 129-130; Roy deposition at 32.

696/ Kelly July 7, 1979, deposition at 10.

increasing. Kelly felt reassured by what Lind said, but he did not review the procedures or the training materials to see what was actually being taught. He did not suggest running the Davis-Besse transients on the simulator to analyze them more closely. Nor did he suggest that the two transients should be reviewed in upcoming training programs to ensure that operators understood when they could secure high pressure injection.697/

Lind never incorporated the Davis-Besse transients into the B&W training program, although there was a clear conflict between what Lind said B&W was teaching and what the operators had actually done at Davis-Besse.698/

As a result of the Dunn-Kelly discussion and at Dunn's urging Kelly on Nov. 1, 1977, directed a memorandum 699/ entitled "Customer Guidance on High Pressure Injection Operation" to seven people, all holding responsible positions in either the engineering or customer services departments.700/ After describing the Davis-Besse incident, Kelly stated:

> Since there are accidents which require the continuous operation of the high pressure injection system, I wonder what guidance, if any, we should be giving to our customers on when they can safely shut the system down following an accident? . . . I would appreciate your thoughts on this subject.701/

The only written response was a Nov. 10, 1977, memorandum from James Walters, a supervisory engineer in the Customer Service Department,702/ who pointed out:

697/ Id. at 23-26.

698/ Lind deposition at 107-108.

699/ This memorandum and the four other B&W memoranda concerning premature termination of HPI are attached as Appendices L through N.

700/ Those receiving the memorandum were: Bruce Karrasch, manager, Plant Integration Unit, Plant Design Section, Customer Services Department; B.W. Swanson, supervisor, Plant Integration, Plant Design Section, Customer Service Department; R. Finnin, engineer, Plant Performance Services Section, Customer Service Department; Bert Dunn, manager, Emergency Core Cooling System Unit, Plant Design Section, Engineering Department; D. LaBelle, manager, Safety Analysis Unit, Plant Design Section, Engineering Department; Norman Elliott, manager, Training Services Department; and Donald Hallman, manager, Plant Performance Services Section, Customer Service Department.

701/ Memorandum from Kelly (B&W) to Distribution (B&W), Nov. 1, 1977; Womack deposition exhibit 24.

702/ The Customer Service Department was called the Nuclear Service Department until February 1979. To avoid confusion, the department is always referred to by its present name in this paper.

> In talking with training personnel and in the opinion of this writer, the operators at Toledo responded in the correct manner considering how they had been trained and the reasons behind this training.
>
> My assumption and the training assumes first that RC [Reactor Coolant] Pressure and Pressurizer Level will trend in the same direction under a LOCA [loss-of-coolant accident]. For a small leak, they keep the HPI [high pressure injection] System up to a certain flow to maintain presr. [pressurizer] on Level.703/

Walters also stated that an instruction calling for continued operation of HPI might raise questions of vessel mechanics and of the primary system "going solid" -- filling completely with water and collapsing the steam bubble at the top of the pressurizer.

According to Dunn, in the months following Kelly's Nov. 1 memorandum, B&W took no action to provide its customers with information concerning the proper use of HPI. So on Feb. 9, 1978, in an effort to "kick . . . tail,"704/ Dunn wrote a memorandum entitled "Operator Interruption of High Pressure Injection" and sent it to James Taylor, manager of licensing, the unit concerned with safety questions. Eleven engineers within B&W received copies of the memorandum. Dunn wrote:

> The direct concern here rose out of the recent incident at Toledo [Davis-Besse]. During the accident the operator terminated high pressure injection due to an apparent system recovery indicated by high level within the pressurizer. This action would have been acceptable only after the primary system had been in a subcooled state. Analysis of the data from the transient currently indicates that the system was in a two-phase [steam and water] state and as such did not contain sufficient capacity to allow high pressure injection termination. This became evident at some 20 to 30 minutes following termination of injection when the pressurizer level again collapsed and injection had to be reinitiated. During the 20 to 30 minutes of noninjection flow they were continuously losing important fluid inventory even though the pressurizer indicated high level. I believe it fortunate that Toledo was at an extremely low power and extremely low burnup. Had this event occurred in a reactor at full power with other than insignificant burnup it is possible, perhaps probable, that core uncovery and possible fuel damage would have resulted.
>
> The incident points out that we have not supplied information reactor operators in the area of recovery from LOCA.

703/ Memorandum from Walters (B&W) to Kelly (B&W), Nov. 10, 1977 (Appendix K); Dunn deposition exhibit 35.

704/ Dunn June 30, 1979, deposition at 71.

I believe this is a very serious matter and deserves our prompt attention and correction (emphasis added).705/

Dunn never heard from Taylor about his memorandum. In May 1979 Taylor told Dunn he believed Dunn's memorandum had been "misdirected." Taylor said he believed Dunn's concerns were not safety-related because they had not been submitted on the proper company form for safety questions.

QUESTION: . . . [H]ad the Dunn memorandum been typed . . . on a PSC form and had it arrived on your desk in that form, rather than in memorandum form, in February of 1978, would you still characterize it as having been misdirected?

TAYLOR: No, because PSCs are supposed to come to my desk according to procedure.

QUESTION: Is the Dunn memorandum an appropriate subject for inclusion in a PSC?

TAYLOR: It is a good subject to be addressed on a PSC because the PSC system prevents it from dropping in the crack.

QUESTION: And it would have been a good subject for being contained or put into a PSC form at the time of February 1978?

TAYLOR: Yes-706/

Since the memorandum was not written on the proper form, Taylor thought it belonged with Customer Service rather than Licensing.

Customer Service did not dispute Dunn's prediction of core uncovery and possible fuel damage. Instead discussion between Dunn and Customer Service centered on the proper remedy for the problem. The results of those discussions were contained in a second memorandum from Dunn to Taylor707/ a week later in which Dunn said that he concurred in Customer Service's solution to the question of when it was,proper to terminate HPI. After that Dunn considered the question closed, assuming that Customer Service would convey to B&W's customers the new instructions

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705/ Memorandum from Dunn (B&W), Feb. 9, 1978 (Appendix 1); Womack deposition exhibit 23.

706/ Taylor deposition at 80.

707/ Memorandum from Dunn (B&W) to Taylor (B&W), Feb. 15, 1978 (Appendix M); Dunn deposition exhibit 36.

for terminating HPI following a LOCA.708/ In fact, those instructions were never sent before the accident at TMI-2.709/

Walters continued to have doubts about the solution reached between his subordinates and Dunn. Sometime between February and July 1978 Walters asked Plant Integration to evaluate those doubts, but apparently Plant Integration took no action on the matter.

Meanwhile, the Michelson report had been sent to B&W in late April.710/ The Michelson report raised a concern about operators throttling HPI on the basis of pressurizer level alone. Bert Dunn was briefed on the report by his deputy Bob Jones, recognized that it addressed the same issue he had raised 3 months earlier in his memorandum to Taylor, but did not double check to see whether B&W's utilities had actually been notified of the concern.

In August, in order to get Plant Integration moving, Walters drafted a memorandum for his supervisor Hallman's signature, once again requesting Plant Integration to focus on these questions. In that memorandum, Customer Service was concerned that if an operator did not manually interrupt the HPI:

> . . . this mode can cause the RCS (including the pressurizer) to go solid. The pressurizer reliefs will lift, with a water surge through the discharge piping in the quench tank.
>
> We believe the following incidents should be evaluated:
>
> - If the pressurizer goes solid with one or more HPI pumps continuing to operate, would there be a pressure spike before the reliefs open which could cause damage to the RCS?
> - What damage would the water surge through the relief valve discharge piping and quench tank cause?

The Aug. 3, 1978, memorandum concludes:

> To date, [Customer Service] has not notified our operating plants to change HPI policy consistent with References 1 and 2 because of

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708/ Walters and Dunn are in conflict on this point. According to Walters, there were further discussion over the next 2 to 4 months among Customer Service, Plant Integration, and ECCS Analysis. Walters deposition at 18-22; Dunn June 30, 1979, deposition at 88.

709/ Dunn June 30, 1979, deposition at 88.

710/ See the subsection on the Michelson report, infra.

our above-stated questions. Yet, the references suggest the possibility of uncovering the core if present HPI policy is continued.711/

When the manager of plant integration, Burce Karrasch, received the Aug. 3, 1978, memorandum, he glanced over it "very quickly" 712/ and sent it to a subordinate (either Eric Swanson or A. McBride) who, Karrasch thought, would best be able to answer Walters' questions.713/ Karrasch said:

> I don't recall ever really feeling the significance of what Mr. Hallman was trying to communicate. It seemed to me that it was a routine matter; [Customer] Service was asking Bruce Karrasch two questions, and I sent it on, two of the questions [to be] answered in a rather routine manner.714/

When Karrasch questioned Swanson and McBride after the accident, neither recalled receiving the memorandum from him.715/

On at least two occasions between Karrasch's receipt of the Aug. 3, 1978, memorandum and the end of 1978, Hallman contacted Karrasch informally and asked whether any action had been taken. On both occasions Karrasch told Hallman that he had passed the memorandum on to somebody in his group for action, and that he assumed Hallman would receive a response shortly. On neither occasion did Karrasch go back and talk to McBride or Swanson:

> "All I can remember is in the fall of '78 that things were very, very busy . . . and my attention and the whole group's attention [was given] to what were perceived to be higher priority matters." 716/

Sometime between Jan. 15 and March 15, 1979, Hallman ran into Karrasch at the soda machine in the B&W building in Lynchburg, Va. Hallman asked Karrasch for a third time whether any action had been taken on the Aug. 3, 1978, memorandum. At the point, Karrasch said, he read the memorandum "quite carefully"717/ and told Hallman that he agreed

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711/ Memorandum from Hallman (B&W) to Karrasch (B&W), Aug. 3, 1978 (Appendix N); Dunn deposition exhibit 37. "References 1 and 2" in the text of the above quotation refer to the Dunn memoranda of Feb. 9 and 16, Womack deposition exhibit 23, and Dunn deposition exhibit 37.

712/ Karrasch deposition at 27-28.

713/ Id. at 25-26.

714/ Id. at 26.

715/ Id. at 28.

716/ Id. at 29-30.

717/ Id. at 31.

with Bert Dunn's recommendations set forth in Dunn's Feb. 9 and 16, 1978, memoranda. He thought the questions raised in the Aug.3, 1978, memorandum were insignificant compared to Dunn's concerns, and that Hallman should take the action necessary to resolve Dunn's concern.718/

Hallman's recollection of the conversation is different. Hallman remembers only that Karrasch told him "there was no problem"719/ with the Aug. 3, 1978 memorandum. Hallman testified:

> That response was confusing. I did not realize at the time whether he [Karrasch] meant there was no problem with action or there was no problem with operator inaction, and I did not ask him for a clarification at that time 720/

Hallman assumed that Karrasch would clarify in writing what he had meant.721/ After about 2 weeks had passed and he had not received written clarification, 722/ Hallman tried once or twice to contact Karrasch but was unsuccessful. 723/ Customer Service thus took no action on Dunn's concerns prior to the accident.

Seven days after the TMI-2 accident, an instruction was finally sent by B&W to its utilities. The instruction was essentially what Bert Dunn had proposed 14 months earlier in his memorandum to Taylor.724/ The NRC issued an instruction shortly after the accident in its Bulletin 79-05A which also reflected the substance of Dunn's original recommendation. 725/ On Sept. 25, 1979, a transient occurred at VEPCO's North Anna-1 nuclear power plant, involving the initiation of high pressure injection. As required by NRC Bulletin 79-05A, the operators did not terminate HPI until it had been in operation for a minimum of 20 minutes. Keeping the HPI on for 20 minutes resulted in repressurizing the

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718/ Id. at 32.

719/ Hallman deposition at S.

720/ Id.

721/ Id. at 13.

722/ Id.

723/ Id. at 9.

724/ Supplementary Operating Instructions for HPI System, April 4, 1979, from Fairburn (B&W) to Distribution, Olds deposition exhibit 102; and Supplementary Operating Instructions for HPI, April 17, 1979, from Brazille (B&W) to Fairburn (B&W), Olds deposition exhibit 103.

725/ Dunn June 30, 1979 deposition at 175.

primary system to the PROV pressure setpoint causing the PORV to cycle open and close for approximately 13 minutes until HPI was terminated. 726/ An "Assessment of HPI Termination Criteria from North Anna Unit 1 Transient," prepared by the NRC, questioned the advice concerning the operation of HPI as provided in Bulletin 79-05A. 727/ It stated: "From this transient, it was shown that requiring HPI operation for as long as 20 minutes may not be necessary, and that shorter periods of operation would also be acceptable."728/

In summary, Davis-Besse revealed that operators had been provided with inadequate procedures for termination of HPI following a Davis-Besse-type LOCA. B&W employees sought to get the company to correct that error. Yet through neglect and bureaucratic mistakes that information was never conveyed to the B&W customers prior to TMI-2. On March 28, 1979, at 4 minutes and 38 seconds into the accident, the operators stopped one HPI pump and greatly reduced the flow from the second pump, thereby effectively eliminating HPI, which led to core uncovery, fuel damage, and releases of radiation into containment.

Following the accident, B&W was "under pressure" to give its assessment of the events to the press. But the decision was made to "stonewall it" with the media and to defer to Met Ed/GPU and the NRC for public assessment of the events that had occurred. 729/ Then on June 5, 1979, B&W broke its silence in a press conference held at the headquarters of the Nuclear Power Generation Division in Lynchburg, Va.

The decision to hold the press conference was made in New Orleans, La., at a meeting of George Zipf, president of B&W and vice chairman of J. Ray McDermott; Louis Favret, executive vice president, Power Generation Group, B&W; John MacMillan, vice president, Nuclear Power Generation Division, B&W; and Phil Miracle, director of external communications for J. Ray McDermott.730/

Preparations for the press conference seem to have been extensive. The press flew to Lynchburg, Va., and was bused to the B&W plant for a briefing and a tour. The reporters were also given a substantial packet of background information.731/

At the time the decision to call a press conference was made, John MacMillan had received and read both of Bert Dunn's February 1978

726/ Memorandum from Denton (NRC) to Hendrie, Gilinsky, Kennedy, Bradford and Ahearne (NRC), Oct. 4, 1979. Accession #10112001.

727/ Id. at Enclosure 2.

728/ Id.

729/ MacMillan hearing testimony at 440-442.

730/ MacMillan deposition at 40-41.

731/ Id. at 45.

memoranda.732/ MacMillan did not tell Zipf of the Dunn memoranda and was uncertain about whether he told Favret of the memoranda before the press conference.733/

MacMillan stated during the press conference that B&W did not believe it held any "blame" for the accident at TMI 734/ and suggested that the operator's termination of high pressure injection based on the pressurizer level alone was the most significant factor in the accident.735/

The following exchange took place during MacMillan's deposition:

QUESTION: You did know [at the time of the press conference] that the Dunn memorandum had specifically identified operator error in throttling HPI as a danger, did you not?

MACMILLAN: What was that question?

QUESTION: You did know that the Dunn memorandum had specifically identified operator error in the premature throttling of HPI as a danger or as a source of significant concern?

MACMILLAN: Yes. Mr. Dunn expressed the concern that the operator might, on the basis of pressurizer level only, cut back on HPI.

QUESTION: I take it at this time you also knew that Dunn had identified the problem of premature termination of HPI, based on the focus on pressurizer level as a serious concern?

MACMILLAN: Yes.

QUESTION: And you knew that he had identified it as a concern "requiring marked attention and correction"?

MACMILLAN: Yes. I believe those are the words that he said in his letter.

QUESTION: I refer you to the last sentence of the memorandum.

MACMILLAN: Yes.

QUESTION: Did you tell anyone at the press conference about the Dunn memorandum?

MACMILLAN: I did not-736/

732/ Id. at 45.

733/ Id. at 43-45.

734/ Id. at 44; June 5, 1979, Press Conference at 83-84.

735/ MacMillan deposition at 48; June 5, 1979, Press Conference at 25.

736/ MacMillan deposition at 50-51.

MacMillan was then asked whether it had ever occurred to him that he had misled the public or the press by suggesting that operator termination of HPI was the significant cause of the accident without disclosing the February 1978 Dunn memoranda. He essentially replied that he did not mislead anyone and that he did not believe the Dunn memoranda were relevant to his statements.737/

MacMillan said in his press conference that B&W had made the assumption in its training that emergency equipment would perform as designed. He conceded in his deposition, however, that the intent of the 1978 Dunn memoranda was to point out that emergency "process" might not perform as designed. MacMillan also stated in his press conference that B&W training did not assume "inappropriate operator action," but conceded in his deposition that "inappropriate operator action" was exactly the issue Dunn had addressed 14 months before the accident.738/

After the accident a technical review committee was set up, within B&W, to assess its role in the accident.739/ The task of the review committee was threefold:

- to review the technical aspects of the TMI-2 occurrence;
- to develop recommendations and engineering programs to improve plant safety and reliability, with emphasis on the nuclear steam system and the interaction of that system with the balance of plant; and
- to assess the impact of the TMI-2 occurrence and resulting changes in NRC regulations on B&W technical programs, procedures, and standards. 740/

With reference to the last task, the committee was charged to consider the relationships among B&W's engineering, service, training, licensing, human engineering, and research and development programs.

737/ Id. at 52-56.

738/ Id. at 66-68.

739/ The group was headed by B&W's manager of product development, Russell M. Ball, and included Charles Welch, laboratory manager at Alliance Research Center; Robert W. Kubik, formerly manager of advanced controls and experimental physics laboratory at B&W's Lynchburg Research Center; James Taylor, B&W's manager of licensing; Don W. Montgomery, B&W's manager of advanced reactor department; Doug Cannon, Bailey Controls Systems; and Allen Womack, manager of the plant design section in the B&W Engineering Department. Taylor deposition at 90-92. Although we were not advised that Norman Elliott, B&W's director of training, was in the group, his name appears on the report.

740/ B&W Technical Review Committee, Final Report on the TMI-2 Occurrence (Hereinafter "B&W Report"), Oct. 15, 1979.

A draft of the committee report was reviewed in mid-October by TMI Commission staff.741/ The committee made a number of findings and recommendations, and proposed programs to implement the latter. 742/ One example of the scope of the findings and recommendations was in the control room area. There the committee concluded:

Findings: Operators were apparently unable to understand and interpret plant condition from available control room information. They had no "mental image" of the NSS [nuclear steam system] system characteristics when boiling occurred in the primary loop. Their analysis of the system conditions led to action decisions which caused the incident to result in core damage.

Recommendations:

1. Use systematic engineering tools to extend transient analysis in scope[,] duration and events considered.

2. Improve control room design through human engineering to better couple the operator with the information available and important control situations. Provide integrated data to operator on system status for selected systems. Use display techniques to focus the operator's attention rapidly on the most important conditions.

3. Provide additional information to reduce operator need for implied analytical decision. Examples include:

   -- Primary T_{sat} vs T_{hot}*

   -- Positive flow indications as opposed to valve position indications.

4. Provide greater input to operating procedures developed by the utility to correctly direct the operator during both normal and emergency situations. Provide means to assure that all operating procedures are consistent with the capabilities of plant equipment and assumptions made in safety analyses.

741/ B&W has asserted that the report is confidential and has declined to produce a copy of it to the Commission. However, B&W made the report available to Commission staff for review and the taking of notes. All but two sections of the report (which were not available) were reviewed by the Commission staff.

742/ The report defined "findings" as statements of fact or conclusions drawn from a collection of facts. "Recommendations" were defined as statements of actions which B&W believed were the appropriate responses to the findings.

Insure procedures are designed to maximize probability of correct implementation and execution.

5. Provide enhanced basic fundamental knowledge and understanding to operator through training.

6. Evaluate worth of additional improved automation of normal plant operation[,] trading operator oversight against boredom and inattention. Increased emphasis on the trade-offs between operator response to upsets and contingencies versus automated response with little or no manual overrides required. 743/

The committee proposed at least three programs to address the findings and recommendations in the control room area.744/ For example, one program recommended the design of a standard control room to "bring forth from nuclear power plant operators appropriate and timely action and inhibit inappropriate action during contingency situations." 745/ This same program stated that "none of the NSSS vendors have achieved a mature design for a control room, as yet; and B&W has the greatest room for improvement. . . . To do this job properly, B&W must acquire a new skill -- human factors engineering. There are no human factors engineers in B&W at present. . . ."746/

Part of another findings and recommendations package of the committee addresses B&W's safety responsibility:

> The responsibility for plant safety and the oversight of safety issues within NPGD [B&W] is not as clearly defined as it should be. The resolution of safety issues has, at times, taken too long and the completion of resolution action, particularly where customer action is required, is not assured.
>
> Consideration should be given to forming a safety review group comprised of management personnel to oversee and audit the processing of safety-related issues through to complete resolution. The purpose of this group would be to assure timely and appropriate action on safety matters. . . . A review of all NPGD procedures

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743/ B&W Report, Findings and Recommendations 1-1, Section 2.

744/ The proposed programs that specifically addressed the control room areas were 1-1-1 (Normal Operations Instrumentation and Control); 1-1-2 (Control Room Design/Procedures/ Training); 2-1-1 (Incident Monitoring Instrumentation).

745/ B&W Report, Program 1-1-2 (Purpose).

746/ Id., Program 1-1-2 (Discussion).

should be made to determine the need for clarification and strengthening in regard to the handling of safety-related issues.747/

While the findings and recommendations on safety responsibility addressed internal B&W procedures, another finding addressed the problem of B&W interface with the balance of plant designers:

> The B&W NSSS has been combined with too many different balance-of-plant (BOP) designs for which B&W has little or no responsibility.
>
> It is recommended that:
>
> 1. For future contracts, B&W should require standardization of those parts of the BOP which are crucial to the operation of the 205 plants.
>
> 2. On existing and backlog plants wherein no wholesale changes to the BOP are possible, B&W should recommend or propose a design review of the BOP to assure that satisfactory system operation can be obtained.
>
> 3. B&W should establish agreements with customers allowing approval rights over future changes in the BOP.748/

The committee proposed various programs to implement its recommendations.749/ For example, one program was:

> <u>System Behavior Analysis</u>
>
> Purpose: To develop an improved safety analysis concept which will provide the capability for a mechanistic and systematic analysis of sequences of events with multiple independent causes. The analysis of this class of events is expected to result in improved nuclear plant safety systems,

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747/ B&W Report, Findings and Recommendations 4-1 (Factors Which Influence The Product), Background Information Section.

748/ Id. In addition to those listed above, the findings and recommendations included: 1-2 (Off-Normal Analysis); 2-1 (Reactimeter; 2-2 (PORV); 2-3 (Main Feedwater Reliability); 2-4 (Auxiliary Fluid Systems Evaluation); 2-5 (Valve Status); 2-6 (Vapor/Gases in the Primary System); 2-7 (Decay Heat Removal (Natural Circulation)); 2-8 (High Pressure Injection Lock In); 2-9 (Pressurizer Loop Seal); 2-10 (Radioactive Liquid Waste Handling); 2-11 (Environmental Stress on Components); 2-12 (Plant Computer-Alarm Recorder); 2-13 (Readout Ranges); 2-14 (Containment Isolation System); 3-1 (Communication Between NPGD And Site); 3-2 (NPGD Organization for Site Emergencies).

749/ The programs were set forth in Section 3 (Programs Which Support the Findings and Recommendations). In all 24 programs were proposed.

control room designs, and operator training programs. These improvements will in turn improve the response to the events analyzed and also reduce their probability of occurrence.750/

This program, in effect, was a reevaluation of the single-failure analysis approach which had been used in the TMI-2 design and which had been established by the NRC as the basis for the design of all commercial nuclear power plants in this country up until the accident.

Two other programs (given in part here) were:

PORV

Purpose: Determine alterations to the B&W system to alleviate or eliminate pressure relief system malfunctions.

Objectives:

1. To develop reactor/PORV trip and setpoints to reduce the probability of the PORV being required to operate.751/

2. Provide positive valve position and flow indication for the PORV.

3. Provide automatic isolation of the PORV by closing the PORV block valve on low reactor coolant system pressure.

4. Consider elimination of PORV on new designs.752/

Operator Training Methods

Purpose: Improve operator effectiveness in all regions of plant operation including normal and abnormal conditions.

Objectives:

1. Develop a means of measuring operator effectiveness[,] including measures of relative merit and probability of error for various circumstances.

750/ B&W Report, Program 1-2-1. An earlier version of the Report stated that development of this program would cost approximately $150,000-$200,000 and require 4-6 months to complete. The analysis itself would cost approximately $2 million per plant design and would require one year to complete.

751/ B&W Report, Program 2-2-1. The report noted that this objective has already been accomplished. In fact, after the accident, the NRC ordered that the PORV pressure setpoint be raised and the reactor trip pressure setpoint be lowered in order to reduce the frequency of challenges to the PORV. NRC Inspection & Enforcement Bulletin 79-05B, April 21, 1979, at 3.

752/ B&W Report, Program 2-2-1.

2. Develop optimum teaching methods which convey the appropriate understanding or perception of the NSSS.753/

Another program proposed "[d]evelopment of a B&W NPGD Emergency Response Plan. . . . to improve the timeliness and quality of the support available to our customers **in**. . . emergencies."754/

Jim Taylor, head of licensing at B&W, said that after the accident B&W discussed how to prevent things like the Dunn memorandum from "slipping into the crack":755/

> The most significant thing . . . [involves] efforts to try to close the loop between the key participants in the cycle that goes from design to operation of a power plant, and we have discussed a number of possibilities, or I have been involved in a number of discussions about possible ways or possibilities of doing that, where we try to tighten the loop between the system designers, the system analysts, the procedure writers, the trainers, and the operators. . . .
>
> Some of the steps that have been considered and are being followed up on are training programs for the analysts or programs involving the analysts in the use of the simulator, greater in-depth follow-up on operating experiences of any significance to ferret out the root causes in the disturbances in the primary system and the secondary system, and as those operating experiences are followed up on to again involve these key participants, the system designers, the analysts, the procedure writers, the trainers, and the operators, and to ask questions like:
>
> Did the design behave the way we predicted it would behave?
>
> Were the procedures adequate?
>
> Was the training adequate?756/

It is noteworthy that 3 months after the accident neither Donald Roy, head of the B&W engineering department, nor Richard Kosiba, head of B&W's customer service department, had made any serious inquiry about or had any understanding of the details of the handling of the Dunn memorandum.757/

753/ Id., Program 1-2-4. An earlier version of the report estimated development costs for the training program to be $100,000, not including new simulators.

754/ B&W Report, Program 3-1-1.

755/ Taylor deposition at 89-90; Womack deposition at 85-87.

756/ Taylor deposition at 102-103.

757/ Roy deposition at 30; Kosiba deposition at 29-30.

Met Ed's Role

Some people at Met Ed were aware that a transient had occurred at Davis-Besse on Sept. 24, 1977, but they were unaware of the significance of that transient. The TMI-2 control room operators, the shift foreman, and the shift supervisor on duty at 4:00 a.m. on March 23, 1979, say they were totally unaware of the transient at Davis-Besse or even that any previous transient had involved the total loss-of-feedwater, a failed open PORV, pressurizer level indication high, and premature termination of HPI.758/

An Oct. 7, 1977, LER was filed by Toledo Edison concerning the Sept. 24, 1979, transient at Davis-Besse.759/ It mentioned only two significant aspects of the event -- the failed open PORV and the pressurizer level went off-scale high. On Nov. 14, 1977, an LER supplement was filed by Toledo Edison. 760/ This supplement cited additional significant events of the Sept. 24, 1979, transient:

> The loss-of-feedwater, first to one and then both steam generators, caused an increase in reactor coolant temperature, which resulted in an increase in pressurizer level and reactor coolant system pressure.
>
> * * *
>
> At T-6 minutes 14 seconds the operator stopped the high pressure injection pumps.
>
> J. JL J.
>
> This caused an insurge of water into the pressurizer and the pressurizer level went off-scale at 320 inches. During this level increase the operator, seeing average reactor coolant system temperature and pressurizer level increasing, stopped one reactor coolant pump in each loop (T-9 minutes) to reduce the heat input into the reactor coolant system.
>
> At approximately T-21 minutes, it was determined that the power relief valve was remaining open and the block valve was closed, isolating the power relief valve on the pressurizer and stopping the venting of the reactor coolant system to the quench tank.

758/ Faust deposition at 168-172; Scheimann deposition at 49; Zewe deposition at 48-49.

759/ LER #NP-32-77-16 [Toledo Edison] to NRC [Oct. 7, 1977); Accession #8140027.

760/ LER supplement #NP-32-77-16 [Toledo Edison] to NRC [Nov. 14, 1977); Accession #8140029.

However, the supplement also stated that "operator action was timely and proper throughout the sequence of events." Moreover, though the LER and the supplement recognized'that there had been a total loss-of-feedwater, that pressurizer level indication had gone off-scale high, and that the PORV had failed open, they failed to recognize that the operator had terminated high pressure injection in reliance on the pressurizer level indication. Neither the LER nor the supplement was received by Met Ed until after March 28, 1979.

B&W periodically sent to its utility customers a bulletin, "Operating Plant Service Bulletin," that briefly described each plant's status. The Sept. 30, 1977, issue included the following description of the Sept. 24, 1979, transient at Davis-Besse:

> A spurious closure of a feedwater valve caused the RCS pressure to increase and actuate the electromatic relief valve. A relay was missing from the valve controller and caused it to cycle several times and finally stick open. The stuck electromatic relief valve blew down continuously for approximately 20 minutes before it was isolated by closing its block valve. The RCS was subjected to a rapid depressurization.
>
> Engineering and Service personnel are working closely with TECO to assess the causes and effects of the transient and to assist in the recovery, including discussions with the NRC.761/

The bulletin stated that the PORV had failed open, but did not say that high pressure injection was prematurely terminated because of operator reliance on the pressurizer level and that the pressurizer level indication had gone off-scale high.

At the Nov. 15, 1977, meeting of the B&W User's Group (two weeks after Kelly worte his Davis-Besse memorandum), the superintendent of Davis-Besse reported on his unit's operations. The minutes of that meeting indicated that the Sept. 24, 1979, incident was described as follows:

> Electromatic relief valve stuck open. Rupture disc ruptured. 762/

Gary Miller, TMI station superintendent, attended the meeting but did not remember any further explanation or discussion of the incident by either Toledo Edison or B&W.763/ There was no mention of pressurizer

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761/ Letter from Arnold [GPU] to Kemeny [President's Commission], Aug. 30, 1979. Assession #1018019.

762/ B&W User's Group meeting minutes, Feb. 3, 1978; Miller deposition exhibit 109.

763/ Miller deposition at 129.

level indication going off-scale high, operator termination of HPI in reliance on the pressurizer level indication, or total loss-of-feedwater. In fact, the Sept. 24, 1977, transient was only one of many incidents mentioned in Toledo Edison's plant experience report and was not elevated in importance above any of the others.764/

Met Ed received computer printouts of all licensee tvent reports from the Atomic Energy Clearinghouse and the NRC.765/ Neither printout provided any type of analysis of the transients, and the descriptions of the transients were often incomplete. The full LERs were not sent to Met Ed.766/ The Dec. 9. 1977, Clearinghouse computer printout that was received and reviewed by TMI staff described the September 24, 1977, incident at Davis-Besse as follows:

> Routine Shutdown Operations -- Half trip to steam and feedwater rupture control system caused rise in reactor coolant system temperature and pressure. Caused pressurizer power relief valve to open and valve failed to close, causing reduction in RCS pressure. LCOS here exceeded for 5 T.5., 3.4.1, 3.4.5, 3.4.6.2, 3.6.1.4 and 3.7.1.2. Half trip condition from SFRCS Channel 2, which caused valve FWSP7A to close. Cause of this half trip has not been positively determined although extensive investigation has revealed loose connections at terminal boards (possible cause).767/

That description did say that the PORV failed open; however, it did not include the significant facts that there was a total loss-of-feedwater, that pressurizer level indication went off-scale high, and that in reliance on that indication the operators had terminated HPI.

Nelson Brown, the Met Ed employee in the training department who set up annual classes on operating experience at other plants, reviewed this LER summary but did not think it was significant.768/ In fact, Brown said:

After I found out about the Davis-Besse incident, after March 28, 1979, I then went back and looked and I did find this and I said to myself that I still didn't see the significance of it.769/

764/ B&W Users' Group meeting minutes, Feb. 3, 1978; Miller deposition exhibit 109.

765/ Brown deposition at 38-40.

766/ Id. at 40. See also letter Kemeny (President's Commission) from Arnold (GPU), Aug. 30, 1979. Assession #101809.

767/ Excerpt list of LER summaries from NRC, Dec. 9, 1977; Brown deposition exhibit 82.

768/ Id. at 71.

769/ Id. at 72.

Met Ed Generation and Training received the NRC's Monthly Operating Units Status Report (NUREG 0020, the "Grey Book"). 770/ The November and December 1977 issues of the Grey Book mentioned the Sept. 24, 1977, Davis-Besse incident; however, the information contained in this report also was inadequate. The November Grey Book stated, "Plant outage from the Sept. 24, 1977, RCS depressurization event continued until Oct. 16, 1977." It also indicated that a 14-day report had been filed by Toledo Edison on Oct. 7 concerning "loss of RCS pressure due to failure of pressurizer pilot-operated relief valve."771/ The December Grey Book stated:

> As a result of a spurious trip on Sept. 24, 1977, in the steam Feedwater Rupture Control System, feedwater was lost to No. 2 steam generator. This resulted in a sudden depressurization transient in both the secondary and primary water systems. There operational transients were aggravated by the failure of the No. 2 auxiliary feedwater pump to come up to operating speed and the pressurizer pilot-operated relief valve failing open. Design modifications were made to the governor on the auxiliary feedwater pump turbine and the pilot-operated relief valve to prevent reoccurrence. (77-52). 772/

The November Grey Book did not discuss any of the four significant aspects of the Davis-Besse incident. Though the December issue did say that there was a loss-of-feedwater and the PORV failed open, it failed to state that the pressurizer level indication had gone off-scale high and that in reliance on the pressurizer level the operators had prematurely terminated HPI.

The December 1977 issue of an NRC newsletter, "Current Events," included a discussion of the Sept. 24, 1977, incident at Davis-Besse under a section entitled "Valve Malfunctions." The facts that there had been a loss-of-feedwater and that the PORV failed open were included in the discussion, but it was not mentioned that the pressurizer level indication went off-scale high or that in reliance on the pressurizer level the operators had terminated HPI.773/

Brown did not remember reviewing this issue of "Current Events," although he was on the regular distribution for the newsletter. 774/ Similarly, no one else at Met Ed remembered reviewing this document.

770/ Letter from Arnold (GPU) to Kemeny (President's Commission) Aug. 30, 1979. Assession #1018019.

771/ NUREG 0020, Vol. 1. No. 3, Nov. 1977.

772/ NUREG 0020, Vol. 1, No. 4, Dec. 1977.

773/ "Current Events Power Reactors" (NRC), December 1977; Porter deposition exhibit 2.

774/ Brown deposition at 75.

GPUSC received a commercial monthly newsletter, "Nuclear Power Experience." This document was not distrubuted to Met Ed.775/ The July 1978 issue summarized the LER supplement on the Sept. 24, 1979, incident but did not flag it as important.776/

This summary included the facts that HPI was terminated, that there was a total loss-of-feedwater, and that the PORV failed open but failed to cite that HPI was terminated in reliance on the pressurizer level. Thus it did not recognize the significance of the operator action.

In sum, the information Met Ed received concerning the Sept. 24 Davis-Besse transient was incomplete and, unlike the Dunn memorandum, did not emphasize the real importance of the event -- namely, that operator termination of HPI, in reliance on pressurizer level going off-scale high, could result in core uncovery and fuel damage.

The NRC'S Role

The NRC was informed of the Sept. 24 transient and sent a representative to Davis-Besse immediately. The NRC's knowledge of Davis-Besse and its failure to convey that knowledge to operating utilities is explained in detail in the staff report on the NRC.

Davis-Besse November 29, 1977, Transient

On Nov. 29, 1977, a transient occurred at Davis-Besse-l during which pressurizer level went off-scale low (in contrast to level going off-scale high during the Sept. 24 transient).

James Creswell, an NRC Region III inspector, raised questions about the adequacy of B&W's response to that transient. Through a series of events explained in more detail in the report on the NRC, a meeting was called 14 months later on Feb. 14, 1979, to discuss the adequacy of the B&W response to the Nov. 29, 1977, transient. Three NRC inspectors and four utility representatives, including John Hilbish from Met Ed, attended the meeting in Lynchburg. 777/ Although Bert Dunn attended the meeting, the subject was strictly confined to the November 1977 Davis-Besse transient and the issue of pressurizer level going low. No mention was made of the September 1977 Davis-Besse transient when pressurizer level had gone high, which had been the subject of Dunn's 1978 warning memorandum.778/

775/ Letter from Arnold (GPU) to Kemeny (President's Commission), Aug. 30, 1979. Assession #1018019.

776/ "Nuclear Power Experience," July 1978.

777/ Memorandum from Willse (B&W) to distribution (B&W) March 9, 1979; Willse deposition exhibits; Hilbish July 9, 1979, deposition at 6.

778/ Willse deposition at 103.

Five days before the Feb. 14 meeting, B&W held an internal preparatory meeting; the subject of the September 1977 Davis-Besse transient did not come up there either. 779/ Nor did the subject come up at a second preparatory meeting held on Feb. 13 involving B&W and utility representatives.780/

The incidents illustrate the compartmentalization that the legal staff saw so often in the course of this investigation. Even though pressurizer level was the issue, no one thought to talk about pressurizer level going high when the subject at hand was pressurizer level going low.

PORV FAILURE HISTORY

An NRC report781/ published in May 1979 listed a total of four PORV failures which had occurred in B&W plants before the TMI-2 accident. John MacMillan, vice president of B&W's Nuclear Power Generation Division, referred to five PORV failures (including the one during the accident). However, both NRC and MacMillan were wrong. The Commission's own investigation found 11 PORV failures in B&W plants before the TMI-2 accident, nine of them failures in the open position-782/ All but one of the nine failures have now been confirmed by B&W.783/ The TMI-2 failure was the 10th.

When John MacMillan discussed the five failures known to him after the accident, he said only three were significant because in two cases the failure was not intrinsic to the valve itself but was-caused by some other factor. MacMillan's comment reflected an emphasis on hardware rather than people. While it may be true that only three of the five failures raised questions about valve design, all of the failures created a small-break LOCA which a control room operator must identify so that the block valve can be closed and the plant returned to a safe condition.

Although B&W took steps to deal with the mechanical causes of the previous failures,784/ it neglected to address fully the operator's

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779/ Dunn June 30, 1979, deposition at 208.

780/ Hilbish July 9, 1979, deposition at 12.

781/ A Generic Assessment of Feedwater Transients in Babcock and Wilcox 205 Assembly Reactors, NUREG 0560, May 7, 1979.

782/ Commission staff report on "Pilot-Operated Relief Valve Design and Performance."

783/ Memorandum from Spangler (B&W) to Olds (B&W), May 21, 1979.

784/ Commission staff report on "Pilot-Operated Relief Valve (PORV), Design and Performance," Oct. 19, 1979; see description of incidence #1-9 in appendix.

ability to identify the failures and stop the loss of coolant from the primary system. For instance, following the PORV failure at Davis-Besse on Sept. 24, 1977, a substantial effort was made to analyze why the valve failed. 785/ But the fact that the operators had not recognized the existence of a hole in the primary system (PORV failure) for more than 20 minutes did not trigger any notification to other B&W utilities, nor did it lead to any modifications in B&W training or to any changes in procedures for identifying an open PORV. Further, the history of PORV failures at B&W nuclear plants was not addressed at any B&W Users Group meetings before March 28, 1979.786/ Nor was there a systematic recording or analysis of the growing history of PORV failures.

In the course of the Commission's investigation, B&W supplied a summary fact sheet for each of the nine pre-TMI-2 PORV failures that had been identified. Those summaries can be found in the appendix to the staff report on the PORV. They show for each incident the type of malfunction, a summary of the incident, and B&W followup action. A review of the nine incident reports shows that on one occasion B&W notified its utilities of a seating failure, on a second occasion utilities were notified of a failure due to corrosion and were advised to inspect their own PORVs for corrosion, and on a third occasion field changes in the pilot valve lever pin were recommended. And Met Ed did in fact receive notice of the corrosion problem from B&W.787/

In no case did B&W recommend additional training of operators to ensure that they were aware of the likelihood of a PORV failure and knew how to identify quickly the resulting small-break LOCA and shut the PORV block valve. Nor did B&W ever recommend an across-the-board modification of all PORVs to provide a reliable, direct valve position indicator in the control room.

On March 29, 1978, one year before the TMI-2 accident, the PORV stuck open at TMI-2 because of an electrical malfunction. 788/ In November 1978 the PORV at TMI-2 failed again, this time in the closed position. Although Met Ed training did discuss the March 1978 TMI-2 PORV failure, none of the operators had been told about the full failure history of the PORV.789/

785/ MacMillan deposition at 17.

786/ Miller deposition at 129.

787/ Letter from Rogers (B&W) to Herbein (Met Ed), July 30, 1975; Accession #1008011.

788/ Special report concerning the TMI-2 ECCS actuation of March 29, 1978, undated and unsigned; License Event Report 78-21/3L. Accession #8270019.

789/ Zewe deposition at 89-90; Scheimann deposition at 160-161; Faust deposition at 215-216; Frederick deposition at 371. See Commission "Quality Assurance," Section IV (A) (3) (c); see also, staff report on NRC.

Between August 1977 and October 1978, three B&W site problem reports were filed on the TMI-2 PORV.790/ On Oct. 8, 1977, it was reported that the PORV was leaking around the seat. The report shows that the valve was to be replaced by Dresser because of the problem.791/

On April 20, 1978, a site problem report stated that the PORV failed in an open position on loss of power to its control, during a March 29, 1978, reactor trip. It was discovered that the logic of the valve wiring led it to fail open rather than closed. The operators at that time did not recognize the valve was open because they had no control room indication of valve position. The resolution of that problem was to (1) change the wiring on the valve to make it fail closed and (2) install a control room indication of power to the solenoid operating the PORV to give the operators an indirect indication of whether it was open.792/ The NRC's Harold Denton has said that the "fail open" logic of the PORV was a generic design problem.793/

MICHELSON REPORT

In May 1977, Carlyle Michelson, a nuclear engineer for the Tennessee Valley Authority (TVA), wrote an analysis of decay heat removal problems associated with recovery from a small-break LOCA in pressurized water reactors. Michelson raised essentially the same concern that Bert Dunn would raise 9 months later.

After a number of contacts with the NRC (described in detail **in** the staff's NRC report), Michelson prepared a typed summary of his original paper in early 1978 and had that forwarded by his supervisor, D. Patterson, to B&W on April 27, 1978. The transmittal letter from TVA to B&W said in part:

> Also associated with operation in each of the above conditions is a concern that the pressurizer level is not a correct indicator of water level over the reactor core. Because of the loop seal on the pressurizer, it may be possible to have a full pressurizer while the core is partially uncovered. This could lead to incorrect operator actions .794/

790/ See discussion of site problem reports earlier in this paper.

791/ Site problem report #143 from Rogers (B&W) to B&W change control, Aug. 22, 1977, Rogers deposition exhibit 13.

792/ Site problem report 195 Rev. 0, 1978, and site problem report 183 Rev. 0, April 10, 1978, Rogers deposition exhibits 11 and 12.

793/ Memo from Steinberg (NRC) to Seyfrit (NRC), March 31, 1978; Denton deposition exhibit 3.

794/ Transmittal letter from Patterson (TVA) to McFarland (B&W) April 27, 1978; Dunn deposition exhibit 41.

The Michelson analysis itself made the same point:

> A full pressurizer may convince the operator to trip the HPI pump and watch for subsequent loss of level. Although this response appears desirable, a full pressurizer may not always be a good indication of high water level in the reactor coolant system.795/

At B&W the Michelson report was routed to Bob Jones, a member of the ECCS analysis unit. Jones briefed his boss Bert Dunn on the issues raised in Michelson's report. 796/ Dunn believed he realized at that point that one of the concerns raised by Michelson was very similar to the concern that he had expressed in his Davis-Besse memorandum 3 months earlier. 797/ He did not know at the time he received Michelson's report whether his Davis-Besse concerns had been transmitted to B&W's operating utilities. 798/ Nor did he advise the Customer Service Department, which he assumed was following up on his Davis-Besse memorandum, that the concerns addressed in that memorandum were now being raised from another source.799/

It should be noted here that repeated questioning of B&W witnesses disclosed that no one knew of the Novak memorandum 800/ before the accident. After reading the Novak memorandum, Dunn offered the analysis that Novak's mechanism -- the loop seal -- was not the controlling factor. Rather, said Dunn, the diameter of the surge line is the controlling factor and the artificial holding-up of pressurizer level by voiding in the core could happen in any nuclear power plant. Expanding the diameter of the surge line sufficiently to permit two-directional flow, said Dunn, would destroy the utility of the pressurizer. 801/ This investigation has no evidence that anyone at Met Ed know of the Novak memorandum before the accident.

795/ Decay heat removal during a very small-break LOCA for a B&W 205-fuel assembly PWR -- Michelson Report (TVA), January 1978, at 29.

796/ Dunn June 30, 1979, deposition at 178.

797/ Id. at 179, 183.

798/ Id. at 183.

799/ Id. at 186.

800/ Taylor deposition at 74; Kelly deposition at 44; Dunn June 30, 1979, deposition at 132-133. Memorandum from Novak (NRC) to RSB members re: loop seals in pressurizer surge line, Jan. 10, 1978, Dunn deposition exhibit 38. See full discussion of Novak memorandum in Commission staff report on the NRC.

801/ Dunn June 30, 1979, deposition at 134-140.

After being briefed on the Michelson report, Dunn concluded that it did not raise any concerns different from those raised in his memorandum.802/ The report was then treated as an action item to be handled as other work permitted. 803/

On May 3, 1978, James Taylor, manager of the licensing section at B&W, received a copy of the Michelson report. When Taylor received it, he "skimmed" the cover letter, did not read the report, and forwarded both to one of his unit managers, Frank Levandoski, with the note: "Frank, what is this all about?" 804/ Levandoski gave the report to one of his engineers, Frank Bailey, for analysis. Three weeks later Bailey sent a brief analysis back to Levandoski.

Bailey specifically highlighted the part of Michelson's report which raised the possibility of operator error in terminating HPI:

> A more valid concern may be the subject of operator action and the potential for erroneous pressurizer level. This matter is discussed also at some length. No additional communication with TVA has occurred on this matter and ECCS analysis has taken no action on this report. Bert Dunn plans to start looking at the report next week to see what's there and to consider what action or investigation should be pursued (if any).805/

Bailey not only highlighted the operator error aspect of Michelson's report, but also he connected Michelson's concerns to questions that Jesse Ebersole had been raising in the 1977 ACRS hearings on licensing of the B&W Pebble Springs plant in Portland, Ore.

"The attached TVA letter," said Bailey, "is an apparent response to the concerns that Mr. Ebersole has expressed during ACRS meetings."806/

Ebersole had prepared written questions in Portland General Electric's Pebble Springs licensing proceeding. One of those questions was:

> Does applicant know that time-dependent levels will occur in pressurizer, steam generator, and reactor vessel after a relatively

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802/ Id. at 183; Dunn July 13, 1979, deposition at 13-14; see also Womack deposition at 55.

803/ Womack deposition at 55.

804/ Taylor deposition at 114-116.

805/ Memorandum entitled "Small Break Report" from Bailey (B&W) to Levandoski (B&W), May 25, 1978; Dunn deposition exhibit 40.

806/ Id. For a complete discussion of the ACRS questions, see the NRC paper.

> small primary coolant break which causes coolant to approach or even partly uncover fuel pins? What does operator do in respect to interpreting level in pressurizer?807/

The question was sent to B&W in the fall of 1977 for answering since B&W was supplying the nuclear reactor for Pebble Springs, but B&W did not answer the part of the question dealing with operator interpretation of pressurizer level.

Answers to those ACRS questions had been submitted by B&W on Nov. 30, 1977, and Bailey recalled the questions and brought Levandoski's and Taylor's attention to the similarity between the ACRS questions and Michelson's report.808/

Although Bailey's memorandum was forwarded to James Taylor, Taylor maintains he never made a connection between Bailey's description of the Maichelson report and the concerns expressed in Dunn's memorandum 3 months before. 809/ A handwritten note over Taylor's initials at the top of Bailey's memorandum says "please stay on top of this problem." 810/

In summary, by the end of May 1978 B&W knew that concern about operator interruption of HPI based on pressurizer level had been expressed from three sources: Dunn, Michelson, and the ACRS. Still nothing happened. This investigation found no evidence that Met Ed had any knowledge of the Michelson report before the accident.

Beginning in June 1978 there were a number of telephone conversations between B&W and TVA and on Jan. 23, 1979, 9 months later, B&W sent its first written reply to TVA. It said in part:

> As far as the appropriateness of the operator using pressurizer level indication to trip the HPI pumps, B&W agrees that the level indication is not a reliable indication of the state of the RCS. However, use of the pressurizer level indication, along with system temperature and pressure measurements to ensure that the system is still in a substantially subcooled state, will provide sufficient guidance for operator action.811/

807/ NRC staff report on the generic assessment of feedwater transients in pressurizer water reactors designed by B&W, NUREG 0560, May 1979.

808/ Neither Bailey nor Levandoski has been deposed on these issues.

809/ Taylor deposition at 116. Dunn also believes he saw Bailey's memorandum, Dunn June 30, 1979, deposition at 200.

810/ Memorandum entitled "Small Break Report" from Bailey (B&W) to Levandoski (B&W); Dunn deposition exhibit 40.

811/ Letter from McFarland (B&W) to Patterson (TW), Jan 23, 1979; Dunn deposition exhibit 42, at 2.

That analysis was not forwarded to other B&W utilities before the TMI-2 accident.

In early February, TVA followed up B&W's response with a request for more information. 812/ B&W had not replied as of the time of the accident. On May 7, 1979, B&W published a three-volume analysis addressing in detail Michelson's report.813/

Also after the accident, Dunn wrote a memorandum entitled, "Michelson Story Comments" in which he said:

> . . . Pressurizer level is not a good indicator of primary liquid inventory. No operator action should be based on that signal alone. It is quite possible to have a smaller break causing a slow loss of RC [reactor coolant] inventory and eventual dryout of the core while maintaining a full pressurizer if HPI is terminated prematurely. The only positive indication of reactor liquid inventory is a subcooled indication in all RCS pressure and temperature indicators excepting those in the pressurizer. 814/

CONDENSATE POLISHERS 815/

Although there has been some uncertainty about the initiating event of the March 28 accident, the Electric Power Research Institute (EPRI) has stated in its July 1979 analysis of the accident816/ that the following events in the condensate polishing system probably initiated the accident sequence:

1. Operators were attempting to transfer resin from one of the polishers to a receiving tank on the regeneration skid.817/

812/ Letter from Simmons (TVA) to Lightle (B&W), Feb. 8, 1979; Dunn deposition exhibit 43.

813/ Evaluation of Transient Behavior and Small Reactor Coolant System Breaks in 177 Fuel Assembly Plant, Vol. 1, May 7, 1979; Appendices, Vol. 2, May 7, 1979; Raised Loop Plant Davis-Besse 1, Vol 3; May 16, 1979.

814/ Michelson story comments, March 14, 1979; Dunn deposition exhibit 44.

815/ This subject is treated in more detail in a Commission staff report on condensate polishers.

816/ Nuclear Safety Analysis Center (EPRI), Analysis of Three Mile Island-Unit 2 Accident, NSAC-1, July 1979. A similar analysis is contained in the Commission staff report on the condensate polisher.

817/ Id. Appendix C/FDW at 2.

2. Water was forced from the demineralized water system back into the service air system because of check valve leakage.818/

3. From the service air system the water leaked through another valve into the instrument air system where it travelled to the condensate polishing system, a low point, and sent a spurious signal to close the discharge valves on the downstream side of all polishers.819/

4. Loss of suction head on the auxiliary feedwater pumps led those pumps to trip, leading to a trip of the main feedwater pumps, which in turn tripped the turbine.820/

5. An attempt was made to open the polisher bypass valve from the control room with no success. Eventually the valve was opened manually, but with considerable difficulty.821/

Virtually every detail of this condensate polisher sequence had been duplicated in an incident 17 months earlier on Oct. 19, 1977, at TMI-2. Following that 1977 incident, Michael Ross and John Brummer of the Met Ed staff investigated and reported their findings to Gary Miller and Jim Seelinger in a memorandum dated Nov. 14, 1977.822/ After summarizing the facts they said:

> If this would have happened while at power the unit would have been placed in severe transient condition resulting in an emergency feedwater actuation, main steam relief to atmosphere, turbine trip, and reactor runback with possible trip.823/

The memorandum went on to analyze the incident in considerable detail and then recommended nine steps that "should be acted on to preclude a recurrence." According to Ross, the memorandum was reviewed by Seelinger who recommended that it be attached to a GPU startup problem report.824/

818/ Id.

819/ Id.

820/ Id. at 2-3.

821/ Zewe April 6, 1979, TMI staff interview at.8-9; Faust March 30, 1979, TMI staff interview at 8.

822/ Startup problem report from Brummer and Ross (Met Ed), Nov. 14, 1977; Miller deposition exhibit 11.

823/ Id. at 1.

824/ Ross Aug. 10, 1979, deposition at 17.

Brummer, co-author of the memorandum, filled out the startup problem report but his summary did not reflect the full breadth of the underlying memorandum. R. J. Toole, director of the GPU startup group, apparently acted only on the very brief startup problem report without reading the underlying memorandum. On Nov. 17, 1977, he closed out the report with the comment, "No further action required."

Included in Ross' memorandum was a recommendation to change the bypass valve in TMI-2 to automatic. Gary Miller testified:

> I believe there was discussion, but I would be hardpressed for a number of specifics, and I believe we, Met Ed, would have liked an automatic valve, and I don't believe GPU thought it was required.825/

Ross recalled filling out field questionnaires for other problems in the condensate polishing system. 826/ Scheimann also said there had been a series of problems with the system. 827/ The Commercial Operating Review Board report of Oct. 26, 1978, also referred to problems in the condensate polishing system.828/

Another incident duplicating the March 1979 and the October 1977 incidents occurred at TMI-2 on July 5, 1979.

While a failure in the condensate polishing system certainly was not directly responsible for the core damage on March 28, 1979, had Met Ed or GPU given careful followup attention to the Oct., 29, 1977, incident the polisher system might not have malfunctioned on March 28, 1979, and the accident sequence might never have had a chance to begin.

Given the history of problems in the polishing system, the shift foreman could have directed that no resin transfers should be made unless the polishing system was bypassed using the bypass valve. Had this been done on March 28, 1979, the accident would not have occurred. Mike Ross, TMI-1 supervisor of operations, told a member of the Commission staff that the polishers system could be bypassed for such maintenance work.

APRIL 23, 1978, TRANSIENT

On April 23, 1978, TMI-2 experienced a reactor trip at 30 percent power. The trip caused a pressure transient that lifted the main steam relief valves in the feedwater system. After lifting, a number of the valves failed to reseat. During the transient a rapid depressurization

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825/ Miller deposition at 170.

826/ Ross July 31, 1979, deposition at 108-110.

827/ Scheimann deposition at 112-115.

828/ Report (Met Ed/GPU), Oct. 26, 1978; Finfrock deposition exhibit 2.

in the primary system apparently put the plant into saturation conditions, leading to the formation of a steam bubble in the RCS.829/ This transient is significant because saturation in the RCS occurred again in the March 1979 accident.

Saturation

The transient was analyzed by Met Ed site personnel, by GPUSC, and by B&W. In the analyses there was considerable discussion of whether saturation conditions 830/ had been reached with consequent steam bubble formation in the hot legs. The Met Ed analysis concluded that a steam bubble had formed in one or both hot legs as a result of saturation conditions having been reached in the RCS.831/

B&W also analyzed the possibility of steam bubble formation in the RCS based on possible voiding in the pressurizer. B&W concluded the pressurizer had not emptied completely (although pressurizer level had gone off-scale low) and that no steam was either drawn into the RCS or formed spontaneously in the RCS as a result of saturation.832/

The GPUSC task force report considered both the Met Ed analysis and the B&W analysis and concluded that a steam bubble did form in the reactor vessel's upper head but not in the hot legs.833/

The issue of saturation is significant because it involves core boiling and steam formation. Steam formation is a threat to the integrity of the core because steam is a much less efficient heat transfer medium; it inhibits RCS circulation flow necessary for core cooling; and a significant steam fraction may ultimately damage or destory the reactor coolant pumps if they are not tripped, although a trip is required by the applicable procedure in such circumstances. If saturation occurs in the primary coolant system, it is accepted that immediate steps must be taken to increase pressure and/or decrease temperature to stop steam formation.

829/ GORB Action Item No. 30, June 15, 1978; Zechman deposition exhibit 62.

830/ "Saturation" is a temperature-pressure relation that defines when water exists in a liquid state and when it exists in a gaseous state.

831/ Reactor Trip/ES Incident of April 23, 1979, report from Seelinger (Met Ed), May 4, 1978; Zechman deposition exhibit 62 at 3, 29-30.

832/ Letter from Rogers (B&W) to Miller (Met Ed), May 5, 1978; Zechman deposition exhibit 62 at 32-34.

833/ TMI-2 transient on April 23, 1978; task force report, Aug. 1978 at 25; Zechman deposition exhibit 62.

Before the April 1978 transient, the TMI-2 operators had never had specific training at Met Ed about the dangers of boiling in the reactor coolant system, although they were familiar with saturation at the top of the pressurizer and on the secondary side of the steam generator.834/

Even after the April 1978 transient and all the discussion and analysis of saturation that it triggered on the part of Met Ed, GPUSC, and B&W, no changes were made in the Met Ed training program to educate the operators about the dangers of saturation, to educate them to be alert for saturation conditions, and to teach what to do if saturation occurred.835/

At the time of the March 1979 accident there was not even an official steam table for determining saturation conditions in the TMI-2 control room, although one of the operators happened to have a personal steam table tucked away in a desk drawer. 836/ More importantly, the operators either never recognized saturation conditions existed or they did not know what to do when saturation conditions occurred during the March 28, 1979, accident; at any rate, they never took remedial steps to increase pressure. Zewe, shift supervisor on duty at 4:00 a.m. on March 28, 1979, testified that "I did look at the temperature and the pressure, but I really didn't correlate that to the saturation pressure for that temperature," 837/ although Faust makes a reference to having recognized saturation at some point during the accident. 838/ Since saturation conditions were reached at about 5-1/2 minutes into the accident, prompt diagnosis and appropriate follow-up action by the operators would likely have led to increasing pressure before damage was done to the core.

Marshall Beers, Met Ed's group supervisor of technical training, said that saturation was not discussed in the Met Ed training program because of emphasis on control of pressurizer level:

> All our procedures addressed the fact that you must try to keep the pressurizer level within its operating limits, and if you keep the pressurizer level within these operating limits, you should not reach a saturated condition in the reactor coolant system and, therefore retain some margin of subcooling [i.e., margin below saturation] .839/

834/ Beers deposition at 105-107.

835/ Id. at 168-169.

836/ Frederick deposition at 113-114; Brown deposition at 61-62.

837/ Zewe May 30, 1979, hearing testimony at 188.

838/ Faust March 30, 1979, TMI staff interview at 2.

839/ Beers deposition at 107, as corrected by Beers' errata sheet.

Although Beers had read the Met Ed analysis of the April 23, 1978, transient, he did not recall having read the section showing that saturation conditions had been reached during that transient.840/

Steam Relief Valve Failure and Other Aspects of the Transient

The TMI staff analysis of the April 23, 1978, transient said that:

> . . . while the operators responded correctly to the reactor trip, they did not realize the casualty they were dealing with was a major steam leak (through the relief valves) . . . operator action with feedwater shows that the operator watched the needles on the Bailey stations instead of the actual measured parameters.841/

In addition, the report stated:

> . . . we must understand each specific evolution and the most likely consequences of equipment failure or malfunction. We must approach evolutions with the question, "how would I respond if happened." We must stop and regroup when something is marginally understood. Adverse effects can be additive.842/

Edward Frederick, A TMI-2 control room operator on shift during the April 23 transient, wrote a letter843/ to James Seelinger, then TMI-2 superintendent for technical support, listing the problems that he saw in the accident that he did not think were touched by Seelinger's evaluation.

Frederick's letter set forth the following observations:

- It was just as significant that three or four of the main steam relief valves did not lift at the pressure setpoint, as it was that some valves failed open.

- Two valves that provide normal make-up to the reactor coolant system should have been shut upon emergency safeguard activation so as not to starve high pressure injection.

840/ Id. at 168-169.

841/ GORB Action Item No. 30, June 15, 1978; Zechman deposition exhibit 62 at 11.

842/ Id. at 12.

843/ Handwritten letter from Frederick (Met Ed) to Seelinger (Met Ed), May 3, 1978; Frederick deposition exhibit 17.

- The alarms were inadequate. There were too many alarms to determine which were important. The display was too difficult to read, and the acknowledging system was poor in that acknowledging one alarm cancelled out older alarms.

- There should have been a position indication for the main feedwater control block valves in the control room.

- A mechanical switch to activate an alarm indicating the steam safeties lifted would have been preferred over a sound-actuated system.

- Criteria for testing the reactor protection system and the integrated control system were inadequate.

- The operators were not trained to deal with multiple casualties.

- Mechanical failures, poor system designs, and improperly prepared control systems were very much more the major cause of this incident than was operator action. 844/

Frederick concluded by saying that the concerns he had listed were "only the tip of the iceberg" and asked for an opportunity to talk with Seelinger "to try to prevent this from happening again." 845/ Seelinger responded with a note to Frederick, but there was no systematic follow-up on Frederick's concerns.846/

Seelinger's reply indicated that Frederick's suggestions were "appreciated." In his memorandum, Seelinger asked Frederick to explain further certain points, indicated he would look at other items, stated certain issues had been addressed in the transient analysis, and agreed with certain of Frederick's comments.847/ Frederick did not get back to

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844/ Frederick deposition at 450-500. It should be noted that there was no formal mechanism by which Frederick could raise these safety concerns other than sending a memorandum through the management chain. Id at 459-460

845/ Handwritten letter from Frederick (Met Ed) to Seelinger (Met Ed), May 3, 1978; Frederick deposition exhibit 17.

846/ Handwritten memo from Seelinger (Met Ed), May 3, 1978; Frederick deposition exhibit 18. See also Frederick deposition at 474, 489.

847/ Memorandum from Seelinger (Met Ed) to Frederick (Met Ed), May 3, 1979; Frederick deposition exhibit 18.

Seelinger on the questions Seelinger had raised. And according to Frederick, Seelinger did not pursue, to conclusion, the issues he said he would look into.848/ In fact, there was no in-depth discussion with Frederick as to the substance of his memorandum.

> QUESTION: Did you ever have a chance to talk with him in person about the points you had made and the responses he had given?
>
> FREDERICK: No, I don't recall. After he sent this letter in reply to mine, I didn't follow it up because I was waiting to see what actual programs were undertaken as a result of this letter and our correspondence.
>
> QUESTION: Up until the time of March 28, 1979, did you ever have a chance or occasion to talk with him about your letter and his response?
>
> FREDERICK: I can vaguely recall discussing the content of the letter. Neither one of us had a copy of the letter with us at the time and we were just discussing whether or not in general, things were going to be done about my concerns, and I believe he stated at that time that the analysis that he wrote up was going to be forwarded to GPU with various action items noted, and then he would have to wait and see what GPU considered to be important before they could take action.849/

848/ Frederick deposition at 474, 489.

849/ Id. at 474-475.

NRC INSPECTIONS

The routine at a nuclear power plant includes periodic inspections by the NRC's Office of Inspection and Enforcement (I&E). I&E periodically performs on-site inspections at TMI.850/ There was a principal NRC inspector assigned to TMI. In addition, the NRC had other inspectors that visit TMI in specialized areas such as health physics.851/

Site personnel usually had no advance warning of an NRC inspection. The inspections involved spot checks of various items, such as surveillance test logs. Exit interviews were held with NRC inspectors at which TMI management was told of the results of an inspection. A written report was then sent to Met Ed by I&E. Gary Miller required a superintendent and the department head whose area had been inspected to attend the exit interviews and draw up action items as a result of the discussion.852/

Before TMI-2 went commercial, GPU kept track of the action items resulting from NRC inspections. After going commercial, the responsibility for tracking the action items rested with Met Ed Licensing and PORC. Licensing handled communications with the NRC, while PORC was responsible for follow-through and completion of the action items. Noncompliance items -- deviations from the technical specifications -- required a formal response to the NRC, but unresolved items -- abnormalities that were not violations of the technical specifications -- did not.853/

Although they had site inspection duties, the NRC inspectors were not familiar with the TMI-2 plant nor were they experienced operators. With reference to the NRC's approval of an emergency feedwater system surveillance procedure which violated TMI-2's technical specifications, Gary Miller said:

> For example, I know they reviewed the emergency feed procedures that we changed that had the 12s both shut. They reviewed that for meeting the criteria of the inspection program.

850/ See further discussion of I&E inspections from the NRC perspective in the legal report on the NRC. In addition to health physics, I&E inspectors performed inspections in the security, fire protection, and emergency planning areas. There were no inspectors specializing in plant operations.

851/ Kunder deposition at 105-107.

852/ Floyd deposition at 170-174, 179; Miller deposition at 112-113, 116; Kunder deposition at 103-104.

853/ Miller deposition at 114-115; Kunder deposition at 106-107.

> If [the inspector] was qualified in our plant, he might have picked it up. They looked at the inspection criteria of the codes and, yes, we met it, but I am just saying that a guy with operational familiarity might have said, "You shouldn't shut off these 12s."854/

Evaluating the benefit of NRC inspections to the TMI staff Miller stated:

> There were times when I considered them beneficial, and there were times that I considered that the amount of details that they were looking at, I really wasn't sure that they were accomplishing much. But there were times when it was extremely helpful.855/

854/ Miller deposition at 121. This assertion is contradicted by the Haverkamp deposition and documentary record. See the Commission staff report on the NRC, section on inspection and enforcement.

855/ Miller deposition at 119.

In analyzing the management approach to the TMI-2 emergency, three questions are raised: first, how did management perceive the events; second, was management prepared to deal with the events; and third, how did it, in fact, deal with the events?

EMERGENCY PERCEPTION

Robert Arnold, GPUSC's vice president for generation, was asked to state what consideration the company gave to the need for having technical staff available during an emergency:

> . . . [Y]ou have to hear the answer to that question in the context of the industry's general perception of these types of incidences. And at least my characterization of that would be that the type of accidents that we have been concerned about are by and large the ones that take place in a very short time frame . . . I don't think any of [us) really thought of plant accidents stretching out over a period of many hours. I think the experience of March 28th and succeeding days certainly give us cause to rethink that.856/

Arnold's statement dramatizes the problem in attemping to analyze management's response to the accident. By definition, emergency management has two elements.

First, there must be a perception of an emergency. It seems clear from the testimony of Met Ed personnel that many management level personnel did not view the events in the early hours of the accident as amounting to an emergency. For example, at approximately 4:35 a.m. on March 28, TMI-1 shift foreman, Fred Scheimann, telephoned TMI-1 supervisor of operations, Michael Ross, at home to discuss TMI-1-related problems. According to Ross, the two discussed problems related to TMI-1 loss of steam caused by the TMI-2 reactor trip.857/ He was not asked to come to the plant, although he was informed that a trip had occurred in TMI-2.858/ Shortly thereafter, Ross went to the plant of his own accord, arriving at approximately 5:30-5:40 a.m. Upon arrival, Ross assisted the shift foreman with the TMI-l's chemistry problem, but ". . . .still was not overly alarmed [about the TMI-2 trip]."859/

856/ Arnold May 9, 1979, NRC interview at 27-28.

857/ Ross July 31, 1979, deposition at 130.

858/ Id. at 131.

859/ Id. at 132.

Arnold arrived at his office at 8:00 a.m. on March 28 and remained there all day. Between 10:00 and 10:30 a.m. he talked with plant staff. According to Arnold:

> [The plant status given] was not indicative of conditions which increased my concerns significantly. . . I suspected that we had a moisture problem or some type of failure from steam and containment because I was aware that the ruptured disc had failed on the compartment drain tank. . . . So I did not have the. . . degree of alarm that perhaps was called for.860/

Arnold did not recall whether he was ever specifically aware that the site emergency had been raised to general emergency.861/

Walter Creitz, then Met Ed's president, was informed of the accident between 6:45-7:30 a.m. on March 28. Upon arriving at his office, Creitz stated that he called the plant. Creitz issued no instructions to the staff ". . . other than to keep me posted on changes in condition, I certainly didn't attempt to give any technical instructions.862/ According to Creitz, his primary concern was to gather sufficient information to tell the media what had happened beyond the fact that an accident had occurred: "It was only several days before that, that I had seen a movie called the 'China Syndrome' and I was particularly sensitive to having the abilitiy to tell the public what happened. . . ."863/

Herman Dieckamp, president of GPU, was in Harrisburg on the morning of the March 28 meeting with the State Public Utility Commission. He learned of the TMI-2 accident at about 8:45 a.m. when he received a message to call Creitz. That conversation left him with " . . the impression that it was a reactor shutdown transient of some sort and actuation of the safety features, but that it was basically over and done with and it was a case now of sorting out what had happened."864/

Though Creitz had indicated to Dieckamp that "there was concern or evidence about fuel damage," Dieckamp "was immediately reluctant to believe that there had been a problem in terms of fuel damage." 865/ At that time, he was not aware that HPI had been throttled or of the high radiation readings in the containment building.866/ Dieckamp then spoke

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860/ Arnold May 9, 1979, NRC interview at 19, 21.

861/ Id. at 20.

862/ Creitz deposition at 97.

863/ Id. at 99-100.

864/ Dieckamp deposition at 122.

865/ Id. at 122-123.

866/ Id. at 123.

with Arnold who also gave him the impression that the plant was under control but that what exactly had happened was unclear.867/

On the afternoon of March 28, Dieckamp by chance met Herbein, Miller, and Kunder at the state capitol building as they were on their way to brief the lieutenant governor. They gave Dieckamp a brief status report. Dieckamp testified, "I expressed my concern to them as to how come there are so many of you here and not back at the plant."868/

Only on Friday morning, more than 2 days after the accident had begun, did Dieckamp recognize the seriousness of the accident. 869/ At that time, he called in outside experts to help assess the situation.870/ Dieckamp testified that there had been a "slow recognition of exactly what was the problem."871/ He further stated that the mindset that led to this problem was "having everything geared toward normal, steady state operations."872/

In addition, Dieckamp testified that "it is not likely that a normal. . . operating organization would have either that number of people or that spectrum of skills on-site at all times" to deal with an event similar to the TMI-2 accident. 873/ Therefore, he thought a standing organization of experts that could be called on in an emergency would be beneficial.874/

Joseph Logan, TMI-2 superintendent, was called at approximately 4:30 a.m. and told there had been a reactor and turbine trip, but that there was no serious problem. 875/ Logan called back the plant to ask that George Kunder and Ivan Porter report to TMI-2 to prepare for a shutdown. 876/ Not long before the accident Logan had been discussing what should be done in the event of an unscheduled shutdown, so when he was told of the trip, his immediate concern was to prepare for shutdown maintenance. Gary Miller had the same initial reaction.877/ Although

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867/ Id. at 124.

868/ Id. at 127-128.

869/ Id. at 129.

870/ Id. at 129-131.

871/ Id. at 131.

872/ Id. at 136.

873/ Id. at 132.

874/ Id. at 131-136.

875/ Logan deposition at 165.

876/ Id. at 166-167.

877/ Miller deposition at 239.

he lived only 10 miles away, Miller did not,arrive at the plant until 7:05 a.m., 3 hours after he was first notified of the trip.

MANAGING THE EMERGENCY

It is generally agreed that if certain remedial action had been taken within the first hour, the TMI-2 accident would not have occurred.

Shift Supervisor William Zewe was the senior person on-site at 4:00 a.m. and accordingly was in overall charge of the plant as the accident sequence began.878/ Zewe, who was stationed in the partitioned shift supervisor's office, went into the control room and remained there for several minutes. At approximately 4:20 a.m., he left the control room and went to the basement of the turbine building to isolate a condensate line and open the polisher bypass valve.879/ Zewe left in part because he suspected that the condensate polishers had isolated. 880/ Zewe's actions suggest that he was concerned with preparing to bring the plant back on line, instead of attending to events as they unfolded.

From the basement, Zewe called the TMI-1 shift foreman and requested that he call the TMI-1 supervisor of operations (Ross) and the station manager (Miller). Zewe testified it was normal procedure to inform the station manager of a trip. The TMI-1 supervisor of operations, however, is not generally called, but was in this instance because the TMI-2 supervisor of operations, Floyd, was in Lynchburg, Va., attending B&W simulator training.881/

George Kunder, the TMI-2 superintendent for technical support, arrived on-site at approximately 4:50 a.m. He was the first person called after the accident to arrive and assist the on-site staff. He had been designated as the on-call "duty section head" for March 28.882/ Upon arrival Kunder was briefed on the problems: a turbine trip due to a loss of feedwater, a reactor trip shortly thereafter, and problems with the pressurizer.883/

After the briefing, Kunder surveyed the panel indicators himself. 884/ He held a senior reactor operator license on TMI-1 and had started a training program for a TMI-2 license shortly before March 28

878/ TMI Station Radiation Emergency Procedure, Site Emergency Procedures 1670.2, Revision 9, Nov. 22, 1978, at 4.2.1.

879/ Zewe deposition at 108-109.

880/ Id. at 109.

881/ Id.

882/ Kunder interview with Commission staff, June 26, 1979.

883/ Kunder deposition at 143.

884/ Id.

but held no license on the unit. Though Kunder was the duty section head, he questioned his own ability to interpret the meaning of the many alarms and what he was being told by those in the control room that morning.885/ He called for additional technical and operations support.886/

In addition to Kunder, those summoned to the plant during the first hours included Joseph Logan, TMI-2 superintendent, and Richard Dubiel, station supervisor, radiation protection and chemistry.887/

Shortly after 4:00 a.m., Station Manager Miller was notified by a TMI-1 shift foreman of the reactor and turbine trip.888/ At approximately 5:15 a.m. Miller called TMI-2. He talked with Kunder and expressed concern about the conflicting signals of low RCS pressure and high pressurizer level.889/ Yet Miller testified that:

> At that time I was probably thinking most of all of the fact that Unit 2 had come down and Unit 1 was hot and there was the end of refueling. I guess my biggest single concern would have been with the maintenance we were to do in Unit 2 while shut down, and secondly, we couldn't keep both units hot because of the auxiliary steam capacity.890/

As a result of that conversation, Miller set up a conference call among John Herbein, Met Ed vice president for generation (the first corporate level person to be contacted), Leland Rogers, B&W's on-site representative, Kunder, and himself. The call took place at approximately 6:00 a.m.891/

Although admittedly not fully informed himself, Kunder briefed the conference call participants on the transient. 892/ By this time, the conflicting RCS pressure and pressurizer signals were of great concern. According to Kunder, it was agreed by the parties that:

885/ Id.

886/ Id. at 149.

887/ Id.

888/ Miller deposition at 234.

889/ Id. at 237-238.

890/ Id. at 239.

891/ Id.

892/ Kunder deposition at 145.

> . . . [W]e should continue to believe our instruments, the pressurizer level specifically, because we raised the question occasionally was the pressurizer level inaccurate, and I know that question was in the minds of the operators.893/

During this conversation Leland Rogers asked whether the PORV block valve was closed. A few minutes later it was reported that the block valve was shut.894/

Because there was continuing uncertainty about the condition of the plant,895/ Herbein asked Miller and Rogers go to the site. "I don't think any of us understood the reason for the pressurizer being high. We all kind of agreed we do need help," Miller said.896/

At approximately 5:45 a.m. Logan, TMI-2 superintendent, arrived on-site. During his first hour in the control room, Logan concentrated on ascertaining the plant status. 897/ After a review of certain indicators and a briefing by Zewe, Logan's ". . . immediate concern was to get a [reactor coolant] pump running."898/

Up until this point apparently neither Kunder, Logan, nor Zewe had recognized that they had a loss-of-coolant accident or that the PORV was stuck open.

At approximately 6:55 a.m. high radiation alarms were sounded. Logan immediately declared a site emergency.899/

At approximately 7:05 a.m. Miller arrived at the TMI-2 control room and assumed the position of emergency director. 900/ Miller declared a general emergency at 7:24 a.m. based on "the dome meter radiation exceeding the 8 rem criteria."901/

893/ Id. at 146, as corrected by Kunder's errata sheet.

894/ Miller deposition at 242-243. See complete discussion of the closure of the block valve in the "Procedures" section.

895/ Miller deposition at 246.

896/ Id.

897/ Logan deposition at 171.

898/ Id. at 174. The RC pumps had been shut off at 73 and 100 minutes into the accident. See Nuclear Safety Analysis Center (EPRI), "Analysis of Three Mile Island-Unit 2 Accident," NSAC-1, July 1979, sequence of events.

899/ Logan deposition at 171.

900/ Miller deposition at 260-261. Miller was not a licensed operator on either TMI-1 or TMI-2. Miller deposition at 50.

901/ Id. at 270.

When Miller proclaimed himself emergency director he assigned individuals specific tasks and organized a senior advisory group to serve as his "think tank." It was through this group that information was filtered to Miller.902/ According to Logan, continuous discussions were held by the advisory group throughout the day.903/

On April 14, 1979, about 2-1/2 weeks after the accident, Gary Miller organized and led a private discussion among key plant management personnel. The object of the session, which was tape-recorded, was to recapitulate the accident events from 4:00 a.m. on March 28 until 4:00 a.m. on March 29. In addition to Miller, those present included Joseph Logan, James Seelinger, Michael Ross, Richard Dubiel, William Zewe, and B&W's site representative, Leland Rogers.

The 2-1/2 hours of tape were made available to the Commission, but have not been transcribed because many voices are unclear, there are frequent interruptions, and speakers are not identified. The Commission staff has been able to identify many of the speakers because of familiarity with their voices from lengthy depositions. Listening to the full tape leaves the impression that in the first 24 hours of the accident there was considerable confusion as to what was occurring and what should be done to manage the accident.

For instance, operators ". . came in [to the control room] and yelling at you Joe [Logan] failing fuel."904/ Based on a 600 millirem reading, Dubiel recognized at 6:30 a.m. that "Holy s---, we must have failed fuel."905/

902/ Since the accident the think tank or caucus method of crisis response has, according to James Seelinger, TMI-1 Unit Superintendent, been incorporated into B&W simulator training. The approach requires the individuals involved "to draw back from the plant in a corner with the senior people, discuss the situation in caucus form, and decide what the most prudent course of action to be used to handle the plant's problem. . . ." Seelinger deposition at 219. On Sept. 12, 1979, Met Ed announced that Seelinger resigned effective mid-October.

903/ Logan deposition at 178.

904/ Tape recording, Gary Miler et al. review of TMI-2 accident, April 14, 1979, tape 1, side 1 Accession #1008014.

905/ Id.

At 6:50 a.m. Logan declared a site emergency; however, he "didn't even look at actual readings, everything was out of hand" and on that basis he declared the emergency. 906/ Somebody else commented that he "didn't look at numbers either. [He had] seen alarms and knew we had a problem."907/

As stated above, Gary Miller named himself emergency director once he arrived in the TMI-2 control room and in fact did manage the events from that time:

> . . . in middle of caucus and we sent somebody out to secure make-up pumps and we talked and they secured make-up pumps and we talked for about two more minutes and Gary came to the conclusion and we decided through his impetuous, we don't fully understand it, let's go start make-up pump again.908/

Yet Miller had basic questions about plant operations:

> Let me ask you something in my own ignorance of the system. Normally does the reactor building sump fill up and discharge to the auxiliary building automatically?909/

On the tape, the think tank articulated its three goals during the accident -- protect the public, keep the core covered, and the third is inaudible. However, a member of the group commented, "Great goals, now to figure out how to do it."910/

transient was the operators' thought that "we were still trying to clean this up by Friday and be back on line."911/

> I must have been an eternal optimist that day cause I don't know how many times I said to you, Mike [Ross], and to Gary [Miller], let's start thinking about what we gotta do to clear up this mess.
>
> [At 7:30 a.m.] we all thought we had the core covered.912/

906/ Id.

907/ Id.

908/ Id. at tape 2, side 3.

909/ Id. at tape 1, side 1

910/ Id. at tape 1, side 2.

911/ Id. at tape 2, side 4.

912/ Id. at tape 2, side 3.

UNDERSTANDING OF CORE CONDITION ON MARCH 28

Throughout the first day of the accident there was confusion and uncertainty about the condition of the core.

There were a variety of indications on March 28 that the core had been uncovered. Among those indications were hot leg temperatures that began to rise about 1-1/2 hours into the accident, high radiation alarms that began about 2 hours and 45 minutes into the accident, and several pressure spikes in the containment building, the largest of which occurred about 10 hours into the accident. 913/ This section, however, focuses on the indications of core condition provided by in-core thermocouple temperatures. In doing so, it does not mean to suggest that these indications were more significant than the others. At the end of the section there is a discussion of the NRC's understanding of the condition of the core on March 28 and of some of the related actions taken by the NRC.

At the top of 52 of the 177 fuel assemblies in the TMI-2 core there were temperature-measuring devices called thermocouples. 914/ Thermocouple data could ordinarily be read from the printout sheets of the control room computer, but on the morning of March 28 many of the thermocouple readings were off the high end of the computer's scale (which went to 700°F) and thus could not be read from the printout sheet.915/ At approximately 8:00 a.m., station manager and emergency director Gary Miller asked Ivan Porter, a TMI-2 instrumentation and control engineer, whether the thermocouples could be read from somewhere other than the computer sheet. Porter said the thermocouples could be read in the cable room where the thermocouple data fed into the back of the computer.916/

Shortly after 8:00 a.m., Porter went down to the cable room, where he was joined by several maintenance foremen and instrument technicians -- Jim Wright, Skip Bennett, Bob Gilbert, and one person who requested

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913/ Nuclear Safety Analysis Center (EPRI), "Analysis of Three Mile Island Unit 2 Accident," NSAC-1, July 1979, Sequence of Events.

914/ Id., Appendix C at 15 and Figure CI-1.

915/ Porter deposition at 20.

916/ Id. The cable room, immediately below the control room, was sometimes referred to as the cable spreading room or the relay room.

confidentiality and will be referred to as "John."917/ Four thermocouple readings were taken. Two were exceptionally high -- somewhere above 2,300°F -- and two were exceptionally low -- slightly above 200°F.918/

Porter doubted the validity of both the high and the low readings. He discounted the low readings because all the other plant instruments he had looked at -- the loop instruments and the resistance temperature detector (RTD) that measured RCS temperature -- indicated that the plant was above 620°F or 700°F.919/ Porter said that he "had no real reason not to believe the high reading[s] once it was fairly obvious to me that the low ones weren't accurate."920/ But the apparent inaccurancy of the low readings caused him to doubt the accuracy of the high ones as well. When asked whether he believed the high readings, Porter said, "I can't say that I really believed them, no. They concerned me. But the fact that we had some low readings also, to me just confused and made the whole things somewhat unreliable."921/

Porter's reaction to these first four thermocouple readings was not shared by at least one of the technicians who had taken them. "John," after seeing the first high readings, told Porter that he thought the core was uncovered. Porter said he did not remember anyone making such a statement to him,922/ but Wright confirms "John's" account. 923/ Under questioning, "John" insisted that he had told Porter he thought the core was uncovered, and said:

917/ All of them arrived in the cable room at approximately, but not exactly, the same time. "John" June 20, 1979, NRC interview, Tape #315 at 10-13. Accession #1008007.

918/ Porter deposition at 21. "John"'s recollection of these first readings was different from Porter's, Wright's and Bennett's. "John" said that the first readings included one around 4000°F and he did not recall seeing any low readings (around 200°F). "John" NRC interview at 14, 36. "John" was promised confidentiality by the NRC, not the President's Commission.

919/ Porter deposition at 24.

920/ Porter May 21, 1979, NRC interview, Tape #237, at 22. Accession #1008004.

921/ Porter July 2, 1979, NRC interview, Tape #324, at 7. Accession #1008008.

922/ Id. at 6.

923/ Wright June 15, 1979, NRC interview, Tape #310 at 13. Accession #1008005.

> I believe Ivan [Porter] didn't really want to believe what was really taking place. I don't know whether it was an attitude of hey your measurements are wrong, you guys don't know what the heck you're doing or whatnot. I think the general consensus throughout the whole first day was number one, nobody really knew what was actually happening, number two, some that had an inkling of what was happening didn't really want to believe what was going on.924/

But whether or not "John" told Porter after the initial readings that he ["John"] thought the core was uncovered, Porter did not relay any such remark to Miller when reporting the first four readings to him. Miller testified that he and Porter agreed that those readings "might be unreliable and probably were."925/ Leland Rogers, B&W's representative at the TMI site, said that when this set of thermocouple readings was reported to Miller's decision-making group, "no one was sure what that was really meaning at that point."926/

After the technicians in the cable room finished taking the first few readings with a device called a fluke thermocouple reader, one of them, Skip Bennett, suggested that it would be easier to use a digital voltmeter, and then convert the voltage readings into temperatures with a standard conversion chart.927/ Since the first four readings had convinced Porter that none of the thermocouple data could be worth much, he allowed the technicians to use the voltmeter, although it was a slightly less precise method of taking the measurements.928/

Using the voltmeter, the technicians took a complete set of thermocouple readings that Bennett recorded on v computer printout listing thermocouple points called a computer point identification book.929/ This complete set of readings confirmed the first few readings -- it

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924/ "John" NRC interview at 18-19. The first high readings he saw clearly alarmed "John" considerably. See id. at 14-16.

925/ Miller May 31, 1979, Commission hearing testimony at 9. See also Miller May 24, 1979, hearing testimony before House Subcommittee on Energy and the Environment (Udall Subcommittee at 73.) Accession #627008.

926/ Rogers May 4, 1979, NRC interview, Taple #118, at 10. Accession #1008002.

927/ Bennett June 19, 1979, NRC interview, Tape #311, at 14-16. Accession #1008006.

928/ Porter deposition at 2223.

929/ Bennett NRC interview at 17.

showed some extremely low temperatures and some extremely high temperatures. 930/ While the presence of the low temperatures remained puzzling, the confirmation of the extremely high temperatures convinced the other technicians that "John" was right -- that it was very likely that the core had been uncovered.931/

Porter left the cable room shortly after the second set of readings began.932/ It is unclear exactly what the technicians told Porter after they finished the second set of readings (about 8:50 a.m.) and reached the consensus that the core had probably been uncovered. Bennett said that after finishing the readings he put the computer point identification book back on the computer console and "informed Mr. Porter that there [were] several thermocouples that were extremely hot in the neighborhood of 2,000°F ... "933/ Shortly after that Bennett and the other technicians who had been in the cable room left TMI-2 under the policy of evacuation of all "nonessential" personnel.934/

Whatever the technicians told Porter about the second set of readings, Porter, by his own admission, forgot entirely that that set of readings had ever been taken.935/ That Porter forgot was perhaps partly due to the confusion in the cable and control rooms and to the fact that he had already discounted any thermocouple data as unreliable. Porter did not remember that the second set of readings had been taken until Bennett's record of it was found in the computer point identification

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930/ Most of the low temperatures were in fuel assemblies around the core's periphery, while most of the high temperatures were in fuel assemblies around the center of the core. This did not become clear until on or after May 7, when Porter transferred the voltage readings (which he had just found) tc a map of the in-core thermocouples. See Porter deposition at 70-72 and in-core thermocouple map, Porter deposition exhibit 3. See also EPRI Report, footnote 901, supra, Appendix CI at 17-18 and Figure CI-12.

931/ Bennett NRC interview at 18; Wright NRC interview at 12; "John" NRC interview at 18.

932/ Porter July 2, 1979, NRC interview at 11.

933/ Bennett NRC interview at 18-19.

934/ Porter deposition at 22. One technician, Doug Weaver, remained in the unit to deal with any instrumentation problems that might arise. Bennett NRC interview at 20.

935/ Porter July 2, 1979, NRC interview at 12. Porter had no recollection of being told anything about the second set of readings, but assumed that he must have been told something and therefore must have forgotten.

book in the control room on May 7 -- more than a month after it had been written.936/ Since Porter was acting on March 28 as the liaison between the technicians and Gary Miller, 937/ Miller may never have been informed about the second set of readings and thus may have missed what the four technicians believed was a fairly clear indication that the core had been uncovered.938/

The technicians who took the thermocouple readings in the cable room were not the only ones on-site on the morning of March 28 who realized that the core had been uncovered. At about 10:00 or 10:30 a.m., John Flint, a resident B&W engineer at the site, reached the same conclusion.

Flint's account of his actions is as follows: He arrived in the TMI-2 control room around 9:00 a.m. (about when the cable room technicians finished the second set of readings), and was asked by Leland Rogers to evaluate the condition of the core from available computer information. 939/ On the basis of computer and strip chart data, Flint concluded that there had probably been a change in the leakage flux from the core, and so informed Rogers, as well as William Zewe and Edward Frederick. 940/ Flint told Rogers that "we needed to induce natural circulation or run a reactor coolant pump."941/ Rogers discussed this with Miller's think tank and reported back to Flint that operators were trying to establish natural circulation. 942/ Flint then proceeded -- unaware of the efforts of the technicians in the cable room -- to examine the in-core thermocouple temperature readouts on the computer sheet, most of which were off the high end of the computer's scale (above 700°F). 943/ From this, Flint inferred that the core was superheated.944/ Some time later, at around 10:00 or 10:30 a.m., Flint

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936/ Porter deposition at 21-22.

937/ Id. at 25.

938/ Miller did , however, have access to other indications of core uncovery, such as the hot leg temperatures and radiation alarms.

939/ Flint deposition at 16-17.

940/ Id. At 18.

941/ Id. at 19.

942/ Id. at 19-20.

943/ Id. At 20.

944/ Id. at 21.

concluded, after getting further information about the course of accident events, that the core had been uncovered for an extended period of time but was no longer uncovered. 945/ He told this to Rogers, who went to discuss it with Miller and Kunder. Flint was not present at that discussion and Rogers did not report back to him. Flint also told Zewe and Frederick that he thought the core had been uncovered. 946/ Zewe and Frederick were surprised, but they had been trying to establish natural circulation or forced flow, which seemed to Flint to be what they should have been doing had they known the core had been uncovered.947/ Flint had inferred that the core was no longer uncovered from source range detector indications, the fact that not all the thermocouple temperatures were off-scale high on the computer, and the fact that the pressurizer was not empty.948/

Neither Rogers nor Zewe had any recollection that Flint told them anything on March 28 about the core's condition. 949/ Zewe testified that he was unaware until 3 or 4 days after March 28 that there had been extensive core damage.950/

In summary, during the first 6 or 7 hours of the accident the group of technicians in the cable room and John Flint independently reached the conclusion that the core had been uncovered. In neither instance, apparently, did their liaisons with emergency director Gary Miller -- Ivan Porter in the case of the technicians and Leland Rogers in the case of Flint -- report to Miller their conclusion that the core had been uncovered.

Zewe testified that the high radiation alarms received on March 28 were in response to "a radioactive source that had to initiate from the reactor itself." 951/ But Zewe did not associate the alarms with the possibility of core damage:

945/ Id. at 21-22.

946/ Id. at 23.

947/ Id. at 25.

948/ Id. at 27-28. Wright also reached the conclusion (independently of Flint)-that the core had been uncovered and then re-covered. Wright NRC interview at 12.

949/ Rogers NRC interview, Tape #118, at 20-21.

950/ Zewe May 30, 1979, Commission hearing testimony at 159.

951/ Zewe deposition at 181-182.

> Core damage, to me, is very severe. I was still thinking in terms of crud bursts and maybe some cladding cracking, but nothing when we look at fuel damage as it actually was.... If I had suspected we had core damage, I would have expected tremendously higher [radiation] levels than what we did see.952/

Zewe testified that he did not see a 6,000 rem reading that had registered in the reactor building. Moreover, he said, "[I] just didn't in my own mind believe we actually had radiation levels in the building that high. I did not have the confidence in those readings that they were actually that high."953/

With regard to the first set of thermocouple readings, TMI-2 Shift Supervisor Ross said that:

> Thermocouple temperatures were brought up to Gary [Miller] and I guess the bottom line they got out of that, was that they were not conclusive. It showed the core was hot, basically.... He [Porter] was saying he had various temperatures scattered throughout. So ... Gary and he discussed it, and basically I think the bottom line was yeah, the core is hot, or it is at least hot.954/

Miller's statements about his perception of the core's condition on March 28 were conflicting. At one point in his NRC interview, Miller suggested that he did not discount the first thermocouple readings when Porter gave them to him:

> ... I had Ivan Porter read out the thermocouples on the in-cores which are not [devices] that are extremely accurate, but they are an indicator ... He sent an instrument tech down, the instrument tech came back and Ivan told me that some read 200[,] some read 400[,] and some read 2,500[,] and some didn't read. Then he explained to me that if they were really hot they would melt and form other junctions and that the calibration wouldn't be good anymore. So, you know, the bottom line here was that they're hot, they were hot enough that they scared you, as far as what you're looking for. It told me the reason the computer was off scale at 700 degrees ... The in-cores were reading anywhere from, 2,500 or so, and I picked 2,500 it could have been higher than that. But

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952/ Id. at 182-183.

953/ Id. at 184.

954/ Ross NRC interview (excerpts), Tape #226, at 42. Accession #1008021.

it.... I know that we were super heated and all that sort of thing, ... but we just knew we didn't have a control, we were out of control. We knew the situation was one we hadn't anticipated too many times here.955/

This statement that Miller knew "we were super heated" (presumably meaning that he knew the core was superheated) conflicted with other statements Miller made on the subject. For instance, in a June 14 letter responding to questions of Congressman Udall, Miller wrote:

> Since ... I received only a few points with a wide disparity of readings from the thermocouples, I did not believe that the initial temperature measurement in the range of 2,400° or any of the other thermocouple readings were necessarily reliable and did not pause to consider their significance.956/

In the NRC interview Miller said:

> We weren't totally convinced the core was covered. But we didn't know what instrument to look at to tell us that.... We really didn't know what indicator told us the core is covered.957/

In his deposition Miller testified,

> I think we believed on the 28th there was fuel damage, and it is very hard to remember about core uncoverage.958/

> All morning we discussed the core coverage, and we didn't believe the core was uncovered.... 959/

> I don't think anybody would have thought the core was covered or uncovered. I think we thought there was fuel damage because of the sequence of events. I don't think we analyzed in our mind whether

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955/ Miller May 7, 1979, NRC interview, Tape #159, at 51-52. Accession #1008003. See also May 21, 1979, Udall subcommittee hearing at 37. (Miller statement quoted by Rep. James Weaver, D-Ore.). Accession #6210226.

956/ Letter (excerpts) from Miller (Met Ed) to Udall (House Subcommittee on Energy and the Environment) June 14, 1979, Accession #1008021.

957/ Miller NRC interview, Tape #159, at 55-56.

958/ Miller deposition at 271.

959/ Id. at 272.

> core coverage or uncoverage or the amount of fuel damage, or at least I don't think I did.960/

Miller was not the only one to make directly conflicting statements about his understanding of the condition of the core. In his Aug. 11 deposition Robert Arnold testified that it was "my rather vague recollection" that:

> I was concerned ... in the afternoon of the 28th that the core may have become uncovered. I believe that information I received the evening of the 28th led me to think that it undoubtedly had happened.961/

But on Oct. 1 Arnold said in a news interview, according to The New York Times, that:

> [B]ecause of the low reliability of some of the instruments and conflicting nature of some of [the] evidence ... top executives [of Met Ed] had not reached the conclusion on March 28 that the core had been uncovered.962/

On the morning of March 28 James Floyd, TMI-2 supervisor of operations, was at B&W in Lynchburg, Va., for simulator training. According to Gary Miller, Floyd said he called TMI-2 at 7:30 a.m. on that day, had a reading taken on the reactor building atmosphere monitor, and based on calculations he had done in 1973 estimated that the amount of fuel damage was 12 percent. Floyd told this to B&W management in Lynchburg at around 9:30 a.m., according to Miller, but the information did not reach Miller until several days later.963/

At least two (and probably more) NRC officials realized on March 28 that the core had been uncovered. They were Victor Stello, director of NRC's Office of Inspection and Enforcement, and Richard Vollmer, director of NRC's TMI Support Task Group and acting assistant director of NRC's Systematic Evaluation Program. Vollmer concluded that the core had been uncovered on the morning of March 28, based on the fact that:

960/ Id. at 287-288.

961/ Arnold deposition at 230.

962/ "Lag in Telling of Damage at Reactor to be Studied," The New York Times, Oct. 2, 1979.

963/ Miller May 25, 1979, taped statement, at 5-6. Accession #1008013. See also the "Procedures" section of this paper.

[t]he temperatures in the hot leg above the core were higher than the saturation temperatures of the liquid. And the only way this can occur is if the steam above the core had been superheated, which would mean that the core would have had to be uncovered.964/

On the morning of March 29 Vollmer took a team of NRC employees to the observation center at the TMI site. He was not aware that the extent of core damage was significant until March 30, when it became clear that a large amount of hydrogen had been generated in the containment building.965/

Stello arrived at the NRC Incident Response Center (IRC) in Bethesda, Md., at about 9:00 a.m. on March 28.966/ He testified that:

[A]s the morning wore on it became apparent to me and others **[in** the IRC] that they [TMI-2] had a condition where the hot light [leg] temperatures were indicating the possibility of a super heat condition.967/

Since a super heat condition meant core uncoverage had occurred, Stello tried to get in-core thermocouple temperatures to confirm this.968/ This was difficult because the communication system originally set up between the TMI site and the IRC "was very poor."969/ Stello eventually found out (at about 4:00 p.m.)970/ that the computer thermocouple data were mainly question marks, from which he correctly inferred that the temperatures were off-scale high. By the afternoon of March 28 he:

...became satisfied in my mind that the prudent thing to do was to believe that those thermocouple readings did, in fact, indicate superheated steam, and that even in spite of what the pressurizer level was telling him [the licensee], he ought to believe his core was uncovered.971/

964/ Vollmer deposition at 18.

965/ Id. at 16-17.

966/ Stello deposition at 73.

967/ Id. at 75.

968/ Id. at 76.

969/ Id. at 74. See also Statement of P. Leventhal and James Asselstine, Co-Directors, Investigation of Three Mile Island Nuclear Accident, Subcommittee on Nuclear Regulation, Senate Committee on Environment and Public Works, Oct. 2, 1979, at 26-28. Accession #1008009. Hereinafter cited as Hart subcommittee statement.

970/ Hart subcommittee statement, footnote 969, supra, at 10.

971/ Stello deposition at 78.

Thus, Stello said:

> [T]hrough most of the afternoon ... we were trying to advise the licensee that he may have a condition of inadequate core cooling and that there would be a need to get more water into the core to cool it.972/

At one point in the afternoon Stello reached someone (he does not remember who) in the TMI-1 control room,973/ and told him he thought the core was uncovered and that the flow rate in the HPI pumps should be increased. Vollmer said:

> I certainly know, from people who were there [the Incident Response Center], that he [Stello] was yelling into the phone that the operator should understand clearly that the core is uncovered, because the temperatures were too high.974/

The person in the control room told Stello the core flood tanks had been discharged and that this ensured there was adequate water level in the core.975/ Stello "tried to make him understand" that discharging the flood tanks did not guarantee core coverage. 976/ If Stello had had more complete information about the accident, he would have ordered the site to increase HPI flow, but he did not because he felt his information was too fragmentary.977/ Stello remembered discussing his understanding of the core's condition with others at the IRC; he also mentioned his belief that the core was uncovered to NRC Commissioners Ahearne, Bradford, and Gilinsky when they were at the IRC at about 4:45 p.m. on March 28.978/

972/ Id. at 77.

973/ The Hart subcommittee statement, footnote 969, supra, at 30 reported that "During crucial periods of time the [Incident] Response Center had no direct contact with the TMI-2 Control Room. On the first day, it appears that IRACT [Incident Response Action Coordination Team] had only a handful of direct conversations with a Metropolitan Edison employee located in the TMI-1 control room -- not in TMI-2 where the accident was being managed."

974/ Vollmer deposition at 18.

975/ Stello deposition at 79.

976/ Id. at 79-80.

977/ Id. at 82.

978/ Id. at 84-85, and Hart subcommittee statement, footnote 969, supra, at 11.

The knowledge of Stello and others at the IRC that the core had been uncovered was not communicated by the NRC to concerned federal agencies and the White House on March 28. In fact, between 4:30 and 6:00 p.m. Bernard H. Weiss, NRC senior technical operations specialist acting under the direction of Dudley Thompson, executive officer for operations support, told individuals at HEW's Center for Disease Control and at the White House Situation Room that the core had not been uncovered. Weiss said he could not remember who instructed him to tell agencies that the core had not been uncovered.979/

Moreover, core uncoverage was not explicitly mentioned at the NRC's briefing of the Udall subcommittee on the morning of March 29. When Commissioner Gilinsky was asked why it was not, he replied:

> I don't remember the point [about core uncoverage] being made by anyone other than Mr. Stello in those hours [the first hours after the accident] or in the first two days.... I think the orientation during the first few days was not so much on the question of core uncoverage or not, but with the degree of fuel damage. And that was what was being discussed, how much fuel damage there was, which is really the ultimate question. Although there is no question that the uncovering of the core adds to the seriousness of the accident. 980/

When asked "If you have extensive fuel damage, haven't you usually had core uncovery? Don't the two go together?" Gilinsky answered:

> I think that is probably right. I think it is probably pretty hard to think of one or the other. Except that I must say the very early stage, I was getting reports ... that fuel may have been damaged simply from the rapid reduction in pressure. Now gradually that went by the boards. There was some discussion of the fuel simply being at high temperature for a long time, but not -- well, let me leave it to say that I think that is right. I think fuel damage and uncovering really [go] together.981/

979/ Hart subcommittee statement, footnote 969, supra, at 32-33.

980/ Gilinsky deposition at 135.

981/ Id. at 136.

GOALS

The TMI-2 recovery effort has two major long-term phases. The first is the "cleanup" of TMI-2; the second is its rehabilitation. The "cleanup" phase has two goals: (1) "to insure reliable long-term cooling of the core," and (2) "to contain, control, and re-collect dispersed fission products."982/

Two systems are being used to achieve long-term core cooling. One, currently operating, is a core pressure and volume control system which uses nitrogen to control pressure. The second is "a mini-decay heat removal system for a cold shutdown plant." 983/ Robert Arnold testified on Aug. 11 that this system "**is** probably 6 weeks away" and that it "would replace the use of the 'A' steam generator which is currently removing decay heat through natural circulation. 984/ This system is expected to be ready for operation by Nov. 23, 1979.

The most important aspect of the second cleanup objective -- containment, control, and collection of dispersed fission products -- is the decontamination of the approximately l million gallons of radio-active water located in several parts of the TMI-2 system. Approximately 250,000! gallons located in the TMI-2 auxiliary building are in the lower or intermediate ranges of radioactivity. A demineralization system called EPICOR-2 985/ has been set up since the accident to decontaminate this intermediate-level water. According to Ronald Williams,986/ EPICOR-2 first filters out all particulate activity and some iodine from the water; it then passes the water through resin, removing the other dissolved activities by ion exchange. 987/ The NRC has recently, given permission to Met Ed to use EPICOR-2. 988/ Arnold estimated that the intermediate-level water could be cleaned within 2 to 3 months after EPICOR-2 becomes operational.989/

982/ Arnold deposition at 257.

983/ Id. at 260.

984/ Id.

985/ After the manufacturer, EPICOR, Inc.

986/ Senior Consultant, Generation Division, GPUSC.

987/ Williams deposition at 48.

988/ Nucleonics Week, Oct. 18, 1979, at 3.

989/ Arnold deposition at 261-262.

Approximately 550,000 gallons of water discharged from the reactor coolant system folrowing the accident and now located in the containment building particularly the building basement, or sump) contains a higher level of radioactivity. This high-level water will be treated by a system desi ned by Chem Nuclear Systems. In the Chem Nuclear system, according to'.,Willtams:

> The demineralizers are located . . . under water in the fuel pool, and the reason for that is to provide shielding from the radioactivity that will be built up in the filters or the demineralizers as the water is being processed. And then they will be handled under water. Filters will be put into casks and then shipped off-site as dewatered resin.990/

The preliminary design of the Chem Nuclear system is complete and the system is presently expected to be on-site and ready for use by early 1980. Arnold estimated that it will take 3 or 4 months to process the containment building water once the system is operational.991/

There is relatively little work being done currently on the second major phase of the recovery program, rehabilitation of TMI-2. The work being done consists of a small-scale effort to identify "what might be the long lead time items" in the unit that require replacement. 992/ Arnold does not expect that the reactor vessel itself will have to be replaced, but some reactor vessel internals with long lead times probably will have to be replaced, as will almost all of the electrical wiring inside the containment building.993/

ORGANIZATIONAL STRUCTURE

Organizationally, the recovery effort represents a pooling of Met Ed and GPUSC resources, 994/ to which have been added personnel "from other utilities and nuclear industry organizations across the country."995/

The organizational structure has gone through several stages. For approximately a week after the accident the structure was fairly informal, but the effort, according to Arnold, could be said to have been divided into three main departments:

990/ Williams deposition at 54.

991/ Arnold deposition at 263.

992/ Id. at 256.

993/ Id. at 256-257.

994/ Dieckamp deposition at 160.

995/ First Interim Report on the TMI-2 Accident -- submitted by Met Ed to NRC (I&E) on May 15, 1979. Section II, at 1. Accession #7240040.

1. The Plant Operations Group, headed by John Herbein,996/ consisted of the Met Ed TMI staff, personnel from other utilities, and personnel from Nuclear Service Supply Company, a private firm. This group was responsible for performing all plant operations and required maintenance activities limiting personnel exposure to radiation, stopping uncontrolled off-site releases of radiation, returning the plant to a safe status, and ensuring the plant's ability to respond to any future emergencies. As the organizational structure became increasingly formal, a number of divisions were set up under the Plant Operations Group -- Health Physics (headed by Lawrence Lawyer997/), Security, Maintenance, and Shift Operations.998/

2. The Technical Support Group, headed by Arnold, consisted of engineers and was responsible for analyzing plant situations, developing emergency and special operating procedures, and serving as a link between the Plant Operations Group and various off-site sources of analysis and information.999/

3. The Industry Advisory Group (IAG) was established as a "think tank" to function in parallel with all ongoing activities and "was not to be part of the implementation structure. The group would of its own initiative look into potential problems of any kind, maintain . . . awareness of the perceived status of the core, and provide assessments based on experience and judgment as opposed to detailed engineering review and calculation."1000/

Five days after the accident, on April 2, 1979, the initial recovery decision-making structure was considerably expanded and made more formal. The program was organized under the general direction of Herman Dieckamp; 1001/ Arnold became GPIJ operations manager, "with responsibility for the overall management of all on-site and near-site capabilities and resources related to the recovery effort . . . ."1002/

996/ Vice President for Nuclear Operations, Met Ed.

997/ Manager, Generation Operations, Met Ed.

998/ First Interim Report on the TMI-2 Accident, footnote supra, Section II, at 2; Arnold deposition at 234-235.

999/ Arnold deposition at 235-236.

1000/ First Interim Report on the TMI-2 Accident, footnote 994, supra, Section II, at 2.

1001/ President and chief operating officer of GPU and GPUSC.

1002/ First Interim Report on the TMI-2 Accident, footnote 994, supra, Section II, at 1.

The three original branches of the recovery -- the Plant Operations Group, the Technical Support Group, and the Industry Advisory Group -- remained in place, but six new departments were created. Waste management activities were centralized in a single Waste Management Activities Group.1003/ The Plant Modifications Group was set up to take charge of design and construction of needed modifications. The Task Management/ Scheduling Group was charged with coordinating and monitoring the work progress of all groups. The Technical Working Group included representatives of all the above groups in addition to a Babcock and Wilcox representative (usually John MacMillan), a representative of the NRC's Office of Nuclear Reactor Regulation (usually Victor Stello), and Warren Cobean of Burns and Roe, who also headed the Plant Modifications Group. Completing the organization were two groups: Administration and Logistics, and Public and Government Affairs. These last two groups reported directly to Dieckamp; all the others reported directly to Arnold.1004/

Since April 2, a variety of changes in the organizational structure have been made. By the end of April, increasingly stable plant conditions permitted the IAG to be disbanded, subject to re-formation if necessary. By mid to late May many of the people in the Technical Support Group had left the TMI site and returned to their normal work locations. 1005/

In June, increased focus on radioactive waste accumulation on-site triggered reorganization of the Waste Management Activities Group. Three new divisions were set up: The Decontamination Group, responsible "for cleanup of surface contamination in the auxilliary and fuel handling buildings"; the Processing Group, responsible for consolidating "the existing liquid and gas processing teams"; and the Disposal Group, "responsible for packaging, transportation, on-site staging, off-site shipping, and disposal of all forms of radioactive waste generated on-site." 1006/

Finally, Arnold expects that after the systems necessary for long-term core cooling are operating, the Technical Working Group will be replaced "by another group which concentrates just on. . . the containment building cleanup and entry."1007/

1003/ During the second week of April, Ben Rusche replaced Frank Palmer as head of the Waste Management Activities Group. Rusche was formerly director of the office of Nuclear Reactor Regulation at the NRC.

1004/ First Interim Report on the TMI-2 Accident, footnote 994, supra, Section II, at 2, 3; Arnold deposition at 240-241, 246-8.

1005/ Arnold deposition at 247.

1006/ Third Interim Report on the TMI-2 Accident, submitted by Met Ed to NRC (I&E) on July 16, 1979.

1007/ Arnold deposition at 249.

CONCLUSION

The Three Mile Island accident had three major corporate participants: General Public Utilities Corporation (and its subsidiaries, GPUSC and Met Ed), Babcock & Wilcox, and Burns and Roe.

General Public Utilities was an early entrant into the commercial generation of nuclear power in the United States. Its first nuclear plant, in Oyster Creek, N.J., went into operation in 1969.

GPU Service Company Vice President Robert Arnold described the period from GPU's entry into the nuclear power field in 1963 up to the March 28, 1979, accident at Three Mile Island as a learning experience lasting 10 to 15 years.

Despite that experience there were significant weaknesses in the operation of TMI-2 at the time of the accident:

- Operating experience at TMI-2 and other nuclear power plants was not being effectively gathered, analyzed, or followed up.

- Training of operators and management personnel was seriously inadequate and did not stress fundamentals of reactor safety.

- Although plant procedures went through a multiple-step review process, there were significant deficiences in the procedures in use at the time of the accident.

- There was insufficient transfer of the knowledge gained by GPUSC in the design and construction of the plant to the Met Ed personnel responsible for operating the plant.

In retrospect, Arnold said he did not believe that in the future a utility should be permitted to go through such a learning process at the risk of the public.1008/

The TMI-2 accident demonstrated the weakness of B&W's ability to understand and convey operating experience from one of its customers to another. This was illustrated by the Dunn memorandum "dropping in the crack" and by B&W's failure to instruct operators in light of a history of PORV failures. 1009/ Although B&W disavowed resonsibility for the content of its utilities' plant procedures, B&W was the first to criticize the TMI-2 operators for not following a part of a procedure that B&W itself had failed to supply.1010/

1008/ Arnold deposition at 150-151.

1009/ Taylor deposition at 38.

1010/ Roddis deposition at 14, 30; Neely deposition at 45.

A senior executive of Burns and Roe described its role as selling engineering services "by the yard" to a utility: what the utility wanted, Burns and Roe would supply. The product, as illustrated in the design of the TMI-2 control was a patchwork of the varying desires of the participants in the design process (Burns and Roe, B&W, GPUSC, Met Ed, and Jersey Central Power and Light).1011/

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During the design and construction phase of TMI-2, GPU made the decision to form a Nuclear Power Activities Group, later to become GPUSC, to centralize its design and construction expertise in the nuclear field.1012/ But the centralization of expertise moved slowly. Although GPUSC engineers testified that final design authority rested in their organization, they did not always have the expertise in-house to make design judgments when key design decisions were being made for TMI-2 in the early 1970s.1013/ Often they were forced to go to outside consultants. That meant that synthesis of the TMI-2 design into an integrated whole could not effectively be performed within GPUSC.

Although there had been some discussion of GPUSC ultimately operating the nuclear power plants that it had designed and built, GPUSC never became actively involved in the operation of Oyster Creek-1, TMI-1, or TMI-2 until after March 28, 1978.1014/ As a result, the knowledge acquired during the design and construction process was not applied in a systematic and direct fashion to the plants once they became operational.

Robert Arnold said that problems had been recognized in 1977 when he moved from vice president of Met Ed to vice president of GPUSC:

> The issue was a very real one to us. It was one that was emphasized by Herman Dieckamp when I went into the job of the need to couple together the operating plant experience with the plant design and to provide the kind of technical review of what was happening at the plant that was necessary to have the reliability of operation and safety of operation that was necessary. 1015/

The problem was also identified in a management audit of GPUSC and Met Ed completed in the spring of 1977. Yet having been identified, the problem was not effectively resolved. Arnold commented:

1011/ Roddis deposition at 14, 30; Neely deposition at 45.

1012/ Dieckamp deposition at 11; see also Neely desposition at 8.

1013/ Neely deposition at 20-21, 24; Williams deposition at 27.

1014/ Arnold deposition at 17; 222-223

1015/ Id. at 68.

"We ... established a procedure which we had a great deal of difficulty getting executed reliably, so I would not want to taken too much credit for what it was."1016/

And GPU President Herman Dieckamp said:

> To me that is probably one of the most significant learnings of the whole accident the degree to which the inadequacies of that experience feedback loop ... significantly contributed to making us and the plant vulnerable to this accident. 1017/

Two other complicating factors in the continuity of design and construction were the change of the site from Oyster Creek to Three Mile Island in December 1968, with an accompanying change in the operating subsidiary, and delays in construction apparently resulting from cash flow problems within General Public Utilities. 1018/ At the time of the site change it was intended that TMI-2 should be completed by 1973, although construction was actually not completed until 1978.

When the site change was announced, GPU said:

> It is a requirement that the minimum possible disturbance be made to the existing design, so as not to detract from the schedule. A design will be used, even though not optimum, provided it is adequate and can save time.1019/

By the time of the site change in late 1968, many of the basic design decisions for the plant had been made. When Met Ed became involved in the project at that point, it was given little say about the design of the plant.1020/

The control room was originally designed by Burns and Roe based in part on the preferences of control room operators at the Oyster Creek-1 boiling water reactor.1021/ After the site change Met Ed representatives asked that the TMI-2 control room be made to conform to the control room for TMI-1. That request was ultimately rejected. 1022/

1016/ Id. at 69.

1017/ Dieckamp deposition at 153.

1018/ Creitz deposition at 55.

1019/ Conference note 235, Burns and Roe, December 26, 1968; Caplan deposition exhibit 67, at 3.

1020/ Dieckamp deposition at 53; Creitz deposition at 45, 47-48.

1021/ Gottilla deposition at 16-17, 21-22; Stevens deposition at 9, 19; Gahan deposition at 35-37.

1022/ Gahan deposition at 30-34.

No serious effort was made to learn from the then-existing state of the art of human engineering or from control room design thinking in other industries such as aerospace. 1023/ Howard Stevens, the B&W engineer who had principal responsibility for B&W's contributior to the TMI-2 control room, described the atmosphere at that time:

> [T]he utility industry is by nature a very conservative industry particularly where operation of the plant is concerned, [and] therefore, tends to be somewhat slower in response to the state of the art for fear that in adopting the state of the art, they will create a problem in their ability to respond to the network, and so they tend to move slowly, and control room design is one of those areas in which they have traditionally moved slowly, and you will find more control room consoles throughout the utility industry which lean toward the concept that what was used at Three Mile Island, that is, the large pistol-grip switches to operate pumps and somewhat smaller switches to operate valves, simply because that is the way it was done before, and it worked, and with no motivation to change it and risk involved in changing, they tend to stay with it.1024/

Although Burns and Roe recognized a conflict between demands for more control room instruments and alarms on the one hand, and the danger of overloading operators during an emergency on the other hand, the problem was never resolved.1025/

The selection of criteria for containment isolation was made by B&W and was based essentially on the thinking that had gone into TMI-1.1026/ But even with respect to TMI-1, the Advisory Committee on Reactor Safeguards (ACRS) had raised concerns in 1968 about the lack of diversity in signals. Nonetheless, no serious consideration was given to using more than the single containment pressure criterion that was in effect at the time of the accident. 1027/ Nor was the NRC requirement for multiple containment isolation criteria, adopted in 1975 as part of the Standard Review Plan, imposed on the TMI-2 design, although at that time TMI-2 was still 3 years away from commercial operation. 1028/

1023/ Gottilla deposition at 96.

1024/ Stevens deposition at 31-32.

1025/ Gottilla deposition at 211, 227.

1026/ Zwickler deposition at 25, Ward deposition at 13.

1027/ Mallay deposition at 45; Beisel deposition at 51; Ward deposition at 26.

1028/ Final Safety Analysis Report, Three Mile Island Nuclear Station Unit 2, Volume 5, Section 6.2.4, Containment Isolation System; U. S. Nuclear Regulatory Commission, Standard Review Plan, Section 6.2.4, NUREG-75/087, 1975, at 6.2.4.5.

GPUSC retained control of the TMI-2 plant through the completion of construction and startup, which did not officially end until the plant went "commercial" on Dec. 30, 1978. Until then, GPUSC controlled the TMI-2 budget and continued to make decisions about plant systems and plant modifications. 1029/ After construction, GPUSC continued to provide various services to Met Ed such as engineering support and long-term policy planning.

Met Ed had begun to take a more active role in 1975, but that was limited primarily to training operators, writing procedures, and performing tests during startup under the direction of GPUSC engineers. 1030/

Declaring TMI-2 commercial on Dec. 30, 1978, placed the capital cost of the plant in Met Ed's rate base and may have allowed Met Ed to gain certain tax benefits. 1031/ If an inference can be drawn that there was a rush to place TMI-2 on line, it must be drawn from the unit's operating history during all of 1978 and not the event of clearing the plant commercial.

With the plant in operation, three separate engineering organizations -- TMI site, Met Ed in Reading, and GPUSC in Parsippany, N.J. -- had responsibility of one kind or another for the plant. Despite Robert Arnold's assertion that parallel engineering organizations provide dual appeal paths to upper management, thus facilitating conflict resolution, in a number of cases relevant to the accident no action was taken by anyone. For instance, neither problems in the condensate polishing system in 1977 nor suspected saturation in the core during an April 1978 transient were ever effectively followed up by the engineering groups. Both problems were repeated in the TMI-2 accident. 1032/

Site management was substantially independent in the day-to-day operation of TMI-2. Two months before the accident TMI generation station manager Gary Miller expressed serious concern about senior level management's distance from the problems and needs of TMI-2.1033/ Although there was an adminstrative procedure requiring written policy orders, long-term policy was communicated orally by site management rather than in writing. No line management supervisor took responsibility for the training of operators. The shift foreman's time was devoted to administrative work rather than to the direct supervision of

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1029/ In 1978 modification was made in the TMI-2 control room to provide some indication of position of the (PORV). This decision was solely GPUSC's. Seelinger deposition at 114-115; Klingaman deposition at 180-181.

1030/ Herbein deposition at 23, 29; Klingaman deposition at 40-42.

1031/ Dieckamp deposition at 104-106.

1032/ Frederick deposition at 450-495. Letter from Frederick (Met Ed) to Seelinger (Met Ed), May 3, 1978; Frederick deposition exhibit 17.

1033/ Miller deposition at 213.

plant operations. Surveillance tests were run with no independent check to see that they had been completed properly. There was no requirement that an itemized check of plant status be performed at the time of a shift change. Probably as a result of the manner in which a March 26, 1979, surveillance test was performed and the fact that there was no routine check of valve positions at a shift change, the emergency feedwater valves (EF-V-12 A and B) were closed on the morning of March 28, 1979.1034/

Several off-site and on-site committees reviewed quality assurance audits, changes in procedures, plant modifications, and TMI-2's licensee event reports.1035/ The review undertaken by these committees lacked sufficient depth to catch a serious misinterpretation of a B&W small-into a Met Ed procedure change. Nor did the NRC provide an effective review since it approved Met Ed's incorrect change. More often than not these various review committees appear to have reacted to events rather than initiating action or giving affirmative direction to plant management.

Operating and emergency procedures for TMI-2 were drafted through the combined efforts of B&W, Burns and Roe, on-site engineers, and outside consultants. Despite what was an apparently elaborate structure for review and approval of the procedures, several of the key procedures involved in the accident were ambiguous or simply failed to provide guidance to the operators during the accident. 1036/

On March 28, 1979, high pressure injection was terminated by the TMI-2 operators when pressurizer level went high. Their training and procedures had not given them adequate guidance as to when the concern about going solid should be subordinated to the goal of keeping the core covered.1037/

Although the operators had a loss-of-coolant procedure, they never used it in the early hours of the accident sequence because they did not realize they had a LOCA.1038/ After the accident John MacMillan, vice president of B&W stated that the Met Ed loss-of-coolant procedure

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1034/ Set of handwritten notes by O'Conner (Met Ed), April 18, 1979; O'Conner deposition exhibit 3.

1035/ Three Mile Island Technical Specification 6.5.1 and 6.5.2.

1036/ Miller May 25, 1979, transcript. Accession #1008013.

1037/ Beers deposition at 154-155, Frederick deposition at 149, 152, 160; Lind deposition at 111-113, 116.

1038/ Frederick deposition at 230, 238, 243. See generally 230-245.

required that high pressure injection be maintained until both pressure and pressurizer level had stabilized. 1039/ He was wrong. Although the B&W simulator training procedures had that provision, 1040/ the Met Ed procedure did not, even though B&W had reviewed it when it was drafted.

The loss-of-coolant emergency procedure defined a small-break LOCA only in terms of loss of one make-up pump, or loss of electric power for that pump, which was a narrow and misleading definition of the concept of a small-break LOCA.1041/ After the accident, James Seelinger, former TMI-2 superintendent for technical support, reviewed the loss-of-coolant and said he could not understand it. Yet he had originally approved it as acting TMI-2 superintendent.1042/

The operators did not realize that they had a failed open PORV for over 2 hours and 20 minutes. That failure was due in part to a pre-existing leak in the PORV, to inadequacy of the procedure for identifying an open PORV, to lack of a direct valve position indicator, to inadequate display of information in the control room, and to inadequate training. 1043/ Before the accident, the procedure requiring closure of the PORV block valve when temperature in the tailpipe exceeds 130°F was not followed, even though tailpipe temperature had been in the range of 170°F to 185°F for weeks. Following that procedure alone would have prevented the loss-of-coolant accident.

There were at least five events or series of events that foreshadowed aspects of the TMI-2 accident. Had adequate attention and follow-up been given to any one of those five histories, it is possible that the TMI-2 accident would not have occurred.

First, the TMI-2 accident was duplicated in several respects by a transient that occurred 18 months earlier at Toledo Edison's Davis-Besse nuclear power plant in Ohio. Although B&W's Bert Dunn had identified the possibility of a repeat occurrence of incorrect operator action with possible core uncovery and fuel damage, no information was ever given to B&W customers until after the TMI-2 accident. 1044/ Even when

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1039/ MacMillan oral statement before the Subcommittee on Energy and the Environment of the House Committee on Interior and Insular Affairs (Udall Committee), May 24, 1979.

1040/ B&W Operations Manual for Nuclear Power Plant Simulator, OP 1202 6, Loss of Reactor Coolant/Reactor Coolant System Pressure; Lind deposition exhibit 59.

1041/ Zewe hearing testimony, May 30, 1979, at 128, 195-196. Frederick deposition at 294; see also Frederick hearing testimony at 173, May 30, 1979.

1042/ Miller May 25, 1979, transcript at 14.

1043/ Frederick deposition at 294; see also Frederick hearing testimony at 173, May 30, 1979; Zewe hearing testimony at 130.

possible core uncovery and fuel damage, no information was ever given to B&W customers until after the TMI-2 accident. 1044/ Even when Dunn's concerns were mirrored in ACRS member Jesse Ebersole's questions from the ACRS and the report by Carlyle Michaelson of the Tennessee Valley Authority (TVA), no action was taken by B&W.

Second, the pilot-operated relief valve had failed at least nine times at B&W plants before the TMI-2 accident. Even though B&W knew about that failure history, it had not communicated details to its utility customers so that design modifications could be made, procedures changed, or training adapted.

Third, in the spring of 1978, Carlyle Michelson, a TVA engineer, forwarded to B&W an analysis that confirmed the same possibility of operator error that Bert Dunn had already identified as a result of the Davis-Besse transient. 1045/ That analysis, representing an independent confirmation of the lesson of Davis-Besse, was not answered by B&W until 9 months later and never prompted any communication by B&W to its utilities. 1046/

Fourth, the TMI-2 accident began with a malfunction in the condensate polishing system in the feedwater system. In October 1977, a malfunction occurred in the condensate polishing system modeling almost exactly what was to happen 15 months later at TMI-2.1047/ Met Ed personnel identified the problem, expressed concern about its happening again, and recommended remedial action. No action was taken. Again in the spring of 1978 a note from a TMI supervisor urged action in response to continuing problems in the polishing system. None was taken.

Fifth, as a result of an analysis of an April 1978 transient at TMI-2, it was believed that a steam bubble had formed somewhere in the reactor coolant system because saturation or boiling had occurred in the system.1048/ Although GPUSC, B&W and TMI site engineers all analyzed the saturation question, no additional training relating to the identification of saturation conditions in the core was given to the operators between the spring of 1978 and the time of the accident. 1049/

1044/ Memo from Dunn (B&W) to Taylor (B&W), Feb. 9, 1978; Womack deposition exhibit 23. Dunn June 30, 1979, deposition at 88; Roy deposition at 32.

1045/ Decay heat removal during a very small LOCA for a B&W 205-Fuel-assembly PWR, Michelson Report (TVA), January 1978.

1046/ Dunn June 30, 1979, deposition at 179, 183.

1047/ Startup Problem Report from Brummer and Ross (Met Ed), November 14, 1977; Miller deposition exhibit 111.

1048/ GORB action Item No. 30, June 15, 1978; Zechman deposition exhibit 62.

1049/ Beers deposition at 168-169.

As discussed at the beginning of this paper, time and limited resources limited pursuit of every possible avenue of inquiry. Although this report, and other Commission staff reports, cover the broad questions relevant to an analysis of the role of the managing utility and its suppliers, there are areas that deserve further investigation. These areas include:

- The TMI-2 design decision-making process, tracing the responsibility for final design approval on a system-by-system basis -- specifically including the OTSG, the polishers, and the PORV.

- The extent to which Burns and Roe understood the practical aspects of operating a nuclear power plant and applied that understanding to the design of TMI-2;

- The reasons why the use of diverse signals for containment isolation were not considered more seriously and implemented at TMI-2;

- The role of B&W as an "educator" -- making sure that its utility customers had a fundamental understanding of B&W's nuclear steam supply system;

- The issues specified as needing more investigation in the section, "Going Commercial";

- The overall impact of NRC regulations on the mindset of the managing utility and its suppliers -- the extent to which compliance with the letter of NRC regulations was viewed as the limit of responsibility, regardless of the logic, or adequacy, of those regulations;

- Whether there is sufficient breadth and linkage in the reporting requirements of 10 CFR Part 21 and Part 50.55 (e) to cover the kind of safety concerns represented by the Dunn memoranda. Those two regulations appear to be primarily oriented toward hardware problems to the exclusion of people problems;

- Whether the withholding of information, illustrated in the Womack deposition, exhibit 29 (see Appendix H), is representative of a pattern of conduct by B&W or is an exception. (See "Procedures");

- The scope of NRC's vendor inspection program at B&W;

- The allegations of quality control deficiencies at Bailey Control Company made by a Bailey employee;

- The extent to which the B&W Owners Group and B&W Users Group served as effective channels of communication;

- The extent to which B&W had analyzed the risks of going solid, and the conclusions that had been drawn about those risks -- if any;

- The allegations which appeared in the April 16, 1979, <u>Philadelphia Inquirer</u> article entitled, "Workers Talk of Rush Job"

- A comprehensive analysis of the persons who knew what and when they knew it, during the time that the core was uncovered from March 28 through March 30;

- A further exploration of the role of GPUSC, Met Ed, B&W, and Burns and Roe in recovery and cleanup operations.

APPENDIX A

SUBPOENA DUCES TECUM
UNITED STATES OF AMERICA

PRESIDENT'S COMMISSION
ON THE ACCIDENT AT THREE MILE ISLAND

TO: General Public Utilities Corporation, 260 Cherry Hill Road

Parsippany, New Jersey 07054

You are hereby required to appear before the President's Commission on the Accident at Three Mile Island at its offices at Suite 714, 2100 'M' Street, N.W., in the City of Washington, D.C. on the 15th day of June, 1979 at 10:00 a.m., to testify on the accident at Three Mile Island and matters related thereto.

You are hereby further required to bring with you at said time and place the documents specified in the attached schedule.

Fail not at your peril

In testimony whereof, the undersigned, an authorized official of the President's Commission at Three Mile Island has hereunto set his hand at Washington, D.C., this 4th day of June, 1979.

/S/ ______________________________
John G. Kemeny, Chairman

Notice to Witness: If claim is made for witness fee or mileage, this subpoena should accompany voucher.

I. INSTRUCTIONS

1. Unless otherwise specifically indicated, the time period covered by this request is January 1, 1966 through the date of service of this subpoena.

2. If a claim of privilege is asserted with respect to any document, please state, with respect to each such document, the date thereof, the author, the recipients, and a description of the document sufficient to show the applicability of the privilege claimed.

3. All documents produced should be segregated and identified by each numbered request to which they are responsive.

II. DEFINITIONS

Unless otherwise indicated, as used herein:

1. "Company" shall mean General Public Utilities Corporation, its predecessors and successors, its subsidiaries, divisions, affiliates, and other organizational or operating units and all of their predecessors and successors, and each of their employees, agents, or representatives, and all persons acting or purporting to act on their behalf for any purpose whatsoever.

2. "Document" or documents" refer to all written or graphic matter, however produced or reproduced, or to any other tangible permanent record, and, without limitation, shall include, among other things: all letters, correspondence, memoranda, notes, reports, papers, files, books, records, studies, appraisals, analyses, lists, surveys, budgets, financial statements, financial projections, financial calculations, contracts, agreements, recommendations, summaries, periodicals, charts, graphs, tables and tabulations, interviews, speeches, affidavits, transcripts, depositions, brochures, books of accounts, bills, invoices and other records of obligations or expenditures, cancelled checks, vouchers, receipts and other records of payment, press releases, photographs, calendars, diary entries, telegrams and other communications sent or received, minutes or notes of meetings, visits or telephone conversations, interoffice communications, results of investigations, working papers, maps or papers similar to any of the foregoing, including all drafts, outlines and proposals of any such documents (whether or not acutally used). The term "document" also includes voice recordings, film, tapes, computer printouts or other data compilations from which information can be obtained.

3. "Person" shall mean any individual, partnership, firm, association, corporation, or other business or any other public or private legal entity.

4. "Babcock & Wilcox" shall mean Babcock & Wilcox Company, its predecessors and successors, its subsidiaries, divisions, affiliates and other organizational or operating units and all of their predecessors and sucessors, and each of their employees, agents, or representatives, and all persons acting or purporting to act on their behalf for any purpose whatsoever.

5. "Commission" shall mean the Atomic Energy Commission and the Nuclear Regulatory Commission and each of them.

6. "TMI" shall mean Three Mile Island.

7. "TMI-1" shall mean the nuclear power plant constructed at TMI referred to as Unit 1 and all facilities necessary to the operation of that plant.

8. "TMI-2" shall mean the nuclear power plant constructed at TMI referred to as Unit 2 and all facilities necessary to the operation of that plant.

9. "Burns & Roe" shall mean Burns & Roe, Inc., its predecessors and successors, its subsidiaries, divisions, affiliates and other organizational or operating units and all of their predecessors and successors, and each of their employees, agents, or representatives, and all persons acting or purporting to act on their behalf for any purpose whatsoever.

10. "United Engineers & Constructors" shall mean United Engineers and Constructors Co., its predecessors and successors, its subsidiaries, divisions, affiliates and other organizational or operating units and all of their predecessors and successors, and each of their employees, agents, or representatives, and all persons acting or purporting to act on their behalf for any purpose whatsoever.

III. <u>DOCUMENTS REQUESTED</u>

1. All documents which refer or relate, directly or indirectly, to the design, manufacture, construction, start-up and operation of TMI-2, including but not limited to

(a) all contracts between the Company and any other person;

(b) the selection of Babcock & Wilcox as the supplier of the nuclear steam supply system used in TMI-2 and the criteria utilized in that selection;

(c) the selection of United Engineers & Constructors as the construction company for TMI-2 and the criteria utilized in that selection;

(d) the selection of Burns & Roe as the Architect-Engineer of TMI-2 and the criteria utilized in that selection;

(e) the decision to use the design adopted for TMI-2;

(f) minutes of the Company's Board of Directors or any committee or subcommittee thereof relating to TMI-2, as well as any other documents prepared by or on behalf of the Company and submitted to the Board of Directors or any committee or subcommittee thereof;

(g) the cost and financing of TMI-2;

(h) all communications between or among the Company and Babcock and Wilcox, Burns & Roe, United Engineers & Constructors, and/or any other person;

(i) all analyses, studies and reports made by or on behalf of the Company or received by the Company, including construction progress reports, radiological studies, and all documents reflecting any proposed or actual design, construction, manufacture, or operational change and any analysis or action taken with respect to each such actual or proposed change;

(j) the bids submitted by any person to the Company with respect to TMI-2;

(k) the training and certification of personnel to operate TMI-2;

(l) the decision to put TMI-2 into commercial operation on December 30, 1978;

(m) all company plans, procedures, and programs, including Quality Assurance Plan, Maintenance Plan, Security Plan, Safety Plan, Operations Plan, Emergency Operations Plan, Radiation Monitoring Plan, Administrative Procedures, Operating Procedures, Emergency Procedures, Abnormal Procedures, Maintenance Procedures, Surveillance Procedures, Start Up and Test Program, all minutes, reports, analyses, memoranda, and studies made by or reviewed by the Plant Operations Review Committee, the Nuclear Plant Management Review, the Three Mile Island General Office Review Board, and the Generation Review Committee.

2. All reports submitted by or on behalf of the Company to the Securities and Exchange Commission, or distributed to shareholders from January 1, 1975 through the date of service of this subpoena.

3. All documents which relate or refer, directly or indirectly, to the licensing of TMI-2 by the Commission, including but not limited to:

(a) representations made by the Company to the Commission or to any person acting on behalf of the Commission;

(b) representations made by the Commission or any person acting on behalf of the Commission to the Company;

(c) negotiations between the Company and the Commission or any person acting on behalf of the Commission;

(d) the Company's program for training operators or management personnel of TMI-2;

(e) emergency plans and procedures;

(f) inspections of TMI-2 by the Commission, and all actual or proposed actions of the Company resulting from each such inspection.

4. All documents which refer or relate, directly or indirectly, to all, known or reported, verified, or nonverified, corrected or not corrected, malfunctions, failures, incidences, non-conformances to specifications of any and all devices, systems, sub-systems, components, valves, or instrumentation of TMI-2 during the design, manufacturing, construction, start-up and operational phases of TMI-2, including but not limited to time histories of measured parameters for each such described event above.

5. All documents which refer or relate, directly or indirectly, to any action, investigation, analysis, study, report, or statements by or on behalf of the Company or received by the Company relating to the events which occurred at TMI-2, commencing at 4:00 a.m. on March 28, 1979 and continuing thereafter, including but not limited to, activities of the Recovery Organization and its groups, all plant, operator and telephone logs, time histories of measured parameters during the event of TMI-2, press releases and transcripts of press conferences.

6. Such documents as will show

(a) all companies, suppliers, and consultants employed or retained by the Company during the design, manufacture, construction, start-up and operation of TMI-2;

(b) the names, home addresses, job descriptions and employment history of all Company employees with responsibilities relating to the design, manufacture, construction, start-up and operation of TMI-2;

(c) the names, last known home addresses, telephone numbers, job descriptions and employment history of all Company personnel with any responsibility for the design, manufacture, construction, start-up and operation of TMI-2 who have left the Company's employ for any reason whatsoever (including retirement) since January 1, 1978;

(d) the Company's filing system, including but not limited to the document retention system utilized by the Company and when that retention system was adopted;

(e) the persons that submitted bids to design, manufacture or construct TMI-2 and the bids actually submitted.

7. All documents which refer or relate directly or indirectly to any documents that the Company is required to maintain or file with the Commission with respect to TMI-2 pursuant to Commission regulations or any other directive of the Commission.

8. All documents which refer or relate directly or indirectly to possible or actual claims filed against the Company in any local, state or federal court, agency, board or any other entity established to hear such claim, regarding the design, construction, start-up or operation of TMI-2.

9. All documents which refer to, relate directly or indirectly to the selection of Three Mile Island as a site for nuclear power plants.

10. All documents which refer or relate, directly or indirectly, to public relations, promotional informational programs directed to the public with respect to the operations of TMI-1 and 2.

11. Such documents as will show all design, construction and operational differences between TMI-1 and 2.

12. Such documents as will show the organizational structure, responsibility and interrelationship of each division or unit of the Company with respect to the design, manufacture, construction, start-up and operational phases of TMI-2.

13. All documents which relate or refer, directly or indirectly, to transients, incidents, accidents or other abnormalitites that occurred at nuclear power plants other than TMI-2 prior to March 28, 1979.

PRESIDENT'S COMMISSION ON THE
ACCIDENT AT THREE MILE ISLAND

of the city of

Washington, in the District of Columbia, certifies that on the

day of , 1979, he/she served the annexed

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upon the following ________________ by mailing to them

by mail a copy thereof, enclosed in an

envelope, postage prepaid, and by depositing same in the Post

Office at Washington, D. C. directed to said

at the following addresses:

General Public Utilities Corporation
260 Cherry Hill Road
Parsippany, New Jersey 07054

____
Winthrop A. Rockwell

APPENDIX B

SUBPOENA DUCES TECUM
UNITED STATES OF AMERICA

PRESIDENT'S COMMISSION ON
THE ACCIDENT AT THREE MILE ISLAND

TO: Westinghouse Electric Corporation
Westinghouse Building, Gateway Center
Pittsburgh, Pennsylvania 15222

You are hereby required to appear before the President's Commission on the Accident at Three Mile Island at its offices at Suite 714, 2100 'M' Street, N.W., in the City of Washington, D.C. on the 20th day of June, 1979 at 10:00 a.m., to testify on the accident at Three Mile Island and matters related thereto.

You are hereby further required to bring with you at said time and place the documents specified in the attached schedule.

Fail not at your peril

In testimony whereof, the undersigned, an authorized official of the President's Commission at Three Mile Island has hereunto set his hand at Washington, D.C., this 11th day of June, 1979.

Harry C. McPherson, Jr., Commissioner

APPENDIX C

LIST OF DEPONENTS

NAME	EMPLOYER OR FORMER EMPLOYER	DATE OF DEPOSITION
John T. Willse	B&W	6/29/79
Leland Rogers	B&W	6/29/79
John Flint	B&W	6/29/79
Allen Womack	B&W	6/30/79
Bert Dunn	B&W	6/30/79 & 7/13/79
George Wandling	B&W	7/02/79
John Lind, Jr.	B&W	7/03/79
Richard Kosiba	B&W	7/03/79
Norman Elliott, Jr.	B&W	7/03/79
John MacMillan	B&W	7/05/79
Howard Stevens	B&W	7/05/79
John Castanes	B&W	7/06/79
Granville Olds	B&W	7/06/79
James Walters	B&W	7/06/79 & 7/13/79
James Taylor	B&W	7/07/79
James Mallay	B&W	7/07/79
Joseph Kelly, Jr.	B&W	7/07/79 & 7/13/79
Donald Roy	B&W	7/07/79
Bruce Karrasch	B&W	7/16/79
Donald Hallman	B&W	7/16/79
John G. Miller	Met Ed	6/5, 9/79
Ed O'Connor	JCP&L	7/5/79
John Hilbish	Met Ed	7/09 & 8/09/79
Jeffrey Fritzen	Met Ed	7/19/79
Ivan Finfrock	JCP&L	7/19/79
Joseph Deman	Met Ed	7/20/79
Richard Dubiel	Met Ed	7/20/79
John McGarry	Met Ed	7/20/79
Ivan Porter, Jr.	Met Ed	7/21/79
Craig Faust	Met Ed	7/22/79
Edward Frederick	Met Ed	7/22/79
Frederick Scheimann	Met Ed	7/24/79
Brian Mehler	Met Ed	7/25/79
William Zewe	Met Ed	7/26/79
Daniel Shovlin	Met Ed	7/27/79
Richard Zechman	Met Ed	7/27/79
Marshall Beers	Met Ed	7/30/79
Nelson Brown	Met Ed	7/31/79
Michael Ross	Met Ed	7/31/79 & 8/10/79
James Floyd	Met Ed	8/01/79
George Kunder	Met Ed	8/02/79
Paul Christman	Met Ed	8/02/79
Hugh Bodden	Met Ed	8/03/79
Richard Klingaman	Met Ed	8/03/79
George Troffer	Met Ed	8/04/79

NAME	EMPLOYER OR FORMER EMPLOYER	DATE OF DEPOSITION
James Seelinger	Met Ed	8/06/79
Gary Miller	Met Ed	8/07/79
Lawrence Lawyer	Met Ed	8/09/79
John Herbein	Met Ed	8/09/79
Ronald Williams	Met Ed	8/09/79
Robert Arnold	GPU	8/10/79
Walter Creitz	Met Ed	8/14/79
Herman Dieckamp	GPU	8/15/79
Tom A. Hendrickson	Burns & Roe	8/01/79
Harold R. Teague	Burns & Roe	8/02/79
Salvatore C. Gottilla	Burns & Roe	8/02/79
Warren R. Cobean, Jr.	Burns & Roe	8/06/79
Samuel McPherson	Burns & Roe	8/07/79
Pio Nardone	Burns & Roe	8/08/79
Robert Bredder	Burns & Roe	8/08/79
Samuel Zwickler	Burns & Roe	8/08/79
Edward Gahan	Burns & Roe	8/06/79
*William Dornsife	Pennsylvania	7/25179
Wilford Beisel, Jr.	B&W	8/28/79
Edwin Ward	B&W	8/28/79
Louis Roddis	Met Ed	8/27/79

This was an interview.

APPENDIX D

NRC OPERATING LICENSE REVIEW OF TMI-2

Operating license application filed	February 15, 1974
NRC accepts application for docketing	April 18, 1974
NRC publishes Federal Register Notice re: opportunity for hearing	May 28, 1974
NRC meets with potential intervenors to prehearing conference	May 15, 1975
First prehearing conference held	May 22, 1975
After review completion, NRC project manager issues safety evaluation report	September 17, 1976
Environmental project manager issues final supplement to final environmental statement	December 1976
ACRS review application in open meeting	October 15, 1976
ACRS advises that TMI-2 should receive an Operating License	October 22, 1976
Supplemental safety evaluation reports issued	March 25, 1977
Second prehearing conference held	January 28, 1977
Public Hearing held	April 5-June 10, 1977
Atomic Safety Licensing Board render initial decision to issue Operating license for TMI-2	December 19, 1977
NRC Office of Inspection and Enforcement provides final approval to issue Operating license	February 8, 1979
Operating license issued by NRC	February 8, 1978

APPENDIX E

SIGNIFICANT EVENTS AT TMI-2 BETWEEN TIME CRITICAL UNTIL DECLARED COMMERCIAL

The following lists significant events that had occurred at TMI-2 since the unit went critical and prior to it being declared commercial.25/

March 28 (1978)	initial criticality
March 29	reactor trip due to pump monitor; PORV opened; ECCS actuation.
April 8	went critical
April 18	reactor trip - noise spike
April 19	reactor trip die to loss of feedwater
April 20	reactor trip - noise spike
April 23	reactor trip - noise spike; steam reliefs stuck open; ECCS actuation.
September 17	achieved criticality
September 20	reactor trip due to loss of a condensate booster pump and a main feed pump.
September 21	unit returned to power at 1:17; at 2:43 reactor tripped due to problems with feedwater valves and the main feed pump
September 25	reactor tripped due to main feed pump trip
October 13	reactor shutdown to repair pressurizer spray valve
October 14	reactor trips die to loss of main feedwater pump
October 20	turbine trips
October 21	turbine trips
October 28	turbine shutdown for repair

25/ TMI-2 Monthly Operating Reports, October-December 1978; Finfrock deposition exhibit 2.

November 3	reactor trip due to loss of feedwater
November 7	reactor trip due to reduced feedwater; ECCS actuation
December 2	turbine trips from loss of feedwater; reactor trips due to low feedwater
December 2	reactor trips again from manual excess feedwater flow; ECCS actuation
December 16	turbine shutdown to repair main feedwater pump
December 29	44 percent attained26/
December 30	8:20 p.m., 80 percent attained 11:00 p.m., plant declared commercial

26/ During October the plant had achieved 90 percent power. Monthly Operating Report, October, dated November 15, 1978.

APPENDIX F

M. J. Whitman & Co., Inc.
115 BROADWAY
NEW YORK, NEW YORK 10006

212 - 267 - 1670

September 18, 1979

President's Commission on the Accident
at Three Mile Island
2100 "M" Street, N.W.
Washington, D.C. 20037

RE: Financial Practices of General Public Utilities Corporation 1968 Through March 1979

Gentlemen:

You have retained us to examine the financial practices of General Public Utilities Corporation and Subsidiaries (GPU or the Utility) from 1968 through March 1979 to ascertain if, and how, such financial practices contributed to the March 28, 1979 accident at the Three Mile Island 2 Nuclear Station (TMI-2). The results of this examination are contained in the report accompanying this letter.

The report is **in** two parts. First, there is a description of the environment in which the industry operated from 1968 through March 1979 and an examination of electric utility financial practices. Second, there is an examination of GPU's financial practices, how they compared with other utilities that we deem to be most comparable to GPU, and how these financial practices might have contributed to the March 1979 accident. In the examination of financial factors in late 1978 early 1979, emphasis is placed on a) GPU's access to outside sources of finance as of late 1978-early 1979 relative to the Utility's cash requirements, b) income tax implications in bringing TMI-2 into commercial service before the end of calendar 1978, and c) rate increases granted GPU as a result of TMI-2 being brought into commerical service.

In brief, we drew the following conclusions:

1) The U.S. investor-owned electric utility industry was viable during the relevant period but, because of general economic conditions, and the financial practices followed, companies in the industry lost considerable financial integrity after 1968.

2) The basic financial practices followed by companies in the industry were as follows:

a) finance the bulk of construction expenditures by recourse to outside financing through the sale (mostly public sale as distinct from private placement) of debt and equity securities

b) pay a large portion of net income to common stockholders as dividends and sell new issues of common stock periodically to the public.

3) The general economic climate worsened for companies in the industry after 1968 because of the following:

a) rapid increases in fuel costs

b) increases in the price of money, both for debt and equity securities

c) huge inflation in construction costs, including the costs of nuclear generating facilties.

4) GPU followed general industry practices and, after reconciling individual company differences, probably was not materially different in its financing practices, and results achieved, from the other electric utilities which had facilities in New Jersey or Pennsylvania.

5) While GPU was anxious to place TMI-2 on stream as soon as possible in order to include these facilities in its rate base, there is no evidence that the financial position of GPU was such that its viability would have been threatened had Unit 2 remained inoperative for an indefinite period. The evidence indicates the following:

a) GPU had reasonable access to outside financing within the financial community to cover its 1979 construction and debt retirement programs. While Utility's access to outside sources of finance, especially debt finance, was restricted during periods in the 1970's including portions of 1974 and again in 1976, GPU appeared to have ready access to capital markets in late 1978 and early 1979.

b) the Utility, alternatively and supplementarily, had unused bank lines of credit

c) GPU could count on generating an historically high 50% or so proportion of its 1979 construction budget from internal sources, albeit the percentage of funds generated internally for construction probably would have declined for 1980 through 1983 because of projected large increases in capital spending.

d) GPU probably had sources from which it could obtain power if Unit 2 did not become operative, including access to the PJM interconnect.

6) Even if TMI-2 were not in commerical service by the end of 1978, GPU would have had an opinion of counsel that, for income tax purposes, TMI-2 would have gone into service for investment credit and depreciation purposes not later than the fall of 1978. GPU counsel would have relied on Internal Revenue Ruling 76-428 and would have deemed TMI-2 in service no later than October 1978, because TMI-2, in the language of 76-428, "had been placed in the control of the taxpayer by the contractor, and the generating unit had been synchronized into the taxpayer's power grid for its function in the business of generating nuclear electric energy for the production of income, even though the generating unit would undergo further testing to eliminate any defects . . . and to demonstrate reliability." Income taxes, too, should be netted in that tax effects are taken into account in determining appropriate rates by the utility commissions in Pennsylvania and New Jersey. Thus, had GPU not deducted depreciation and investment tax credits attributable to TMI-2 in 1978, the Utility's subsequent rate base would have been larger than was the case because of deductions taken in 1973.

7) In Pennsylvania, and in large measure in New Jersey, TMI-2 was included in the rate base for regulatory purposes when final rate orders were issued in January through March 1979, which final rates would not have been issued until the facility entered commercial service. The cost of delays, of weeks, or months, around the end of 1978, in having TMI-2 enter commercial service does not appear to have been critical to GPU in the Utility's over-all financial context.

We would be pleased to discuss in detail the contents of this letter and the accompanying report, with the Commission and the Staff, either individually or collectively, at a mutually convenient time.

Sincerely yours,

M. J. WHITMAN & CO., INC.

Martin J. Whitman, C. F. A.
President

MJW:mh
Attachments

APPENDIX G

TMI-2 ORGANIZATIONAL CHART
(As of 4:00 a.m. on March 28, 1979)

STATION MANAGER*
(Gary Miller)

UNIT SUPERINTENDENT FOR TECHNICAL SUPPORT*
(George Kunder)

UNIT SUPERINTENDENT* -
(Joe Logan)

SUPERVISOR OF OPERATIONS*
(Jim Floyd)

SHIFT SUPERVISOR-"-
(Bill Zewe)

SHIFT FOREMAN'--*
(Fred Scheimann)

CONTROL ROOM OPERATORS**
(Ed Frederick, Craig Fawst)

AUXILIARY OPERATORS**

There was only one individual in these positions.

The individual in these positions changed with each shift.

APPENDIX H

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

Womack Dep., 29
6/30/79

TO: R. C. LUKEN, NUCLEAR SERVICE

From: L. R. CARTIN, PLANT INTEGRATION

Subj: TECO STATUS REPORT

DECEMBER 19, 1978

Reference:

1. L.R. Cartin to B. A. Karrasch, "TEC - B&W Meeting Minutes", dated November 29, 1978

2. N. H. Shah to L. R. Cartin, "Ten-Feet AFW Control", NSS-14, dated December 13, 1978

3. R. C. Jones to L. R. Cartin, "Small Break Analysis with R. C. Pumps Powered", dated December 11, 1978

Since issuance of Reference 1, several activities have been initiated to assist TECo in their attempts to resolve NRC concerns relative to AFW actuation and control. Attachment 1 is a TECo letter requesting B&W analysis support; our progress or position to date to supply the seven items requested is as follows:

<u>Items 1 - 3</u>

Control Analysis performed the requested analyses and a preliminary report was submitted to TECo on December 5, 1978. Attachment 2 is a summary of the conclusions drawn. The Control Analysis work has been subsequently Q.A.'d and the preliminary conclusions presented to TECo were found to be valid. A formal report for submittal to TECo is scheduled to be completed by December 22, 1978.

<u>Item 4</u>

No plant specific (Davis-Besse 1) ECCS analysis is available or planned to address steam generator water levels when the R.C. pumps are operative. The customer is to be advised at this time to automate the present site instruction which requires auxiliary feedwater control to a ten-foot steam generator level following an ESFAS actuation. Under these conditions, B&W's position is that the small break topical (BAW-10075A, Revision 1) remains valid for Davis-Besse 1. Further, discussion is presented below on this general subject.

<u>Item 5</u>

ECCS has completed a listing of available analyses which support the use of a ten-foot auxiliary feedwater control setpoint (see Reference 2). The customer is to be advised that a portion of these results are available upon request to support the B&W/TECo position that the topical remains valid. No additional ECCS analysis with a ten-foot auxiliary feedwater control setpoint is planned. ECCS, if required, plans to defend the validity of topical report via arguments that emphasize that the injection of auxiliary feedwater in the upper part of steam generator tube bundle would be continuous (at least intermittent) and that the simulation of primary to secondary heat transfer process (not steam generator level) in the topical is valid. This memo is also to advise Nuclear Service that approximately 100 manhours and a span time of three weeks would be required to assimilate the analysis results with a ten-foot auxiliary feedwater control setpoint into suitable form for an NRC submittal.

Item 6

B&W position to TECo is that the status of R.C. pumps should not be included in the dual setpoint control logic at this time. If questioned by the NRC, however, B&W must be in a position to state that the small break topicals have considered the worst possible conditions (i.e., loss of offsite power). Our inability to respond conclusively to such an inquiry could result in the NRC derating or shutting down all of B&W's 177 F.A. operating plants (except SMUD) until the issue is resolved. ECCS (Reference 3) has proposed that a generic study with the R.C. pumps powered be initiated now on the 205 F.A. plant, ECCS model. I agree that this analysis work should take place and be performed at B&W's expense. This course of action will require identification of funding (B.M. Dunn to secure) to resolve this unanalyzed small break. If this work effort is completed and results are acceptable, B&W may then be in a better position to support TECo's request to include the status of the R.C. pumps into the dual setpoint logic.

Note: The customer should not be informed of the ECCS analysis efforts to examine the pumps running case. It is imperative that B&W be totally prepared to defend an FOAK analysis of this type or to have a planned course of action if results are unacceptable.

Item 7

B&W position is that no new analysis is required. Commitments to perform additional analyses either in the LOCA or long-term safety analysis area are not to be made unless specifically requested by the NRC.

In addition to the above, TECo submitted a report to the NRC justifying the interim site instruction as an adequate basis to support continued operation of Davis-Besse 1. B&W had provided TECo with an alternate submittal which I feel was a better defended conclusion drawn from B&W supplied analyses. TECo refused to use the B&W write-up, but they did agree to put less emphasis on ECCS. TECo's submittal to the NRC is given in Attachment 3.

A letter to TECo will be prepared by R.C. Luken of Nuclear Service consistent with the above and/or modified position as soon as concurrence within B&W is obtained.

LRC/dww

cc: B.A. Karrasch, E.W. Swanson, E.A. Womack, R.C. Jones, N.H. Shah, B.M. Dunn, R.W. Winks, R.O. Vosburgh

Attachments /s/

APPENDIX I

5/3/78

Dear Jim,

Your evaluation of the 4/23 incident would have been more complete and accurate if mention were made of these items:

(1) Along with the problem of the stuck-open safeties it should be noted that some safeties did not lift when they should have.

(2) Flow testing of Mu-V-16's completely ignores the fact that Mu-V-17/18 are open during ES. This causes runout on the makeup pumps and erroneous flow indications, which mis-lead the operator.

(3) The alarm system in the control room is so poorly designed that it contributes little in analysis of a casualty. The other operators and myself have several suggestions on how to improve our alarm system - perhaps we can discuss them sometime - preferably before the system as it is causes severe problems.

(4) Your report mentions adding more valve indications to the control room on FW/MS related valves - This should be given very high-priority!

(5) The suggestion is made in your report to provide the CR with a system & tank volume reference -- that is an excellent idea.

(6) You might want to consider a mechanical switch to actuate an alarm which indicates the steam safeties are lifting. It would be actuated by the steam flow and seems more reliable than a sound actuated sytem.

(7) I feel that the mechanical failures, poor system designs, and improperly prepared control systems were very much more the major cause of this incident than was operator action.

Although training is always essential and welcome - nothing that we study or practice could have prepared us for this unforunate chain of events.

(8) I feel that a very critical eye should be turned toward the Test Acceptance Criteria we are using on RPS & ICS.

(9) You might do well to remember that this is only the tip of the iceberg. Incidents like this are easy to get into - and the best operators in the world can't compensate for multiple casualities which are complicated by mechanical and control failures.

Some of our susggestions are good. We made suggestions on FW valve indication 2 years ago (submitted many FCR's). We have complained about this alarm system since day one.

Let's get together and try to prevent this from happening again.

/s/ Ed. Frederick

P.S. By the way we had a 17 gpm primary leak during this evolution.

APPENDIX J

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

EXHIBIT
FOR IDENTIFICATION
R. ZERKIN

TO: Distribution

FROM: J.J. Kelly, Plant Integration

CUST: Generic

File No.
Or. Ref. VIII 3

SUBJ: Customer Guidance On High Pressure Injection Operation

Date: November 1, 1977

DISTRIBUTION

B. A. Karrasch	D. W. LaBelle
E. W. Swanson	N. S. Elliott
R. J. Finnin	D. F. Hallman
B. M. Dunn	

Two recent events at the Toledo site have pointed out that perhaps we are not giving our customers enough guidance on the operation of the high pressure injection system. On September 24, 1977, after depressurizing due to a stuck open electromatic relief valve, high pressure injection was automatically initiated. The operator stopped HPI when pressurizer level began to recover, without regard to primary pressure. As a result, the transient continued on with boiling in the RCS, etc. In a similar occurrence on October 23, 1977, the operator bypassed high pressure injection to prevent initiation, even though reactor coolant system pressure went below the actuation point.

Since these are accidents which require the continuous operation of the high pressure injection system, I wonder what guidance, if any, we should be giving to our customers on when they can safely shut the system down following an accident? I recommend the following guidelines be sent:

a) Do not bypass or otherwise prevent the actuation of high/low pressure injection under <u>any</u> conditions except a normal, controlled plant shutdown.

b) Once high/low pressure injection is initiated, do not stop it unless: Tave is stable or decreasing <u>and</u> pressurizer level is increasing and primary pressure is at least 1600 PSIG and increasing.

I would appreciate your thoughts on this subject.

APPENDIX K

DATE: 11/10/77

TO: J. J. Kelly Plant Integration

FROM: F. Walters Nuclear Service

CUSTOMER: TOLEDO

SUBJECT: High Pressure Injection during transient

Ref: Your letter to DISTRIBUTION; same subject Dated Nov. 1, 1977.

In talking with training personnel and in the opinion of this writer the operators at Toledo responded in the correct manner considering how they have been trained and the reasons behind this training.

My assumption and the training assumes first that R C Pressure and Pressurizer level will trend in the same direction under a LOCA. For a small leak they keep the H P System on up to a certain flow to maintain pressure level.

In the particular case at Toledo, there was no LOCA of magnitude and with the small leak the inventory in the system came back as expected but due to the [word unintelligible] of the RCS, pressure cannot respond any quicker than the pressurizer heaters can heat the cold water now pushed back into the pressurizer. Leaving the HPI system on after pressurizer level indications lasted high, will result in the RCS pressure [word unintelligible] and essentially hydroing the RCS when it becomes solid. If this is the intent of your letter and the thoughts behind it, then the operators are not taught to hydro the RCS <u>everytime</u> the HPI pumps are initiated.

If you intend to go solid what about problems with [word unintelligible] mechanics. Also will the Code and electromagnetic valves relief water (via steam) at significant flow rate to keep the RCS from being hydroed.

cc. R. J. Finnin

APPENDIX L

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

TO: Jim Taylor, Manager, Licensing

EXHIBIT
FOR IDENTIFICATION
R. ZERKIN

FROM: Bert M. Dunn, Manager
ECCS Analysis (2138)

CUST.

File No.
or Ref.

SUBJ: Operator Interruption of High Pressure Injection

Date: February 9, 1978

This memo addresses a serious concern within ECCS Analysis about the potential for operator action to terminate high pressure injection following the initial stage of a LOCA. Successful ECCS operation during small breaks depends on the accumulated reactor coolant system inventory as well as the ECCS injection rate. As such, it is mandatory that full injection flow be maintained from the point of emergency safety features actuation system (ESFAS) actuation until the high pressure injection rate can fully compensate for the reactor heat load. As the injection rate depends on the reactor coolant system pressure, the time at which a compensating match-up occurs is variable and cannot be specified as a fixed number. It is quite possible, for example, that the high pressure injection may successfully match up with all heat sources at time t and that due to system pressurization be inadequate at some later time t2.

The direct concern here rose out of the recent incident at Toledo. During the accident the operator terminated high pressure injection due to an apparent system recovery indicated by high level within the pressurizer. This action would have been acceptable only after the primary system had been in a subcooled state. Analysis of the data from the transient currently indicates that the system was in a two-phase state and as such did not contain sufficient capacity to allow high pressure injection termination. This became evident at some 20 to 30 minutes following termination of injection when the pressurizer level again collapsed and injection had to be reinitiated. During the 20 to 30 minutes of noninjection flow they were continuously losing important fluid inventory even though the pressurizer indicated high level. I believe it fortunate that Toledo was at an extremely low power and extremely low burnup. Had this event occurred in a reactor at full power with other than insignificant burnup it is quite possible, perhaps probable, that core uncovery and possible fuel damage would have resulted.

The incident points out that we have not supplied sufficient information to reactor operators in the area of recovery from LOCA. The following rule is based on an attempt to allow termination of high pressure injection only at a time when the reactor coolant system is in a subcooled state and the pressurizer is indicating at least a normal level for small breaks. Such conditions guarantee full system capacity and thus assure that during any follow on transient would be no worse than the initial accident. I, therefore, recommend that operating procedures be written to allow for termination of high pressure injection under the following two conditions only:

1. Low pressure injection has been actuated and is flowing at a rate in excess of the high pressure injection capability and that situation has been stable for a period of time (10 minutes).

2. System pressure has recovered to normal operating pressure (2200 or 2250 psig) and system temperature within the hot leg is less than or equal to the normal operating conditions (605° or 630°F).

I believe this is a very serious matter and deserves our prompt attention and correction.

BMD/lc

cc: E.W. Swanson
D.H. Roy
B.A. Karrasch
H.A. Bailey
J. Kelly
E.R. Kane
J.D. Agar
R.L. Pittman
J.D. Phinny
T. Scott

APPENDIX M

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

EXHIBIT
FOR IDENTIFICATION
R. ZERKIN

TO: Jim Taylor, Manager, Licensing

FROM: Bert M. Dunn, Manager,
ECCS Analysis (2138)

CUST:

File No.
or Ref.

SUBJ: Operator Interruption of High Pressure Injection

Date: February 16, 1978

In review of my earlier memo on this subject, dated February 9, 1978, Field Service has recommended the following procedure for terminating high pressure injection following a LOCA.

1. Low pressure injection has been actuated and is flowing at a rate in excess of the high pressure injection capability and that situation has been stable for a period of time (10 minutes). Same as previously stated.

2. At X minutes following the initiation of high pressure injection, termination is allowed provided the hot leg temperature indication plus appropriate instrument error is more than 50°F below the saturation temperature corresponding to the reactor coolant system pressure less instrument error. X is a time lag to prevent the termination of the high pressure injection immediately following its initiation. It requires further work to define its specific value, but it is probable that 10 minutes will be adequate. The need for the delay is that normal operating conditions are within the above criteria and thus it is conceivable that the high pressure injection would be terminated during the initial phase of a small LOCA.

I find that this scheme is acceptable from the standpoint of preventing adverse long range problems and is easier to implement. Therefore, I wish to modify the procedure requested in my first memo to the one identified here.

cc: E.W. Swanson
D.H. Roy
B.A. Karrasch
H.A. Bailey
J. Kelly
E.R. Kane
J.D. Agar
R.L. Pittman
J. D. Phinny
T. Scott
R. Davis

APPENDIX N

BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

TO: B.A. Karrasch, Manager, Plant Integration

cc: E.R. Kane
J.D. Phinney
B.W. Street
B.M. Dunn
J.F. Walters

FROM: D.F. Hallman, Manager,
Plant Performance Services Section (2149)

CUST:

File No.
or Ref.

SUBJ: Operator Interruption of High Pressure Injection (HPI)

Date: August 3, 1978

References: (1) B. M. Dunn to J. Taylor, same subject, February 9, 1978
(2) B. M. Dunn to J. Taylor, same subject, February 16, 1978

References 1 and 2 (attached) recommend a change in B&W's philosophy for HPI system use during low-pressure transients. Basically, they recommend leaving the HPI pumps on, once HPI has been initiated, until it can be determined that the hot leg temperature is more than 50°F below Tsat for the RCS pressure.

Nuclear Service believes this mode can cause the RCS (including the pressurizer) to go solid. The pressurizer reliefs will lift, with a water surge through the discharge piping into the quench tank.

We believe the following incidents should be evaluated:

1. If the pressurizer goes solid with one or more HPI pumps continuing to operate, would there be a pressure spike before the reliefs open which could cause damage to the RCS?

2. What damage would the water surge through the relief valve discharge piping and quench tank cause?

To date, Nuclear Service has not notified our operating plants to change HPI policy consistent with References 1 and 2 because of our above-stated questions. Yet, the references suggest the possibility of uncovering the core if present HPI policy is continued.

We request that Integration resolve the issue of how the HPI system should be used. We are available to help as needed.

/s/ ______________________
D. F. Hallman

DFH/fch
Attachments

EXHIBIT
FOR IDENTIFICATION
R. ZERKIN

APPENDIX 0

THREE MILE ISLAND NUCLEAR STATION
GPU STARTUP PROBLEM REPORT

UTILITY
TMI UNIT 2

System: Condensate
MTX No.: 25

PROBLEM DESCRIPTION: Based on the Loss of Feedwater occurrence on Unit #2 as identified in attached letter, Met Ed feels that Burns & Roe should re-evaluate the control of COVIZ. The desirable change appears to be a control in place of the present gate valve, motor operator, with a control loop which will open the valve either on high DP across the Condensate Polishing System or low effluent flow. At a minimum, if the above recommended change is not incorporated B&R should re-evaluate the DP across COVIZ as it would not open as designed during the occurrence.

FOR RESOLUTION BY: R. J. Toole DATE SENT: 11-17-77

PROPOSED RESOLUTION: The Condensate Densin System was underwater during the flood. The water damage you observed could have been a result of this damage. We have previously operated CO-V-12 without problems, therefore, we do not consider the DP to be the problem with the valve operation.

FOR ACTION BY: R. J. Toole DATE SENT: 11-17-77

No further action required by this PR. If when the plant is restored the problem is better defined, we will resolve the problem.

METROPOLITAN EDISON COMPANY Subsidiary of General Public Utilities Corporation

Subject: WATER IN THE INSTRUMENT AIR LINES AT THE CONDENSATE POLISHER CONTROL PANEL AND REGENERATION SKID RESULTING IN A LOSS OF FEEDWATER CONDITION IN UNIT #2 ON OCTOBER 19, 1977

Location: TMI Nuclear Station
Middletown, PA 17057

Date: November 14, 1977

To: G. P. MILLER
J. L. SEELINGER

Plant Conditions:

At this time of occurrence the reactor plant was in a cold shutdown mode. The secondary plant had a vacuum and feedwater heating established with one condensate pump and feedwater heater string in service. The main turbine was on turning gear.

Summary of Events:

At the time of the occurrence the Unit #2 50,000 gallon demineralized water tank was out of service, therefore, in order to regenerate #2 condensate polisher bed, Demineralized Water was supplied via Unit #1 Demineralized Water pump to the Unit #2 Demineralized Water pump supplying Demineralized Water to the regeneration skid. Since the Unit #1 pump was supplying suction to the Unit #2 pump, resulting in an abnormally high suction pressure to the Unit #2 pump the discharge pressure of the Demineralized Water system was greater than 190 psi. The normal pressure of the Unit #2 Demineralized Water system is 130 psi.

During or shortly after the attempted transfer of resin from mix bed polisher #2 to the receiving tank on the regeneration skid, the Auxiliary Operator noted water running out of the air operated recorders on the condensate polisher control panel, No. 304. Shortly thereafter the discharge valves on the condensate polishers closed resulting in a total LOSS OF FEEDWATER condition. Upon detection, the Control Room Operator immediately tried to open CO-V12, condensate polisher bypass valve; however, he was unable to open this valve from the control room. The auxiliary operator was then notified to manually open CO-V12, after about 5-10 minutes and assisted by another Auxiliary Operator CO-V12 was opened. If this would have happened while at power the unit would have been placed in a severe transient condition resulting in an Emergency Feedwater Actuation, Main Steam Relief to Atmosphere, Turbine Trip and Reactor runback with possible trip.

After discussing the problem with the operators, Mike Ross and myself, Doug Weaver was concerned that it was an instrument problem which induced this condition. As directed, his people dismantled, inspected, cleaned and reassembled all 42 of the diaphragm operated air valves on the condensate polishing regeneration skid, since these valves would provide an interface point in the event of a ruptured diaphragm. In addition all instrument air lines have been blown down to insure that all moisture has been removed from these lines. In almost all of these valves water was either found or indications that water had been there were found. Three quarters of the valves had rusty water and rust rings on the diaphragms indicating that water had been there for some time. The remaining quarter contained no visible indication, by rust color of the duration of time that the water was present. However, no ruptured diaphragms were found in the system.

As a result of above discussed investigation and the tracing of all instrument air lines in the vicinity, no fluid path has been found that would explain this occurrence. One remote fluid path was recognized that being that the demineralized water, because it was at an abnormally high pressure, was forced through the service air system, through three check valves, the instrument air dryer and back to the condensate polishing controls, being the lowest point in the system and the most consuming point of instrument air. However, dew point readings taken periodically after this occurrence in the instrument air system indicated that this probably was not the case.

In summary we conclude that the only way left available to try and identify how this happened, is to reenact this occurrence in a controlled fashion, however, this may not be desirable. As a result of our findings, we feel that the following should be acted upon to preclude a reoccurrence:

1. Change/replace the desiccant condition indicator on the instrument air dryers.

2. Completely realign all air and water controls on the condensate polishing regeneration system.

3. Checkout air control loop for valve C-5 to insure proper operation.

4. Submit problem report on CO-V12 as it appears that the dp across the valve was too high to allow openings.

5. Install drain trap on control lines on condensate polisher discharge valves.

6. Develop a PM program to take dew readings in the instrument air system as a minimum on a weekly basis, at the instrument air dryer and at the condensate polishing control panel.

7. Revise the Operations log to require blowing down the air compressors on each mid-shift and record the amount of water in the Auxiliary Operator's Log. Log any abnormal amounts of moisture, indicating a leak.

8. Revise the Operations log to require blowing down the instrument air line that feeds the condensate polishing control panel each mid-shift and record any abnormal moisture levels in the Auxiliary Operator's Log indicating excessive condensation problems.

9. Inspect the following check valves.

    1. SA-V360

    2. Two check valves circled on Figure 1.

/S/ J. A. Brummer
Instrument & Control Engineer

/S/ M. J. Ross
Shift Supervisor

JAB:sw

CC: J. R. Floyd
W. J. Marshall
T. E. Morck
D. M. Shovlin
Shift Supervisor
Unit #2 Shift Foremen

* U. S. GOVERNMENT PRINTING OFFICE : 1980 306-903/6733

Staff Reports To

THE PRESIDENT'S COMMISSION ON
THE ACCIDENT AT
THREE MILE ISLAND

The Nuclear Regulatory Commission, Report of the Office of Chief Counsel

The Role of the Managing Utility and Its Suppliers, Report of the Office of Chief Counsel

Emergency Preparedness, _Emergency Response,_ Reports of the Office of Chief Counsel

Reports of the Technical Assessment Task Force, Vol. I
- "Technical Staff Analysis Reports Summary"
- "Summary Sequence of Events"

Reports of the Technical Assessment Task Force, Vol. II
- "Chemistry"
- "Thermal Hydraulics"
- "Core Damage"
- "WASH 1400 -- Reactor Safety Study"
- "Alternative Event Sequences"

Reports of the Technical Assessment Task Force, Vol. III
- "Selection, Training, Qualification, and Licensing of Three Mile Island Reactor Operating Personnel"
- "Technical Assessment of Operating, Abnormal, and Emergency Procedures"
- "Control Room Design and Performance"

Reports of the Technical Assessment Task Force, Vol. IV
- "Quality Assurance"
- "Condensate Polishing System"
- "Closed Emergency Feedwater Valves"
- "Pilot-Operated Relief Valve Design and Performance"
- "Containment: Transport of Radioactivity from the TMI-2 Core to the Environs"
- "Iodine Filter Performance"
- "Recovery: TMI-2 Cleanup and Decontamination"

Reports of the Public. Health and Safety Task Force
- "Public Health and Safety Summary"
- "Health Physics and Dosimetry"
- "Radiation Health Effects"
- "Behavioral Effects"
- "Public Health and Epidemiology"

Report of the Emergency Preparedness and Response Task Force

Report of the Public's Right to Information Task Force