



UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

May 2, 1979

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ACRS MEMBERS

HIGHLIGHT OF 3rd HEARING ON THREE MILE ISLAND UNIT 2 BY THE SENATE
SUB-COMMITTEE ON NUCLEAR REGULATION APRIL 30, 1979

The list of witnesses is attached. In addition to the stated people,
all the NRC Commissioners were in attendance.

1. Senator Hart opened the hearing. He stated that the discussions today will cover.
 - a. shutdown and modification of Babcock and Wilcox reactors
 - b. actions taken to bring TMI-2 to shutdown on Friday
 - c. discussion of March 30th - the evacuation, the bubble of hydrogen and the disagreement regarding the means to eliminate it
 - d. why recommendation to evacuate not heeded
 - e. how serious was TMI-2 accident
 - f. how close to a Class 9 accident
 - g. should Class 9 accidents be considered in licensing process
 - h. why didn't inspectors discover two closed valves
 - i. the role played by B&W in the hours after the accident

- II. Senator Simpson's opening remarks. Senator Simpson stated that one lesson learned from this accident is that the reactor operator response to emergency situations is less than adequate.

He stated that he will propose to the NRC:

- a. operator response to emergency situations be stressed
- b. that criteria be prepared delineating engineering backup
- c. plans be developed for emergency engineering response
- d. Commission to prepare review program to see if less severe incidents are considered in sufficient detail
- e. to accelerate program to have resident inspector at each reactor site.
- f. propose increase in civil penalties for violations
- g. recommend plant management be held accountable for plant operations and licensing
- h. propose direct link between nuclear reactor control room and NRC, (a dedicated hard wired telephone) and a designated individual to communicate with the NRC
- i. monitoring of plant conditions by NRC
- j. plans for swift response by NRC to plants with emergencies

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- k. proposal that licensing of reactors dependent state's emergency plan
- l. improved safety research as suggested by ACRS
- m. more work on generic safety questions

III. Harold Denton was the leadoff witness. He stated that the current status of TMI-2 was in natural circulation. Temperature is about 180°F, the steam generator has a delta T of about current iodine release is at very low levels.

The most current pressing problem is what modifications are necessary to isolate the water in the containment from the environment.

Q. Senator Hart

What is gained by shutting only one Oconee reactor at a time? Why is Rancho Seco shut down immediately?

A. Denton

Oconee to provide an operator at each auxiliary feed water pump - this will provide a high degree of assurance of the pumps to start.

The valve lineup will be manually maintained so that each unit could supply other units. This resolution is satisfactory for the short term basis.

Q. Hart - What is short term?

A. Denton - On the order of 2 months.

Q. Hart - It took 5 days to shut reactors down for seismic criteria and 1 month to shut down B&W reactors - why?

A. Denton - it took longer to perceive risks at B&W plants.

Q. Hart - what convinced staff to go to lesser of shutdown requirements for B&W plant?

A. Denton - The only change is that 2 units of Oconee not shut down immediately.

Q. Hart - to what extent did economics play in the situation?

A. Denton - none.

Q. Hart - Why stable shutdown (TMI-2) 5 days early?

A. Denton - mainly failure of pressurizer instruments. Wanted to go to natural circulation at time when experts are readily available and maximum amount of instrumentation available.

Q. Hart - Describe condition of instrumentation. Can you operate without pressurizer level?

Can calculate levels using makeup tank levels and outflow. Another gage has been installed outside containment. A third method is using a Delta P level indication. The pressurizer is kept solid.

Q. Hart - Did control room operators wear gas masks during the accident?

A. Denton - At one time iodine was suspected to be leaking from the steam generators - When it was confirmed that it was not, the masks were removed.

Senator Simpson Q

Economics, energy considerations, blackout conditions, did not enter into your consideration to shutdown B&W reactors?

A. Denton - They were not primary considerations.

Q. Why weren't B&W reactors shut down right after accident?

A. Denton - my activities were involved with the TMI-2 situation. The staff was studying the contribution of design in the TMI-2 accident. The initial concept involved operator effects. Further study revealed that B&W reactors had many feed water transients.

Q. The computer response showed the pressure valve (relief) open. Is it true there was no way to verify this on the panel?

A. Mattson - There were thermocouple indications that the valve was open. In addition there were quench tank temperature and pressure indications.

Q. Senator Simpson - regarding operator training actions to improve operator training - how long to complete?

A. Actions to be completed in about one month.

Senator Domenici Q - Does NRC plan to implement hot line communications with reactors?

A. This is under active study.

Q. Should NRC monitor computer output remotely?

A. Present setup requires licensee call NRC within one hour. I&E has 24 hour service with professional standing by at a telephone. The concept of a hot line and remote computer readout is being investigated.

Q. Did NRC avail itself of DOE expertise, that is, National Labs?

A. NRC used DOE expertise.

Senator Hart Q - The concept of remote monitoring and a nuclear "SWAT" team - what are your thoughts on this?

A. These are under consideration.

Q. Describe a Class 9 accident.

A. These are accidents that are not in the scope of review-- accidents beyond the design basis.

Hart Remark - This sounds like a Catch 22 situation.

Q. Will this accident alter the licensing process?

A. Yes - changes will be made.

Q. How would you define the TMI-2 accident? Would you call it a Class 9 accident?

A. The initiating basis was a design basis accident. The resulting accident was a Class 9 accident.

Q. How close did core come to melting down?

A. Too early to answer question. The largest risk was during the first day. The fuel reached very high temperatures.

Q. My understanding is that the core was fully uncovered for one hour - is this true?

A. Yes. (Answer included cycles of partial covering).

Q. Why did it take Commission as long as it did to measure extent of damage?

A. Full extent of damage not indicated until coolant sample analyzed.

Q. If all this information had been available earlier, would you have recommended evacuation?

A. Work was on a day-by-day basis. Evacuation was recommended on Friday morning - report of noble gas release. Concern was breaking of containment. Later report was that offsite dose release was much lower and releases not from breaking of containment.

Senator Simpson Q - Have you verified difference in radiation readings between upper and lower containment?

A. Traverse radiation readings were taken outside containment. Back calculations correlated with interior readings. The lower containment reading is believed to be a possible malfunction.

Q. Would you say that this (high radiation) will be a deterrent to cleanup and restoration?

A. Difficult, but not impossible.

Q. When did you know about the deterioration of the zirconium clad?

A. Somewhere between Wednesday morning and Thursday night. It became apparent from the thermocouple data and the trending of the data. The hydrogen explosion in the containment was additional evidence. Another indicator was analysis of the primary coolant.

Q. Are simulators effective training methods?

A. Not as effective as they should be. B&W is adding abnormal situations in simulator training.

Q. Should plant managers be licensed?

A. Chairman Hendrie - This is difficult question. There may be other ways to handle this.

Hart raised concern about uranium falling to bottom of containment and becoming critical.

Q. How long will uranium remain in plant.?

A. Mattson - I believe core is relatively stable. Some uranium may be suspended by the fluid flow. Calculations of bounding conditions indicate no safety concern.

Q. Can you rely on your present instruments.?

A. The instruments have been calibrated. The present instruments should continue to perform well.

Q. Can you detect loose uranium at the bottom of the core?

A. There is no mechanism for additional uranium to settle to bottom of core.

Senator Hart

- Q. Senator Hart asked about the threat of Met Ed to remove all TMI-2 personnel
- A. Denton - This didn't happen in my presence. The understanding is for NRC to approve all procedures in advance. There were confrontations over various issues. Only plant employees actually operate plant.
- Q. Was there any doubt that utility would do what you require?
- A. Absolutely not.
- Q. What technical basis used to advise Governor the basis of a meltdown, about 1%?
- A. Don't recall 1% figure. The concerns were with hydrogen bubble and the possible use of R.H.R. to cool down.

Senator Moynihan

- Q. The 1 in 100 probability of a meltdown seems high.
- A. The mitigating considerations were that it would take considerable time to initiate event and the probability of losing cooling was very low.

Senator Simpson

- Q. To what extent do you observe licensee activities?
- A. Davis, I&E - Mainly we inspect hardware to verify Q.A. There are no large samples. We are moving into the resident inspector program.
- Q. There were inspections March 23 and March 26. How many inspectors inspect control room?
- A. One inspector involved. Observation not item of non-compliance.
- Q. Were valves closed and switches tagged during inspection?
- A. This is under investigation.
- Q. A photo in a magazine shows tagged switches - couldn't plant supervision and inspectors detect this?
- A. Don't have details - this is under investigation.
- Q. Why did operator withhold information re hydrogen explosion?

A. Don't know answer.

Q. Moynihan- Questioned competence of Met. Ed. engineering staff.

A. Not as extensive as many other utilities.

Q. Simpson- What arrangements have been made to cooperate with Presidential Commission?

A. Hendrie - We will cooperate in everyway.

IV. Babcock & Wilcox

Louis Favret -Executive Vice President

John H. MacMillan, Vice President - Nuclear Power

The prepared testimony is attached. Favret had introductory remarks and then presented MacMillan to give the main presentation.

John MacMillan presented the significant event of the accident.

- a. closed auxiliary feedwater valves
- b. pressure relief valve opened properly, but didn't close properly
- c. the high pressure injection system prematurely closed by operator
- d. had high pressure injection been allowed to continue, no damage to fuel would have occurred.

Q. ~~Hart~~ - when was high pressure injection terminated?

A. In first few minutes of accident.

Mr. MacMillan continued his presentation.

- e. The indicated pressurizer level not significantly in error
- f. the shutting of all reactor coolant pumps resulted in uncovering of the core.
- g. B&W equipment with the exception of the relief valve performed as designed.

Regarding the shutdown of B&W reactors, Mr. MacMillan said he preferred the decision rather than full forced shutdown. He believes the reactor plants could continue to operate without hazard to public.

Q. Hart -How many subcontractors for primary system?

A. Could be as many as 50.

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Q. Could there be as many as 100?

A. There could be that many main suppliers.

Q. Dr. Lipinski stated that status of instrumentation should be displayed on main control panel. Mr. Michelson stated that his comments were not responded to.

A. Not familiar with Lipinski's comments. B&W responded to Michelson and were told that Michelson had no further comments.

Q. Hart - orally?

- Long pause -

A. Taylor B&W initial response to Michelson. Feb 1979 Michelson responded that he required further clarification. It appeared to B&W that very minor points needed clarification.

Q. Hart - is it true that the pressurizer relief valve actuated 150 times?

A. Yes, in over 38 reactor years operation it actuated over 150 times.

Q. How do you account for the 150 times?

A. The design of the system initiates reactor rollback during a turbine trip. This helps the reactor stay on line. During the rollback, the relief valve opens.

Q. Hart - If you had been in operator's shoes, would you have done what he did?

A. This is a highly speculative question. Information from data center indicated leak in coolant system.

Q. Simpson - Which of the events would you designate as operator error and which equipment failure?

A. Equipment failure - the relief valve and the transfer to the auxiliary building. The others as operator error.

Q. Was the operator getting clear and unambiguous information as part of operator training?

A. Operator exposed to large number of equipment malfunctions during training - one is loss of coolant malfunction.

Operator has several indications pressurizer level was valid reading.

System pressure indication - As the pressure decreased, quench tank indicator and containment pressure indicator. Evidence that opening in reactor coolant system existed.

Q. Hart - Why technical specifications require valve closure during testing of auxiliary feed water system?

A. This is not a B&W system, this is supplied by A-E.

Q. Do you believe that licensing training should be reassessed?

A. Yes.

Q. Regarding the hydrogen bubble, why was this not anticipated, where did the bubble go?

A. The hydrogen was generated by the oxidation of the zirconium cladding. Hydrogen is soluble in the coolant. Part was released in the vapor phase of pressurizer and part in the vapor phase of letdown tank.

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Simpson - Does B&W have any further comment?

MacMillan - B&W is conducting an analysis far beyond that required by the NRC.

V. W. Wilson Goude - Pennsylvania Public Utility Commission

Mr. Goude stated

1. safety regulation of nuclear reactors is a federal function
2. if the costs of the accident are passed on to the consumer, the bills will be increased 30-40%
3. Mr. Goude stated that new legislation would be required to spread costs across all nuclear utilities

Attached are copies of the prepared testimony and a newspaper clipping describing this hearing.

Herman Alderman

Herman Alderman,
Reactor Operating Experience
Engineer

cc: Technical Staff

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NEWS RELEASE

FOR RELEASE:
April 30, 1979
9:00 a.m.

CONTACT:
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OPENING STATEMENT BY
SENATOR GARY HART
CHAIRMAN, SUBCOMMITTEE ON NUCLEAR REGULATION

Today's hearing is the third in the preliminary phase of our special investigation and study of the accident at the Three Mile Island nuclear plant.

We will review today two very important developments:

--The agreement reached last Friday between the Nuclear Regulatory Commission and affected utilities regarding shutdown and modification of all Babcock and Wilcox reactors, and

--The action taken at the Three Mile Island site, also last Friday to bring the damaged reactor down to a "stable shutdown" condition nearly a week ahead of schedule.

We also wish to explore today the Commission's decision-making process and a critical element in the sequence of events during the height of the crisis.

On the morning of Friday, March 30, the top technical staff of the NRC was recommending to both the Commission and the Pennsylvania State officials that there be an immediate evacuation to a distance of five miles from the plant. That recommendation was not followed.

As I understand it, the staff was acting on the basis of some very disturbing information:

First, the bubble trapped in the top of the reactor vessel was determined to be hydrogen and was presumed at the time to be potential explosive.

Second, there was strong disagreement over how to get rid of the bubble. The Metropolitan Edison officials wanted to depressurize the reactor; the NRC staff was concerned that such an action would enlarge the bubble, block the flow of coolant to the core and precipitate a meltdown.

Finally, it was also determined there was only a one-hour capacity left in the gas-holding tanks of the auxiliary building, which meant that radioactive gas might have to be released into the atmosphere.

I am advised by the Subcommittee staff that this is a fair summary of the situation that prompted the senior technical staff of the NRC to recommend evacuation.

We would like to question the NRC staff today about that recommendation to evacuate, and we will also question Chairman Hendrie and the other Commission members who are present about why the recommendation was not heeded.

It is important for us to understand the fact-finding and decision-making process as it worked--or did not work--so that if bad precedents were established, we are now in a position to break them and be better prepared to deal with such emergencies in the future.

We also will explore today just how serious the accident at Three Mile Island was. Specifically, we want to know how close it came to becoming a catastrophic, so-called "Class 9 accident"--one involving a meltdown of the nuclear fuel, a breach of the containment building, and a rapid spread of radioactive materials to the surrounding communities.

This is an important question because present procedures for designing, building and licensing reactors do not take into account the possibility of a Class 9 accident. Such an accident has been deemed so improbable as to be virtually impossible. Does this accident confirm or dispute this assumption? This is an issue which should be raised and aired fully.

We also want to determine why, during NRC inspections of the Three Mile Island plant during the days immediately prior to the accident, the inspectors failed to discover the two shut valves which were so critical in causing the accident.

Finally, we will be asking the NRC witnesses to comment on proposals which this subcommittee is considering in connection with the fiscal year 1980 authorization bill, and in the form of separate legislation, to strengthen NRC's capabilities for preventing and dealing with future emergencies.

In addition to the NRC witnesses, we will also be hearing from top executives of the Babcock and Wilcox Company and from W. Wilson Goode, Chairman of the Pennsylvania Public Utilities Commission.

We wish to explore with the Babcock and Wilcox executives the operating record of their pressurized water reactor, as it compares with that of such reactors built by other manufacturers.

We will also ask about the significance of the agreement between the NRC and the utilities on shutting down B&W reactors; the interaction among design defects, mechanical failures and human errors in the operation of nuclear reactors; and finally, the role played by B&W during the first hours and days after the accident at Three Mile Island.

With Chairman Goode, we wish to explore the important issues of who will pay the cost and assume the risk of the accident at Three Mile Island--the investors or the customers of the utility. The Pennsylvania Public Utilities Commission is examining the economic fallout of the accident now. We will want to discuss how its inquiry is proceeding and ways in which there can be cooperation and coordination between its inquiry and ours.

If the Three Mile Island nuclear accident has taught us anything, it is the need to face squarely problems and issue from which the public has been generally shielded until now. Nuclear power has a future only in the people have confidence in it. That means there must be a full understanding of the benefits and the risks. Health and safety questions and economic-impact issues must be fully explored. That is what this Subcommittee's hearings and special investigation are intended to achieve.

-end-

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
SUBCOMMITTEE ON NUCLEAR REGULATION
HEARING ON
THREE MILE ISLAND NUCLEAR POWER PLANT ACCIDENT
APRIL 30, 1979

9.00 a.m.
Room 4200 Dirksen
Senate Office Building

WITNESS LIST

1. Nuclear Regulatory Commission Panel

Harold Denton
Director, Office of Nuclear Reactor Regulation

accompanied by: Edson D. Case
Deputy Director, Office of
Nuclear Reactor Regulation

Roger J. Mattson
Director, Division of
Systems Safety

John G. Davis
Acting Director
Office of Inspection
and Enforcement

Chairman Joseph M. Hendrie
and Members of Nuclear
Regulatory Commission

2. Babcock and Wilcox Panel

Louis Favret
Executive Vice President
Power Generation Group

John H. MacMillan
Vice President of Nuclear Power

3. W. Wilson Goode
Chairman of the Pennsylvania Public Utilities Commission

SUMMARY
STATEMENT OF
THE BABCOCK & WILCOX COMPANY
BEFORE
THE SUBCOMMITTEE ON
NUCLEAR REGULATION
OF THE SENATE COMMITTEE ON
ENVIRONMENT AND PUBLIC WORKS
APRIL 30, 1979

John H. MacMillan
Vice President
Nuclear Power Generation Division
The Babcock & Wilcox Company
Lynchburg, Virginia

Good morning, my name is John H. MacMillan. As Mr. Favret mentioned, I am Vice President of the Nuclear Power Generation Division of The Babcock & Wilcox Company.

My remarks today are highlights of my written statement submitted to the Subcommittee.

As a way of introduction and background for our purposes today, the key participants in a nuclear plant are the utility, the NRC, the engineering firm, and manufacturers of equipment such as B&W.

As a general rule, the responsibilities of a nuclear steam system manufacturer are 1) to design and manufacture and/or provide the components of the primary system and reactor safety systems; 2) to provide interface information to the engineering firm for the balance of plant; and 3) to provide licensing and startup support to the utility.

The general responsibilities of the engineering firm are 1) to coordinate the design of the entire plant 2) to provide the containment design and design of the balance of plant (that part of the plant not included in the nuclear steam system), and 3) to integrate the various participants' workscopes into the overall plant design.

The NRC 1) reviews the plant designs and approves them; 2) issues construction permits, as required by the Atomic Energy Act, prior to commencement of any significant construction; 3) issues an operating license prior to fuel loading following its approval of final design; 4) establishes criteria and requirements for licensing of operators; and 5) monitors operating plants.

With this background, it is appropriate to move into a discussion of the incident at Three Mile Island. To provide a context for these remarks, the six significant factors identified by the NRC shall be used as a framework. Following discussion of the significant factors, B&W's near and long term planned actions in response to the incident will be set forth.

• First, after the loss of feedwater occurred, two closed isolation valves prevented auxiliary feedwater from reaching the steam generators for a period in excess of eight minutes. This eliminated the capability of the steam generator to remove heat from the reactor coolant system, and resulted in a corresponding increase in reactor coolant system temperature and pressure, and diminished the ability of the plant to promptly stabilize reactor coolant system temperature and pressure as designed.

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- Second, as a result of the initial reactor coolant system pressure and temperature increase, the pilot-operated pressurizer relief valve (located at the top of the pressurizer) opened as designed, but did not reseal properly, thus allowing reactor coolant system pressure to continue decreasing. After approximately 2½ hours, the operator recognized the data from plant instrumentation which indicated that the valve was open, and closed the block valve in the relief valve discharge line, thus preventing any further loss of primary coolant.
- Third, the high pressure injection system, which had automatically actuated as designed on low reactor coolant system pressure, was prematurely terminated by the operator even though there were simultaneous indications of an opening in the reactor coolant system pressure boundary, such as increasing quench tank pressure, decreasing reactor coolant system pressure and increasing reactor containment pressure. This led to a diminished capability to cool the reactor core as primary coolant inventory diminished.
- Fourth, the containment isolated in accordance with the licensed design. However, this allowed the transfer of radioactive water from the reactor building sump to the auxiliary building, from which subsequent radiation releases occurred.
- Fifth, high pressure injection was evidently manually operated based on high pressurizer level indication. We have conducted reviews of data from Three Mile Island and

performed analyses that lead us to conclude that the indicated pressurizer level was not significantly in error. We believe that the pressurizer was essentially full during a long period of this transient, but a portion of the reactor coolant system was void due to the decrease in system pressure. This conclusion has been supported by an independent NRC study. Consequently, operation of high pressure injection flow should not have been based on the single parameter of pressurizer level.

• Sixth, in addition to two reactor coolant pumps having been shut off at 73 minutes, the remaining two reactor coolant pumps were shut off at 100 minutes after the initiation of the incident. Although shutting off one reactor coolant pump in each loop in response to indications of low coolant flow may be advisable, shutting off all pumps under the circumstances then present is believed to have caused an uncovering of the core and a degradation in core cooling capability. Ultimately, at about thirteen hours after initiation of the transient, the reactor coolant system was repressurized, and at about 15 hours the reactor coolant pumps were restarted.

Our analysis of the foregoing factors and the need credibly to build public confidence in the reliability of nuclear power has led us to conclude that we should take further measures to assure and enhance continued safe operation of B&W-supplied reactors.

For actions that B&W has already taken, I would refer you to a full explanation of them in my written statement.

With respect to near term actions, B&W recognizes that additional measures should be taken so that operators are better able to manage transients. The following summarizes the actions B&W has currently underway or will be commencing soon to further enhance the safety of B&W units.

1. On Monday, April 9, B&W began conducting training for operating and management personnel on the events involved in the TMI-2 incident. The training consists of the following:

- Discussion of the TMI-2 transient from the information available to B&W.
- Demonstration of the incident on the B&W simulator.
- Training session of the simulator having students recover the plant from a depressurization event which involves the formation of steam voids in the reactor coolant system outside the pressurizer.

Six operators are included in each training session. The training sessions last one day. All utilities with B&W systems presently have this training in progress or scheduled for personnel.

2. The B&W supplied equipment in both the primary and secondary plant, with the exception of the pilot-operated pressurizer relief valve, performed as designed. However, in view of the events at TMI-2, design improvements are being

considered to further enhance the ability of plant operators to control nuclear power plants during transients.

In the near term we expect to recommend design improvements which do not affect other systems within the plant or require extensive analysis to improve operator performance during transients similar to TMI-2. In this category are such things as: More positive indication of pilot-operated relief valve position and instrumentation which will indicate to the operator whether the reactor coolant is approaching the saturated condition. We anticipate that recommendations of this type will be made within six weeks.

3. A special B&W task force has been appointed to advise of other implications for plant design as a result of the TMI-2 incident. This task force is comprised of a diverse group of technical personnel with a charter to

- Review technical aspects of the TMI-2 incident;
- Develop recommendations for equipment improvements, operator interface, recovery requirements and incident support;
- Assess impact of the TMI-2 incident and potential resulting changes in regulatory requirements on Nuclear Power Generation Division technical activities.

Beyond the immediate and near-term actions, longer-term actions will be undertaken.

B&W intends to undertake a review of those anticipated transients which result in the opening of the pilot-operated relief valve to confirm that an open pilot-operated relief valve in conjunction with anticipated transients is adequately covered by existing safety analyses. In parallel with these anticipated transient reviews, B&W intends to review its operator training programs and will make changes as appropriate.

Beyond those actions for design modifications under our near-term efforts, B&W will be examining other actions, but with the understanding that each must be carefully evaluated with respect to any impact on other design requirements.

In conclusion, Babcock & Wilcox appreciates the seriousness of the incident at Three Mile Island and is committed to take responsive actions to incorporate the lessons learned. B&W is continuing to maintain an "around-the-clock" communications center at our Lynchburg facilities and an on-site team -- which I headed until recently -- who have at their disposal all of the resources of B&W to support the efforts of Metropolitan Edison and the NRC. B&W as well as all others are gratified that the situation at TMI is under control and progressing towards cold shutdown.

B&W will continue to give top priority to support the efforts at the site and to implement the actions by the NRC, Met Ed and all other utilities towards prevention of any further occurrences in the nuclear power generation industry.

Babcock & Wilcox appreciates the opportunity to participate in the Subcommittee's investigation and review of the TMI incident.