April 5, 1983

Judge Gary J. Edles, Chairman
Atomic Safety & Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Judge John H. Buck
Atomic Safety & Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Judge Reginald L. Gotchy
Atomic Safety & Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

In the Matter of
METROPOLITAN EDISON COMPANY, ET AL.
(Three Mile Island Nuclear Station, Unit No. 1)
Docket No. 50-289

Dear Appeal Board Members:

The Staff was asked by Chairman Edles to determine and to report back to the Appeal Board whether the draft document, on which the comments in UCS Exhibit No. 53 were made, could be released for inclusion in the record of the reopened hearing. Tr. 784-5. A copy of that draft document is enclosed for the Board's use as it sees fit. The draft document contains incorrect, incomplete and potentially misleading information that was omitted or modified in the final version. Moreover, as the Board knows, Dr. Ornstein indicated that the final version of the document adequately captured the intent of AEOD's comments in UCS Exhibit No. 53. Tr. 758 and 780.

Sincerely,

James M. Cutchin IV
Counsel for NRC Staff

Enclosure: as stated

cc: w/enclosure
Thomas A. Baxter, Esq.
Ellyn R. Weiss, Esq.
Robert W. Adler, Esq.

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Redraft
5/24/82

MEMORANDUM FOR: Harold Denton, Director, Office of Nuclear Reactor Regulation

FROM: Roger Mattson, Director, Division of Systems Integration
Hugh Thompson, Acting Director, Division of Human Factors Safety

SUBJECT: NRC STAFF RELIANCE ON "FEED AND BLEED" AT TMI-1 RESTART HEARING

As requested in your memorandum of April 29, 1982, we have prepared the attached report addressing each of the four issues which you identified. To summarize, the NRC staff did not rely on "feed and bleed" cooling to protect the core at TMI-1. This position was made clear to the board. Babcock and Wilcox performed feed and bleed analyses for the development of inadequate core cooling procedures. Such procedures would be utilized as defense in depth for events beyond the design basis. These procedures instruct the operator to establish and maintain feed and bleed cooling following a complete loss of heat sink until feedwater can be restored.

This response was prepared by the Division of Systems Integration. The Division of Human Factors Safety concurs in the statements regarding the reliance that we place on operator actions for initiation of emergency feedwater and on feed and bleed cooling in emergency operating procedures for accidents beyond the design basis. The offices of ELD and AEOD have reviewed this response and their comments have been incorporated.

Attachment: As stated

Roger J. Mattson, Director, DSI

cc: B. Sheron
O. Parr
S. Byron
H. Thompson
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J. Stolz
J. Wermiel
J. Mazetis
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Hugh L. Thompson, Jr., Acting Director
Division of Human Factors Safety

REPORT ON NRC STAFF POSITION ON FEED AND BLEED COOLING AT TMI-1 RESTART HEARING

Item 1 A description of the staff position at the TMI-1 restart hearing on the role of "feed and bleed" during a SBLOCA.

RESPONSE

In the following paragraph we describe what we understand today about the role of feed and bleed cooling. We believe it is the same understanding that we had at the time of the TMI-1 restart hearing. In succeeding paragraphs we quote staff testimony from the record of the hearing to corroborate our belief.

The Feed and Bleed method of cooling is the defense-in-depth process which would be utilized by operators at TMI-1 to remove decay heat from the primary system in the unlikely event of either a complete loss of both main and auxiliary feedwater, or small break LOCAs too small to remove decay heat by the break alone coupled with the complete loss of both main and auxiliary feedwater. These events are beyond the design basis. However, since the accident at TMI-2, we require procedures and training to deal with these and other complex multiple-failure events. Following a complete loss of feedwater, primary coolant would be discharged from the relief and/or safety valves. Uncovering of the core is prevented by the manual actuation of High Pressure Injection within 20 minutes (feed process). This has been confirmed by calculations by Babcock and Wilcox. The method of heat removal would be by boiling

in the core and steam flow out the PORV or the safety valves (bleed process). With proper justification, the NRC staff would allow applicants or licensees to rely on the capability to remove decay heat by feed and bleed to demonstrate conformance to the Commission's design basis requirements for nuclear power plants. Our position was consistent with this in the restart review of TMI-1 (NUREG-0680). This position was made clear to the ASLB in the TMI-1 restart hearing in (1) written testimony by NRC staff witness J. Wermiel and (2) oral testimony of W. Jensen as follows.

(1) Written Testimony by J. Wermiel in Response to Board Question 6:

Question 6i. Will the reliability of the emergency feedwater system be greatly improved upon conversion to safety-grade, and is it the licensee's and staff's position that the improvement is enough such that the feed-and-bleed backup is not required?

(Witness Wermiel)

Response: Based on knowledge of the improvement in reliability gained by eliminating first order failure sources, it is the staff's judgement that the reliability of the emergency feedwater system will be improved once the fully safety-grade system is installed. The single failure problem associated with integrated control system/non-nuclear instrumentation described in the response to 6a and b above will be eliminated. In addition, various other hardware, procedural and administrative improvement as identified in the TMI-1 Restart SER, NUREG-0680 under Order Item 1a. should

grade EFW system has not been performed. The feed-and-bleed back-up is not required by the staff and, therefore, need not meet all requirements of a safety system. However, it is recognized as additional defense in depth for providing core cooling in the very unlikely event that emergency feedwater is lost, and the HPI pumps and primary safety valves which comprise the feed and bleed mode are required to be available by Technical Specifications. //

(2) Oral Testimony of W. Jensen Regarding UCS Contentions 1 and 2

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(Dr. Jordan)

I would address the question then directly to Mr. Jensen. Did I misstate what said? Do you believe that the high pressure injection system is important in that it not only supplies emergency cooling inventory but it also removes heat in the feed and bleed mode? That that is an important safety feature?

(The Witness)

The high pressure injection system is an important safety feature for making up the coolant lost from a small break LOCA. The NRC does not rely on this system for heat removal in the feed and bleed mode by which core decay heat would be forced through the safety valve or the PORV. Instead, we rely on the heat removal from the emergency feedwater system.

(Dr. Jordan)

Okay. That's fine.

(Ms. Weiss)

It I can refer, Dr. Jordan, I think the exact question you are asking is answered on page 9 of the staff testimony in response to Board question number 6. I was going to read the sentence to you. (Warmiel testimony above)

The feed and bleed back up is not required by the staff and therefore need not meet all the requirements of the safety system. It's just simply a direct quote.

(Dr. Jordan)

Yes. I remember that and thank you for pointing that out. I think that clears up the matter."

Item 2 <u>An interpretation of the TMI-1 Licensing Board decision regarding the need for reliable and effective "feed and bleed" during SBLOCA.</u>

<u>RESPONSE</u>

There is an interest in whether the ASLB accepted the staff position on the reliance to be placed on feed and bleed cooling. We believe that the ASLB did not accept our position, as shown in the following excerpts from its decision.

Page 224 of the TMI-1 Licensing Board decision acknowledges the NRC Staff position (see Item 1 above) by noting that:

"The Staff's position is that the loss of emergency feedwater following a main feedwater transient is not an accident which must be protected

against with safety-grade equipment."

To us, this observation by the ASLB says that our position in Item 1 above was understood by the Board. At Page 242 of the decision the Board goes on to point to a precedent ruling made by the St. Lucie-2 Appeal Board for a complete loss of all AC power (loss of offsite power plus loss of both diesels). The TMI-1 Board noted that:

"The (St. Lucie) Appeals Board decided that measures were required to mitigate such an event should it occur. We believe that similar measures are necessary at TMI-1; that the reliability of the EFW system has not been demonstrated to be adequate by itself. However, the EFW system is backed up by the high pressure injection system, so that in the event of failure of the EFW system the core can be cooled by feed and bleed while repairs are being made to the EFW system."

We conclude from this statement that the TMI-1 Board has relied upon the availability of feed and bleed in reaching its finding that the TMI-1 design is acceptable. The question then is how the Board reached this conclusion in light of the Staff position (Item 1 above). The answer is summarized on page 250 of the TMI-1 Board decision where the Board states:

"We have relied on the staff figures on reliability of the EFW system <u>and our own estimates</u> (emphasis added) of the adequacy of the

is adequately protected from a loss of main feedwater transient, the dominant challenge to the EFW system."

We conclude that the Licensing Board reached the same conclusion as the staff (the TMI-1 design satisfies the Commission's regulations), although the bases for the conclusion are different. The basis for the staff position is summarized in Question 3. below. We have studied the Licensing Board decision to understand its basis for the conclusion. At paragraph 1056 we find the following: |

"Since the EFW System is backed up by a safety-grade HPI, designed to protect the core in the event of a small break LOCA, we believe we can conservatively assume an additional safety factor of 100, or an overall probability of failure to protect the core of about 10^{-6}/yr. Lacking any demonstration that the above failure probabilities are grossly in error, we conclude that the EFW system, as modified, will, with the HPI backup, adequately protect the health and safety of the public."

During the TMI-1 hearing, the NRC Staff did not provide any detailed discussion, for or against, the above Licensing Board assessment. ← We do not have sufficient information on the viability of feed and bleed cooling to credit it with a 100 fold reduction in the probability of core melt.

Item 3a <u>A detailed explanation of the staff's technical basis for its position on "feed and bleed" at TMI-1.</u>

RESPONSE

It was the Staff's position during the TMI-1 hearing that the emergency feedwater (EFW) system is required to be available for decay heat removal in feedwater transients and certain small break loss-of-coolant accidents without feedwater. We also noted that should EFW be initially unavailable, there is at least 20 minutes time available to take action to establish EFW flow prior to uncovering of the core following a loss of main feedwater or certain small break loss of coolant accidents. The TMI-1 EFW system will, at the time of restart, meet the Commission's requirements for safety related equipmer if credit for operator action is given (to initiate the system) within 20 minutes. The TMI-1 EFW system will be fully automatic for these events by the first refueling outage after restart. The staff recognizes that a feed and bleed capability exists at TMI-1 to provide additional defense in depth for decay heat removal should EFW fail. The inadequate core cooling procedures at TMI incorporate the feed-and bleed process. Operators are trained in the use of these procedures at TMI-1 and feed and bleed is covered in the scope of OLB examinations of the TMI operators. It is also frequently covered in the simulator portion of the examination. Safety grade equipment to accomplish feed and bleed backup to EFW in the event of a complete loss of all feedwater is not required to be included within the design basis since the EFW system at the time of restart is sufficiently

Item 3b Discussion of Decay Heat Removal Techniques Including "Feed and Bleed"

RESPONSE

For small breaks below a certain size, the break area is not large enough to relieve all the energy generated by decay heat. For this condition, heat transfer through the steam generator is the preferred method of providing additional required energy removal capability. To accomplish this, emergency or auxiliary feedwater systems must be operating. Since the reactor coolant pumps are tripped for most small breaks, coolant flow through the core is by natural circulation. Natural circulation heat removal in PWRs with either main or emergency feedwater can be classified into four modes as follows:

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1. Single phase- In this mode the entire primary system remains in a subcooled liquid state. Core flow is maintained solely by density differences between hot and cold liquid.

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2. Two phase continuous - This mode is similar to mode 1 except that the hot side is at saturation and at low steam quality. Bubbles are found in the upper portion of the core and are swept, as part of a continuous two phase mixture, into the steam generator and condensed. During this time, some of the steam generated in the core will rise into the upper head and accumulate there as a single large bubble. For Westinghouse and CE plants this heat removal mode can persist until the vessel bubble becomes large enough to drop the mixture level into the hot leg nozzles. For B&W plants this heat removal mode will persist until the liquid level drops below the bottom of the hot leg U-bend.

DOUBLE-SPACE

3. Boiler/Condenser - When the hot leg U-bend is voided, liquid will not be carried into the steam generator. However, when sufficient steam has accumulated such that a condensing surface is exposed within

the tube walls. If the condensate is formed in, or carried over, to the down side of the steam generator, the method of heat removal is called the Boiler/Condenser method. Since the B&W once-through steam-generator (OTSG) has only primary system (tube side) downflow, this is the only mode of steam generator condensation heat removal for those plants. Under certain conditions in CE and Westinghouse Inverted U-tube steam generators, steam may carry condensed droplets from the up side of the tubes over to the down side. This is not considered a dominant mode of condensation heat removal for U-tube steam generators.

4. Reflux Boiling - This mode of heat removal is associated solely with inverted U-tube steam generators and can occur when the hot leg is voided as with mode 3. In this case, the steam is condensed on the up side of the primary system tube walls and the condensate runs back down the wall, back through the hot leg and into the vessel. Thus, there is countercurrent flow of steam and liquid in the hot leg.

If heat removal through the steam generator cannot be achieved due to loss of all feedwater (an event not required as a design basis), "feed and bleed" can be used as an alternate heat removal method. The procedure involves energy removal by venting through the primary system PORVs and/or safety valves (bleeding), and replacing the vented coolant with cold HPI water (feeding).

Item 3c Assessment of Current Status and Existing Information on "Feed and Bleed"

RESPONSE

As you recall, in a recent communication to Dr. Henry Meyers we noted that for a small break LOCA which is subsequently isolated, a phenomena similar to "feed and bleed" might ultimately occur as the means of decay heat removal if a steam bubble was trapped at the top of hot leg high points and did not rapidly condense. This method of heat removal from the primary system might occur if the core were sufficiently cooled so that decay heat no longer boiled the incoming HPI water but forced it through the safety valves as liquid. If boiling occurred in the core the steam production would act to increase the size of the bubble size in the hot leg U-bends. If the hot leg bubble size increased sufficiently, a condensing surface on the steam generator tubes would be exposed. This would establish natural circulation in the boiler condenser mode. The bubbles could not expand sufficiently to uncover the core or to exhaust steam out of the pressurizer since the secondary system water level in the steam generators would be above the core and the pressurizer surge line entry elevation. Although our study of this scenario is recent and was not discussed during the TMI-1 hearing, no additional staff reliance on feed and bleed should be implied since if the feed and bleed process discussed above were insufficient to remove decay heat, natural circulation would be established in the boiler/condenser mode. The letter to Dr. Meyer is attached for further information on these recent developments.

All three PWR suppliers are developing emergency procedure guidance to licensees on how to use equipment to perform "feed and bleed" operations as a backup method of heat removal if all measures

open issue in other licensing proceedings.) It is important to stress that at this time "feed and bleed" is not a preferred method of decay heat removal. The equipment used for feed and bleed operation was not designed for that purpose. Feed and bleed is only one possible emergency alternative for core cooling. All PWRs have in their emergency guidelines, methods for use of decay heat removal schemes other than the design basis equipment. In particular, guidance is given to provide alternate sources of secondary cooling if main and auxiliary feedwater are unavailable (e.g., by depressurizing the secondary system and activating the condensate pumps). Operators would resort to feed and bleed only if none of the sources of water are available to feed the steam generators. The NRC has no design requirements for these other alternate schemes, just as we have none for the "feed and bleed" capability. What is required for the design basis is a reliable safety related auxiliary feedwater system to remove decay heat until cold shutdown is achieved and the RHR system is activated. However, in spite of the fully qualified safety grade emergency feedwater system, feed and bleed procedural instructions should be available to operators because the capability to feed and bleed exists.

DOUBLE-SPACE

It is also possible that at some future time, on the basis of operating experience, the design basis might change (e.g., emergency feedwater reliability may not sufficient for some designs). In these cases, the staff would require that t feed and bleed capability meet branch position ASB 10.1, i.e., safety and proposed grade equipment and proper design justification. For existing plant designs we have not yet imposed such a requirement, absent a conclusion that the Commission's regulations require it.

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As to the technical performance of "feed and bleed," we know it depends

all three PWR suppliers to examine "feed and bleed" capability for their designs. Also, NRC contractors at LANL and INEL have analyzed "feed and bleed" with the computer codes TRAC and RELAP. As noted previously, a B&W calculation for a TMI class plant showed that "feed and bleed" was an effective heat removal method even if no credit is taken for PORV actuation. This is because most B&W plants have HPI pumps with a very high shutoff head, and enough energy can be relieved at high pressure through the safety valves. Westinghouse calculations have shown that for its plants with moderately high shutoff head HPI pump, automatic operation of the PORV provides a sufficient energy relief capacity to insure adequate core cooling and heat removal. For all other plants with PORVs, one or more PORVs must be manually opened to assure that pressure is low enough to provide adequate core cooling and heat removal. It is important to note that the assessment of "feed and bleed" rests almost exclusively on analysis. Analytical uncertainties related to such phenomena as non-equilibrium thermodynamics, bubble formation and repressurization caution against taking too much credit for analytical predictions of system behavior.

One LOFT experiment (L9-1/L3-3) explored "feed and bleed" in a limited way. After a simulated loss of feedwater, the PORV was latched open to allow depressurization. The results showed that depressurization to the HPI actuation point did indeed occur. However, HPI actuation was purposely not allowed to occur so that other accident mitigation schemes could be explored.

Item 4. Recommendations for Future Action

It would be desirable to provide an improved experimental basis for understanding system behavior during "feed and bleed". This should improve the guidance in emergency procedures and training. To accomplish this, we are exploring ways to expand the current Semiscale test series to include "feed and bleed" experimental data. We expect shortly to issue a request to RES which will include these propos

The current Semiscale configuration cannot simulate the unique features of the B&W NSSS. You know from previous discussions that we have been trying to resolve the problem of uncertainties for the B&W analytical methods in predicting long term LOCA recovery because of the unique features of the B+W design and the lack of integral systems data (attach latest letter to B&W owners). We will shortly transmit to all B&W owners our conclusion that such data are required. The basis for this conclusion is the need for additional verification of of some aspects of the thermal-hydraulic behavior during natural circulation cooling of the B+W design with feedwater available during small break LOCAs, as well as uncertainty in the feed and bleed process.

We will continue to require licensees to develop emergency operating procedures for the inability to feed steam generators for those PWR's having the "feed and bleed" capability.