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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

October 23, 1979

TO ALL PRESSURIZED WATER REACTOR LICENSEES

SUBJECT: SUMMARY OF MEETING HELD ON OCTOBER 12, 1979 TO DISCUSS RESPONSES TO IE BULLETINS 79-05C AND 79-06C AND HIGH PRESSURE INJECTION (HPI) TERMINATION CRITERIA

On October 12, 1979, members of the NRC staff (the staff) met with the three pressurized water reactor (PWR) vendors and representatives of the corresponding Owners' Groups in Bethesda, Maryland. The purpose of the meeting was to discuss the variations in analyses and operator guidelines submitted in response to IE Bulletins 79-05C and 79-06C and to discuss differences in proposed HPI termination criteria. A list of attendees is provided as Enclosure 1.

BACKGROUND

The initial review of the preliminary chronology of events which occurred at the Three Mile Island Nuclear Station, Unit 2 (TMI-2) led to the identification of six potential human, design, and mechanical failures which appeared to have led to core damage in the reactor. One of the identified items was the tripping of the reactor coolant pumps (RCPs) during the course of the accident. Once forced flow was terminated by securing the RCPs, core damage occurred since the steam and water separated in the primary system and caused the core to become uncovered. Instructions were issued to the holders of operating licenses, in the form of IE bulletins, which required operating procedures to specify that in the event of HPI initiation with RCPs operating, forced flow would be maintained in the RCS.

Subsequent analyses by each of the Nuclear Steam Supply System (NSSS) vendors indicated that for a certain spectrum of small breaks in the RCS, continued operation of the RCPs would increase the mass lost through the break and prolong or aggravate the uncovering of the reactor core if the RCPs were subsequently tripped at certain times into the accident. While the size and location of such a break and the time of tripping the RCPs, which would produce unacceptable results, varied for each analysis, all three vendors agreed that an acceptable action under loss-of-coolant-accident (LOCA) symptoms would be to trip all operating RCPs immediately, before significant voiding in the RCS occurred. As a result of this information, IE Bulletins 79-05C and 79-06C were issued which required immediate tripping of all operating RCPs upon reactor trip and initiation of HPI caused by system low pressure. These bulletins also required the licensees to perform more detailed analyses on the effect of RCP trip for both LOCA and non-LOCA transients.

The conclusions reached by the PWR vendors in these analyses vary to a considerable degree as summarized in Enclosure 2. It is the NCR staff's present judgment that the major differences in results are attributable to model differences, which are highlighted in Enclosure 3. The various RCP trip criteria that have been proposed by the vendors are shown in Enclosure 4.

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An additional concern relates to the criteria for HPI termination. Enclosure 5 lists the criteria proposed by the various vendors. The staff can see no reason why the same set of safety considerations would lead to more than one uniform criterion for termination of HPI.

This meeting was requested by the staff to discuss, in an administrative sense, how the PWR regulated industry can reach agreement on these two issues.

DISCUSSION

The NRC staff opened the meeting by stating that its goal for the discussions was to attempt to reach agreement among the staff, the Owners' Groups, and the NSSS vendors on several issues involving small break LOCA analyses and RCP trip criteria, as well as the criteria which should be used for termination of HPI. The staff pointed out that NUREG-0578 ("TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations" - July 1979) requires that the implementation of small break LOCA emergency procedures and the associated operator training be completed by December 31, 1979. Therefore, the staff considers timely resolution of these issues to be imperative.

1. SMALL BREAK LOCA AND RCP TRIP REQUIREMENTS

There was general agreement among the participants that: (1) there are significant differences in the small break LOCA models used by the vendors; (2) there are differences of opinion on what model features are conservative; and (3) none of the models have been demonstrated to be overall conservative by integral test comparison. The staff said it has done some calculations with RELAP-4/Mod 7, as summarized in Enclosure 6; however, these calculations are also not definitive enough to enable the staff to determine which set of model assumptions is suitably conservative. Based on the above conditions, the staff pointed out that it is not surprising that the conclusions reached by each vendor in their small break LOCA calculations vary with those reached by the other vendors. The staff stated, it believes that the different results obtained by the vendors cannot be attributed solely to physical plant differences. The other participants, however, were not able to reach the same conclusion.

All participants were able to agree that resolution of differences is needed in order to proceed with the task of writing/rewriting the small break LOCA operator guidelines. The staff pointed out that it is very important for the licensed operators to be convinced that tripping of RCPs is the proper course of action for a small break LOCA, and in order to achieve this, there should be general agreement among the vendors, supported by analyses, on the criteria to be used to formulate the licensees' emergency procedures.

Westinghouse (W) stated that the resolution of this issue was on its critical path for completing the requirements of NUREG-0578 (Section 2.1.9) on schedule. Combustion Engineering (CE) stated that it was not a critical issue at this time; however, continued inability to reach a common agreement would impact its schedule. Babcock & Wilcox (B&W) has completed its small break LOCA guidelines, detailed emergency procedures, and operator training. B&W's concern was centered around not confusing the operator. B&W does not want to modify

its guidelines and subsequent licensees' emergency procedures and training based upon another interim position. B&W would like to resolve the issue in a timely fashion, and if changes are needed in the guidelines, procedures, and training, the changes should not be made until the issue is resolved.

The next item discussed was the need for an automatic RCP trip for small break LOCAs. B&W desires that an automatic trip design be approved by the staff based on its recent proposed design submittal. The B&W design uses coincident signals from: (a) safety injection initiation (1600 psig) and (b) RCP current. W desired to have a detailed technical meeting in the near future to discuss its proposal of using coincident signals from: (a) safety injection initiation and (b) low primary system pressure of 1250 psig. CE has not decided about the need for an automatic trip. CE's analysis shows that in most cases it would require only two out of four RCPs to be tripped. In addition, the CE analysis shows that no RCP trip would be required provided at least two HPI pumps were used during the accident.

The NRC staff questioned whether the requirements of IE Bulletins 79-05C and 79-06C to "immediately" trip all operating RCPs upon a reactor trip and HPI initiation caused by low pressure is too restrictive. Agreement was reached by the participants that the requirement to immediately trip the RCPs should be modified such that additional time is allowed for the operator to determine if the transient which causes the low pressure is a LOCA or non-LOCA event. It was generally agreed that the reduced pressure for the RCP trip should fall between the setpoint of the steam generator relief valves and the safety injection actuation setpoint. B&W stated that while they agreed that a lower pressure than the 1600 psig used for safety injection actuation could be acceptable, the reasons it had chosen its coincident signals was because the B&W plants do not have a safety-grade pressure transmitter that would assure a reliable signal, at a lower pressure, from which to trip the RCPs. CE modified its response by stating that it also agreed with the concept of using a lower pressure; however, it still felt that a certain time delay (after reaching the specified pressure limit) should be afforded the operator prior to tripping the RCPs to allow for operator actions to recover from the transient, if appropriate.

This topic was closed out by a restatement by the staff that it was critical for the industry to reach agreement on the subject to assure that the licensed operators understood that tripping of the RCPs and the criteria for doing so do not represent an arbitrary NRC decision, but in fact are based on the recommendation of the NSSS vendors and have the endorsement of the licensees.

2. HIGH PRESSURE INJECTION TERMINATION CRITERIA

The basic thrust of this portion of the meeting was to come to agreement on the necessity to pursue a common set of criteria for the manual termination of HPI following automatic initiation caused by reactor coolant system (RCS) low pressure.

As a result of the investigation of the TMI-2 accident, one of the prime contributors to the damage which occurred to the core was attributed to the premature termination of HPI. Shortly after the accident, IE Bulletins 79-05A, 79-06A, and 79-06B (applicable to B&W, W, and CE operating plants respectively) were issued which directed licensees to take certain actions which would minimize the chances of such an accident. One of the action items of these bulletins dealt with HPI termination criteria. In general, the bulletins required, as an interim measure, that if HPI automatically initiated because of a low pressure condition in the RCS, it must remain operating until one of two criteria is met. These criteria are:

a. Both low pressure injection (LPI) pumps are in operation and flowing for 20 minutes or longer at a flow rate which would assure stable plant behavior or

b. The HPI system has been in operation for 20 minutes, and all hot leg and cold leg temperatures are at least 50°F below the saturation temperature for the existing RCS pressure. If the 50°F subcooling cannot be maintained after HPI cutoff, HPI shall be reactivated. The degree of subcooling and the length of time HPI is in operation shall be limited by the pressure/temperature considerations for vessel integrity.

Subsequent to these bulletins and based on vendor analyses, vendor guidelines were developed independently for HPI termination criteria. The various criteria are summarized in Enclosure 5. The staff stated its position that there should only be one set of criteria for HPI termination and that it should be equally applicable to all PWR facilities. All participants agreed on this position. The staff's goal in this area is to get one set of reliable criteria which can be easily monitored and will not cause operator confusion.

The mechanics of getting agreement on the criteria to be used was then discussed. It was agreed that the simplest set of criteria which would still satisfy all concerns would be the logical choice. The criteria selected would have to hold for all cases; i.e., could not lead the operator to erroneous conclusions concerning the status of the RCS inventory and degree of subcooling. The criteria would also have to assure that the influence, if any, on pressure vessel integrity would be considered. All participants, including the staff, agreed that these criteria do not need to include a requirement that the HPI system be operated for any arbitrary length of time, such as the 20-minute requirement specified in the IE bulletins.

CONCLUSIONS

All participants agreed that, based on the information presently available to the staff, no clear solution to establishing a unified set of criteria for RCP trip during small break LOCAs and HPI termination is readily apparent. An indepth technical meeting with the W Owners' Group to discuss its analysis and criteria associated with these issues will be scheduled shortly. A similar meeting will be arranged with the CE Owners' Group if it is necessary. A meeting with B&W does not appear necessary at this time. Following the technical meeting(s), it may be

necessary to have another administrative meeting with the Chairmen of the Owners' Groups and the NSSS vendors to obtain a decision on criteria selection.

The criteria selected by the staff should have full vendor and licensee endorsement. These criteria will most likely be transmitted to the Chairmen of the Owners' Groups for comment followed by individual letters being sent to the licensees.

R. A. Capra

R. A. Capra, B&W Project Manager
Project Management Group
Bulletins & Orders Task Force

Enclosures:
1. List of Attendees
2. Summary of Conclusions on IE Bulletins 79-05C and 79-06C
3. Model Differences for SBLOCA Analyses
4. RCP Trip Criteria
5. HPI Termination Criteria
6. Summary of Staff Calculations

ENCLOSURE 1

LIST OF ATTENDEES

ORGANIZATION	NAME	POSITION
B&W OWNERS' GROUP	R.L. GILL	Chairman, TMI-2 Effects Subcommittee
	S.I. ANDERSON	Nuclear Engineer (SMUD)
	P.M. ABRAHAM	Nuclear Engineer (Duke Power Co.)
B&W COMPANY	G.O. GEISSLER	Manager, Generic Licensing Unit
	R.B. BORSUM	Bethesda Licensing Rep.
CE OWNERS' GROUP	R.T. HARRIS	Chairman, Technical Committee
CE, INC.	P.G. DELOZIER	Project Manager
	J. LONGO	Manager, ECCS Analysis
W OWNERS' GROUP	D.B. WATERS	Chairman, Analysis Group
W ELECTRIC CORP.	T.M. ANDERSON	Manager, Nuclear Safety Dept.
NRC STAFF	D.F. ROSS, JR	Director, Bulletins & Orders Task Force (B&OTF)
	T.M. NOVAK	Deputy Director (B&OTF)
	W.F. KANE	Leader, Project Management Gp.(B&OTF)
	P.D. O'REILLY	W Project Manager (B&OTF)
	R.A. CAPRA	B&W Project Manager (B&OTF)
	S. ISRAEL	Leader, Systems Group (B&OTF)
	G.B. KELLY	Systems Group (B&OTF)
	G.R. MAZETIS	Section Leader, Systems Group (B&OTF)
	C.C. GRAVES	Reactor Systems Eng. (RSB)
	B.A. WILSON	Systems Group (B&OTF)
	Z.R. ROSZTOCZY	Leader, Analysis Group (B&OTF)
	W.L. JENSEN	Analysis Group (B&OTF)
	B.W. SHERON	Analysis Group (B&OTF)
	D.J. GARNER	Rancho Seco/Davis-Besse 1 Proj Mgr.
	L.E. SIMMON	Training Section (IE)
	S.K. SHOWE	Chief, PWR Training Section (IE)
	P.A. BOEHNERT	ACRS Staff
	J.G. STAMPELOS	ACRS Staff
	R.K. HOEFLING	NRC Staff Counsel (OELD)
	J.M. CUTCHIN	NRC Staff Counsel (OELD)

ENCLOSURE 2

CONCLUSIONS REACHED BY PWR VENDORS IN RESPONSE TO BULLETINS 79-05C AND 79-06C

	BREAK LOCATION	BREAK SIZE	MAXIMUM AVAILABLE TIME FOR PUMP TRIP	EFFECT OF CONTINUOUS PUMP OPERATION	EFFECT OF TRIPPING ONE PUMP IN EACH LOOP
B&W	RESULTS NOT SENSITIVE DUE TO HOMOGENEOUS MODELING ASSUMPTION	LIMITING BREAK SIZE ABOUT 0.02 - 0.2FT^2	~3 MINUTES (BASED ON PRELIMINARY CALCULATIONS)	ACCEPTABLE CORE COOLING	NO EVALUATION
CE*	FOUND HOT LEG BREAKS LIMITING/ SOME COLD LEG BREAKS COULD EXCEED 2200^{0}F	LIMITING BREAK SIZE ABOUT .02 - .1 FT^2	6 MINUTES AFTER TRIP + SIAS FOR EM ANALYSIS 10 MINUTES AFTER TRIP + SIAS FOR BE ANALYSIS	0.1 FT^2 BREAK IN HOT LEG LEADS TO PCT's $\geq$ 2200^{0}F	ACCEPTABLE CORE COOLING FOR BE ANALYSIS PROVIDED TWO PUMPS TRIPPED WITHIN 5 MINUTES AFTER BREAK
W	COLD LEG BREAKS LIMITING, NO HOT LEG BREAKS ANALYZED RESULTED IN PCT'S $\sim$ 2200^{0}F	LIMITING BREAK SIZE .02-.05 FT^2	10 MINUTES FOR ALL PLANT TYPES (2, 3, 4 LOOPS)	ACCEPTABLE CORE COOLING	NO EVALUATION

*CE ANALYSES PERFORMED FOR PLANTS WITH 200 PSI SIT'S. 1200 PSI HPSI PUMPS. ANALYSES CONSIDERED CONSERVATIVE WRT PLANTS WITH 600 PSI SITS AND/OR HIGHER HEAD HPSI PUMPS.

ENCLOSURE 3

MODEL DIFFERENCES DURING SBLOCA WITH PUMPS RUNNING

Item	MODEL W	CE	B&W	RELAP/MOD-7
Cold Leg Pump Discharge Pipe	Stratified Flow	Homogeneous flow	Homogeneous flow	Heterogeneous flow
Downcomer	Heterogeneous model	Model switches from homogeneous to heterogeneous model when drift velocity criteria met.	Homogeneous flow	Heterogeneous flow
Core	Heterogeneous flow	Heterogeneous flow	Homogeneous flow	Heterogeneous flow
Hot Leg Pipe	Homogeneous flow	Heterogeneous flow CE represents the hot leg with two flow paths. This representation allows counter-current flow in horizonal paths.	Homogeneous flow	Heterogeneous flow. No counter-current flow allowed
Steam Generator Hot Side Tubes	Homogeneous flow	Drift flux model - allows liquid fallback to hot leg if possible	Homogeneous flow	Heterogeneous flo no vertical slip/ fluid runback to hot leg
Steam Generator Cold Side Tubes	Homogeneous flow	Homogeneous flow	Homogeneous flow	Heterogeneous flo no vertical slip
Cold Leg Loop Seal (suction pipe)	Homogeneous flow	Homogeneous flow	Homogeneous flow	Homogeneous flow

Model/Method	W	CE	B&W	EG&G Idaho
ECC Injection	No injection assumed in broken loop for cold leg breaks	No spillage assumed for hot leg breaks - no injection assumed in broken loop for cold leg breaks	~ 30% spillage of water injected in broken loop for cold leg breaks	Consistent with vendor assumptions
ECC Injection Location	Downcomer/lower plenum node (cold leg by design)	Downcomer (cold leg by design)	Cold Leg (cold leg by design)	W - upper downcor CE - cold leg B&W - cold leg
Quench Behavior during Recovery	No carryover accounted for	No carryover accounted for	No carryover accounted for	No carryover accounted for
Steam Super-Heat Calculation	Superheating considered (description proprietary)	12 axial coolant nodes in core. Superheating of each node allowed	No superheat calculated due to single control volume model of core. All core heat added to liquid phase. Separate heat-up model calculates superheat but uses CRAFT mixture level.	3 axial coolant nodes in core. Superheating of each node allowed.
Core fluid quality	Thermodynamic equilibrium assumed - actual quality not calculated	Thermodynamic equilibrium assumed - actual quality not calculated	Thermodynamic equilibrium assumed - actual quality not calculated	Thermodynamic equilibrium assumed - actual quality not calculated

ENCLOSURE 4

RCP CRITERIA PROPOSED
OR
IN-PLACE AT PLANTS

NRC CRITERIA

A. Upon reactor trip and initiation of HPI caused by low reactor coolant system pressure, immediately trip all operating reactor coolant pumps.

B. Two licensed operators.

WESTINGHOUSE

A. Westinghouse proposed criteria is that reactor coolant pumps be tripped on low reactor coolant pressure of 1250 psig after verification of high head safety injection.

B. Responses from licensees are under review - most adopt NRC criteria.

COMBUSTION ENGINEERING

A. Stop two reactor coolant pumps, one in each loop after it has been verified that the rods have been inserted fully for five seconds. If this action has not been completed within the first five minutes after SIAS, all reactor coolant pumps must be stopped within 10 minutes after SIAS.

B. Responses from licensees are under review - some adopt NRC criteria.

BABCOCK & WILCOX

A. B&W proposed criteria is that reactor coolant pumps be tripped on initiation of HPI caused by low reactor coolant system pressure.

B. Licensees are currently using NRC criteria*.

*Most recent proposals for future automatic pump trip have the signal from safety injection only (not low pressure or current).

ENCLOSURE 5

HPI TERMINATION CRITERIA PROPOSED OR INPLACE AT PLANTS

NRC CRITERIA

Operating procedures currently, or are revised to, specify that if the high pressure injection (HPI) system has been automatically actuated because of low pressure condition, it must remain in operation until either:

(1) Both low pressure injection (LPI) pumps are in operation and flowing at a rate in excess of 1000 gpm each and the situation has been stable for 20 minutes, or

(2) The HPI system has been in operation for 20 minutes*, and all hot and cold leg temperatures are at least 50 degrees below the saturation temperature for the existing RCS pressure. If 50 degrees subcooling cannot be maintained after HPI cutoff, the HPI shall be reactivated. The degree of subcooling beyond 50 degrees F and the length of time HPI is in operation shall be limited by the pressure/temperature considerations for the vessel integrity.

BABCOCK & WILCOX

"A. The LPI System is in operation and flowing at a rate in excess of 1000 gpm in each line and the situation has been stable for 20 minutes.

or

B. All hot and cold leg temperatures are at least 50^{o} below the saturation temperature for the existing RCS pressure, the hot leg temperatures are not more than 50^{o} hotter than the secondary side saturation temperature, and the action is necessary to prevent the indicated pressurizer level from going off-scale high. If 50^{o} subcooling cannot be maintained, the HPI shall be reactivated. The degree of subcooling beyond 50^{o} and the length of time HPI is in operation shall be limited by the pressure/temperature considerations for the vessel integrity."

*Current staff view is that this time period should be deleted (see Table 6)

C. All licensees have adopted these criteria, for the most part.

WESTINGHOUSE - (UNDER REVIEW)

The criteria proposed by W are as follows:

"In the event of a spurious safety injection signal, the sequence of reactor trip, turbine trip and safeguards actuation will occur.

The operator must assume that the safety injection signal is non-spurious unless the following are exhibited:

a. Normal readings for containment temperature, pressure, radiation and recirculation sump level AND

b. Normal readings for auxiliary building radiation and ventilation monitoring AND

c. Normal readings for steam generator blowdown and condenser air ejector radiation AND

d. All steam generators exhibit normal pressure and water level following reactor trip and safety injection actuation (similar to a reactor trip from normal conditions).

IF all of the symptoms a through d above are met, THEN secure Safety Injection when the following are exhibited:

a. Reactor coolant pressure is greater than 2000 psig and increasing AND

b. Pressurizer water level is greater than 50% of span AND

c. Water level in at least one steam generator is in the narrow range span, or in the wide range span at a level sufficient to assure that the U-tubes are covered."

COMBUSTION ENGINEERING - (UNDER REVIEW)

"After any SIAS, operate the SIS for at least 20 minutes and until RCS hot and cold temperatures are at least 50°F below the saturation temperature for the RCS pressure unless the cause of the SIAS has been verified to be an inadvertent actuation. If 50° subcooling cannot be maintained after the system has been stopped, the high pressure injection system must be restarted."

ENCLOSURE 6

STAFF CALCULATIONS FOR PWR VENDORS

PWR VENDOR	BREAK SIZE	BREAK LOCATION	RC PUMPS TRIPPED	FLUID MODEL ASSUMPTIONS
WESTINGHOUSE	4 INCH DIAMETER	COLD LEG	AT REACTOR SCRAM	HETEROGENEOUS
	4 INCH DIAMETER	COLD LEG	NOT TRIPPED	HOMOGENEOUS (BEFORE TRIP / AFTER TRIP)
	4 INCH DIAMETER	COLD LEG	AT 511 SECONDS (WORST CASE)	HOMOGENEOUS/HETEROGENEOUS
	4 INCH DIAMETER	COLD LEG	AT 760 SECONDS	HOMOGENEOUS/HETEROGENEOUS
	1 INCH DIAMETER	COLD LEG	AT REACTOR SCRAM	HETEROGENEOUS
	1/2 INCH DIAMETER	COLD LEG	AT REACTOR SCRAM	HETEROGENEOUS
	1 STUCK PORV	PRESSURIZER	AT REACTOR SCRAM	HETEROGENEOUS
COMBUSTION ENGINEERING	0.1 SQUARE FEET	COLD LEG	AT REACTOR SCRAM	HETEROGENEOUS
	0.02 SQUARE FEET	COLD LEG	AT REACTOR SCRAM	HETEROGENEOUS
	1 STUCK PORV	PRESSURIZER	AT REACTOR SCRAM	HETEROGENEOUS
	2 STUCK PORV'S	PRESSURIZER	AT REACTOR SCRAM	HETEROGENEOUS
BABCOCK & WILCOX	0.1 SQUARE FEET	COLD LEG	AT REACTOR SCRAM	HETEROGENEOUS
	0.07 SQUARE FEET	COLD LEG	AT REACTOR SCRAM	HETEROGENEOUS
	1 STUCK PORV	PRESSURIZER	AT REACTOR SCRAM	HETEROGENEOUS

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