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EVALUATION OF ALTERNATE COOLING SYSTEMS FOR STEAM GENERATORS

Attached are general comments and questions developed by the NRR duty teams on alternate cooling systems. This material was developed based on a review of the information received to date from the site. Recognizing that plans have not been finalized and details are not yet available, the teams have tried to provide comments that are generally applicable to whatever schemes are finally selected.

We have no current plans to provide further comments on this subject until such time as more detailed or finalized information is received or a specific request for further duty team review is made. Duty team members are ready to discuss the attached material if such discussion is desired.

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Team A Coordinator

Attachment:
As stated

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A. Evaluation of Alternate Cooling Systems for Steam Generators

1.0 Introduction

Alternate cooling systems on the secondary side of the steam generators have been proposed to facilitate cooldown of the TMI-2 plant to about 100°F. All of these schemes utilize a water-solid secondary system and remove heat from the steam generator by forced convection rather than boiling. Short-term (low pressure systems) and long-term (high pressure systems) schemes were proposed with special emphasis on the steam generator "B" loop which has a potential primary-to-secondary leak and/or radioactivity in the shell side water.

2.0 General

All of the schemes are connected to the existing steam and feedwater lines. The connection on the steam line was downstream of the main steam isolation valve. However, the latest revision showed connections upstream of the main steam isolation valve for the short term fixes. The connections should be made downstream. This provides isolation capability in the event of a major primary-to-secondary leak in the steam generator. The line connecting the alternate cooling system to the main steam line should have a pressure rating equal to the steam line up to the first isolation valve to provide redundant isolation capability. Lines connecting two closed isolation valves should have small relief valves to preclude overpressurization by thermal expansion of the fluid trapped between the valves. The connections of the alternate systems on the feedwater side are upstream of existing check valves and feedwater isolation valves which provide redundant isolation capability between the steam generator and the cooling system.

Because the short-term schemes have low pressure components, the primary system pressure should be kept at or below the most limiting secondary system pressure limit to preclude a small LOCA outside of containment. Alarms and procedures should be provided for isolating the low pressure cooling system and venting the steam generator if the primary system pressure exceeds the secondary system limit.

Because the cooling schemes utilize existing steam and feedwater piping, all alternate flow paths in this piping should be isolated and secured to preclude spurious or inadvertent actuation of these alternate paths. Also, difficulty with high feedwater flow resistance can be reduced by removing non-operating pump impellers.

The auxiliary feedwater pumps should be available at all times to provide backup feedwater flow in the event of failure of cooling systems to both steam generators. The pumps should be aligned to a filled condensate storage tank with an alternate source (e.g., fire water, river water) available. We are concerned about flooding out the redundant cooling systems and the auxiliary feedwater system in the event of a major leak in one of the cooling systems. A piping layout study and structural modifications should be performed to preclude flooding of this equipment.

With regard to OTSG "A" short-term proposal, a referred flow control location is downstream of OSTG "A". Control at the pump discharge would be sluggish. Provisions should be made for the operator to identify the specific types of failures to aid in his decision process of the next course of action. For example, should CO-V68 fail closed, could other portions of the secondary side fill up and be overpressurized?

It is noted that the OTSG "A" proposal utilizes the condenser as the means of heat removal. It is our recommendation that a more positive and simpler means of heat removal exist with an additional Westinghouse skid to be implemented on OTSG "A" for both short and long term. The condenser is always available to be used as a backup to the proposed heat exchanger(s). A positive aspect of the skid concept is that a standby power source can more easily accommodate a loss of offsite power.

Also, it is our observation that the overall evolution should proceed as follows:

A. While steaming on OTSG "A" (current status), install DHR system on OTSG "B".

B. Test and operate OTSG "B" DHR system.

C. Secure OTSG "A" and confirm OTSG "B" continued heat removal capability.

D. While water solid on OTSG "B", install DHR system on OTSG "A".

E. Test and operate OTSG "A" DHR system with OTSG "B" DHR system.

F. Install DHR third train on primary side noting the various precautions enclosed.

B. Decay Heat Removal Third Train

A major concern with regard to this installation is that the existing DHR system is undergoing a major modification. Faulty installation procedures or faulty design could reduce the availability of the existing DHR. Since there is no immediate need for the third train, the recommendation is that the installation not proceed without a thorough QA of the proposed installation (including hydro testing), and a high confidence that compromises are minimal.

Specific concerns related to the proposed installation include probable debris in the DHR drop line during initial operation, either from the welding operation or from the primary system when opened. Damage to the DHR pumps or the ability to isolate the drop line could result. It is recommended that filters be used to catch this expected debris when the line is opened. Provisions should exist to bypass the filters if needed. The existing DHR pumps should not be used until flow has been filtered for a reasonable period by the skid mounted system.

It is recognized that pump and valve seals could suffer radiation damage. While it is true that one train operating at a time could extend the time of DHR operation before seal failure, if the expected radiation damage is fairly quick, it would not be meaningful to add a third train with the same weakness.

To further minimize the potential for a LOCA outside containment, pressure relief for the third train, similar to the existing DHR system, should be provided to handle potential overpressure problems...both from such events as inadvertant actuation of a makeup pump, or from possible thermal expansion of isolated water legs between isolation valves. Primary side pressure control should be a consideration when sizing the relief valve. If the design pressure capability is the same as the existing DHR, it is possible that the current overpressure protection is adequate (RV and auto valve closure inside containment)

A concern exists that trapped gas or steam from the primary system hot leg could be entrained into the suction of the DHR pumps causing damaging cavitation and/or water hammer. Provisions should be made if possible (surge tank?) to lessen these effects or, as a minimum, pump status should be monitored closely for excessive cavitation and vibration. Reduced flow due to air trapped in the pump casing could be precluded by the installation of a remote casing vent piped to waste.

With regard to the Decay Heat Closed Cooling Water System, provisions should be made for makeup capability to the decay heat closed water surge tank for expected seal and packing leaks. Also, surge tank level indication should be available to provide continuous indication of adequate water.

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The operating capability of the heat exchangers should be available to the operator as well as provisions for accommodating fouled heat exchangers. Tandum connections for future exchanger additions should be considered.

Other points which were not discussed in existing documentation include provisions for flow regulation, accelerometers to measure unacceptable DHR pump vibration, and long-term flooding and weather protection if exposed or if in areas with other piping.

The discussed correlation of DHR ΔT to core ΔT should consider the effects of expected core blockage and reverse flow with regard to interpretation of the value observed.

C. Added Failure Considerations

1. Condenser Leak to Turbine Building

A leak to the turbine building may flood out the condensate pumps. Prolonged leakage would drain water from the steam generator thereby degrading heat transfer from the primary to secondary system. If the level in the condenser is lowered sufficiently, the condensate pump may cavitate. As long as the three water-tight openings between the turbine building and the control building at the 281-foot level are secure, flooding should not affect "safety-related" equipment -- in particular the auxiliary feedwater pumps.

If the leak cannot be isolated, the auxiliary feedwater pumps should be started and their flow injected into the steam generator. Chillers will be required for auxiliary feedwater flow if the condensate storage tank bulk temperature is not sufficiently cold to reduce primary temperatures. Should the condensate storage tank be exhausted, some alternate source (e.g., fire water, river water, etc.) must be supplied. See also the discussion of item 3.

Proper alignment of the auxiliary feedwater pumps should be verified. Alarms that annunciate when any of the three water-tight openings are ajar should be verified. There is no alarm for water on the floor of the turbine building. Condenser and steam generator water level should be monitored. If the condenser is not designed for water-solid operation, installation of a pressure gauge on the condenser should be considered.

2. Leak to or from Circulating Water System

A leak from the circulating water system (which normally supplies tubeside coolant to the condenser) into the condenser may overpressurize the condenser by raising the hotwell level above the bottom of the condenser tube sheet. If the leak were unchecked, it could possibly drive the secondary system water solid.

Leakage from the condenser to the circulating water system would be less limiting than Section C. 1 above, since it would not flood any equipment and would be alarmed on low hotwell level. Also, the hotwell should be at a lower pressure than the circulating water system.

3. Condensate Pump Fails with no Restart of Other Condensate Pumps

The operator would turn on one or two auxiliary feedwater pumps which draw from the condensate storage tank and inject into the steam generator. There is a line from the hotwell back to the condensate storage tank to complete the loop. A new pump could be tapped into this line if accessibility to condensate lines from the hotwell is questionable (i.e., flooding).

4. Hotwell Level Control Fails

The level of water in the secondary system would fall as the condensate is diverted to the condensate storage tank. This would degrade heat transfer. The operator would manually override the level control or would isolate the failed valves and use one of several alternate paths.

Monitor condensate storage tank level.

5. Feedwater Heater Bypass Valve Closes

It is assumed that to reduce the pressure drop, condensate flow would be bypassed around the feedwater heaters. Should a bypass valve fail closed, flow to the steam generator would stop. The operator would become cognizant of this event by observing increasing primary temperature and no flow indication on feedwater flow meters. The operator would either redirect the flow through the bypassed heater or would operate the auxiliary feedwater system.

6. Feedwater Pump Locks in Position

This would increase the flow resistance to the steam generator, thereby reducing flow. The operator would either open the feedwater flow control valve wider, start an additional condensate pump, start an auxiliary feedwater pump, or remove the impeller.

7. Inadvertent Startup of an Auxiliary Feedwater Pump

The major concern is potential overpressure of secondary components due to the higher discharge head of these pumps.

8. Feedwater Flow Control Failure

A failure closed of the flow control valve would result in a primary side temperature rise due to a partial loss of heat sink. Immediate corrective action would be to use the parallel flow control valve or, if not available, inject feedwater in the upper header path. Condensate pump discharge pressure should be sufficient for the upper header. If the initial flow path was through the upper injection location, then loss of flow control would require returning to the normal feedwater path (lower injection location), with a possible reduction in natural circulation capability on primary side of steam generator.

A failure open of the flow control valve would result in an excessive cooldown rate and possible overfilling of the once-through steam generator if still steaming. Immediate action is to isolate the failed open valve using the downstream isolation valve (FW-V17A or FW-V17B). The alternate injection path could then be used; or the parallel startup valves.

9. Loss of Condenser Vacuum

The secondary system would lose its primary heat sink and primary and secondary system pressure would increase. If the steam generator has no leaking tubes, the steam generator could be drained partially and steaming resumed with steam dumped via the atmospheric steam dump valves. It also may be possible to jury-rig the secondary system to pump river water through the steam generator and back to the river. If the steam generator has leaking tubes, it may be possible to send water from the condensate storage tank or hotwell to the spent fuel pool where it would be cooled. Then the cooled water could be pumped back (via a fire hose) to the condensate storage tank or the hotwell. The cooled water would then be pumped to the OTSG using the existing feedwater flow path.

10. Loss of Offsite Power with Diesel Failure

If offsite power is lost and the diesel generators fail to operate, all plant AC electrical equipment will be out of service. Cooling of the reactor may be conducted only be means of natural circulation.

Water for the secondary system will have to be provided from an auxiliary source. It will be necessary to provide pumps and/or electrical power through other means. One way would be to station auxiliary gasoline, diesel or DC-powered pumps, such as those available on fire trucks, on the site. Flexible hoses and connections must be available to permit withdrawal of water from the condenser hotwell and discharge into the steam generator. In addition, pumps are required to circulate water through the tubes in the condenser, into the cooling towers, and return, as the heat sink for the plant, with another pump providing makeup water to the circulating system from the river.

An alternate method would be to provide steam to the turbine-driven emergency feedwater pump to maintain cooling water through the steam generator. This pump could draw water directly from the river, pump it into the steam generator where it could be returned to the river continually. Since this method uses the river as the heat sink, cooling towers and the circulating water systems are not required.

Note that continuous monitoring of the water returned to the river is required to detect radioactivity which may result if any of the steam generator tubes start to leak. If this occurs, the unused steam generator will have to be used for cooling the primary system. In the event both steam generators start to leak, the secondary system -- that containing the steam generators -- will have to be kept as a closed system and a path to the ultimate sink will have to be provided via the circulating water system.

11. Loss of Control Air

Several control valves currently in the feedwater flow path are air operated. Since a flow control capability is of importance to the rate of heat removal, it is recommended that these throttling valves have the capability for hookups of portable air bottles for use until air can be restored. Of particular interest are valves which fail closed on loss of air.

QUESTIONS WITH REGARD TO

GPU MEMO APRIL 10, 1979

The enclosed questions for the secondary side cooldown cover areas which were not clear in the 4/10 GPU memo. Specific concerns can be deduced from the thrust of many questions and, as such, could be of some benefit.

1. What is the elevation at the condenser of the makeup line and the turbine bypass line? Identify makeup control valve.

2. Why can't flow be made throttleable in this line?

3. NOT USED

4. What is "L.A. water" on Figure 1?

5. Provide a list of each new modification to existing system.

6. Loss of condenser vac - How much cooler is the condensate discharge expected to be compared to the hotwell? Describe complete loop after loss of vac. Is this a 6-in. line as shown on DWG. 2005?

7. Dynamic effects of flashing in the condenser injection line?

8. What is meant by "Provisions shall be made for slow, controlled filling...?"

9. Can turbine bypass line be used if loss of the "condenser makeup line" occurs?

10. Is condensate pump discharge head sufficient to push water through system when water solid? If condensate pump cannot, will two condensate pumps? Will you need booster pumps? What of fouling of lines? Are booster pumps on diesels now? If not, why not?

11. Won't the makeup control valve need to be modulated to maintain hotwell level, steam line pressure and level, and pressure drop to the condenser from the steam line, rather than locked in position?

12. Won't the flow to penetration 49 in the condenser through the makeup line be partially diverted and fill up the condensate storage tank rather than recirculating to the hotwell?

13. How does hooking into the condenser makeup line effect the ability to makeup to the condenser via the condenser storage tank?

14. What path will be used to recirculate condensate if condenser vacuum is lost? Why not use turbine exhaust hood temperature control lines?

15. There does not appear to be any bypass around heaters SC-CIA to 1C per drawing 2018. Is this to be a new line? The 20-inch line with valve SC-V126 in it will, when open, appears to send flow from the discharge of the pump back through the coolers bypassing the steam generator, rather than the intended path of bypassing the secondary services coolers.

16. Are diesels protected against lightening?

17. What are flooding problems for closed loop systems in turbine building? On new valves?

18. What is the effect of high river water temperatures on natural circulation (long term)?

19. For the long term, river water heat exchanger must be designed for maximum operating inlet (from river) temperature of 95°F (not 85°F) since Susquehanna River temperatures have in recent years approached 90°F.

20. Long-term cooling heat exchangers must also be designed for 95°F inlet river water.

21. Discuss recirculation pumps on condenser which take water from hotwell and spray on tubes (for loss of vacuum).

22. How is makeup to the closed cycle provided for such contingencies as leakage?

23. Will discharge head of closed cooling pumps be sufficient?

24. What are the "<u>provisions</u>" to control filling the SG too quickly?

25. Section 2.4 - is the flow quoted (3000 gpm) for both SGs? ...why is river water flow different in each scheme? ...Maximum SG outlet temperature is 200°F. What is lineup for 230°F? ...200°F?

26. How is the manual valve to be installed at the pump discharge controlled? What instrumentation is available?

27. Do we have sufficient range on condenser water level?

28. Figure 1 - Main Steam Line - MS-V4B/7B should be MS-V4A/7A.

29. For the loss of offsite power situation what precautions are taken to prevent fouling of condenser tubes?

30. What precautions are taken to prevent fouling of the secondary services cooler when using river water?

31. For loss of offsite power D/G power will supply the discharge valve of the circulating water pumps. Is this valve used for control?

32. What is the range and accuracy of the following instrumentation (emphasis on proposed new operating requirements such as low FW flow, etc.):

a. FW flow, temperature
b. SG level, SG outlet pressure
c. Main steam temperature
d. Condenser level.

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