
Issue 31: Natural Circulation Cooldown

DESCRIPTION

Historical Background

This issue corresponds to AEOD recommendation 4 highlighted in an AEOD memorandum¹ to NRR in December 1980. The AEOD recommendation resulted from a natural circulation cooldown event from full power at St. Lucie Unit No. 1 on June 11, 1980. A cooldown via natural circulation was required because the main coolant pumps normally used for cooling the reactor became unavailable due to a loss of cooling water to their seals (see Issue 65, "Probability of Core-melt Due to Component Cooling Water System Failures"). The reactor was shut down and a cooldown via natural circulation was initiated. The cooldown via natural circulation was successfully completed but with complicating conditions developing. These conditions included drawing a steam bubble in the vessel head. Level indication in the pressurizer, a key parameter to monitor during cooldown in this mode, became unstable as a result. This condition also masked a concurrent loss of coolant from the primary system to a water storage tank through leaking valves. AEOD recommended that guidance be developed such that operators are aware of what conditions will lead to voids in the primary system other than the pressurizer, how to recognize the presence of voids, and how to either cooldown the RCS with voids or collapse the voids.

The staff response² to the AEOD recommendation on natural circulation cooldown provided AEOD with information from staff reviews already in progress. These reviews included Multiplant Action (MPA) No. B-66 and Item II.K.2(17) of the TMI Action Plan.³ The staff response also suggested that AEOD's final report and recommendations include a summary of the ongoing NRR actions related to natural circulation cooldown.

The staff felt that such a summary section in AEOD's final report would dispell possible misinterpretations that natural circulation concerns were newly-identified phenomena. An update of staff actions related to further developments in operator guidance is provided herein.

Safety Significance

Development of a void (steam bubble) in the reactor vessel could interrupt natural circulation during cooldown if the void extends down to the vessel hot leg piping. Drawing and collapsing a steam bubble in the head of the reactor vessel during the cooldown requires operator awareness of the symptomatic RCS responses because the event upsets the instrumentation used to confirm that a stable condition exists in the primary system. At such times, it also becomes difficult to reliably monitor the inventory of reactor coolant. A significant loss of primary coolant from a break in the primary system can be masked for extended periods. The core, however, is ultimately protected from loss of coolant by the shutdown cooling system (SDCS) and the emergency core cooling system (ECCS) if the operator is not deceived by unreliable water level indications.

Possible Solution

In all PWRs, cooldown of the reactor system can be managed with natural circulation of the primary coolant in the subcooled mode. Natural circulation and continued heat transfer from the reactor system to the steam generators occur as a consequence of the higher elevation of the steam generator relative to the reactor. The temperature differential between the reactor coolant exit line (hot leg) and the entrance

¹ Memorandum for H. Denton from C. Michelson, "AEOD Report on the St. Lucie Natural Circulation Cooldown on June 11, 1980," December 24, 1980. [8101120011]

² Memorandum for C. Michelson from H. Denton, "Report on St. Lucie Natural Circulation Cooldown," April 6, 1981. [8104150248]

³ NUREG-0737, "Clarification of TMI Action Plan Requirements," U.S. Nuclear Regulatory Commission, November 1980, (Supplement 1) January 1983.

line from the steam generators (cold leg) sustains natural circulation at flow rates up to 2% to 3% of full power flows at the start of the cooldown and at decreasing flow rates as the cooldown progresses.

To improve the operator recognition of symptomatic reactor response, less ambiguous information signals should be provided during cooldown. This improved instrumentation for detection of inadequate core cooling is the focus of TMI Action Plan Item II.F.2 of NUREG-0737.⁴ On December 10, 1983, Generic Letter 82-28⁵ was sent to all licensees of operating Westinghouse and Combustion Engineering PWRs (except ANO-1 Unit 2 and SONGS-1, 2). The above excepted reactors and all B&W reactors were sent Orders on the same date. The purpose of the generic letter was to request detailed schedules for engineering, procurement, and installation of equipment to meet Item II.F.2. The Orders to the B&W plants (and other plants stated above) called for the submittal of plans for implementation of the Item II.F.2 requirements or those requirements as specified in the Orders. As specified in Item II.F.2, guidelines for use of the additional instrumentation, analyses used to develop the procedures, and how these procedures will be implemented are required.

Staff review of the emergency operating procedures, which will be affected by the additional instrumentation, will be performed under Item I.C.1 of NUREG-0737.⁶ Generic Letter 82-33,⁷ issued on December 17, 1983, requested all licensees and holders of construction permits to submit their schedules for implementation of the affected requirements.

CONCLUSION

This issue (AEOD recommendation) that operation guidance be developed to deal with potential complications (voids in primary system) during natural circulation cooldown was already under staff review. Development

of the guidelines resulting from these staff reviews are part of Item I.C.1 of NUREG-0737.⁸ Implementation of the guidelines will be in accordance with Generic Letter 82-33.⁹ In the interim, IE Circular No. 80-15¹⁰ recommends specific licensee actions dealing with operator awareness and operator procedures. In summary, this issue is considered part of Item I.C.1 of NUREG-0737.¹¹

⁴ NUREG-0737, "Clarification of TMI Action Plan Requirements," U.S. Nuclear Regulatory Commission, November 1980, (Supplement 1) January 1983.

⁵ Letter to All Licensees of Operating Westinghouse and CE PWRs (Except Arkansas Nuclear One—Unit 2 and San Onofre Units 2 and 3) from U.S. Nuclear Regulatory Commission, "Inadequate Core Cooling Instrumentation System (Generic Letter No. 82-28)," December 10, 1982. [\[ML031210719\]](#)

⁶ NUREG-0737, "Clarification of TMI Action Plan Requirements," U.S. Nuclear Regulatory Commission, November 1980, (Supplement 1) January 1983.

⁷ Letter to All Licensees of Operating Reactors, Applicants for Operating Licenses, and Holders of Construction Permits from U.S. Nuclear Regulatory Commission, "Supplement 1 to NUREG-0737, Requirements for Emergency Response Capability (Generic Letter No. 82-33)," December 17, 1982. [\[ML031080548\]](#)

⁸ NUREG-0737, "Clarification of TMI Action Plan Requirements," U.S. Nuclear Regulatory Commission, November 1980, (Supplement 1) January 1983.

⁹ Letter to All Licensees of Operating Reactors, Applicants for Operating Licenses, and Holders of Construction Permits from U.S. Nuclear Regulatory Commission, "Supplement 1 to NUREG-0737, Requirements for Emergency Response Capability (Generic Letter No. 82-33)," December 17, 1982. [\[ML031080548\]](#)

¹⁰ IE Circular 80-15, "Loss of Reactor Coolant Pump Cooling and Natural Circulation Cooldown," U.S. Nuclear Regulatory Commission, June 20, 1980. [\[ML080310701\]](#)

¹¹ NUREG-0737, "Clarification of TMI Action Plan Requirements," U.S. Nuclear Regulatory Commission, November 1980, (Supplement 1) January 1983.

