April 14, 1994

MEMORANDUM FOR: Jared S. Wermiel, Chief
Instrumentation & Control Branch
Division of Reactor Controls & Human Factors

FROM: Timothy E. Collins, Acting Chief
Reactor Systems Branch
Division of Systems Safety & Analysis

SUBJECT: REVIEW OF BWR OWNERS' GROUP LICENSING TOPICAL REPORT NEDO-32291 (TAC NO. M83089)

Enclosed is the Reactor Systems Branch input to the Safety Evaluation Report being prepared by your Branch to review the BWR Owners' Group Licensing Topical Report, NEDO-32291, "System Analyses for Elimination of Selected Response Time Testing Requirements". It is my understanding that you will use this input for developing the overall staff safety evaluation for this license amendment.

/s/

Timothy E. Collins, Acting Chief
Reactor Systems Branch
Division of Systems Safety & Analysis

Enclosure:
As stated

cc: M. Virgilio

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504-2882

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ENCLOSURE

SAFETY IMPACT OF 5 SECONDS DELAY IN TRIP FUNCTIONS SELECTED FOR RTT ELIMINATION

This section provides an assessment of a delayed instrumentation response on the order of 5 seconds for the trip functions selected for RTT elimination. The following paragraphs present the trip functions selected for elimination, the purpose of the trip functions, and an evaluation of the impact of 5 second trip delay on reactor safety.

1) System: Reactor Protection System (RPS)
   Trip Function: Reactor Water Level 3

Purpose of Trip:

A low level trip indicates that the water level in the reactor vessel has dropped, and a continued decrease in level would cause steam to bypass the seal skirts of the separators or dryers. Generally, this is indicative of a problem with the level control system or reactor feedwater system. Under these circumstances, reactor scram is initiated at this low level by a RPS trip to substantially reduce steam production. If the Residual Heat Removal (RHR) system is operating in the shutdown cooling mode, the isolation valves on the RHR system suction piping are also closed to prevent further loss of vessel water inventory via that path. This low level trip also serves as a permissive signal for initiation of the Automatic Depressurization System (ADS) to avoid inadvertent activation of the low pressure Emergency Core

Cooling Systems (ECCS) on a spurious high drywell pressure signal. This low level signal only provides confirmation that the reactor vessel water level is low; ADS is not actually activated until the Reactor Water Level 1 signal is received and other logic also indicates the need for depressurization.

Effect of Trip Delay:

Current response time Technical Specification (T/S) requirements for this trip range from 1.03 to 1.05 seconds. The design basis event for the Level 3 scram is the Loss of Feedwater Event (LOFW). The Level 3 scram may occur during other events but it would be a backup function after other scram signals have occurred. For example, in the postulated LOCA, the primary scram signal is the high drywell pressure signal. The LOFW is a non-limiting event for the determination of the core thermal limits. Therefore, a 5 second delay in the scram actuation would not affect plant thermal limits or fuel integrity. The core cooling function for the LOFW will still be provided by High Pressure Coolant Injection/High Pressure Core Spray (HPCI/HPCS) and Reactor Core Isolation Cooling (RCIC) systems which will initiate on Level 2 which is much lower than Level 3. A 5 second delay in scram would neither affect the capability of these systems to initiate nor to provide core cooling function.

2) System: Reactor Protection System

   Trip Function: Reactor Water Level 8

Purpose of Trip:

A high level trip signal indicates that the water level in the reactor vessel has increased. Protective actions are initiated to prevent further vessel overfill. The trip signal is selected low enough to protect the turbine against gross carryover of moisture and to provide adequate core thermal margins during abnormal events. This signal initiates the closure of main turbine stop valves and trips the reactor feedwater pumps. For BWR/6 plants, a reactor scram is initiated by a RPS trip. For BWR/2 to 5 plants, the reactor scram is initiated by the turbine stop valves fast closure on high water level. The purpose of this RPS trip is to minimize the effect on core thermal margins from the resulting turbine trip caused by the high water level signal.

Effect of Trip Delay:

Current response time T/S requirements for this trip range from 1.03 to 1.05 seconds. The design basis event for the Level 8 scram is the Feedwater Controller Failure (FWCF). The reactor water level is estimated to increase by less than 2 inches. This increase in reactor water level would not result in cold water intrusion in the main steam lines (MSLs) as the level 8 is still several feet below the MSL elevation. Power rise and approach to thermal limits for FWCF are relatively slow and would not be significantly affected by the delay (of 5 seconds) in the Level 8 trip. A trip on high power level would act before exceeding thermal limits. Therefore, the 5 second delay in the Reactor Water Level 8 trip does not affect plant safety.

3) System: Reactor Protection System

Trip Function: Reactor High Steam Dome Pressure

Purpose of Trip:

The reactor vessel pressure must be maintained within the limits prescribed by the ASME Boiler & Pressure Vessel Code, Section III. If pressure increases to a preset value, a trip signal to the RPS will initiate scram in order to shutdown nuclear heat generation. Reactor scram is initiated by high pressure if other signals have failed to scram the reactor to limit the effect of increased pressure on reactor power and provide assurance that reactor vessel integrity will be maintained within emergency limits.

This scram also serves to shutdown the plant for non-design basis events that may involve slightly higher steam flow than the turbine and/or bypass valves can handle. If no other trip occurs first, the high pressure scram will shutdown the unit before initiation of relief valve flow to the suppression pool. An example of this sequence is a Turbine/Generator (T/G) trip at a power level above the bypass capacity, but below the power interlock which activates the T/G trip scram (typically at 5% above the bypass capacity). If the bypass response is normal, the flux scram may be avoided, but the pressure will gradually increase to the pressure scram setpoint.

Effect of Trip Delay:

Current response time T/S requirements for this trip range from 0.33 to 0.55 seconds. The reactor high steam dome pressure is primarily a backup scram signal. The primary scram signals for various pressurization events are the position switches (or other appropriate logic at some plants) for the turbine stop valves or MSIVs, the pressure switches for the turbine control valves, or in some cases, the high neutron flux scram signal. The ASME Boiler and Pressure(upset) Code Section III is 110% of the reactor vessel design pressure or 1375 psig(1.10 x 1250 psig design pressure). The normal margin for pressurization events is 80-100 psi. For a 5 second trip delay the loss of margin will be approximately 10-15 psi, i.e, 65 to 85 psi margin remains (Ref. 2). Under the current ATWS rules, plants can meet the ASME Section III Code Limit of overpressure protection(1500 psig) without taking credit for the high pressure scram. For the non-design basis events, the reactor pressure response is also much slower due to the lower power level. Consequently, the delay would not affect the integrity of the reactor vessel. A 5 second delay in the pressure scram does not affect the core thermal limits for the non-design basis events.

The only exception for the use of the high pressure scram signal is for plants with the Average Power Range Monitor-Rod Block Monitor Technical Specifications (ARTS) implementation. The Minimum Critical Power Ratio (MCPR) and power-dependent Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) were determined by taking credit for the high pressure scram for events which occur at reactor power below the bypass of the turbine trip or generator trip scrams (typically between 30% to 45% of rated power). Given the large operating margin normally available at these low power ranges, a 5 second delay in this scram signal is not likely to affect fuel integrity. **However, plant specific evaluations must be performed for these plants to determine the impact on these power-dependent limits.**

4) System: Isolation Actuation (MSIV Closure)
   Trip Function: Reactor Water Level 1 or 2

Purpose of Trip:

Abnormally low reactor water level is used to generate initiation signals for several functions, one of which is closure of the MSIVs. The signal is at either Level 1 or 2, depending on the plant configuration. Fuel cladding integrity must be assured by the initiation of the ECCS systems. To limit the possibility of off-site release, the MSIVs will be closed at the low water level signals.

Effect of Trip Delay:

The current response time TS requirement for this trip is 1.0 second. Closure of the MSIVs at low reactor water level would occur during events which involves loss of reactor inventory, such as LOFW or LOCA events. However, immediate valve closure is not required for core or plant safety. The reactor would have been scrammed at either Level 2 or 1. The MSIV closure does not affect core cooling. The only purpose of the MSIV closure at low reactor water level during this type of event is to limit the potential increase in the off-site dose. However, at these reactor water levels, no fuel damage is expected and the radioactivity is expected to be limited to the inventory in the steam lines. For MSIV isolation delays caused by reactor water level trip delays, there is no fuel damage and no associated increase in off-site releases (Ref. 2). Therefore, the 5 second delay in the MSIV closure on low reactor water level does not affect plant safety.

5) System: Isolation Actuation (MSIV Closure)
   Trip Function: MSL Radiation High

Purpose of Trip:

MSIV Closure on MSL radiation high signal is provided to prevent the large release of radioactivity to the environment. The protection is provided primarily for events which may result in fuel failures, such as the control rod drop accident (CRDA) or loss of coolant accidents (LOCA).

Effect of Trip Delay:

The current response time TS requirement for this trip is 1.0 second. MSIV closure on high radiation level is required when fuel failure has occurred. For CRDA, fuel failure is limited due to the restriction placed on the rod worth. In response to a staff question, the BWROG stated that the design basis CRDA is detected and mitigated by subsystems of the Neutron Monitoring System, which will initiate a scram within 5 seconds. The MSL radiation monitor response time would not initiate a scram until approximately 10 seconds after the rod drop and this is of little help in mitigating a CRDA. It further stated that the delay in MSIV isolation (Neutron Monitoring System does not isolate MSIVs) of 5 seconds could potentially increase the amount of activity released to the steam lines; however, the off-gas radiation monitors would isolate the off-gas system prior to a significant off-site radioactivity increase (Ref.2). The staff agrees that the off-gas system isolation can be significant in mitigating radioactivity releases. However, for radiation releases which could activate the MSLRM, a 5 seconds delay in MSIV Closure must be demonstrated to be insignificant on a plant specific basis since important factors affecting dose calculations are plant and site dependent. To do this individual licensees must meet either of the following conditions:

1. The licensees may reference NEDO-31400 (Ref.4) in support of their licensing application to remove the MSLRM trips that automatically shut down the reactor and close MSIVs, and that they meet the conditions stated in the staff SER (Ref.3). OR,
2. The licensees must perform a plant specific evaluation to confirm that a 5 seconds delay in MSIV Closure will not result in the violation of licensing bases radiological limits.

For LOCA events, the MSIVs would have been closed on other signals prior to the high radiation signal. Therefore, a 5 second delay in the MSIV closure on MSL high radiation signal does not affect plant safety.

6) System: Isolation Actuation (MSIV Closure)
Trip Function: Main Steam Line Low Pressure

Purpose of Trip:

MSIV closure on low steam line pressure is provided to protect the reactor system during normal power generation (RUN Mode) against transients that could cause uncontrolled depressurization. Protection is provided primarily for a pressure regulator malfunction which results in turbine control and/or bypass valves opening. The MSL low pressure trip setpoint is specified to limit the duration and severity of the depressurization so that vessel thermal stresses (resulting from vessel cooldown rate) remain below the appropriate safety limit and inventory loss is limited to prevent uncovering the core. The setpoint is chosen to be low enough that unnecessary isolation are avoided.

Effect of Trip Delay:

Current response time TS requirements for this trip range from 1.0 to 2.0 seconds. The MSL low pressure trip signal is used primarily to protect the reactor system in case of a pressure regulator malfunction event. This event is not a limiting event for the core thermal limits. The primary concern is the reactor inventory loss and the thermal cyclic effect on the reactor vessel. During this event, the rapid depressurization causes an increase in water level which results in the high water level trip. This in turn initiates a turbine trip and reactor scram. After reactor scram, reactor water level can be maintained by HPCI/HPCS or RCIC systems which are initiated at Level 2. The trip setpoint for many BWRs is approximately 850 psig. GE stress analysis shows that the setpoint could be lowered from 850 psig to 750 psig without affecting vessel integrity. A trip delay of 5 seconds would reduce this pressure margin by approximately 5 to 10 psig (Ref.2). The reactor vessel is designed to accommodate more rapid depressurization than this event. Therefore, a 5 second delay would not affect vessel integrity or plant safety.

7) System: Isolation Actuation (MSIV Closure)
   Trip Function: Main Steam Line Flow High

Purpose of Trip:

MSIV closure on high steam line flow is provided to protect the reactor system against transients or accidents that could cause unexpected increase in steam flow. Protection is provided primarily for a break in the steam line outside the primary containment. Flow restrictors are provided to limit the maximum steam flow to 140% of rated steam flow. The MSL high flow trip setpoint is specified to limit the duration and severity of the high steam flow condition so that any off-site release will remain below the appropriate limit and inventory loss is limited to prevent uncovering the core. The setpoint is chosen to be high enough that unnecessary isolation are avoided.

Effect of Trip Delay:

Current response time TS requirements for this trip range from 0.5 to 1.0 seconds. The MSL high flow is designed primarily to protect against a MSL break outside containment. The high steam flow from the postulated double ended break would result in releasing a large amount of steam and water outside the primary containment. However, fuel failure would not result from this event as the break would be isolated long before the reactor water level has any significant drop. The analysis of this event for older plants assumes a 10 second valve closure time, although the TS requirements for the MSIVs are 3 to 5 seconds. Even with the conservative valve closure time, the off-site release for this event is only a small fraction of the allowable 10CFR100 limits. A 5 second delay in the MSIV closure on high steam flow would still meet the requirements of 10CFR100. Therefore, the 5 second trip delay for this function does not affect plant safety.

8) System: Isolation Actuation

Trip Function: RCIC System

HPCI System (BWR3/4)

HPCS System (BWR 5/6)

RWCU System

RHR Shutdown Cooling/Head Spray

Primary Containment

Secondary Containment

Purpose of Trip:

Depending on this system, this instrumentation is either for high flow or high area temperature. The instrumentation is provided on various systems to protect the reactor system against accidents that could cause unexpected loss of reactor coolant caused primarily by a break or a leak in the process lines outside the primary containment. For the primary and secondary containment, the protection is to prevent release of radioactivity materials to the surrounding environment.

Effect of Trip Delay:

The Isolation Actuation Instrumentation is provided to limit the release of reactor inventory following a break in the system process lines. Each system listed above is connected to the nuclear boiler and penetrates the primary containment. These lines are equipped with an ac and dc powered isolation valve. The design basis evaluation for the reactor inventory release for these lines are based on the assumption that the dc valve has failed and that the plant has lost off-site power. In this case, the ac powered isolation valve cannot close until the onsite emergency diesel generator provides the power for the valve. The delay for the emergency diesel generator is typically between 10 to 13 seconds which is longer than the 5 second delay for the instrumentation. The emergency diesel generator is initiated upon loss of off-site power and is independent of the isolation actuation instrumentation. Therefore, this 5 second delay on isolation actuation does not have any effect on the plant safety.

9) System: Emergency Core Cooling System Actuation

Trip Function: HPCI/HPCS

LPCS

LPCI

Purpose of Trip:

The ECC system is provided to assure adequate core cooling following loss of normal reactor cooling capability. The HPCI/HPCS provides core cooling at high reactor pressure conditions. In case of a LOCA or when the reactor pressure is sufficiently low, the low pressure ECC systems (LPCI or LPCS) initiate to provide core cooling. In the event of a small leak in the primary coolant system where HPCS cannot provide adequate core cooling, the ADS would initiate to depressurize the reactor vessel to allow the low pressure ECC system to provide the necessary core cooling. The typical response time for the ECCS is as shown below

- HPCI/HPCS (27 to 35 seconds)
- LPCS (27 to 43 seconds)
- LPCI (37 to 69 seconds)

Effect of Trip Delay:

The ECC systems are required to mitigate LOCAs. The application of the GE SAFER/GETSR code for BWRs has demonstrated that there is significant safety margin for LOCA events. The realistic peak cladding temperature for the design basis LOCA is 1000°F which is significantly below the 2200°F Peak Cladding Temperature (PCT) limit. The delay in the HPCI/HPCS response time does not have any significant impact on the design basis LOCA because the system is not used as the primary cooling source due to the rapid reactor depressurization. For isolation and small breaks, a 5 second delay in system response has minimal impact since the release of the reactor inventory from the break is significantly reduced. For the design basis LOCA, analysis (Ref. 1) has demonstrated that a 11 second increase in the response time for the core spray system would increase the PCT by approximately 84°F. A 15 second increase in the LPCI response time would increase the PCT by 131°F. The combined effect of a 10 second delay for LPCS and 9 second for LPCI is an increase in the PCT by 137°F, still considerably below the PCT limits. Therefore, a 5 second delay in the ECCS system response time does not affect plant safety.

Based on the discussion of the above mentioned trip functions, and also realizing that within a trip function, redundancy exists in individual channels (e.g., 1 out of 2 twice) and diversity exists in most safety trip functions (e.g., neutron flux, water level, drywell pressure), the staff concludes that a 5 second instrumentation delay is not expected to cause any significant impact on plant safety. However, as discussed in the preceding paragraphs, some of the trip functions will require plant specific analysis to confirm that the 5 second delay will not impact plant safety.

REFERENCE

1. "Basis for Relaxing ECCS Performance Requirements for BWR4s/6s", EPRI, NSAC-131, September 1988.

2. Response to the staff questions by letter from T. Green(BWROG) to P. Loeser(NRC), dated March 16, 1994.

3. Memorandum from L.J.Cunningham, Chief, Reactor Protection Branch, "Removal of Reactor Trip Function of BWR Main Steam Line Radiation Monitor", June 18, 1991.

4. NEDO-31400, "Safety Evaluation of Eliminating the Boiling Water Reactor Main Steam Line Isolation Valve Closure Function and Scram Function of the Main Steam Line Radiation Monitor," May 1987, General Electric Company.