

September 6, 2017

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SUBJECT: SUPPORTING INFORMATION FOR STAFF RECOMMENDATIONS IN
RESPONSE TO EXECUTIVE DIRECTOR FOR OPERATIONS TASKING
IN SEPTEMBER 15, 2016, EXELON BACKFIT APPEAL DECISION

In a memorandum to the Director, Office of Nuclear Reactor Regulation (NRR), dated September 15, 2016, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16246A247), the Executive Director for Operations (EDO) communicated his decision to grant a backfit appeal submitted by Exelon Generation Co., LLC. In his memorandum, the EDO identified two issues that warranted further U.S. Nuclear Regulatory Commission (NRC) consideration. These two issues were: (1) the need to assess the treatment of the underlying technical issue described in the 1993 Westinghouse Nuclear Safety Advisory Letter (NSAL)-93-013 on pressurizer safety valve (PSV) performance after water discharge at pressurized water reactors and (2) given the decision communicated, the positions included in Regulatory Issue Summary (RIS) 2005-29, dated December 14, 2005 (ADAMS Accession No. ML051890212), as well as its proposed Revision 1, should be (re)assessed through the appropriate generic process to ensure they receive appropriate backfit consideration. The technical staff was to inform the EDO within 120 days of how it planned to address those issues.

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The staff's plan was communicated to you in a January 3, 2017, memorandum (ADAMS Accession No. ML16334A188) from the NRR Office Director. The staff also stated in this memorandum that: (1) as part of its re-assessment of the underlying technical issue in NSAL 93-013, the staff would provide documentation of what constitutes acceptable qualification of PSVs for liquid discharge and (2) it would review whether Generic Issue (GI) 70, "Power-Operated Relief Valve [PORV] and Block Valve Reliability," should be re-opened or re-visited.

The staff's efforts in response to the EDO's September 15, 2016, tasking have been completed and the results of these efforts will be communicated to the EDO in a response from the NRR Office Director. This memorandum provides supporting information for the following staff positions, which are to be communicated to the EDO:

1. For new licensing actions which introduce or change the characteristics of subcooled liquid discharge through PSVs, appropriate qualification and testing for liquid discharge of affected PSVs should be required. Licensees with prior approval for liquid discharge through PSVs should not be subject to backfitting of this position.
2. Replace RIS 2005-29 with a new RIS that clarifies applicable staff positions and will be subjected to a Committee to Review Generic Requirements (CRGR) review for backfit considerations.
3. Do not subject GI-70 to further review.

EDO Tasking Item 1: Re-assessment of the underlying technical issue described in Westinghouse NSAL-93-013

The underlying technical issue associated with NSAL-93-013 for the inadvertent operation of emergency core cooling system event is "the PSRVs [Pressurizer Safety Relief Valves]...must be capable of closing after release of subcooled water." In assessing this issue the staff considered: (1) available data concerning whether PSVs will reliably close and reseal following the discharge of subcooled liquid and (2) the safety significance of a PSV failing to close

Safety Significance of the underlying technical issue:

The staff has re-assessed the technical issue and notes that there are a number of strategies that plants have employed in response to NSAL-93-013. The staff is aware that in at least some cases, including the Byron and Braidwood case that was the subject of the backfit appeal, licensees credit PSVs for liquid relief. In the event the PSVs are not demonstrated to reliably close following liquid discharge, the reactor coolant system (RCS) mass addition event could transition into a small break loss-of-coolant accident (LOCA). This represents a transition from a Condition II event to a Condition III event, which violates non-escalation language included in the current licensing bases for many plants. However, the consequences of a failure of a PSV to close are bounded by small break LOCA analyses, and licensees have demonstrated that offsite doses as a result of a small break LOCA are within the regulatory limits and do not adversely impact the health and safety of the public. Although failure to prevent this escalation would increase the frequency of a small break LOCA to beyond that assumed for a Condition III event, the consequences of the event (i.e., offsite dose) should not change.

It is also instructive to consider an important difference between the analytical basis for events and the operational response to mitigating events. Analyses tend to focus on the most limiting scenario which, in this case, could be liquid discharge through the PSVs, whereas procedural responses to this event would not preclude use of operator action to secure the pumps filling the pressurizer or use of the PORVs and associated block valves to provide their intended pressure relief function prior to pressure reaching the relief setpoint of the PSVs. Crediting of PSVs for liquid discharge in response to a reactor coolant system mass addition event assumes that facilities are operating with both block valves closed such that the pressure relieving function of the PORVs is not initially available. This is typically not the case. If both block valves were closed, liquid discharge through PSVs would need to be assumed and unqualified PSVs would, thus, be assumed to fail open in analysis space. However, in reality this eventuality may not always occur and PSV closure would depend on the discharge conditions of the liquid (e.g., degree of subcooling, mass flow rate, duration of the discharge, etc.). Operators would also have to fail to act to secure emergency core cooling system (ECCS) pumps that are filling the pressurizer or fail to open a block valve to allow use of a PORV. Only if the above sequence of events resulted in the most adverse outcomes would a failed open PSV as a result of liquid discharge lead to an unisolable small break LOCA. An assessment of risk was also performed in support of the Byron/Braidwood backfit appeal, which provided insights into the change in risk based on the likelihood of the above scenario. The results showed that the change in risk between the existing condition and a condition where PSVs are not relied on to discharge liquid was very small (i.e., 1.5×10^{-7} per Section 4.5 of the Backfit Appeal Review Panel Report (ADAMS Accession No. ML16236A208)). Also of note, this stuck open PSV small break LOCA is bounded by the design basis small break LOCA.

In evaluating the safety significance of the issue, the staff considered whether the adequate protection exception in the backfit rule was applicable. The fact that the consequences of the technical issue in question are bounded by an existing analyzed event (small break LOCA) and the risk benefit from ensuring PSVs are not relied upon for liquid discharge was shown to be small led the staff to determine that the adequate protection exception could not be applied. The staff also noted that the compliance exception was not applicable. Specifically, as documented in the EDO appeal panel's report for Byron/Braidwood, the various NRC decisions and communications associated with relief valve qualification for liquid discharge in the past were shown to not be consistent enough to represent a known and established standard.

Finally, the staff does not believe that a cost-benefit analysis would demonstrate that costs are justified to impose a backfit in light of the safety benefits of requiring PSV liquid qualification. This determination was informed by information previously discussed in this section, including section 4.5 of the referenced Backfit Appeal Review Panel Report. The staff recognizes that the information provided by the Office of Research in that section of the Report was not a comprehensive study of the issue but views it as generally informative of the level of risk of the issue. It is reasonable to conclude that the safety benefit would not be appreciably greater from a more detailed analysis considering other facilities.

Use of Electric Power Research Institute (EPRI) test results for qualification of PSVs for liquid discharge:

Pressurizer safety valves were designed with the intent of passing steam only. Initial certification testing of the valves in accordance with American Society of Mechanical Engineers (ASME) BPV Code, Section III only considered steam service and in this regard

only assured the ability of a PSV to open at the correct set pressure, to pass the quantity of steam required to limit the overpressure excursion, and subsequently to reclose without leakage. This is a one-time proof-of-design certification requirement prior to a valve receiving an ASME "N-stamp." If a licensee were to later add a credited liquid relief function to the required performance envelope of the valve, it would not be sanctioned by the original ASME BPV, Section III certification and, therefore, the valve may not perform as anticipated. Going forward, licensees who choose to credit PSVs for mitigation of water-solid overpressure events (in addition to steam overpressure events) should require supplier certification testing using both media for newly designed or newly purchased valves.

The staff reviewed the EPRI testing cited by Exelon in the backfit appeal. While a PSV never specifically stuck open during an EPRI water discharge test, the EPRI testing clearly showed the propensity of PSVs to chatter (unstable condition in which the PSV cycles open and closed at several hundred Hz) when subjected to water discharge, which always resulted in galled guiding surfaces and damaged internal parts. Several EPRI water discharge tests were terminated manually at the onset of chatter, so it is unknown how the valve would have ultimately performed. It is also unclear how accurate the EPRI tests are in simulating a particular plant's inadvertent operation of emergency core cooling system (IOECCS) event or other RCS mass addition event, especially in terms of duration of the transient and number of open-close cycles. This same EPRI test data has been cited by other licensees in various past licensing actions in which water discharge through the PSVs was relevant.

While the staff finds that the EPRI test results are not sufficient to demonstrate that PSVs will reliably reseal and preclude escalation of an RCS mass addition event into a small break LOCA, the staff acknowledges that the NRC has historically accepted and approved this testing as a basis for crediting liquid discharge from PSVs. Based on a re-assessment of the EPRI test results, which identified that certain testing had to be terminated to avoid excessive damage to the valves that could adversely impact the ability of a valve to reclose, the staff no longer has confidence that these test results provide reasonable assurance that the PSVs will reliably close following subcooled liquid discharge. The staff now believes that referencing the EPRI test results as a demonstration of PSV closure capability following subcooled liquid discharge to be inappropriate, but does not recommend pursuing backfitting to address prior approvals based on the EPRI test data that determined that the PSVs could reseal even if there is leakage. The staff believes that licensees who currently credit PSVs for liquid discharge have included appropriate measures to inspect and repair these PSVs, as necessary, following liquid discharge and have implemented appropriate plant procedures that allow operators to perform pressurizer pressure relief functions in response to mass addition events using the PORVs and block valves, as necessary. The staff does, however, recommend that approvals for qualification of pressurizer relief valves for liquid discharge based on reference to the EPRI test reports may not be appropriate, depending on plant-specific circumstances, going forward.

Acceptable methods of qualification of PSVs for liquid discharge:

With regard to documentation of acceptable qualification of PSVs for liquid discharge, the staff's review revealed that plant specific parameters as well as variances in the EPRI test data based on valve type and manufacturer are instrumental in determining whether EPRI test report information could adequately demonstrate reliable PSV performance following liquid discharge. It is clear that there are certain subcooled liquid conditions in which this is not the case. Examples of potentially applicable certification and testing requirements are

ASME BPV Code, Section III for initial PSV certification and ASME OM Code for inservice testing of PSVs. When a licensee voluntarily opens its licensing basis in an area that may affect the volume or characteristics of media discharged through PSVs, it is incumbent upon the licensee to demonstrate the appropriateness of the selected qualification method. Also, the staff notes that the long standing regulations of 10 CFR 50.55a still require licensees to comply with ASME BPV Code, Section III for the design and certification of safety and relief valves unless an alternative to the regulations has been authorized by the NRC.

EDO Tasking Item 2: Re-assessment of the positions in RIS 2005-29 and proposed Revision 1

The underlying document that was the subject of RIS 2005-29 and proposed Revision 1 to RIS 2005-29 is Westinghouse NSAL-93-013. For reference, the staff summarized the positions contained in NSAL-93-013 and NSAL-93-013, Supplement 1 below:

- Potentially non-conservative assumptions used in licensing bases for IOECCS
- Use of revised assumptions could result in pressurizer water-solid condition in less than 10 minutes, which may be less than operator action time assumed to secure pumps
- If PORVs were blocked, PSRVs [pressurizer safety relief valves, referred to as PSVs elsewhere in this memorandum] would relieve water and potentially violate non-escalation criterion
- To meet standard review plan criteria, it must be demonstrated that:
 - Pressurizer does not become water solid within minimum allowable operator action time
 - PSRVs do not open, or
 - PSRVs are capable of successfully closing following water relief
 - Downstream piping is capable of handling water discharge flow
 - Radiological consequences of breaking the pressurizer relief tank rupture disk do not violate applicable offsite dose limits
- Water relief through the PORVs is not a concern because PORV Block Valves can be used to isolate the PORVs if they fail to close

In its review of RIS 2005-29 and the current version of the proposed Revision 1, the staff identified several regulatory and technical positions that either required clarification or were no longer supported. The staff also determined that some of the positions remain acceptable as stated and would continue to apply going forward. The staff's assessment of the identified positions is included below.

Staff positions identified in RIS 2005-29:

- i. Licensing bases of some plants fail to demonstrate that anticipated transients (i.e., Condition II events) will not progress to more serious events (Condition III or IV events).

(b)(5)



(b)(5)

- ii. Concern is limited to plants equipped with ECCSs capable (i.e., charging pumps in SI mode) of pressurizing RCS to levels greater than opening setpoint pressures for their pressurizer relief or safety valves.

(b)(5)

- iii. Inadvertent actuation/operation of ECCS (IOECCS) events can become a small break LOCA if the pressurizer fills, unqualified PORVs or PSVs open, discharge water, and fail to close

(b)(5)

- iv. A major assumption in RIS 2005-29 is that unqualified PORVs and PSVs will likely fail open following water discharge.

(b)(5)

- v. NSAL-93-013 offered three alternatives to address potential non-conservative assumptions used in the licensing basis analysis of the IOECCS event.
- a. Operation of PORVs may be credited (does not mention if PORVs need to be safety-related or qualified to discharge water).
 - b. Use a less restrictive operator response time. Justifying and crediting more timely operator actions to mitigate the inadvertent ECCS actuation may preclude filling of the pressurizer.
 - c. Reduce the maximum ECCS flow used in the safety analysis. Using less conservative flow may sufficiently delay filling the pressurizer such that operator action to terminate the event can be successfully credited.

(b)(5)

- vi. Closing a block valve to isolate an unqualified PORV that has failed open as a result of discharging water is a response to a Condition III small break LOCA, not a Condition II IOECCS event.

(b)(5)

- vii. Operation of PORVs may only be credited if safety-related.

(b)(5)

Staff positions identified in the proposed Revision 1 to RIS 2005-29:

- i. Chapter 15 safety analysis for mass addition events (anticipated operational occurrences) failed to meet non-escalation criterion (i.e., Condition II events escalated to a Condition III event).

(b)(5)

- ii. Scope of RIS expanded beyond IOECCS to include chemical and volume control system (CVCS) malfunction and inadvertent opening of a pressurizer PORV or PSV:

(b)(5)

- iii. For the CVCS malfunction event, some licensees claim that:

- Evaluation of CVCS malfunction is not required because it is already analyzed as a reactivity anomaly in the licensing basis.
- Evaluation of CVCS malfunction is not required because it is not as severe as the IOECCS.

(b)(5)

- iv. For the IOECCS event, the following issues are discussed:

a.

(b)(5)

- b. Application of the PSVs as a protection system (i.e., reliance on PSVs for liquid discharge to mitigate the event):

(b)(5)

- c. Stuck-open PORV or PSV resulting from IOECCS is already addressed as an inadvertent opening of a PORV or PSV:

(b)(5)

- d. Stuck-open PORV or PSV is not as severe as a small break LOCA:

(b)(5)

- e. Reactor coolant system inventory that exits through the PORV(s) or PSV(s) is made up by ECCS flow:

(b)(5)

- f. Predicting no liquid relief (i.e., sufficient time is available for operator action terminates event):

(b)(5)

- g. Application of liquid-qualified PORVs as a mitigation system:

(b)(5)

- h. Addition of an interlock to the ECCS actuation signal logic (to preclude IOECCS):

The staff proposes to carry this position forward in the new RIS.

- v. For inadvertent opening of a PORV or PSV followed by closure of block valve after ECCS actuation:

(b)(5)

The staff proposes to develop a new RIS to clarify the staff's position on the underlying technical issue in NSAL-93-013. The existing RIS 2005-29 would be withdrawn and development of Revision 1 to RIS 2005-29 would be canceled. The staff will follow the established generic communications process in developing and issuing this new RIS, which will ensure a review by both the Office of the General Counsel and the CRGR with respect to backfitting.

Item 3: Re-assessment of the positions in RIS 2005-29 and proposed Revision 1

In the staff's January 3, 2017, memorandum responding to your tasking, the staff indicated that it would review whether GI-70, "Power-Operated Relief Valve [PORV] and Block Valve Reliability," should be re-opened or re-assessed given the assigned re-evaluation of the technical issue at hand. The conclusions associated with closure of GI-70 in NUREG-1316, "Technical Findings and Regulatory Analysis Related to Generic Issue 70," identified that:

it is not cost-effective to upgrade (backfit) existing non-safety-grade PORVs and block valves (and associated control systems) to full safety-grade qualification status...Subsequent to the TMI-2 accident a number of improvements were required of PORVs, such as requirements to be powered from Class 1E buses and to have valve position indication in the control room. Therefore, additional improvements that would result from upgrading PORVs to fully safety-grade status are considered to be of marginal benefit.

Section II.D.1, NUREG-0737 discusses that:

...Qualification of [pressurized-water reactor] PWR block valves is a new requirement. Since block valves must be qualified to ensure that a stuck-open relief valve can be isolated, thereby terminating a small loss of coolant accident due to a stuck-open relief valve ...

The staff's review of EPRI test data for PSVs and PORVs revealed that PORVs performed better in testing than PSVs. Of particular note is that the improved test results of PORVs over PSVs applied even in cases of discharge of subcooled liquid, which is the liquid characteristic of primary concern. The test results, presence of a qualified PORV block valve, and prior GI-70 determination that additional improvement to PORVs would be of marginal safety benefit, led the staff to conclude that there was no need to re-visit GI-70.

SUPPORTING INFORMATION FOR STAFF RECOMMENDATIONS IN RESPONSE TO
SEPTEMBER 15, 2016, EXELON BACKFIT APPEAL DECISION; DATED: September 6, 2017**DISTRIBUTION:**RidsNrrDss Resource
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