NEI 99-02 FAQ 18-04

ANO-1 Scram One-Time Exemption Request

Plant: Arkansas Nuclear One, Unit 1 (ANO-1)
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Performance Indicator: 1E04, Unplanned Scrams with Complications (USwC)

Site-Specific FAQ (see Appendix D)? Yes

FAQ to become effective when approved.

Question Section

NEI 99-02 Guidance needing interpretation (include page and line citation):

NEI 99-02, Revision 7, Page 24, Lines 33-36, and

NEI 99-02, Revision 7, Appendix H, Section H.1.6, Page H-6, Lines 7-9

Note: NEI 99-02, Revision 7 page and line references are with respect to the markup version of NEI 99-02 (ML13261A116).

Event or circumstances requiring guidance interpretation:

Sequence of Events

This FAQ is being submitted to request a plant-specific exemption from the guidance related to Unplanned Scrams with Complications (USwC) for ANO-1. This request is due to the unique circumstances of the event which led to operators entering the Overcooling Emergency Operating Procedure (EOP). The Overcooling EOP entry was required due to low decay heat levels present because the event occurred upon initial startup following a refueling outage and not due to equipment malfunctions or abnormal plant response.

On May 16, 2018, ANO-1 had reached approximately 10% reactor power following an extended refueling outage that lasted approximately two months. The Main Turbine Generator (MTG) had not yet been placed in service or connected to the offsite power grid. As discussed later in this document, the MTG gland seals and secondary feedwater heaters were being supplied by main steam from the Steam Generators (SGs). Due to operation at this low power level, the in-service Main Feedwater Pump (MFWP) was being operated in manual to maintain SG levels. At 1750 hours, the ANO-1 reactor automatically scrammed following a trip of the in-service MFWP. The MFWP trip occurred on high discharge pressure due to Operator error. The scram resulted in Emergency Feedwater (EFW) initially supplying the SGs post-scram. All control rods fully inserted, all electrical power remained available, and no safety injection signal was received during the event.

MFW Response

The MFWP automatically tripped on high discharge pressure and remained undamaged. One indicator of an USwC described in NEI 99-02, Revision 7, is the inability to recover main feedwater, if needed, within about 30 minutes post-scram:

> "Operations should be able to start a Main Feedwater pump and start feeding Steam Generators with the Main Feedwater System within about 30 minutes from the time it was recognized that Main Feedwater was needed."

In addition, NEI 99-02, Revision 7, recognizes the potential differences in main feedwater and plant designs by stating the following:

> "The estimated 30-minute timeframe for restart of main Feedwater was chosen based on restarting from a hot and filled condition. Since this timeframe will not be measured directly it should be an estimation developed based on the material condition of the plants systems following the reactor trip. If no abnormal material conditions exist the 30 minutes should be met. If plant procedures and design would require more than 30 minutes even if all systems were hot and the material condition of the plants systems following the reactor trip were normal, that routine time should be used in the evaluation of this question, provided SG dry-out cannot occur on an uncomplicated trip if the time is longer than 30 minutes. The judgment of the on-shift licensed SRO during the reactor trip should be used in determining if this timeframe was met."

Because EFW had automatically actuated, recovery of main feedwater was not required. Nevertheless, no adverse impact to the main feedwater system resulted from the MFWP trip; therefore, the MFWP was capable of being reset and returned to service from the Control Room, if needed. The standby MFWP was ongoing minor maintenance at the time of the scram which did not require the pump to be tagged out or render the pump non-functional. Therefore, the standby pump could also have been placed in service, if necessary,.

The ANO-1 MFWPs are steam driven and require more time to place in service than a motor-driven pump. In the judgement of the on-shift senior licensed operator (SRO), either MFWP could have been returned to service without incident within a timeframe commensurate with the intent of the NEI guidance. To further verify this potential, a simulator session was performed given the plant conditions at the time of the May 2018 scram. Upon initiation of the scram, all available feedwater sources (EFW, Auxiliary Feedwater, and Common Feedwater) were failed or otherwise made unavailable to the operating crew. Using the procedures required to respond to such a condition, the operating crew returned a MFWP to service in approximately 19 minutes from the time the crew identified all other feedwater sources were unavailable. Total time from scram initiation to the idle MFWP being in service was 26 minutes. SG levels remained well above dry-out conditions at the time main feedwater was restored. Based on this information, Entergy considers the NEI criteria associated with MFW restoration to be met.

RCS Cooldown Response

The plant immediately entered normal hot standby conditions. The Reactor Trip EOP was used to perform immediate actions, which were completed with no exceptions. However, decay levels were not sufficient to support the normal MTG gland seal system and secondary

feedwater heater steam loads. In addition to the steam demands, the EFW pumps provide much cooler water into the SGs (approximately 100 °F) in comparison with Main Feedwater. The aggregate effect was the reduction of Reactor Coolant System (RCS) temperature and SG pressure, which eventually resulted in entry into the station Overcooling EOP at 1803 hours.

The normal post-scram action was initiated to place the station Startup Boiler in service to permit transfer of the MTG gland seal and secondary feedwater heater loads from the main steam system to the Startup Boiler. The Overcooling EOP was entered when SG pressure and RCS temperature were verified to meet the entry conditions of < 900 psig and < 540 °F, respectively. The steam-driven EFW pump was secured in accordance with procedures since the motor driven EFW pump was in operation and sufficient for the SG makeup needs.

RCS temperature began slowly rising. When MTG gland seals realignment to the Startup Boiler was completed at 1908 hours, the RCS heat up rate increased more substantially. The Overcooling EOP was exited at 2028 hours. A summary timeline is as follows:

1750	MFWP trip with subsequent reactor scram and EFW actuation
1803	Entered Overcooling EOP
1809	Secured steam-driven EFW pump using normal operating procedure (Reactor Coolant System temperature and SG pressure began to stabilize and slowly rise approximately 8 minutes later)
1826	Startup Boiler in service
1908	Completed transfer of MTG gland seal steam load to Startup Boiler as part of normal scram response
2020	Completed transfer of secondary feedwater heater steam load to the Startup Boiler as part of normal scram response
2028	Exited Overcooling EOP

Normal operating procedures direct realignment of steam loads, such as the aforementioned MTG gland seals and FW heaters. Auxiliary Feedwater is placed in service and EFW secured. The subject ANO-1 scram, however, involved an off-normal condition of substantially reduced decay heat load. No actions associated with the Overcooling EOP entry were taken that would not have been taken during any non-emergency plant shutdown or scram. The only difference associated with the May 16, 2018, scram was that sufficient time to perform these actions was not available to avoid entry into the Overcooling EOP due to the low decay load. In addition to the above, the overcooling event was not caused by any equipment or process malfunction.

Because the plant stabilized and recovery began soon after the securing of the steam-driven EFW pump, no Overcooling EOP related remedial actions were required. The recovery accelerated following the normal transfer of steam loads to the Startup Boiler. Operations allowed RCS temperature and SG pressure to recover without further intervention. The slower than normal recovery was due to the low decay heat level present at the time.

Main Steam Alignments at Zero or Low Power Level

ANO-1 procedures dictate that steam loads such as the MTG gland seal system and FW heating be realigned from the Startup Boiler to the Main Steam system either before the

approach to criticality or at ~2% power following criticality. While these loads could be supplied by the Startup Boiler at higher power levels, there is a risk of failure of the MTG gland seal rupture disk when these loads are realigned from one source to another. In addition, a trip of the Startup Boiler can result in a loss of condenser vacuum depending on system alignments at the time of the event. To avoid the potential transient risk of a plant shutdown or scram, the realignment is performed at zero or low power levels, prior to placing the MTG in service.

Brief History of USwC

The original predecessor to the current indicator, Unplanned Scrams with Loss of Normal Heat Removal, was an indicator proposed to monitor risk important scrams. Since it was not an indicator normally monitored by the international community, the reason for the inclusion of this indicator in the ROP was discussed in some detail in SECY-99-007. In the "Scrams – unplanned automatic and manual scrams while critical per 7,000 critical hours and risk-important scrams" section of SECY-99-007, "Recommendations for Reactor Oversight Process Improvements," Appendix A states:

> Also, a separate count is made of risk-important scrams over a 12 quarter moving sum to differentiate these scrams from the scrams without any complications. Risk-Significant Scrams = Scrams with LOCA, SGTR, LOOP, Total Loss of Heat Sink, Total Loss of Feedwater; or Scrams with a failure one or more trains of the SSPI systems. The SSPI systems are: BWRs -Emergency AC Power; High Pressure Coolant Injection Systems (HPCI, HPCS, FWCI); High Pressure Heat Removal Systems (RCIC, IC); and RHR for the suppression pool and shutdown cooling functions. PWRs –Emergency AC Power, HPSI, AFW, and RHR for the post-accident recirculation and shutdown cooling functions.

Note that an overcooling event by itself is not listed as a risk-significant event that was intended to be captured. This goal of capturing risk significant scrams was implemented by an indicator to monitor Unplanned Scrams with Loss of Normal Heat Removal.

To decrease the complexity of the indicator, the indicator was modified to Unplanned Scrams with Complications by NRC Regulatory Issue Summary (RIS) 2007-12, "Changes to the Unplanned Scrams with Loss of Normal Heat Removal Performance Indicator." This RIS states:

> The USwC is designed to identify facilities that are outliers in complications that can elevate the risk of an unplanned manual or automatic reactor trip or scram. The PI will monitor the following six actions or conditions that have the potential to complicate the post trip recovery; reactivity control, pressure control (boiling water reactors)/turbine trip (pressurized water reactors), availability of power to emergency buses, actuation of emergency injection sources, availability of main feedwater, and the use of emergency operating procedures to address complicated scrams.

None of the listed parameters would be significantly impacted by the ANO-1 event. Only the later item, use of an EOP, is subject to the ANO-1 event and, as discussed in the RIS, it was intended to capture events including "the use of emergency operating procedures to address complicated scrams." This intent is consistent with original goal to capture the risk significant events with this PI.

NRC Inspection Manual Chapter (IMC) 308, "Reactor Oversight Process Basis Document," with respect to performance indicators, states:

The USwC is designed to identify facilities that are outliers in complications that can elevate the risk of an unplanned manual or automatic reactor trip or scram.

Since the actions taken in response to entering the Overcooling EOP are the same as would normally be taken following a scram and equipment failures did not result in the overcooling, this event did not included complications that elevated the risk of the scram.

In addition to not being one of the identified risk significant events of concern, ANO-1 personnel quantitatively evaluated the risk significance of the subject event. ANO risk analyst personnel determined that the ΔCDF for the subject ANO-1 event was 3.94E-8/yr, well below the risk significance threshold level intended for a PI's Green to White threshold. Because the ANO-1 event was not significant to containment bypass events, the subsequent ΔLERF is a factor of ten less than the ΔCDF based on a review of the LERF model. This quantitative result is consistent with the deterministic assessment of this event against the goals for this PI in that it supports that the event should not be considered a complicated event.

Contributing Design Differences

An event involving an excess steam demand, noting that the term "excess" can be subjective depending on available decay heat input, would understandably have a greater and more rapid impact cooldown impact based on plant type/design. In light of potential design differences and because the described ANO-1 (a Babcock & Wilcox plant) event did not involve a traditional "excess" steam demand (i.e., resulting from some equipment malfunction), the magnitude and rate of the ANO-1 RCS cooldown was compared to ANO-2 (a Combustion Engineering plant) using the unit-specific simulators. This review was performed to determine if ANO-1 design differences may have resulted in meeting the EOP entry conditions.

A scenario was performed on the ANO-2 simulator with all normal steam loads (including MTG gland seals and FW heating) remaining aligned post-scram. Plant conditions were established at 10% power following a refueling outage and the in-service MFWP tripped, followed by manual scram of the reactor (ANO-2 does not automatically scram on loss of a MFWP). The Overcooling EOP was not entered. RCS temperature and SG pressure lowered somewhat during EFW injection and would rise when EFW was not feeding the SGs (ANO-2 EFW automatically cycles between ~23-25% SG level).

For informational purposes, the described scenario was performed on the ANO-1 simulator, but with MTG gland seals and FW heating secured (only the steam-driven EFW pump was in operation post-scram as a steam load). In this case, Overcooling EOP entry conditions were not achieved. This result was substantiated by an informal hand-calculation performed by ANO Design Engineering personnel.

Finally, a scenario was performed on the ANO-1 simulator beginning with the trip of the in-service MFWP at 43% power upon initial startup from refueling. The MTG gland seal steam load remained aligned post trip. The scenario was continued until the plant stabilized in Mode 3. The entry conditions of the Overcooling EOP were not reached during this scenario (note that no action was taken to realign the MTG gland seals to the Startup Boiler).

The results of these simulator scenarios suggest that the reason for ANO-1 meeting the entry conditions for this Overcooling EOP is due to design differences and being in a narrow window

of low power operation versus the generically intended “use of emergency operating procedures to address complicated scrams.”

Conclusion

Per NEI 99-02, Revision 7, Page 24, this scram was counted as an USwC due to entry into the Overcooling EOP. Based on the following, the licensee requests an exemption from reporting this event as an USwC:

- Actions performed were no different than those required for other non-emergency plant shutdowns or scrams.
- No equipment malfunctions caused the Overcooling EOP entry.
- No off-normal actions or complications occurred.
- The overcooling sequence did not result in automatic actuation of safety injection systems.
- As indicated by informal calculations and simulator scenarios which assumed initial startup from a refueling outage, the overcooling would not have occurred if the unit had reached 43% power prior to trip and would not occur on the ANO-2 CE plant even following a trip at 10% power.
- The ANO-1 entry into the Overcooling EOP was not the result of a risk-significant event and, therefore, did not meet the intent of the USwC PI.

NEI 99-02, Revision 7, Page 21, states that the purpose for the USwC is to monitor “scrams that either require additional operator actions beyond that of the normal scram or involve the unavailability of or inability to recover main feedwater.” As discussed previously, the MFWP in service pre-event or the standby MFWP could have been placed in service within a timeframe consistent with plant procedures and the NEI 99-02 guidance, if needed. The USwC designation for this event is solely associated with entry into the Overcooling EOP after entering the normal scram response procedure. With consideration of the bullets listed above, the ANO-1 event does not meet the intent of the complicated scram performance indicator.

If licensee and NRC resident/region do not agree on the facts and circumstances, explain:

The NRC Region IV Branch Chief provided the following input on June 12, 2018:

> The cause of the overcooling appears to be a combination of the loss of main feedwater due to personnel error operating the MFP above its high discharge pressure trip setpoint which eliminated pre-heated feedwater flow to the steam generators, combined with low decay heat plus the addition of the colder EFW flow.
>
> It is unclear from the guidance whether the initial loss of main feedwater is enough to cause this scram to be considered a complicated scram, and the FAQ does not provide a basis for the statement that MFW could be recovered within about 30 minutes. Therefore, it appears that the criteria for loss of feedwater should be considered, contrary to the licensee’s position.

As a result of the above feedback, the FAQ was updated to include additional information regarding the recovery of MFW.

Potentially relevant FAQs:

To some extent, this request is related to FAQ 18-03, "Columbia Scram Exemption Request," with respect to normal actions required during normal post-trip events. While the Columbia USwC did not involve an overcooling event, it did involve a normal plant response based on operator actions and no actions were performed that would not normally be required. The NRC stated in its acceptance of the Columbia FAQ, in part (emphasis added):

> The purpose of the IE04, "Unplanned Scrams with Complications," performance indicator, as stated in NEI 99-02, Revision 7, is to monitor "that subset of unplanned automatic and manual scrams that either require additional operator actions beyond that of the "normal" scram or involve the unavailability of or inability to recover main feedwater…
>
> The staff views this as a rare and unique instance in which the complicated scram criteria in NEI 99-02 were met for a scram that the staff could not reasonably conclude had the potential to present additional challenges to the plant operations staff beyond that of a normal scram.

As noted previously, the ANO-1 event did not require additional operator actions beyond that of a normal scram or involve the unavailability of or inability to recover main feedwater. The ANO-1 event should be considered rare and unique in that the event was a result of low decay heat levels which only exist very early following initial startup from an outage of sufficient duration.

Although not approved, this FAQ is also related to FAQ 12-03, "St. Lucie Unplanned Scram with Complications." In the St. Lucie overcooling event, a steam dump to condenser had inadvertently opened and during recovery, St. Lucie operators closed the Main Steam Isolation Valves (MSIVs) which is not a normal post-scram response. The NRC stated in its non-approval of this FAQ, in part:

> The equipment performance attribute is relevant because the failure of the steam dump valve both initiated the event and caused the excessive RCS cooldown…
>
> Although operators may not have been significantly challenged by plant conditions and appear to have adequately responded to the event, the conditions did require additional actions (closure of MSIVs).

As noted previously, the ANO-1 overcooling event was not initiated by a malfunction of any equipment and no off-normal actions were performed.

Response Section

Proposed Resolution of FAQ:

This FAQ is proposed as a plant-specific exemption for the subject event as being an uncomplicated scram for ANO-1 due to the unique circumstances of the event which led to entry into the Overcooling EOP. No accident conditions existed, no malfunctions occurred which cause the overcooling event, and no additional actuations were required different than those associated with non-emergency events, i.e., the event was no more complicated than non-emergency scram response.

If appropriate, provide proposed rewording of guidance for inclusion in next revision:

NA

PRA update required to implement this FAQ? No

MSPI Basis Document update required to implement this FAQ? No

NRC Response