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To: "'Thomas Alexion'" <TWA@nrc.gov>
Date: 6/26/03 9:26AM
Subject: ANO-2 LPSI AOT Ext RAI Response-DM1.doc

Tom,

Attached is a draft copy of ANO's response to the PRA RAI questions associated with the LPSI AOT.

Dana

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REQUEST FOR ADDITIONAL INFORMATION
EXTENSION OF LOW PRESSURE SAFETY INJECTION ALLOWABLE OUTAGE TIME
ARKANSAS NUCLEAR ONE, UNIT 2

QUESTION 1:

What is the present annual average core damage frequency (CDF)?

RESPONSE:

The present annual average internal events and external Core Damage Frequency (CDF) and Large Early Release Frequency (LERF) values were provided by letter dated January 8, 2003 to the NRC (Supplement to Amendment Request Extension of Emergency Diesel Generator Allowable Outage Time (2CAN010303)). This information is repeated in Table 1-1, below.

Table 1-1

Risk Metric	Internal Events (excludes ATWS, ISLOCA)	External Events (includes ATWS, ISLOCA)
Nominal CDF (with nominal test and maintenance (T&M))	8.3E-6/rx-yr [Note 1]	5.1E-6/rx-yr [Note 2]
Nominal LERF (with nominal T&M)	9.0E-7/rx-yr [Note 2]	4.2E-7/rx-yr [Note 2]

Notes: 1. based on quantitative assessment of the Arkansas Nuclear One, Unit 2 (ANO-2) Probabilistic Safety Analysis (PSA) model using a quantification truncation of 1E-9
2 based on qualitative assessment using insights from ANO-2 Individual Plant Examination (IPE) and the IPE for External Events (IPEEE)

QUESTION 2:

What is the present annual average large early release frequency (LERF)?

RESPONSE:

See the response to Question 1.

QUESTION 3:

What is the proposed delta LERF/year?

RESPONSE:

Table 3-1, below, provides incremental conditional core damage probability (ICCDP), annual average delta core damage frequency (ΔCDF), incremental conditional large early release probability (ICLERP), and annual average delta large early release frequency (ΔLERF) values

for both internal and external events risk contributors and for both preventative and corrective maintenance conditions associated with the proposed ANO-2 Low Pressure Safety Injection (LPSI) Allowed Outage Time (AOT) extension to 7 days.

Table 3-1

	Preventative Maintenance		Corrective Maintenance	
Risk Metric	Internal Events (excludes ATWS, ISLOCA)	External Events (includes ATWS, ISLOCA)	Internal Events (excludes ATWS, ISLOCA)	External Events (includes ATWS, ISLOCA)
ICCDP	3.61E-08 [Note 1]	4.7E-09 [Note 2]	2.81E-07 [Note 1]	5.6E-09 [Note 2]
Annual Average ΔCDF (/rx-yr) [Note 3]	1.08E-07 [Note 1]	1.4E-08 [Note 2]	1.85E-07 [Note 1]	3.7E-09 [Note 2]
ICLERP	3.8E-09 [Note 2]	4.6E-10 [Note 2]	2.8E-08 [Note 2]	5.5E-10 [Note 2]
Annual Average ΔLERF (/rx-yr) [Note 3]	1.1E-08 [Note 2]	1.4E-09 [Note 2]	1.9E-08 [Note 2]	3.6E-10 [Note 2]

Notes:
1. These values were provided by letter dated September 19, 2002 (License Amendment *Request to Extend Allowed Outage Time for Low Pressure Safety Injection System* (2CAN090201); they are repeated here for completeness. These values are based on quantitative assessment of the ANO-2 PSA model using a quantification truncation of 1E-9.
2. These values are based on qualitative assessment using insights from ANO-2 IPE and the ANO-2 IPEEE.
3. The annual average ΔCDF and annual average ΔLERF values assume 1.5 events/year/train for preventative maintenance and 0.33 events/year/train for corrective maintenance.

The bases for qualitative assessments are provided in the response to Question 6.

These results indicate that the risk impact of increasing the LPSI AOT from 72 hours to seven (7) days is not significant. When transition and shutdown risks are considered, it was expected that performing LPSI maintenance at-power, rather than during shutdown conditions, would be either risk beneficial, or at the very least, risk neutral.

QUESTION 4:

What is the proposed incremental conditional large early release probability (ICLERP)?

RESPONSE:

See the response to Question 3.

QUESTION 5:

Provide the above information in addition to the delta CDF/year and the incremental conditional core damage probability (ICCDP) for external events. (See the emergency diesel generator allowable outage time application for external events.)

RESPONSE:

See the response to Question 3.

QUESTION 6:

Provide additional external events information as is presently being prepared for the emergency diesel generator allowable outage time application, as follows:

a. Please describe the methodology used to generate the external events risk numbers, including the final numbers generated for each external event. If aspects of the external events analysis approach used in this application are substantially different from the methods described in previous recent applications (e.g., the power uprate application), please explain and justify the use of the different approach.

b. For the fire analyses, as an alternative to justifying the use of a different approach discussed in Question 6.a above, the licensee could describe how this application would impact each of the unscreened fire quadrant analyses and results identified in the June 28, 2001, letter to the U.S. Nuclear Regulatory Commission (NRC) regarding its power uprate application. The NRC staff notes that in this letter, the licensee identified 17 unscreened fire quadrants involving 15 fire areas and provided the associated post-uprate core damage frequency for each quadrant.

RESPONSE:

Non-Modeled Contributors to ICCDP and Annual Average ΔCDF

The ANO-2 PSA model does not address the risk associated with the external events, including seismic events, internal fires, and other external events (i.e., high winds, external flooding, and accidents involving nearby industries, transportation, and military facilities). Nor does this model address the risk associated with several other risk contributors, namely Anticipated Transients Without Scram (ATWS) scenarios, Interfacing System Loss of Coolant Accidents (ISLOCAs), and High and Medium Energy Line Breaks (HELBs and MELBs). Qualitative analyses were performed to assess the risk impact of these non-modeled events on extending the current LPSI AOT. These analyses are considered qualitative, since they are relatively simplistic and not based on comprehensive and detailed fault tree/event tree models. The intent of these methods and results was to provide an order-of-magnitude assessment of the risk associated with these risk contributors.

This methodology is essentially the same as that used for the ANO-2 Emergency Diesel Generator (EDG) AOT extension reported to the NRC by letter dated May 22, 2003 (2CAN050303). Differences in the methodology are due to differences in the risk issues associated with extending the EDG and LPSI AOTs. Since the methodology was previously described in the May 22, 2003 letter, the discussion below focuses on the differences in the use of this methodology for the LPSI application.

Removing a LPSI train from service does not affect the risk associated with any of the external events listed above. This conclusion is based on the following observations:

- The LPSI system has two safety functions:
  (1) the LPSI emergency core cooling (ECC) mode provides reactor coolant system (RCS) makeup during the injection phase of a large break LOCA (LBLOCA) and
  (2) the LPSI shutdown cooling (SDC) mode provides a means of cooling the RCS during shutdown conditions.

- None of the non-modeled events (including external events) cause or involve a LBLOCA. Thus, degradation of the LPSI emergency core cooling function due to the removal of a LPSI train from service does not affect the risk associated with any of the non-modeled risk contributors.
- The safe end state for most of the non-modeled events is the Hot Standby (HSB) condition. Thus, degradation of the LPSI emergency core cooling function due to the removal of a LPSI train from service affects only those non-modeled events which require entry into the SDC mode as a safe end state.

It should be noted that at ANO-2 the HSB condition is considered to be the safe end state for all but a few accident scenarios. The position is consistent the NUREG-0933 Item A-31 statement that the "safe shutdown for a nuclear power plant following an accident not related to a LOCA has been typically interpreted as achieving a 'hot-standby' condition (i.e., the reactor is shut down, but system temperature and pressure are still at or near normal operating values)." The ANO-2 PSA model is consistent with this position. This position also applies to accidents not included in the ANO-2 PSA model. Thus, entry into the SDC mode is not generally required for successful mitigation of any of the non-modeled events, including external events. A review of each of the non-modeled risk contributors was performed using insights from the ANO-2 IPEEE results, where available, in order to assure that this general rule applies to each of the non-modeled risk contributors. The effect of each non-modeled event to cause either a LBLOCA or a Steam Generator Tube Rupture (SGTR) event, both of which required the use of LPSI, was considered

A review of the external events indicates that none inherently require entry into the SDC mode for successful mitigation. All can be modeled as a special transient event that is already included in the ANO-2 PSA model. Specific observations for each of the non-modeled risk contributors follow:

- A fire event is assumed to cause a transient that involves the failure of a specific set of components. None of these failures directly cause a LBLOCA or a SGTR. The ANO-2 IPEEE fire risk analysis assumed that the HSB condition was a safe end state; thus, LPSI failures do not appear in any of the fire risk analysis cutset results for any fire initiator. Hence, the effect of removing a LPSI train from service has essentially no impact on the assessed fire risk. Given this conclusion, the need for a detailed assessment of the fire risk, requested in Question 6b, was deemed not necessary.
- A seismic event is also a special transient event. No seismic event smaller than the 3.0g Review Level Earthquake (RLE) was identified to result in a LBLOCA or SGTR. Thus, no seismic event within the scope of the ANO-2 IPEEE study is expected to require entry into SDC mode. Given that a seismic event large enough to result in a LBLOCA or SGTR would probably also disable the LPSI system or systems that support it, the effect of removing a LPSI train from service has essentially no impact on the seismic risk.
- The case is similar for internal floods and other external events (i.e., high winds, external flooding, and accidents involving nearby industries, transportation, and military facilities). None result in a LBLOCA or SGTR event and all could be modeled as a special transient event. Hence, the effect of removing a LPSI train from service has essentially no impact on the risk of the other external events.
- The case is similar for HELB and MELBs and the conclusions regarding the impact of LPSI unavailability are the same.
- The remaining risk contributors not included in the ANO-2 PSA model, the ATWS and

ISLOCA events, require additional consideration. This is provided below.

ISLOCA

The ANO-2 IPE identified three ISLOCA scenarios:
(1) LPSI system injection line failures,
(2) SDC suction line failures, and
(3) Reactor Coolant Pump (RCP) seal cooler failures.

The first two situations contribute to core damage significantly only if either involves the loss of reactor coolant system (RCS) inventory outside of the containment building. Without mitigation, if RCS inventory is lost outside of the containment, core damage will occur regardless of LPSI availability. For these events, if the break is isolated, the RCS repressurizes and a LPSI train is not required to mitigate either of the events. The last situation does not result in a LBLOCA and, as such, does not require the LPSI ECC mode. Since the HSB condition is a safe end state, the LPSI SDC mode is not required for this event. In conclusion removing a LPSI train from service when at power does not significantly increase the risk associated with an ISLOCA, because the LPSI train is not needed to mitigate any of these ISLOCA events.

ATWS

A scoping level analysis of the ANO-2 ATWS event was performed as part of the ANO-2 IPE reported to the NRC by letter dated August 28, 1992 (2CAN089201). This analysis assumed that successful termination of the ATWS event required entry into the SDC mode. Thus, an insight from this analysis is that the proposed extension of the LPSI AOT will impact the plant risk due to an ATWS.

The nominal ANO-2 ATWS CDF is estimated to be 1.59E-06/rx-yr. This value is reported to the NRC by letter dated May 22, 2003 (2CAN050303).

The effect of removing a LPSI train from service on the ATWS contribution to CDF was assessed by adjusting the Long Term Cooling (LTC) event probabilities in the ATWS event tree logic. The LTC event accounts for the failure of the shutdown cooling function following an ATWS event.

The CDF impact of removing a single LPSI train from service for Preventative Maintenance (PM) and for Corrective Maintenance (CM) on the non-modeled (i.e., ATWS) risk contributors is provided in Table 6-1, below. The value reported represents the larger of the LPSI Train A or Train B CDF values for the PM and CM cases. It should be noted that basic events representing the common cause failure of LPSI pumps and injection valves were set to the values of their respective common cause beta values in the CM cases.

Table 6-1

Non-Modeled	Instantaneous CDF (/rx-yr)		
Contributor	Nominal	LPSI Train PM	LPSI Train CM
ATWS	1.59E-06	1.84E-06	1.88E-06

Since the ATWS contributor is the only non-modeled risk contributor affected by the LPSI AOT

extension, the ATWS instantaneous CDF values reported in Table 6-1 represent the risk impact of the LPSI AOT extension that is not accounted for in the ANO-2 PSA model.

These results were used to generate an estimate for the non-modeled portion of the ICCDP and annual average ΔCDF associated with the LPSI AOT extension. The non-modeled portions of the ICCDP values associated with removing a single LPSI train from service for PM and for CM for a 7 day AOT were calculated as follows:

$$\text{ICCDP NonModeled PM} = (7\ \text{days}/365\ \text{days/yr}) * (1.84\text{E}-06/\text{yr} - 1.59\text{E}-06/\text{yr}) = 4.7\text{E}-09$$

$$\text{ICCDP NonModeled CM} = (7\ \text{days}/365\ \text{days/yr}) * (1.88\text{E}-06/\text{yr} - 1.59\text{E}-06/\text{yr}) = 5.6\text{E}-09$$

The non-modeled portions of the annual average ΔCDF values for preventative maintenance and for corrective maintenance on an ANO-2 LPSI pump for a 7-day AOT were calculated as follows:

$$\text{Annual Average } \Delta\text{CDF for LPSI NonModeled PM} = (2)(1.5/\text{rx}-\text{yr})(\text{PM ICCDP}) = 1.4\text{E}-08/\text{rx}-\text{yr}$$

$$\text{Annual Average } \Delta\text{CDF for LPSI NonModeled CM} = (2)(0.33/\text{rx}-\text{yr})(\text{CM ICCDP}) = 3.7\text{E}-09/\text{rx}-\text{yr}$$

Note that these values assume 1.5 entries per year into the 7 day AOT for PM activities on each of the LPSI trains and 0.33 entries per year into the 7 day AOT for CM activities on each of the LPSI trains. This is consistent with the assumptions reported to the NRC by letter dated September 19, 2002 (2CAN090201).

ICLERP and Annual Average ΔLERF

The ANO-2 PSA model does not generate LERF results. The impact of the LPSI AOT extension on ICLERP and annual average ΔLERF were estimated by generating LERF/CDF factors (hereafter called "LERF factors"). Several LERF factors were generated:

(1) a SGTR LERF factor – this factor is relatively high for SGTRs, since the fission products bypass the containment,
(2) a Station Blackout (SBO) LERF factor -- active containment mitigative functions are unavailable during SBO events increasing the ratio of LERF to CDF, and
(3) an "Other" LERF factor representing core damage contributors except those associated with SGTRs and SBOs.

The SGTR LERF factor was estimated as the ratio of the SGTR event large release frequency (LRF) and the SGTR CDF value using results from the ANO-2 IPE. The SGTR LERF factor was calculated to be 0.500.

The SBO LERF factor was estimated as the ratio of the SBO event LRF and the SBO CDF value using results from the ANO-2 IPE. The SBO LERF factor was calculated to be 0.0974.

The "Other" LERF factor was estimated as the ratio of the LRF and CDF associated with other core damage contributors using results from the ANO-2 IPE. The "Other" LERF factor was calculated to be 0.0650. It is smaller than either the SGTR or SBO LERF factors.

Note that use of the LRF values, rather than the LERF values, to generate the LERF factor conservatively overestimates the values of LERF factors, since the LRF value includes both the large early and large late releases.

In order to estimate the LERF values, both the modeled and the non-modeled core damage contributors were parsed into two groups: core damage events involving containment bypass scenarios (namely, SGTRs) and those involving SBOs and other core damage contributors. The LERF values were then calculated as the sum of the products of the CDF values and their respective LERF factors, i.e.,

$$\text{LERF} = (\text{SGTR LERF factor}) * (\text{SGTR CDF}) + (\text{SBO LERF factor}) * (\text{SBO and Other CDF Contributors})$$

Note that this approach conservatively overestimates LERF, since the SBO LERF factor is applied to both SBO and "Other" core damage contributors and is larger than the " Other" LERF factor.

The modeled internal events PM and CM ICLERP and the annual average ΔLERF values were estimated in a similar manner, i.e. the sum of the products of the SGTR and other ICCDP and annual average ΔCDF values and their respective LERF factors. The resulting modeled internal events ICLERP and annual average ΔLERF values are provided in the "Internal Events" columns of Table 3-1.

The above equation was also employed to calculate the LERF associated with the non-modeled risk contributors. Since the only significant non-modeled CDF contributor was the ATWS event, a special case of the above equation was used to estimate the non-modeled LERF, i.e.,

$$\text{Non-modeled LERF} = (\text{SBO LERF factor}) * (\text{ATWS CDF})$$

Note that the SBO LERF factor was assumed applicable for ATWS core damage scenarios, because active containment mitigation functions are unavailable during a SBO event and they are available in an ATWS event.

For the non-modeled events, the PM and CM ICLERP and the annual average ΔLERF values were estimated in a similar manner, i.e. the product of the ATWS ICCDP and annual average ΔCDF values and the SBO LERF factor. The resulting ICLERP and annual average ΔLERF values are provided in the "External Events" column of Table 3-1.