PrairieIslandNPEm Resource

From: Vincent, Robert [Robert.Vincent@xenuclear.com]
Sent: Friday, May 08, 2009 1:20 PM
To: Plasse, Richard; Goodman, Nathan
Cc: Eckholt, Gene F.; Davis, Marlys E.
Subject: PINGP LR Supplemental Letter with Environmentally-Assisted Fatigue Clarifications
Attachments: 20090508 Supplemental Information Re EAF.pdf; 20090508 Supplemental Information Re EAF.doc

Attached are pdf and WORD versions of the NSPM letter responding to NRC requests for clarifications of our April 28 submittal regarding environmentally-assisted fatigue analyses.

Please call Gene or me if you have any questions.

Bob Vincent
Licensing Lead, License Renewal Project
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May 8, 2009

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10 CFR 54

U S Nuclear Regulatory Commission
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Washington, DC 20555-0001

Prairie Island Nuclear Generating Plant Units 1 and 2
Dockets 50-282 and 50-306
License Nos. DPR-42 and DPR-60

Supplemental Information Regarding Application for Renewed Operating Licenses

By letter dated April 11, 2008, Northern States Power Company, a Minnesota Corporation, (NSPM) submitted an Application for Renewed Operating Licenses (LRA) for the Prairie Island Nuclear Generating Plant (PINGP) Units 1 and 2. In a letter dated April 28, 2009, NSPM updated the LRA to incorporate the results of additional analyses of the effects of the environment on fatigue usage of selected Reactor Coolant System components. In a conference call on May 4, 2009, the NRC requested clarification of several items in that submittal. Enclosure 1 provides the requested clarifications.

If there are any questions or if additional information is needed, please contact Mr. Eugene Eckholt, License Renewal Project Manager.

Summary of Commitments

This letter contains no new commitments or changes to existing commitments.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on May 8, 2009.

Michael D Wadley

Michael D. Wadley
Site Vice President, Prairie Island Nuclear Generating Plant Units 1 and 2
Northern States Power Company - Minnesota

Enclosure (1)

cc:

Administrator, Region III, USNRC
License Renewal Project Manager, Prairie Island, USNRC
Resident Inspector, Prairie Island, USNRC
Prairie Island Indian Community ATTN: Phil Mahowald
Minnesota Department of Commerce

Enclosure 1
Supplemental Information Related to Environmentally-Assisted Fatigue Calculations

In letter L-PI-09-060 dated April 28, 2009, NSPM updated the LRA to incorporate the results of additional analyses of the effects of the environment on fatigue usage of selected Reactor Coolant System components. In a conference call on May 4, 2009, the NRC requested clarification of several items contained in that submittal. NSPM agreed to provide clarifying information to supplement the discussion in the April 28 letter.

NRC Clarification Request Part (A)

On Page 1 of Enclosure 1, 3rd paragraph states "… The results of those analyses are being incorporated into the LRA …." Does this mean that NSPM will issue a new version of LRA? If not, please explain.

NSPM Response to Part (A)

Enclosure 1 of the April 28, 2009, letter provides the LRA amendment necessary to address License Renewal Commitment No. 36. As stated in the preamble to the response, "LRA Section 4.3.3 … is revised in its entirety to read as follows:" The content of Enclosure 1 replaces the original LRA text in Section 4.3.3, Environmentally-Assisted Fatigue (GSI-190). NSPM does not intend to submit or issue a new version of the PINGP LRA.

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On Page 2 of Enclosure 1, paragraphs under the subsection titled, "Determination of Fatigue Usage Unadjusted for Environmental Effects" contained in the NSPM letter L-PI-09-060, under Section 4.3.3, describes the transients used for the Safety injection accumulator nozzle, charging nozzle, and PZR surge line hot leg nozzle. Some of the transients used in fatigue evaluations for these components are not included in LRA Table 4.3-1. These undefined transients are listed below.

> *inadvertent RCS depressurization, inadvertent auxiliary spray actuation, control rod drop, excessive feedwater flow, RCS refueling, OBE, inadvertent accumulator blowdown, RHR operation during plant cooldown, high head safety injection*

Request:

(1) Specify the number of design cycles for the transients listed above as well as the cycles most recently accrued and the cycles projected for 60 years.

(2) Confirm that all transients (including those listed above) used for the fatigue analysis have been tracked and monitored since the plant startup and tracking for all transients that may contribute fatigue usage will be continued during the period of extended operation.

Enclosure 1
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(1) In accordance with the Westinghouse Systems Standards, the numbers of design cycles for the transients of interest are as follows:

Inadvertent RCS depressurization – 20
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RCS refueling – 80
OBE – 50
Inadvertent accumulator blowdown – 4
RHR operation during plant cooldown – 200
High head safety injection – 89

For the fatigue analyses of the PINGP Units 1 & 2 Safety Injection accumulator nozzle and RHR Tee, the following numbers of transients were analyzed:

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High head safety injection – This transient was not considered in the analyses as there is no flow path from the SI pumps to the SI accumulator nozzle or RHR Tee at PINGP.

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Inadvertent RCS depressurization – 1 / 1
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Excessive feedwater flow – 45 / 45
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OBE – 2 OBE events with 10 cycles each

Enclosure 1
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ADDITIONAL TRANSIENTS	Cycles accrued through 2/26/07		Cycles projected for 60 years	
	Unit 1	Unit 2	Unit 1	Unit 2
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Control rod drop (Historically, not counted)	No data	No data	--	--
Excessive feedwater flow (Historically, not counted)	No data	No data	--	--
RCS refueling	23	23	38.1	41.1
OBE (Historically, not counted)	0	0	0	0
Inadvertent accumulator blowdown (Historically, not counted)	0	0	0	0
RHR operation during plant cooldown (Historically, not counted)	187	163	295.6	258.6
High head safety injection	1	0	1.6	0

(2) Not all of the additional transients have been tracked and monitored since initial plant startup. As stated in NSPM letter L-PI-09-060, “The additional transients and revised cycle limits used in the fatigue evaluation will be added to the Metal Fatigue of Reactor Coolant Pressure Boundary Program in conjunction with License Renewal Commitment No. 33," and environmentally-assisted fatigue at these locations will be managed during the period of extended operation using cycle counting or cycle-based fatigue monitoring in accordance with 10 CFR 54.21(c)(1)(iii).

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On Page 3, the top paragraph states “… charging/letdown system flow shutoff and flow change transients were defined based on a standard set of Westinghouse design transients for auxiliary systems, as modified for the expected number of occurrences at 60 years ...".

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Request:

(1) Provide basis for making the cycle modification on the flow shutoff and the flow change transients and specify the actual cycles used for the analysis.

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(1) For the fatigue analyses of the PINGP Charging Nozzles, the following numbers of charging/letdown flow transients were analyzed (U1 / U2). For comparison, the numbers of design cycles from the Westinghouse Systems Standard are also shown.

Charging & letdown flow shutoff & return to service – 7 / 18 (Design = 60)
Letdown flow shutoff with prompt return to service – 55 / 75 (Design = 200)
Letdown flow shutoff with delayed return to service – 3 / 30 (Design = 20)
Charging flow shutoff with prompt return to service – 5 / 10 (Design = 20)
Charging flow shutoff with delayed return to service – 8 / 3 (Design = 20)
Charging flow step decrease & return to normal – 36,000 / 36,000 (Design = 24,000)
Charging flow step increase & return to normal – 36,000 / 36,000 (Design = 24,000)
Letdown flow step decrease & return to normal – 3000 / 3000 (Design = 2000)
Letdown flow step increase & return to normal – 36,000 / 36,000 (Design = 24,000)

Charging & Letdown flow shutoff transients have historically been tracked by the PINGP Metal Fatigue of Reactor Coolant Pressure Boundary Program. The numbers of these transients used in the analyses were based upon Unit-specific transient projections for 60 years of operation. The transient projections were made using a linear extrapolation of historical transient counts.

Charging & Letdown flow change transient events have not been counted in the past. The numbers of these transients used in the analyses were based upon increasing the 40-year design values by 50% to account for an additional 20 years of operation.

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LRA Table 4.3-8 shows the results of environmentally assisted cumulative fatigue usage (CUF_{en}) for the NUREG/CR-6260 components. For the nozzle components, it is unclear exactly for what spot/location of the nozzles the CUF values are representing.
Example: nozzle safe end; nozzle knuckle (nose); etc.

Request:

Please specify for spots/locations where the CUF shown in Table 4.3-8 is representing. Consider the following nozzles.

(1) Surge line hot leg nozzle
(2) Safety injection accumulator nozzle

(3) Charging system nozzle

NSPM Response to Part (D)

(1) The CUF for the surge line hot leg nozzle is at the surge pipe-to-nozzle weld, on the nozzle at the inside surface.

(2) The CUF for the safety injection accumulator nozzle is at the pipe-to-nozzle weld.

(3) The CUF for the charging system nozzle is at the charging nozzle-to-charging pipe weld root, inside surface.

NRC Clarification Request Part (E)

Pages 5 & 6 of Enclosure 1 discuss the F_{en} calculations.

Request:

(1) Please describe how you handled the strain rate and temperature going into calculation for F_{en} of each load set pair.

(2) What was the “conservatively-assumed” DO-level used for the calculations described in (1)?

NSPM Response to Part (E)

(1) The following discussion from the EAF calculation packages illustrates how strain rate and temperature were used in the calculation for each load set pair:

The F_{en} relationships described in NUREG/CR-5704 were used in the analyses. MRP-47, Revision 1 was also used for guidance in the calculations.

For Types 304 and 316 Stainless Steel: $F_{en} = \exp(0.935 - T^*\dot{\varepsilon}^*O^*)$, where:

F_{en} = fatigue life correction factor
T = fluid service temperature of transient, °C
T* = 0 for T < 200°C
= 1 for T ≥ 200°C
$\dot{\varepsilon}$ * = 0 for strain rate, $\dot{\varepsilon}$ > 0.4%/sec
= $\ln(\dot{\varepsilon}/0.4)$ for $0.0004 \le \dot{\varepsilon} \le 0.4$%/sec
= $\ln(0.0004/0.4)$ for $\dot{\varepsilon} < 0.0004$%/sec
O* = 0.260 for dissolved oxygen, DO < 0.05 parts per million (ppm)
= 0.172 for DO ≥ 0.05 ppm

Enclosure 1
Supplemental Information Related to Environmentally-Assisted Fatigue Calculations

The above equation was evaluated for several sets of parameter values, as shown below:

F_{en} = 2.55 (T < 200°C, any $\dot{\varepsilon}$, any DO)
F_{en} = 2.55 (T ≥ 200°C, $\dot{\varepsilon}$ ≥ 0.4%/sec, any DO)
F_{en} = 3.78 (T ≥ 200°C, $\dot{\varepsilon}$ = 0.04%/sec, DO ≥ 0.05 ppm)
F_{en} = 4.64 (T ≥ 200°C, $\dot{\varepsilon}$ = 0.04%/sec, DO < 0.05 ppm)
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F_{en} = 8.43 (T ≥ 200°C, $\dot{\varepsilon}$ = 0.004%/sec, DO < 0.05 ppm)
F_{en} = 8.36 (T ≥ 200°C, $\dot{\varepsilon}$ ≤ 0.0004%/sec, DO ≥ 0.05 ppm)
F_{en} = 15.35 (T ≥ 200°C, $\dot{\varepsilon}$ ≤ 0.0004%/sec, DO < 0.05 ppm)

F_{en} values were determined for each load pair in a detailed fatigue calculation, using the Integrated Strain Rate approach outlined in MRP-47. The environmentally-assisted fatigue (EAF) cumulative usage factor (CUF) was then determined as U_{env} = (U)(F_{en}), where U is the original fatigue CUF and F_{en} is the EAF multiplier.

The EAF evaluation was performed using the Integrated Strain Rate method described in MRP-47, Rev. 1. The F_{en} values for the individual load sets were calculated. The combined stress components for these transients from the fatigue analysis were used as the input for the EAF calculations. Strain rate ($\dot{\varepsilon}$) is calculated based on the stress time histories from the fatigue analysis. The stress intensity for the total stress from the combined stress results was calculated for each time step, using the six stress components. Strain values in terms of percent strain were computed from the signed stress intensity values based on:

$$\varepsilon = (100 \ast \sigma_{SI}) / E$$

The value of Young's Modulus, E, was taken as the E of the stainless steel fatigue curve. In accordance with the Integrated Strain Rate approach, strain is integrated between the minimum and maximum stress states of the paired events.

An environmentally-assisted fatigue factor (F_{en}) was calculated for each time step for steps of tensile strain change (e.g., $\varepsilon_t - \varepsilon_{t-1} \geq 0$), according to the methodology described above. In this process, the strain rates and strain contributions of each time step were also calculated. The fluid temperature (as defined by the transient temperature profile) associated with each time step was considered in the F_{en} calculation. To determine the overall F_{en} for each transient, the summation of all tensile strain contributions for each time step was performed. Then the F_{en} for each time step was multiplied by the difference in strain amplitude between the current and previous time steps. The results of this product were summed. F_{en} is calculated for all time steps in which strain is increasing (becoming more tensile).

Enclosure 1
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The F_{en} for the entire transient was calculated as follows:

$F_{en\ (total)} = \Sigma(F_{en\ (individual)} \times \Delta\varepsilon) / \Sigma\Delta\varepsilon$, where:

$F_{en\ (individual)}$ = the calculated F_{en} for each time step.
$\Delta\varepsilon$ = the difference between the strain amplitude (%) of the current time step and that for the preceding time step, calculated for each time step.
$\Sigma\Delta\varepsilon$ = the sum of the strain amplitude (%) contributions for each time step.

Using the results for the load pairs in the fatigue table, the F_{en} for each transient was calculated. F_{en} values were only calculated for the load pairs with a reasonably significant normal fatigue contribution (i.e.; fatigue usage values ≥ 0.001 for charging nozzle, ≥ 0.0015 for hot leg nozzle). For all other load pairs, the F_{en} was taken to be 15.35, which is the maximum value for a stainless steel material.

The fatigue table from the fatigue calculation was appended to include the F_{en} results to determine the EAF results for each load pair. The summation of the EAF results for the individual load pairs represents the cumulative EAF for the nozzle through 60 years of operation. The total EAF was divided by the total CUF (cumulative fatigue usage without environmental effects), resulting in the overall effective F_{en} for the nozzle.

(2) The following discussion from the EAF calculation packages discusses the assumption for dissolved oxygen:

The level of dissolved oxygen in the environment is assumed to be less than 0.05 ppm, which corresponds to a low oxygen environment. The O* value of 0.260 is applicable; this is conservative since this value yields higher F_{en} values. This is the conservative choice – as shown in the equation for the Fen above, the value for $\dot{\varepsilon}^*$ will always be negative or zero, which means that a larger value for O* will result in a higher F_{en}.

May 8, 2009

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10 CFR 54

U S Nuclear Regulatory Commission
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Prairie Island Nuclear Generating Plant Units 1 and 2
Dockets 50-282 and 50-306
License Nos. DPR-42 and DPR-60

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/S/ Michael D. Wadley

Michael D. Wadley
Site Vice President, Prairie Island Nuclear Generating Plant Units 1 and 2
Northern States Power Company - Minnesota

Enclosure (1)

cc:

Administrator, Region III, USNRC
License Renewal Project Manager, Prairie Island, USNRC
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OBE – 1 OBE event including 20 internal cycles

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The above equation was evaluated for several sets of parameter values, as shown below:

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F_{en} = 5.62 (T ≥ 200°C, $\dot{\varepsilon}$ = 0.004%/sec, DO ≥ 0.05 ppm)
F_{en} = 8.43 (T ≥ 200°C, $\dot{\varepsilon}$ = 0.004%/sec, DO < 0.05 ppm)
F_{en} = 8.36 (T ≥ 200°C, $\dot{\varepsilon}$ ≤ 0.0004%/sec, DO ≥ 0.05 ppm)
F_{en} = 15.35 (T ≥ 200°C, $\dot{\varepsilon}$ ≤ 0.0004%/sec, DO < 0.05 ppm)

F_{en} values were determined for each load pair in a detailed fatigue calculation, using the Integrated Strain Rate approach outlined in MRP-47. The environmentally-assisted fatigue (EAF) cumulative usage factor (CUF) was then determined as U_{env} = (U)(F_{en}), where U is the original fatigue CUF and F_{en} is the EAF multiplier.

The EAF evaluation was performed using the Integrated Strain Rate method described in MRP-47, Rev. 1. The F_{en} values for the individual load sets were calculated. The combined stress components for these transients from the fatigue analysis were used as the input for the EAF calculations. Strain rate ($\dot{\varepsilon}$) is calculated based on the stress time histories from the fatigue analysis. The stress intensity for the total stress from the combined stress results was calculated for each time step, using the six stress components. Strain values in terms of percent strain were computed from the signed stress intensity values based on:

$$\varepsilon = (100 * \sigma_{SI}) / E$$

The value of Young's Modulus, E, was taken as the E of the stainless steel fatigue curve. In accordance with the Integrated Strain Rate approach, strain is integrated between the minimum and maximum stress states of the paired events.

An environmentally-assisted fatigue factor (F_{en}) was calculated for each time step for steps of tensile strain change (e.g., $\varepsilon_t - \varepsilon_{t-1} \geq 0$), according to the methodology described above. In this process, the strain rates and strain contributions of each time step were also calculated. The fluid temperature (as defined by the transient temperature profile) associated with each time step was considered in the F_{en} calculation. To determine the overall F_{en} for each transient, the summation of all tensile strain contributions for each time step was performed. Then the F_{en} for each time step was multiplied by the difference in strain amplitude between the current and previous time steps. The results of this product were summed. F_{en} is calculated for all time steps in which strain is increasing (becoming more tensile).

Enclosure 1
Supplemental Information Related to Environmentally-Assisted Fatigue Calculations

The F_{en} for the entire transient was calculated as follows:

$F_{en\ (total)} = \Sigma(F_{en\ (individual)} \times \Delta\varepsilon) / \Sigma\Delta\varepsilon$, where:

$F_{en\ (individual)}$ = the calculated F_{en} for each time step.
$\Delta\varepsilon$ = the difference between the strain amplitude (%) of the current time step and that for the preceding time step, calculated for each time step.
$\Sigma\Delta\varepsilon$ = the sum of the strain amplitude (%) contributions for each time step.

Using the results for the load pairs in the fatigue table, the F_{en} for each transient was calculated. F_{en} values were only calculated for the load pairs with a reasonably significant normal fatigue contribution (i.e.; fatigue usage values ≥ 0.001 for charging nozzle, ≥ 0.0015 for hot leg nozzle). For all other load pairs, the F_{en} was taken to be 15.35, which is the maximum value for a stainless steel material.

The fatigue table from the fatigue calculation was appended to include the F_{en} results to determine the EAF results for each load pair. The summation of the EAF results for the individual load pairs represents the cumulative EAF for the nozzle through 60 years of operation. The total EAF was divided by the total CUF (cumulative fatigue usage without environmental effects), resulting in the overall effective F_{en} for the nozzle.

(2) The following discussion from the EAF calculation packages discusses the assumption for dissolved oxygen:

The level of dissolved oxygen in the environment is assumed to be less than 0.05 ppm, which corresponds to a low oxygen environment. The O* value of 0.260 is applicable; this is conservative since this value yields higher F_{en} values. This is the conservative choice – as shown in the equation for the Fen above, the value for $\dot{\varepsilon}^*$ will always be negative or zero, which means that a larger value for O* will result in a higher F_{en}.