ATTACHMENT II TO IPN-94-044

IP3 CALCULATION - IP3-CALC-RCS-00280
RT-PTS FOR PROPOSED NEW LICENSE EXPIRATION DATES

New York Power Authority
Indian Point 3 Nuclear Power Plant
Docket No. 50-286

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CAL. NO. IP3-CALC-RCS-00280 REV. 0 IP3 [x] JAF [ ]

MOD/TASK NO. N/A

QA CATEGORY: I PRELIMINARY: ____ FINAL: x

PROJECT/TASK: N/A
SYSTEM NO./NAME: Reactor Coolant System
TITLE: RT-PTS for Proposed New License Expiration Dates

	NAME	SIGNATURE	DATE
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PROBLEM/OBJECTIVE/METHOD In accordance with the methodology of Reg. Guide 1.99 Rev. 2, calculate End-of-License RT-PTS for the IP3 limiting Reactor Vessel baseplate and all beltline welds at these proposed EOL dates: 12/12/15, 12/12/25, 12/12/30, 12/12/35. Determine whether the requirements of 10CFR50 are met for all dates

DESIGN BASIS/ASSUMPTIONS

Assume 75% and 80% Capacity Factors (separate calculations).
Base current Reactor Vessel fluence on Capsule Z measurements.
Calculate EOL Reactor Vessel fluence based on Capsule Z measurements and also low-leakage core design (separate calcs).

SUMMARY/CONCLUSIONS Plant may operate until 12/12/2015 for up to 80% Capacity Factor without exceeding screening criteria of 10CFR50. This is also true for operation up to 12/12/25 with some restrictions. See Table 1 for summary of results.

REFERENCES

See enclosed Reference Section.

AFFECTED SYSTEMS/COMPONENTS/DOCUMENTS

Indian Point Unit 3 Operating License

[ ] VOIDED OR SUPERSEDED BY: N/A (CALC. NO.)

[ ] VOIDS OR SUPERSEDES: N/A (CALC. NO.)

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10CFR Part 50 and Reg. Guide 1.99 Rev. 2 have established a formula for the determination of RT_{PTS} and also a screening criterion, which says in effect that any plant whose reactor vessel (RV) is expected to have an RT_{PTS} >270°F prior to Expiration of License (EOL) must take special steps, such as adoption of low-leakage fuel management, to confirm that this screening criterion will in fact not be exceeded, or perform a plant specific analysis of the vessel material prior to exceeding screening criteria. Similar criteria exist for axial welds (270°F) and circumferential welds (300°F) (Ref 5)

The purpose of this calculation is to determine the limiting RT_{PTS} for EOL under a variety of circumstances, as noted below.

EOL Dates: 12/12/2015
12/12/2025
12/12/2030
12/12/2035

Capacity Factors (C_F) 75% and 80%

Two different values of neutron flux (ϕn) are to be used:

$\phi n = 1.43 \times 10^{10}$ n/cm^{2}s(avg.ϕn through Cycle 5 as measured in Ref. 4, Table 6.5)

and

$\phi n = 1.30 \times 10^{10}$ n/cm^{2}s (avg.ϕn using low-leakage design) (Ref 3, Table II.2-4)

Calculations are to be consistent with the methodology in Ref. 2

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From Reg. Guide 1.99, Rev. 2 (Ref. 1):

$$RT_{PTS} = I + M + [CF]\ f^{(0.28 - 0.10 \log_{10} f)} \qquad \{Eq.\ 1\}$$

where f = Predicted fluence for EOL, in units of 10^{19} n/cm^2

Note: The variable "f" represents neutron fluence on the Reactor Vessel. As used in EQ. 1, it is in units of 10^{19} n/cm^2. Otherwise it is in units of n/cm^2.

CF = Chemistry Factor = 158.70°F (CF is defined in Ref 1), based on calculations from Reference 2, Section 2.2 and based on Cu = .24, Ni = .52 (from Ref 3)

I = Initial Limiting RT_{NDT} = 74°F on Plate B2803-3

M = Margin = $2\sqrt{\sigma_I^2 + \sigma_\Delta^2}$

from Reference 2, Section 2.6:

$$\sigma_I^2 = 0$$

$$\sigma_\Delta^2 = 8.5°F$$

$$M = 2\sqrt{(0^2 + 8.5^2)} = 17°F$$

Measured fluence (Ref. 4) is 0.313×10^{19} n/cm^2 at the end of Cycle 5 (i.e., 9/5/87)

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In order to calculate EOL RT_{PTS}, we must

A - bring fluence up to date from 9/5/87 based on actual operating history, and

B - project an EOL fluence from which RT_{PTS} may be calculated using the Reg. Guide 1.99 formula.

Therefore:

A:

Measured Cycle 6 burnup = 435.9 EFPD (Effective Full Power Days)

Measured Cycle 7 burnup = 394.3 EFPD

Cycle 8 burnup through 11/25/91 = 275.3 EFPD

Total = 1105.5 EFPD

1105.5 EFPD x 24 hrs/day x 3600 sec/hr = 9.5515×10^7 (Eff. full power) secs

$f_{current}$ = fluence(11/25/91) = $(3.13 \times 10^{18}\ n/cm^2) + \phi n \times 9.5515 \times 10^7 s$

= $4.496 \times 10^{18}\ n/cm^2$ for $\phi n = 1.43 \times 10^{10} n/cm^2 s$

= $4.372 \times 10^{18}\ n/cm^2$ for $\phi n = 1.30 \times 10^{10} n/cm^2 s$

B: The formula for EOL fluence becomes:

$$f_{EOL} = \left\{ f_{current} + [(T \times 24\ hrs/day \times 3600\ sec/hr) \times C_F\ \phi n] \right\} \div 10^{19} n/cm^2 \qquad \{Eq. 2\}$$

where T = number of days between proposed EOL date and 11/25/91

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Example: First Calculation Conditions:

EOL = 12/12/15

C_F = 75%

ϕn = 1.43×10^{10} n/cm^{2}s, which implies:

$f_{current} = 4.496 \times 10^{18}$ n/cm^2

T = Days from 11/25/91 to 12/12/15

= ((2015 - 1991) x 365) + (346 - 329) + 5 = 8782 {Eq. 3}

Julian	J.D	Leap years
date of	of	between 1991
12/12	11/25	and 2015

$$f_{EOL} = \left\{4.496\times10^{18} + [(8782\times24\times3600)\times0.75\times(1.43\times10^{10})]\right\} \div 10^{19} = 1.26$$

For the limiting base plate (B2803-3):

$$RT_{PTS} = I + M + [CF]\ f^{(0.28 - 0.10 \log_{10} f)}$$

$$= 74^{\circ}F + 17^{\circ}F + (158.7^{\circ}F)\ (1.26)^{(0.28 - 0.10 \times \log_{10} 1.26)}$$

= 259.92°F <270°F and therefore within the screening criterion

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Two types of vessel weld are also evaluated in the same fashion:

Type 1 Intermediate shell and lower shell longitudinal seam welds, which have a chemistry factor of 220°F (based on Cu=0.19% and Ni= 1.00%) (Refs. 1 and 4)

This type of weld, which has an estimated initial RT_{NDT} of -56°F, uses the following equation for RT_{PTS}.

$$RT_{PTS} = (-56^{o}F) + (56^{o}F) + [220^{o}F]\ f^{(0.28 - 0.10\ \log_{10} f)} \qquad \{Eq.\ 4\}$$

Type 2 Intermediate to Lower Shell Girth Seam, has a Chemistry Factor of 206.4°F (based on Cu= 0.27% and Ni = 0.74%) (Refs 1 and 4)

This type of weld, which has an initial RT_{NDT} of -70°F, uses the following equation for RT_{PTS}:

$$= (-70^{o}F) + (28^{o}F) + [206.4^{o}F]\ f^{(0.28-0.10\ \log_{10} f)} \qquad \{Eq.\ 5\}$$

Note that the uncertainty margin for the Type 1 weld is 56°F (rather than 28°F for the Type 2 weld) since the initial RT_{NDT} for that weld is estimated rather than measured. The screening criteria for Type 1 welds is 270°F and for Type 2 welds is 300°F (Ref 5)

On the next page, a table shows the results of calculations performed on the baseplate and welds, precisely as shown on the included example and using the appropriate equation for RT_{PTS}. Specifically, the value of "T" for each EOL date is calculated using the method of Eq. 3. Then, a value for f is determined using the tabulated capacity Factors and fluxes, via Equation 2. Then RT_{PTS} is determined for baseplate, Type 1 welds and Type 2 welds using Equations 1, 4 and 5, respectively.

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Table 1

RT_{PTS} CALCULATIONS FOR BASEPLATE B2803-3 AND WELDS

Case	EOL Date	T (Days)	ϕ_n (n/cm^{2}s)	C_f	f	RT_{PTS} (°F) Baseplate	Type 1 Weld	Type 2 Weld
1	Dec 12, 2015	8782	$1.30*10^{10}$	0.75	1.18	257.03	230.16	173.93
2				0.80	1.23	258.86	232.70	176.31
3			$1.43*10^{10}$	0.75	1.26	259.92	234.16	177.69
4				0.80	1.32	261.96	236.99	180.34
5	Dec 12, 2025	12,434	$1.30*10^{10}$	0.75	1.48	266.93	243.89	186.81
6				0.80	1.55	268.93	246.66	189.41
7			$1.43*10^{10}$	0.75	1.60	270.29	248.55	191.18
8				0.80	1.68	272.38	251.44	193.90
9	Dec 12, 2030	14,261	$1.30*10^{10}$	0.75	1.64	271.35	250.01	192.56
10				0.80	1.72	273.38	252.83	195.20
11			$1.43*10^{10}$	0.75	1.77	274.59	254.51	196.78
12				0.80	1.86	276.69	257.41	199.50
13	Dec 12, 2035	16,087	$1.30*10^{10}$	0.75	1.79	275.07	255.17	197.40
14				0.80	1.88	277.13	258.03	200.08
15			$1.43*10^{10}$	0.75	1.94	278.45	259.85	201.79
16				0.80	2.04	280.53	262.74	204.50

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Note that in all cases, the RT_{PTS} for the welds stay within the screening criteria (270°F for Type 1, 300°F for Type 2). Baseplate RT_{PTS} stays within the 270°F criterion for Cases 1 through 6. That is to say, the vessel is clearly within the criterion for all operation through December 12, 2015 and is also within the criterion for operation through December 12, 2025, provided that a low-leakage design using a neutron flux of 1.30×10^{10} n/cm^{2}s or less is used. The above statements also assume that average plant capacity factor does not exceed 80 percent during the remainder of license operation; if so, a separate set of calculations will have to be performed.

References

1.0 Reg. Guide 1.99, Rev. 2

2.0 "Final Report on Pressure-Temperature Limits for Indian Point 3 Nuclear Power Plant", ABB Combustion Engineering, July 1990.

3.0 WCAP-11057, "Indian Point Unit 3 Reactor Vessel Fluence and RT_{PTS} Evaluations for Consideration of Life Extension", S. E. Yanichko et al, Westinghouse Electric Corporation, June 1989.

4.0 WCAP-11815, "Analysis of Capsule Z from the New York Power Authority Indian Point Unit 3, Reactor Vessel Surveillance Program" S. E. Yanichko et al, Westinghouse Electric Corporation, March 1988.

5.0 10CFR50, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events", Federal Register, Vol. 56, No. 94, Effective May 15, 1991.