CALCULATION COVER SHEET

ComEd

ZION NUCLEAR STATION

Zion Calculation No.: 22S-B-004E-189

DESCRIPTION CODE: 104

SYSTEM CODE: RC

TITLE: Low Temperature Overpressurization Protection (LTOP) Setpoint Calculation

REFERENCE NUMBERS

Type	Number	Type	Number
PRCJ	4950		

COMPONENT EPN:

EPN Number	Compt Type	Component
1(2)PT-403		
1(2)PT-405		
1(2)PXX-403		
1(2)PXX-405		

DOCUMENT NUMBERS:

Doc Type	Document Number
DWGC	M-9
PROC	See Section 5.3
DATA	See Section 5.4.1
CALC	22S-B-004E-166, Rev. 1

REMARKS: Calculation has been revised to reflect a reduced minimum acceptable Appendix G curve pressure of 470 psig.

REV. NO.	REVISION	APPROVED	DATE
1	Reduced Appendix G curve pressure	D. P. Galvin	11-4-96
0	Original Issue	D. Ewan	5/14/96

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CALCULATION TITLE PAGE

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☒ SAFETY RELATED ☐ REGULATORY RELATED ☐ NON- SAFETY RELATED

CALCULATION TITLE:

Low Temperature Overpressurization Protection (LTOP) Setpoint Calculation

STATION/UNIT: ZION / 1&2 SYSTEM ABBREVIATION: RC

EQUIPMENT NO. 1(2)PT-403
1(2)PT-405
1(2)PXX-403
1(2)PXX-405

PROJECT NO. 4950

REV: 1 STATUS: Approved QA SERIAL NO. OR CHRON NO. N/A DATE: N/A

PREPARED BY: Chuck Hallett C W Hallett DATE: 11/4/96

REVISION SUMMARY: Revised the minimum acceptable Appendix G curve RCS pressure to reflect revised loop uncertainty (Reference 5.2.1). Revised static head correction error to agree with instrument location higher than vessel beltline level.

ELECTRONIC CALCULATION DATA FILES REVISED:
(Name ext/size/date/hour:min/verification method/remarks)

4-189R1.Doc/102912/11-4-96/5:19:10pm

DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION YES ☐ NO ☒

REVIEWED BY: P. VandeVisse C W Hallett for P. VandeVisse DATE: 11/4/96
REVIEW METHOD: Detailed Review COMMENTS (C, NC OR CI): CT

APPROVED BY: Dean Galanis D. B. Galanis DATE: 11-4-96

COMMONWEALTH EDISON COMPANY
CALCULATION REVISION PAGE

CALCULATION NO. 22S-B-004E-189 PAGE NO.: 2 OF 9

REV: 0 STATUS: Approved QA SERIAL NO. OR CHRON NO. N/A DATE: 5/14/96

PREPARED BY: C. Hallett DATE: 5/9/96

REVISION SUMMARY: Initial Issue

ELECTRONIC CALCULATION DATA FILES REVISED: NONE
(Name ext/size/date/hour:min/verification method/remarks)

DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION
YES☐ NO☒

1. REVIEWED BY: S. McCarthy DATE: 5/13/96
2. REVIEW METHOD: Detailed Review COMMENTS (C, NC, CI): NC

3. APPROVED BY: D. Ewan DATE: 5/14/96

REV: STATUS: QA SERIAL NO. OR CHRON NO. DATE:

PREPARED BY: DATE:

REVISION SUMMARY:

ELECTRONIC CALCULATION DATA FILES REVISED:
(Name ext/size/date/hour:min/verification method/remarks)

DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION
YES☐ NO☐

1. REVIEWED BY: DATE:
2. REVIEW METHOD: COMMENTS (C, NC, CI): _____

3. APPROVED BY: DATE:

COMMONWEALTH EDISON COMPANY
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1. PURPOSE / OBJECTIVE

The purpose of this calculation is to determine a minimum Reactor Coolant System (RCS) pressure to be used in the development of new Appendix G Heatup & Cooldown Curves.

The minimum pressure will be based upon the existing Low Temperature Overpressurization Protection (LTOP) Power Operated Relief Valve (PORV) setpoints, minimum RCS temperature of 60°F, and simultaneous operation of one Residual Heat Removal (RHR) Pump and one Reactor Coolant Pump (RCP). The minimum pressure will also account for instrumentation uncertainty, transmitter elevation static head and the American Society of Mechanical Engineers (A.S.M.E) Code Case N-514 maximum vessel pressure.

2. METHODOLOGY / ACCEPTANCE CRITERIA

2.1 Methodology

The RCS Heatup & Cooldown Curves are determined by analysis of reactor vessel weld properties, radiation exposure, etc. These curves represent operational limits for RCS pressure and temperature at low temperature operation, i.e. during heatup and cooldown.

The calibrated PORV setpoint is calculated to ensure there is a high degree of confidence that the operational limit is not exceeded..

A.S.M.E. Code Case N-514 [5.1.3] "Low Temperature Overpressure Protection Section XI, Division 1" states "LTOP systems shall limit the maximum pressure in the vessel to 110% of the pressure determined to satisfy Appendix G, para. G-2215 of Section XI, Division 1" Therefore the PORV setpoint value may be based on 110% of the Appendix G curve operational limit. The Code Case N-514 maximum pressure is designated P_{Max}.

The Appendix G pressure limit refers to the pressure at the vessel beltline region, which region encompasses the center of the reactor core. The core centerline is the reference for all static and dynamic pressure corrections in this calculation.

The operational limit ($P_{App\ G\ curve}$) is reduced by the following factors:

- ΔP due to PORV overshoot (ΔP_{PORV}).
- ΔP between the transmitters and core centerline to account for dynamic head loss due to running the maximum permitted combination of RCPs and RHR pumps at 65°F (ΔP_{pump}).
- static head effect due to differences between the core centerline and transmitter elevations (ΔP_{elev}).
- instrument uncertainty ($P_{Instrument\ Uncertainty}$).

The Total Loop Errors calculated in Reference 5.2.1 are incorporated herein. Methodologies and references which pertain to incorporating the Total Loop Error are not repeated in this calculation.

2.2 Acceptance Criteria

The existing PORV setpoint of 407 psig is adequate to ensure a high degree of confidence that the Code Case N-514 operational limit is not exceeded..

3. ASSUMPTIONS AND LIMITATIONS

None

4. DESIGN INPUT

4.1 Current LTOP setpoints [5.4.1]

1PXX-403	407 psig
2PXX-403	407 psig
1PXX-405	407 psig
2PXX-405	407 psig

$P_{setpoint}$ is the bistable setting pressure where the Power Operated Relief Valves will open.

$P_{setpoint}$ = 407 psig

4.2 Transmitter Elevation Static Head

The calibration of the RCS Wide Range Pressure Transmitters are not compensated for static head between their mounted elevation and the reactor core centerline [5.3.6, 5.3.7, 5.3.8, 5.3.9]. Three transmitters are mounted at 574' 2" and one at 574' 5" [5.4.1].

As depicted in Reference 5.4.2, the core centerline is at elevation 572' 9".

For purposes of conservatism, the largest static head will be used as the P_{elev} variable.

where ρ = 62.453 lbm/ft^3 at 60°F and 407 psig [5.5.1]

$$\Delta P_{elev} = \left(h_{xmtr} - h_{core\ centerline}\right) \bullet \rho$$

$$= \frac{\left(574\ '5'' - 572\ '\ 9''\right) \bullet \frac{62.453\ \text{lbm}}{\text{ft}^3}}{\frac{144\ \text{in}^2}{\text{ft}^2}} = \frac{1.667\ \text{ft} \bullet \frac{62.453\ \text{lbm}}{\text{ft}^3}}{\frac{144\ \text{in}^2}{\text{ft}^2}}$$

$$= 0.72\ \text{psi}$$

Since the transmitter is at a higher elevation than the core centerline, pressure sensed at the transmitter is always lower than core centerline pressure by a quantity equal to ΔP_{elev}. Therefore ignoring all other condierations, $P_{setpoint} = P_{App\ G\ Curve} - \Delta P_{elev}$.

4.3 PORV Overshoot

The PORV Overshoot is the difference between the maximum RCS pressure reached while the PORV strokes open in response to a pressure excursion and the PORV setpoint.

The maximum RCS pressure reached is determined from data in Reference 5.2.4.

Setpoint Assumed psig	PORV Open Stroke Time seconds	Maximum RCS Pressure Reached (P_{MAX}) psig
400	2	442
	4	450
500	2	542
	4	548

The current LTOP Setpoint is 407 psig [4.1]

The PORV Open Stroke time is 3.4 seconds [5.3.2, 5.3.3, 5.3.4]

It is first necessary to determine the maximum RCS pressure reached at 2 and 4 seconds for 407 psig through interpolation

$$\text{Max RCS Press @ 2 seconds} = \frac{542 - 442}{500 - 400} * (407 - 400) + 442$$
$$= 449 \text{ psi}$$

$$\text{Max RCS Press @ 4 seconds} = \frac{548 - 450}{500 - 400} * (407 - 400) + 450$$
$$= 456.86 \text{ psi}$$

The maximum RCS pressure reached at 3.4 seconds is interpolated

$$\text{Max RCS Press @ 3.4 seconds} = \frac{456.86 - 449}{4 - 2} * (3.4 - 2) + 449$$
$$= 454.5 \text{ psi}$$

$$\Delta P_{PORV} = P_{\text{Max RCS Pressure}} - P_{\text{Setpoint}}$$
$$= 454.5 - 407$$
$$= 47.5 \text{ psi}$$

4.4 RCP/RHR Pump Operation Induced ΔP errors

ΔP_{Pump} represents the dynamic headloss between the core centerline and the RCS hot legs.

Pump operations between 65°F and 70°F are limited by Reference 5.3.5 to one RCP and one RHR pump. ΔP errors induced by this pump combination is 22.6 psi [5.2.3].

$$\Delta P_{pump} = 22.6 \text{ psi}$$

4.5 Instrument Uncertainty

The total loop uncertainty as calculated in Zion Calculation 22S-B-004E-166, "COMS/LTOP Pressure Instrument Loop Accuracy Calculation" [5.2.1] is 38.0 psi.

$P_{Instrument\ Uncertainty}$ = 38.0 psi

5. REFERENCES

5.1 METHODOLOGY

5.1.1 TID-E/I&C-10 Rev. 0, "Analysis of Instrument Channel Setpoint Error & Instrument Loop Accuracy",

5.1.2 TID-E/I&C-20 Rev. 0, "Basis for Analysis of Instrument Channel Setpoint Error & Loop Accuracy",

5.1.3 American Society of Mechanical Engineers Cases of ASME Boiler and Pressure Vessel Code Case N-514, February 12, 1992

5.2 CALCULATIONS

5.2.1 22S-B-004E-166 Rev. 1, "COMS/LTOP Pressure Instrument Loop Accuracy Calculation"

5.2.2 Westinghouse Letter CWE-93-181, dated 10/4/93 "Commonwealth Edison Company Zion Units 1 & 2 Evaluation of COMS Analyses"

5.2.3 Ibid., page 11, Table 3: Pressure Differentials Zion Units 1 and 2

5.2.4 Ibid., page 16, Table 4: Pressure Overshoot Due to Mass Injection Transients Zion Units 1 and 2 (Current Values)

5.3 ZION STATION PROCEDURES

5.3.1 NEP 12.02, Rev. 2 "Preparation, Review, and Approval of Calculations"

5.3.2 PT-27A1-ST, Rev 4 "Pressurizer PORV and Block Valve Stroke Time Test With RCS Less Than 320°F"

5.3.3 PT-27A2-ST, Rev. 3 "Pressurizer PORV and Block Valve Stroke Time Test With RCS Greater Than 320°F"

5.3.4 PT-27A3-ST, Rev. 0 "Pressurizer PORV and Block Valve Stroke Time Test With RCS Less Than 200°F"

5.3.5 GOP-1, Rev. 11 "Plant Heatup"

5.3.6 IMTS-1P-403, Rev. 1 "Reactor Coolant Wide Range Pressure Transmitter"

5.3.7 IMTS-1P-405, Rev. 2 "Reactor Coolant Wide Range Pressure Transmitter"

5.3.8 IMTS-2P-403, Rev. 2 "Reactor Coolant Wide Range Pressure Transmitter"

5.3.9 IMTS-2P-405, Rev. 1 "Reactor Coolant Wide Range Pressure Transmitter"

5.4 ZION STATION DRAWINGS

5.4.1 ComEd Instrument Database (IDATA), Specific Data Sheet, and Supplemental Data Sheet for the following instruments:

1PT-403 Rev. D	1PXX-403 Rev. B
1PT-405 Rev. D	1PXX-405 Rev. B
2PT-403 Rev. C	2PXX-403 Rev. B
2PT-405 Rev. C	2PXX-405 Rev. B

5.4.2 M-9 Rev. F "General Arrangement Sections A-A & B-B Zion Station Unit No. 1 & 2"

5.5 MISCELLANEOUS

5.5.1 A.S.M.E. Steam Tables

6. CALCULATIONS

This calculation will determine the minimum pressure to be used by Westinghouse to develop new Appendix G Heatup/Cooldown curves based upon the current LTOP setpoint.

The new RCS pressure will be designated as $P_{App\ G\ curve}$

Per A.S.M.E. Code Case N-514 the LTOP system shall limit the maximum pressure in the vessel to 110% of the Appendix G Curve, therefore;

$$P_{Max} = 110\% \bullet P_{App\ G\ curve}$$

The LTOP setpoint is derived by;

$$P_{setpoint} = P_{Max} - \Delta P_{elev} - \Delta P_{PORV} - \Delta P_{pump} - P_{Instrument\ Uncertainty}$$

by substitution:

$$P_{setpoint} = (110\% \bullet P_{App\ G\ curve}) - \Delta P_{elev} - \Delta P_{PORV} - \Delta P_{pump} - P_{Instrument\ Uncertainty}$$

$$P_{App\ G\ curve} = \frac{P_{setpoint} + \Delta P_{elev} + \Delta P_{PORV} + \Delta P_{pump} + P_{Instrument\ Uncertainty}}{110}$$

Substituting the design input values:

$$P_{App\ G\ curve} = \frac{407\ psig + 0.72\ psi + 47.5\ psi + 22.6\ psi + 38.0\ psi}{1.10}$$

$$= 468.84\ psig$$

Rounded

$P_{App\ G\ Curve} = 469$ psig

7. SUMMARY AND CONCLUSIONS

7.1 The minimum acceptable Appendix G Curve Pressure, based upon the current LTOP setpoint is 469 psig @ 60°F.

FINAL PAGE

Attachment B

Zion Calculation No. 22S-B-004E-166, Revision 1