CALCULATION COVER SHEET

ComEd

ZION NUCLEAR STATION

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

Title: Low Temperature Overpressurization Protection (LTOP) Setpoint Calculation

Project Title: I&C Setpoint Program

PURPOSE: 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.

CALCULATION TYPE: IS SR SOFTWARE USED: None

PLANT DESIGN CHANGE NUMBER: N/A PROJECT NUMBER: 4950

RELATED/REFERENCED CALCULATIONS: 22S-B-004E-166, Rev. 0

COMPONENT IDENTIFICATION NUMBERS:
(2)1PT-403
(2)1PT-405
(2)1PXX-403
(2)1PXX-405

DRAWING NUMBERS: M-9, Rev. E

REMARKS: CHRON # N/A

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0	Original Issue	Dan Ewan	5/14/96

COMMONWEALTH EDISON COMPANY
CALCULATION TITLE PAGE

CALCULATION NO. 22S-B-004E-189 PAGE NO.: 1 OF 8

☒ SAFETY RELATED ☐ REGULATORY RELATED ☐ NON- SAFETY RELATED

CALCULATION TITLE:

Low Temperature Over-Pressurization Protection (LTOP) Setpoint Calculation

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

EQUIPMENT NO. PROJECT NO. 4950

1PT-403	1PXX-403
1PT-405	1PXX-405
2PT-403	2PXX-403
2PT-405	2PXX-405

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

PREPARED BY: Chuck Hallett *C Hallett* DATE: 5/9/96

REVISION SUMMARY: Rev. 0 - INITIAL ISSUE

ELECTRONIC CALCULATION DATA FILES REVISED: None
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DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION YES ☐ NO ☒

REVIEWED BY: Steve McCarthy *S.S. McCarthy* DATE: 5/13/96
REVIEW METHOD: Detailed Review COMMENTS (C OR NC): NC

APPROVED BY: Dan Ewan *Dan Ewan* DATE: 5/14/96

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, the minimum head bolt-up temperature of 65°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 PORV setpoint ensures the operational limit is never 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

Not applicable

REVISION NO.	0			

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 = 62.422 lbm/ft^3 at 65°F and 407 psig [5.5.1]

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

$$= \frac{(572'\ 9" - 574'\ 5") \bullet \frac{62.422\ lbm}{ft^3}}{\frac{144\ in^2}{ft^2}}$$

$$= \frac{-1.667\ ft \bullet \frac{62.422\ lbm}{ft^3}}{\frac{144\ in^2}{ft^2}}$$

$$= -0.72\ psi$$

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

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

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

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 42.3 psi.

$$P_{Instrument\ Uncertainty} = 42.3 \text{ psi}$$

5. REFERENCES

5.1 METHODOLOGY

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

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

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. 0, "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. 10 "Plant Heatup"

5.3.6 IMTS-1P-403, Rev. 0 "Reactor Coolant Wide Range Pressure Transmitter"

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

5.3.8 IMTS-2P-403, Rev. 1 "Reactor Coolant Wide Range Pressure Transmitter"

5.3.9 IMTS-2P-405, Rev. 0 "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. E "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:

$$P_{App\ G\ curve} = \frac{407\ psig + (-0.72\ psi) + 47.5\ psi + 22.6\ psi + 42.3\ psi}{1.10}$$

$$= 47153\ psig$$

Rounded

$$P_{App\ G\ Curve} = 472\ psig$$

7. SUMMARY AND CONCLUSIONS

The minimum acceptable Appendix G Curve Pressure, based upon the current LTOP setpoint is 472 psig @ 65°F.

FINAL PAGE

Attachment C

Westinghouse letter CWE-93-181, dated October 4, 1993

Westinghouse
Electric Corporation

Energy Systems

Box 355
Pittsburgh Pennsylvania 15230 0355

CWE-93-181
October 4, 1993

Mr. E. A. Broccolo
Commonwealth Edison Company
Zion Nuclear Station
101 Shiloh Boulevard
Zion, IL 60099

Commonwealth Edison Company
Zion Units 1 & 2
Evaluation of COMS Analyses

Dear Mr. Broccolo:

The purpose of this letter is to transmit the report regarding the Cold Overpressure Mitigating System (COMS) at the Zion Station units.

If you have any questions or require further information on this matter, please contact me.

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

B. S. Humphries, Manager
Commonwealth Edison Project
Domestic Customer Projects

Attachment

0063/e

cc: Station VETIP Coordinator

J. A. Johnson	Zion
K. A. Ainger	Zion
D. B. Wozniak	Zion
M. E. Lohmann	Zion
N. P. Mueller	Energy Center
S. M. DiTommaso	Energy Center
K. W. Norris	Zion

0063jb

ZION UNITS 1 AND 2
REVISED COMS PORV SETPOINT ANALYSIS
OCTOBER 1993

Revised PORV COMS (Cold Overpressure Mitigation System) setpoints have been determined for Zion Units 1 and 2. The setpoints have been developed over a range of PORV stroke times for various Effective Full Power Years (EFPY) of operation for both units 1 and 2. Major assumptions in their development are provided below.

This COMS setpoint analysis has been performed in response to a nonconservatism identified after the previous setpoint development had been completed. The pressure difference from the reactor vessel midplane, where Appendix G Limits are defined, and the wide range pressure transmitter had not been considered which resulted in a higher RCS pressure at the midplane than that transmitted to actuate the PORVs. Thus, the potential existed for violation of Appendix G Limits. This new analysis accounts for the pressure difference between the pressure transmitter and the reactor midplane. (See Table 2 of this document). As this nonconservative pressure difference is proportional to the number of reactor coolant pumps and residual heat removal pumps (RHRP) in operation, unique groups of setpoints are determined for 1, 2 and 4 operating reactor coolant pumps, as well as 1 and 2 operating residual heat removal pumps.

Single setpoints for operating with reactor vessel exposures of 14, 20, 25 and 32 EFPY are presented over a range of primary PORV opening stroke times between 1 and 10 seconds. These maximum allowable setpoints are bounded by the steady state Appendix G limit at 85 deg F, without margin for instrument channel uncertainty either in the setpoint or the pressure temperature limit. The evaluation does not consider the pressure limit associated with the number one reactor coolant pump seal limit.

Setpoints are generally evaluated following a comprehensive parametric analysis of Reactor Coolant System behaviour during one of two design transients under water solid conditions. The first is a mass injection transient characterized by loss of letdown, due to the spurious isolation of the residual heat removal system, concurrent with the failure of the charging flow controls to full flow. The second is a heat injection transient, resulting from the start of a reactor coolant pump when there is temperature asymmetry between the Steam Generators and the rest of the Reactor Coolant System, the Steam Generators operating at the higher temperature. This causes heat transfer from the secondary to the primary side of the system.

The COMS Setpoint program for both Zion units is independent of RCS temperature, so that the single setpoint value is defined by the most limiting value of the pressure/temperature (Appendix G) limit at 85°F. Previous COMS analyses for Zion Units 1 and 2 have confirmed the dominance of the mass injection event at low temperatures (generally less than 150 deg F). Therefore, overpressures caused by the mass injection transient form the basis for setpoint determination in this COMS/evaluation (see Table 4). This is consistent with the 1990 Zion

COMS setpoint evaluation which accounted for signal delays anticipated in the Eagle 21 digital protection system then being installed in both units for which the heat injection event was not reanalyzed.

Assumptions and initial conditions of the mass injection design transient begin on page 12 of this report, followed by limiting mass injection rates. While the heat injection transient was not analyzed to account for Eagle 21 implementation, relevant assumptions and results of the 1986 COMS analyses are included for information along with the setpoint pressure overshoots. (See Tables 5 and 6). The Zion maximum charging flow for a single centrifugal charging pump is provided in Figure 7 and is consistent with the previous COMS analyses.

Maximum allowable setpoints for Zion Units 1 and 2 are provided in Tables 1 and 2. Figures 1-6 illustrate the maximum allowable setpoints versus PORV stroke time, for each vessel exposure period and number of RCPs and RHRPs in operation.

TABLE 1: ZION UNITS 1 AND 2

MAXIMUM ALLOWABLE LTOPS PORV SETPOINTS
1 RHRP PUMP IN OPERATION

EFPY (Stroke Time)		SETPOINTS (PSIG) 1 PUMP	2 PUMPS	4 PUMPS
14 EFPY	Stroke Time			
	1 s	428	421	384
	2	424	417	381
	4	416	409	372
	6	407	400	362
	8	399	391	354
	10	389	381	343
20 EFPY	Stroke Time			
	1 s	420	413	376
	2	416	409	373
	4	408	401	364
	6	399	391	354
	8	390	383	345
	10	380	373	334
25 EFPY	Stroke Time			
	1 s	417	410	373
	2	413	406	370
	4	405	398	361
	6	395	388	351
	8	387	380	342
	10	377	369	331
32 EFPY	Stroke Time			
	1 s	413	406	369
	2	409	402	366
	4	401	393	357
	6	391	384	346
	8	383	376	338
	10	373	365	326

TABLE 2: ZION UNITS 1 AND 2

MAXIMUM ALLOWABLE LTOPS PORV SETPOINTS
2 RHR PUMPS IN OPERATION

EFPY (Stroke Time)		SETPOINTS (PSIG) 1 PUMP	2 PUMPS	4 PUMPS
14 EFPY	Stroke Time			
	1 s	425	418	381
	2	421	414	378
	4	413	406	369
	6	404	396	359
	8	395	388	351
	10	386	378	339
20 EFPY	Stroke Time			
	1 s	417	410	373
	2	413	406	370
	4	405	398	361
	6	395	388	351
	8	387	380	342
	10	377	369	331
25 EFPY	Stroke Time			
	1 s	414	407	370
	2	410	403	367
	4	402	394	358
	6	392	385	347
	8	384	377	339
	10	374	366	328
32 EFPY	Stroke Time			
	1 s	410	403	366
	2	406	399	363
	4	398	390	354
	6	388	381	343
	8	380	372	335
	10	369	362	323

Figure 1: Maximum Allowable Setpoints
1 RCP, 1 RHRP

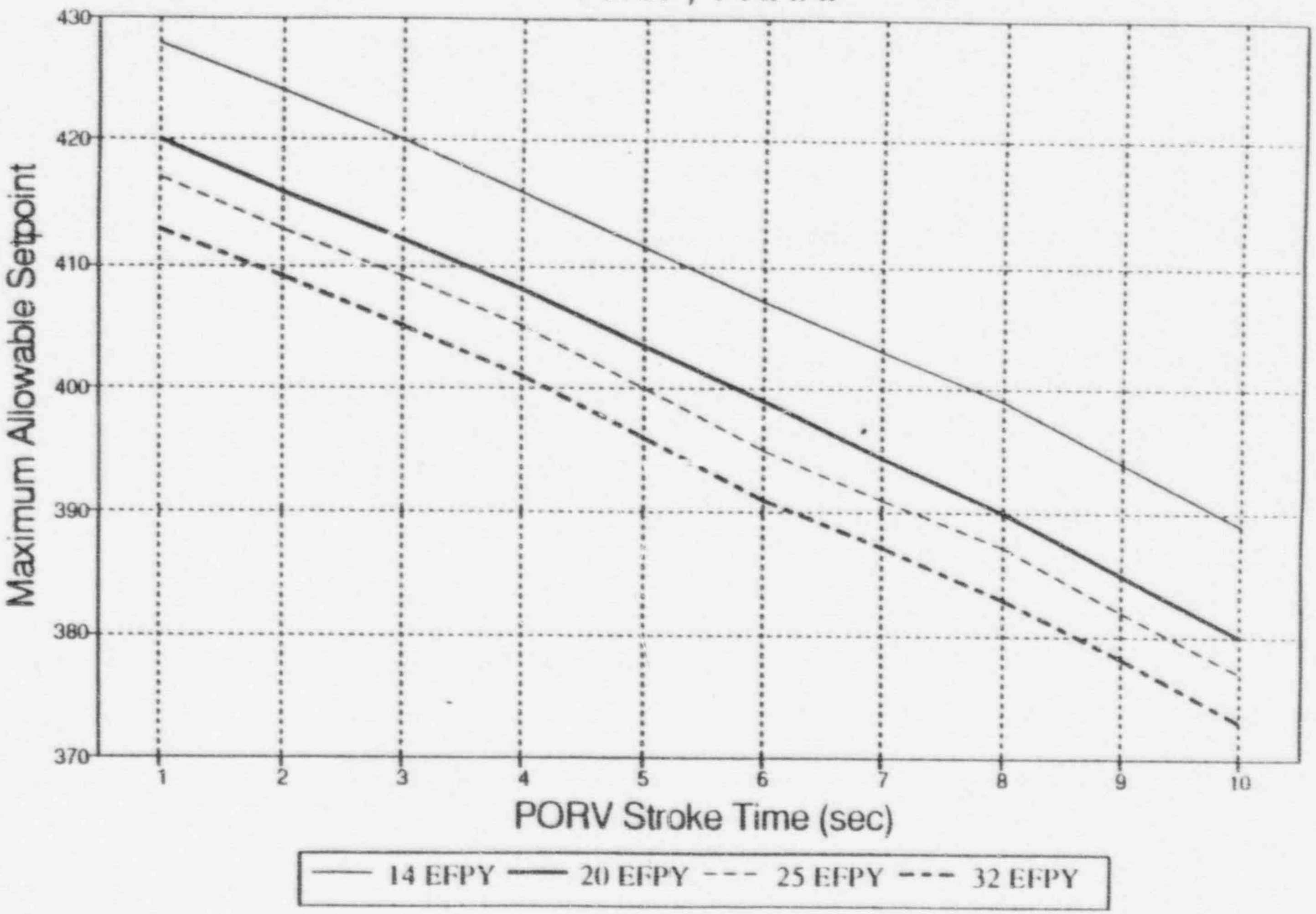

Figure 2: Maximum Allowable Setpoints
2 RCPS, 1 RHRP

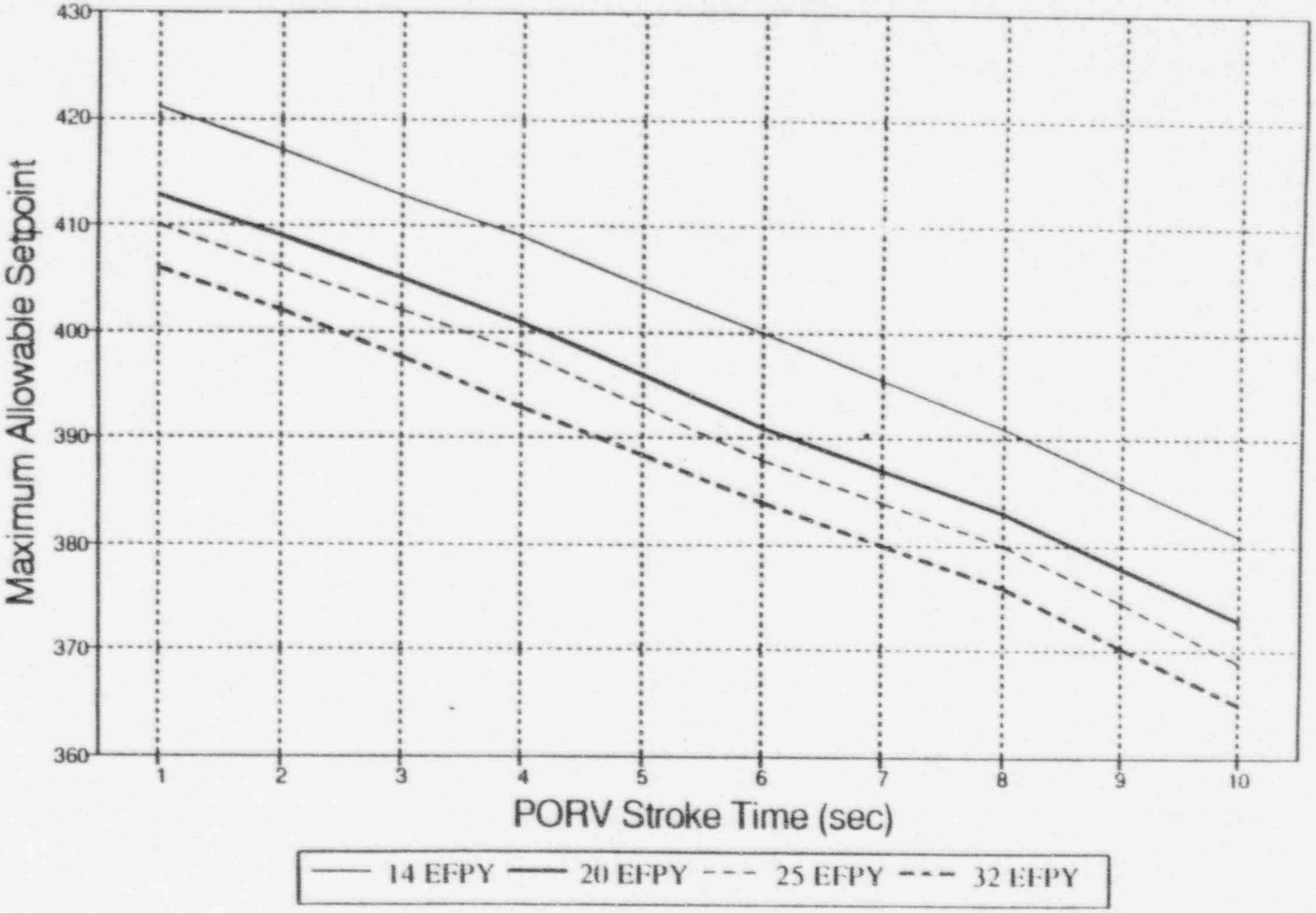

Figure 3: Maximum Allowable Setpoints
4 RCPS, 1 RHRP

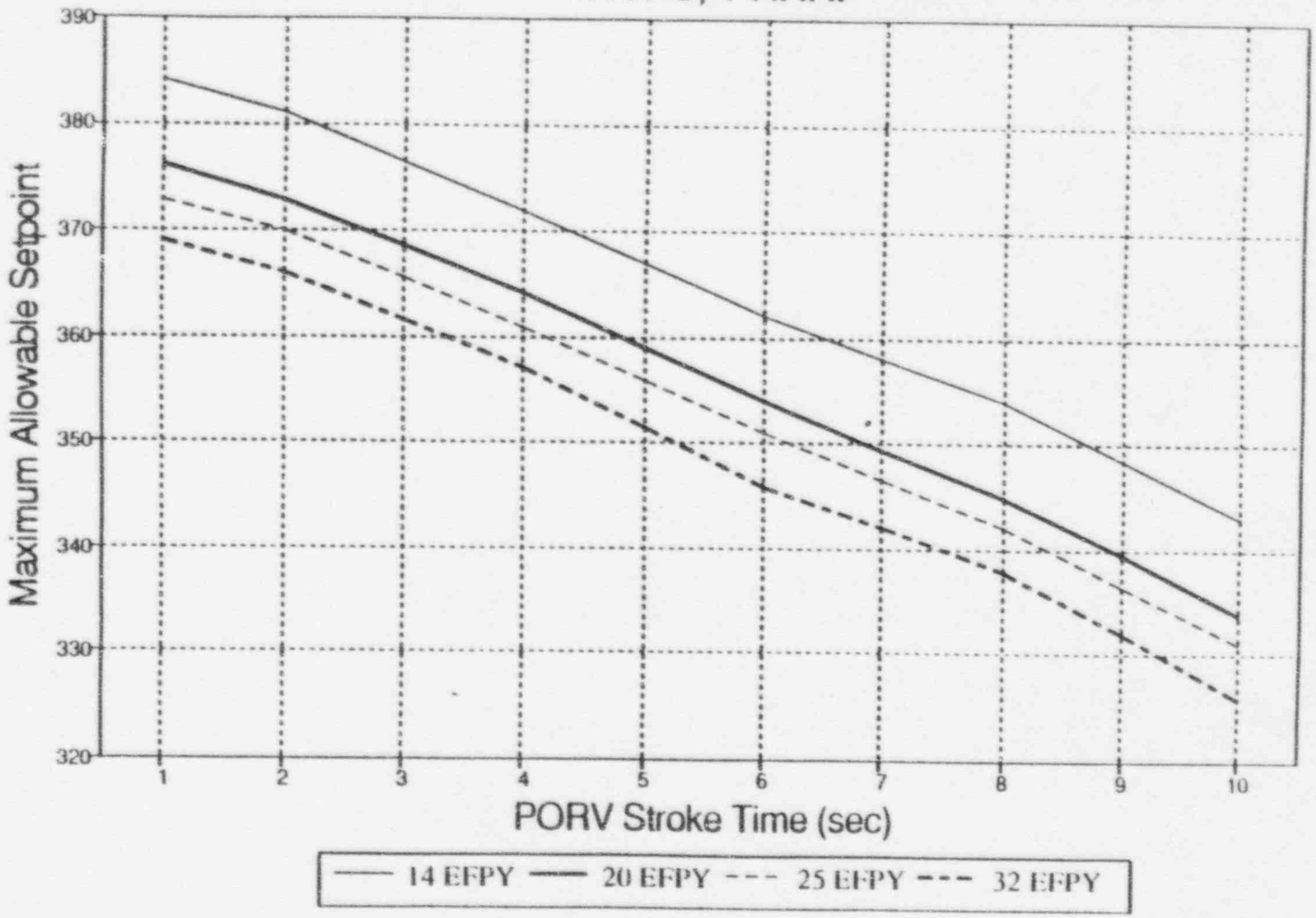

Figure 4: Maximum Allowable Setpoints
1 RCP, 2 RHRPS

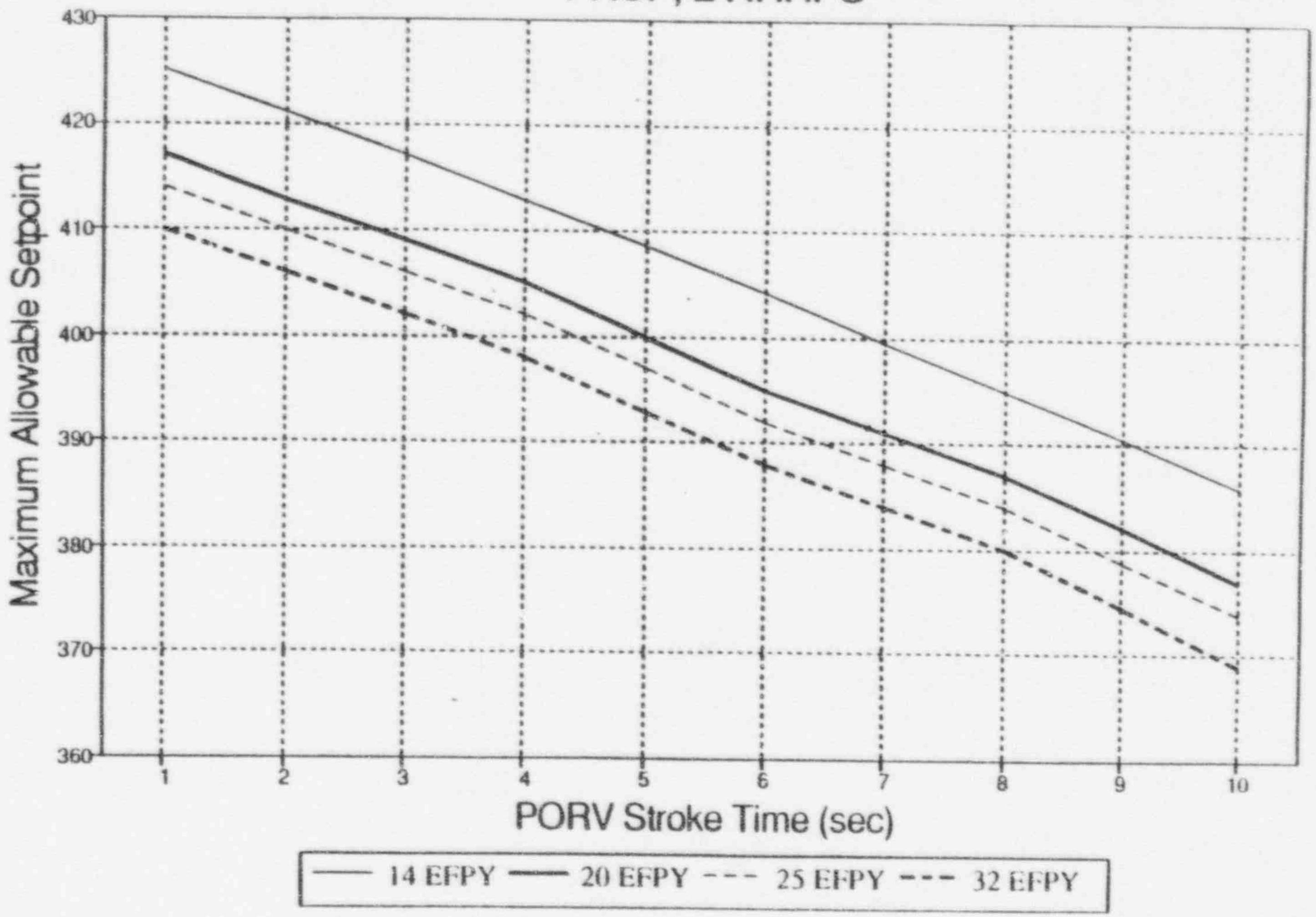

Figure 5: Maximum Allowable Setpoints
2 RCPS, 2 RHRPS

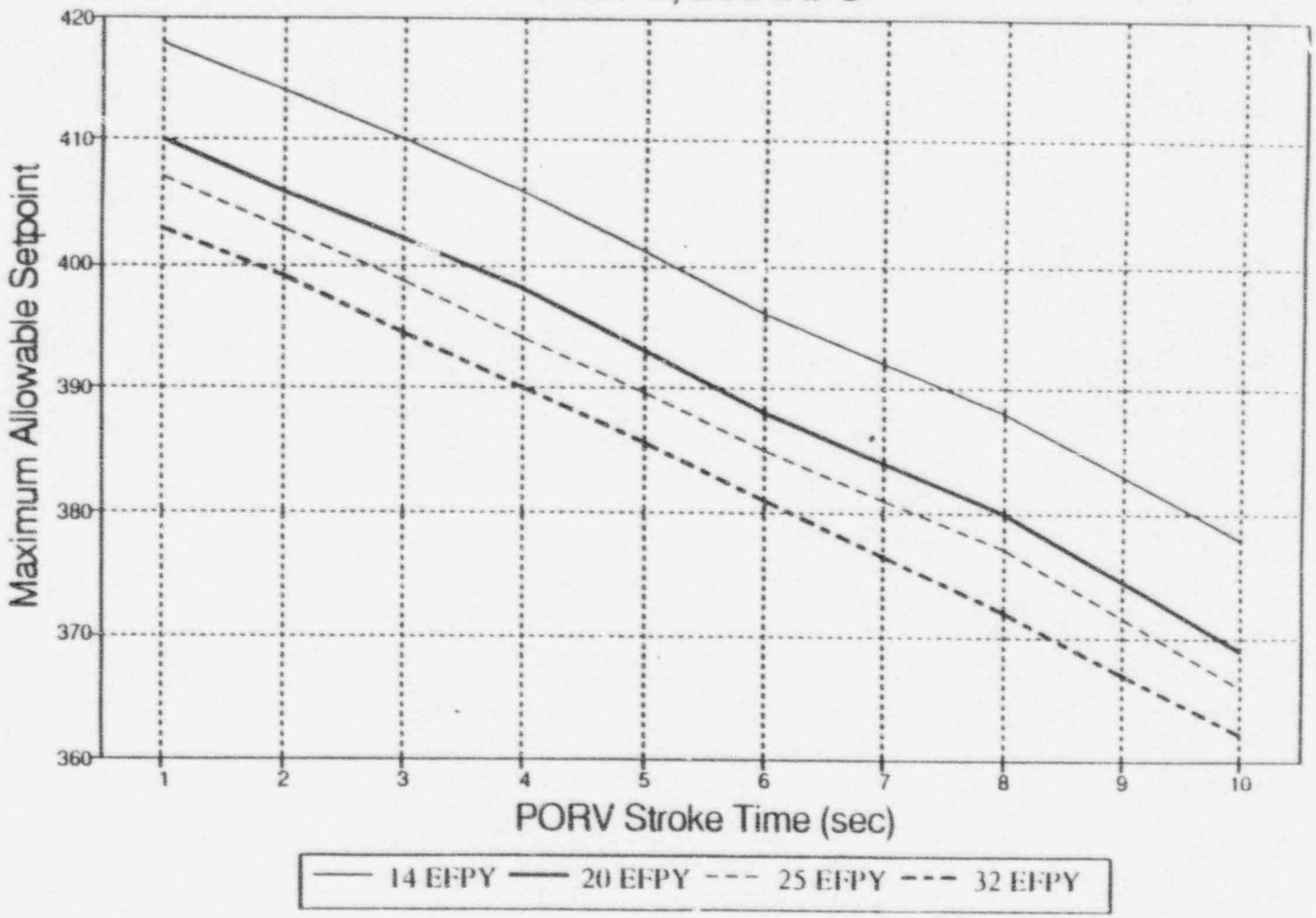

Figure 6: Maximum Allowable Setpoints

4 RCPS, 2 RHRPS

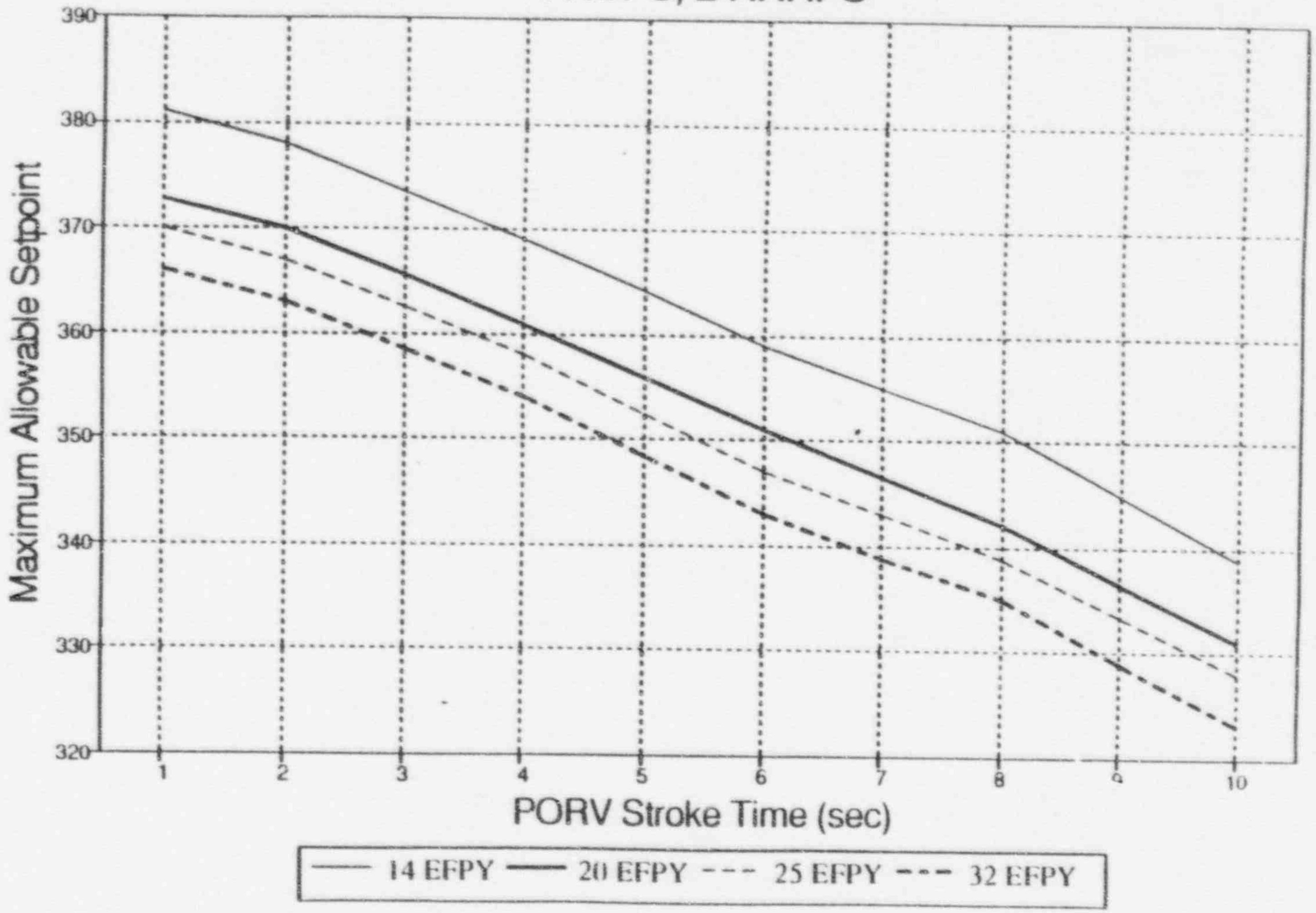

TABLE 3: PRESSURE DIFFERENTIALS
ZION UNITS 1 AND 2

Number of RCPs	Delta P 1 RHRP	Delta P 2 RHRPs	Delta P No RHRP
1	22.6 psi	25.5 psi	21.6
2	30.0	33.0	29.0
4	65.7	68.6	64.7

*The contributions of 1 and 2 RHRPs to the total delta P value are .97 psi and 3.89 psi, respectively.

Assumptions:

Pressure drops were calculated between the mid core elevation in the reactor vessel downcomer region and the wide range pressure transmitter off of the RHR line, which is used as input to the Cold Overpressure Mitigation System at Zion Units 1 and 2. Other assumptions are as follows:

1) 0% power
   RCS temperature of 70 °F
   RCS pressure of 500 psia
2) Steam generator tube plugging of 4.0%
   (lower tube plugging yields the highest pressure drop)
3) 102% of best estimate flow with 4 RCPs in operation. 100% of best estimate flow with 1 and 2 RCPs in operation
4) Elevation difference between the middle of the core and the pressure transmitter is -1.14 feet
5) Averaged reactor coolant pump coefficients applied to each case

SPECIFICATIONS FOR MASS INJECTION TRANSIENT

A parametric study was performed using constant mass injection rates between 100 gpm and 600 gpm. This range was sufficiently extensive to envelope RCS mass injection rates associated with the maximum possible injection rates from one charging pump following letdown isolation for the range of setpoints considered.

The mass injection design basis transient results from a sudden loss of letdown concurrent with the failure of the charging pump speed control to full flow. The allowable charging configuration with the LTOPS enabled, below an RCS temperature of 320 deg F, is limited by technical specification to a maximum of one charging pump aligned for injection into the RCS.

System/Operating Parameters

a. Temperatures

Reactor Coolant System temperature is equal to 85 deg F.

b. Reactor Coolant System Volume

The RCS volume is conservatively assumed to be 12598.1 cubic feet for Zion Units 1 and 2.

c. Initial Reactor Coolant System Pressure

The initial RCS pressure is 200 psi less than the setpoint pressure.

d. Reactor Coolant System Relief Capability

The transient is analyzed for actuation of one power operated relief valve. (Failure of one pressurizer PORV is assumed).

e. Power Operated Relief Valve Characteristics

1. System behavior was analyzed for RCS pressure setpoints of 400, 500, 600 and 700 psig.

2. Consistent with previous COMS methodology for Zion Units 1 and 2, PORV stroke times were assumed as follows:

Opening Stroke Time	*Closing Stroke Time*
1.0 s	0.97 s
1.5	1.45
2.0	1.94
2.5	2.42
3.0	2.91
4.0	3.88
5.0	4.85
6.0	5.82
8.0	7.76
10.0	9.70

3. $C_v = 50\ gpm/P^{1/2}$

f. Pressure Signal Transmission Characteristics

The time delay from reaching the setpoint presssure in the reactor coolant system until PORV motion is 1.15 seconds. This does not include any delay from the surge withstand circuit identified by Commonwealth Edison as recently being installed with the Eagle-21. The 1990 Analysis shows that RCS pressure is increasing at a rate of approximately 28 psi per second when the PORVs open during a mass injection transient of 400 gpm. An additional delay of 50 (fifty) milliseconds would result in a pressure increase of only 1.4 psi. Therefore, an additional delay of 5-10 milliseconds estimated by Rick Mason of CECo would have a negligible effect on the results of the analysis.

Results of the Mass Injection Transient analysis are presented in Table 4 which summarizes setpoint pressure overshoot and maximum RCS pressure reached for each case analyzed.

SPECIFICATIONS FOR HEAT INJECTION TRANSIENT

While the design basis heat injection transient is not required for this particular setpoint evaluation, the assumptions are described below for informational purposes. These specifications apply to a 1986 COMS analysis, before Eagle-21 implementation.

The transient results from the start of a reactor coolant pump with the existence of 50 deg F temperature asymmetry between the steam generator secondary side water and the water in the reactor coolant system. No credit is taken for residual heat removal system's relief valves.

a. Temperature

1. Temperature asymmetry between primary and secondary side = 50 deg F.

2. Steam Generator (heat source) temperature = 120, 150 and 200 deg F.

b. Reactor Coolant System Volume

The RCS volume is conservatively assumed to be 12598.5 cubic feet.

c. Initial RCS Pressure

Initial RCS pressure is 315 psia, at least 100 psi less than any PORV setpoint pressure used for the parametric study.

d. Pressurizer PORV Characteristics

1. System behavior was analyzed for RCS pressure setpoints of 400, 500, 600 and 700 psig.

2. Consistent with previous COMS methodology for Zion Units 1 and 2, PORV stroke times were assumed as follows:

Opening Stroke Time	*Closing Stroke Time*
1.0 s	0.97 s
1.5	1.45
2.0	1.94
2.5	2.42
3.0	2.91
4.0	3.88
5.0	4.85
6.0	5.82
8.0	7.76
10.0	9.70

3. $C_v = 50$

e. Steam Generator Design

1. Steam Generator tube heat transfer surface area = 51,500 square feet.
2. Steam Generator type = Standard Model 51.

f. Pressure Signal Transmission Characteristics

With the exception of the Eagle 21 contribution, the signal delay is the same as that for the mass injection case.

TABLE 4: PRESSURE OVERSHOOT DUE TO MASS INJECTION TRANSIENTS ZION UNITS 1 AND 2 (CURRENT VALUES)

Setpoint Assumed (P_S)	Mass Injection Rate	PORV Stroke Time Open	PORV Stroke Time Close	Maximum RCS Pressure Reached* (P_{MAX})
400 psig	389.8 gpm	1.0 s	0.97 s	438 psig
		2.0	1.94	442
		4.0	3.88	450
		6.0	5.82	459
		8.0	7.76	467
		10.0	9.73	476
500 psig	376.6 gpm	1.0 s	0.97 s	536 psig
		2.0	1.94	542
		4.0	3.88	548
		6.0	5.82	555
		8.0	7.76	563
		10.0	9.73	569
600 psig	369.6 gpm	1.0 s	0.97 s	635 psig
		2.0	1.94	638
		4.0	3.88	645
		6.0	5.82	651
		8.0	7.76	659
		10.0	9.73	664
700 psig	359.5 gpm	1.0 s	0.97 s	733 psi
		2.0	1.94	736
		4.0	3.88	742
		6.0	5.82	748
		8.0	7.76	755
		10.0	9.73	761

*Setpoint pressure overshoot = $P_{MAX} - P_S$

TABLE 5: PRESSURE OVERSHOOT DUE TO HEAT INJECTION EVENT ZION UNITS 1 AND 2 (FROM 1986 ANALYSIS, BEFORE EAGLE-21 IMPLEMENTATION)

Setpoint Assumed (P_S)	PORV Stroke Time Open	PORV Stroke Time Close	Maximum RCS Pressure Reached* (P_{MAX}) T_{SG}/T_{RCS} = 150/100°F	Maximum RCS Pressure Reached* (P_{MAX}) T_{SG}/T_{RCS} = 200/150°F
435 psig	1.0 s	0.97 s	455 psig	469
	2.0	1.94	458	473
	4.0	3.88	460	480
	6.0	5.82	464	487
	8.0	7.76	468	495
	10.0	9.73	472	504
500 psig	1.0 s	0.97 s	520 psig	533
	2.0	1.94	522	537
	4.0	3.88	525	545
	6.0	5.82	529	553
	8.0	7.76	532	562
	10.0	9.73	536	571
600 psig	1.0 s	0.97 s	620 psig	633
	2.0	1.94	622	636
	4.0	3.88	624	645
	6.0	5.82	628	633
	8.0	7.76	632	662
	10.0	9.73	635	670
700 psig	1.0 s	0.97 s	719 psig	733
	2.0	1.94	720	736
	4.0	3.88	723	743
	6.0	5.82	727	751
	8.0	7.76	731	759
	10.0	9.73	734	767

*Setpoint pressure overshoot = P_{max} - P_s

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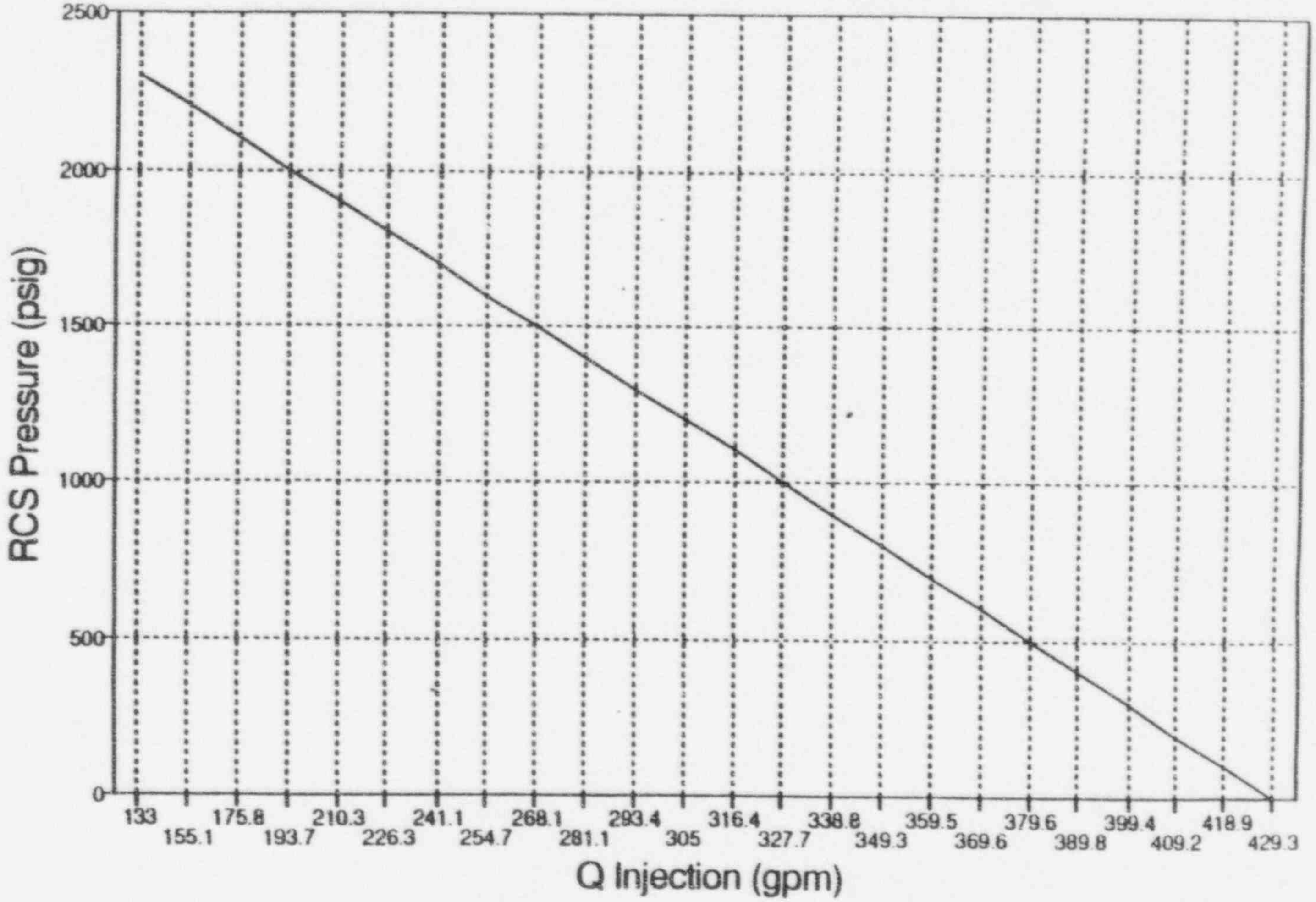
TABLE 6: PRESSURE OVERSHOOT DUE TO HEAT INJECTION EVENT (CONT'D) ZION UNITS 1 AND 2 (FROM 1986 ANALYSIS, BEFORE EAGLE-21 IMPLEMENTATION)

Setpoint Assumed (P_S)	PORV Stroke Time Open	PORV Stroke Time Close	Maximum RCS Pressure Reached* (P_{MAX}) T_{SG}/T_{RCS} = 120/70°F
435 psig	1.0 s	0.97 s	447
	1.5	1.45	449
	2.0	1.94	448
	2.5	2.42	449
	3.0	2.91	450
500	1.0	0.97	513
	1.5	1.45	513
	2.0	1.94	513
	2.5	2.42	514
	3.0	2.91	514
600	1.0	0.97	611
	1.5	1.45	612
	2.0	1.94	613
	2.5	2.42	614
	3.0	2.91	614
700	1.0	0.97	709
	1.5	1.45	713
	2.0	1.94	713
	2.5	2.42	713
	3.0	2.91	713

*Setpoint pressure overshoot = $P_{max} - P_s$

Note: The analysis was performed for the maximum PORV opening stroke time of 3.0 sec.

Figure 7: Zion Charging Flow
at Indicated RCS Pressures



Attachment D

Westinghouse Letter MSE-REME-0308, dated June 21, 1996

MSE-REME-0308, *Revision 1*

Westinghouse Electric Corporation
Energy Systems

P. O. Box 355
Pittsburgh, Pennsylvania 15230-0355

June 21, 1996
(412) 374-5438

Mr. Richard Skowzgird
Commonwealth Edison Company
Zion Station
101 Shiloh Blvd.
Zion, IL 60099

Dear Mr. Skowzgird:

Subject: **Zion Units 1 & 2 Enable Temperature Calculations (including ASME Code Case N-514)**

Westinghouse has updated the previous T-enable calculation provided under Westinghouse letter CWE-92-244, dated August 1992. Please find attached the enable temperature calculations using the methodology of NRC Standard Review Plan, Section 5.2.2, Overpressure Protection (NUREG-0800, Revision 2). These results show that the enable temperature for Zion Units 1 and 2 is **345°F**.

Additionally, per the request of the Commonwealth Edison (ComEd) Company, Westinghouse calculated the enable temperature per the ASME Code Case N-514 methodology, although it is not yet approved. Therefore, also attached are the Code Case N-514 calculations which show that the enable temperature for Zion Units 1 and 2 is **305°F**.

The latest limiting adjusted reference temperature (ART) values presented in WCAP-14664 were used in the calculations. Additionally, ComEd has requested that the more realistic 60°F/hr values be used for calculating T-enable. This calculation did not consider temperature measurement uncertainty since this will be addressed by the Zion station.

This work was completed under a change notice to Customer Order No. 815196 (Westinghouse G.O. WM-60176, OCS 9610177), shop order number CEVP-139B.

If you have any questions or require additional information, please contact the undersigned.

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

Paula A. Grendys
Reactor Equipment & Materials Engineering

Reviewed By: Ed Terek
Reactor Equipment & Materials Engineering

Attachment

The enable temperature was determined using the methodology from the following document since the NRC has not yet approved the methodology of ASME Code Case N-514:

> NRC Standard Review Plan, Section 5.2.2, Overpressure Protection, NUREG-0800, Revision 2, November 1988, Branch Technical Position RSB 5-2, *Overpressure Protection of Pressurized Water Reactors While Operating at Low Temperatures*, Revision 1, November 1988.

Enable Temperature = RT_{NDT} + 90 + max (ΔT_{metal}), °F

where, RT_{NDT} is either the 1/4T Adjusted Reference Temperature (ART) or the 3/4T ART

ΔT_{metal} is the temperature difference between RCS water and either the 1/4T or 3/4T metal temperature at the controlling location

The following calculations were completed using the latest curves documented in WCAP-14664, *Zion Units 1 and 2 Heatup and Cooldown Limit Curves for Normal Operation*, dated June 1996.

Per WCAP-14664, the Zion Units 1 and 2 ART values are:

1/4T ART = 233.0°F   3/4T ART = 183.3°F

From the fiche OPER010 (Configuration #5685883132544) of Calc Note REME-96-040, *Zion Units 1 and 2 HU/CD Curves Applicable to 32 & 25.63 EFPY, Respectively*, P. A. Grendys, dated 5/30/96:

Cooldown Rate (Steady-State Cooldown):
- max (ΔT_{metal}) at 1/4T = 0°F
- max (ΔT_{metal}) at 3/4T = 0°F

Heatup Rate of 60°F/Hr:
- max (ΔT_{metal}) at 1/4T = 17.660°F
- max (ΔT_{metal}) at 3/4T = 36.886°F

Enable Temperature (ENBT) = RT_{NDT} + 90 + max (ΔT_{metal}), °F

Cooldown Rate (Steady-State Cooldown) :
- ENBT at 1/4T = 233.0 + 90 + 0 = 323.0°F
- ENBT at 3/4T = 183.3 + 90 + 0 = 273.3°F

Heatup Rate of 60°F/Hr:
- ENBT at 1/4T = 233.0 + 90 + 17.660 = 340.660°F
- ENBT at 3/4T = 183.3 + 90 + 36.886 = 310.186°F

Therefore, a conservative enable temperature of 345°F shall be used in determining the LTOP system setpoints since this value bounds all possible cases during heatup and cooldown.

ASME CODE CASE N-514

ASME Code Case N-514 allows low temperature overpressure protection systems (LTOPS, as the code case refers to COMS) to limit the maximum pressure in the reactor vessel to 110% of the pressure determined to satisfy Appendix G, paragraph G-2215, of Section XI of the ASME Code. The application of ASME Code Case N-514 increases the operating margin in the region of the pressure-temperature limit curves where the COMS system is enabled.

Although expected soon, use of Code Case N-514 has not yet been formally approved by the NRC. In the interim, an exemption to the regulations must be granted by the NRC before Code Case N-514 can be used in the determination of the COMS setpoints and enable temperature.

Code Case N-514 requires LTOPS to be effective at coolant temperatures less than 200°F or at coolant temperatures corresponding to a reactor vessel metal temperature less than RT_{NDT} + 50°F, whichever is greater. RT_{NDT} is the highest adjusted reference temperature for weld and base metal in the beltline region at a distance one-fourth of the vessel section thickness from the vessel inside surface, as determined by Regulatory Guide 1.99, Revision 2.

Per WCAP-14664, the Zion Units 1 and 2 1/4T ART value is 233.0°F.

$$\textbf{Enable Temperature} = RT_{NDT} + 50 + \max(\Delta T_{metal}),\ ^\circ F$$

$$= 233 + 50 + 17.660 = 300.660^\circ F$$

Therefore, a conservative enable temperature of **305°F** shall be used in determining the LTOP system setpoints.

Attachment E

Zion Calculation No. 22S-B-004E-192, Revision 0