ATTACHMENT 2

Salem Nuclear Generating Station, Unit Nos. 1 and 2

Facility Operating License Nos. DPR-70 and DPR-75
NRC Docket Nos. 50-272 and 50-311

Calculation S-1-SJ-MDC-1539, Rev. 3
Accumulator Pressure Decay Time during Discharge Testing

FORM 3
DESIGN ANALYSIS COVER SHEET

Design Analysis (Major Revision)		**Last Page No.** [6]	Attachment 3, Page 6 of 6
Analysis No.: [1]	S-1-SJ-MDC-1539	**Revision:** [2]	3
Title: [3]	Accumulator Pressure Decay Time During Discharge Testing		1 of 39
EC/ECR No.: [4]	80017344 R2 CD M503 R0 80017349 R2 CD M503 R0	**Revision:** [5]	N/A

Station(s): [7]	Salem Generating Station	**Component(s):** [14]	
Unit No.: [8]	1	S1SJ -11SJ54	
Discipline: [9]	Mechanical	S1SJ -12SJ54	
Descrip. Code/Keyword: [10]		S1SJ -13SJ54	
Safety/QA Class: [11]	Safety-related	S1SJ -14SJ54	
System Code: [12]	SJ		
Structure: [13]	Containment		

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To
S-2-SJ-MDC-1394	From	S1.OP-ST.SJ-0006	To

Is this Design Analysis Safeguards Information? [16] **Yes** ☐ **No** ☒ If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] **Yes** ☐ **No** ☒ If yes, ATI/AR#

This Design Analysis SUPERCEDES: [18] N/A **in its entirety.**

Description of Revision (list affected pages for partials): [19]

Revised analysis for increased stroke times for valves S1SJ -11SJ54 and S1SJ -12SJ54 as a result of DCPs 80017344 and 80017349. Incorporates 80017344 R2 CD M503 R0 and 80017349 R2 CD M503 R0.

	Print Name	Sign Name	Date
Preparer: [20]	J. Duffy	J. Duffy	2/2/07

Method of Review: [21] **Detailed Review** ☒ **Alternate Calculations (attached)** ☐ **Testing** ☐

	Print Name	Sign Name	Date
Reviewer: [22]	K. King	Kevin King	2/2/07

Review Notes: [23] Independent review ☒ Peer review ☐

(For External Analyses Only)

	Print Name	Sign Name	Date
External Approver: [24]	N/A	N/A	N/A
Exelon Reviewer: [25]	N/A	N/A	N/A

Is a Supplemental Review Required? [26] **Yes** ☐ **No** ☒ If yes, complete Attachment 3

	Print Name	Sign Name	Date
Exelon Approver: [27]	A. Johnson	Alan Johnson	2/5/07

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Revision History

Revision No.	Date	Description
0	Feb 5, 1996	Original issue
1	Feb. 25, 2005	Added analysis for increased stroke times of 13SJ54 and 14SJ54 valves as a result of DCP's 80017350 and 80037351
2	Aug 08, 2005	Included the effect of dead period during the beginning of the stroke. Developed the acceptance criterion for each loop.
3	01/XX/07	Revised analysis for increased stroke times for valves S1SJ -11SJ54 and S1SJ -12SJ54 as a result of DCPs 80017344 and 80017349.

Page Revision Index

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1	3	14	3	27	3	Att. 1	2
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1. INTRODUCTION:

ACCUMULATOR DUMP TEST IS DONE IN MODE 6 USING PROCEDURE S1.OP.-ST, SJ-0006(Q) Rev 6 FOR SALEM UNIT 1. THE PURPOSE OF THE TEST IS TO DEMONSTRATE OPERABILITY OF DISCHARGE PIPING CHECK VALVES SJ55 AND SJ56.

IN REF [1] AN ACCEPTANCE CRITERION WAS ESTABLISHED FOR ACCUMULATOR PRESSURE DECAY TIME FOR SALEM UNIT 2. THE PRESSURE DECAY TIME WAS CALCULATED FOR A SITUATION WHEN THE REACTOR HEAD IS OFF AND THE ACCUMULATOR WATER IS DIRECTED TO THE REACTOR CAVITY.

IN THE PRESENT CALCULATION AN ACCEPTANCE CRITERION FOR PRESSURE DECAY TIME WILL BE GENERATED FOR UNIT 1.

THE FLOW LINE UP IS FROM THE ACCUMULATOR TO THE REACTOR VIA VALVE SJ54, SJ55, AND SJ56. INITIALLY THE GAS PRESSURE IN THE ACCUMULATOR IS 70 psig. DURING THE TEST SJ54 IS OPENED AND THE ACCUMULATOR PRESSURE DECAYS. THE TIME FOR THE PRESSURE TO DECAY FROM 70 psig TO 35 psig IS RECORDED.

IN THIS CALCULATION, AN ACCEPTANCE CRITERION FOR THIS PRESSURE DECAY TIME HAS BEEN CALCULATED. SEE REF [1] FOR DETAILS.

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The NRC approved the method of testing SJ55 and SJ56 check valves by passing accumulator water to the reactor cavity by opening the SJ54 valve via relief requests V-24 and V-25 (TAC No. M98259 and M98260). The acceptance criterion specified in these relief requests was applicable for the SJ54 gate valve stroke time of 12.5 seconds. Since then, the stroke times of 13SJ54 and 14SJ54 valves have been increased via DCPs 80017350 and 80037351. Since, the stroke time of SJ54 valve directly influences the accumulator pressure decay time, a revised acceptance criteria are needed for the 13 and 14 loop valves.

Also, it has been discovered that there is a delay time between the instant the SJ54 valve push button is pressed and the valve disc begins to move. Therefore, the actual stroke time of the SJ54 valves is lower than the value used. The effect of this dead time has been incorporated in this calculation.

To keep the analysis as realistic as possible, the pressure decay time acceptance criterion has been developed for each loop.

Similarly, DCPs 80017344 and 80017349 have increased the stroke times of valves 11SJ54 and 12SJ54.

2. DESCRIPTION OF CONFIGURATION

CONFIGURATION IS DESCRIBED IN REF [1] AND WILL NOT BE REPEATED HERE.

3. ANALYSIS

IN THIS SECTION A MATHEMATICAL MODEL OF ACCUMULATOR DUMP PROCESS HAS BEEN DEVELOPED. THE DETAILS ARE DESCRIBED IN REF [1].

3.1 ACCUMULATORS

FIGURE 3.1.1 SHOWS THE VARIOUS ACCUMULATOR LEVEL ELEVATIONS. [Ref 2, 3, 4]

AT 100% LEVEL, ELEVATION = 91.4 ft, WATER VOL = 7116 GAL = 951.3 ft^3

AT 0% LEVEL, ELEVATION = 88.9 ft, WATER VOL = 5325 GAL = 711.9 ft^3

LET Z_A = ELEVATION OF WATER LEVEL IN THE ACCUMULATOR (ft)

V_{WA} = VOLUME OF WATER IN THE ACCUMULATOR (ft^3)

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THEREFORE,

$$V_{WA} = 95.76\, Z_A - 7801.2 \quad ; \quad 85.65\ ft \le Z \le 91.4\ ft$$

FOR 96% INITIAL WATER LEVEL, $Z_{A,INIT} = 88.9 + 0.96 * 2.5\ ft = 91.3\ ft$

$V_{WA,INIT} = 941.7\ ft^3$

TOTAL VOLUME OF ACCUMULATOR = 1350 ft^3 [Ref 5]

INITIAL NITROGEN VOLUME = 1350 − 941.7 ft^3

= 408.3 ft^3

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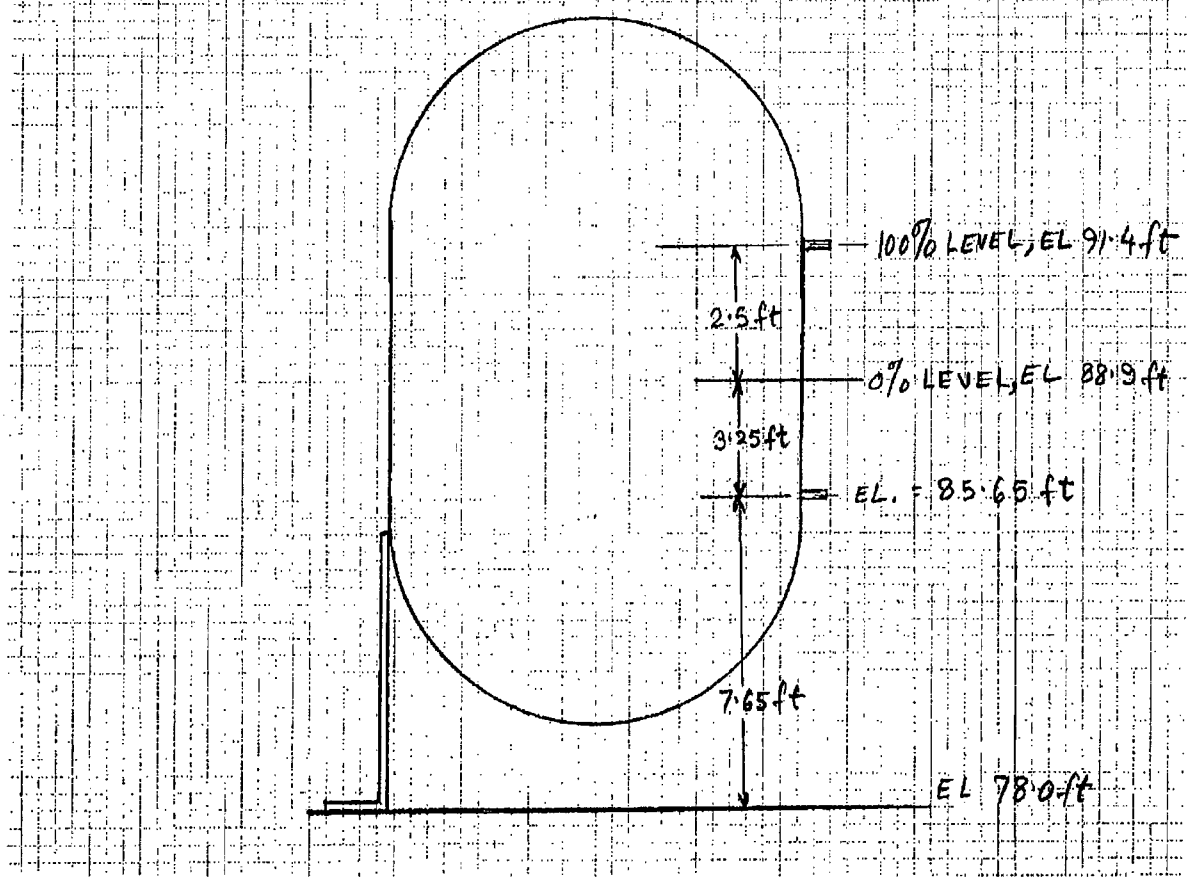
FIGURE 3.1.1 ACCUMULATOR WATER LEVEL ELEVATIONS (Ref 2, 3, 4)



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3.2 PRESSURIZER

PRESSURIZER LEVEL ELEVATIONS VS. VOLUME RELATIONSHIP WAS DEVELOPED IN REF [1]. AT THAT TIME Rev. 0 OF CBD-DE-CB.RC-0042(Q) WAS CURRENT. HOWEVER, A CBD CHANGE NOTICE FOR FIGURE F17-1 WAS OUTSTANDING AGAINST IT. AT THAT TIME, IT WAS EXPECTED THAT THE CHANGE NOTICE WOULD BE INCORPORATED IN REV. 1. HOWEVER, AT PRESENT THE DMS SYSTEM HAS REV 1. BUT THE CBD CHANGE NOTICE IS NOT INCORPORATED IN IT. TO AVOID THE CONFUSION, THE MARKED COPY OF FIGURE F17-1 IS ATTACHED HERE.

(THIS INFORMATION IS FOR HISTORICAL PURPOSES ONLY AND HAS NOT BEEN USED IN THIS CALCULATION)

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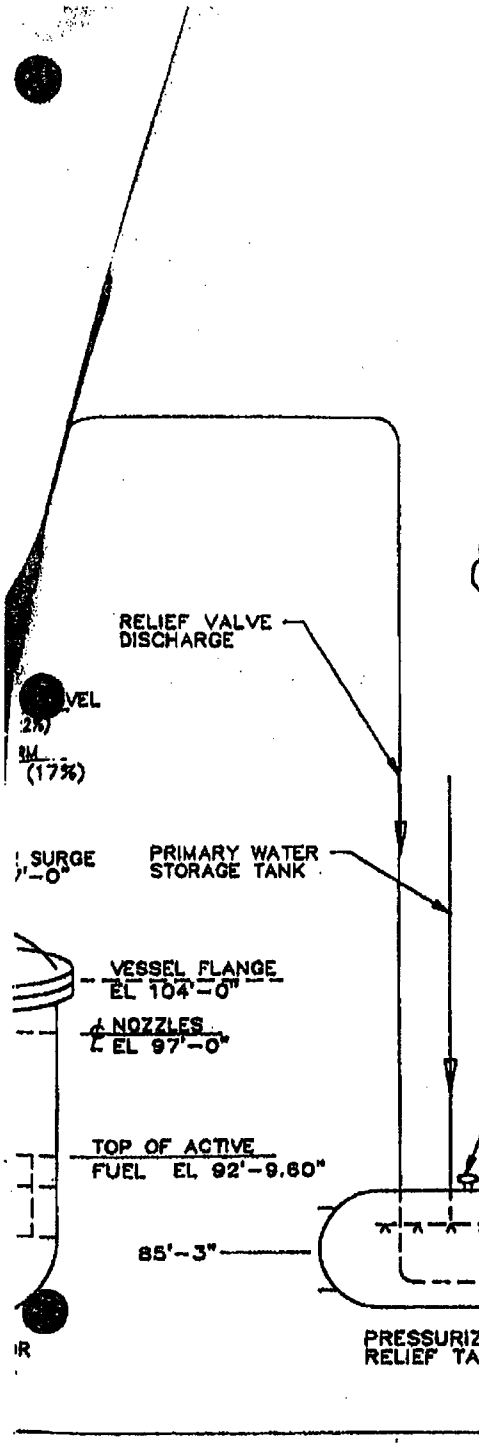

COMPONENT	ELEVATION FEET	INCHES
STEAM GENERATORS		
NARROW RANGE LEVEL TAP (UPPER)	154	7
HI-HI TRIP (67%)	150	2
FULL LOAD (44%)	147	10
NO LOAD (33%)	146	6
FEEDWATER NOZZLE & SPARGER (78% WIDE RANGE)	144	6
LOW LEVEL TRIP (8.5%)	143	7
NARROW RANGE LEVEL TAP (LOWER)	142	7
TOP OF TUBE BUNDLE (70% WIDE RANGE)	140	3
PRIMARY SIDE INLET & OUTLET NOZZLES CENTERLINE	98	7.25
PRIMARY SIDE MANWAY (BOTTOM)	98	7
REACTOR COOLANT PUMPS		
RCP CONNECTIONS (SEAL INJECTION, SEAL RETURN, PRESSURE TAPS)	99	11
PUMP DISCHARGE CENTERLINE	97	0
PUMP INLET NOZZLE	91	2.25
PUMP SUCTION CENTERLINE	86	8.25
PRESSURIZER		
~~100% TOP OF PRESSURIZER~~	147	11
~~92% HIGH LEVEL TRIP~~	144	5
~~70% HIGH LEVEL ALARM~~	134	9
~~60% OPERATING RANGE (UPPER LIMIT)~~	130	4.60
~~22% OPERATING RANGE (LOWER LIMIT)~~	113	8.70
~~17% LOW LEVEL ALARM~~	111	6.40
~~16% HEATERS UNCOVERED~~	110	7.90
BASE	104	1
SURGE LINE CENTERLINE	97	0
REACTOR VESSEL		
REACTOR VESSEL FLANGE	104	0
SEAL TABLE	104	0
RCS HOT LEG - TOP OF PIPE	98	2.50
NOZZLES CENTERLINE	97	0
TOP OF ACTIVE FUEL	92	9.60
RHR SYSTEM		
RHR DISCHARGE CONNECTION TO RCS CENTERLINE	97	9.75
RHR SUCTION CONNECTION TO RCS CENTERLINE	96	6
RHR HEAT EXCHANGER OUTLET CENTERLINE	50	6
RHR PUMP SUCTION CENTERLINE	46	10

REVISE

SAFETY HEAD

	(FT)	(IN)
LEVEL TAP-UPPER TAP	152	9
HIGH LEVEL TRIP (92%)	149	3
HIGH LEVEL ALARM (70%)	139	7
OPERATING RANGE UPPER LIMIT (60%)	135	2
OPERATING RANGE LOWER LIMIT (22%)	118	7
HEATERS UNCOVERED (15%)	115	6
LEVEL TAP-LOWER TAP	108	11

FIGURE F-17

RCS COMPONENT ELEVATIONS
DE-CB.RC-0042(Q)
REV. 0
PAGE F17-1 (LAST)

Low Alarm and Letdown isolated 116-4

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3.3 Check Valves SJ55 and SJ56

The flow rate versus pressure drop relationship for these check valves was developed in Ref. [1] and will not be repeated here.

3.4 Gate Valve SJ54

The valve flow loss factor vs. stroke position was developed in Ref. [1] and will not be repeated here. Table 3.4.1 shows the stroke times and the delay times of each of the SJ54 valves. The gross stroke time is the duration between the instants the push button is pressed and the disc stops moving. The delay time is the period when the motor is spinning and the disc is not moving. The net disc stroke time was calculated by subtracting the delay time from the gross stroke time.

Table 3.4.1
SJ54 Valve Stroke and Delay Times

Valve ID No.	Gross Opening Stroke Time (sec)	Reference	Delay Time (sec)	Reference	Net Disc Movement Time (sec)
11SJ54	18.702	Att. 3	1.228	Att. 3	17.47
12SJ54	21.098	Att. 3	1.259	Att. 3	19.84
13SJ54	20.5	Notification 20188810	1.38	Att. 1	19.12
14SJ54	21.3	Notification 20188814	1.36	Att. 1	19.94

3.5 Friction Loss Factors and Inertial Lengths of Accumulator Discharge Piping

Tables 3.5.1, 3.5.2, 3.5.3, and 3.5.4 show the friction loss factors of the discharge piping. The effective $\frac{L}{A}$ is shown underneath each table.

$$\text{Effective } \frac{L}{A} = \sum_i \frac{L_i}{A_i}$$

where,

L_i = Length of ith pipe segment
A_i = Flow area of ith pipe segment

(See Ref. 1 page 24 for its use)

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TABLE 3.5.1

II ACCUMULATOR DISCHARGE LINE FITTINGS

VALVES ARE NOT INCLUDED, REF. STRESS ISO 267241 [Ref 9]
267246 [Ref 10]

DESCRIPTION		REF. AREA, A (ft^2)	LOSS FACTOR $K = \frac{\Delta P}{\frac{1}{2}\rho v^2}$	$\frac{K}{A^2}$ (ft^{-4})
29.7 ft LONG PIPE, I.D = 0.835 ft	$\frac{fl}{d} = \frac{0.0146 * 29.7}{0.835} = 0.519$	0.548	0.519	1.73
1 SR ELBOW	K = 1 * 0.27	0.548	0.27	0.9
2 LR ELBOW	K = 2 * 0.18	0.548	0.36	1.2
79.1 ft LONG PIPE, I.D = 0.7083 ft	$\frac{fl}{d} = \frac{0.0146 * 79.1}{0.7083} = 1.63$	0.394	1.63	10.5
8 LR ELBOWS	K = 8 * 0.18	0.394	1.44	9.28
1 SR ELBOW	K = 1 * 0.27	0.394	0.27	1.74
2 TEE RUNS	K = 2 * 0.05	0.394	0.1	0.64
1 ENTRANCE	K = 0.5	0.394	0.5	3.22
1 T-BR AND MISCELLANEOUS VENTS, COLD LEG AND REACTOR		0.437	0.51	2.67
1 EXIT		0.437	1	5.24

$$\sum \frac{K}{A^2} = 37.12\ ft^{-4}$$

$$\sum \frac{L_i}{A_i} = \frac{29.7}{0.548} + \frac{79.1}{0.394} + \underbrace{\frac{26}{412}}_{\text{COLD LEG AND REACTOR}} ft^{-1}$$

$$= 261.3\ ft^{-1}$$

[Ref. 7]

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TABLE 3.5.2

12 ACCUMULATOR DISCHARGE LINE FITTINGS

VALVES ARE NOT INCLUDED; Pal STRESS ISO. 267241C [11]
267242 [12]

DESCRIPTION	REF. AREA, A (ft^2)	LOSS FACTOR, $K = \frac{\Delta P}{\frac{1}{2}\rho v^2}$	$\frac{K}{A^2}$ (ft^{-4})
23.9 ft LONG PIPE, ID = 0.835 ft $\frac{fl}{d} = \frac{0.0146 * 23.9}{0.835}$	0.548	0.418	1.39
2 LR ELBOWS K = 2 * 0.18	0.548	0.36	1.2
1 SR ELBOW K = 1 * 0.27	0.548	0.27	0.9
81.5 ft LONG PIPE, ID = 0.7883 ft $\frac{fl}{d} = \frac{0.0146 * 81.5}{0.7883} = 1.52$	0.394	1.68	10.82
7 LR ELBOWS, K = 7 * 0.18	0.394	1.26	8.12
2 SR ELBOWS, K = 2 * 0.27	0.394	0.54	3.48
2 TEE RUNS, K = 2 * 0.05	0.394	0.1	0.644
1 ENTRANCE K = 0.5	0.394	0.5	3.22
1 - TBR, MISC. VENTS, COLD LEG, REACTOR	0.437	0.51	2.67
1 EXIT	0.437	1.0	5.24

$$\sum \frac{L_i}{A_i} = \frac{23.9}{0.548} + \frac{81.5}{0.394} + \frac{26}{4.12} \; ft^{-1}$$

$$= 256.8 \; ft^{-1}$$

4 OLD LEG AND REACTOR [Ref 7]

$$\sum \frac{K}{A^2} = 37.69 \, ft^{-4}$$

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TABLE 3.5.3

13 ACCUMULATOR DISCHARGE LINE FITTINGS

VALVES ARE NOT INCLUDED, REF. STREE 150 267243 267246 [13] [10]

DESCRIPTION	REF. AREA, A (ft^2)	LOSS FACTOR $K = \frac{\Delta P}{\frac{1}{2}\rho v^2}$	$\frac{K}{A^2}$ (ft^{-4})
13.8 ft LONG PIPE, ID = 0.835 ft; $\frac{fl}{d} = \frac{0.0146 * 13.8}{0.835} = 0.241$	0.548	0.241	0.803
3 SR ELBOW, K = 3 * 0.27	0.548	0.81	2.697
1 LR ELBOW K = 1 * 0.18	0.548	0.18	0.599
80.4 ft LONG PIPE, ID = 0.7083 ft; $\frac{fl}{d} = \frac{0.0146 * 80.4}{0.7083} = 1.657$	0.394	1.657	10.674
5 LR ELBOW K = 5 * 0.18	0.394	0.9	5.798
2 SR ELBOW K = 2 * 0.27	0.394	0.54	3.479
2 TEE RUNS, K = 2 * 0.05	0.394	0.10	0.644
1 ENTRANCE, K = 0.5	0.394	0.5	3.221
T-BR, MISC. VENTS, COLD LEG, REACTOR	0.437	0.51	2.67
EXIT	0.437	1	5.24

$$\sum \frac{K}{A^2} = 35.83 \ ft^{-4}$$

$$\sum \frac{L_i}{A_i} = \frac{13.8}{0.548} + \frac{80.4}{0.394} + \underbrace{\frac{26}{4.12}}$$

$$= 235.6 \ ft^{-1}$$

COLD LEG AND REACTOR [Ref. 7]

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TABLE 3.5.4

14 ACCUMULATOR DISCHARGE LINE FITTINGS

VALVES ARE NOT INCLUDED, REF. STRESS ISO. 267244 [Ref. 14]

DESCRIPTION	REF. AREA, A (ft^2)	LOSS FACTOR $K = \frac{\Delta P}{\frac{1}{2}\rho v^2}$	$\frac{K}{A^2}$
23.9 ft LONG PIPE, ID = 0.835 ft $\frac{fl}{d} = \frac{0.0146 \times 23.9}{0.835} = 0.42$	0.548	0.42	1.4
1 SR ELBOW $K = 1 \times 0.27$	0.548	0.27	0.9
2 LR ELBOWS $K = 2 \times 0.18$	0.548	0.36	1.2
68 ft LONG PIPE, ID = 0.7083 ft $\frac{fl}{d} = \frac{0.0146 \times 68}{0.7083} = 1.40$	0.394	1.40	9.03
6 LR ELBOWS $K = 6 \times 0.18$	0.394	1.08	6.96
2 SR ELBOWS $K = 2 \times 0.27$	0.394	0.54	3.5
2 TEE RUNS $K = 2 \times 0.05$	0.394	0.1	0.64
1 ENTRANCE $K = 0.5$	0.394	0.5	3.22
1 T-BR, MISC. VENTS, COLD LEG, REACTOR	0.437	0.51	2.67
1 EXIT	0.437	1	5.24

$\sum \frac{K}{A^2} = 34.76\ ft^{-4}$

$$\sum \frac{L_i}{A_i} = \frac{23.9}{0.548} + \frac{68}{0.394} + \underbrace{\frac{2.6}{4.12}}_{\text{COLD LEG AND REACTOR REF. [7]}}$$

$$= 222.5\ ft^{-1}$$

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3.6 EQUATIONS OF MOTION

FOLLOWING THE METHOD DESCRIBED ON PAGE 24 OF [REF 1], WE GET,

$$\rho \frac{L}{A} \frac{dQ}{dt} = (P_A + \rho g Z_A) - (P_C + \rho g Z_C) - \frac{1}{2} \rho \frac{K}{A^2} Q^2 - \Delta P_{f,VALVES} \quad (6)$$

$$Z_A = \frac{V_{WA} + 7801.2}{95.76} \quad \text{(FROM SEC. 3.1)} \quad (7)$$

$$V_{WA} = 1350 - V_{NA} \quad (8)$$

$$P_A = P_{A0} \left(\frac{V_{NA0}}{V_{NA}} \right)^n ; \quad n = 1.3 \quad (9)$$

$$\frac{dV_{NA}}{dt} = Q \quad (10)$$

Z_C = ELEVATION OF WATER LEVEL IN THE CAVITY = 127 ft

INITIAL CONDITIONS

$V_{WA} = 941.7 \text{ ft}^3$

$V_{NA} = 1350 - 941.7 \text{ ft}^3 = 408.3 \text{ ft}^3$

$P_A = 847 \text{ psia}$

$Q = 0 \text{ ft}^3/\text{s}$

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EXPLANATION OF SYMBOLS

ρ = DENSITY OF LIQUID WATER $\left(\frac{SLUG}{ft^3}\right)$

$\frac{L}{A} = \sum_i \frac{L_i}{A_i}$

L_i = LENGTH OF i^{TH} SEGMENT OF PIPE (ft)

A_i = FLOW AREA OF i^{TH} SEGMENT OF PIPE (ft^2)

Q = LIQUID FLOW RATE (ft^3/s)

P_A = PRESSURE OF GAS IN THE ACCUMULATOR $\left(\frac{lbf}{ft^2}\right)$

g = ACCELERATION DUE TO GRAVITY (ft/s^2)

Z_A = WATER LEVEL ELEVATION IN THE ACCUMULATOR (ft)

P_C = GAS PRESSURE IN THE CAVITY $\left(\frac{lbf}{ft^2}\right)$

Z_C = WATER LEVEL ELEVATION IN THE CAVITY (ft)

$\frac{K}{A^2} = \sum \frac{K_i}{A_i^2}$

K_i = FRICTION LOSS FACTOR OF i^{TH} FRICTION ELEMENT

$\Delta P_{f\,VALVES}$ = FRICTIONAL PRESSURE DROP ACROSS VALVES $\left(\frac{lbf}{ft^2}\right)$

V_{WA} = VOLUME OF WATER IN THE ACCUMULATOR (ft^3)

V_{NA} = VOLUME OF NITROGEN IN THE ACCUMULATOR (ft^3)

EQUATIONS (6) THROUGH (10) WERE SOLVED NUMERICALLY. THE COMPUTER PROGRAM LISTING IS SHOWN IN THE FOLLOWING PAGES.

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Table 3.6.1
Computer Program Listing: Analysis of 11 Loop, Check Valve Maximum Lift = 60 Deg.

```
C       Last change:  VC   29 Jan 2007   10:56 am
        DIMENSION VVOF(12),CVCV(12)
        OPEN(1,FILE='Acc11-hoff-60deg.out', STATUS='old')
        DATA VVOF/0.,.05,.1,.2,.3,.4,.5,.6,.7,.8,.9,1./
        DATA CVCV/0., 0.0194, 0.055, 0.1, 0.146, 0.204,
       #        0.277,0.3536,0.4613,0.6086,0.767,1./
C  PARAMETERS
C  SINPHM =SINE OF MAXIMUM ANGLE OF CHECK VALVE TRAVEL (NONDIMENSIONAL)
        SINPHM=0.866
C  AKASQ = SUMMATION K/A**2 [FT**(-4)]
        SKASQ=37.12
C  SLOA = SUMMATION L/A [FT**(-1)]
        SLOA=261.3
C  VOT1 = DISK MOVEMENT TIME OF SJ54 GATE VALVE (SEC)
        VOT1=17.47
C  CONSTANTS
        GAM=1.3
        G=32.174
        RHO=1.94
        AREA=0.394
        DT=0.01
        PCAV=14.7*144.
C  INITIAL CONDITIONS
        TIME=0.1
        NSTEP=-1
        VNAZ=408.3
        VNA=VNAZ
        PAZ=84.7*144.
        PA=PAZ
        Q=.001
        ZCAV=127.
        WRITE(1,101)
  101   FORMAT(T19'TIME',  T28'ACCUMULATOR PRESSURE   FLOW RATE')
  103   FORMAT(T19'(SEC.)',T28'        (PSIG)            (GPM)  ',//)
        WRITE(1,103)
   31   NSTEP=NSTEP+1
        TIME=TIME+DT
C  CALCULATE ACCUMULATOR LEVEL ELEVATION
        VWA=1350.-VNA
        ZA=(VWA+7801.2)/95.76
C  CALCULATE ACCUMULATOR GAS PRESSURE
        PA=PAZ*(VNAZ/VNA)**GAM
C  CALCULATE SJ54 LOSS FACTOR
        GVKZ=.15
        IF(TIME .LT. VOT1) THEN
            VOF=TIME/VOT1
            CALL INTER(VOF,CVND,12,VVOF,CVCV)
            GVK=GVKZ/(CVND*CVND)
          ELSE
            GVK=GVKZ
        ENDIF
C  CALCULATE CHECK VALVE DP
        VEL=Q/AREA
        AV2=38.3/(VEL*VEL)
        SINPHI=0.5*(SQRT(AV2**2+4.)-AV2)
        IF (SINPHI .GE. SINPHM) SINPHI=SINPHM
```

(contd.)

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Table 3.6.1 (contd.)

```
      DPCHK=2.*8.98*RHO*VEL*VEL*(1.-SINPHI)
C  CALCULATE DERIVATIVES
      DQDT=(PA+RHO*G*ZA-PCAV-RHO*G*ZCAV-0.5*RHO*SKASQ*Q*ABS(Q)
     #        -0.5*GVK*RHO*Q*ABS(Q)/AREA**2 - DPCHK)/(RHO*SLOA)
      DVNADT=Q
C  CALCULATE VALUES AT NEW TIME STEP
      QQ=Q+DQDT*DT
      VVNA=VNA+DVNADT*DT
      IF (TIME .LE. 2.) THEN
      IF(MOD(NSTEP,10) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #   Q*7.48*60.
      ELSE
      IF(MOD((NSTEP+10),100) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #   Q*7.48*60.
      ENDIF
  102 FORMAT(F23.3,8F17.2)
C  UPDATE THE OLD VARIABLES
         Q=QQ
         VNA=VVNA
      IF(TIME .GT. 41.) STOP
      GO TO 31
      END
      SUBROUTINE INTER(X,Y,N,XX,YY)
      DIMENSION XX(N),YY(N)
      IF(X .LT. XX(1) .OR. X .GT. XX(N)) GO TO 3
      DO 2 J=2,N
      IF(X .GE. XX(J-1) .AND. X .LE. XX(J)) GO TO 101
      GO TO 2
  101 Y=YY(J-1)+(YY(J)-YY(J-1))*(X-XX(J-1))/
     1  (XX(J)-XX(J-1))
      RETURN
    2 CONTINUE
    3 WRITE(6,1) X,(XX(I),I=1,N)
    1 FORMAT('  BEYOND RANGE',G10.4,5X,20G10.4)
      RETURN
      END
```

USER RESPONSIBLE FOR VERIFYING REVISION, STATUS AND CHANGES

Table 3.6.2
Computer Program Listing: Analysis of 12 Loop, Check Valve Maximum Lift = 60 Deg.

```
C     Last change:  VC   29 Jan 2007   10:51 am
      DIMENSION VVOF(12),CVCV(12)
      OPEN(1,FILE='Acc12-hoff-60deg.out', STATUS='old')
      DATA VVOF/0.,.05,.1,.2,.3,.4,.5,.6,.7,.8,.9,1./
      DATA CVCV/0., 0.0194, 0.055, 0.1, 0.146, 0.204,
     #       0.277,0.3536,0.4613,0.6086,0.767,1./
C  PARAMETERS
C  SINPHM =SINE OF MAXIMUM ANGLE OF CHECK VALVE TRAVEL (NONDIMENSIONAL)
      SINPHM=0.866
C  AKASQ = SUMMATION K/A**2 [FT**(-4)]
      SKASQ=37.69
C  SLOA = SUMMATION L/A [FT**(-1)]
      SLOA=256.8
C  VOT1 = DISK MOVEMENT TIME OF SJ54 GATE VALVE (SEC)
      VOT1=19.84
C  CONSTANTS
      GAM=1.3
      G=32.174
      RHO=1.94
      AREA=0.394
      DT=0.01
      PCAV=14.7*144.
C  INITIAL CONDITIONS
      TIME=0.1
      NSTEP=-1
      VNAZ=408.3
      VNA=VNAZ
      PAZ=84.7*144.
      PA=PAZ
      Q=.001
      ZCAV=127.
      WRITE(1,101)
  101 FORMAT(T19'TIME',  T28'ACCUMULATOR PRESSURE   FLOW RATE')
  103 FORMAT(T19'(SEC.)',T28'        (PSIG)           (GPM)  ',//)
      WRITE(1,103)
   31 NSTEP=NSTEP+1
      TIME=TIME+DT
C  CALCULATE ACCUMULATOR LEVEL ELEVATION
      VWA=1350.-VNA
      ZA=(VWA+7801.2)/95.76
C  CALCULATE ACCUMULATOR GAS PRESSURE
      PA=PAZ*(VNAZ/VNA)**GAM
C  CALCULATE SJ54 LOSS FACTOR
      GVKZ=.15
      IF(TIME .LT. VOT1) THEN
          VOF=TIME/VOT1
          CALL INTER(VOF,CVND,12,VVOF,CVCV)
          GVK=GVKZ/(CVND*CVND)
        ELSE
          GVK=GVKZ
      ENDIF
C  CALCULATE CHECK VALVE DP
      VEL=Q/AREA
      AV2=38.3/(VEL*VEL)
      SINPHI=0.5*(SQRT(AV2**2+4.)-AV2)
      IF (SINPHI .GE. SINPHM) SINPHI=SINPHM
```

(contd.)

USER RESPONSIBLE FOR VERIFYING REVISION, STATUS AND CHANGES

Table 3.6.2 (contd.)

```
      DPCHK=2.*8.98*RHO*VEL*VEL*(1.-SINPHI)
C  CALCULATE DERIVATIVES
      DQDT=(PA+RHO*G*ZA-PCAV-RHO*G*ZCAV-0.5*RHO*SKASQ*Q*ABS(Q)
     #        -0.5*GVK*RHO*Q*ABS(Q)/AREA**2 - DPCHK)/(RHO*SLOA)
      DVNADT=Q
C  CALCULATE VALUES AT NEW TIME STEP
      QQ=Q+DQDT*DT
      VVNA=VNA+DVNADT*DT
      IF (TIME .LE. 2.) THEN
      IF(MOD(NSTEP,10) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #   Q*7.48*60.
      ELSE
      IF(MOD((NSTEP+10),100) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #   Q*7.48*60.
      ENDIF
  102 FORMAT(F23.3,8F17.2)
C  UPDATE THE OLD VARIABLES
         Q=QQ
         VNA=VVNA
      IF(TIME .GT. 41.) STOP
      GO TO 31
      END
      SUBROUTINE INTER(X,Y,N,XX,YY)
      DIMENSION XX(N),YY(N)
      IF(X .LT. XX(1) .OR. X .GT. XX(N)) GO TO 3
      DO 2 J=2,N
      IF(X .GE. XX(J-1) .AND. X .LE. XX(J)) GO TO 101
      GO TO 2
  101 Y=YY(J-1)+(YY(J)-YY(J-1))*(X-XX(J-1))/
     1  (XX(J)-XX(J-1))
      RETURN
    2 CONTINUE
    3 WRITE(6,1) X,(XX(I),I=1,N)
    1 FORMAT('  BEYOND RANGE',G10.4,5X,20G10.4)
      RETURN
      END
```

USER RESPONSIBLE FOR VERIFYING REVISION, STATUS AND CHANGES

Table 3.6.3
Computer Program Listing: Analysis of 13 Loop, Check Valve Maximum Lift = 60 Deg.

```
DIMENSION VVOF(12),CVCV(12)
    OPEN(1,FILE='Acc13-hoff-60deg.out', STATUS='old')
    DATA VVOF/0.,.05,.1,.2,.3,.4,.5,.6,.7,.8,.9,1./
    DATA CVCV/0., 0.0194, 0.055, 0.1, 0.146, 0.204,
   #     0.277,0.3536,0.4613,0.6086,0.767,1./
C  PARAMETERS
C  SINPHM =SINE OF MAXIMUM ANGLE OF CHECK VALVE TRAVEL (NONDIMENSIONAL)
    SINPHM=0.866
C  SKASQ = SUMMATION K/A**2 [FT**(-4)]
    SKASQ=35.83
C  SLOA = SUMMATION L/A [FT**(-1)]
    SLOA=235.6
C  VOT1 = DISK MOVEMENT TIME OF SJ54 GATE VALVE (SEC)
    VOT1=19.12
C  CONSTANTS
    GAM=1.3
    G=32.174
    RHO=1.94
    AREA=0.394
    DT=0.01
    PCAV=14.7*144.
C  INITIAL CONDITIONS
    TIME=0.1
    NSTEP=-1
    VNAZ=408.3
    VNA=VNAZ
    PAZ=84.7*144.
    PA=PAZ
    Q=.001
    ZCAV=127.
    WRITE(1,101)
  101 FORMAT(T19'TIME',  T28'ACCUMULATOR PRESSURE   FLOW RATE')
  103 FORMAT(T19'(SEC.)',T28'       (PSIG)          (GPM)  ',//)
    WRITE(1,103)
   31 NSTEP=NSTEP+1
    TIME=TIME+DT
C  CALCULATE ACCUMULATOR LEVEL ELEVATION
    VWA=1350.-VNA
    ZA=(VWA+7801.2)/95.76
C  CALCULATE ACCUMULATOR GAS PRESSURE
    PA=PAZ*(VNAZ/VNA)**GAM
C  CALCULATE SJ54 LOSS FACTOR
    GVKZ=.15
    IF(TIME .LT. VOT1) THEN
       VOF=TIME/VOT1
       CALL INTER(VOF,CVND,12,VVOF,CVCV)
       GVK=GVKZ/(CVND*CVND)
     ELSE
       GVK=GVKZ
    ENDIF
C  CALCULATE CHECK VALVE DP
    VEL=Q/AREA
```

(contd.)

USER RESPONSIBLE FOR VERIFYING REVISION, STATUS AND CHANGES

Table 3.6.3 (contd.)

```
      AV2=38.3/(VEL*VEL)
      SINPHI=0.5*(SQRT(AV2**2+4.)-AV2)
      IF (SINPHI .GE. SINPHM) SINPHI=SINPHM
      DPCHK=2.*8.98*RHO*VEL*VEL*(1.-SINPHI)
C  CALCULATE DERIVATIVES
      DQDT=(PA+RHO*G*ZA-PCAV-RHO*G*ZCAV-0.5*RHO*SKASQ*Q*ABS(Q)
     #      -0.5*GVK*RHO*Q*ABS(Q)/AREA**2 - DPCHK)/(RHO*SLOA)
      DVNADT=Q
C  CALCULATE VALUES AT NEW TIME STEP
      QQ=Q+DQDT*DT
      VVNA=VNA+DVNADT*DT
      IF (TIME .LE. 2.) THEN
      IF(MOD(NSTEP,10) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #  Q*7.48*60.
      ELSE
      IF(MOD((NSTEP+10),100) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #  Q*7.48*60.
      ENDIF
  102 FORMAT(F23.3,8F17.2)
C  UPDATE THE OLD VARIABLES
        Q=QQ
        VNA=VVNA
      IF(TIME .GT. 41.) STOP
      GO TO 31
      END
      SUBROUTINE INTER(X,Y,N,XX,YY)
      DIMENSION XX(N),YY(N)
      IF(X .LT. XX(1) .OR. X .GT. XX(N)) GO TO 3
      DO 2 J=2,N
      IF(X .GE. XX(J-1) .AND. X .LE. XX(J)) GO TO 101
      GO TO 2
  101 Y=YY(J-1)+(YY(J)-YY(J-1))*(X-XX(J-1))/
     1  (XX(J)-XX(J-1))
      RETURN
    2 CONTINUE
    3 WRITE(6,1) X,(XX(I),I=1,N)
    1 FORMAT('  BEYOND RANGE',G10.4,5X,20G10.4)
      RETURN
      END
```

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Table 3.6.4
Computer Program Listing: Analysis of 14 Loop, Check Valve Maximum Lift = 60 Deg.

```
      DIMENSION VVOF(12),CVCV(12)
        OPEN(1,FILE='Acc14-hoff-60deg.out', STATUS='old')
        DATA VVOF/0.,.05,.1,.2,.3,.4,.5,.6,.7,.8,.9,1./
        DATA CVCV/0., 0.0194, 0.055, 0.1, 0.146, 0.204,
     #     0.277,0.3536,0.4613,0.6086,0.767,1./
C  PARAMETERS
C  SINPHM =SINE OF MAXIMUM ANGLE OF CHECK VALVE TRAVEL (NONDIMENSIONAL)
        SINPHM=0.866
C  SKASQ = SUMMATION K/A**2 [FT**(-4)]
        SKASQ=34.76
C  SLOA = SUMMATION L/A [FT**(-1)]
        SLOA=222.5
C  VOT1 = DISK MOVEMENT TIME OF SJ54 GATE VALVE (SEC)
        VOT1=19.94
C  CONSTANTS
        GAM=1.3
        G=32.174
        RHO=1.94
        AREA=0.394
        DT=0.01
        PCAV=14.7*144.
C  INITIAL CONDITIONS
        TIME=0.1
        NSTEP=-1
        VNAZ=408.3
        VNA=VNAZ
        PAZ=84.7*144.
        PA=PAZ
        Q=.001
        ZCAV=127.
        WRITE(1,101)
  101 FORMAT(T19'TIME',  T28'ACCUMULATOR PRESSURE   FLOW RATE')
  103 FORMAT(T19'(SEC.)',T28'       (PSIG)          (GPM)  ',//)
        WRITE(1,103)
   31 NSTEP=NSTEP+1
        TIME=TIME+DT
C  CALCULATE ACCUMULATOR LEVEL ELEVATION
        VWA=1350.-VNA
        ZA=(VWA+7801.2)/95.76
C  CALCULATE ACCUMULATOR GAS PRESSURE
        PA=PAZ*(VNAZ/VNA)**GAM
C  CALCULATE SJ54 LOSS FACTOR
        GVKZ=.15
        IF(TIME .LT. VOT1) THEN
          VOF=TIME/VOT1
          CALL INTER(VOF,CVND,12,VVOF,CVCV)
          GVK=GVKZ/(CVND*CVND)
         ELSE
          GVK=GVKZ
        ENDIF
C  CALCULATE CHECK VALVE DP
        VEL=Q/AREA
```

(contd.)

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Table 3.6.4 (contd.)

```
      AV2=38.3/(VEL*VEL)
      SINPHI=0.5*(SQRT(AV2**2+4.)-AV2)
      IF (SINPHI .GE. SINPHM) SINPHI=SINPHM
      DPCHK=2.*8.98*RHO*VEL*VEL*(1.-SINPHI)
C  CALCULATE DERIVATIVES
      DQDT=(PA+RHO*G*ZA-PCAV-RHO*G*ZCAV-0.5*RHO*SKASQ*Q*ABS(Q)
     #     -0.5*GVK*RHO*Q*ABS(Q)/AREA**2 - DPCHK)/(RHO*SLOA)
      DVNADT=Q
C  CALCULATE VALUES AT NEW TIME STEP
      QQ=Q+DQDT*DT
      VVNA=VNA+DVNADT*DT
      IF (TIME .LE. 2.) THEN
      IF(MOD(NSTEP,10) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #  Q*7.48*60.
      ELSE
      IF(MOD((NSTEP+10),100) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #  Q*7.48*60.
      ENDIF
  102 FORMAT(F23.3,8F17.2)
C  UPDATE THE OLD VARIABLES
        Q=QQ
        VNA=VVNA
      IF(TIME .GT. 41.) STOP
      GO TO 31
      END
      SUBROUTINE INTER(X,Y,N,XX,YY)
      DIMENSION XX(N),YY(N)
      IF(X .LT. XX(1) .OR. X .GT. XX(N)) GO TO 3
      DO 2 J=2,N
      IF(X .GE. XX(J-1) .AND. X .LE. XX(J)) GO TO 101
      GO TO 2
  101 Y=YY(J-1)+(YY(J)-YY(J-1))*(X-XX(J-1))/
     1  (XX(J)-XX(J-1))
      RETURN
    2 CONTINUE
    3 WRITE(6,1) X,(XX(I),I=1,N)
    1 FORMAT('  BEYOND RANGE',G10.4,5X,20G10.4)
      RETURN
      END
```

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Table 3.6.5
Computer Program Listing: Analysis of 11 Loop, Check Valve (Free)

```
C       Last change:  VC   29 Jan 2007   10:15 am
        DIMENSION VVOF(12),CVCV(12)
        OPEN(1,FILE='Acc11-hoff-free.out', STATUS='old')
        DATA VVOF/0.,.05,.1,.2,.3,.4,.5,.6,.7,.8,.9,1./
        DATA CVCV/0., 0.0194, 0.055, 0.1, 0.146, 0.204,
       #        0.277,0.3536,0.4613,0.6086,0.767,1./
C  PARAMETERS
C  SINPHM =SINE OF MAXIMUM ANGLE OF CHECK VALVE TRAVEL (NONDIMENSIONAL)
        SINPHM=0.9532
C  SKASQ = SUMMATION K/A**2 [FT**(-4)]
        SKASQ=37.12
C  SLOA = SUMMATION L/A [FT**(-1)]
        SLOA=261.3
C  VOT1 = DISK MOVEMENT TIME OF SJ54 GATE VALVE (SEC)
        VOT1=17.47
C  CONSTANTS
        GAM=1.3
        G=32.174
        RHO=1.94
        AREA=0.394
        DT=0.01
        PCAV=14.7*144.
C  INITIAL CONDITIONS
        TIME=0.1
        NSTEP=-1
        VNAZ=408.3
        VNA=VNAZ
        PAZ=84.7*144.
        PA=PAZ
        Q=.001
        ZCAV=127.
        WRITE(1,101)
  101   FORMAT(T19'TIME',  T28'ACCUMULATOR PRESSURE   FLOW RATE')
  103   FORMAT(T19'(SEC.)',T28'        (PSIG)           (GPM)  ',//)
        WRITE(1,103)
   31   NSTEP=NSTEP+1
        TIME=TIME+DT
C  CALCULATE ACCUMULATOR LEVEL ELEVATION
        VWA=1350.-VNA
        ZA=(VWA+7801.2)/95.76
C  CALCULATE ACCUMULATOR GAS PRESSURE
        PA=PAZ*(VNAZ/VNA)**GAM
C  CALCULATE SJ54 LOSS FACTOR
        GVKZ=.15
        IF(TIME .LT. VOT1) THEN
            VOF=TIME/VOT1
            CALL INTER(VOF,CVND,12,VVOF,CVCV)
            GVK=GVKZ/(CVND*CVND)
          ELSE
            GVK=GVKZ
        ENDIF
C  CALCULATE CHECK VALVE DP
        VEL=Q/AREA
        AV2=38.3/(VEL*VEL)
        SINPHI=0.5*(SQRT(AV2**2+4.)-AV2)
        IF (SINPHI .GE. SINPHM) SINPHI=SINPHM                    (contd.)
```

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Table 3.6.5 (contd.)

```
      DPCHK=2.*8.98*RHO*VEL*VEL*(1.-SINPHI)
C  CALCULATE DERIVATIVES
      DQDT=(PA+RHO*G*ZA-PCAV-RHO*G*ZCAV-0.5*RHO*SKASQ*Q*ABS(Q)
     #        -0.5*GVK*RHO*Q*ABS(Q)/AREA**2 - DPCHK)/(RHO*SLOA)
      DVNADT=Q
C  CALCULATE VALUES AT NEW TIME STEP
      QQ=Q+DQDT*DT
      VVNA=VNA+DVNADT*DT
      IF (TIME .LE. 2.) THEN
      IF(MOD(NSTEP,10) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #   Q*7.48*60.
      ELSE
      IF(MOD((NSTEP+10),100) .EQ. 0)WRITE(1,102) TIME,+(PA/144.-14.7),
     #   Q*7.48*60.
      ENDIF
  102 FORMAT(F23.3,8F17.2)
C  UPDATE THE OLD VARIABLES
         Q=QQ
         VNA=VVNA
      IF(TIME .GT. 41.) STOP
      GO TO 31
      END
      SUBROUTINE INTER(X,Y,N,XX,YY)
      DIMENSION XX(N),YY(N)
      IF(X .LT. XX(1) .OR. X .GT. XX(N)) GO TO 3
      DO 2 J=2,N
      IF(X .GE. XX(J-1) .AND. X .LE. XX(J)) GO TO 101
      GO TO 2
  101 Y=YY(J-1)+(YY(J)-YY(J-1))*(X-XX(J-1))/
     1  (XX(J)-XX(J-1))
      RETURN
    2 CONTINUE
    3 WRITE(6,1) X,(XX(I),I=1,N)
    1 FORMAT('  BEYOND RANGE',G10.4,5X,20G10.4)
      RETURN
      END
```

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4. Results

All four loops were analyzed inidividually with their own specific data and geometrical input. For 11 loop, two analyses were run for pressure decay time calculation (one for the check valve free case and other with check valve having maximum lift 60 degrees). Table 4.1 shows the time history of pressure decay and the discharge flow rate of 11-accumulator for the 60 degree check valve lift. Table 4.2 shows the pressure decay time history and the discharge flow rate of 11-accumulator for the free check valve case. The associated computer program listing is shown in Table 3.6.5.

For 12, 13, and 14 loops, the pressure decay analyses were done for the case where the maximum lift for the check valves is 60 degrees. Table 4.3 shows the time history of pressure decay and the discharge flow rate of 12-accumulator for the 60 degree check valve lift. Table 4.4 shows the time history of pressure decay and the discharge flow rate of 13-accumulator for the 60 degree check valve lift. Table 4.5 shows the time history of pressure decay and the discharge flow rate of 14-accumulator for the 60 degree check valve lift.

For all cases analyzed, the flow rate exceeded 3537 gpm (corresponding to 20 ft/s velocity in 0.394 ft^2 aea pipe), the minimum flow rate required for full disk lift.

Figure 4.1 shows the plots of pressure decay time history of 11 accumulator and Figure 4.2 shows the discharge flow rate time histories of 11 accumulators for the two cases analyzed (check valves are free and the check valves maximum lift is 60 degrees).

From the tabular data, the following results are obtained for 60 degree maximum lift cases.

For 11-accumulator, the pressure decay time from 70 psig to 35 psig is 28.52 seconds.
For 12-accumulator, the pressure decay time from 70 psig to 35 psig is 29.07 seconds.
For 13-accumulator, the pressure decay time from 70 psig to 35 psig is 28.63 seconds.
For 14-accumulator, the pressure decay time from 70 psig to 35 psig is 28.63 seconds.

As per the recommendation of the safety evaluation report docket No. 50-311 dated January 2, 2004 (Relief Request RR S2-RR-03-V01 and RR S2-RR-03-V02) and docket Nos. 50-271 and 50-311 dated March 12, 1999, the acceptance criterion for the pressure decay time is 1.5 second less than the calculated pressure decay time for the 60 degree check valve lift case.

Therefore, the valve passing acceptance criteria for the check valves are as follows:

Acceptance criterion pressure decay time for 11 loop check valves is less than or equal to 27.02 seconds
Acceptance criterion pressure decay time for 12 loop check valves is less than or equal to 27.57 seconds
Acceptance criterion pressure decay time for 13 loop check valves is less than or equal to 27.13 seconds
Acceptance criterion pressure decay time for 14 loop check valves is less than or equal to 27.13 seconds

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Table 4.1
11 Accumulator Pressure and Discharge Flow Rate Time History
(Check Valve Maximum Lift = 60 deg)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)
0.110	70.00	0.45
0.210	69.99	178.98
0.310	69.98	263.46
0.410	69.96	347.16
0.510	69.94	429.97
0.610	69.91	511.84
0.710	69.88	592.81
0.810	69.84	672.95
0.910	69.80	757.03
1.010	69.75	878.76
1.110	69.69	1010.72
1.210	69.63	1143.42
1.310	69.56	1275.08
1.410	69.48	1405.17
1.510	69.39	1533.42
1.610	69.30	1659.63
1.710	69.20	1783.65
1.810	69.09	1901.54
1.910	68.97	2001.58
2.010	68.85	2089.57
3.010	67.45	2715.78
4.010	65.81	3149.23
5.010	64.03	3444.16
6.010	62.19	3656.32
7.010	60.34	3795.07
8.010	58.52	3882.58
9.010	56.74	3917.60
0.010	55.04	3915.37
11.010	53.41	3892.04
12.010	51.86	3859.03
13.010	50.38	3815.32
14.010	48.98	3763.51
15.010	47.65	3704.54
16.010	46.39	3641.72
17.010	45.19	3578.94
18.010	44.06	3513.35
19.010	42.98	3444.23
20.010	41.96	3376.29
21.010	40.99	3310.25
22.010	40.06	3246.10
23.010	39.18	3183.75
24.010	38.34	3123.08
25.010	37.54	3064.00
26.010	36.78	3006.41
27.011	36.04	2950.25
28.011	35.34	2895.42
29.011	34.67	2841.86
30.011	34.03	2789.51
31.011	33.41	2738.30
32.011	32.82	2688.17
33.010	32.25	2639.08
34.010	31.70	2590.97

(contd.)

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Table 4.1 (Contd.)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)
35.010	31.17	2543.79
36.010	30.67	2497.51
37.010	30.18	2452.08
38.010	29.71	2407.47
39.009	29.26	2363.63
40.009	28.82	2320.53
41.009	28.40	2278.15

When pressure = 35 psig, time = 28.52 sec

USER RESPONSIBLE FOR VERIFYING REVISION, STATUS AND CHANGES

Table 4.2
11 Accumulator Pressure and Discharge Flow Rate Time History
(Check Valve Free)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)
0.110	70.00	0.45
0.210	69.99	178.98
0.310	69.98	263.46
0.410	69.96	347.16
0.510	69.94	429.97
0.610	69.91	511.84
0.710	69.88	592.81
0.810	69.84	672.95
0.910	69.80	757.03
1.010	69.75	878.76
1.110	69.69	1010.72
1.210	69.63	1143.42
1.310	69.56	1275.08
1.410	69.48	1405.17
1.510	69.39	1533.42
1.610	69.30	1659.63
1.710	69.20	1783.65
1.810	69.09	1901.54
1.910	68.97	2001.58
2.010	68.85	2090.22
3.010	67.43	2794.25
4.010	65.72	3342.97
5.010	63.81	3748.07
6.010	61.81	4041.49
7.010	59.77	4249.37
8.010	57.75	4392.73
9.010	55.78	4465.66
10.010	53.88	4484.18
11.010	52.07	4469.83
12.010	50.35	4440.26
13.010	48.73	4393.46
14.010	47.19	4333.58
15.010	45.74	4261.59
16.010	44.37	4182.55
17.010	43.08	4102.63
18.010	41.86	4018.17
19.010	40.71	3927.59
20.010	39.63	3837.95
21.010	38.61	3750.84
22.010	37.64	3666.40
23.010	36.73	3584.52
24.010	35.86	3503.60
25.010	35.04	3413.33
26.010	34.26	3319.89
27.011	33.52	3227.15
28.011	32.82	3136.23
29.011	32.16	3047.40
30.011	31.54	2960.67
31.011	30.94	2875.96
32.011	30.38	2793.20
33.010	29.84	2712.27
34.010	29.33	2633.11

(contd.)

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Table 4.2 (contd.)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)
35.010	28.85	2555.62
36.010	28.39	2479.75
37.010	27.95	2405.43
38.010	27.53	2332.60
39.009	27.13	2261.22
40.009	26.75	2191.25
41.009	26.38	2122.65

When pressure = 35 psig, time = 25.06 sec

USER RESPONSIBLE FOR VERIFYING REVISION, STATUS AND CHANGES

Table 4.3
12 Accumulator Pressure and Discharge Flow Rate Time History
(Check Valve Maximum Lift = 60 deg)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)
0.110	70.00	0.45
0.210	69.99	159.07
0.310	69.98	234.28
0.410	69.97	308.91
0.510	69.95	382.86
0.610	69.92	456.08
0.710	69.89	528.55
0.810	69.86	600.31
0.910	69.82	671.42
1.010	69.78	742.71
1.110	69.73	846.85
1.210	69.68	964.62
1.310	69.62	1083.71
1.410	69.55	1202.08
1.510	69.47	1319.21
1.610	69.39	1434.90
1.710	69.30	1548.99
1.810	69.21	1661.35
1.910	69.11	1771.87
2.010	69.00	1879.95
3.010	67.70	2526.17
4.010	66.16	2957.09
5.010	64.46	3267.68
6.010	62.69	3478.19
7.010	60.91	3644.58
8.010	59.13	3745.90
9.010	57.38	3812.44
10.010	55.69	3837.24
11.010	54.06	3832.01
12.010	52.50	3806.00
13.010	51.02	3774.85
14.010	49.61	3732.78
15.010	48.26	3686.34
16.010	46.99	3633.01
17.010	45.77	3575.15
18.010	44.62	3514.62
19.010	43.52	3454.70
20.010	42.48	3393.84
21.010	41.48	3329.39
22.010	40.54	3265.09
23.010	39.64	3202.39
24.010	38.78	3141.37
25.010	37.97	3081.96
26.010	37.19	3024.08
27.011	36.44	2967.64
28.011	35.72	2912.57
29.011	35.04	2858.78
30.011	34.38	2806.22
31.011	33.75	2754.82
32.011	33.15	2704.52
33.010	32.57	2655.27
34.010	32.01	2607.01

(contd.)

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Table 4.3 (contd.)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)
35.010	31.48	2559.71
36.010	30.96	2513.31
37.010	30.46	2467.78
38.010	29.99	2423.07
39.009	29.52	2379.15
40.009	29.08	2335.98
41.009	28.65	2293.53

When pressure = 35 psig, time = 29.07 sec

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Table 4.4
13 Accumulator Pressure and Discharge Flow Rate Time History
(Check Valve Maximum Lift = 60 deg)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)	
0.110	70.00	0.45	
0.210	69.99	165.51	
0.310	69.98	243.73	
0.410	69.96	321.31	
0.510	69.94	398.14	
0.610	69.92	474.18	
0.710	69.89	549.43	
0.810	69.85	623.95	
0.910	69.81	697.79	
1.010	69.77	781.38	
1.110	69.72	899.98	
1.210	69.66	1024.42	
1.310	69.60	1148.73	
1.410	69.53	1271.91	
1.510	69.45	1393.65	
1.610	69.36	1513.77	
1.710	69.27	1632.12	
1.810	69.17	1748.59	
1.910	69.06	1863.04	
2.010	68.95	1966.00	
3.010	67.61	2599.23	
4.010	66.03	3035.70	
5.010	64.29	3346.58	
6.010	62.49	3558.90	
7.010	60.67	3724.33	
8.010	58.87	3821.96	
9.010	57.10	3883.04	
10.010	55.39	3899.61	
11.010	53.75	3887.52	
12.010	52.18	3859.46	
13.010	50.69	3824.28	
14.010	49.28	3779.19	
15.010	47.93	3728.39	
16.010	46.65	3670.69	
17.010	45.43	3609.19	
18.010	44.28	3547.07	
19.010	43.19	3484.65	
20.010	42.14	3418.66	
21.010	41.16	3351.48	
22.010	40.21	3285.91	
23.010	39.32	3222.16	
24.010	38.47	3160.15	
25.010	37.65	3099.79	
26.010	36.88	3040.97	
27.011	36.13	2983.62	
28.011	35.42	2927.66	When pressure = 35 psig, time = 28.63 sec
29.011	34.74	2873.01	
30.011	34.09	2819.60	
31.011	33.46	2767.36	

(contd.)

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Table 4.4 (contd.)

32.011	32.86	2716.25
33.010	32.29	2666.20
34.010	31.73	2617.16
35.010	31.20	2569.09
36.010	30.69	2521.93
37.010	30.19	2475.65
38.010	29.72	2430.21
39.009	29.26	2385.57
40.009	28.82	2341.69
41.009	28.40	2298.54

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Table 4.5
14 Accumulator Pressure and Discharge Flow Rate Time History
(Check Valve Maximum Lift = 60 deg)

TIME (SEC.)	ACCUMULATOR PRESSURE (PSIG)	FLOW RATE (GPM)	
0.110	70.00	0.45	
0.210	69.99	159.52	
0.310	69.98	234.93	
0.410	69.97	309.78	
0.510	69.95	383.94	
0.610	69.92	457.37	
0.710	69.89	530.06	
0.810	69.86	602.06	
0.910	69.82	673.42	
1.010	69.78	744.56	
1.110	69.73	850.40	
1.210	69.68	970.47	
1.310	69.61	1091.35	
1.410	69.55	1211.33	
1.510	69.47	1330.04	
1.610	69.39	1447.32	
1.710	69.30	1563.04	
1.810	69.20	1677.06	
1.910	69.10	1789.29	
2.010	68.99	1899.45	
3.010	67.69	2546.68	
4.010	66.12	2985.03	
5.010	64.41	3303.10	
6.010	62.63	3519.77	
7.010	60.82	3693.01	
8.010	59.02	3799.00	
9.010	57.26	3869.68	
10.010	55.54	3896.98	
11.010	53.90	3892.90	
12.010	52.32	3866.93	
13.010	50.82	3835.78	
14.010	49.40	3793.13	
15.010	48.04	3745.87	
16.010	46.75	3691.39	
17.010	45.52	3632.00	
18.010	44.36	3569.68	
19.010	43.25	3507.99	
20.010	42.20	3445.49	
21.010	41.20	3379.10	
22.010	40.26	3312.62	
23.010	39.35	3247.83	
24.010	38.49	3184.80	
25.010	37.67	3123.46	
26.010	36.89	3063.71	
27.011	36.14	3005.46	
28.011	35.42	2948.62	When pressure = 35 psig, time = 28.63 sec
29.011	34.74	2893.13	
30.011	34.08	2838.90	

(contd.)

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Table 4.5 (contd.)

31.011	33.45	2785.88
32.011	32.85	2734.00
33.010	32.27	2683.20
34.010	31.71	2633.44
35.010	31.17	2584.67
36.010	30.66	2536.83
37.010	30.16	2489.88
38.010	29.69	2443.79
39.009	29.23	2398.51
40.009	28.78	2354.01
41.009	28.36	2310.25

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Fig. 4.1
11-Accumulator Pressure Time History

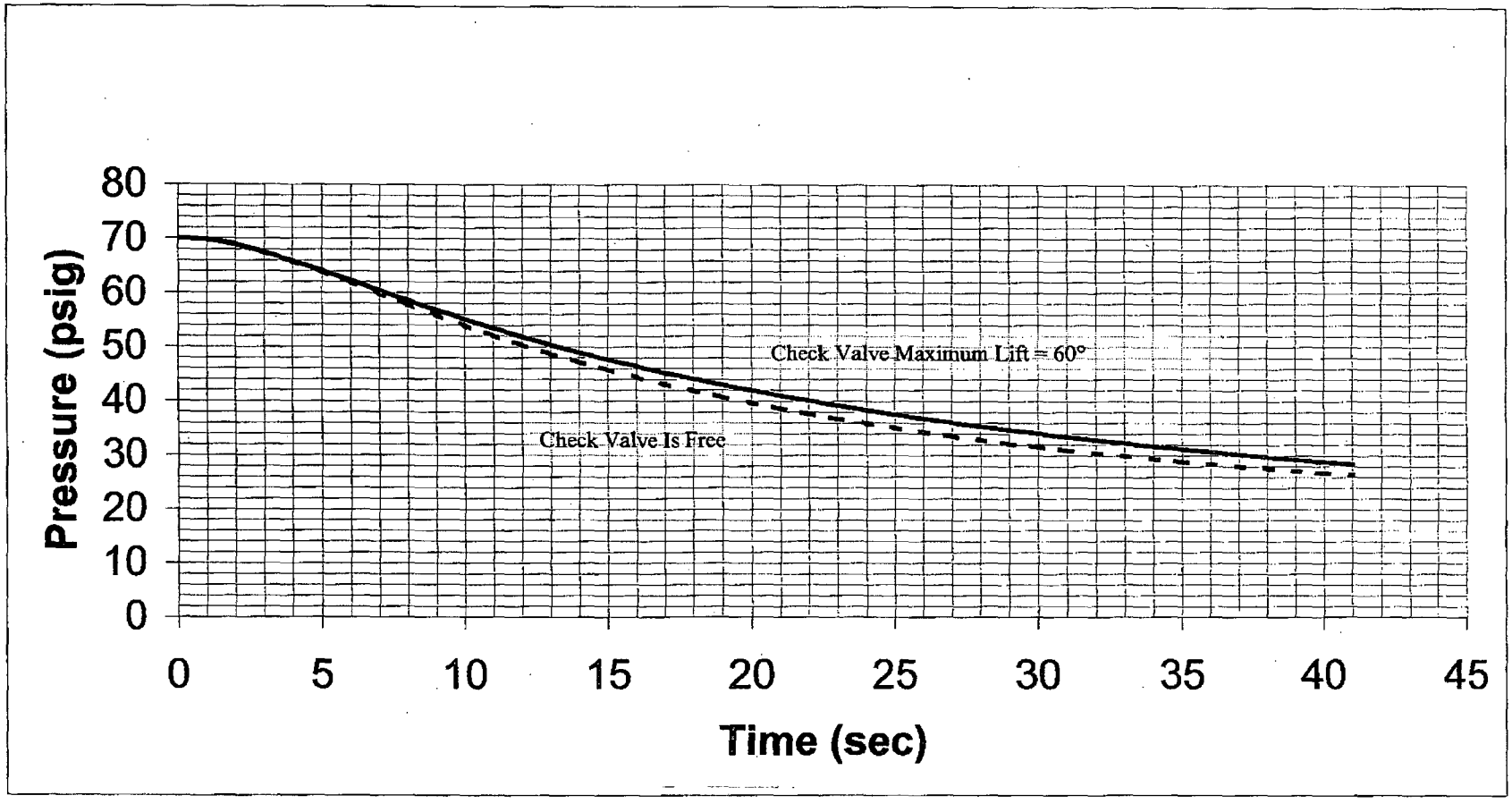
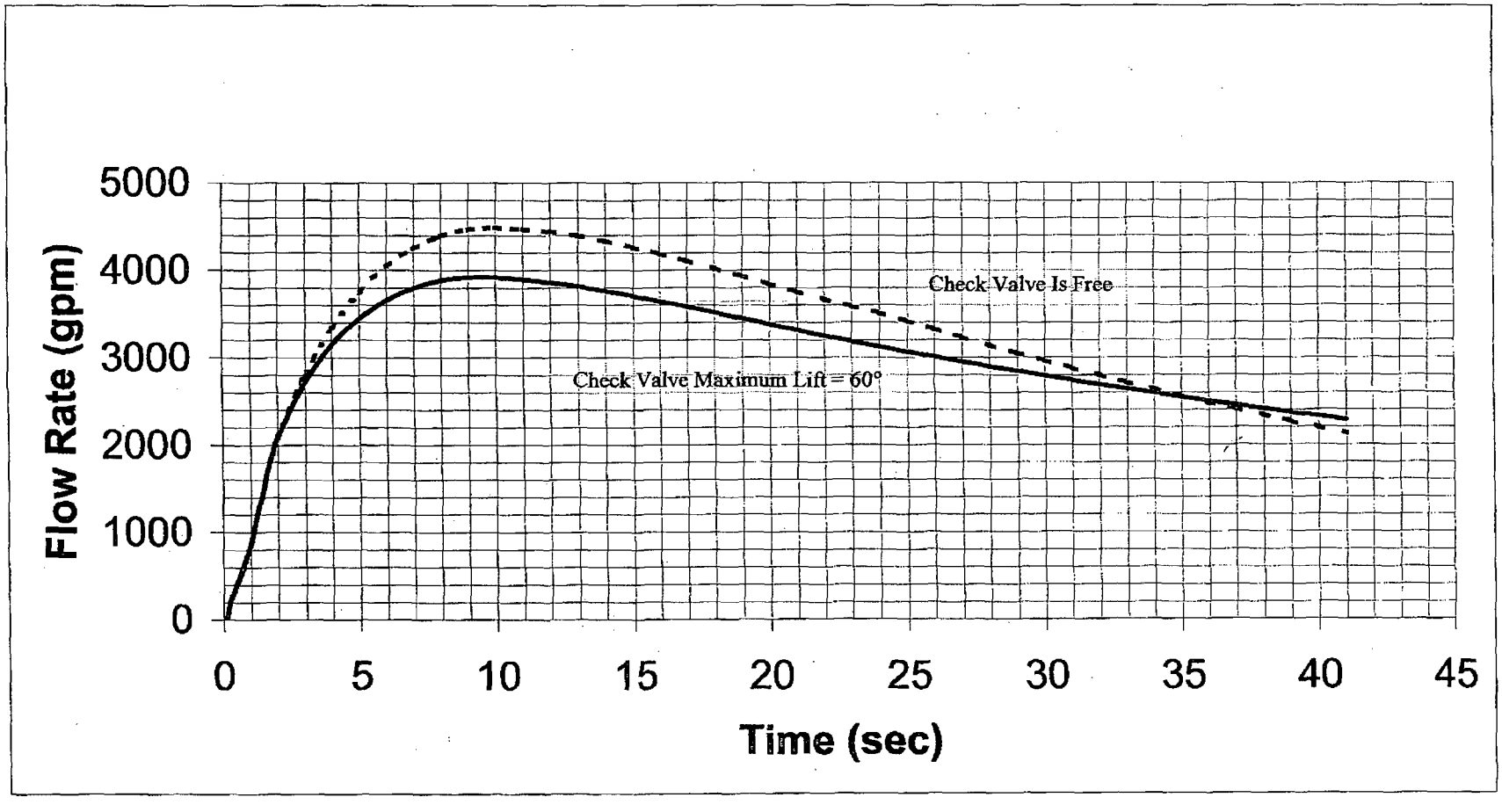


Fig. 4.2
11-Accumulator Discharge Flow Rate



5. Conclusions

As calculated in Section 4 the acceptance criterion for pressure decay from 70 psig to 35 psig in the accumulators is as follows:

Acceptance criterion pressure decay time for 11 loop check valves is less than or equal to 27.02 seconds
Acceptance criterion pressure decay time for 12 loop check valves is less than or equal to 27.57 seconds
Acceptance criterion pressure decay time for 11 loop check valves is less than or equal to 27.13 seconds
Acceptance criterion pressure decay time for 11 loop check valves is less than or equal to 27.13 seconds

6. Documents Affected

Procedure S1.OP-ST.SJ-0006 will be revised after this calculation is issued. See NUTS 80017344, Operation 0650, and NUTS 80017349, Operation 0650.

7. Design Margin

The calculation established the acceptance criterion for the pressure decay time to ascertain the valve functionality. A design margin is not applicable for this calculation.

8. References

1. Calculation S-2-SJ-MDC-1394. Rev. 5, Accumulator Pressure Decay During Discharge Test
2. Drawing 207464, Rev. 22, No. 1 Unit - Reactor Containment Residual Heat Removal & Safety Inj. Piping ...
3. VTD 107632, Rev. 3, ... Accumulator Tanks ...
4. Procedure S1.OP-TM.ZZ-0002, Rev. 6, Tank Capacity Data (accumulator and pressurizer levels vs. volume curves)
5. SGS-UFSAR Table 6.3-2, Rev. 19, Accumulator Design Parameters
6. Procedure S1.OP-ST.SJ-0004, Rev. 5, Inservice Testing Safety Injection Valves Modes 3-6
7. Drawing 206929, Rev. 8, No. 1 Unit – Reactor Containment Reactor Coolant Primary Loop Piping
8. NRC letter to PSEG Nuclear dated September 30, 2005, Salem Nuclear Generating Station, Unit No. 1, Evaluation of Relief Requests S1-RR-04-V01 and S1-RR-04-V02 Related to the Third 10-Year Interval Inservice Testing Program (TAC No. MC3855)
9. Stress Calculation 267241, Rev. 4, No. 11 Reactor Coolant Loop
10. Stress Calculation 267246, Rev. 5, Safety Injection Piping
11. Stress Calculation 267241C, Rev. 1, Safety Injection Piping
12. Stress Calculation 267242, Rev. 3, Safety Injection Piping
13. Stress Calculation 267243, Rev. 1, SI Piping from #13 Accumulator to Anchor C-13SIA-6
14. Stress Calculation 267244, Rev. 1, Safety Injection Piping

9. Attachments

1. E-mail from D. Johnson to V. Chandra dated July 8, 2005, Delay Times of Salem 1 SJ54 Valves (1 page)
2. E-mail from D. Johnson to V. Chandra dated August 8, 2005, 11 & 12 SJ54 Stroke Time (1 page)
3. Transmittal Number DES070025, dated January 24, 2007, Diagnostic Test Traces for MOVs 11SJ54 and 12SJ54 (6 pages)

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