Calculation S-1-SJ-MDC-1539, Revision 2

Accumulator Pressure Decay Time During Discharge Test

(NC.DE-AP.ZZ-0002(Q), Rev. 12, Form 1)	CALCULATION COVER SHEET	Page 1 of 40
CALCULATION NUMBER: S-1-SJ-MDC-1539		REVISION: 2
TITLE: Accumulator Pressure Decay Time During Dischanrge Test		
#SHTS (CALC): 40	#ATT/#SHTS: 2/2	#IDV/50.59/72.48 SHTS: 2/9/0 #TOTAL SHTS: 53

CHECK ONE:

☒ FINAL ☐ INTERIM (Proposed Plant Change) ☐ VOID

☐ FINAL (Future Confirmation Req'd, enter tracking Notification number:)

SALEM OR HOPE CREEK: ☒ Q – LIST ☒ IMPORTANT TO SAFETY ☐ NON-SAFETY RELATED

HOPE CREEK ONLY: ☐Q ☐Qs ☐Qsh ☐F ☐R

ISFSI: ☐ IMPORTANT TO SAFETY ☐ NOT IMPORTANT TO SAFETY

☒ ARE STATION PROCEDURES IMPACTED? YES ☒ NO ☐

If "yes", interface with the system engineer & procedure sponsor. All impacted procedures should be identified in a section in the calculation body **[crca 70038194-0280]**. Include an sap operation for update and list the sap orders here and within the body of this calculation.

S1.OP-ST.SJ-0006 SAP order 80017350, op. 0690

☐ CP and ADs INCORPORATED (IF ANY):

DESCRIPTION OF CALCULATION REVISION (If applicable.):

1. Incorporated the efffect of increased stroke times of 13SJ54 and 14SJ54 valves
2. Developed acceptance criterion for each loop separately.
3. Incorporated the effect of dead period in the beginning of SJ54 stroke.

PURPOSE:

Determine the acceptane criteria for the pressure decay in the accumulator during the discharge test done in support of testing of SJ55 and SJ56 check valves.

CONCLUSIONS:

Acceptance criterion for pressure decay time for 11 loop check valves is less than or equal to 25.26 seconds.
Acceptance criterion for pressure decay time for 12 loop check valves is less than or equal to 25.62 seconds.
Acceptance criterion for pressure decay time for 13 loop check valves is less than or equal to 27.13 seconds.
Acceptance criterion for pressure decay time for 14 loop check valves is less than or equal to 27.13 seconds.
The time is measured from the instant when SJ54 valve disc begins to move.
This calculation needs NRC approval before implementation.

	Printed Name / Signature	Date
ORIGINATOR/COMPANY NAME:	Vijay Chandra/PSEG Vijay Chandra	Aug 8, 2005
REVIEWER/COMPANY NAME:	James Murphy/PSEG [signature]	Aug 11, 2005
VERIFIER/COMPANY NAME:	James Murphy/PSEG [signature]	Aug 11, 2005
CONTRACTOR SUPERVISOR (If applicable)		
PSEG SUPERVISOR APPROVAL: (Always required)	John Duffy John Duffy	8/12/05

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.

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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. △2

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. △2

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. △1

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

Reason for Calculation Revision

The method of testing SJ55 and SJ56 check valves by passing accumulator water to the reactor cavity by opening the SJ54 valve was approved by NRC 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 DCP's 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.

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)

THEREFORE,

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

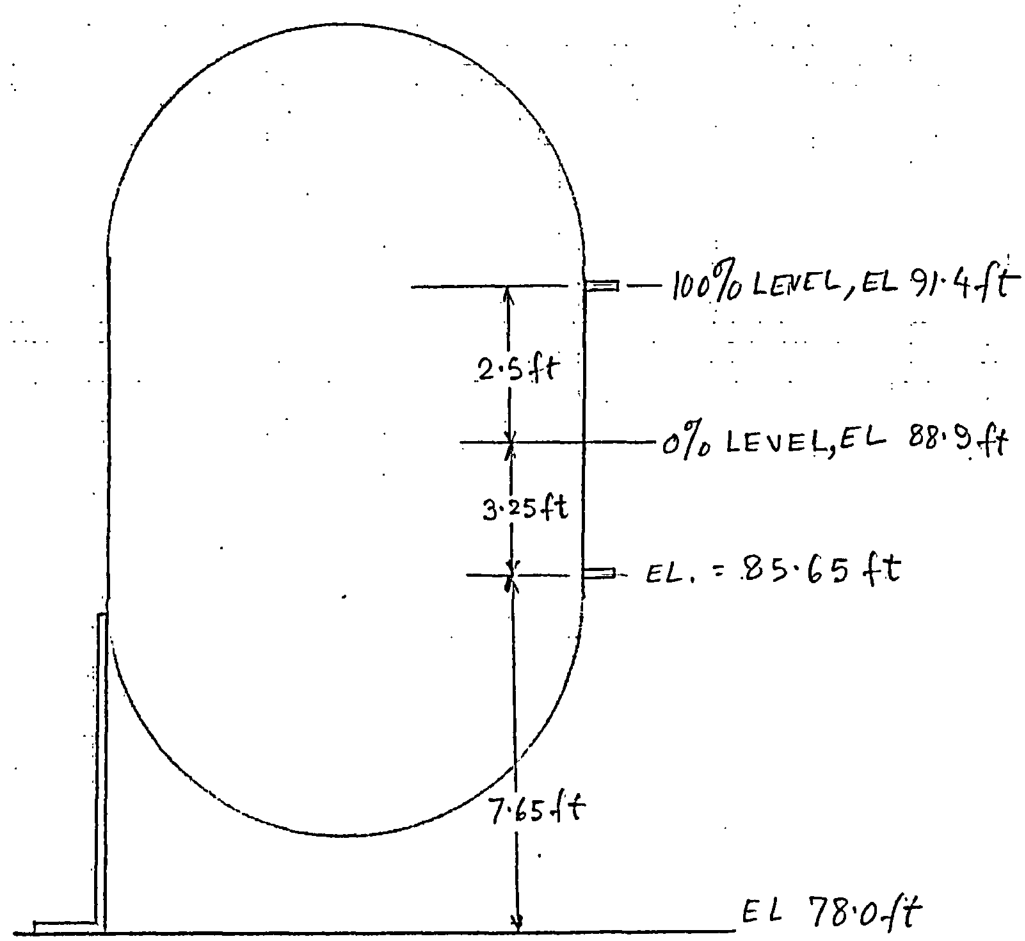
FOR 96% INITIAL WATER LEVEL, $Z_{A,INIT} = 88.9 + 0.96 * 2.5$ ft
$= 91.3$ ft

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

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

INITIAL NITROGEN VOLUME = 1350 − 941.7 ft^3
= 408.3 ft^3

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



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) 2

COMPONENT	ELEVATION FEET	ELEVATION 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~~
~~15% 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

	(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

Low Alarm and Letdown isolated 116'-4"

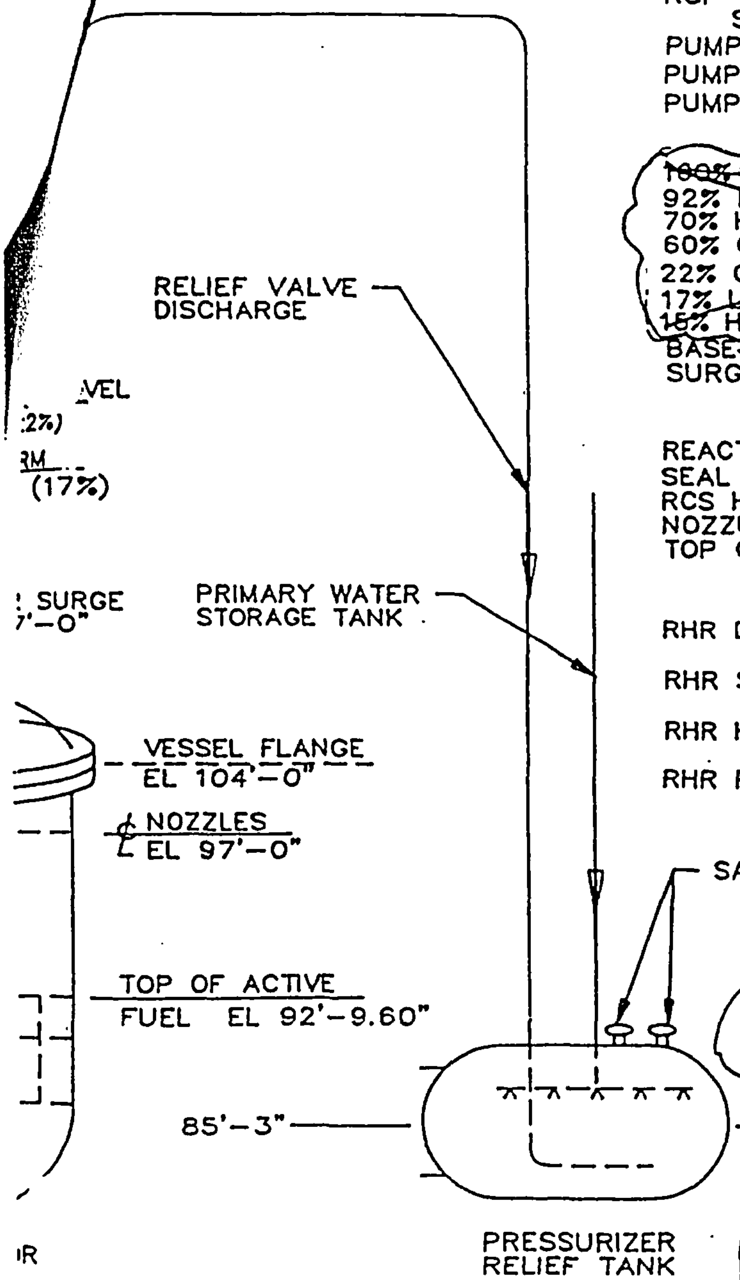


FIGURE F-17

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

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 3.1 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	9.6	Att. 2	0.83	Att. 2	8.77
12SJ54	10.5	Att. 2	0.69	Att. 2	9.81
13SJ54	20.5	Notification 20188810	1.38	Att. 1	19.12
14SJ54	21.3	Notification 20188884	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 i^{th} pipe segment
A_i = Flow area of i^{th} pipe segment

(See Ref. 1 page 24 for its use)

TABLE 3.5.1

11 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

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

$$\sum \frac{L_i}{A_i} = \frac{29.7}{0.548} + \frac{79.1}{0.394} + \underbrace{\frac{26}{4.12}}_{\text{COLD LEG AND REACTOR}} ft^{-1}$$

[Ref. 7]

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

TABLE 3.5.2

12 ACCUMULATOR DISCHARGE LINE FITTINGS

VALVES ARE NOT INCLUDED; Ref. 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; $\frac{fl}{d} = \frac{0.0146 \times 23.9}{0.835}$	0.548	0.418	1.39
2 LR ELBOWS $K = 2 \times 0.18$	0.548	0.36	1.2
1 SR ELBOW $K = 1 \times 0.27$	0.548	0.27	0.9
81.5 ft LONG PIPE, ID = 0.783 ft; $\frac{fl}{d} = \frac{0.0146 \times 81.5}{0.7083} = 1.52$	0.394	1.68	10.82
7 LR ELBOWS; $K = 7 \times 0.18$	0.394	1.26	8.12
2 SR ELBOWS; $K = 2 \times 0.27$	0.394	0.54	3.48
2 TEE RUNS, $K = 2 \times 0.05$	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

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

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

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

COLD LEG AND REACTOR [Ref. 7]

TABLE 3.5.3

13 ACCUMULATOR DISCHARGE LINE FITTINGS

VALVES ARE NOT INCLUDED, REF. STREE ISO 267243 [13]
267246 [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
1 T-BR, MISC. VENTS, COLD LEG, REACTOR	0.437	0.51	2.67
1 EXIT	0.437	1	5.24

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

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

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

COLD LEG AND REACTOR [Ref. 7]

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 $\frac{fl}{d} = \frac{0.0146 * 23.9}{0.835} = 0.42$	0.548	0.42	1.4
1 SR ELBOW $K = 1 * 0.27$	0.548	0.27	0.9
2 LR ELBOWS $K = 2 * 0.18$	0.548	0.36	1.2
68 ft LONG PIPE, ID = 0.7083 ft $\frac{fl}{d} = \frac{0.0146 * 68}{0.7083} = 1.40$	0.394	1.40	9.03
6 LR ELBOWS $K = 6 * 0.18$	0.394	1.08	6.96
2 SR ELBOWS $K = 2 * 0.27$	0.394	0.54	3.5
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, MISC. VENTS, COLD LEG, REACTOR	0.437	0.51	2.67
1 EXIT	0.437	1	5.24

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

$$\sum \frac{L_i}{A_i} = \frac{23.9}{0.548} + \frac{68}{0.394} + \underbrace{\frac{26}{4.12}}$$

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

COLD LEG AND REACTOR REF.[7]

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

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

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

$P_A = 84.7$ psia

$Q = 0 \ ft^3/s$

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 $\left(\frac{lb_f}{ft^2}\right)$

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

z_A = WATER LEVEL ELEVATION IN THE ACCUMULATOR (ft)

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

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 $\left(\frac{lb_f}{ft^2}\right)$

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.

(NC.DE-AP.ZZ-0002(Q), Rev. 12, Form 2)	CALCULATION CONTINUATION SHEET			SHEET: 18	
CALC NO.: S-1-SJ-MDC-1539	REV: 2	REF:		CONT'D ON SHEET:	
ORIGINATOR: Vijay Chandra	DATE: Aug 08, 2005	REVIEWER: James Murphy	DATE: Aug 11, 2005	VERIFIER: James Murphy	DATE: Aug. 11, 2005

Table 3.6.1

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

```
      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=8.77
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)
```

(contd.)

Table 3.6.1 (contd.)

```
      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
```

Table 3.6.2

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

```
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=9.81
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)
```

(contd.)

Table 3.6.2 (contd.)

```
      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
```

(NC.DE-AP.ZZ-0002(Q), Rev. 12, Form 2)	CALCULATION CONTINUATION SHEET			SHEET: 22	
CALC NO.: S-1-SJ-MDC-1539	REV: 2	REF:		CONT'D ON SHEET:	
ORIGINATOR: Vijay Chandra	DATE: Aug 08, 2005	REVIEWER: James Murphy	DATE: Aug 11, 2005	VERIFIER: James Murphy	DATE: Aug. 11, 2005

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.)

(NC.DE-AP.ZZ-0002(Q), Rev. 12, Form 2)	CALCULATION CONTINUATION SHEET			SHEET: 23	
CALC NO.: S-1-SJ-MDC-1539	REV: 2	REF:		CONT'D ON SHEET:	
ORIGINATOR: Vijay Chandra	DATE: Aug 08, 2005	REVIEWER: James Murphy	DATE: Aug 11, 2005	VERIFIER: James Murphy	DATE: Aug. 11, 2005

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
```

ORIGINATOR:	DATE:	REVIEWER:	DATE:	VERIFIER:	DATE:
Vijay Chandra	Aug 08, 2005	James Murphy	Aug 11, 2005	James Murphy	Aug. 11, 2005

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.)

ORIGINATOR:	DATE:	REVIEWER:	DATE:	VERIFIER:	DATE:
Vijay Chandra	Aug 08, 2005	James Murphy	Aug 11, 2005	James Murphy	Aug. 11, 2005

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
```

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 21-accumulator for the free check valve case.

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 26.76 seconds.
For 12-accumulator, the pressure decay time from 70 psig to 35 psig is 27.12 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 for pressure decay time for 11 loop check valves is less than or equal to 25.26 seconds.
Acceptance criterion for pressure decay time for 12 loop check valves is less than or equal to 25.62 seconds.
Acceptance criterion for pressure decay time for 13 loop check valves is less than or equal to 27.13 seconds.
Acceptance criterion for pressure decay time for 14 loop check valves is less than or equal to 27.13 seconds.

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	331.13
0.310	69.96	486.85
0.410	69.93	638.29
0.510	69.89	814.87
0.610	69.83	1040.08
0.710	69.76	1271.14
0.810	69.68	1500.05
0.910	69.59	1722.89
1.010	69.48	1917.43
1.110	69.36	2088.16
1.210	69.23	2239.23
1.310	69.10	2375.40
1.410	68.95	2500.59
1.510	68.80	2616.95
1.610	68.65	2725.73
1.710	68.49	2827.71
1.810	68.32	2923.51
1.910	68.15	3013.92
2.010	67.97	3099.09
3.010	66.04	3717.72
4.010	63.93	4063.75
5.010	61.79	4211.16
6.010	59.72	4246.59
7.010	57.74	4230.09
8.010	55.87	4176.19
9.010	54.11	4105.84
10.010	52.45	4018.54
11.010	50.90	3930.78
12.010	49.44	3846.08
13.010	48.07	3764.53
14.010	46.78	3685.92
15.010	45.56	3610.05
16.010	44.40	3536.72
17.010	43.31	3465.76
18.010	42.27	3397.02
19.010	41.28	3330.35
20.010	40.34	3265.63
21.010	39.45	3202.74
22.010	38.60	3141.56
23.010	37.78	3082.00
24.010	37.01	3023.96
25.010	36.27	2967.37
26.010	35.56	2912.14
27.011	34.87	2858.20
28.011	34.22	2805.48
29.011	33.60	2753.93
30.011	33.00	2703.47
31.011	32.42	2654.07
32.011	31.87	2605.66

WHEN PRESSURE = 35 psig, TIME = 26.76 Sec.

(contd.)

Table 4.1 (contd.)

33.010	31.33	2558.20
34.010	30.82	2511.65
35.010	30.33	2465.96
36.010	29.85	2421.10
37.010	29.39	2377.03
38.010	28.95	2333.71
39.009	28.52	2291.11
40.009	28.11	2249.20
41.009	27.72	2207.96

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	331.13
0.310	69.96	486.85
0.410	69.93	638.29
0.510	69.89	814.87
0.610	69.83	1040.08
0.710	69.76	1271.14
0.810	69.68	1500.05
0.910	69.59	1722.89
1.010	69.48	1917.43
1.110	69.36	2088.44
1.210	69.23	2244.83
1.310	69.10	2391.19
1.410	68.95	2529.92
1.510	68.80	2662.33
1.610	68.64	2789.15
1.710	68.47	2910.80
1.810	68.30	3027.64
1.910	68.12	3140.28
2.010	67.94	3248.70
3.010	65.86	4083.23
4.010	63.53	4587.00
5.010	61.13	4836.43
6.010	58.78	4922.30
7.010	56.54	4926.44
8.010	54.42	4869.63
9.010	52.45	4783.51
10.010	50.61	4668.92
11.010	48.90	4551.15
12.010	47.31	4437.40
13.010	45.83	4328.29
14.010	44.44	4223.55
15.010	43.14	4122.85
16.010	41.91	4025.89
17.010	40.76	3932.38
18.010	39.68	3842.07
19.010	38.65	3754.73
20.010	37.68	3670.15
21.010	36.77	3588.15
22.010	35.90	3507.44
23.010	35.07	3417.51
24.010	34.29	3324.09
25.010	33.55	3231.29
26.010	32.86	3140.28
27.011	32.19	3051.35
28.011	31.57	2964.53
29.011	30.97	2879.73
30.011	30.40	2796.88

(contd.)

ORIGINATOR:	DATE:	REVIEWER:	DATE:	VERIFIER:	DATE:
Vijay Chandra	Aug 08, 2005	James Murphy	Aug 11, 2005	James Murphy	Aug. 11, 2005

Table 4.2 (contd.)

31.011	29.87	2715.87
32.011	29.36	2636.63
33.010	28.87	2559.07
34.010	28.41	2483.13
35.010	27.97	2408.74
36.010	27.55	2335.84
37.010	27.15	2264.40
38.010	26.76	2194.36
39.009	26.40	2125.71
40.009	26.05	2058.40
41.009	25.72	1992.44

ORIGINATOR:	DATE:	REVIEWER:	DATE:	VERIFIER:	DATE:
Vijay Chandra	Aug 08, 2005	James Murphy	Aug 11, 2005	James Murphy	Aug. 11, 2005

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	301.90
0.310	69.97	443.15
0.410	69.94	581.47
0.510	69.90	719.06
0.610	69.85	911.44
0.710	69.79	1123.51
0.810	69.72	1336.27
0.910	69.63	1546.00
1.010	69.53	1750.23
1.110	69.42	1928.19
1.210	69.31	2083.43
1.310	69.18	2220.47
1.410	69.04	2344.12
1.510	68.90	2458.16
1.610	68.76	2564.62
1.710	68.60	2664.64
1.810	68.45	2758.91
1.910	68.28	2847.87
2.010	68.12	2931.91
3.010	66.27	3552.77
4.010	64.23	3923.24
5.010	62.14	4115.87
6.010	60.09	4175.89
7.010	58.12	4179.19
8.010	56.25	4146.63
9.010	54.48	4087.07
10.010	52.81	4017.04
11.010	51.25	3933.06
12.010	49.77	3848.67
13.010	48.39	3767.14
14.010	47.08	3688.53
15.010	45.85	3612.67
16.010	44.68	3539.36
17.010	43.58	3468.44
18.010	42.53	3399.73
19.010	41.54	3333.12
20.010	40.59	3268.45
21.010	39.69	3205.62
22.010	38.83	3144.50
23.010	38.01	3085.02
24.010	37.23	3027.06
25.010	36.48	2970.55
26.010	35.76	2915.40
27.011	35.07	2861.55
28.011	34.42	2808.93
29.011	33.79	2757.47
30.011	33.18	2707.11
31.011	32.60	2657.81

WHEN PRESSURE = 35 psig, TIME = 27.12 Sec.

(contd.)

Table 4.3 (contd.)

32.011	32.04	2609.50
33.010	31.50	2562.15
34.010	30.99	2515.70
35.010	30.49	2470.13
36.010	30.01	2425.37
37.010	29.55	2381.41
38.010	29.10	2338.21
39.009	28.67	2295.73
40.009	28.26	2253.94
41.009	27.86	2212.81

ORIGINATOR:	DATE:	REVIEWER:	DATE:	VERIFIER:	DATE:
Vijay Chandra	Aug 08, 2005	James Murphy	Aug 11, 2005	James Murphy	Aug. 11, 2005

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
29.011	34.74	2873.01
30.011	34.09	2819.60
31.011	33.46	2767.36

WHEN PRESSURE = 35 psig, TIME = 28.63 Sec.

(contd.)

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

(NC.DE-AP.ZZ-0002(Q), Rev. 12, Form 2)	CALCULATION CONTINUATION SHEET			SHEET: 35	
CALC NO.: S-1-SJ-MDC-1539	REV: 2	REF:		CONT'D ON SHEET:	
ORIGINATOR: Vijay Chandra	DATE: Aug 08, 2005	REVIEWER: James Murphy	DATE: Aug 11, 2005	VERIFIER: James Murphy	DATE: Aug. 11, 2005

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
29.011	34.74	2893.13
30.011	34.08	2838.90

WHEN PRESSURE = 35 psig, TIME = 28.63 Sec.

(contd.)

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

11 Accumulator Flow Rate (gpm)

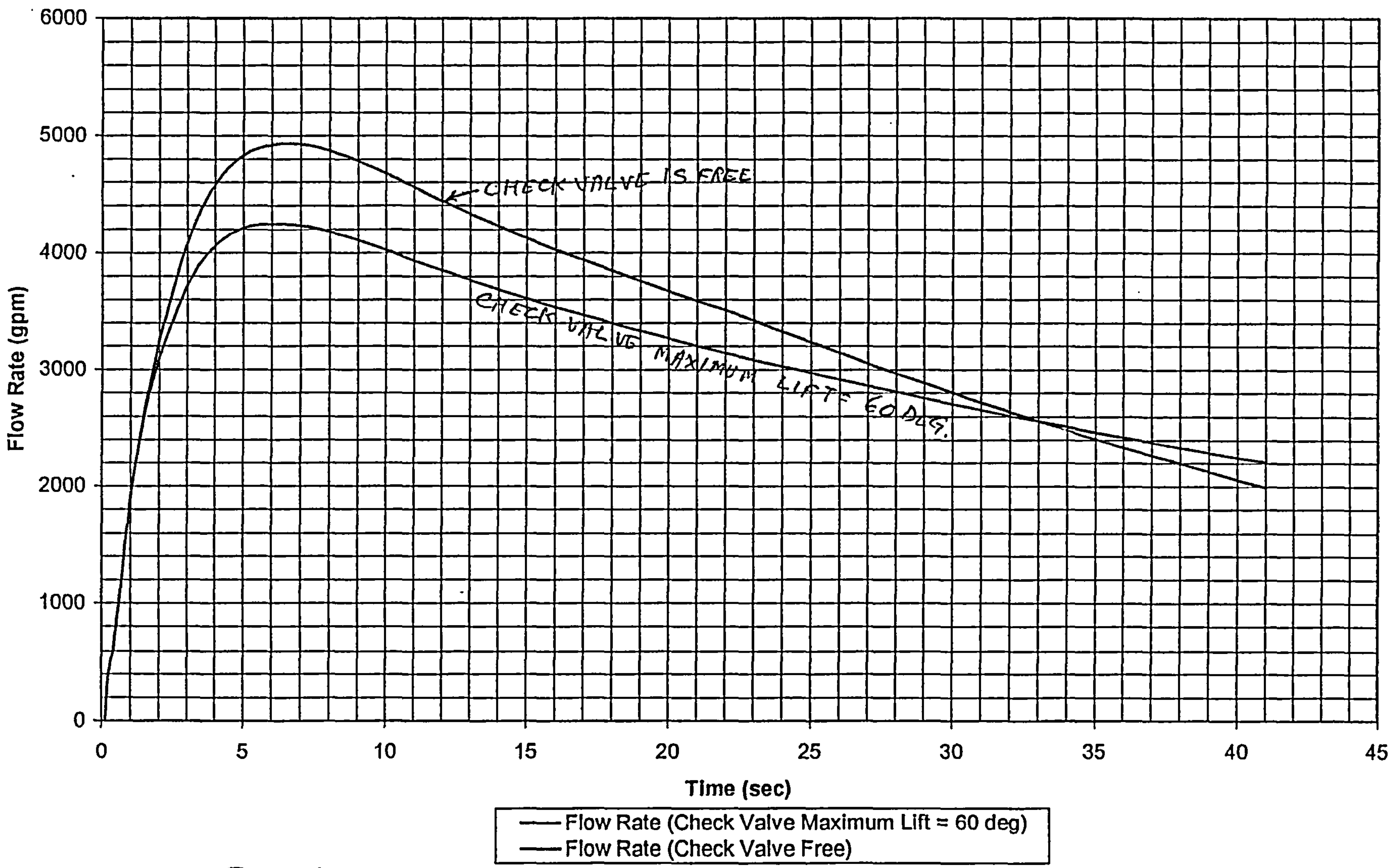


FIG. 4. 2   11- ACCUMULATOR DISCHARGE FLOW RATE.

S-1-SJ-MDC-1539, Rev. 2

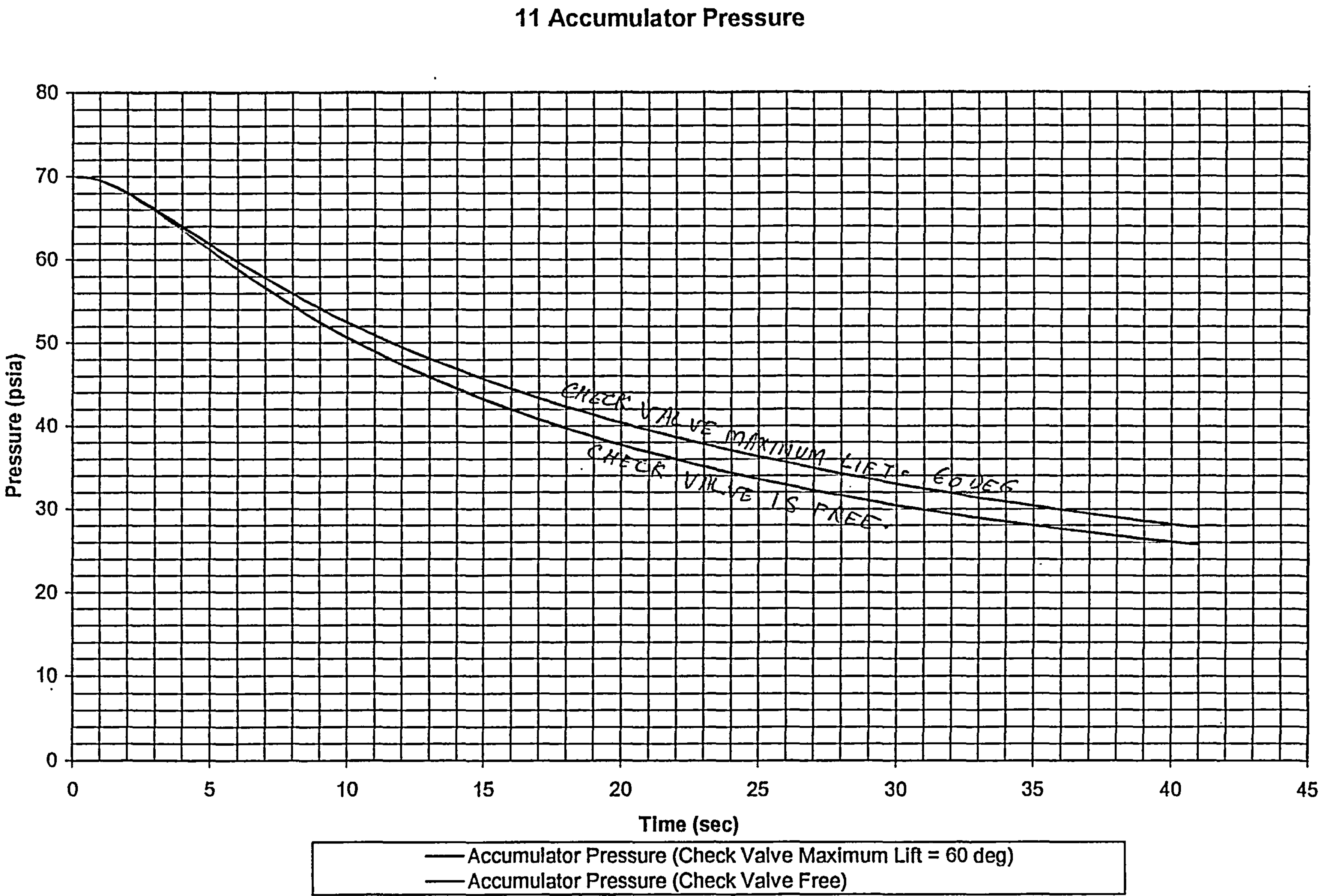


FIG. 4.1, 11-ACCUMULATOR PRESSURE TIME HISTORY

S-1-SJ-MDC-1539, Rev. 2

ORIGINATOR:	DATE:	REVIEWER:	DATE:	VERIFIER:	DATE:
Vijay Chandra	Aug 08, 2005	James Murphy	Aug 11, 2005	James Murphy	Aug. 11, 2005

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 for pressure decay time for 11 loop check valves is less than or equal to 25.26 seconds.
Acceptance criterion for pressure decay time for 12 loop check valves is less than or equal to 25.62 seconds.
Acceptance criterion for pressure decay time for 13 loop check valves is less than or equal to 27.13 seconds.
Acceptance criterion for pressure decay time for 14 loop check valves is less than or equal to 27.13 seconds.

The time is measured from the instant when SJ54 valve disc begins to move.

6. Documents Affected

Procedure S1.OP-ST.SJ-0006 will be revised after this calculated is issued and approved by NRC.

7. Design Margin

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

8. REFERENCES:

1. PSE&G. CALC. S-2-SJ-MDC-1394 Rev. 5. 2
2. DRAWING 207464 A8844-21
3. PSBP 107632 Rev. 003
4. ACCUMULATOR AND PRESSURIZER LEVEL VS. VOLUME CURVES GIVEN IN PROCEDURE S1.OP-~~TM~~ ZZ-0002 Rev. 6. 1
5. UFSAR TABLE 6.3-2, Rev. 6, OVERALL REV. 13
6. PROCEDURE SJ.OP-ST.SJ-0004 (Q), Rev. 1, ATT 2.
7. DRAWING 206929 A 8791-8.
8. RELIEF V24 AND V25 GRANTED BY NRC FOR TESTING OF ACCUMULATOR CHECK VALVES (TAC NO. M98259 AND M98260). INTERNAL PSEG NO. 99-028.
9. STRESS CALC. 267241, Rev. 4
10. STRESS CALC. 267246, Rev. 4
11. STRESS CALC. 267241C, Rev 1. 1
12. STRESS CALC. 267242, Rev. 3
13. STRESS CALC. 267243, Rev. 1
14. STRESS CALC. 267244, Rev. 1.

INSERVICE INSPECTION PROGRAM RELIEF REQUESTS
S1-RR-04-V01 and V02
SALEM GENERATING STATION UNIT 1

FACILITY OPERATING LICENSE NO. DPR-70
DOCKET NO. 50-272

Salem Unit1 Inservice Test Program
VALVE RELIEF REQUEST
S1-RR-04-V01

COMPONENTS: 11SJ55, 12SJ55, 13SJ55 and, 14SJ55

FUNCTION:

These check valves are located in the discharge lines from the respective safety injection accumulators. The valves perform an active safety function in the open and closed positions. The valves must be capable of opening during a large break Loss of Coolant Accident (LOCA) to provide a flow path for Safety Injection (SI) accumulator discharge to the Reactor Coolant System (RCS) cold legs when reactor pressure drops below accumulator pressure. The valve must be capable of closure to prevent divergence of safety injection and recirculation flow subsequent to the accumulators dumping their contents. This valve also functions as an RCS pressure isolation valve. This function prevents exposing the SI accumulators to RCS pressure that would compromise accumulator pressure boundary integrity.

CATEGORY: AC

CLASS: 1

TEST REQUIREMENTS:

Open & Closed Position - Check valves shall be exercised at least once every 3 months in accordance with the requirements of OMa-1988, Part 10-4.3.2.1.

BASIS FOR RELIEF:

During power operation, these valves are maintained in the closed position by RCS pressure on the downstream side of the valve disk. Quarterly exercising these valves to the full or partially open position during power operation is impracticable because the only flow path is into the RCS. The operating accumulator pressure cannot overcome normal operating RCS pressure to establish flow. Full stroke exercising these valves at cold shutdown is impracticable because of' the potential for low temperature over pressurization due to insufficient expansion volume in the RCS to accept required flow. This testing could also result in the intrusion of nitrogen into the core, which could interrupt the normal circulation of cooling water flow. The associated motor-operated isolation valve (one per accumulator) cannot be partially stroked, but must complete a full stroke before changing direction. This could cause a complete discharge of the water volume in the accumulator and possibly inject nitrogen into the reactor coolant system, causing gas binding of the residual heat removal pumps and a subsequent loss of shutdown cooling. These valves are also verified to close by leak testing per plant technical specifications for Pressure Isolation Valves (PIV's). Reverse exercising these check valves at any time other than refueling is burdensome without a commensurate increase in the level of quality and safety. The valves are normally in the closed position. Accumulator pressure is continuously monitored to ensure that an adequate nitrogen blanket is maintained and to verify the lack of RCS inleakage.

ALTERNATE TESTING:

These check valves shall be full stroke exercised to the open position during refueling utilizing a reduced pressure, partial accident flow test method. This controlled method is performed with the reactor vessel head removed. The test method establishes accumulator pressure of 70 psig, accumulator level between 96 and 100% and refueling cavity level between 125.5 and 126.5 feet. After establishment of the fixed parameters, the test then measures the time interval required for the pressure in the associated safety injection accumulator to drop from an initial pressure to 35 psig. Engineering calculation S-1-SJ-MDC-1539 Rev. 2, "Accumulator Pressure Decay Time During Discharge Test" establishes the test conditions and acceptance criterion and concludes that this methodology is adequate in determining the associated check valve disk moves to the full open position. Information from other nuclear stations was reviewed regarding partial flow, full stroke exercising using a calculational method. The testing performed at Salem provides a valid methodology for verifying the open function even though the test method differs from the various methods reviewed. Approval of the methodology described above (and in calculation S-1-SJ-MDC-1539 Rev. 2) will allow for establishing acceptance criteria if changes are made to accumulator motor operator discharge valve stroke times.

In attempting to utilize the guidance of NUREG 1482, Section 4.1.2 - "Exercising Check Valves with Flow and Nonintrusive Techniques", nonintrusive equipment was used during informational testing. These valves are Darling Valve & Manufacturing Co. "Clear Waterway" swing checks that are fabricated without a backstop. The valve design permits the disk to move sufficiently out of the flow path without contacting the valve body. Nonintrusive testing using acoustic and magnetic technology provides sufficient data for monitoring degradation on a periodic basis; however, full open acoustic indication is not detected nor is expected to show on the test trace. Nonintrusive testing does not verify full stroke exercising, however occasional use of this equipment during the pressure decay test provides useful condition monitoring information.

This method of forward flow check valve testing complies with the guidance provided in Generic Letter 89-04, Attachment 1, Position 1.

Regarding reverse flow exercise testing, these valves shall be verified in the closed position during the process of performing seat leakage testing at the frequency specified in Unit I Technical Specification (TS) 4.4.6.3 and Unit 2 TS 4.4.7.2.2.

The open stroke frequency change was previously approved in NRC Safety Evaluation April 15, 1994 (TAC Nos. M88144 and M88145)

The use of the alternate testing methodology was previously approved in NRC Safety Evaluation March 12, 1999 (TAC Nos. M98259 and M98260)

Salem Unit 1 Inservice Test Program
VALVE RELIEF REQUEST
S1-RR-04-V02

COMPONENTS: 11SJ56, 12SJ56, 13SJ56 and, 14SJ56

FUNCTION:

These check valves are located in the discharge lines from the respective safety injection accumulators downstream of the branch connection from Residual Heat Removal System (RHR). The valves perform an active safety function in the open position. The valves must be capable of opening during, a large break Loss of Coolant Accident (LOCA) to provide a flow path for Safety Injection (SI) accumulator discharge to the Reactor Coolant System (RCS) cold legs when reactor pressure drops below accumulator pressure. The valve must also be capable of opening to provide a path for low head safety injection and cold leg recirculation flow. This valve also functions as an RCS pressure isolation valve. This function prevents exposing the SI accumulators and RHR system piping to RCS pressure.

CATEGORY: AC

CLASS: 1

TEST REQUIREMENTS:

Open & Closed Position - Check valves shall be exercised at least once every 3 months, in accordance with the requirements of OMa-1988, Part 10-4.3.2.1.

BASIS FOR RELIEF:

During power operation, these valves are maintained in the closed position by RCS pressure on the downstream side of the valve disk. Quarterly exercising these valves to the full or partially open position during power operation is impracticable because the only flow path is into the RCS. The operating accumulator pressure cannot overcome normal operating RCS pressure to establish flow. Full stroke exercising these valves at cold shutdown is impracticable because of the potential for low temperature over pressurization due to insufficient expansion volume in the RCS to accept required flow. This testing could also result in the intrusion of nitrogen into the core, which could interrupt the normal circulation of cooling water flow. The associated motor-operated isolation valve (one per accumulator) cannot be partially stroked, but must complete a full stroke before changing direction. This could cause a complete discharge of the water volume in the accumulator and possibly inject nitrogen into the reactor coolant system, causing gas binding of the residual heat removal pumps and a subsequent loss of shutdown cooling. These valves are also verified to close by leak testing per plant technical specifications for Pressure Isolation Valves (PIV's). Reverse exercising these check valves at any time other than refueling is burdensome without a commensurate increase in the level of quality and safety.

ALTERNATE TESTING:

These check valves shall be full stroke exercised to the open position during refueling utilizing a reduced pressure, partial accident flow test method. This controlled method is performed with the reactor vessel head removed. The test method establishes accumulator pressure between

67 and 70 psig, accumulator level between 96 and 100% and refueling cavity level between 125.5 and 126.5 feet. After establishment of the fixed parameters the test then measures the time interval required for the pressure in the associated safety injection accumulator to drop from an initial pressure to 35 psig. Engineering calculation S-1-SJ-MDC-1539 Rev. 2, "Accumulator Pressure Decay Time During Discharge Test" establishes the test conditions and acceptance criterion and concludes that this methodology is adequate in determining that the associated check valve disk moves to the full open position. Information from other nuclear stations was reviewed regarding partial flow, full stroke exercising using a calculational method. The testing performed at Salem provides a valid methodology for verifying the open function even though the test method differs from the various methods reviewed. Approval of the methodology described above (and in calculation S-1-SJ-MDC-1539 Rev. 2) will allow for establishing acceptance criteria if changes are made to accumulator motor operator discharge valve stroke times.

In attempting to utilize the guidance of NUREG 1482, Section 4.1.2 - "Exercising Check Valves with Flow and Nonintrusive Techniques", nonintrusive equipment was used during informational testing. These valves are Darling Valve & Manufacturing Co. "Clear Waterway" swing checks that are fabricated without a backstop. The valve design permits the disk to move sufficiently out of the flow path without contacting the valve body. Nonintrusive testing using acoustic and magnetic technology provides sufficient data for monitoring degradation on a periodic basis; however, full open acoustic indication is not detected nor is expected to show on the test trace. Nonintrusive testing does not verify full stroke exercising however occasional use of this equipment during the pressure decay test provides useful condition monitoring information.

The valves shall be partial stroke exercised at cold shutdown during normal RHR shutdown cooling operations.

This method of forward flow check valve testing complies with the guidance provided in Generic Letter 89-04, Attachment 1, Position 1.

Regarding reverse flow exercise testing, these valves shall be verified in the closed position during the process of performing seat leakage testing at the frequency specified in Unit 1 Technical Specification (TS) 4.4.6.3 and Unit 2 TS 4.4.7.2.2

The open stroke frequency change was previously approved in NRC Safety Evaluation April 15, 1994 (TAC Nos. M88144 and M88145).

The use of the alternate testing methodology was previously approved in NRC Safety Evaluation March 12, 1999 (TAC Nos. M98259 and M98260)

INSERVICE INSPECTION PROGRAM RELIEF REQUESTS
S1-RR-04-V01 and V02
SALEM GENERATING STATION UNIT 1

FACILITY OPERATING LICENSE NO. DPR-70
DOCKET NO. 50-272

General Approach Proposed For Full Open Testing Of Accumulator Check Valves

General Approach Proposed For Full Open Testing Of Accumulator Check Valves

PSEG procedure S1.OP-ST.SJ-0006 (Q), Inservice Testing Safety Injection Valves Mode 6, provides instructions necessary to perform Inservice Inspection and Testing IAW Technical Specification 4.0.5 for the following Safety Injection (Accumulator) check valves:

- 11SJ55 and 11SJ56 - 13 Accumulator Discharge to Cold Leg
- 12SJ55 and 12SJ56 - 14 Accumulator Discharge to Cold Leg
- 13SJ55 and 13SJ56 - 13 Accumulator Discharge to Cold Leg
- 14SJ55 and 14SJ56 - 14 Accumulator Discharge to Cold Leg

The testing procedure involves open-stroke testing each tank's discharge check valves with the reactor depressurized and the vessel head removed. The initial tank liquid volume is set to 96 - 100%, and initial tank pressure is set at 70 psig. Flow is initiated by opening the tank motor operated valve (MOV). Per the procedure, the valve is to be stroked fully open, left in the open position until the Accumulator reaches a pressure of 35 psig, and then closed. Tank pressure is set low enough to prevent injection of nitrogen gas into the reactor coolant system (RCS). Velocities achieved should also be sufficient to fully stroke the valves, according to calculation.

The bases for the testing are captured in Calculation No. S-1-SJ-MDC-1539 Rev.2, Accumulator Pressure Decay Time During Discharge Test. The purpose of this calculation is to establish a mathematical model of test conditions to develop acceptance criterion for establishing the valves tested go full open. The description below describes the calculation with reactor head removed as is currently performed during testing.

The following parameters are fixed by procedure:

- The Unit is in Mode 6 (Defueled) with the Upper Internals installed.
- Safety Injection Accumulators are at a fixed and defined pressure.
- Safety Injection Accumulators are at a fixed and defined level.
- Refueling Cavity is at a fixed and defined level.
- Acceptance criteria - Maximum blowdown time in seconds.
- Failure of testing to result in corrective action for both SJ55 and 56.

During valve stroking, Accumulator pressure and level measurements, which are acquired from inputs from normal plant instrumentation, are recorded. Based on the measured level and pressure change with time, the relationship between the check valve disc angle, flow rate and pressure difference are calculated using information supplied by Westinghouse Letter PSE-90- 530 for full lift velocity for the valves being tested. The loss factor for the MOV isolation valve as well as friction losses associated

with the piping system is calculated. Equations of motion are then solved simultaneously.

The calculation solves six unknown variables simultaneously using a FORTRAN computer program. The following are calculated to determine flow and pressure at a point in time under a variety of disc angles:

- o Accumulator level elevation
- o Accumulator gas pressure
- o MOV loss factor
- o Check valve Delta P
- o Derivatives
- o Values at new time step