ITT GRINNELL VALVE COMPANY INC.
DIA-FLO DIVISION
33 CENTERVILLE ROAD
LANCASTER, PA 17603

SEISMIC CALCULATIONS

FOR

MILL POWER SUPPLY COMPANY
(DUKE POWER)
CATAWBA NUCLEAR STATION

ASME SECTION III, CLASS 2 VALVES

DUKE POWER SPECIFICATION NO. CNS-1205.04-1
ADDENDUM 1-3

ITT GRINNELL DIA-FLO ORDER NO. N79-52207

CALCULATIONS PERFORMED BY [signature] 22 Sept 83
M. J. Panciera, Sen. Prod. Eng. Date

CALCULATIONS APPROVED BY [signature] 9/22/83
R. D. Randall, Mgr. Prod. Eng. Date

REPORT NO. W-156

SEPTEMBER 1983
REV. 1

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INTRODUCTION

The purpose of these calculations is to demonstrate that the valves being supplied by ITT Grinnell Dia-Flo Division are designed in accordance with Duke Power Specification No. ~~MCS~~ CNS-1205.04-1 and meet all seismic design requirements of the specification. These calculations apply to the below-listed valves.

Dia-Flo Item No.	Drawing No.	Dia. Valve Description	Duke Power Tag Number
2	SD-C-108417	2"-150 S.S.	5B-263
3	SD-C-108416	4"-150 S.S.	5B-473

One analysis was done for each of the above-listed valves. For the actual seismic calculations, see Appendices A and B.

METHODS OF ANALYSIS

The method of analysis is based on applying a static resultant force resulting from the equivalent earthquake accelerations acting at the center of gravity of the valve assembly. The valves are analyzed assuming worst case mounting.

Principal stresses were calculated for valve component parts (other than the body) which are essential to the pressure integrity or functional adequacy of the valve. These stresses were then compared to the applicable allowable stresses in the 1977 ASME Boiler and Pressure Vessel Code, including the 1978 Winter Addenda. The valve bodies were analyzed by comparing their metal areas and section moduli to the connecting pipe's metal areas and section moduli.

LOADING

For the analysis of these valves, the load combinations considered were those resulting from the Faulted Plant Condition as defined in the design specification since this represents the most severe load case.

The equivalent static forces were calculated by multiplying the applicable valve component part by the appropriate resultant seismic coefficient (i.e., the square root of the sum of the squares of the vertical and both horizontal seismic coefficients).

The vertical seismic coefficient of 3 is determined by taking the 2g coefficient required by design specification and adding 1g to it to account for the valve weight. The horizontal seismic coefficient of 3g's was specified in the design specification.

RESULTS OF THE SEISMIC ANALYSIS

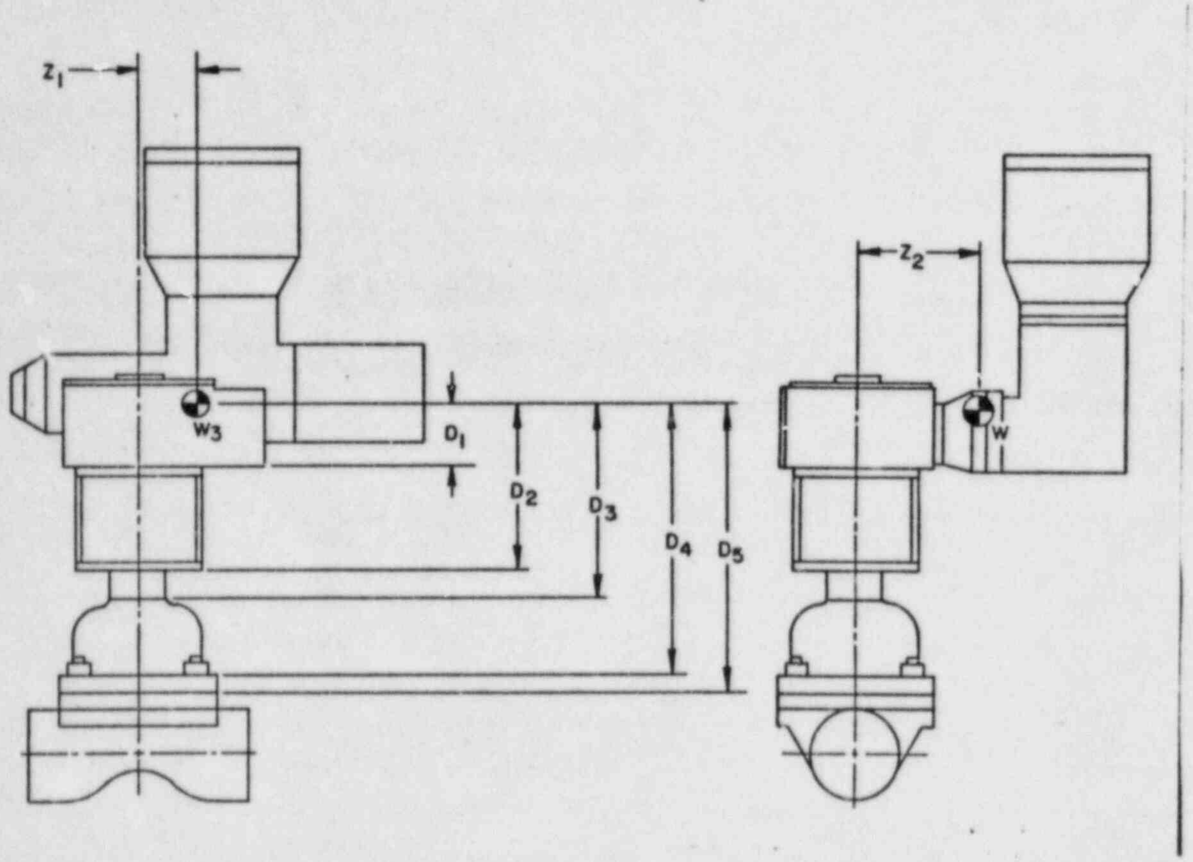
The results of the seismic calculations are as follows:

1. The stresses in the valve components resulting from the applied loads caused by the Faulted Condition were below the allowable stress limits allowed by the 1977 ASME Boiler and Pressure Vessel Code including the 1978 Winter Addenda for normal operating conditions. This demonstrates that the structural and functional integrity of the valve will be maintained for the various plant conditions.

2. The ratios of the valves' section moduli and cross-sectional areas were found to be equal to or in excess of 120% of the attached piping section moduli and cross-sectional areas. This demonstrates that the attached piping, rather than the valve, is the limiting factor in the piping system.

APPENDIX A

2" DIAPHRAGM VALVE
WITH
7NAT1 ROTORK ACTUATOR



DESIGN DATA FOR A 2 IN. POWER OPERATED DIAPHRAGM VALVE

VALVE ASSEMBLY WEIGHT W= 154.9 LB

DISTANCE FROM THE VALVE CENTER OF GRAVITY TO:

ACTUATOR BRACKET JOINT D1= 3.23 IN

BOTTOM OF ACTUATOR JOINT D2= 5.73 IN

BUSHING-BONNET JOINT D3= 6.8 IN

TOP OF BONNET FLANGE D4= 8.83 IN

BODY-BONNET JOINT D5= 9.49 IN

DISTANCE FROM THE VERTICAL CENTERLINE OF THE VALVE TO:

THE VALVE C. G. ALONG THE PIPELINE AXIS Z1= .156 IN

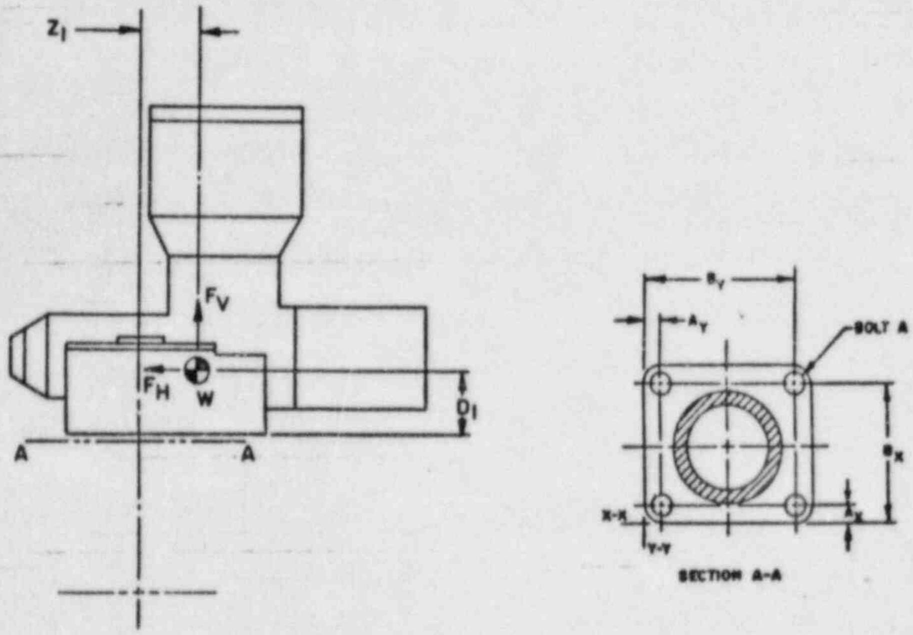
THE VALVE C. G. PERPENDICULAR TO THE PIPELINE Z2= 1.969 IN

DESIGN PRESSURE P= 150 PSI DESIGN TEMPERATURE T= 260 F

SEISMIC ACCELERATION:

G1= 3 G2= 3 HORIZONTAL RESULTANT G3= 4.24

ACTUATOR-BRACKET BOLTING ANALYSIS



BOLTING DIMENSIONS:

AX= 1.06 IN AY= 1.06 IN
BX= 3.88 IN BY= 3.88 IN
BOLT STRESS AREA = .0775 IN^2

SEISMIC FORCES ACTING ON THE BOLTING

FH=G*W= 804.884 LB FV=G1*W= 464.7 LB
WHERE G IS THE RESULTANT ACCELERATION: (2*(G1^2)+(G2^2))^0.5

THE GREATEST AXIAL FORCE ON THE BOLTING IS DETERMINED BY SUMMING MOMENTS ABOUT THE X-X AXIS AND THE Y-Y AXIS. THE LOAD ON THE BOLT FURTHEST FROM THE POINT OR LINE ABOUT WHICH THE BONNET FLANGE WOULD PIVOT IF FREE TO MOVE IS DETERMINED.

THE MOMENT IN THE X-X DIRECTION IS:

M(XX)=(FH*D1)+(FV*Z1)
=(804.88* 3.23)+(464.70* 0.16)= 2672.3 IN-LB

THE MOMENT IN THE Y-Y DIRECTION IS:

M(YY)=(FH*D1)+(FV*Z2)
=(804.88* 3.23)+(464.70* 1.97)= 3514.8 IN-LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT X-X
FX1=(M(XX)*B(X))/[2(A(X)^2+B(X)^2)]
=(2672.3*3.88)/[2((1.06)^2+(3.88)^2)]= 320.4 LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT Y-Y
FY1=(M(YY)*B(Y))/[2(A(Y)^2+B(Y)^2)]
=(3514.8*3.88)/[2((1.06)^2+(3.88)^2)]= 421.5 LB

THE FORCE DUE TO A VERTICAL LOAD ON EACH BOLT IS:
FV1=0.25(FV)=0.25(464.70)= 116.18 LB

THE TOTAL LOAD ON BOLT A IS:
FVT=FX1+FY1+FV1= 320.44+ 421.47+ 116.18= 858.09 LB

THE TOTAL SHEAR FORCE PER BOLT IS:
SB=0.25*(FH+(FH*Z)/Z4)=0.25*(804.88+(804.88*1.98)/2.00)
= 399.97 LB

WHERE Z4 IS THE DISTANCE FROM THE VALVE VERTICAL CENTER LINE TO THE FURTHEST CAPSCREW AND Z=[Z1^2+Z2^2]^0.5.

THE STRESS ON EACH BOLT IS:

TENSILE STRESS-SIGMA M=FVT/AB= 858.09/.0775= 11072.1 PSI

SHEAR STRESS-TAU=SB/AB= 399.97/.0775= 5161.0 PSI

THE PRINCIPLE STRESSES ARE:

THE PRINCIPAL STRESSES AT A-A

SIGMA 1={(SIGMA M + SIGMA B)/2}+{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.5

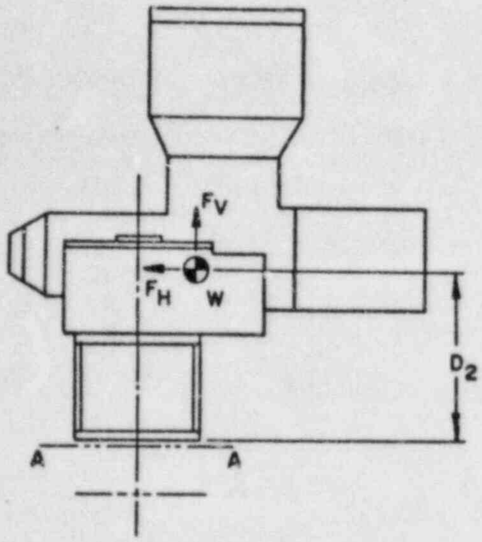
= 13104.65 PSI

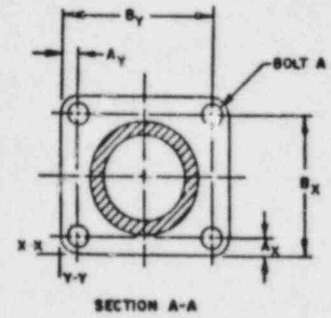
SIGMA 2={(SIGMA M + SIGMA B)/2}-{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.5

= -2032.519 PSI

BOLT MATERIAL: ASTM A193-B8 YEILD STRENGTH: 30000 PSI

ACTUATOR-BONNET ADAPTER BRACKET ANALYSIS





ADAPTER BRACKET POST DIMENSIONS:

AX= 0.30 IN AY= 0.50 IN
BX= 6.75 IN BY= 3.50 IN
BOLT STRESS AREA = .1419 IN^2

SEISMIC FORCES ACTING ON THE BOLTING

FH=G*W= 804.884 LB FV=G1*W= 464.7 LB
WHERE G IS THE RESULTANT ACCELERATION (2*(G1^2)+(G2^2))^0.5

THE GREATEST AXIAL FORCE ON THE BOLTING IS DETERMINED BY SUMMING MOMENTS ABOUT THE X-X AXIS AND THE Y-Y AXIS. THE LOAD ON THE BOLT FURTHEST FROM THE POINT OR LINE ABOUT WHICH THE BONNET FLANGE WOULD PIVOT IF FREE TO MOVE IS DETERMINED.

THE MOMENT IN THE X-X DIRECTION IS:

M(XX)=(FH*D2)+(FV*Z1)
=(804.88* 5.73)+(464.70* 0.16)= 4684.5 IN-LB

THE MOMENT IN THE Y-Y DIRECTION IS:

M(YY)=(FH*D2)+(FV*Z2)
=(804.88* 5.73)+(464.70* 1.97)= 5527.0 IN-LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT X-X
FX1=(M(XX)*B(X))/[2(A(X)^2+B(X)^2)]
=(4684.5*6.75)/[2((0.50)^2+(6.75)^2)]= 345.1 LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT Y-Y
FY1=(M(YY)*B(Y))/[2(A(Y)^2+B(Y)^2)]
=(5527.0*3.50)/[2((0.50)^2+(3.50)^2)]= 773.8 LB

THE FORCE DUE TO A VERTICAL LOAD ON EACH BOLT IS:
FV1=0.25(FV)=0.25(464.70)= 116.18 LB

THE TOTAL LOAD ON BOLT A IS:
FVT=FX1+FY1+FV1= 345.10+ 773.78+ 116.18= 1235.06 LB

THE TOTAL SHEAR FORCE PER BOLT IS:
SB=0.25*(FH+(FH*Z)/Z4)=0.25*(804.88+(804.88*1.98)/3.47)
= 315.88 LB

WHERE Z4 IS THE DISTANCE FROM THE VALVE VERTICAL CENTER LINE TO THE FURTHEST CAPSCREW AND Z=[Z1^2+Z2^2]^0.5.

THE STRESS ON EACH BOLT IS:

TENSILE STRESS-SIGMA M=FVT/AB= 1235.06/.1419= 8703.7 PSI

SHEAR STRESS-TAU=SB/AB= 315.88/.1419= 2226.1 PSI

THE PRINCIPLE STRESSES ARE:

THE PRINCIPAL STRESSES AT A-A

SIGMA 1={(SIGMA M + SIGMA B)/2}+{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.5

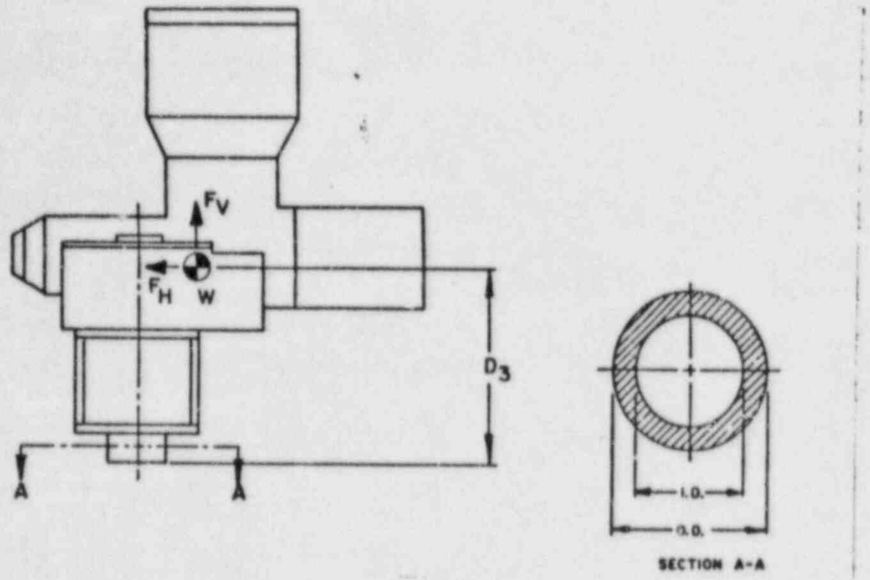
= 9240.01 PSI

SIGMA 2={(SIGMA M + SIGMA B)/2}-{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.5

= -536.2954 PSI

BOLT MATERIAL: ASTM A108 PROOF STRENGTH: 36000 PSI

BONNET-BRACKET ADAPTER BUSHING ANALYSIS



MIMIMUM BUSHING SECTION OD = 1.12 IN ID = .757 IN

SEISMIC FORCES AT SECTION A-A

FH=W*G=154.90* 5.20= 804.9 LB
FV=W*G1=154.90* 3.00= 464.7 LB
M=FH*D3+FV*Z10= 804.9* 6.80+ 464.7* 1.97= 6388.2 IN-LB
WHERE Z10 IS THE GREATER OF Z1 OR Z2

CROSS SECTIONAL PROPERTIES AT SECTION A-A

A=(PI/4)*(O.D.^2-I.D.^2)=(PI/4)*((1.12)^2-(0.76)^2)= 0.54 IN^2

I=(PI/64)*(O.D.^4-I.D.^4)=(PI/64)*((1.12)^4-(0.76)^4)= 0.0611 IN^4

C=O.D./2=1.12/2=0.56 IN

STRESSES DUE TO SEISMIC LOADING AT A-A

TENSILE STRESS=SIGMA M=FV/A= 464.70/ 0.54= 868.38 PSI

BENDING STRESS=SIGMA B=M*C/I= 6388.21*0.56/ 0.06= 58530.37 PSI

SHEAR STRESS=TAU=FH/A= 804.89/ 0.54= 1504.09 PSI

THE PRINCIPAL STRESSES AT A-A

SIGMA 1=((SIGMA M + SIGMA B)/2)+((((SIGMA M + SIGMA B)/2)^2)+(TAU)^2)^0.5

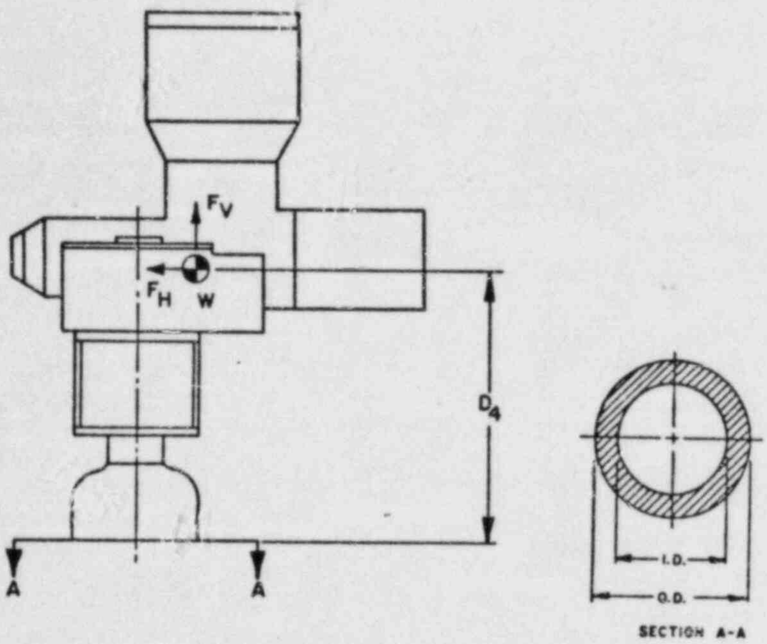
= 59436.81 PSI

SIGMA 2=((SIGMA M + SIGMA B)/2)-((((SIGMA M + SIGMA B)/2)^2)+(TAU)^2)^0.5

= -38.06055 PSI

BUSHING MATERIAL: AISI 4340 ALLOWABLE STRESS 114000 PSI

VALVE BONNET ANALYSIS



MINIMUM BONNET SECTION O.D.= 3.48 IN I.D.= 3 IN

SEISMIC FORCES AT SECTION A-A

FH=W*G=154.90* 5.20= 804.9 LB
FV=W*G1=154.90* 3.00= 464.7 LB
M=FH*D4+FV*Z10= 804.9* 8.83+ 464.7* 1.97= 8022.1 IN-LB
WHERE Z10 IS THE GREATER OF Z1 OR Z2

CROSS SECTIONAL PROPERTIES AT SECTION A-A

A=(PI/4)*(O.D.^2-I.D.^2)=(PI/4)*((3.48)^2-(3.00)^2)= 2.44 IN^2

I=(PI/64)*(O.D.^4-I.D.^4)=(PI/64)*((3.48)^4-(3.00)^4)= 3.2232 IN^4

C=O.D./2=3.48/2=1.74 IN

STRESSES DUE TO SEISMIC LOADING AT A-A

TENSILE STRESS=SIGMA M=FV/A= 464.70/ 2.44= 190.22 PSI

BENDING STRESS=SIGMA B=M*C/I= 8022.12*1.74/ 3.22= [illegible].68 PSI

SHEAR STRESS=TAU=FH/A= 804.88/ 2.44= [illegible]9.48 PSI

BONNET STRESSES DUE TO INTERNAL PRESSURE

BONNET LONGITUDINAL STRESS = SIGMA L=

=PRES.*ID/(4*((OD-ID)/2))
=150.0*3.00/[4*((3.48-3.00)/2)]= 468.7 PSI

BONNET TANGENTIAL STRESS = SIGMA T=

=PRES.*ID/(2*((OD-ID)/2))
=150.0*3.00/[2*((3.48-3.00)/2)]= 937.5 PSI

THE TOTAL BONNET STRESSES ARE:

SIGMA Y = TENSILE STRESS+BENDING STRESS+SIGMA L
= 190.22+ 4330.7+ 468.7= 4989.7 PSI

SIGMA Z = SIGMA T= 937.4999 PSI

TAU X-Y = SHEAR STRESS = 329.4789 PSI

THE PRINCIPAL STRESSES CAN BE DETERMINED BY THE FOLLOWING EQUATION

(SIGMA P)^3-I1*(SIGMA P)^2+I2*(SIGMA P)-I3=0

WHERE: I1=SIGMA Y+SIGMA Z= 5927.156 PSI
I2=(SIGMA Y)*(SIGMA Z)-(TAU XY)^2= 4569246 PSI
I3=-(TAU XY)^2*SIGMA Z=-1.017715E+08 PSI

NOTE: SIGMA X=TAU XZ=TAU YZ=0

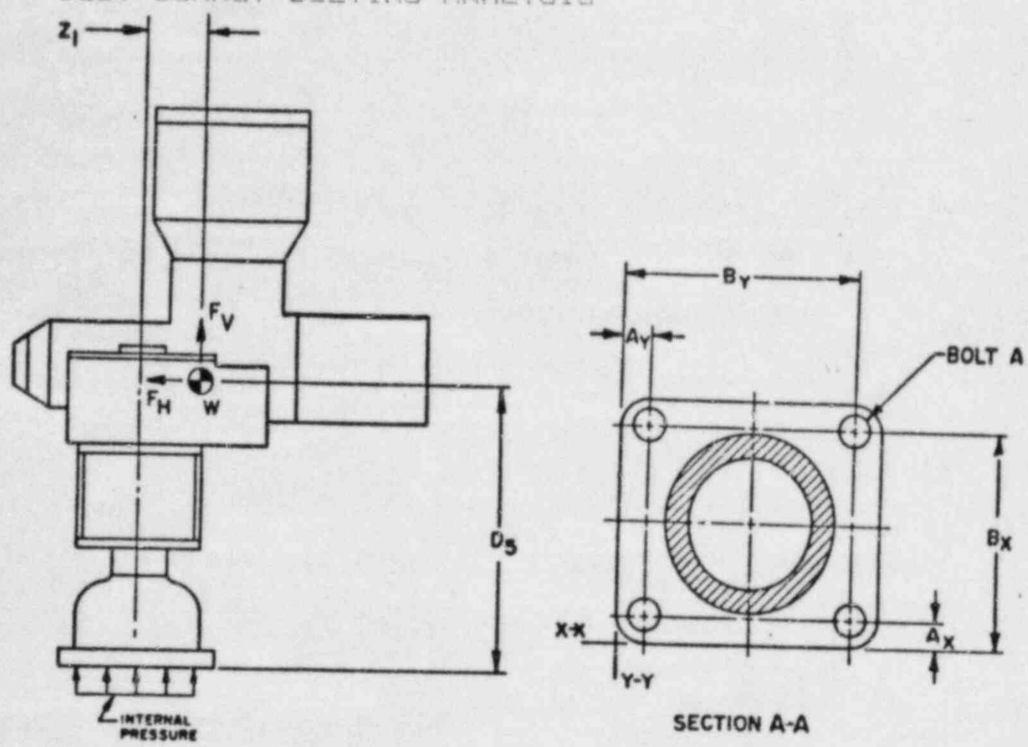
SOLVING THE ABOVE EQUATION FOR THE PRINCIPAL STRESSES:

SIGMA 1 = 5010.261 PSI
SIGMA 2 = 935.5935 PSI
SIGMA 3 = -18.70325 PSI

BONNET MATERIAL: ASME SA-351-CF8
ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III

DIVISION 1 TABLE I-7.2 IS: 14800 PSI AT 260 F

BODY-BONNET BOLTING ANALYSIS



BOLTING DIMENSIONS:

AX= 0.60 IN AY= 0.89 IN
BX= 3.67 IN BY= 4.15 IN
BOLT STRESS AREA = .1167 IN^2

SEISMIC FORCES ACTING ON THE BOLTING

FH=G*W= 804.884 LB FV=G1*W= 464.7 LB
WHERE G IS THE RESULTANT ACCELERATION (2*(G1^2)+(G2^2))

THE GREATEST AXIAL FORCE ON THE BOLTING IS DETERMINED BY SUMMING MOMENTS ABOUT THE X-X AXIS AND THE Y-Y AXIS. THE LOAD ON THE BOLT FURTHEST FROM THE POINT OR LINE ABOUT WHICH THE BONNET FLANGE WOULD PIVOT IF FREE TO MOVE IS DETERMINED.

THE MOMENT IN THE X-X DIRECTION IS:

M(XX)=(FH*D5)+(FV*Z1)
=(804.88* 9.49)+(464.70* 0.16)= 7710.6 IN-LB

THE MOMENT IN THE Y-Y DIRECTION IS:

M(YY)=(FH*D5)+(FV*Z2)
=(804.88* 9.49)+(464.70* 1.97)= 8553.3 IN-LB

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FORCE ON BOLT A DUE TO MOMENTS ABOUT X-X
    FX=(M(XX)*B(X))/[2(A(X)^2+B(X)^2)]
      =( 7710.8*3.67)/[2((0.60)^2+(3.67)^2)]=  1023.2 LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT Y-Y
    FY=(M(YY)*B(Y))/[2(A(Y)^2+B(Y)^2)]
      =( 8553.3*4.15)/[2((0.89)^2+(4.15)^2)]=   985.2 LB

THE FORCE DUE TO A VERTICAL LOAD ON EACH BOLT IS:
     FV1=0.25(FV+(PRES*EFF AREA))
        =0.25(  464.7+(150*PI/4( 3.00)^2)=   381.3 LB

THE TOTAL LOAD ON BOLT A IS:
     FVT=FX1+FY1+FV1= 1023.18+  985.21+  381.25=  2389.63 LB

THE TOTAL SHEAR FORCE PER BOLT IS:
     SB=0.25*(FH+(FH*Z1)/Z4)=0.25*(  804.88+(  804.88*0.16)/2.24)
       =  215.24 LB

   WHERE Z4 IS THE DISTANCE FROM THE VALVE VERTICAL CENTER LINE
   TO THE FURTHEST CAPSCREW.

THE STRESS ON EACH BOLT IS:

     TENSILE STRESS-SIGMA M=FVT/AB= 2389.63/.1187= 20131.7 PSI

     SHEAR STRESS-TAU=SB/AB=  215.24/.1187=  1813.3 PSI

THE PRINCIPLE STRESSES ARE:

THE PRINCIPAL STRESSES AT A-A

SIGMA 1={(SIGMA M + SIGMA B)/2}+{((SIGMA M + SIGMA B)/2)+(TAU)^2}^0.5

     =  20293.74 PSI

SIGMA 2={(SIGMA M + SIGMA B)/2}-{((SIGMA M + SIGMA B)/2)+(TAU)^2}^0.5

     = -162.0264 PSI


BOLT MATERIAL: ASME SA-453-660
ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III
DIVISION 1 TABLE I-7.3 IS:  20500 PSI AT 260 F
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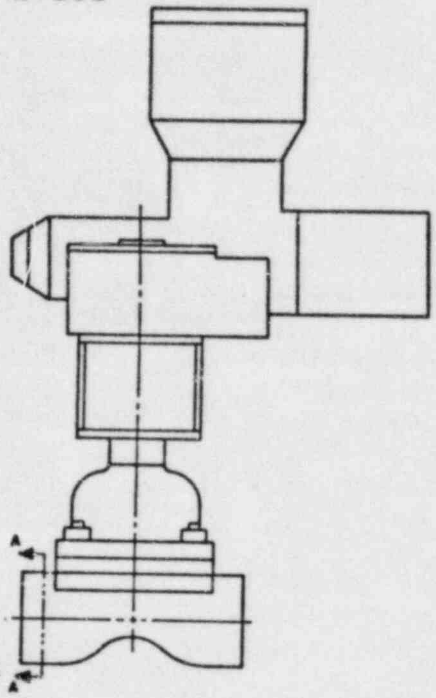
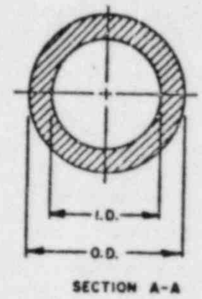
VALVE BODY ANALYSIS





VALVE BODY O.D. AND I.D.

O.D. = 2.5 IN I.D. = 1.94 IN

CROSS SECTIONAL PROPERTIES AT SECTION A-A

A.V.=(PI/4)*[(OD^2)-(ID^2)]
=(PI/4)*[(2.50)^2-(1.94^2)]= 1.953 IN^2
Z.V.=(PI/32)*[(OD^4)-(ID^4)]/OD
=(PI/32)*[(2.50)^4-(1.94^4)]/2.50= 0.978 IN^3

VALVE BODY MATERIAL: ASME SA-351-CF8
ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III DIVISION 1 TABLE I-7.2 IS: **14860** PSI AT 260 F

ATTACHED PIPING: SCHEDULE 40
PIPE SECTION PROPERTIES: AP= 1.075 IN^2 ZP= .561 IN^3

PIPE MATERIAL:312 TP304

ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III DIVISION 1 TABLE I-7.2 IS: **17080** PSI AT 260 F

RATIO OF VALVE BODY METAL AREA TO PIPE METAL AREA IS:

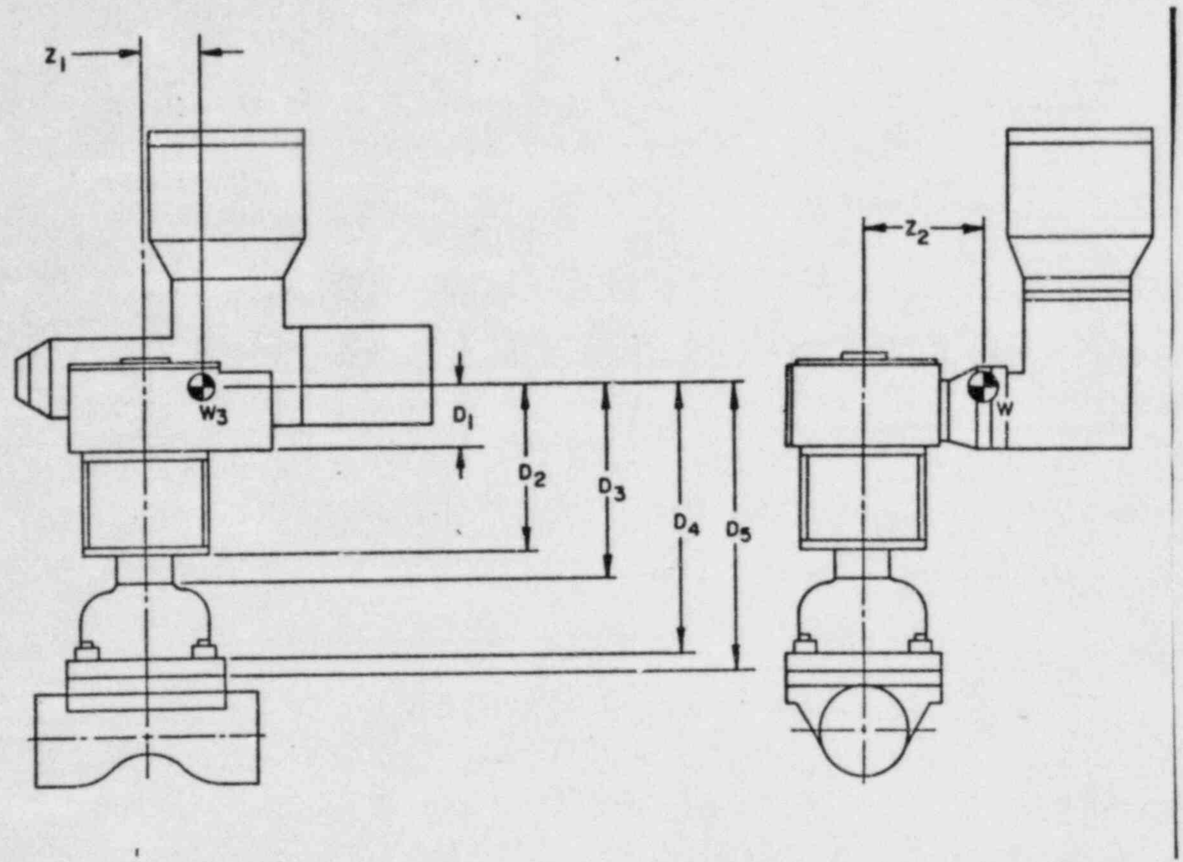
(AV/AP)*(ASV/ASP)=(1.953/ 1.075)*(**14860** / **17080**)=**1.6**

RATIO OF VALVE BODY SECTION MODULUS TO PIPE SECTION MODULUS IS:

(ZV/ZP)*(ASV/ASP)=(0.978/ 0.561)*(**14860**/ **17080**)=**1.5**

APPENDIX B

4" DIAPHRAGM VALVE
WITH
14NAT1 ROTORK ACTUATOR



DESIGN DATA FOR A 4 IN. POWER OPERATED DIAPHRAGM VALVE

VALVE ASSEMBLY WEIGHT W= 312.6 LB

DISTANCE FROM THE VALVE CENTER OF GRAVITY TO:

ACTUATOR BRACKET JOINT D1= 6.12 IN

BOTTOM OF ACTUATOR JOINT D2= 9.37 IN

BUSHING-BONNET JOINT D3= 10.69 IN

TOP OF BONNET FLANGE D4= 14.23 IN

BODY-BONNET JOINT D5= 14.92 IN

DISTANCE FROM THE VERTICAL CENTERLINE OF THE VALVE TO:

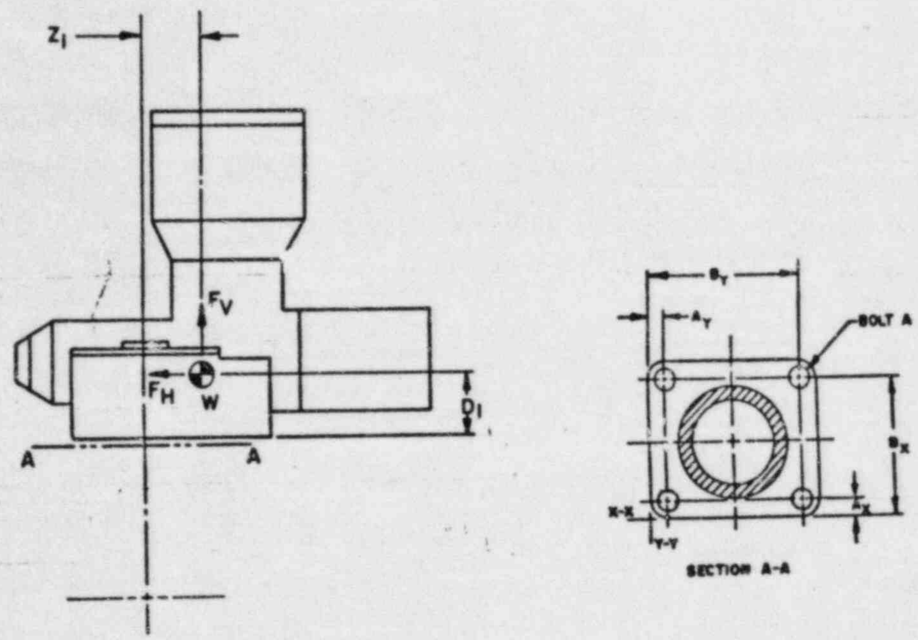
THE VALVE C. G. ALONG THE PIPELINE AXIS Z1= 2.91 IN

THE VALVE C. G. PERPENDICULAR TO THE PIPELINE Z2= 2.75 IN

DESIGN PRESSURE P= 150 PSI DESIGN TEMPERATURE T= 260 F

SEISMIC ACCELERATION:
G1= 3 G2= 3 HORIZONTAL RESULTANT G3= 4.24

ACTUATOR-BRACKET BOLTING ANALYSIS



BOLTING DIMENSIONS:

AX= 1.62 IN AY= 1.62 IN
BX= 5.51 IN BY= 5.51 IN
BOLT STRESS AREA = .226 IN^2

SEISMIC FORCES ACTING ON THE BOLTING

FH=G*W= 1624.317 LB FV=G1*W= 937.8001 LB
WHERE G IS THE RESULTANT ACCELERATION {2*(G1^2)+(G2^2)}^0.5

THE GREATEST AXIAL FORCE ON THE BOLTING IS DETERMINED BY SUMMING MOMENTS ABOUT THE X-X AXIS AND THE Y-Y AXIS. THE LOAD ON THE BOLT FURTHEST FROM THE POINT OR LINE ABOUT WHICH THE BONNET FLANGE WOULD PIVOT IF FREE TO MOVE IS DETERMINED.

THE MOMENT IN THE X-X DIRECTION IS:

M(XX)=(FH*D1)+(FV*Z1)
=(1624.32* 6.12)+(937.80* 2.91)=12669.8 IN-LB

THE MOMENT IN THE Y-Y DIRECTION IS:

M(YY)=(FH*D1)+(FV*Z2)
=(1624.32* 6.12)+(937.80* 2.75)=12519.8 IN-LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT X-X
FX1=(M(XX)*B(X))/[2(A(X)^2+B(X)^2)]
=(12669.8*5.51)/[2((1.62)^2+(5.51)^2)]= 1058.2 LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT Y-Y
FY1=(M(YY)*B(Y))/[2(A(Y)^2+B(Y)^2)]
=(12519.8*5.51)/[2((1.62)^2+(5.51)^2)]= 1045.7 LB

THE FORCE DUE TO A VERTICAL LOAD ON EACH BOLT IS:
FV1=0.25(FV)=0.25(937.80)= 234.45 LB

THE TOTAL LOAD ON BOLT A IS:
FVT=FX1+FY1+FV1= 1058.24+ 1045.70+ 234.45= 2338.39 LB

THE TOTAL SHEAR FORCE PER BOLT IS:
SB=0.25*(FH+(FH*Z)/Z4)=0.25*(1624.32+(1624.32*4.00)/2.75)
= 997.17 LB

WHERE Z4 IS THE DISTANCE FROM THE VALVE VERTICAL CENTER LINE TO THE FURTHEST CAPSCREW AND Z=[Z1^2+Z2^2]^0.5.

THE STRESS ON EACH BOLT IS:

TENSILE STRESS-SIGMA M=FVT/AB= 2338.39/.2260= 10346.8 PSI

SHEAR STRESS-TAU=SB/AB= 997.17/.2260= 4412.2 PSI

THE PRINCIPLE STRESSES ARE:

THE PRINCIPAL STRESSES AT A-A

SIGMA 1={(SIGMA M + SIGMA B)/2}+{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.5

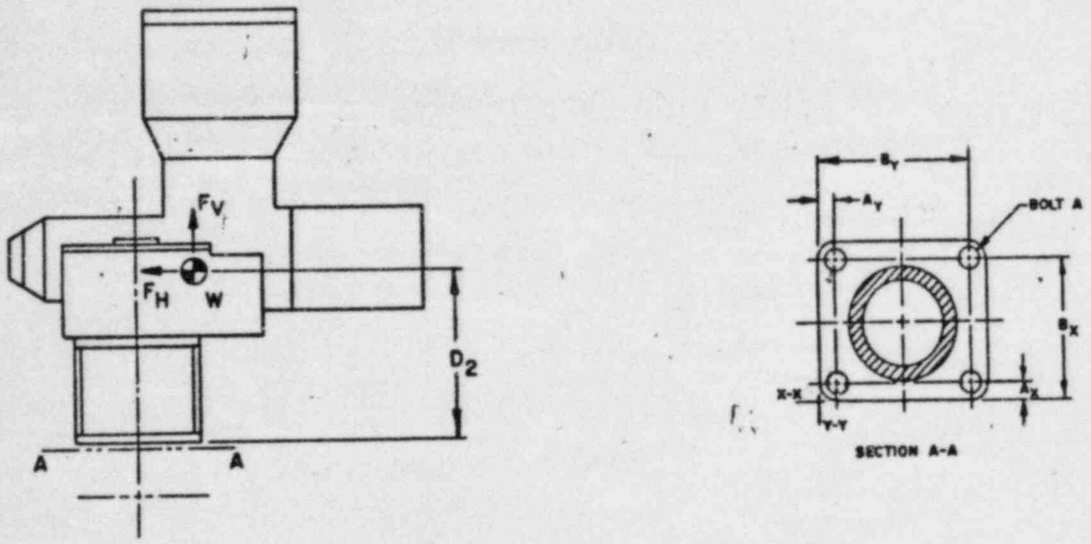
= 11972.85 PSI

SIGMA 2={(SIGMA M + SIGMA B)/2}-{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.5

= -1626.001 PSI

BOLT MATERIAL: ASTM A193-B8 YEILD STRENGTH: 30000 PSI

ACTUATOR-BONNET ADAPTER BRACKET ANALYSIS



ADAPTER BRACKET POST DIMENSIONS:

AX= 0.38 IN AY= 0.38 IN
BX= 5.57 IN BY= 6.63 IN
BOLT STRESS AREA = .226 IN^2

SEISMIC FORCES ACTING ON THE BOLTING

FH=G*W= 1624.317 LB FV=G1*W= 937.8001 LB
WHERE G IS THE RESULTANT ACCELERATION (2*(G1^2)+(G2^2))^0.5

THE GREATEST AXIAL FORCE ON THE BOLTING IS DETERMINED BY SUMMING MOMENTS ABOUT THE X-X AXIS AND THE Y-Y AXIS. THE LOAD ON THE BOLT FURTHEST FROM THE POINT OR LINE ABOUT WHICH THE BONNET FLANGE WOULD PIVOT IF FREE TO MOVE IS DETERMINED.

THE MOMENT IN THE X-X DIRECTION IS:

M(XX)=(FH*D2)+(FV*71)
=(1624.32* 9.37)+(937.80* 2.91)=17948.9 IN-LB

THE MOMENT IN THE Y-Y DIRECTION IS:

M(YY)=(FH*D2)+(FV*Z2)
=(1624.32* 9.37)+(937.80* 2.75)=17798.8 IN-LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT X-X
FX1=(M(XX)*B(X))/[2(A(X)^2+B(X)^2)]
=(17948.9*5.57)/[2((0.38)^2+(5.57)^2)]= 1605.4 LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT Y-Y
FY1=(M(YY)*B(Y))/[2(A(Y)^2+B(Y)^2)]
=(17798.8*6.63)/[2((0.38)^2+(6.63)^2)]= 1339.0 LB

THE FORCE DUE TO A VERTICAL LOAD ON EACH BOLT IS:
FV1=0.25(FV)=0.25(937.80)= 234.45 LB

THE TOTAL LOAD ON BOLT A IS:
FVT=FX1+FY1+FV1= 1605.37+ 1339.02+ 234.45= 3178.83 LB

THE TOTAL SHEAR FORCE PER BOLT IS:
SB=0.25*(FH+(FH*Z)/Z4)=0.25*(1624.32+(1624.32*4.00)/4.06)
= 806.35 LB

WHERE Z4 IS THE DISTANCE FROM THE VALVE VERTICAL CENTER LINE TO THE FURTHEST CAPSCREW AND Z=[Z1^2+Z2^2]^0.5.

THE STRESS ON EACH BOLT IS:

TENSILE STRESS-SIGMA M=FVT/AB= 3178.83/.2260= 14065.6 PSI

SHEAR STRESS-TAU=SB/AB= 806.35/.2260= 3567.9 PSI

THE PRINCIPLE STRESSES ARE:

THE PRINCIPAL STRESSES AT A-A

SIGMA 1={(SIGMA M + SIGMA B)/2}+{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.

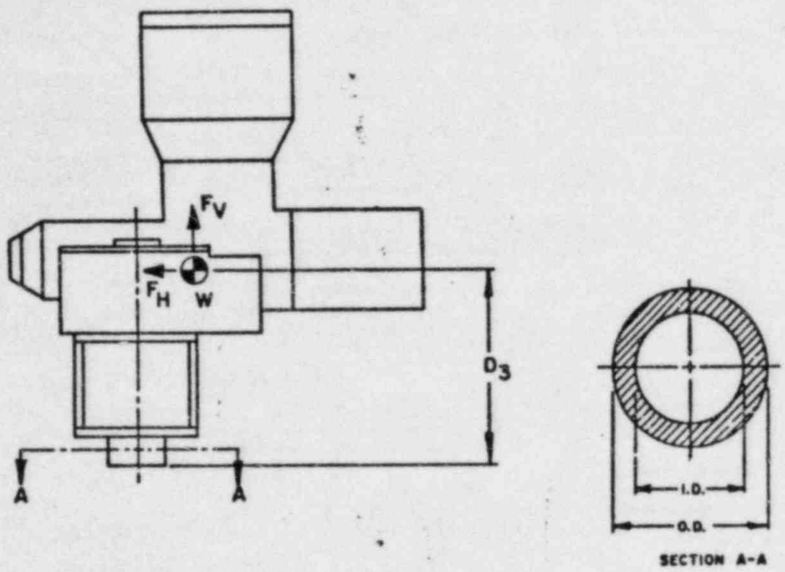
= 14918.9 PSI

SIGMA 2={(SIGMA M + SIGMA B)/2}-{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.

= -853.2734 PSI

BOLT MATERIAL: ASTM A108 PROOF STRENGTH: 36000 PSI

BONNET-BRACKET ADAPTER BUSHING ANALYSIS



MIMIMUM BUSHING SECTION OD = 1.5 IN ID = 1.007 IN

SEISMIC FORCES AT SECTION A-A

FH=W*G=312.60* 5.20= 1624.3 LB
FV=W*G1=312.60* 3.00= 937.8 LB
M=FH*D3+FV*Z10= 1624.3*10.69+ 937.8* 2.91=20092.9 IN-LB
WHERE Z10 IS THE GREATER OF Z1 OR Z2

CROSS SECTIONAL PROPERTIES AT SECTION A-A

A=(PI/4)*(O.D.^2-I.D.^2)=(PI/4)*((1.50)^2-(1.01)^2)= 0.97 IN^2

I=(PI/64)*(O.D.^4-I.D.^4)=(PI/64)*((1.50)^4-(1.01)^4)= 0.1980 IN^4

C=O.D./2=1.50/2=0.75 IN

STRESSES DUE TO SEISMIC LOADING AT A-A

TENSILE STRESS=SIGMA M=FV/A= 937.80/ 0.97= 966.09 PSI

BENDING STRESS=SIGMA B=M*C/I=20092.95*0.75/ 0.20= 76098.75 PSI

SHEAR STRESS=TAU=FH/A=1624.32/ 0.97= 1673.32 PSI

THE PRINCIPAL STRESSES AT A-A

SIGMA 1={(SIGMA M + SIGMA B)/2}+{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.5

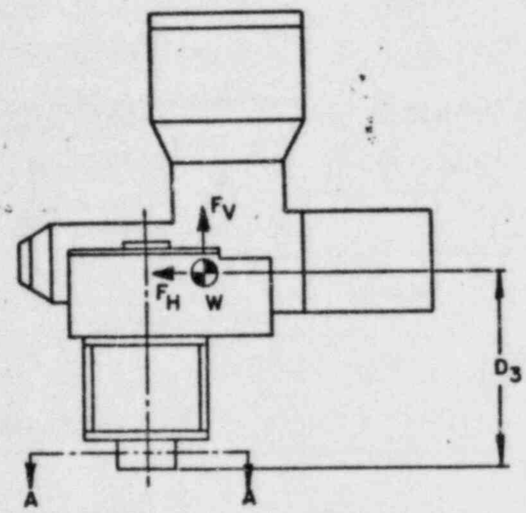
= 77101.16 PSI

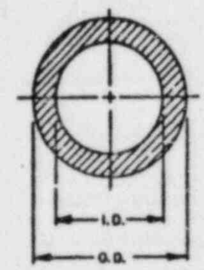
SIGMA 2={(SIGMA M + SIGMA B)/2}-{(((SIGMA M + SIGMA B)/2)^2)+(TAU)^2}^0.

= -36.31641 PSI

BUSHING MATERIAL: AISI 4340 ALLOWABLE STRESS 114000 PSI

VALVE BONNET ANALYSIS





MINIMUM BONNET SECTION O.D.= 5.88 IN I.D.= 5.38 IN

SEISMIC FORCES AT SECTION A-A

FH=W*G=312.60* 5.20= 1624.3 LB
FV=W*G1=312.60* 3.00= 937.8 LB
M=FH*D4+FV*Z10= 1624.3*14.23+ 937.8* 2.91=25843.0 IN-LB
WHERE Z10 IS THE GREATER OF Z1 OR Z2

CROSS SECTIONAL PROPERTIES AT SECTION A-A

A=(PI/4)*(O.D.^2-I.D.^2)=(PI/4)*((5.88)^2-(5.38)^2)= 4.42 IN^2

I=(PI/64)*(O.D.^4-I.D.^4)=(PI/64)*((5.88)^4-(5.38)^4)=17.5541 IN^4

C=O.D./2=5.88/2=2.94 IN

STRESSES DUE TO SEISMIC LOADING AT A-A

TENSILE STRESS=SIGMA M=FV/A= 937.80/ 4.42= 212.09 PSI

BENDING STRESS=SIGMA B=M*C/I=25843.03*2.94/17.55= 4328.24 PSI

SHEAR STRESS=TAU=FH/A=1624.32/ 4.42= 367.34 PSI

BONNET STRESSES DUE TO INTERNAL PRESSURE

BONNET LONGITUDINAL STRESS = SIGMA L=

=PRES.*ID/(4*((OD-ID)/2))
=150.0*5.38/[4*((5.88 - 5.38)/2)]= 807.0 PSI

BONNET TANGENTIAL STRESS = SIGMA T=

=PRES.*ID/(2*((OD-ID)/2))
=150.0*5.38/[2*((5.88 - 5.38)/2)]=1614.0 PSI

THE TOTAL BONNET STRESSES ARE:

SIGMA Y = TENSILE STRESS+BENDING STRESS+SIGMA L
= 212.09+ 4328.2+ 807.0= 5347.3 PSI

SIGMA Z = SIGMA T= 1614.002 PSI

TAU X-Y = SHEAR STRESS = 367.3445 PSI

THE PRINCIPAL STRESSES CAN BE DETERMINED BY THE FOLLOWING EQUATION

(SIGMA P)^3-I1*(SIGMA P)^2+I2*(SIGMA P)-I3=0

WHERE: I1=SIGMA Y+SIGMA Z= 6961.328 PSI
I2=(SIGMA Y)*(SIGMA Z)-(TAU XY)^2= 8493650 PSI
I3=-(TAU XY)^2*SIGMA Z=-2.177965E+08 PSI

NOTE: SIGMA X=TAU XZ=TAU YZ=0

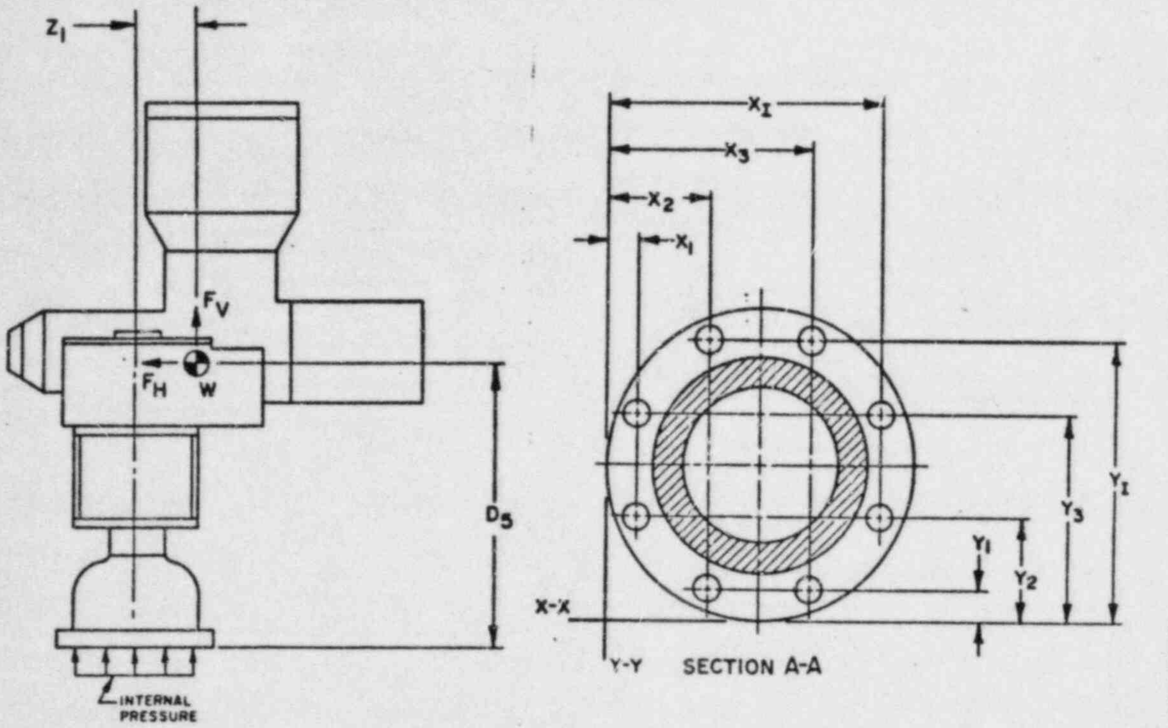
SOLVING THE ABOVE EQUATION FOR THE PRINCIPAL STRESSES:

SIGMA 1 = 5371.292 PSI
SIGMA 2 = 1613.12 PSI
SIGMA 3 = -23.08789 PSI

BONNET MATERIAL: ASME SA-351-CF8
ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III

DIVISION 1 TABLE I-7.2 IS: 14800 PSI AT 260 F

BODY-BONNET BOLTING ANALYSIS



BOLTING DIMENSIONS

	X-X AXIS		Y-Y AXIS	
I	X(I)	NX(I)	Y(I)	NY(I)
1	1.23	2	0.91	2
2	3.19	2	2.74	2
3	5.81	2	6.33	2
4	7.87	2	8.19	2

NUMBER OF BODY BONNET BOLTS = NB = 8
BOLT STRESS AREA = AB = .1519

SEISMIC FORCES ACTING ON THE BOLTING

FH=G*W= 1624.317 LB FV=G1*W= 937.8001 LB
WHERE G IS THE RESULTANT ACCELERATION (2*(G1^2)+(G2^2))

THE GREATEST AXIAL FORCE ON THE BOLTING IS DETERMINED BY SUMMING MOMENTS ABOUT THE X-X AXIS AND THE Y-Y AXIS. THE LOAD ON THE BOLT FURTHEST FROM THE POINT OR LINE ABOUT WHICH THE BONNET FLANGE WOULD PIVOT IF FREE TO MOVE IS DETERMINED.

THE MOMENT IN THE Y-X DIRECTION IS:

M(XX)=(FH*D5)+(FV*Z1)
=(1624.32*14.92)+(937.80* 2.91)=26963.8 IN-LB

THE MOMENT IN THE Y-Y DIRECTION IS:

M(YY)=(FH*D5)+(FV*Z2)
=(1624.32*14.92)+(937.80* 2.75)=26813.8 IN-LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT X-X
FX=(M(XX)*X(IMAX))/[NX(1)*X(1)^2+NX(2)*X(2)^2+...+NX(I)*X(I)^2]
= 988.1 LB

FORCE ON BOLT A DUE TO MOMENTS ABOUT Y-Y
FY=(M(YY)*Y(IMAX))/[NY(1)*Y(1)^2+NY(2)*Y(2)^2+...+NY(I)*Y(I)^2]
= 950.8 LB

THE FORCE DUE TO A VERTICAL LOAD ON EACH BOLT IS:
FV1=(FV+(PRES*EFF AREA))/NB
=(937.80+(150*(PI/4)(5.38)^2))/ 8= 543.47 LB

THE TOTAL LOAD ON BOLT A IS:
FVT=FX1+FY1+FV1= 988.09+ 950.83+ 543.47= 2482.38 LB

THE TOTAL SHEAR FORCE PER BOLT IS:
SB=(FH+(FH*Z*2/BCR))/NB=(1624.3+(1624.3*2.91*2/3.81))/8= 513.0 LB
WHERE BCR = BOLT CIRCLE RADIUS = 3.8125 IN

THE STRESS ON EACH BOLT IS:

TENSILE STRESS-SIGMA M=FVT/AB= 2482.38/.1519= 16342.2 PSI

SHEAR STRESS-TAU=SB/AB= 512.99/.1519= 3377.2 PSI

THE PRINCIPLE STRESSES ARE:

THE PRINCIPAL STRESSES AT A-A

SIGMA 1={(SIGMA M + SIGMA B)/2}+{((SIGMA M + SIGMA B)/2)+(TAU)^2}^0.5

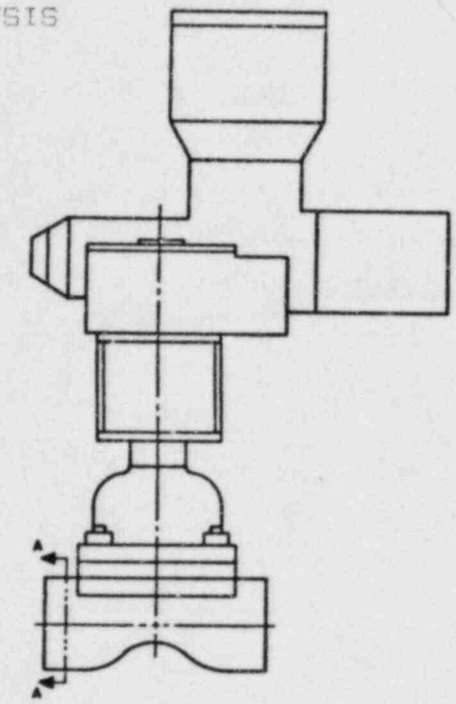
= 17012.6 PSI

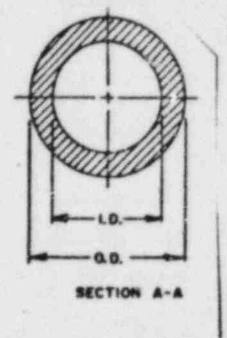
SIGMA 2={(SIGMA M + SIGMA B)/2}-{((SIGMA M + SIGMA B)/2)+(TAU)^2}^0.5

= -670.3999 PSI

BOLT MATERIAL: ASME SA-453-660
ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III
DIVISION 1 TABLE I-7.3 IS: 20300 PSI AT 260 F

VALVE BODY ANALYSIS





VALVE BODY O.D. AND I.D.

O.D. = 4.5 IN I.D. = 3.81 IN

CROSS SECTIONAL PROPERTIES AT SECTION A-A

A.V.=(PI/4)*[(OD^2)-(ID^2)]
=(PI/4)*[(4.50)^2-(3.81^2)]= 4.503 IN^2
Z.V.=(PI/32)*[(OD^4)-(ID^4)]/OD
=(PI/32)*[(4.50)^4-(3.81^4)]/4.50= 4.349 IN^3

VALVE BODY MATERIAL: ASME SA-351-CF8
ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III
DIVISION 1 TABLE I-7.2 IS: **14860** PSI AT 260 F

ATTACHED PIPING: SCHEDULE 40
PIPE SECTION PROPERTIES: AP= 3.17 IN^2 ZP= 3.21 IN^3

PIPE MATERIAL:312 TP304

ALLOWABLE STRESS PER THE ASME BOILER AND PRESSURE VESSEL CODE SECTION III
DIVISION 1 TABLE I-7.2 IS: **17080** PSI AT 260 F

RATIO OF VALVE BODY METAL AREA TO PIPE METAL AREA IS:

(AV/AP)*(ASV/ASP)=(4.503/ 3.170)*(**14860**/ **17080**)= **1.2**

RATIO OF VALVE BODY SECTION MODULUS TO PIPE SECTION MODULUS IS:

(ZV/ZP)*(ASV/ASP)=(4.349/ 3.210)*(**14860**/ **17080**)= **1.2**

ITT GRINNELL 4"-150# VALVE - ITEM 5B-473, ROTORK 14NA1 MOUNTED PERPENDICULAR*TO PIPE RUN AXIS - REVISION 1

0-FREE, 1-FIXED GLOBAL DEGREE OF FREEDOM

Pillar Steel: SA 193, Grade B7

NODE NUMBER	BOUNDARY CONDITION CODES X	Y	Z	XX	YY	ZZ	NODAL POINT COORDINATES X	Y	Z
1	0	0	0	0	0	0	0.000	0.000	0.000
2	1	1	1	1	1	1	-5.750	0.000	0.000
3	1	1	1	1	1	1	5.750	0.000	0.000
4	0	0	0	0	0	0	0.000	2.310	0.000
5	0	0	0	0	0	0	0.000	5.750	0.000
[illegible]	0	0	0	0	0	0	0.000	7.100	0.000
[illegible]	0	0	0	0	0	0	0.000	7.200	0.000
8	0	0	0	0	0	0	-3.120	7.200	2.595
9	0	0	0	0	0	0	3.120	7.200	2.595
10	0	0	0	0	0	0	3.120	7.200	-2.595
11	0	0	0	0	0	0	-3.120	7.200	-2.595
12	0	0	0	0	0	0	-3.120	7.950	2.595
13	0	0	0	0	0	0	3.120	7.950	2.595
14	0	0	0	0	0	0	3.120	7.950	-2.595
15	0	0	0	0	0	0	-3.120	7.950	-2.595
16	0	0	0	0	0	0	-3.120	10.450	2.595
17	0	0	0	0	0	0	3.120	10.450	2.595
18	0	0	0	0	0	0	3.120	10.450	-2.595
19	0	0	0	0	0	0	-3.120	10.450	-2.595
20	0	0	0	0	0	0	-3.120	11.200	2.595
21	0	0	0	0	0	0	3.120	11.200	2.595
22	0	0	0	0	0	0	3.120	11.200	-2.595
23	0	0	0	0	0	0	-3.120	11.200	-2.595
24	0	0	0	0	0	0	0.000	11.200	0.000
25	0	0	0	0	0	0	0.000	17.234	0.000
26	0	0	0	0	0	0	-2.750	17.234	-2.906
27	1	1	1	1	1	1	200.000	200.000	0.000

DESIGN VERIFICATION
CLIENT [illegible]
JOB NO. [illegible]
CALC/PROB NO. 136-[illegible]
BY: [illegible] DATE: 10/10/83
CHKD: [illegible] DATE: [illegible]

[illegible] 10/11/83
PROJ. ENG.

*Rotated 90° from that shown in assembly dwg. CNM 1205.04-0190

IMPELL CORPORATION

ITT GRINNELL 4"-150# VALVE - ITEM 5B-473, ROTORK 14NAI MOUNTED PERPENDICULAR TO PIPE RUN AXIS - REVISION 1

Pillar Steel: SA 193, Grade B7

MATERIAL NO.	YOUNG S MODULUS (PSI)	POISSON S RATIO	MASS DENSITY ($\#-S^2/IN^4$)
1	2.930E+07	3.00000E-01	7.34000E-40
2	2.930E+07	3.00000E-01	1.00000E-90

ALL PROPERTIES IN INCH UNITS (AXIAL-AXIS ORIENTED FROM I TO J-NODE OF MEMBER, 1-AXIS LOCATED IN PLANE OF K-NODE ORTHOGONALLY POSITIONED TO AXIAL-AXIS, LOCAL 2-AXIS DEFINED BY RIGHT HAND RULE).

PROPERTY	AXIAL AREA	SHEAR AREA-1	SHEAR AREA-2	TORSION-1	INERTIA-1	INERTIA-2
1	5.353E+00	2.581E+00	2.581E+00	2.404E+01	1.202E+01	1.202E+01
2	4.422E+00	2.211E+00	2.211E+00	3.511E+01	1.755E+01	1.755E+01
3	2.335E+00	1.417E+00	1.417E+00	3.150E+00	1.575E+00	1.575E+00
4	2.037E+00	1.358E+00	1.358E+00	3.820E-01	1.252E+00	9.500E-02
5	1.227E+00	9.200E-01	9.200E-01	2.410E-01	1.200E-01	1.200E-01
6	9.553E-01	4.830E-01	4.830E-01	3.950E-01	1.970E-01	1.970E-01
7	3.540E-01	2.500E-01	2.500E-01	5.300E-03	3.400E-03	3.400E-03
8	1.000E+02	1.000E+02	1.000E+02	1.000E+03	1.000E+03	1.000E+03

DESIGN VERIFICATION
CLIENT Duke-Catawba
JOB NO. 0073-010
CALC/PROB NO. 136-1A
BY: [illegible] DATE: 10/10/8[illegible]
CHKD: [illegible] DATE: 10/11/8[illegible]

IMPELL CORPORATION

ITT GRINNELL 4"-150# VALVE - ITEM 5B-473, ROTORK [illegible]NAI MOUNTED PERPENDICULAR TO PIPE RUN AXIS - REVI[illegible] N 1

Pillar Steel: SA 193, Grade B7

BEAM NO	NODES I	J	K	MATL NO	PROP NO
1	1	2	27	1	1
2	1	3	27	1	1
3	1	4	27	1	2
4	4	5	27	1	2
5	5	6	27	1	3
6	6	7	27	1	6
7	7	8	1	1	4
8	7	9	1	1	4
9	7	10	1	1	4
10	7	11	1	1	4
11	8	12	1	1	7
12	9	13	1	1	7
13	10	14	1	1	7
14	11	15	1	1	7
15	12	16	1	1	5
16	13	17	1	1	5
17	14	18	1	1	5
18	15	19	1	1	5
19	16	20	1	1	7
20	17	21	1	1	7
21	18	22	1	1	7
22	19	23	1	1	7
23	24	20	27	2	8
24	24	21	27	2	8
25	24	22	27	2	8
26	24	23	27	2	8
27	24	25	27	2	8
28	25	26	27	2	8

DESIGN VERIFICATION
CLIENT Duke Catawba
JOB NO. 0043 210
CALC/PROB NO 7C-TA
BY SAC DATE 10-1083
CHK'D [illegible] DATE 10-11-83

ALL UNITS REPRESENTED AS LB, INCHES, SECONDS IN GLOBAL SYSTEM

NODE NO	RX	RY	RZ	MX	MY	MZ
	------------------- APPLIED LOADS OR MASSES	-------------------				
25	5.933E-01	5.993E-01	5.933E-01	5.233E+01	5.319E+01	1.156E+01

IMPELL

ITT GRINNELL 4"-150# VALVE - ITEM 5B-473, ROTORK 14NA1 MOUNTED PERPENDICULAR TO PIPE RUN AXIS - REVISION 1

Pillar Steel: SA 193, Grade B7

ANALYSIS SUMMARY:

MODAL FREQ. (CPS)	MODAL TYPE	Max. Allow. Seismic Load (G) CALCULATED FOR INCLINED OPERATOR STEM (1) RESULTANT OBE	RESULTANT SSE	Allow. Restraint Load (lbs) RESULTANT OBE	RESULTANT SSE
20.12	B	9.95	11.98	2436.76	2933.90
23.95	T	QUALIFIED BY STATIC DEFLECTION TEST			
32.57	B	-	5.2	-	1225.0

NOTE (1) Resultant applied perpendicular to operator stem axis.

DESIGN VERIFICATION
CLIENT DUKE/AT
JOB NO. 0613-210
CALC/PROB NO. 126-14
BY: SK DATE: 10/10
CHKD: MJD DATE: 10/10

IMPELL CORPORATION

Attachment 3

Frequency Report
for
Valves VQ2A and VQ16A