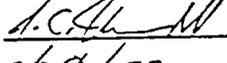


Point Beach Nuclear Plant
CALCULATION COVER SHEET

<u>Calculation/Addendum Number:</u> 2001-0056		<u>Title of Calculation/Addendum:</u> TDAFP Mini Recirc Valve (1/2AF-4002) Instrument Air Accumulator Sizing			
<u>System (CHAMPS Identifier Codes):</u> IA - Instrument Air, AF - Auxiliary Feedwater					
<input type="checkbox"/> Original Calculation/Addendum <input checked="" type="checkbox"/> Revised Calculation/Addendum Revision # <u>01</u>		<input type="checkbox"/> Supersedes Calculation/Addendum _____ _____			
QA Scope <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Discipline <input type="checkbox"/> CIV <input type="checkbox"/> NUC <input type="checkbox"/> ELEC <input type="checkbox"/> COMP <input type="checkbox"/> I&C <input type="checkbox"/> CHEM/RAD <input checked="" type="checkbox"/> MECH <input type="checkbox"/> SYST		Associated Documents: <u>MR 02-001, SCR 2002-0010</u> _____ _____ Superseded By Calculation/Addendum # _____ _____			
This Calculation has been reviewed in accordance with NP 7.2.4. The review was accomplished by one or a combination of the following (check all that apply):					Reviewers' Initials
<input type="checkbox"/> A review of a representative sample of repetitive calculations.					
<input checked="" type="checkbox"/> A review of the calculation against a similar calculation previously performed.					SAM
<input checked="" type="checkbox"/> A detailed review of the original calculation. <u>Rev. 0</u>					SAM
<input type="checkbox"/> A review by an alternate, simplified, or approximate method of calculation.					
Preparer	Reviewer	Discipline	Name	Signature	Date
<input checked="" type="checkbox"/>	<input type="checkbox"/>	MECH	Rob Chapman		3-20-02
<input type="checkbox"/>	<input checked="" type="checkbox"/>	MECH	Scott Manthei		3-20-02
<input type="checkbox"/>	<input type="checkbox"/>				
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<input type="checkbox"/>	<input type="checkbox"/>				
Approver: Printed Name: <u>T.C. KENDALL</u> Signature: <u></u> Date: <u>3/20/02</u>					A/160

Comments And Resolution

Reviewer Comments:	Resolution:
<p>Calculation 2001-0056, Rev. 0 was reviewed in detail.</p> <p>Only the revisions effected by the new tubing length of 1000 inches were reviewed for Rev. 1.</p> <p>SAM 3-20-2002</p>	<p>RCC 3-20-02</p>

1.0 PURPOSE

The purpose of this calculation is to determine the required volume of new instrument air accumulator tanks (1/2T-212) that will be installed by MR 02-001 on the supply to the 1/2AF-4002 Turbine Driven Auxiliary Feedwater Pump (TDAFP) minimum recirculation control valves. These accumulators are required because the AF-4002 valves have a design function in the open position to prevent the TDAFPs (1/2P-29) from being operated at dead head, and the normal instrument air supply cannot be credited to open these valves during an accident.

The valves are required to open if the TDAFP discharge flow is throttled back to control steam generator levels following a Loss of All AC power (LOAC), Loss of Normal Feedwater (LONF), Station Blackout (SBO), Steam Generator Tube Rupture (SGTR), Main Steam Line Break (MSLB), Appendix R fire scenario, Anticipated Transient without Scram (ATWS), or loss of instrument air. The AF-4002 valves will get an open signal when the TDAFP flow drops to 110 gpm. In several of the above scenarios, instrument air will not be available, and the valves will not open. LER 266/2001-005-00 identified that this is a potential common mode failure for the auxiliary feedwater pumps, and that this results in an increased calculated core damage frequency (CDF). Therefore, a backup air source will be installed to reduce CDF.

MR 02-001 will install accumulator tanks in the instrument air supply line to the AF-4002 valves. Dual check valves upstream of the accumulator will isolate the tanks from the rest of the instrument air system when pressure is lost, and the trapped volume of air in the accumulator will provide the necessary air to stroke the valve the required number of times. The minimum required volume of these new tanks will be determined, as will the acceptance criteria for leakage testing of the check valves, tubing, and recirculation valve actuator.

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA

The required volume of the accumulators will be calculated using simple ideal gas equations at constant temperature. The minimum pressure needed to stroke the valves is known, and the tank will be sized such that this minimum pressure is still available after the required time and number of strokes specified. The AF-4002 valves are controlled either full open or full closed. The AF-4002-S solenoid valves open to pressurize the operator and stroke the valve open, then close and vent the entire volume of air from the operator to stroke the valve closed (Ref 4.1). The accumulator tank must contain sufficient air to fill this volume of tubing and the actuator each time the valve is to be stroked. The necessary air volume required to stroke the valve each time and the estimated volume of air leakage will be calculated and used to determine the necessary air volume in standard cubic feet, which will correspond to a certain tank volume.

The leakage rate assumed for tank sizing will be converted into a pressure drop for a specified time duration. This will provide a basis for acceptance criteria for leakage testing that will be performed following modification installation.

This calculation will also verify that for most of the travel the minimum flow recirculation valves will pass sufficient flow to ensure that the 1/2P-29 TDAFPs will have enough flow to prevent pump damage. This provides some additional margin in the system to allow for the recirculation valves not fully opening. This will occur if the accumulator pressure drops below the regulator setpoint.

There are no acceptance criteria for this calculation.

3.0 ASSUMPTIONS

Validated

3.1. The temperature will be considered to be constant at standard conditions (70 °F).

Basis: The local room temperatures will increase when the pumps are running, depending on the accident scenario and whether power is available to the AFP room coolers. However, any increase in room temperature will affect both the air in the accumulator and the air in the valve operator, and the effects will essentially cancel out. Furthermore, an increase in room temperature will tend to increase the accumulator pressure, which will increase the number of times the valve can be stroked before the pressure drops to a level that will not stroke the valve. It is not expected that the temperature will ever be significantly lower than 70 °F. Therefore, this assumption is conservative.

3.2. Total air leakage is assumed to be 0.05 SCFM.

Basis: This accounts for leakage past the check valves, through all fittings, and through the air operator. This is much less than the 0.5 SCFM that was assumed by the original calculation for sizing nitrogen supply for the MDAFP discharge AOVs (Ref 4.2). This is acceptable since all tubing required to maintain the pressure in this portion of the system will be installed with high-quality, safety-related stainless steel tubing and fittings, and redundant check valves will be installed upstream of the accumulators per MR 02-001 (Ref 4.4). Furthermore, leakage through the fittings and past the check valves will be checked following installation to verify that it is below 0.05 SCFM (Ref 4.4). Also, there is no demand on the system when the AF-4002 valve is closed, and no bleed-through present since the valve has no positioners installed. This assumed leakage is an appropriate value representing a very large amount of leakage that can be easily checked.

3.3. The valve will be required to fully stroke 10 times per hour.

Basis: This is consistent with assumptions made in calculation M-09334-266-IA.1 (Ref 4.2) for operation of the MDAFP discharge control valves. The original decision to utilize this value originated in an email dated 6/2/1997 from the PBNP auxiliary feedwater system engineer that is an attachment to that calculation (Ref 4.9). Based on discussions with operations personnel and simulator runs, this is a conservative assumption. The control room operator positions the MDAFP discharge valves automatically by setting the desired steam generator level. Depending on the steam generator level setting, the MDAFP valves will stroke open and closed more frequently. The AF-4002 recirc valves for the TDAFP, while also controlled automatically, only change position when the TDAFP flow changes, which is performed by manually throttling AF-4000 and AF-4001. Operations would typically not control the steam generator levels using the TDAFPs. The only cases when this would be done would be the SBO event where the MDAFPs are not available, and the seismic induced LONF where two auxiliary feedwater pumps have failed and one unit is depending on a TDAFP. Even in these scenarios, the steam generator levels change very slowly, and repeated reduction of the auxiliary feedwater flow will not be necessary. Runs in the simulator have shown that the AF-4002 valves were stroked less than 5 times in one hour. Therefore, this assumption is very conservative, and will result in a tank that is significantly oversized.

3.4. The air supply must be capable of stroking the valve for 2 hours following the initiation of the accident.

Basis: A two hour limit was used for sizing the safety-related nitrogen to operate the MDAFP discharge valves (AF-4012 and AF-4019). This time was chosen to be greater than the one-hour coping duration for the SBO scenario, even though the MDAFPs are not available in that event. There is also a 45 minute requirement for the Appendix R scenario, but these backup systems are currently not credited to perform that function. No other explicit licensing basis requirement could be found for the required duration of automatic valve action before manual operator action can be utilized. To be conservative, the air accumulator tanks will be sized to provide enough air to stroke the valves for 2 hours. This allows sufficient time for the initial transient to pass and for an auxiliary operator to be dispatched to the pump room to manually stroke the valves as needed. This

limit will bound all possible accident scenarios in which instrument air is lost and operator action is required to stroke the 1/2AF-4002 valves.

3.5. The initial tank pressure will be 90 psig.

Basis: The instrument air compressors cycle from 95 to 105 psig (Ref 4.3), but the pressure switches that control the compressors tend to drift slightly (per discussion with the system engineer). Therefore, the instrument header pressure could occasionally be slightly lower than 95 psig. The instrument air demand in the AFP room is very small, with 6 air-operated valves, two Zurn strainers, and a connection to CR/CSR HVAC systems (Ref 4.1, Ref 4.5). The auxiliary feedwater pump room loads are very close to the air compressor room, which will tend to keep the pressure drop to a minimum. Several pressure indicators in the room that indicate the instrument air pressure were studied, and a pressure range was seen to cycle from 93 to 100 psig. A slightly lower pressure is being taken for conservatism and to account for pressure gauge uncertainty.

3.6. The air in the system will be treated as an ideal gas, and the process will be considered to be polytropic and isothermal.

Basis: It is a reasonable assumption to consider air at nearly room temperature and nominal pressures of less than 100 psig will behave as an ideal gas. The expansion of air from the tank will be considered to be a polytropic process with a value of $n=1$, which represents an isothermal process (Ref 4.6). This assumption greatly simplifies the calculation, and will not introduce significant error. All other conservative assumptions made will provide adequate margin in the tank design.

3.7. The resistance coefficient of the recirculation piping may be neglected when determining the flow through the minimum recirculation line.

Basis: The component that controls the flow rate through the TDAFP recirculation line is the restricting orifice RO-4003, which has a maximum C_v of 4.1 (Ref 4.12). This orifice is adjustable (after it is replaced by MR 99-029*D during U2R25 and MR 99-029*C during U1R27), and will actually be set to a smaller C_v value. The existing orifices have a C_v of approximately 2. The pressure drop through all the other piping components are minimal when compared to the drop across the orifice. A review of Calculation N-91-031 (Ref 4.15) indicates that the total pressure drop through the line is 990 psi, and the pressure drop across the orifice is 948 psi. Furthermore, assuming that the piping components have no resistance would increase the effect of the AF-4002 valve on flow. Therefore, this assumption is conservative.

3.8. The length of tubing pressurized during leak testing will be less than 1000".

Basis: The tubing that will be pressurized during the leak test will include everything downstream of the check valves, and up to the pressure gauge next to the accumulator tank. The tank itself will be isolated. The estimated length of tubing will be approximately 80 ft (960") for the Unit 2 tank, and 30 ft (360") for the Unit 1 tank (based on a walkdown for the planned tubing runs per Ref 4.4). The assumption of using 1000" is therefore conservative.

3.9. The pressure in the system during leak testing will be less than 100 psig.

Basis: When the system is leak tested following the installation of MR 02-001, the tank will be pressurized from instrument air, and the instrument air supply will be isolated (Ref 4.4). Then the valve will be stroked open. It is unlikely that the pressure will start greater than 100 psig, and if it did, it would drop when the valve is stroked. Therefore, using 100 psig is a conservative assumption that will lead to a higher than required acceptance criteria for leakage.

Unvalidated

None

4.0 REFERENCES

- 4.1. Bechtel P&ID 6118 M-217 Sh. 1 Rev 69, Auxiliary Feedwater System
- 4.2. Sargent & Lundy Calculation M-09334-266-IA.1, Rev. 0
- 4.3. STPT 14.7 Rev 14, Secondary Systems Instrument, Service, and Breathing Air
- 4.4. MR 02-001 – TDAFP Mini Recirc Valve (1/2AF-4002) Instrument Air Accumulator Addition
- 4.5. Bechtel P&ID 6118 M-209 Sh. 4 Rev 34, Instrument Air
- 4.6. Fundamentals of Engineering Thermodynamics, 2nd Ed., M. Moran and H. Shapiro, 1992
- 4.7. Copes-Vulcan Drawing E-336528 Rev 0, Model D-100-160 Oper. – 2" 1513# ASME Std. Valve Assembly
- 4.8. Letter from Robert Fetterman, Copes-Vulcan to Rob Chapman, PBNP, dated 1/11/2002 (*Attachment 1*)
- 4.9. Email from Jack Hammers to Dave Godshalk dated 6/2/97 (*Attachment 2*)
- 4.10. C_v versus Travel Curve, Modified Parabolic, M-185460 (*Attachment 3*)
- 4.11. Flowscan data for 1AF-4002 and 2AF-4002, August 2001 (*Attachment 4*)
- 4.12. Flowserve Drawing 94-16249 Rev A (drawing to be added to drawing system by MR 99-029*C/*D in 2002)
- 4.13. MR 99-029*C/*D – Aux Feedwater Pump 1/2P-29 Minimum Flow Recirc Line Orifice
- 4.14. Crane Technical Paper 410, Flow of Fluids through Valves, Fittings, and Pipe
- 4.15. Calculation N-91-031, 1/2P-29 Mini-Recirc Line System Characteristics
- 4.16. Letter from P. Prom, Flowserve Corp. to J. P. Schroeder, PBNP, dated 3/2/2001, Aux Feed Water Pumps Minimum Flow Analysis (*Attachment 5*)
- 4.17. Tables of Industrial Gas Container Contents and Density for Oxygen, Argon, Helium, and Hydrogen, National Bureau of Standards, Technical Note 1079, June 1985 (*Attachment 6*)

5.0 INPUTS

- 5.1. The required air pressure to stroke 1/2AF-4002 full open is 65 psig, as set by MR 02-001 (Ref 4.4, 4.11). This will also be used as the final pressure in the accumulator tank after the required number of valve strokes to determine the necessary tank volume.
- 5.2. The swept volume of a Copes-Vulcan D-100-160 valve actuator, including dead volume, is 291 in³ (Ref 4.8)
- 5.3. The total length of the 3/8" diameter instrument air tubing between the solenoid valve and the AF-4002 actuator that is vented is 100" (per walkdown)
- 5.4. The 1/2AF-4002 valves have a C_v of 33 at a position of 1" (Ref 4.7)

- 5.5. Standard conditions are defined as 70 °F and 14.7 psia (Ref 4.17)
- 5.6. The maximum RO-4003 C_v is 4.1 (Ref 4.12)
- 5.7. The normal minimum recirculation flow for 1/2P-29 is 120 gpm (Ref 4.13)
- 5.8. The minimum allowable flow for 1/2P-29 is 75 gpm (Ref 4.13, 4.16)
- 5.9. The length of 3/8" tubing that will be pressurized during leak testing will be less than 1000" (Assumption 3.8)
- 5.10. The pressure in the tank and tubing during testing will be less than 100 psig (Assumption 3.9)
- 5.11. The recirculation valves will be required to stroke 10 times per hour for 2 hours (Assumption 3.3, 3.4)
- 5.12. Air leakage past the check valves and through tubing fittings is 0.05 SCFM (Assumption 3.2)
- 5.13. Initial tank pressure is 90 psig (Assumption 3.5).
- 5.14. The desired pressure test duration is 5 minutes (Ref 4.4)

6.0 CALCULATION

6.1 Tank Sizing Calculation

- Calculation of Volume of Valve Actuator and Tubing

Tubing:

$$\begin{array}{ll} d_t = 0.375 \text{ in} & \text{Tubing nominal diameter (Input 5.3)} \\ L_t = 100 \text{ in} & \text{Maximum length of vented tubing (Input 5.3)} \end{array}$$

$$V_t = \frac{\pi}{4} d_t^2 L_t = \frac{\pi}{4} (.375)^2 (100) \quad (6.1.1)$$

$$V_t = 11 \text{ in}^3$$

Total Volume to Operate the valve:

$$V_v = 291 \text{ in}^3 \quad \text{Swept volume of diaphragm including dead band (Input 5.2)}$$

$$V_{OP} = V_t + V_v = 11 + 291 = 302 \quad (6.1.2)$$

$$V_{OP} = 302 \text{ in}^3 * (0.000578 \text{ ft}^3/\text{in}^3) = 0.17 \text{ ft}^3$$

- Calculation of Standard Cubic Feet of Air (SCFA) Requirement to Stroke Valve

$$\begin{array}{ll} V_{leak} = 0.05 \text{ SCFM} & \text{Volume of air leakage per minute (Input 5.12)} \\ N_{st} = 20 & \text{Total number of valve strokes (Input 5.11)} \\ t = 120 \text{ min} & \text{Time duration for valve operation (Input 5.11)} \\ P_{st} = 65 \text{ psig} = 79.7 \text{ psia} & \text{Pressure required to fully stroke open the valve (Input 5.1)} \end{array}$$

Since the pressure in the valve actuator will always be 65 psig due to the setting of the pressure regulator (Ref 4.4), the required air volume for each stroke will be the same. This volume will be determined at standard conditions. The relation of standard conditions to the actual conditions is:

$$P_{st} V_{OP} = P_{atm} V_{SCFA} \quad (6.1.3)$$

where P_{st} is in units of psia. Rearranging this equation and adding additional terms for leakage, valve strokes, and time duration gives the total required volume of:

$$V_{SCFA} = V_{OP} \frac{(P_{st})}{P_{atm}} N_{st} + V_{leak} t \quad (6.1.4)$$

$$V_{SCFA} = 0.17[\text{ft}^3] \frac{(79.7[\text{psia}])}{14.7[\text{psia}]} (20) + (0.05[\text{ft}^3/\text{min}])(120[\text{min}])$$

$$V_{SCFA} = 18.4 + 6.0 = 24.4 \text{ SCFA}$$

• Calculation of Required Tank Volume

$$P_{Ti} = 90 \text{ psig} = 104.7 \text{ psia}$$

$$P_{Tf} = 65 \text{ psig} = 79.7 \text{ psia}$$

Initial tank pressure (Input 5.13)
 Final tank pressure (Input 5.1)

Variable Definitions:

V_{STi}	–	Initial tank air volume in SCFA
V_{STf}		Final tank air volume in SCFA
V_{TANK}		Actual volume of the accumulator tank

Ideal gas relations (Eq. 3.32, Ref 4.6):

$$P_{Ti} V_{TANK} = P_{atm} V_{STi} = RT = \text{constant} \quad (\text{Initial state}) \quad (6.1.5)$$

$$P_{Tf} V_{TANK} = P_{atm} V_{STf} = RT = \text{constant} \quad (\text{Final state}) \quad (6.1.6)$$

Solving for V_{TANK} in both equations:

$$V_{TANK} = \frac{P_{atm}}{P_{Ti}} V_{STi} = \frac{14.7[\text{psia}]}{(104.7[\text{psia}])} V_{STi} = 0.140 V_{STi} \quad (6.1.7)$$

$$V_{TANK} = \frac{P_{atm}}{P_{Tf}} V_{STf} = \frac{14.7[\text{psia}]}{(79.7[\text{psia}])} V_{STf} = 0.184 V_{STf} \quad (6.1.8)$$

Using the difference in SCFA volumes in the tank as equal to the required demand:

$$V_{STi} - V_{STf} = V_{SCFA} = 24.4 \text{ SCFA} \quad (6.1.9)$$

Inserting Eq 6.1.9 into Eq 6.1.7 and 6.1.8 and solving yields:

$$V_{TANK} = 0.140(24.4 + V_{STf}) = 0.184 V_{STf}$$

$$V_{STf} = \frac{0.140(24.4)}{(0.184 - 0.140)} = 77.6 \text{ SCFA}$$

$$V_{STi} = 24.4 + 77.6 = 102.0 \text{ SCFA}$$

$$V_{TANK} = 0.184(77.6) = 14.3 \text{ ft}^3 * (7.48 \text{ gal/ft}^3) = \underline{107 \text{ gal}}$$

6.2 Calculation of Modification PMT Acceptance Criteria

$V_v = 291 \text{ in}^3$	Swept volume of diaphragm including dead band (Input 5.2)
$d_t = 0.375 \text{ in}$	Nominal tubing diameter (Input 5.9)
$L_t = 1000 \text{ in}$	Maximum length of tubing pressurized (Input 5.9)
$P_t = 100 \text{ psig} = 114.7 \text{ psia}$	Test pressure (Input 5.10)

- Calculation of filled volume of tubing and valve:

$$V_t = \frac{\pi}{4} d_t^2 L_t = \frac{\pi}{4} (.375[\text{in}])^2 (1000[\text{in}]) = 110.4[\text{in}^3] \quad (6.2.1)$$

$$V_{TEST} = V_t + V_v = 110.4 + 291 = 401.4 \text{ in}^3$$

$$V_{TEST} = 401.4 \text{ in}^3 * (0.000578 \text{ ft}^3/\text{in}^3) = 0.232 \text{ ft}^3$$

- Standard cubic feet of air present at test pressure:

First, the equation that relates the leakage rate to volume is:

$$V_{leak} = \frac{(V_{SCF-t} - V_{SCF-f})}{t} \quad (6.2.2)$$

Using Equations 6.1.5 and 6.1.6, the pressures and volume have the following relationship:

$$P_t V_{TEST} = P_{atm} V_{SCF-t} \quad (6.2.3)$$

$$P_f V_{TEST} = P_{atm} V_{SCF-f} \quad (6.2.4)$$

Solving equations 6.2.3 and 6.2.4 for volumes and inserting into equation 6.2.2 yields:

$$V_{leak} = \frac{(P_t - P_f) V_{TEST}}{P_{atm} t}$$

and solving for the pressure drop gives:

$$DP = P_t - P_f = \frac{V_{leak}}{V_{TEST}} P_{atm} t = \frac{0.05[\text{SCFM}]}{0.232[\text{ft}^3]} (14.7[\text{psia}]) (5[\text{min}])$$

$$DP = \underline{15.8 \text{ psi}}$$

Therefore, for a 5 minute leak test, if the pressure drop is less than 15.8 psi, then the tubing and recirculation valve has passed the test, and the leakage assumption used in this calculation has been met.

6.3 Minimum Recirculation Flow Margin

- Calculation of Minimum allowable pressure for AF-4002 to prevent 1/2P-29 dead head:

$C_{vV1} = 33$	C_v of AF-4002 at 1" (Input 5.4)
$C_{vRO} = 4.1$	Maximum possible RO-4003 C_v (Input 5.6)
$Q_{nom} = 120$	Normal minimum 1/2P-29 recirculation flow (Input 5.7)
$Q_{min} = 75$	Minimum allowable 1/2P-29 recirculation flow (Input 5.8)

There must be a minimum of 75 gpm through the TDAFPs (Ref 4.13). The C_v of RO-4003 is the smallest (highest flow resistance) in the recirculation lines. Valve AF-4002 will not start restricting flow until its flow resistance is close to that of RO-4003. From Reference 4.14:

$$K \propto \frac{1}{C_v^2} \propto \frac{1}{Q^2} \quad (6.3.1)$$

Since the flow resistances are additive:

$$K \propto \frac{1}{C_{v4002}^2} + \frac{1}{C_{vRO}^2} \propto \frac{1}{Q^2} \quad (6.3.2)$$

This is neglecting the flow resistances from all other components in the line (Assumption 3.7). A ratio can be developed between the states with the AF-4002 valve open and partially shut, with the C_v of the valve being neglected when it is fully open:

$$\frac{\frac{1}{C_{vRO}^2}}{\frac{1}{C_{v4002}^2} + \frac{1}{C_{vRO}^2}} = \frac{Q_{min}^2}{Q_{nom}^2} = \frac{75^2}{120^2} = 0.39 \quad (6.3.3)$$

Solving for the AF-4002 C_v and inserting the known value for RO-4003 yields:

$$C_{v4002} = C_{vRO} \sqrt{\frac{(0.39)}{1-0.39}} = (4.1) \sqrt{\frac{(0.39)}{1-0.39}} = 3.3 \quad (6.3.4)$$

To be conservative, the AF-4002 stroke will be limited such that the C_v is the same as the RO-4003 orifice, or approximately 4. From Attachment 3, the valve has a C_v of 33 (Input 5.4, Ref 4.7) when at 80% of stroke (1" for a 1.25" full stroke length), which is approximately 75% of full C_v . Therefore, the full open C_v is 44. A C_v of 4 is approximately 10% of full C_v , which from the curve becomes 18% of stem travel, or 0.225 in. From the Flowscan data (Attachment 4), using the more limiting valve curve (for 1AF-4002), this travel equates to an air pressure of approximately 45 psig.

Calculation 2001-0054 Rev 01



VALVES & CONTROLS™

Attachment 1 Page 1 of 1

January 11, 2002.

Attention: Mr. Rob Chapman
Wisconsin Electric Power Co.
Point Beach Nuclear Plant
6590 Nuclear Road
Two Rivers, WI 54241

Reference: Copes-Vulcan drawing E-336528
Valve serial number 7620-95376-248-2
Copes-Vulcan job 0150-65362
Wisconsin Electric Power Co. #4500452680

Subject: Actuator "deadband" or diaphragm chamber minimum volume

Dear Mr. Chapman,

The subject valve assembly is configured with a direct acting trim and a reverse acting model D-100-160 actuator for fail closed operation. The trim incorporates a backseat that permits the actuator to be configured to use the backseat for a travel limit. Based on the use of the backseat as a travel limit and a 0.25 inch margin on the actuator travel the closed volume of the diaphragm chamber has been estimated to be 84 cubic inches. This value is typically increased to 100 cubic inches to compensate for volume of the air supply line and allow some margin of safety for variation in valve setup.

Assuming use of the full 1.12 inch travel permitted, the open volume of the diaphragm chamber would increase by approximately 191 cubic inches for a total volume of 291 cubic inches (based on a 100 cubic inch starting volume).

Increasing the actuator travel margin beyond the 0.25 inch value will increase the volume of the diaphragm chamber. The estimated worst case diaphragm chamber volume is estimated at 600 cubic inches in the full open position. Therefore, the margin on actuator travel must be controlled to prevent excessive air consumption. This is best done by comparing the gap between the lower diaphragm housing and the actuator frame with no air pressure on the actuator and the stem not connected to the gap after final setup of the trim and actuator. The difference in the two gaps is the travel margin.

Robert L. Fetterman
Senior Applications Engineer

DeZURIK - COPES-VULCAN - MUELLER STEAM - FEBCO - POLYJET - K-FLO

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03-02-01 07:54am From-SARGENT & LUNDY

Calculation 2001-0056 Rev 01

Date: Monday, 2 June 1997 2:12pm CT
To: DAVE.GODSHALK
Cc: CHRIS.NORTON
From: JACK.HAMMERS
Subject: MR 97-038 valve strokes

Attachment 2 Page 1 of 1

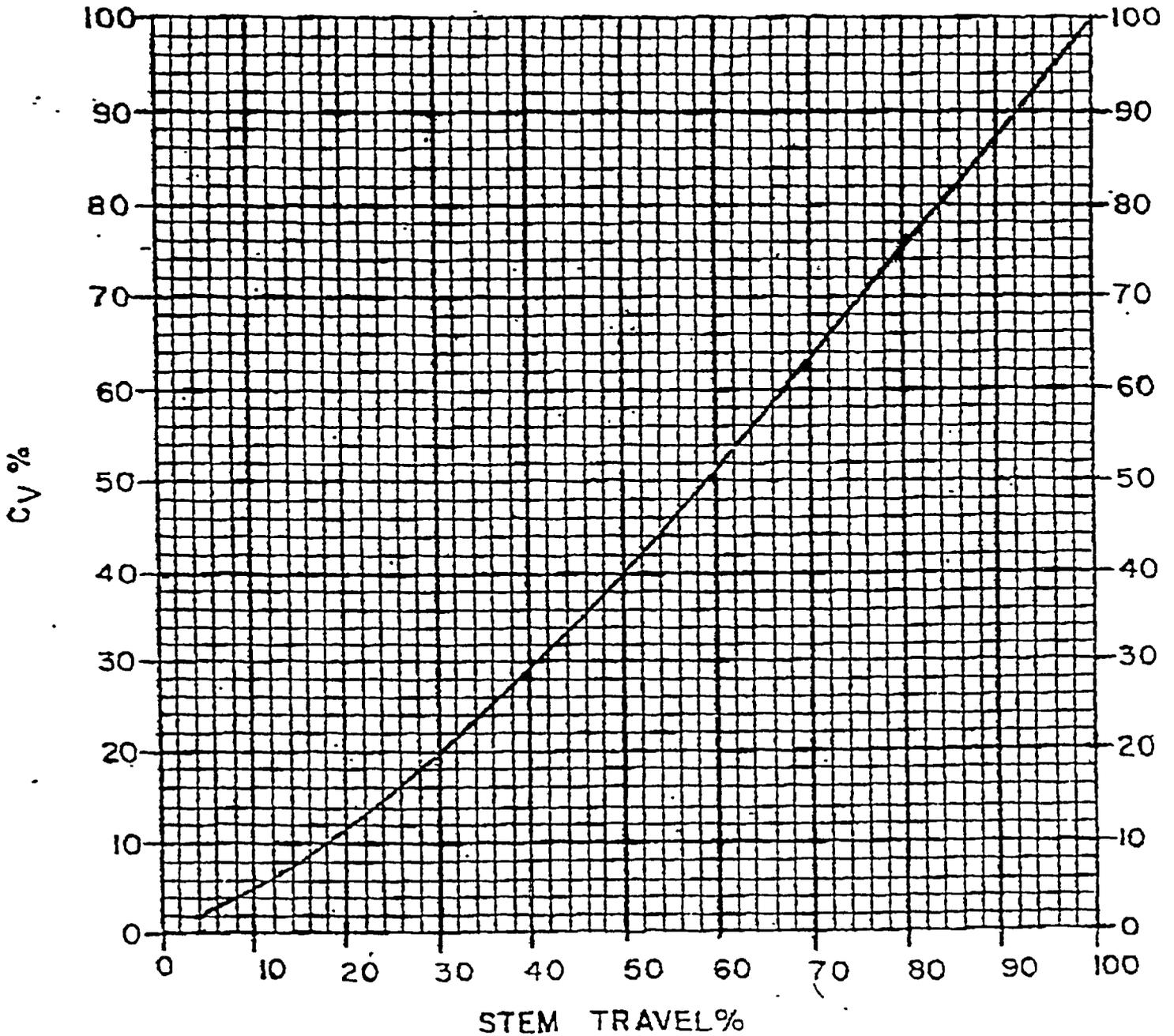
Dave,
The number of valve strokes we need to assume is only an estimate. There is no way to know exactly but I feel that 10 full strokes per hour is reasonable. If you have any further questions give me a call. Jack

BEST COPY AVAILABLE

M-185460

Calculation 2001-0556 Rev 01

Attachment 3 Page 1 of 1

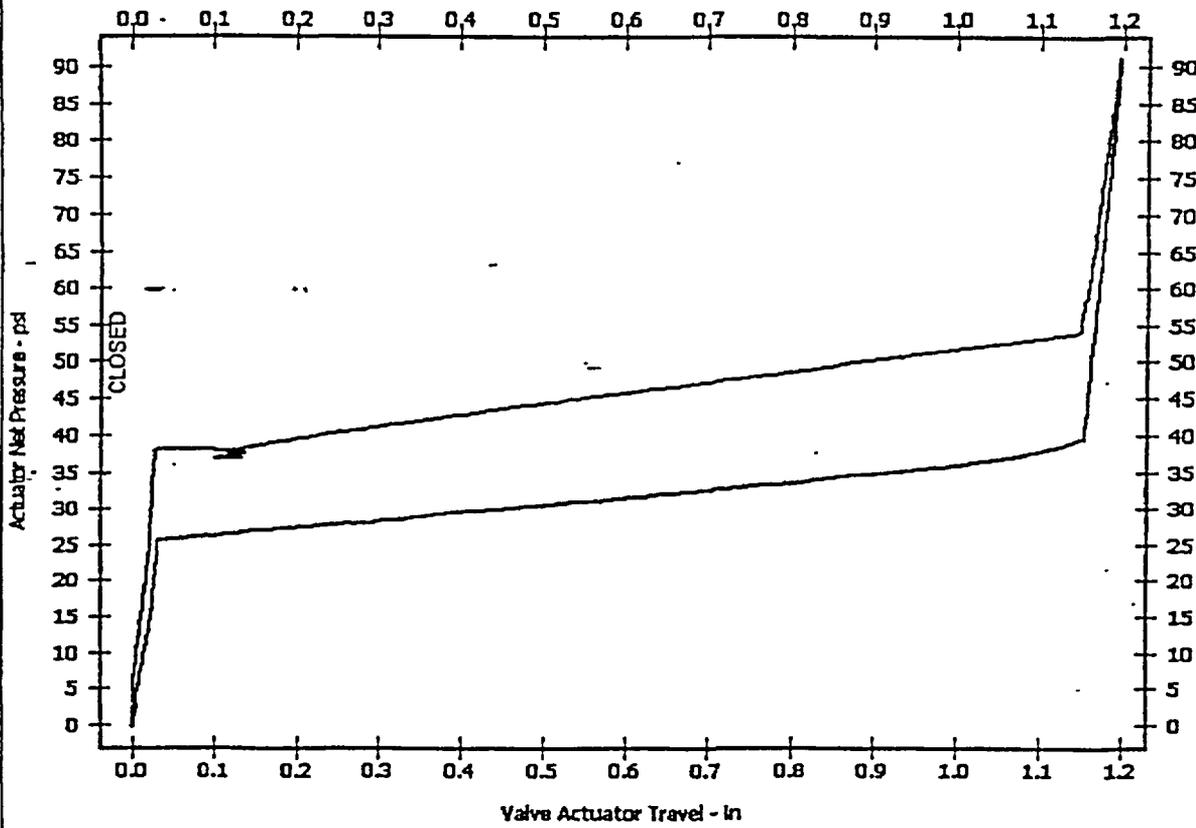


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MODIFIED PARABOLIC

2AF04002 #762095375248
22-Aug-01 10:19 AM

FlowScanner Diagnostics V5.51
Dynamic Scan

(c) FISHER Controls 1989-2000
12-Dec-01 02:55 PM

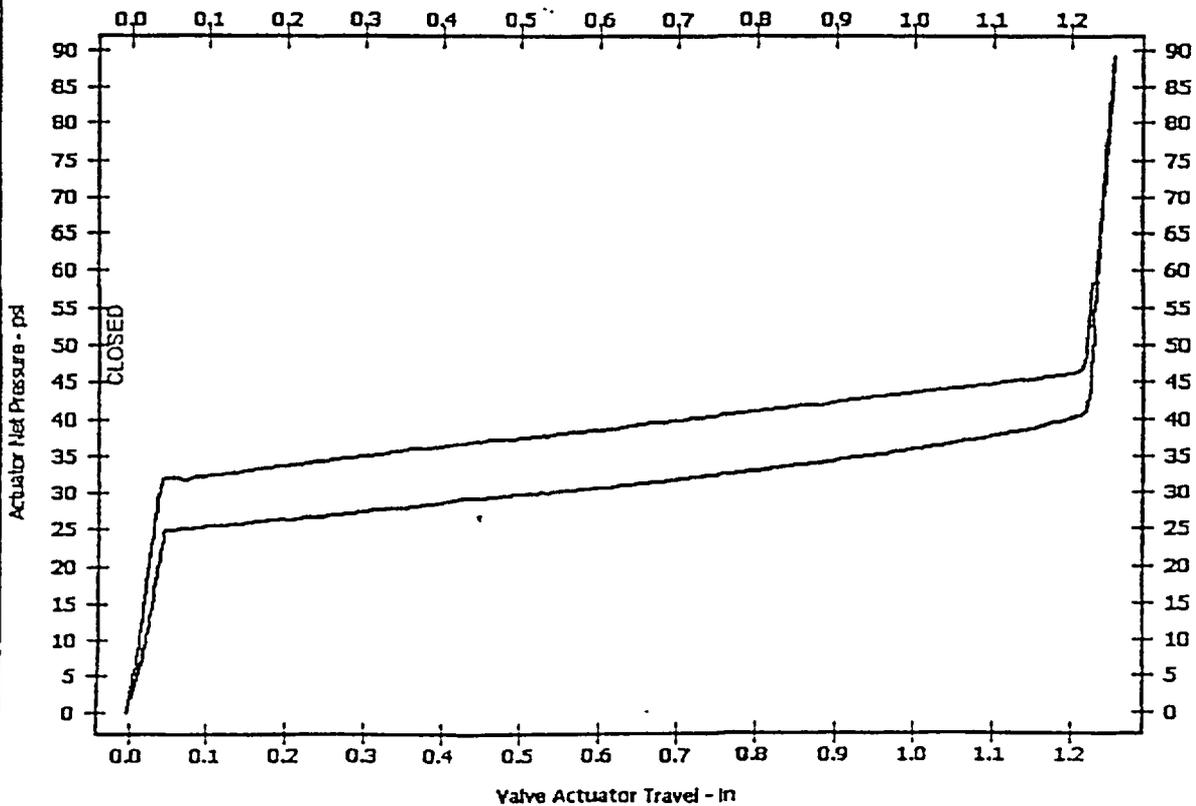


Calculation
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2AF04002
30-Aug-01 09:00 AM

FlowScanner Diagnostics V5.51
Dynamic Scan

(c) FISHER Controls 1989-2000
13-Dec-01 07:28 AM





Attachment 5

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Pump Division
Byron Jackson Pumps
DURCO Pumps
IDP Pumps
Pacific Pumps
Worthington Pumps

March 2, 2001

Wisconsin Electric
Point Beach Nuclear Station
6610 Nuclear Road
Two Rivers, WI 54141
Attn: John P. Schroeder

Subject: Aux. Feed Water Pumps
Minimum Flow Analysis
S/N 681-S-1028/29 Turbine Driven
S/N 681-S-1030/31 Motor Driven

Dear John:

This letter is being sent in regards to our past conversations in regards to the minimum flow requirements for the subject pumps.

We have re-evaluated the flow conditions that were given to Wisconsin Electric in a 7 August 1989 letter directed to Mr. J.P. Austin. The information listed below will supercede these previously supplied minimum flow guidelines.

Calculating minimum flow is a complex evaluation taking into account factors such as NPSHr vs. NPSHa, fluid thermodynamic properties, velocities, piping configuration, etc. The calculated values below encompass these factors.

S/N 681-S-1028/29: 1P-29 / 2P-29

75 GPM: The pump can operate at this flow rate for up to 60 hours of total accumulated hours. The pump should then be scheduled for inspection. After inspection, the amount of wear, the recorded vibration levels and performance deterioration can be reviewed to determine if the hour limitation can be modified.

130 GPM: The pump can operate at this flow rate for up to 1500 hours of total accumulated hours. The pump should then be scheduled for inspection. After inspection, the amount of wear, the recorded vibration levels and performance deterioration can be reviewed to determine if the hour limitation can be modified.

210 GPM: The pump can operate at this flow rate for an unlimited amount of time. This will be the continuous minimum flow rate for the pumps.



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Pump Division
Byron Jackson Pumps
DURCO Pumps
IDP Pumps
Pacific Pumps
Worthington Pumps

S/N 681-S-1030/31:

P 38 A ~ P-7FB

50 GPM: The pump can operate at this flow rate for up to 60 hours of total accumulated hours. The pump should then be scheduled for inspection. After inspection, the amount of wear, the recorded vibration levels and performance deterioration can be reviewed to determine if the hour limitation can be modified.

75 GPM: The pump can operate at this flow rate for up to 1500 hours of total accumulated hours. The pump should then be scheduled for inspection. After inspection, the amount of wear, the recorded vibration levels and performance deterioration can be reviewed to determine if the hour limitation can be modified.

105 GPM: The pump can operate at this flow rate for an unlimited amount of time. This will be the continuous minimum flow rate for the pumps.

In any potential minimum flow condition, high vibration limits may restrict your flow condition to a value that is higher than those indicated. Overall pump performance needs to be taken into account when establishing your minimum flow conditions.

Having a program in which the pumps are monitored for vibrations will greatly assist in determining action requirements for these pumps. We have an experienced team of vibration and engineering professionals that can support Wisconsin Electric in the long-term maintenance of your Aux. Feed water pumps.

If you have any questions in regards to the information listed in this letter, please feel free to contact me at your convenience.

Regards,

Patrick W. Prom
Nuclear Specialist

TABLES OF INDUSTRIAL GAS CONTAINER CONTENTS AND DENSITY FOR
OXYGEN, ARGON, NITROGEN, HELIUM, AND HYDROGEN

Calculation 2001-0056 Rev 01

by

Attachment 6

Ben A. Younglove and Neil A. Olien

Page 1 of 1

Chemical Engineering Science Division
National Engineering Laboratory
National Bureau of Standards
Boulder, Colorado 80303

Custody transfer tables are presented for oxygen, argon, nitrogen, helium, and hydrogen. The tables are based on standard reference data previously compiled by the National Bureau of Standards. Two sets of tables are provided for each fluid. Tables in engineering units cover the range -40 to 130°F with pressures from 100 to 10,000 psig. Tables in SI units (density versus pressure and temperature) cover the range 200 to 370 K with pressures from 0.5 to 70 MPa. The tables in engineering units are designed to provide a means of determining the volume of gas at standard conditions contained in a tank given the volume of the tank and the pressure and temperature of the gas within the tank. The publication also includes four examples of use of the tables in calculating tank quantities.

Key words: argon; custody transfer; gas density; gas volume; helium; hydrogen; nitrogen; oxygen.

1. Introduction

Industrial gases are important commodities in the Chemical Processes Industry as well as in other segments of the U. S. economy. Custody transfer of these gases usually takes place at high pressure and ambient temperatures with a wide variation in the latter depending on location and season. Normal custody transfer is based upon the volume the gas would occupy at standard conditions (standard conditions are defined here as 294.26 K (70.0°F)¹ and 0.101325 MPa (14.696 lb/in²))¹. The tables presented are designed to provide a relatively easy means of determining the volume of gas at standard conditions contained in a tank given the volume of the tank and the pressure and temperature of the gas within the tank. Tables are provided for each of the five fluids: oxygen, argon, nitrogen, helium, and hydrogen. Also included for each of the five

¹Departing from usual NBS practice, the International System of Units (SI) were not used exclusively in this publication in order to meet the needs of the sponsoring agency, the Compressed Gas Association.

7.0 RESULTS AND CONCLUSIONS

This calculation has verified the following:

- An air tank with a minimum volume of 107 gallons will have sufficient volume to stroke the AF-4002 valves 10 times per hour for 2 hours following a loss of instrument air, if the instrument air pressure is maintained above 90 psig, and leakage from the system is maintained at less than 0.05 SCFM.
- For leakage testing of the tubing, check valves, and recirculation valve operator following the installation of MR 02-001 (with instrument air and the accumulator tank isolated), if the pressure drop is less than 15.8 psi in 5 minutes, then the system leakage is less than the 0.05 SCFM assumed in this calculation.
- The air accumulator has been designed to stroke the minimum flow recirculation valves fully open, however, there is additional margin built into the system since the recirculation valves are capable of performing their function to prevent damage to the TDAFPs with only 45 psig of supplied air.