Point Beach Nuclear Plant
CALCULATION COVER SHEET

Calculation/Addendum Number:	Title of Calculation/Addendum:
2002-0002	Nitrogen Backup System for MDAFP Discharge Valves (AF-4012/4019) and Minimum Flow Recirculation Valves (AF-4007/4014)

System (CHAMPS Identifier Codes):

AF – Auxiliary Feedwater

☒ Original Calculation/Addendum
☐ Revised Calculation/Addendum Revision # ____

☒ Supersedes Calculation/Addendum
M-09334-266-IA.1 Rev 0
M-09334-266-IA.1 Rev 0 Addendum A

QA Scope ☒ Yes ☐ No

Discipline ☐ CIV ☐ NUC ☐ ELEC ☐ COMP ☐ I&C ☐ CHEM/RAD ☒ MECH ☐ SYST

Associated Documents: MR 01-144, SCR 2002-0010

Superseded By Calculation/Addendum # ____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
☐ A review of a representative sample of repetitive calculations.	
☐ A review of the calculation against a similar calculation previously performed.	
☒ A detailed review of the original calculation.	SAM
☐ A review by an alternate, simplified, or approximate method of calculation.	

Preparer	Reviewer	Discipline	Name	Signature	Date
☒	☐	MECH	Rob Chapman	[signature]	1-28-02
☐	☒	MECH	Scott Manthei	[signature]	1-28-02
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Comments And Resolution

Reviewer Comments:	Resolution:
No Changes Necessary. Procedure Updates and DBD updates will be completed as part of Mod. MR 01-144.	Agreed. Procedures and DBD updates are listed on PBF-1604 form for MR 01-144. RCC

1.0 PURPOSE

The purpose of this calculation is to verify that the existing nitrogen backup system installed by MR 97-038 (Ref 4.3) on the supply to the Motor Driven Auxiliary Feedwater Pump (MDAFP) discharge control valves AF-4012 and AF-4019, has enough capacity to also provide backup nitrogen to the AF-4007 and AF-4014 MDAFP minimum recirculation control valves. Calculation M-09334-266-IA.1 (Ref 4.2) originally evaluated the capacity of the system for MR 97-038, and Addendum A was done to reflect the trim change to AF-4019 installed by MR 00-077 (Ref 4.19). This calculation will supercede the previous calculation and addendum.

The minimum recirculation valves are required to open if the MDAFP discharge flow is throttled back to control steam generator levels following a Loss of All AC power (LOAC), Loss of Normal Feedwater (LONF), 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 MDAFPs are not available during the SBO event). The AF-4007 and AF-4014 valves will get an open signal when the MDAFP flow drops to less than 75 gpm. In several of the above scenarios, instrument air will not be available, and the valves will not open. Therefore, a backup air source is required.

MR 01-144 (Ref 4.4) will connect the existing nitrogen backup system to the instrument air supply line for the AF-4007 and AF-4014 valves. The existing dual check valves in the instrument air supply line will isolate the nitrogen system from the rest of the instrument air system when pressure is lost, and the volume of nitrogen in the bottles will provide the necessary compressed gas to stroke the valves the required number of times. Currently, one bottle is aligned to the system, and a second full bottle is isolated and in standby. The standby bottle is aligned out when the pressure drops to a point that will provide 90 minutes for AF-4012, and 60 minutes for AF-4019 (Ref 4.23). The trim changeout installed on AF-4019 by MR 00-077 (Ref 4.19) increased the nitrogen demand and reduced the available nitrogen supply, which is why the limit is currently 60 minutes for that valve. Following the installation of MR 01-144, this calculation will provide the basis for changing out both bottles when a 90 minute supply of nitrogen remains. The changeout pressures for a range of time durations will also be calculated. The current acceptance criteria for nitrogen leakage will be evaluated for acceptability based on the assumed leakage used in this calculation.

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA

The required nitrogen demand to operate both the MDAFP discharge valves (AF-4012/4019) and the MDAFP minimum flow recirculation valves (AF-4007/4014) will be calculated using simple ideal gas equations at constant temperature. The minimum pressure needed to stroke the valves is known, and the system will be sized such that this minimum pressure is still available after the required time and number of strokes specified. The AF-4007 and AF-4014 valves are controlled either full open or full closed. The AF-4007-S and AF-4014-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 discharge valves (AF-4012/4019) are control valves that are positioned by an I/P and a P/P controller (Ref 4.27). The valve is spring loaded to fail open, and the volume that is vented each time the valve is closed is smaller than for the recirculation valves. The controllers for the discharge valves have a constant bleed through rate that must be considered. The aligned nitrogen bottle must contain sufficient gas to fill the volume of tubing and the actuator each time the valves are to be stroked. This calculation will assume that each valve will stroke fully, and initially there is no nitrogen in the valve actuator, and that the valve spring is holding the valve in its failed position (closed for AF-4007/4014, and open for AF-4012/4019). The necessary nitrogen volume required to stroke the valve each time and the estimated volume of nitrogen leakage (including the positioner constant bleed through) will be calculated and compared to the volume in the nitrogen bottle at a given pressure to verify that the existing system is adequate, and to determine the necessary bottle changeout pressures.

This calculation will also verify that for most of the travel the minimum flow recirculation valves will pass sufficient flow to ensure that the P-38A/B MDAFPs 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 when the nitrogen bottle pressure has dropped below the regulator setpoint. The MDAFP discharge valves will not be evaluated.

The current acceptance criteria for leakage in IT 10, IT 10A, and IT 10B (Ref 4.20, 4.21, and 4.22) will be converted to a leakage in standard cubic feet per minute, and will be compared to the leakage assumed in this calculation.

The acceptance criteria are that after two hours of stroking both the MDAFP recirculation and the discharge valves for 10 times per hour, the final nitrogen bottle pressure will greater than the pressure needed to stroke the valves, and that the current procedural acceptance criteria for leakage bounds the leakage rate assumed in 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 nitrogen in the bottles and the nitrogen in the valve operators, and the effects will essentially cancel out. Furthermore, an increase in room temperature will tend to increase the bottle 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 nitrogen 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 value is 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 new tubing required to maintain the pressure in this portion of the system will be installed safety-related with high-quality stainless steel tubing and fittings (Ref 4.4). Also, redundant check valves are installed upstream of the nitrogen system, and the downstream valves (AF-133/153) are leak tested quarterly to check for leakage (Ref 4.20, 4.21, and 4.22). Although this assumed value is smaller than what was used for the previous calculation, it is an appropriate value that represents a very large amount of leakage that can be easily checked.

3.3. The valves 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 at the time (Ref 4.18). This limit will be used again for the discharge valves, and for the recirculation valves as well. Based on discussions with operations personnel and simulator runs, this is a conservative assumption. Operations would typically not control the system such that the AF-4007 and AF-4014 valves would be stroked so frequently, but to account for unknown variables, this assumption will be used.

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. The nitrogen bottles will be verified to provide enough gas to stroke the valves for 2 hours when full. 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 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 AF-4007/4014 and AF-4012/4019 valves. The pressure in the aligned bottle will actually be allowed to drop to a point where only 90 minutes of nitrogen is available, and operator action would be required to switch to the full bottle for an additional 120 minutes of supply. This is consistent with the current revision of AOP 5B (Ref 4.23), with the exception that the current bottle changeout pressure for the AF-4019 valve equates to a point where only 60 minutes of nitrogen is available.

3.5. The MDAFP discharge valves (AF-4012/4019) will stroke from fully open to fully closed each time.

Basis: This is a conservative assumption. The nitrogen backup system was originally installed to provide a safety-related source of compressed gas to keep the discharge valves from failing full open and causing the MDAFP to runout. To perform this function, the valve need only go partially closed. However, it is difficult to determine exactly how far open or closed the valve might go, so it will be assumed that the valve will go fully closed. This would cause the minimum flow recirculation valve to open if the MDAFP is still running. Therefore, fully closing the discharge valve will create a situation where the maximum amount of nitrogen is used, and this assumption is conservative.

3.6. The nitrogen 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 nitrogen at nearly room temperature and nominal pressures of less than 100 psig will behave as an ideal gas. The expansion of air from the system into the valves 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. The quantity of nitrogen in the bottles will be based on standard gas tables, since the gas will behave less like an ideal gas at these high pressures.

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

Basis: The component that controls the flow rate through the MDAFP recirculation line is the restricting orifices RO-4008/4015, which has an approximate C_v of 2.3 (Ref 4.12). The pressure drop through all the other piping components are minimal when compared to the drop across the orifice. A review of Calculation N-91-063 (Ref 4.15) indicates that the total pressure drop through the line is 962 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-4007/4014 valves on flow. Therefore, this assumption is conservative.

3.8. The initial nitrogen bottle pressure is 2500 psig.

Basis: The original calculation (Ref 4.2) stated this as an input and gave no reference. MR 97-038 (Ref 4.3) states that the maximum bottle pressure is 2640 psig, but gives no minimum required pressure. This, however, is an irrelevant point. This initial pressure is used only to verify that the existing system is adequate to also stroke the recirculation valves, since this was the original assumed initial pressure. In actuality, if the initial bottle pressure was less than 2500 psig, it would only mean that the bottle would be required to be changed out sooner. It is very unlikely that the initial pressure of a new nitrogen bottle will be lower than the recommended changeout points.

<u>Unvalidated</u>

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 (with Addendum A to Rev. 0)

4.3. MR 97-038 – Motor Driven Aux Feed Pump Discharge Control Valve Modification

4.4. MR 01-144 – AFW Motor Driven Pump Mini Recirc Control Valve Modification

4.5. Tables of Industrial Gas Container Contents and Density for Oxygen, Argon, Helium, and Hydrogen, National Bureau of Standards, Technical Note 1079, June 1985 ***(Selected pages included as Attachment 1)***

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 2***)

4.9. Copes-Vulcan Specification Sheet for AF-4012/4019 valves, C.I. 4.8.2.1, Book 00003-3 ***(Selected page included as Attachment 3)***

4.10. C_v versus Travel Curve, Modified Parabolic, M-185460 (***Attachment 4***)

4.11. Flowscan data for AF-4007 and AF-4014, August 2001 (***Attachment 5***)

4.12. Flowserve Drawing 94-16219 – 2" 600 LB Valtek Mark I Channel Stream Pressure Reducing Device

4.13. MR 99-029*A/*B – Aux Feedwater Pump P-38A/B Minimum Flow Recirc Line Orifice

4.14. Crane Technical Paper 410, Flow of Fluids through Valves, Fittings, and Pipe

4.15. Calculation N-91-063, P-38A/B 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 6***)

4.17. Installation Standard 18-415, Page 2, Foxboro CI 623A3 ***(Select Page included as Attachment 7)***

4.18. Email from Jack Hammers to Dave Godshalk dated 6/2/97 (***Attachment 8***)

4.19. MR 00-077 – Upgrade Trim for AF-4019

4.20. IT 10 Rev 43 – Test of Electrically Driven Auxiliary Feed Pumps and Valves (Quarterly)

4.21. IT 10A Rev 11 – Test of Electrically Driven Auxiliary Feed Pumps and Valves with Flow to Unit 1 Steam Generators (Quarterly)

4.22. IT 10B Rev 10 – Test of Electrically Driven Auxiliary Feed Pumps and Valves with Flow to Unit 2 Steam Generators (Quarterly)

4.23. AOP 5B (Rev 18) – PBNP Abnormal Operating Procedure – Loss of Instrument Air

4.24. Telecon from Clark Hall, Taylor-Wharton Cylinders, to Bret Nelson, Sargent and Lundy, dated 5/14/1997 ***(Attachment 9)***

4.25. Telecon from Bill Worloff, Moore Products Inc., to John P. Schroeder, PBNP, dated 5/3/2001 *(Attachment 10)*

4.26. Telecon from Dave Abbot, Copes Vulcan, to Rob Chapman, PBNP, dated 1/24/2002 *(Attachment 11)*

4.27. Bechtel P&ID 6118 M-217 Sh. 2, Rev 16, Auxiliary Feedwater System

5.0 INPUTS

5.1. Nitrogen cylinders are a Taylor-Wharton Model 3AA2400+ per MR 97-038 (Ref 4.3) with the following characteristics:

Water volume	2990 in^3 (Ref 4.24)
Bottle initial pressure	2500 psig (Assumption 3.8)

5.2. Swept Volume of Diaphragm for AF-4007/4014: 191 in^3 (Ref 4.8)

5.3. AF-4012/4019 valve operators (Copes Vulcan D-100-60).

Stroke length:	0.75 in (Ref 4.9)
Diaphragm area:	60 in^2 (Ref 4.9)

5.4. Valve actuation pressure:

AF-4012/4019	45 psig (Ref 4.19) *[Note: This applies to AF-4019, but bounds AF-4012 which operates at a lower pressure of 20 psig.]*
AF-4007/4014	65 psig (As set by Ref 4.4 by changing PCV-4053/4058)

5.5. The AF-4007/4014 valves have a C_v of 33 at a position of 1" (Ref 4.7)

5.6. Actuator dead volumes:

AF-4007/4014	100 in^3 (Ref 4.8)
AF-4012/4019	40 in^3 (Ref 4.26)

5.7. Tubing to be filled:

Nominal diameter	0.375 in (per walkdown)
AF-4007/4014 length	100 in (per walkdown)
AF-4012/4019 length	20 in (per walkdown)

5.8. Standard conditions are defined as 70 °F and 14.7 psia (Ref 4.5)

5.9. The maximum RO-4008/RO-4015 C_v is 2.3 (Ref 4.12)

5.10. The normal minimum recirculation flow for P-38A/38B is 70 gpm (Ref 4.13)

5.11. The minimum allowable flow for P-38A/P-38B is 50 gpm (Ref 4.13, 4.16)

5.12. The I/P Foxboro 69TA-1 has a bleed off rate of 1.25 SCFM at 20 psig (Ref 4.17)

5.13. The P/P Moore GC-72 has a bleed off rate of 0.75 SCFM at 45 psig (Ref 4.25)

5.14. The current leakage acceptance criteria in IT 10, IT 10A, and IT 10B is a 3 psi drop in pressure in 15 minutes (Ref 4.20, 4.21, 4.22)

5.15. The tubing that is pressurized during the leak test is 3/8" in diameter (0.375 in) and 790 inches long (per walkdown)

5.16. Leakage from the system through fittings and past the check valves: 0.05 SCFM (Assumption 3.2)

5.17. Valve stroking requirements: Time duration = 120 minutes (Assumption 3.4)
Number of strokes – 10 per hour (Assumption 3.3)

5.18. Initial nitrogen bottle pressure: 2500 psig (Assumption 3.8)

6.0 CALCULATION

6.1 Nitrogen System Sizing Calculation

- Calculation of Volume of Mini-Flow Recirculation Valve Actuator and Tubing (AF-4007/4014)

Tubing:

$d_t = 0.375$ in	Tubing nominal diameter (Input 5.7)
$L_t = 100$ in	Maximum length of vented tubing (Input 5.7)

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

$$V_{t\text{-}mf} = 11 \text{ in}^3$$

Valve Actuator:

$V_{st} = 191$ in^3	Swept volume of diaphragm during valve stroke (Input 5.2)
$V_{db} = 100$ in^3	Volume of actuator gap and dead band (Input 5.6)

$$V_v = V_{st} + V_{db} = 191 + 100 \quad (6.1.2)$$

$$V_{v\text{-}mf} = 291 \text{ in}^3$$

Total Volume to Operate the valve:

$$V_{OP\text{-}mf} = V_{t\text{-}mf} + V_{v\text{-}mf} = 11 + 291 \quad (6.1.3)$$

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

- Calculation of Volume of Discharge Valve Actuator and Tubing (AF-4012/4019)

Tubing.

$d_t = 0.375$ in	Tubing nominal diameter (Input 5.7)
$L_t = 20$ in	Maximum length of vented tubing (Input 5.7)

$$V_t = \frac{\pi}{4} d_t^2 L_t = \frac{\pi}{4}(.375)^2(20) \qquad (6.1.4)$$

$V_{t\text{-}d} = 2.2\ \text{in}^3$

Valve Actuator:

$A_{dia} = 60\ \text{in}^2$	Diaphragm area (Input 5.3)
$L_{vs} = 0.75\ \text{in}$	Valve stroke length (Input 5.3)
$V_{db} = 40\ \text{in}^3$	Volume of actuator gap and dead band (Input 5.6)

$$V_v = A_{dia} L_{vs} + V_{db} = (60)(0.75) + 40 \qquad (6.1.5)$$

$V_{v\text{-}d} = 85\ \text{in}^3$

Total Volume to Operate the valve:

$$V_{OP\text{-}d} = V_t + V_v = 2.2 + 85 \qquad (6.1.6)$$

$V_{OP\text{-}d} = 87.2\ in^3 * (0.000578\ ft^3/in^3) = \mathbf{0.050\ ft^3}$

- Calculation of Standard Cubic Feet of Nitrogen (SCF) Requirement to Stroke Valves

$N_{st} = 20$	Total number of valve strokes (Input 5.17)
$t = 120$ min	Time duration for valve operation (Input 5.17)
$P_{st} = 65$ psig = 79.7 psia	Pressure used to stroke open the mini-flow valve (Input 5.4)
$P_{st} = 45$ psig = 59.7 psia	Pressure used to stroke shut the discharge valve (Input 5.4)

For the purpose of verifying the size of the system, the pressure at the valves will always be greater than the regulator settings due to the setting of the nitrogen system pressure regulators (PCV-4053/4058). Therefore, the required air volume for each individual valve stroke will be the same. This volume will be determined at standard conditions. The relation of standard conditions to the actual conditions is:

$$P_{st} V_{OP} = P_{atm} V_{SCF} \qquad (6.1.7)$$

where P_{st} is in units of psia. Using this equation with separate volume terms for the mini-recirc valves and the discharge valves gives:

$$V_{SCF-v} = \left(V_{OP-mf} \frac{P_{st-mf}}{P_{atm}} + V_{OP-d} \frac{P_{st-d}}{P_{atm}} \right) N_{st} \qquad (6.1.8)$$

$$V_{SCF-v} = \left(0.17[ft^3] \frac{79.7[psia]}{14.7[psia]} + 0.050[ft^3] \frac{59.7[psia]}{14.7[psia]} \right)(20)$$

$V_{SCF\text{-}v} = (0.92 + 0.20)*20 = 22.4$ SCF

- Calculation of Nitrogen Leakage Volume

t = 120 min	Time duration for valve operation (Input 5.17)
V_{leak} = 0.05 SCFM	System leakage rate (Input 5.16)
$V_{I/P}$ = 1.25 SCFM	Constant bleed-through rate for I/P controller (Input 5.12)
$V_{P/P}$ = 0.75 SCFM	Constant bleed-through rate for P/P controller (Input 5.13)

Simply adding each leakage term gives:

$$V_{SCF\text{-}l} = (V_{leak} + V_{I/P} + V_{P/P})\,t = (0.05 + 1.25 + 0.75)*120 \qquad (6.1.9)$$

$$V_{SCF\text{-}l} = 246\ \text{SCF}$$

- Calculation of Nitrogen Bottle Pressures and SCF Volume

Using data from Ref 4.5, a list of nitrogen bottle pressure as a function of SCF of nitrogen can be generated (see Table 1 below). The data from Ref 4.5 gives nitrogen volume is SCF/ft^3. The tank volume is 2990 in^3 (Input 5.1), which equates to 1.73 ft^3. Multiplying the values in Ref 4.5 by 1.73 ft^3 results in the data shown in Table 1.

Table 1 – Nitrogen Bottle Pressures and Volumes

Pressure (psig)	*Volume (SCF)*
100	13.5
200	25.3
300	37.5
400	49 0
500	60.9
600	72.7
700	84.6
800	96.4
900	108.1
1000	119.9
1100	131.6
1200	143.3
1300	154.9
1400	166.3
1500	177.8
1600	189.1
1700	200.3
1800	211.4
1900	222.5
2000	233.4
2100	243.9
2200	254.8
2300	265.4
2400	276.1
2500	286.1

When this data is entered into Microsoft Excel, and a second order polynomial function is fit to the data (forcing the curve to intersect the origin), we get the following two relations between bottle pressure in psig (P_b) and the quantity of nitrogen gas contained in SCF (V_b):

$$P_b = 0.0024V_b^2 + 8.0229V_b \qquad (6.1.10)$$

$$V_b = \text{-}3.72\text{E-}06P_b^2 + 1.24\text{E-}01P_b \qquad (6.1.11)$$

These equations are used to convert initial bottle pressure to initial nitrogen gas volume, and final nitrogen gas volume to final bottle pressure.

- Verification of Adequacy of Existing System

$P_{bi} = 2500$ psig — Initial nitrogen bottle pressure (Input 5.18)

From Table 1, the initial bottle pressure of 2500 psig equates to 286.1 SCF of nitrogen. The total nitrogen demand for two hours is simply the sum of the valve demand and the leakage:

$$V_{SCF\text{-}TOT} = V_{SCF\text{-}v} + V_{SCF\text{-}l} = 24.4 + 246 = 270.4 \text{ SCF} < 286.1 \text{ SCF} \quad (6.1.12)$$

Therefore, the existing system has adequate capacity to supply both the discharge valves and the minimum flow recirculation valves.

6.2 Determination of Bottle Changeout Pressures

The final bottle pressure will be fixed at 65 psig, which is the lowest pressure that will fully stroke all the valves, with the recirculation valves being the most limiting (Input 5.4). The total nitrogen demand will be smaller as the time duration is reduced, since fewer valves strokes are required, and there is less leakage through the positioners. Equations 6.1.8 and 6.1.9 can be written as a function of time t (in minutes):

$$V_{SCF\text{-}v} = (0.92 + 0.20)*(10/60)*t = 0.187t \quad (6.1.13)$$

$$V_{SCF\text{-}l} = (V_{leak} + V_{I/P} + V_{P/P})\, t = (0.05 + 1.25 + 0.75)t = 2.05t \quad (6.1.14)$$

which, when added together becomes:

$$V_{SCF\text{-}TOT} = V_{SCF\text{-}v} + V_{SCF\text{-}l} = 0.187t + 2.05t = 2.24t \quad (6.1.15)$$

This represents the SCF of nitrogen used as a function of time. Adding this to the final volume of SCF in the bottle at 65 psig (= 8.04 SCF per equation 6.1.11) gives:

$$V_{bi} = V_{bf} + V_{SCF\text{-}TOT} = 8.04 + 2.24t \quad (6.1.16)$$

Now the initial volume of nitrogen in the bottle can be calculated for several different time durations. This volume, when inserted into equation 6.1.10, will yield the initial bottle pressure:

Table 2 – Bottle Changeout Pressures for several different time durations		
Time (min)	*Initial Bottle Vol (SCF)*	*Initial Bottle Pressure (psig)*
120	277	2406
100	232	1990
90	*210*	*1791*
80	187	1584
60	142	1188
40	97.6	806
30	75.2	617
20	52.8	430

From this table, the bottle changeout pressure to ensure a 90 minute supply of nitrogen is 1791 psig. This is less than the current changeout pressure of 1850 psig given in IT 10, IT 10A, and IT 10B (Ref 4.20, 4.21, 4.22).

6.3 Verification of current IT acceptance criteria

$DP = 3$ psi	Current allowed pressure drop (Input 5.14)
$t_{dp} = 15$ min	Current duration of pressure test (Input 5.14)
$d_t = 0.375$ in	Nominal tubing diameter (Input 5.15)
$L_t = 790$ in	Maximum length of tubing pressurized (Input 5.15)
$P_t = 65$ psig $= 79.7$ psia	Test pressure – equal to PCV-4053/4058 setpoint (Input 5.4)

- Calculation of tubing volume:

$$V_t = \frac{\pi}{4} d_t^2 L_t = \frac{\pi}{4}(.375)^2(790) \tag{6.3.1}$$

$$V_t = 87.3\ in^3 * (0.000578\ ft^3/in^3) = 0.050\ \text{ft}^3$$

- Standard cubic feet of air present at test pressure:

Using equation 6.1.7, the volume of nitrogen in SCF can be determined at the test pressure: and after the pressure drop:

$$P_t V_t = P_{atm} V_{SCF\text{-}i} \tag{6.3.2}$$

$$V_{SCF-i} = V_t \frac{P_t}{P_{atm}} = 0.050[ft^3]\left(\frac{79.7[psia]}{14.7[psia]}\right) = 0.271[SCF]$$

and also after the pressure drop:

$$(P_t - DP)V_t = P_{atm} V_{SCF\text{-}f} \tag{6.3.3}$$

$$V_{SCF-f} = V_t \frac{P_t - DP}{P_{atm}} = 0.050[ft^3]\left(\frac{79.7[psia] - 3[psi]}{14.7[psia]}\right) = 0.261[SCF]$$

- <u>Conversion to standard cubic feet per minute:</u>

The loss of nitrogen in SCFM that represents the acceptance criteria of the test can be calculated as follows:

$$\dot{V}_{SCF-leak} = \frac{\left(V_{SCF-f} - V_{SCF-i}\right)}{t_{dp}} = \frac{(.271-.261)[SCF]}{15[\min]} \qquad (6.3.4)$$

$$\dot{V}_{SCF\text{-}leak} = \mathbf{0.00067\ SCFM < 0.05\ SCFM}$$

Therefore, the current acceptance criteria in IT 10, IT 10A, and IT 10B will bound Assumption 3.2 for this calculation.

6.4 Minimum Recirculation Flow Margin

- Calculation of Minimum allowable pressure for AF-4007/4014 to prevent P-38A/B dead head:

$C_{vVI} = 33$	C_v of AF-4007/4014 at 1" (Input 5.5)
$C_{vRO} = 2.3$	Approximate RO-4008/4015 C_v (Input 5.9)
$Q_{nom} = 70$	Normal minimum P-38A/B recirculation flow (Input 5.10)
$Q_{min} = 50$	Minimum allowable P-38A/B recirculation flow (Input 5.11)

There must be a minimum of 50 gpm through the MDAFPs (Ref 4.13). The C_v of RO-4008/4015 is the smallest (highest flow resistance) in the recirculation lines. Valve AF-4007/4014 will not start restricting flow until its flow resistance is close to that of RO-4008/4015. From Reference 4.14:

$$K \propto \frac{1}{C_v^2} \propto \frac{1}{Q^2} \qquad (6.4.1)$$

Since the flow resistances are additive:

$$K \propto \frac{1}{C_{v4007}^2} + \frac{1}{C_{vRO}^2} \propto \frac{1}{Q^2} \qquad (6.4.2)$$

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-4007/4014 valve open and partially shut, with the C_v of the valve being neglected when it is fully open:

$$\frac{\frac{1}{C_{vRO}^2}}{\frac{1}{C_{v4007}^2} + \frac{1}{C_{vRO}^2}} = \frac{Q_{min}^2}{Q_{nom}^2} = \frac{50^2}{70^2} = 0.51 \qquad (6.4.3)$$

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

$$C_{v4007} = C_{vRO}\sqrt{\frac{(0.51)}{1-0.51}} = (2.3)\sqrt{\frac{(0.51)}{1-0.51}} = 2.3 \qquad (6.4.4)$$

To be conservative, the AF-4007/4014 stroke will be limited such that the C_v is larger than the RO-4008/4015 orifice, or approximately 3. From Reference 4.10 (Attachment 4), the valve has a C_v of 33 when at 80% of stroke (1" for a 1.25" stroke), which is approximately 75% of full C_v. Therefore, the full open C_v is 44. A C_v of 3 is approximately 7% of full C_v, which from the curve becomes 13% of stem travel, or approximately 0.163 in. From the Flowscan data of Reference 4.11 (Attachment 5), this travel equates to an air pressure of approximately 35 psig.

Therefore, there is additional margin built into this calculation, and the minimum flow recirculation valves (AF-4007/4014) need only 35 psig of supply pressure to be open enough to protect the MDAFPs from damage.

7.0 RESULTS AND CONCLUSIONS

This calculation has verified the following:

- The existing nitrogen backup system for the MDAFP discharge valves installed by MR 97-038 has adequate capacity to operate both the discharge valves and the minimum flow recirculation valves (AF-4007/4014), and no upgrades are necessary to the system to be able to utilize it for the recirculation valves per MR 01-144.
- The aligned nitrogen bottle should be changed out at a pressure of 1791 psig to ensure a 90 minute supply from that bottle to stroke the MDAFP discharge and minimum flow recirculation valves.
- The current acceptance criteria for leakage past AF-133/153 given in IT 10, IT 10A, and IT 10B of a 3 psi drop in 15 minutes bounds the leakage assumed by this calculation by a very conservative margin.
- The system has been determined to be capable of stroking 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 MDAFPs with only 35 psig of supplied nitrogen.

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

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Attachment 1
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by

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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 o.. 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/in^2))[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

[1]Departing 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.

8.3

Nitrogen Contents Table (SCF/cu ft)

NITROGEN CONTENTS TABLE (SCF/CU FT).

T F	100 PSIG	200 PSIG	300 PSIG	400 PSIG	500 PSIG	600 PSIG	700 PSIG
-40.0	9.933	18.73	27.45	36.69	45.82	55.05	64.35
-38.0	9.886	18.64	27.31	36.49	45.56	54.73	63.97
-36.0	9.837	18.54	27.16	36.29	45.31	54.41	63.59
-34.0	9.789	18.45	27.22	36.09	45.06	54.10	63.21
-32.0	9.741	18.36	27.08	35.90	44.81	53.79	62.85
-30.0	9.694	18.26	26.94	35.71	44.56	53.49	62.48
-28.0	9.647	18.17	26.80	35.52	44.32	53.19	62.12
-26.0	9.601	18.08	26.66	35.33	44.08	52.90	61.77
-24.0	9.555	17.99	26.53	35.15	43.84	52.60	61.42
-22.0	9.510	17.91	26.39	34.96	43.61	52.32	61.08
-20.0	9.465	17.82	26.26	34.78	43.38	52.03	60.74
-18.0	9.421	17.73	26.13	34.61	43.15	51.75	60.40
-16.0	9.377	17.65	26.00	34.43	42.92	51.47	60.07
-14.0	9.333	17.56	25.87	34.26	42.70	51.20	59.74
-12.0	9.290	17.48	25.75	34.08	42.48	50.93	59.42
-10.0	9.247	17.40	25.62	33.91	42.26	50.66	59.10
-8.0	9.205	17.32	25.50	33.74	42.05	50.40	58.78
-6.0	9.163	17.23	25.37	33.58	41.83	50.14	58.47
-4.0	9.121	17.15	25.25	33.41	41.62	49.88	58.17
-2.0	9.080	17.07	25.13	33.25	41.42	49.62	57.86
.0	9.040	17.00	25.01	33.09	41.21	49.37	57.56
2.0	8.999	16.92	24.90	32.93	41.01	49.12	57.27
4.0	8.959	16.84	24.78	32.77	40.81	48.88	56.97
6.0	8.919	16.76	24.66	32.61	40.61	48.63	56.68
8.0	8.880	16.69	24.55	32.46	40.41	48.39	56.40
10.0	8.841	16.61	24.44	32.31	40.21	48.15	56.11
12.0	8.802	16.54	24.32	32.16	40.02	47.92	55.83
14.0	8.764	16.46	24.21	32.01	39.83	47.68	55.56
16.0	8.726	16.39	24.10	31.86	39.64	47.45	55.28
18.0	8.689	16.32	24.00	31.71	39.46	47.23	55.01
20.0	8.651	16.25	23.89	31.56	39.27	47.00	54.75
22.0	8.614	16.18	23.78	31.42	39.09	46.78	54.48
24.0	8.578	16.11	23.68	31.28	38.91	46.56	54.22
26.0	8.542	16.04	23.57	31.14	38.73	46.34	53.96
28.0	8.506	15.97	23.47	31.00	38.55	46.12	53.70
30.0	8.470	15.90	23.36	30.86	38.38	45.91	53.45
32.0	8.435	15.83	23.26	30.72	38.20	45.70	53.20
34.0	8.400	15.76	23.16	30.59	38.03	45.49	52.95
36.0	8.365	15.70	23.06	30.45	37.86	45.28	52.71
38.0	8.330	15.63	22.96	30.32	37.69	45.08	52.46
40.0	8.296	15.57	22.86	30.19	37.52	44.87	52.22
42.0	8.262	15.50	22.77	30.05	37.36	44.67	51.99
44.0	8.229	15.44	22.67	29.93	37.19	44.47	51.75
46.0	8.195	15.37	22.58	29.80	37.03	44.27	51.52
48.0	8.162	15.31	22.48	29.67	36.87	44.08	51.29
50.0	8.129	15.25	22.39	29.54	36.71	43.89	51.06
52.0	8.097	15.18	22.29	29.42	36.55	43.69	50.83
54.0	8.065	15.12	22.20	29.30	36.40	43.50	50.61
56.0	8.033	15.06	22.11	29.17	36.24	43.32	50.39
58.0	8.001	15.00	22.02	29.05	36.09	43.13	50.17
60.0	7.969	14.94	21.93	28.93	35.94	42.95	49.95
62.0	7.938	14.88	21.84	28.81	35.79	42.76	49.74
64.0	7.907	14.82	21.75	28.69	35.64	42.58	49.52
66.0	7.877	14.76	21.67	28.58	35.49	42.40	49.31
68.0	7.846	14.71	21.58	28.46	35.34	42.23	49.10
70.0	7.816	14.65	21.49	28.34	35.20	42.05	48.89
72.0	7.786	14.59	21.41	28.23	35.05	41.88	48.69
74.0	7.756	14.53	21.32	28.12	34.91	41.70	48.49
76.0	7.727	14.48	21.24	28.00	34.77	41.53	48.28
78.0	7.697	14.42	21.15	27.89	34.63	41.36	48.08
80.0	7.669	14.37	21.07	27.78	34.49	41.19	47.89
82.0	7.639	14.31	20.99	27.67	34.35	41.03	47.69
84.0	7.611	14.25	20.91	27.56	34.22	40.86	47.50
86.0	7.582	14.20	20.83	27.46	34.08	40.70	47.30
88.0	7.554	14.15	20.75	27.35	33.95	40.54	47.11
90.0	7.526	14.10	20.67	27.24	33.81	40.38	46.92
92.0	7.498	14.04	20.59	27.14	33.68	40.22	46.74
94.0	7.471	13.99	20.51	27.04	33.55	40.06	46.55
96.0	7.443	13.94	20.44	26.93	33.42	39.90	46.37
98.0	7.416	13.89	20.36	26.83	33.29	39.75	46.18
100.0	7.389	13.84	20.28	26.73	33.17	39.59	46.00
102.0	7.362	13.79	20.21	26.63	33.04	39.44	45.82
104.0	7.335	13.73	20.13	26.53	32.91	39.29	45.65
106.0	7.309	13.68	20.06	26.43	32.79	39.14	45.47
108.0	7.283	13.64	19.99	26.33	32.67	38.99	45.29
110.0	7.257	13.59	19.91	26.23	32.54	38.84	45.12
112.0	7.231	13.54	19.84	26.14	32.42	38.69	44.95
114.0	7.206	13.49	19.77	26.04	32.30	38.55	44.78
116.0	7.180	13.44	19.70	25.94	32.18	38.40	44.61
118.0	7.155	13.39	19.62	25.85	32.06	38.26	44.44
120.0	7.130	13.34	19.55	25.76	31.94	38.12	44.27
122.0	7.105	13.30	19.48	25.66	31.83	37.98	44.11
124.0	7.080	13.25	19.41	25.57	31.71	37.84	43.95
126.0	7.056	13.20	19.35	25.48	31.60	37.70	43.78
128.0	7.032	13.15	19.28	25.39	31.49	37.56	43.62
130.0	7.007	13.11	19.21	25.30	31.37	37.43	43.46

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NITROGEN CONTENTS TABLE (SCF/CU FT).

T F	800 PSIG	900 PSIG	1000 PSIG	1100 PSIG	1200 PSIG	1300 PSIG	1400 PSIG
-40.0	73.72	83.13	92.58	102.6	111.5	120.9	130.3
-38.0	73.27	82.61	91.99	101.4	110.8	120.1	129.4
-36.0	72.82	82.10	91.40	100.7	110.0	119.3	128.5
-34.0	72.38	81.59	90.83	100.1	109.3	118.5	127.7
-32.0	71.95	81.09	90.26	99.43	108.5	117.7	126.8
-30.0	71.52	80.60	89.70	98.80	107.9	117.0	126.0
-28.0	71.10	80.12	89.15	98.18	107.2	116.2	125.2
-26.0	70.69	79.64	88.61	97.58	106.5	115.5	124.3
-24.0	70.29	79.17	88.07	96.98	105.9	114.7	123.5
-22.0	69.88	78.70	87.54	96.39	105.2	114.0	122.8
-20.0	69.48	78.25	87.03	95.80	104.5	113.3	122.0
-18.0	69.09	77.79	86.51	95.23	103.9	112.6	121.2
-16.0	68.71	77.35	86.01	94.67	103.3	111.9	120.5
-14.0	68.32	76.91	85.51	94.11	102.7	111.2	119.7
-12.0	67.94	76.48	85.02	93.56	102.1	110.6	119.0
-10.0	67.57	76.05	84.54	93.02	101.5	109.9	118.3
-8.0	67.20	75.63	84.06	92.48	100.9	109.3	117.6
-6.0	66.83	75.21	83.59	91.95	100.3	108.6	116.9
-4.0	66.48	74.80	83.12	91.44	99.73	108.0	116.2
-2.0	66.12	74.39	82.66	90.93	99.16	107.4	115.5
.0	65.77	73.99	82.21	90.42	98.60	106.8	114.9
2.0	65.43	73.60	81.76	89.92	98.05	106.2	114.2
4.0	65.09	73.21	81.32	89.43	97.51	105.6	113.6
6.0	64.75	72.82	80.89	88.94	96.97	105.0	112.9
8.0	64.42	72.44	80.46	88.46	96.44	104.4	112.3
10.0	64.09	72.06	80.03	87.99	95.92	103.8	111.7
12.0	63.76	71.69	79.61	87.52	95.40	103.2	111.1
14.0	63.44	71.32	79.20	87.06	94.89	102.7	110.4
16.0	63.12	70.96	78.79	86.60	94.39	102.1	109.8
18.0	62.81	70.60	78.39	86.15	93.89	101.6	109.3
20.0	62.50	70.25	77.99	85.71	93.40	101.1	108.7
22.0	62.19	69.90	77.59	85.27	92.92	100.5	108.1
24.0	61.89	69.55	77.20	84.83	92.44	100.0	107.5
26.0	61.59	69.21	76.82	84.40	91.97	99.49	107.0
28.0	61.29	68.87	76.44	83.98	91.50	98.98	106.4
30.0	61.00	68.53	76.06	83.56	91.04	98.47	105.9
32.0	60.71	68.20	75.69	83.15	90.58	97.98	105.3
34.0	60.42	67.88	75.32	82.74	90.13	97.48	104.8
36.0	60.13	67.55	74.95	82.33	89.68	97.00	104.3
38.0	59.85	67.23	74.59	81.93	89.24	96.52	103.7
40.0	59.57	66.91	74.24	81.54	88.81	96.04	103.2
42.0	59.30	66.60	73.89	81.15	88.38	95.57	102.7
44.0	59.03	66.29	73.54	80.76	87.95	95.11	102.2
46.0	58.76	65.98	73.19	80.38	87.53	94.65	101.7
48.0	58.49	65.68	72.85	80.00	87.11	94.19	101.2
50.0	58.23	65.38	72.52	79.62	86.70	93.74	100.7
52.0	57.96	65.08	72.18	79.25	86.30	93.30	100.3
54.0	57.71	64.79	71.85	78.89	85.89	92.86	99.78
56.0	57.45	64.50	71.52	78.53	85.49	92.43	99.31
58.0	57.20	64.21	71.20	78.17	85.10	92.00	98.85
60.0	56.95	63.92	70.88	77.81	84.71	91.57	98.39
62.0	56.70	63.64	70.57	77.46	84.33	91.15	97.93
64.0	56.45	63.36	70.25	77.11	83.94	90.74	97.48
66.0	56.21	63.09	69.94	76.77	83.57	90.32	97.04
68.0	55.97	62.81	69.63	76.43	83.19	89.92	96.60
70.0	55.73	62.54	69.33	76.09	82.82	89.51	96.16
72.0	55.49	62.27	69.03	75.76	82.46	89.12	95.73
74.0	55.25	62.01	68.73	75.43	82.09	88.72	95.30
76.0	55.02	61.74	68.44	75.10	81.74	88.33	94.88
78.0	54.79	61.49	68.14	74.78	81.38	87.94	94.46
80.0	54.56	61.22	67.85	74.46	81.03	87.56	94.05
82.0	54.34	60.97	67.57	74.14	80.68	87.18	93.64
84.0	54.11	60.71	67.28	73.83	80.34	86.81	93.23
86.0	53.89	60.46	67.00	73.52	79.99	86.43	92.83
88.0	53.67	60.21	66.72	73.21	79.66	86.07	92.44
90.0	53.46	[illegible]	66.45	72.90	79.32	85.70	92.04
92.0	53.24	59.72	66.17	72.60	78.99	85.34	91.65
94.0	53.03	59.48	65.90	72.30	78.66	84.98	91.27
96.0	52.81	59.24	65.64	72.00	78.34	84.63	90.88
98.0	52.60	59.00	65.37	71.71	78.01	84.28	90.51
100.0	52.39	58.76	65.11	71.42	77.69	83.93	90.13
102.0	52.19	58.53	64.84	71.13	77.38	83.59	89.76
104.0	51.98	58.30	64.59	70.84	77.06	83.25	89.39
106.0	51.78	58.07	64.33	70.56	76.75	82.91	89.03
108.0	51.58	57.84	64.08	70.28	76.45	82.58	88.67
110.0	51.38	57.62	63.82	70.00	76.14	82.25	88.31
112.0	51.13	57.39	63.57	69.72	75.84	81.92	87.95
114.0	50.99	57.17	63.33	69.45	75.54	81.59	87.60
116.0	50.79	56.95	63.08	69.18	75.24	81.27	87.26
118.0	50.60	56.73	62.84	68.91	74.95	80.95	86.91
120.0	50.41	56.52	62.60	68.64	74.65	80.63	86.57
122.0	50.22	56.30	62.36	68.38	74.37	80.32	86.23
124.0	50.03	56.09	62.12	68.12	74.08	80.01	85.89
126.0	49.84	55.88	61.88	67.86	73.80	79.70	85.56
128.0	49.66	55.67	61.65	67.60	73.52	79.39	85.23
130.0	49.47	55.46	61.42	67.35	73.24	79.09	84.91

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NITROGEN CONTENTS TABLE (SCF/CU FT).

T F	1500 PSIG	1600 PSIG	1700 PSIG	1800 PSIG	1900 PSIG	2000 PSIG	2100 PSIG
-40.0	139.6	148.9	158.0	167.1	176.0	184.8	193.4
-38.0	138.7	147.8	156.9	165.9	174.7	183.4	192.0
-36.0	137.7	146.8	155.8	164.7	173.5	182.1	190.6
-34.0	136.8	145.8	154.7	163.6	172.3	180.9	189.3
-32.0	135.9	144.9	153.7	162.4	171.1	179.6	188.0
-30.0	134.9	143.8	152.5	161.3	169.9	178.4	186.7
-28.0	134.1	142.9	151.6	160.2	168.8	177.2	185.4
-26.0	133.2	141.9	150.6	159.2	167.6	176.0	184.2
-24.0	132.3	141.0	149.6	158.1	166.5	174.8	182.9
-22.0	131.5	140.1	148.6	157.1	165.4	173.6	181.7
-20.0	130.6	139.2	147.7	156.1	164.3	172.5	180.5
-18.0	129.8	138.3	146.7	155.0	163.3	171.4	179.4
-16.0	129.0	137.4	145.8	154.1	162.2	170.3	178.2
-14.0	128.2	136.5	144.9	153.1	161.2	169.2	177.1
-12.0	127.4	135.7	144.0	152.1	160.2	168.1	176.0
-10.0	126.6	134.9	143.1	151.2	159.2	167.1	174.9
-8.0	125.9	134.1	142.2	150.2	158.2	166.0	173.8
-6.0	125.1	133.3	141.3	149.3	157.2	165.0	172.7
-4.0	124.4	132.5	140.5	148.4	156.3	164.0	171.6
-2.0	123.6	131.7	139.7	147.5	155.3	163.0	170.6
.0	122.9	130.9	138.8	146.7	154.4	162.0	169.6
2.0	122.2	130.1	138.0	145.8	153.5	161.1	168.6
4.0	121.5	129.4	137.2	144.9	152.6	160.1	167.6
6.0	120.8	128.7	136.4	144.1	151.7	159.2	166.6
8.0	120.1	127.9	135.6	143.3	150.9	158.3	165.6
10.0	119.5	127.2	134.9	142.5	150.0	157.4	164.7
12.0	118.8	126.5	134.1	141.7	149.1	156.5	163.8
14.0	118.1	125.8	133.4	140.9	148.3	155.6	162.8
16.0	117.5	125.1	132.6	140.1	147.4	154.7	161.9
18.0	116.9	124.4	131.9	139.3	146.6	153.9	161.0
20.0	116.2	123.7	131.2	138.5	145.8	153.0	160.1
22.0	115.6	123.1	130.5	137.8	145.0	152.2	159.2
24.0	115.0	122.4	129.8	137.0	144.2	151.4	158.4
26.0	114.4	121.8	129.1	136.3	143.5	150.5	157.5
28.0	113.8	121.1	128.4	135.6	142.7	149.7	156.7
30.0	113.2	120.5	127.7	134.9	141.9	148.9	155.9
32.0	112.6	119.9	127.1	134.2	141.2	148.2	155.0
34.0	112.1	119.3	126.4	133.5	140.5	147.4	154.2
36.0	111.5	118.6	125.7	132.8	139.7	146.6	153.4
38.0	110.9	118.0	125.1	132.1	139.0	145.9	152.6
40.0	110.4	117.5	124.5	131.4	138.3	145.1	151.8
42.0	109.8	116.9	123.8	130.8	137.5	144.4	151.1
44.0	109.3	116.3	123.2	130.1	136.9	143.7	150.3
46.0	108.7	115.7	122.6	129.5	136.2	142.9	149.6
48.0	108.2	115.1	122.0	128.8	135.6	142.2	148.8
50.0	107.7	114.6	121.4	128.2	134.9	141.5	148.1
52.0	107.2	114.0	120.8	127.6	134.2	140.8	147.3
54.0	106.7	113.5	120.2	126.9	133.6	140.1	146.6
56.0	106.2	112.9	119.7	126.3	132.9	139.5	145.9
58.0	105.7	112.4	119.1	125.7	132.3	138.8	145.2
60.0	105.2	111.9	118.5	125.1	131.7	138.1	144.5
62.0	104.7	111.4	118.0	124.5	131.0	137.5	143.8
64.0	104.2	110.8	117.4	124.0	130.4	136.8	143.2
66.0	103.7	110.3	116.9	123.4	129.8	136.2	142.5
68.0	103.2	109.8	116.3	122.8	129.2	135.5	141.8
70.0	102.8	109.3	115.8	122.2	128.6	134.9	141.2
72.0	102.3	108.8	115.3	121.7	128.0	134.3	140.5
74.0	101.8	108.3	114.8	121.1	127.4	133.7	139.9
76.0	101.4	107.8	114.2	120.6	126.9	133.1	139.2
78.0	100.9	107.4	113.7	120.0	126.3	132.5	138.6
80.0	100.5	106.9	113.2	119.5	125.7	131.9	138.0
82.0	100.1	106.4	112.7	119.0	125.2	131.3	137.4
84.0	99.62	106.0	112.2	118.5	124.6	130.7	136.8
86.0	99.19	105.5	111.7	117.9	124.1	130.1	136.1
88.0	98.76	105.0	111.3	117.4	123.5	129.6	135.6
90.0	98.34	104.6	110.8	116.9	123.0	129.0	135.0
92.0	97.92	104.1	110.3	116.4	122.5	128.4	134.4
94.0	97.50	103.7	109.8	115.9	121.9	127.9	133.8
96.0	97.09	103.3	109.4	115.4	121.4	127.4	133.2
98.0	96.69	102.8	108.9	114.9	120.9	126.8	132.7
100.0	96.28	102.4	108.4	114.4	120.4	126.3	132.1
102.0	95.89	102.0	108.0	114.0	119.9	125.7	131.5
104.0	95.49	101.5	107.5	113.5	119.4	125.2	131.0
106.0	95.10	101.1	107.1	113.0	118.9	124.7	130.4
108.0	94.71	100.7	106.7	112.6	118.4	124.2	129.9
110.0	94.33	100.3	106.2	112.1	117.9	123.7	129.4
112.0	93.95	99.89	105.8	111.6	117.4	123.2	128.8
114.0	93.57	99.49	105.4	111.2	117.0	122.7	128.3
116.0	93.20	99.09	104.9	110.7	116.5	122.2	127.8
118.0	92.83	98.70	104.5	110.3	116.0	121.7	127.3
120.0	92.46	98.31	104.1	109.9	115.5	121.2	126.8
122.0	92.10	97.92	103.7	109.4	115.1	120.7	126.3
124.0	91.74	97.54	103.3	109.0	114.6	120.2	125.8
126.0	91.38	97.15	102.9	108.6	114.2	119.8	125.3
128.0	91.03	96.75	102.5	108.1	113.7	119.3	124.8
130.0	90.63	96.40	102.1	107.7	113.3	118.8	124.3

Attachment 1 Rev.
Page 6 of 6

NITROGEN CONTENTS TABLE (SCF/CU FT).

T F	2200 PSIG	2300 PSIG	2400 PSIG	2500 PSIG	2600 PSIG	2700 PSIG	2800 PSIG
-40.0	201.8	210.1	219.2	226.1	233.8	241.3	248.7
-38.0	200.4	208.6	216.6	224.5	232.2	239.7	247.0
-36.0	199.0	207.1	215.1	222.9	230.6	238.0	245.3
-34.0	197.6	205.7	213.6	221.4	229.0	236.4	243.6
-32.0	196.2	204.3	212.2	219.9	227.4	234.8	242.0
-30.0	194.8	202.9	210.7	218.4	225.9	233.2	240.4
-28.0	193.5	201.5	209.3	216.9	224.4	231.7	238.8
-26.0	192.2	200.1	207.9	215.5	222.9	230.2	237.3
-24.0	190.9	198.8	206.5	214.1	221.4	228.7	235.7
-22.0	189.7	197.5	205.1	212.7	220.0	227.2	234.2
-20.0	188.4	196.2	203.8	211.3	218.6	225.7	232.7
-18.0	187.2	194.9	202.5	209.9	217.2	224.3	231.3
-16.0	186.0	193.7	201.2	208.6	215.8	222.9	229.8
-14.0	184.8	192.4	199.9	207.3	214.5	221.5	228.4
-12.0	183.7	191.2	198.7	206.0	213.2	220.1	227.0
-10.0	182.5	190.0	197.4	204.7	211.8	218.8	225.6
-8.0	181.4	188.9	196.2	203.4	210.5	217.5	224.2
-6.0	180.3	187.7	195.0	202.2	209.2	216.1	222.9
-4.0	179.2	186.6	193.8	201.0	208.0	214.8	221.6
-2.0	178.1	185.4	192.7	199.8	206.7	213.6	220.3
.0	177.0	184.3	191.5	198.6	205.5	212.3	219.0
2.0	176.0	183.2	190.4	197.4	204.3	211.1	217.7
4.0	174.9	182.2	189.3	196.2	203.1	209.8	216.4
6.0	173.9	181.1	188.2	195.1	201.9	208.6	215.2
8.0	172.9	180.0	187.1	194.0	200.9	207.4	214.0
10.0	171.9	179.0	186.0	192.9	199.6	206.3	212.8
12.0	170.9	178.0	184.9	191.8	198.5	205.1	211.6
14.0	170.0	177.0	183.9	190.7	197.4	204.0	210.4
16.0	169.0	176.0	182.9	189.6	196.3	202.8	209.2
18.0	168.1	175.0	181.8	188.6	195.2	201.7	208.1
20.0	167.1	174.0	180.8	187.5	194.1	200.6	207.0
22.0	166.2	173.1	179.9	186.5	193.1	199.5	205.8
24.0	165.3	172.1	178.9	185.5	192.0	198.4	204.7
26.0	164.4	171.2	177.9	184.5	191.0	197.4	203.7
28.0	163.5	170.3	177.0	183.5	190.0	196.3	202.6
30.0	162.7	169.4	176.0	182.6	189.0	195.3	201.5
32.0	161.8	168.5	175.1	181.6	188.0	194.3	200.5
34.0	161.0	167.6	174.2	180.6	187.0	193.3	199.4
36.0	160.1	166.7	173.3	179.7	186.0	192.3	198.4
38.0	159.3	165.9	172.4	178.8	185.1	191.3	197.4
40.0	158.5	165.0	171.5	177.9	184.1	190.3	196.4
42.0	157.7	164.2	170.6	177.0	183.2	189.4	195.4
44.0	156.9	163.4	169.8	176.1	182.3	188.4	194.4
46.0	156.1	162.5	168.9	175.2	181.4	187.5	193.5
48.0	155.3	161.7	168.1	174.3	180.5	186.5	192.5
50.0	154.5	160.9	167.2	173.5	179.6	185.6	191.6
52.0	153.8	160.1	166.4	172.6	178.7	184.7	190.6
54.0	153.0	159.4	165.6	171.8	177.8	183.8	189.7
56.0	152.3	158.6	164.8	170.9	177.0	182.9	188.8
58.0	151.5	157.8	164.0	170.1	176.1	182.0	187.9
60.0	150.8	157.1	163.2	169.3	175.3	181.2	187.0
62.0	150.1	156.3	162.4	168.5	174.5	180.3	186.1
64.0	149.4	155.6	161.7	167.7	173.6	179.5	185.2
66.0	148.7	154.9	160.9	166.9	172.8	178.6	184.4
68.0	148.0	154.1	160.2	166.1	172.0	177.8	183.5
70.0	147.3	153.4	159.4	165.4	171.2	177.0	182.7
72.0	146.6	152.7	158.7	164.6	170.4	176.2	181.8
74.0	146.0	152.0	158.0	163.8	169.7	175.4	181.0
76.0	145.3	151.3	157.2	163.1	168.9	174.6	180.2
78.0	144.7	150.6	156.5	162.4	168.1	173.8	179.4
80.0	144.0	150.0	155.8	161.6	167.4	173.0	178.6
82.0	143.4	149.3	155.1	160.9	166.6	172.3	177.8
84.0	142.7	148.6	154.4	160.2	165.9	171.5	177.0
86.0	142.1	148.0	153.8	159.5	165.2	170.7	176.2
88.0	141.5	147.3	153.1	158.8	164.4	170.0	175.5
90.0	140.9	146.7	152.4	158.1	163.7	169.3	174.7
92.0	140.2	146.0	151.8	157.4	163.0	168.5	174.0
94.0	139.6	145.4	151.1	156.7	162.3	167.8	173.2
96.0	139.0	144.8	150.5	156.1	161.6	167.1	172.5
98.0	138.4	144.2	149.8	155.4	160.9	166.4	171.7
100.0	137.9	143.6	149.2	154.8	160.2	165.7	171.0
102.0	137.3	143.0	148.6	154.1	159.6	165.0	170.3
104.0	136.7	142.4	147.9	153.5	158.9	164.3	169.6
106.0	136.1	141.8	147.3	152.8	158.2	163.6	168.9
108.0	135.6	141.2	146.7	152.2	157.6	162.9	168.2
110.0	135.0	140.6	146.1	151.6	156.9	162.3	167.5
112.0	134.5	140.0	145.5	150.9	156.3	161.6	166.8
114.0	133.9	139.4	144.9	150.3	155.7	160.9	166.2
116.0	133.4	138.9	144.3	149.7	155.0	160.3	165.5
118.0	132.8	138.3	143.7	149.1	154.4	159.7	164.8
120.0	132.3	137.8	143.2	148.5	153.8	159.0	164.2
122.0	131.8	137.2	142.6	147.9	153.2	158.4	163.5
124.0	131.2	136.7	142.0	147.3	152.5	157.8	162.9
126.0	130.7	136.1	141.5	146.8	152.0	157.1	162.2
128.0	130.2	135.6	140.9	146.2	151.4	156.5	161.6
130.0	129.7	135.1	140.4	145.6	150.8	155.9	161.0

SPX VALVES & CONTROLS™

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 291cubic 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
Robert L. Fetterman
Senior Applications Engineer

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

SPX Valves & Controls · 8843 Martin Ave. · P.O. Box 577 · Lake City, Pennsylvania 16423 USA
Telephone: (814) 774-1500 · Fax: (814) 774-1681
Web Site: www.spxvalves.com · E-mail: info@spxvalves.com

Printed in the USA

FORM #8061130R-4
REV 8/21/88

Calc 2002-0002
Rev 0
Attachment 3
Page 1 of 1

CV-4012

SHEET 56 of

DATE
NAME M Baker

~~CONTROL VALVE SPECIFICATIONS~~ C.V.# 6810-81133

BLAW-KNOX COMPANY, COPES-VULCAN DIVISION — LAKE CITY, PENNSYLVANIA

CUSTOMER BECHTEL CORP ULTIMATE USER WISC-MICH POWER CUSTOMER # 6118-A

1. ITEM NO. 56 *QUANTITY (1)
2. *TYPE D-100 FORMS
3. *LINE SIZE 3" DB-9 *PIPE SCHEDULE 80
4. TAGGING CV-4012
5. APPLICATION AUX SGFP DISCH P-38A

OPERATING CONDITIONS

6. *Fluid WATER
7. *Flow Max. 200 GPM Nor. Min.
8. *Inlet Temp.-Max. 100°F Min. 100°F
9. *Inlet Press.-Max. 1410 PSIG Min. 1188 PSIG
10. *Press. Drop-Max. 1410 PSI *Min. (Sizing) 46.7 PSI

VALVE BODY

11. *Size 3" *USASI Pressure Standard 900#
12. *Material WCB
13. *Style [X] Globe [ ] Angle [ ] 3-Way
14. *Ends [ ] Flanged B16.5 [X] Butt Weld [ ] Socket Weld B16.11 [ ] Other — See Notes:

VALVE BONNET

15. *Type [X] Standard [ ] Cooling Fin
16. Material (Same as Body) WCB
17. Packing [X] Teflon Asb. [ ] Graph Asb. [ ] Other

VALVE

Material [ ] Hardened 416 S.S. [X] Hardened 440C S.S. [ ] Special
Type [ ] Single [X] Double
20. Characteristic [X] Mod. Parabolic [ ] Wear-Tip [ ] Cascade [ ] Special
21. Cv Factor 30/55

VALVE ACTUATOR

22. *Type [X] Diaphragm [ ] Lever [ ] Piston [ ] Electric
23. **Size 60 SQIN
24. *Action [X] Spring Opening (DA) [ ] Spring Closing (RA) [ ] Locks in Position [ ] See Notes
25. Air Press. Available

ACCESSORIES

26. *Handwheel [X] Top Mount [ ] Side Mount [ ] None
27. *Airlock [ ] Yes [X] No
28. *Limit Switches Mfr. NAMCO Type D-2400X Qty. 2
29. *Solenoid Valve Mfr. Type Qty.
30. *Booster Relay Mfr. Type Qty.
31. *E.P. Transducer Mfr. Type Qty.

POSITIONER

32. *Mfr. MOORE [ ] Type 72N
33. *Accessories [ ] By-Pass [X] Gauges
34. *Input Range [X] 3-15 [ ] Others - (Specify)
35. **Action [X] Direct [ ] Reverse
36. *Air Set [X] Yes [ ] No Qty.

SPECIAL REQUIREMENTS

[illegible]ray ASME [ ] Yes [ ] No
Special Tests [ ] See Notes:
Special Engr. [ ] See Notes:

Controller *Mfr.
*Type [ ] Press. [ ] Temp. [ ] Other (Specify)
*Control Form: [ ] Prop. [ ] Prop. – Reset [ ] Prop. + External Reset
*Scale Range
*Output Range
[ ] 3-15 Psi [ ] Other (Specify)
*Capillary Length
*Airset [ ] Yes [ ] No

NOTES:
1 VALVE TO HAVE CAR LOCKS.

TO BE COMPLETED BY C.V.D. ENGR.:
Actuator Spring: S-77857
Precompression: MIN
Air to Operate: 23 PSIG
Trim Size: 2" Stroke 3/4
Serial No.: 6810-81133-39-
Plug: L-134209
Cage: L-93522 MKD.
Stem: M-129506 Packing 83391
Gasket: 81070
Accessory Kit: S-135169 & S-14069

[redacted]
[redacted]

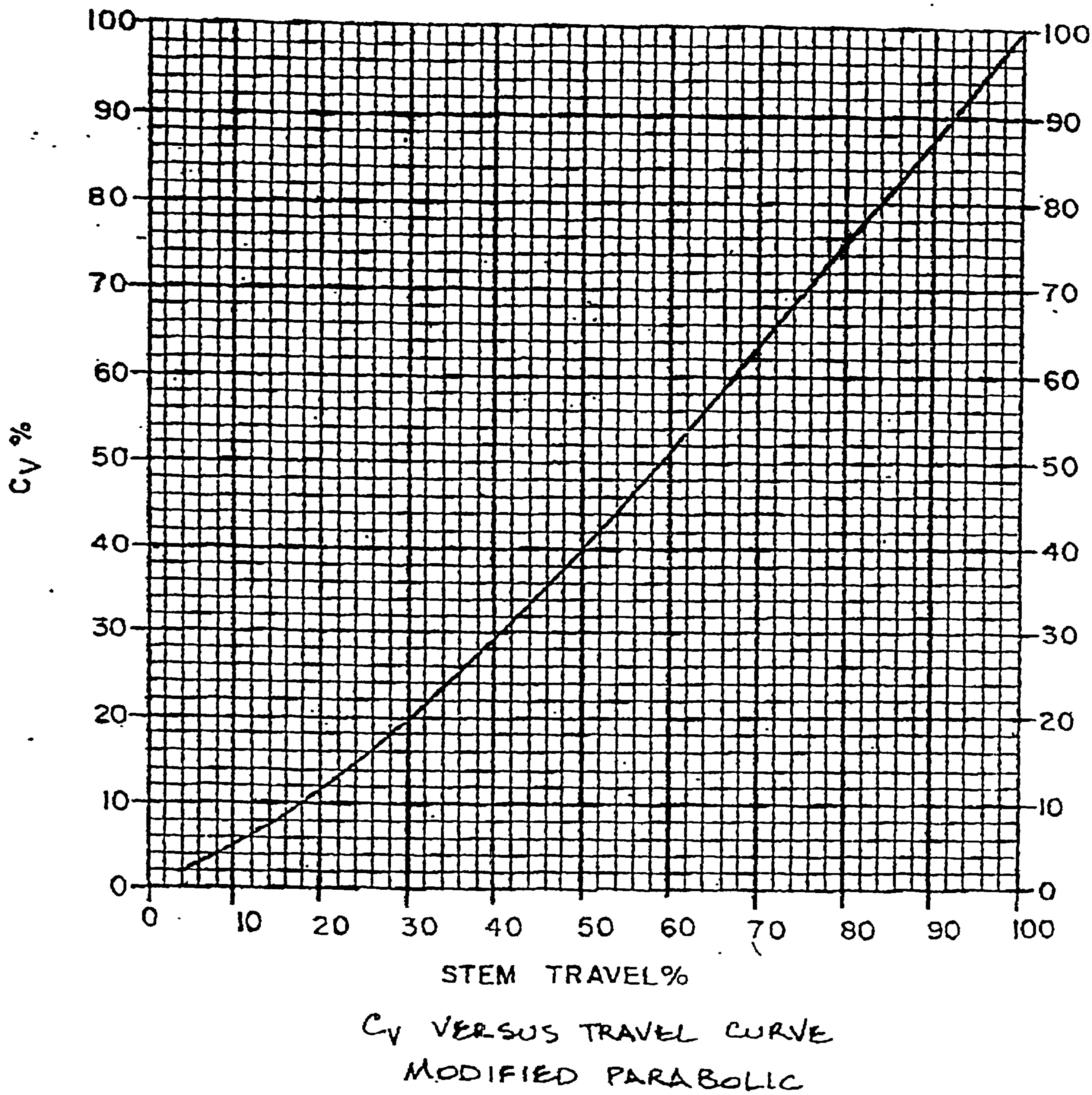
* Indicates Information Required to Process Order
** Indicates to be Reviewed by Engineering

BEST COPY AVAILABLE

M-185460

Calculation 2002-0002 Rev 0

Attachment 4 page 1 of 1

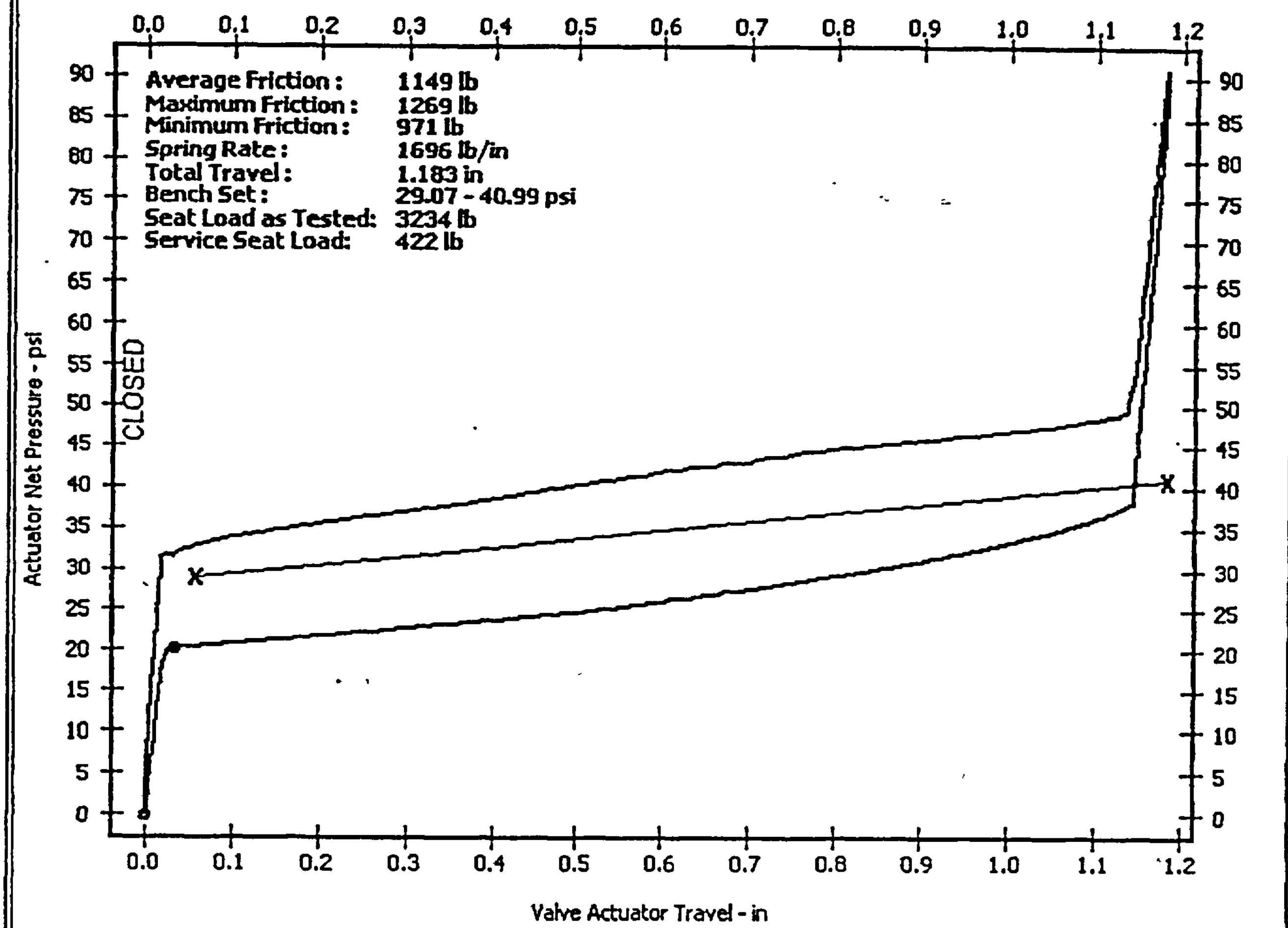


GRAPH

FlowScanner

TAG NUMBER	0AF04007
SERIAL NUMBER	762095376248
DESCRIPTION	2", 1500#, D100-160 RA, None, None
TEST TIME	10/26/1996 12:29:20 AM

0AF04007 #762095376248 26-Oct-96 12:29 AM	FlowScanner Diagnostics V5.51 Dynamic Scan	(c) FISHER Controls 1989-2000 10-Jan-02 11:35 AM

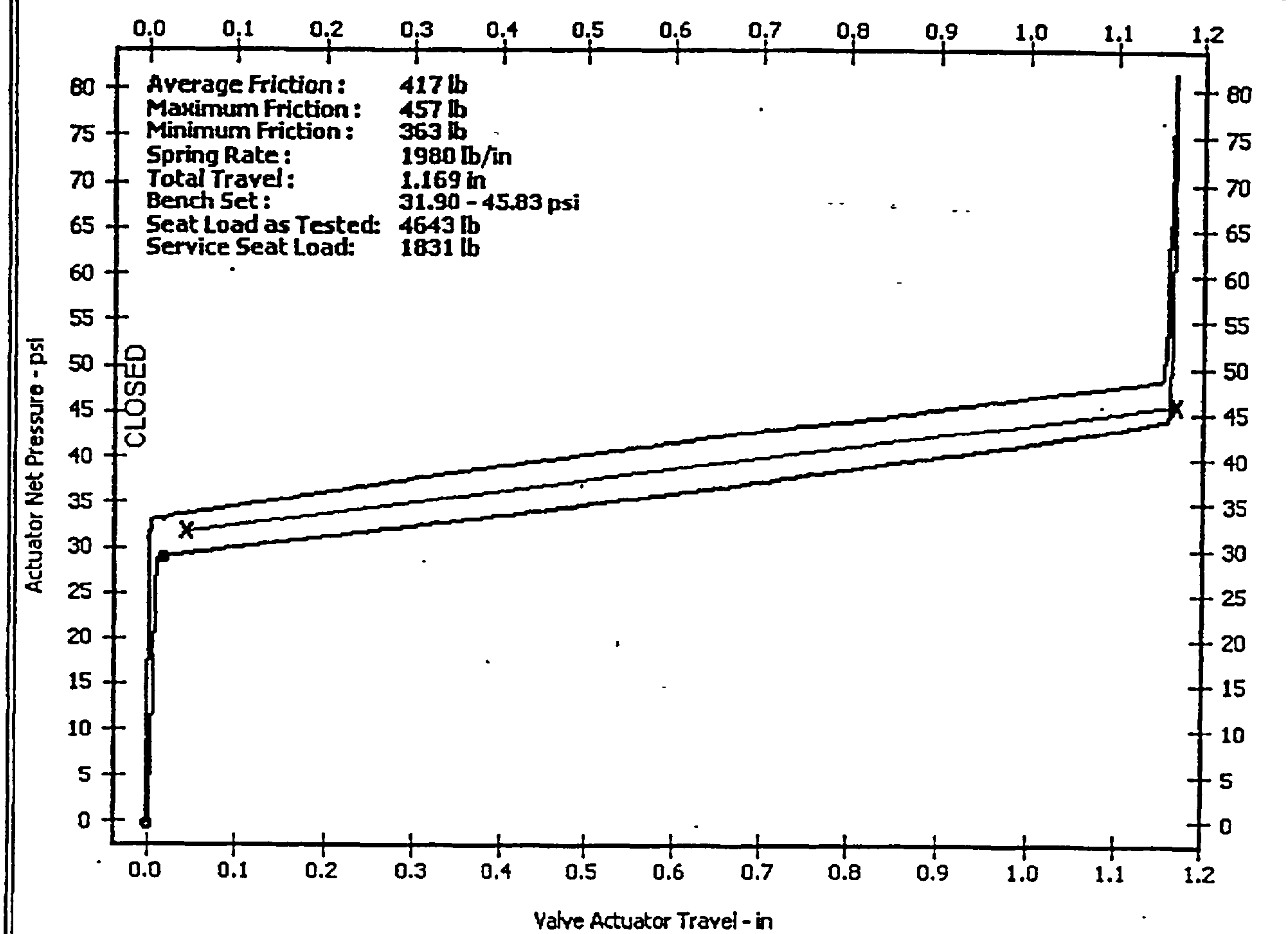


GRAPH

FlowScanner

TAG NUMBER	0AF04014
SERIAL NUMBER	762095376248
DESCRIPTION	2", 1500#, D100-160 RA, None, None
TEST TIME	11/4/1996 8:39:11 AM

0AF04014 #762095376248 04-Nov-96 08:39 AM	FlowScanner Diagnostics V5.51 Dynamic Scan	(c) FISHER Controls 1989-2000 10-Jan-02 09:15 AM



FLOWSERVE

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

<u>S/N 681-S-1028/29:</u> 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 continuos minimum flow rate for the pumps.

FLOWSERVE

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

S/N 681-S-1030/31: P38A & P-38B

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 continuos 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 then 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

Flowserve Corporation
Pump Division
256 Fallbrook Court
East Dundee, IL 60118
Telephone 847-836-8984
Facsimile. 847-836-8985
Email pprom@flowserve.com

FOXBORO CATALOG

Attachment 7

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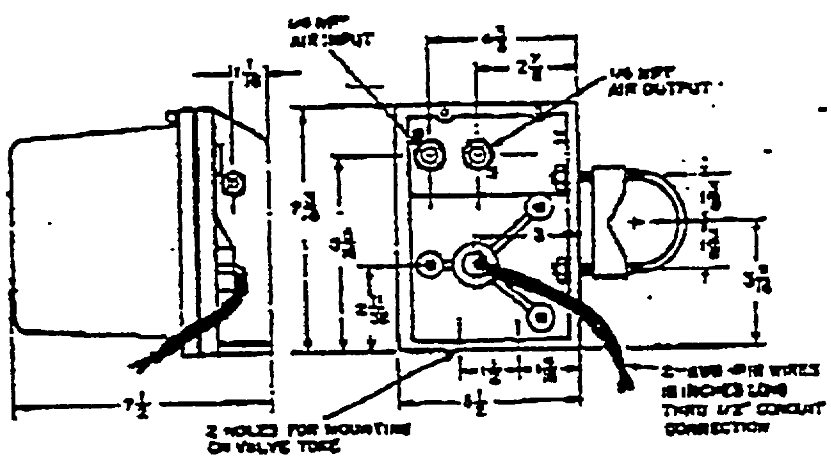
Specifications

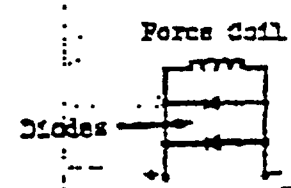
Input and Output Signals:	10-50 ma input with 3-15 (0.2-1 kg per sq cm), 3-27 (0.2-1.8 kg per sq cm), 5-25 and 6-30 psi output 10-30 ma input with 3-15 psi output 30-50 ma input with 3-15 psi output 4-20 ma input with 3-15 psi output Note: Output is calibrated to 0-18 psi or 0-32 psi when transducer is used with a valve.
Input Impedance:	170 ±10 ohms
Action:	Increasing input to increase or decrease output (Reversible in field)
Mounting:	Valve yoke, surface, or 2-inch pipe. Calibrated for vertical mounting unless otherwise specified.
Enclosure Classification:	Weatherproof NEMA 3
Air Supply:	20 psi (1.4 kg per sq cm), or 5 psi above maximum output
Electrical Connections:	Two 18-inch leads through a 1/2-inch threaded conduit connection
Pneumatic Connections:	1/4 NPT
Air Consumption:	With 40D relay (black cover), 1.25 scfm during normal operation With 40C relay, 0.75 scfm during normal operation
Base:	Cast aluminum, polyester finish
Cover:	Molded fiber glass
Color:	Foxboro Green
Accuracy:	1/2 of 1% of full scale (factory calibration) 1/4 of 1% of full scale (on site, in-position calibration)

Mounting Dimensions



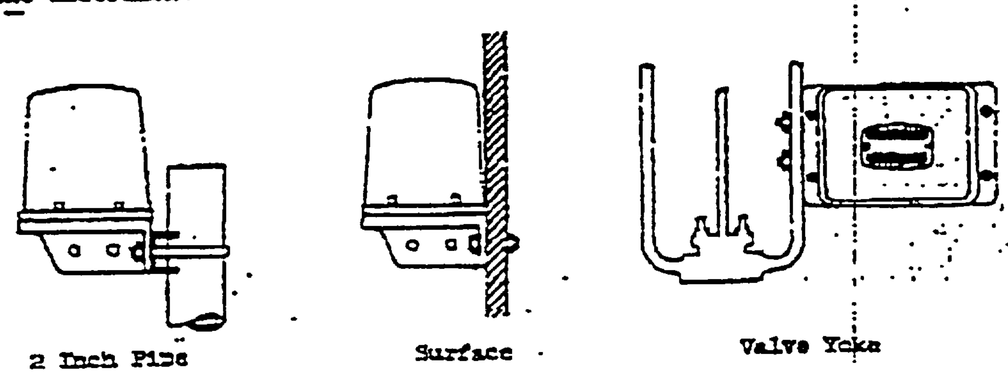
Type T (Intrinsically Safe) Instruments

With instruments listed for use in intrinsically safe loops, 2 diodes (silicon, Type 1N645, Part N1098Z) must be present in parallel across the force coil.



Installation

The instrument is calibrated for vertical mounting unless otherwise specified.



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

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

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Memorandum of Telephone Conversation **SARGENT & LUN**

(717) 234-8021 Date 5/14/97 Time 8:40

Person Called: Clark Hall (Technical Manager)	Company: Taylor-Wharton Cylinders
Person Calling: Bret Nelson	Company: S&L
Project: N_2 bottle sizing for AOV's	Project No. 09334-266

Subject Discussed: N_2 Cylinder Sizing and Fill Parameters

Summary of Discussion Decisions and Commitments: Per the measurements I supplied to Mr. Hall (9.25" O.D. x 55" height w/o valve), the proposed cylinder a "3AA2400". This will be stamped on the cylinder. If stamped with a "+", the cylinder qualifies for a 10% over-fill (2400 psig x 1.10 = 2640 psig)

The water volume of the 3AA2400 cylinder is 2990 in³

For sizing + filling Taylor-Wharton relies on NBS stand at 70°F. NBS Tech Note 1079 provides the following standa volumes for N_2 at 70°F:

psig	SCF/ft³
2700	177.0
2600	171.2
2500	165.4
2400	159.4
1500	102.8

At lower pressures, below 1500 psig, nitrogen more nearly approximates Ideal Gas behavior.

cc

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File

Bret Nelson

Based on a phone conversation on May 3, 2001 between Bill Worloff of Moore Products Inc and John P Schroeder, NMC, the P/P constant bleed will be approximately 0.75 SCFM.

John P. Schroeder

Note: This phone conversation applies to P/P-4012 and P/P-4019.

Rob Chapman

1/25/2002

ATTACHMENT 11

Per a telephone conversation on January 24, 2001 between Dave Abbot of Copes Vulcan and Rob Chapman, PBNP, the approximate dead volume of a D-100-60 valve operator is 40 in^3.

Rob Chapman
PBNP Design Engineering