RPP-CALC-62640
Revision 0

Tank Side Cesium Removal Process Pump Flow Analysis

Prepared by

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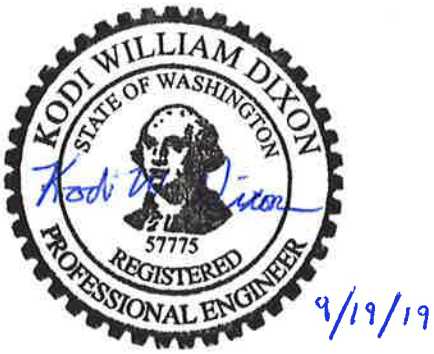
Date Published
July 2019



Prepared for the U.S. Department of Energy
Office of River Protection

Contract No. DE-AC27-08RV14800

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Further Dissemination Unlimited

RPP-CALC-62640, Rev. 0

ARES CORPORATION	**CALCULATION COVER SHEET**	Page No. 1 of 68 Date 7/18/2019 Rev. No. 0 Calculation No: 078906.18.01-M-002

Project No.	Project Title:	Client:
078906.18.01	Design of TSCR Upgrades	Atkins

Title:
Tank Side Cesium Removal Process Pump Flow Analysis

Purpose and Objective:
The purpose of this calculation is to evaluate the performance envelope for sizing of the Tank Side Cesium Removal (TSCR) process pumps (AP07F-WT-P-001 or AP07F-WT-P-002) located in tank 241-AP-107. This calculation also sizes the orifice diameter on the recirculation line dropleg jumper (AP07F-WT-EPDMJ-[C-D]).

Rev. No.	Total Pages		Prepared By	Checked By	PM/TL
0	68	Print Name/ Sign:	JF Gallegos	KW Dixon	PM Dorsh, PE
		Date:	7/25/19	7/25/19	7/25/19

Revision Description (Revision Description/Affected Pages):
Initial release.

		Print Name/ Sign:			
		Date:			

Revision Description (Revision Description/Affected Pages):

CALCULATION REVIEW CHECKLIST

Project No.	Calculation No.	Rev. No.	Page No.
078906.18.01	078906.18.01-M-002	0	2 of 68

Items Checked	Accept Y	Accept N	Accept N/A	Description of Resolution for Unacceptable Items
1. Cover sheets properly completed.	√			
2. Calculation sheet headers complete with calculation number, revision number, etc.	√			
3. Calculation sheet contents are legible, accurate, and complete per format.	√			
4. Listed attachments included.	√			
5. Calculation objective clearly described.	√			
6. Criteria are suitable and properly referenced to task specific documents.	√			
7. Assumptions and input data, selected, described, reasonable, and attached or referenced to task documents.	√			
8. Calculation method identified and appropriate for the design activity.	√			
9. Calculation results reasonable and correctly described in results and conclusions.	√			
10. Physical property calculations generated by CAD software verified via hand calculations.			√	
11. Computer program identified with version and revision.	√			
12. Computer input/output provided or referenced and reasonable.	√			
13. Computer run traceable to calculation (file #, etc.).	√			
14. Computer input/output data and problem type within validation/verification range of use.	√			
15. Computer program validation/verification addressed.	√			
16. Computer operating system in use for calculation preparation is the same as when the software was verified on machine.	√			

Calculation Checking Method	√	Applicable Pages
1. Direct Step-by-Step Check	√	All
2. Reference Chart(s) or Book(s) Comparison (Append Documentation)		
3. Alternate Calculation (Append Documentation)		

Comments:
None.

Preparer (Print Name and Sign):	Date:
JF Gallegos	7/25/19
Checker (Print Name and Sign):	**Date:**
KW Dixon Kodi Dixon	7/25/19

Signatures obtained only after discrepancies are corrected and comments are resolved.

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Acronyms

ATM	Atmosphere
BEP	Best Efficiency Point
cP	centipoise
dH	Differential Head
FCV	Flow Control Valve
ft	Feet
gpm	Gallons Per Minute
HIHTL	Hose-In-Hose Transfer Line
IXC	Ion Exchange Column
lbf	Pound Force
OSD	Operational Specification Document
psid	Pounds Per Square Inch Differential
TSCR	Tank Side Cesium Removal

1.0 PURPOSE

The purpose of this calculation is to evaluate the performance envelope for sizing of the Tank Side Cesium Removal (TSCR) process pumps (AP07F-WT-P-001 or AP07F-WT-P-002) located in tank 241-AP-107. This calculation also sizes the orifice diameter on the recirculation line discharge jumper (AP07F-WT-EPDMJ-[C-D]).

2.0 METHODOLOGY

2.1 System Model

The general layout of the entire TSCR system can be seen in H-14-111331. The system is modeled using the incompressible fluid modeling program AFT Fathom TM[1]. The model starts at the pump located in AP Farm at pit AP-07F. Note that two pump locations are reserved in this pit however; only one pump location will be evaluated for the purposes of this analysis due to minimal jumper flow path differences. The pump does not allow for an adjustable inlet height; therefore, the pump inlet will always be located near the bottom of the tank. Located near the top of the pump column in the head space of the tank are two weep holes (SK-AP-07F-001). Following the weep holes the flow exits the discharge nozzle of the pump and enters the jumpers located in pit AP-07F. Flow exits the pit heading east towards the TSCR unit via Hose-in-Hose Transfer Lines (HIHTL).

Once within the TSCR unit the flow splits. A small fraction of flow (~5 gpm) is bled off through the TSCR unit via flow control valve WP-FCV-306, while the remainder of the flow is redirected to the recirculation leg to go back to AP-07F. The fraction of flow that passes through the TSCR unit is processed as it goes through the numerous components such as Ion-Exchange Columns (IXC), Filter, etc. The pressure loss through this unit during high and low head loss conditions is determined in RPP-CALC-62574. Once exiting the TSCR unit, the now treated effluent is routed to a dropleg in tank 241-AP-106 via HIHTL.

2.1.1 Constant Inputs

Variances in pipe/hose/HIHTL inside diameters, fluid temperature and sending/receiving tank head-space vacuum levels have minimal effect on the results of this evaluation. For the items listed above a nominal value is used regardless of them having a range. Also, note that intermediate elevations in the pipeline have negligible effect on the results as well.

2.2 Flow Optimization Overview

In order to provide the required flow rate through the TSCR unit the orifice diameter of the recirculation jumper needs to be determined. Weep hole diameters on the pump column are sized to be larger than the screen size on the inlet of the pump. Further optimization of the weep holes may be performed if determined to be beneficial for pump operation by the manufacturer.

[1] Fathom is a registered trademark of Applied Flow Technology, Colorado Springs, Colorado.

2.2.1 Flow Optimization

To start the optimization, a representative pump curve is input into the model (see Design Inputs). Pump curve data is provided relative to the discharge nozzle of the pump, therefore weep holes are not modeled. Weep holes are provided in the pump column to ensure fluid backup does not occur in pit jumpers. The only critical characteristic of the weep holes is that the diameters are larger than the pump inlet screen size of ¼" (SK-AP-07F-001). Therefore, a weep hole diameter of 5/16" is sufficient. Further optimization of the weep holes may be performed so that the pump operates closer to its best efficiency point (BEP) if determined to be beneficial for pump operation/longevity by the manufacturer. Finally, the diameter of the orifice located in jumper assembly AP07F-WT-EPDMJ-[C-D] (Ref., H-14-111335) is determined. As the orifice diameter increases, pump flow increases and TSCR flow decreases. As orifice diameter decreases, pump flow decreases and TSCR flow increases. These statements are based on no flow control at the TSCR unit. The goal of the optimization is to size the diameter of the orifice so that it will provide a flow rate above the nominal 5 gpm and below the maximum 6 gpm to the TSCR unit using the highest head loss system parameters.

2.2.2 Pump Model

The TSCR pump is a custom designed long length submersible pump. The pump outlet is defined as the discharge nozzle located approximately 49ft higher than the pump inlet. A representative pump curve is provided, which measures the pump head at the discharge nozzle rather than at the outlet of the last pump impeller. Therefore, in order to correctly model the pump performance in Fathom, the pump curve values must be adjusted.

In Fathom the pump junction is used with the submerged pump option. In this junction the pump inlet is modeled at the low liquid level elevation and the pump outlet is modeled approximately 49ft (ΔH) higher at the discharge nozzle elevation in the pump pit (see Figure 2-1). This allows for the tank liquid levels to be modeled according to actual elevations. Also, since the representative pump curve head values are measured at the pump discharge nozzle, the pump performance can be modeled more accurately without having to determine head loss due to elevation, pump column losses and flow loss due to weep holes in the pump column.

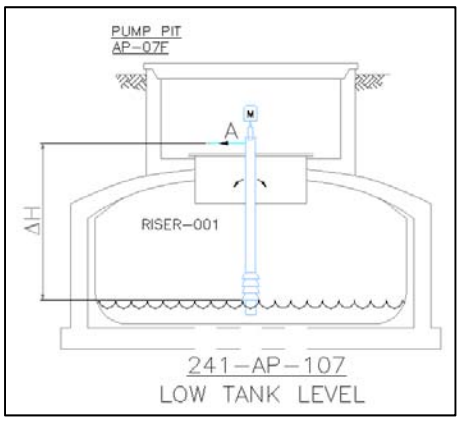

Figure 2-1. Simplified Pump and Tank Elevation Model

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The following steps are taken for adjusting the representative pump curve and system curves for evaluation. **Step 1**: Start with the representative pump curve (Figure 2-2). Head values are measured from the discharge nozzle located in AP-07F pump pit. **Step 2**: To account for the elevation head difference between the pump suction and the point of measurement at the discharge nozzle, 49ft of head is added to the representative pump curve head values (Figure 2-2). This new adjusted pump curve is then input into the Fathom model. After running the model with the adjusted pump curve shown in Step 2, results are populated in Table 6-1.

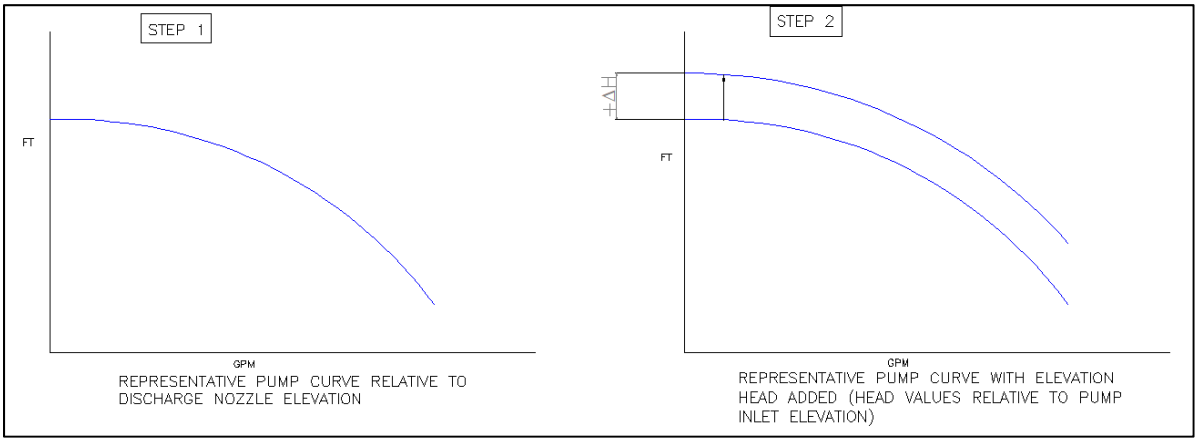

Figure 2-2. Simplified Pump vs System Curve Fathom Model (not to scale)

Step 3: The adjusted pump curve and system curve are plotted from Fathom. These curves are relative to the tank liquid level which is equal to the pump inlet. These curves are then modified by subtracting 49ft from the head values to make them relative to the discharge nozzle (Figure 2-3). This allows any pump curve produced by the manufacturer to be overlaid directly onto the system curve without data manipulation. Note: System curves cannot be generated in Fathom relative to the discharge nozzle. **Step 4:** The resultant curves relative to the discharge nozzle elevation are shown in Figure 2-3. Actual curve values are shown in Figure 6-1. Pump performance values obtained during testing should only be compared to the curves in Figure 6-1.

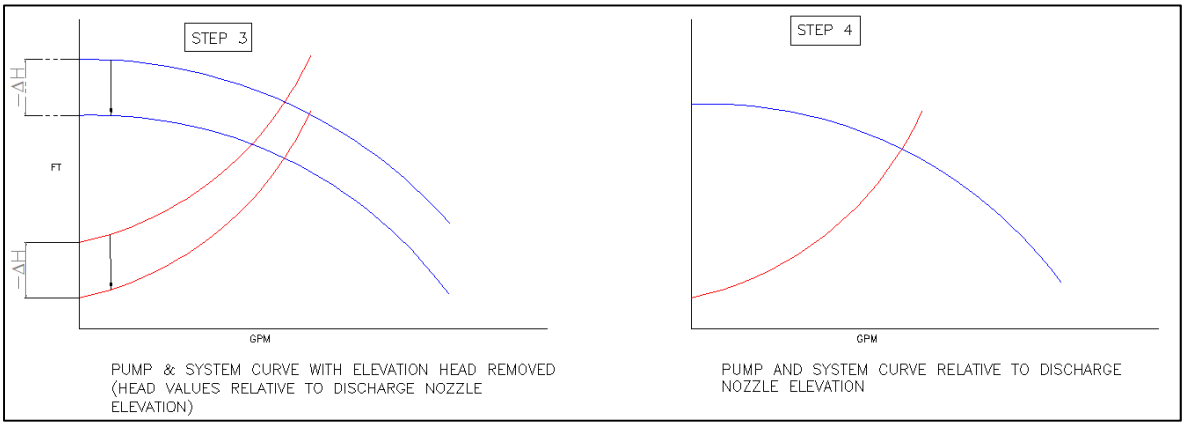

Figure 2-3. Simplified Pump vs System Curve Result Model (not to scale)

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3.0 DESIGN INPUTS

1. Fluid properties are per Attachment 2:

    a. Density of 1.25 g/mL is used for this evaluation. Density has no impact on the system or pump curve head values but is necessary when reporting pressures.

    b. Absolute/dynamic viscosity of 5 cP is used for this evaluation which corresponds to the high end of the nominal range provided. The higher viscosity value results in the highest required pump head.

    Note that although varying fluid temperatures will impact the density or absolute/dynamic viscosity, they will have minimal effect on pump sizing.

2. Tank 241-AP-107 fluid level is modeled at an elevation of 625.9 ft (tank level of 27 inches), which is the pump inlet elevation (see Attachment 1).

3. Tank head space ventilation vacuum levels are not accounted for as they have minimal effect on the overall results. A liquid surface pressure of 1 atmosphere (atm) is used.

4. All pipe outside of the TSCR unit is modeled as carbon steel, with an absolute roughness of 0.0018 inches per Crane pg. A-24. This is higher than the default Fathom stainless steel roughness since the default value could not be independently verified.

5. HIHTL absolute roughness is modeled as 0.00126 inches (RPP-22668).

6. The discharges into tank 241-AP-106, 241-AP-107 and 241-AP-108 are into the head space of the tank at an exit pressure of 1 atm.

7. Nominal flow through TSCR unit is 5 gpm (Ref., RPP-RPT-60603, Table 2-2).

8. The pump curve used in this evaluation is based on a representative pump (Attachment 3) that is modified for the model (see Section 2.2.2). This pump contains 5/16" diameter weep holes. Note that two pump locations are reserved in 241-AP-07F pump pit. For the purposes of this analysis only flow from the furthest pump location will be considered since the difference in flow paths is minimal and will have negligible impact on results. The results of this analysis will be negligibly impacted regardless of which pump location is modeled.

9. The pump column is modeled as a total of 49.3' long per SK-AP-07F-001 (61871-010-RFI-001). This value may vary +/-2ft with insignificant impacts to the pump curve. The diameter of the pump column is unknown but is conservatively modeled as 6" SCH 40S pipe to simulate minimal pressure loss. Losses due to the drive shaft within the column are considered negligible due to the large cross-sectional flow area and are therefore not accounted for.

10. Jumper AP07F-WT-J-[P1-P2-(A)] is modeled per H-14-111334 as 5' of 2" SCH 40S pipe with (1) – 90° PUREX connector, (1) – three-way valve with through flow, and (2) – 90° smooth elbows r/D= 1.5. Note that the magnetic flow meter and pressure isolator have negligible pressure loss and are therefore not modeled.

11. Jumper AP07F-WT-EPDMJ-[A-B] is modeled per H-14-111342 as 45" of 2" inside diameter hose with (2) – 90° smooth elbows r/d=1.5 to account for hose bends and (2) 90° PUREX connectors.

12. The Process Feed HIHTL from AP-07F to the TSCR unit is modeled per H-14-111331 as 2" inside diameter hose, 330' long. (1) - 90° smooth elbow r/d=1.5 per H-14-111340, (10) – 90° smooth bends r/D=6 are modeled to account for bends in the hose per H-14-111331 and H-14-111357.

13. The recirculation line HIHTL to 241-AP-07F discharge from the TSCR unit is modeled as 338 ft with (5) 90° smooth flanged elbows to account for bends in the hose (Ref., H-14-111331). An additional 3 ft of length is added to the supply HIHTL to account for the jumper length to the discharge in H-14-111342.

14. The AP07F-WT-EPDMJ-[C-D] jumper connected to the recirculation discharge contains a 17/32" diameter orifice per H-14-111335. Since the orifice is located at the inlet of the vertical dropleg, flow will spray vertically down into a short 2" diameter pipe (H-14-111336). By inspection the fluid will free fall without building back pressure. Therefore, the discharge elevation is modeled approximately equal to the face of flange elevation at 674' (H-14-111357).

15. The HIHTL treated effluent line from the TSCR unit to 241-AP-106 dropleg is modeled as 211 ft of 2" diameter hose (H-14-111344). The hose includes (5) smooth 90° elbows r/D = 6 in order to account for bends in the hose per H-14-111331.

16. The flow through the dropleg at 241-AP-106 (H-14-111344) is not modeled due to the low flow rate (~5 gpm) through the line. Due to the low flow rate the drop leg flow will be unable to become fully developed resulting in the fluid free falling once reaching the drop leg elbow. Therefore, the flow path ends at the drop leg inlet elevation and does not include gravity head to the end of the drop leg.

17. All TSCR unit design inputs are identified in RPP-CALC-62574. The high head loss inputs of RPP-CALC-62574 are used in this analysis.

4.0 ASSUMPTIONS

No unverified assumptions were used in this calculation.

5.0 COMPUTER SOFTWARE

The pipe flow modeling software, AFT Fathom Version 9.0 (2016.01.20) was used to model the piping system. This software is an engineering tool used in the evaluation of incompressible flow in pipe networks. The program was executed on a Dell™[3] computer having Service Tag No. 70YL1R1. This software has been validated through several hydraulic solution verification models that have been compared to publish results (Ref., ARES V&V No. VV-16-11-020). Mathcad®[2] 15 was used for the hand calculations. All Mathcad®[2] 15 computations are checked using a handheld calculator.

[2] Mathcad® is a registered trademark of Parametric Technology Corporation., Needham, MA.
[3] Dell Technologies, Dell, EMC, Dell EMC, and other trademarks are trademarks of Dell Inc. or its subsidiaries.

6.0 RESULTS

6.1 Pump Sizing

The pump curve identified in the Design Inputs and the system curve associated with high head loss flow through the TSCR unit is shown in Figure 6-2 below. A summary of the model results for the high head loss scenario is provided in Table 6-1.

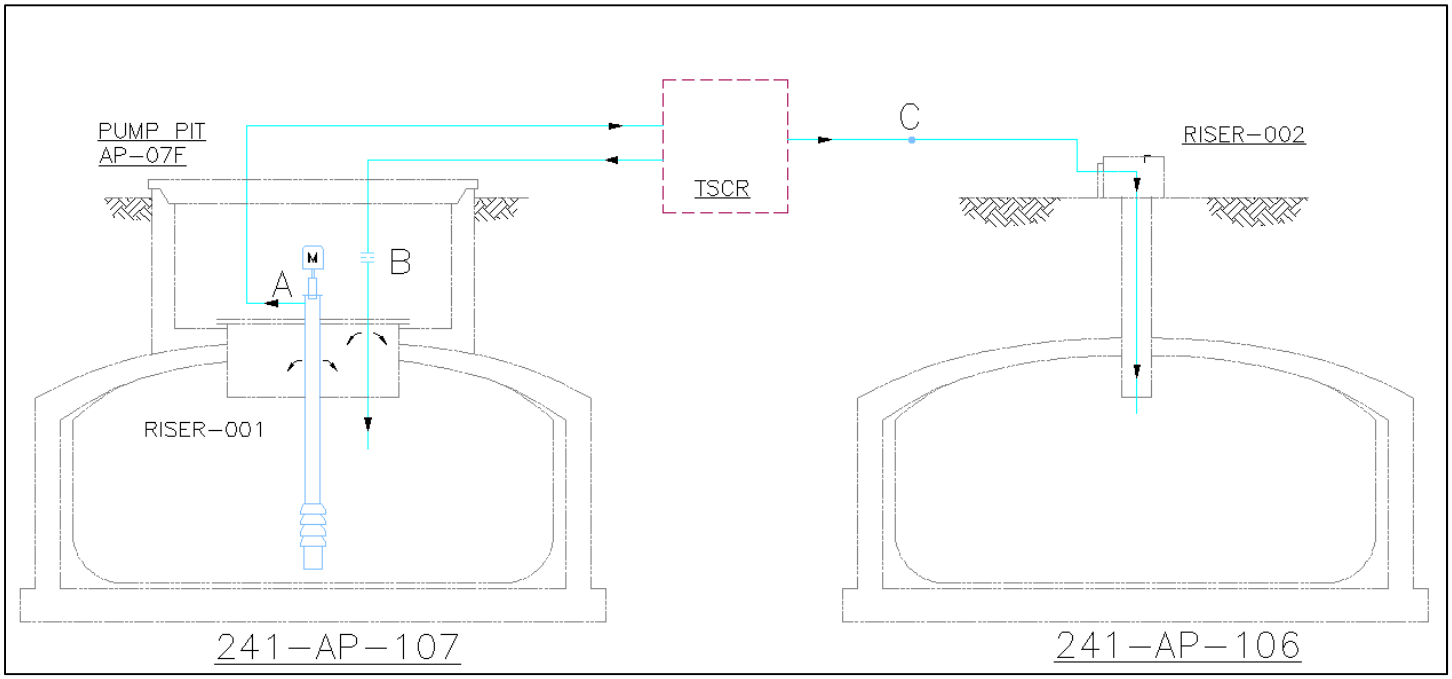

Figure 6-1. Simplified Model

Table 6-1. Model Results from Points Specified in Figure 6-1 Relative to Pump Suction

Variable	High Head Loss
AP-107 Fluid Elevation (ft)	625.9
Fluid Viscosity (cP)	5
Fluid SpG	1.25
A-Pump Flow (gpm)	61.39
A-Pump Differential Head (ft)	396.8
B-Orifice Inlet Pressure (psig)	148.2
B-Orifice Diameter (in)	17/32
C-TSCR Outlet Flow (gpm)	5

Note: All TSCR results are provided in RPP-CALC-62574.

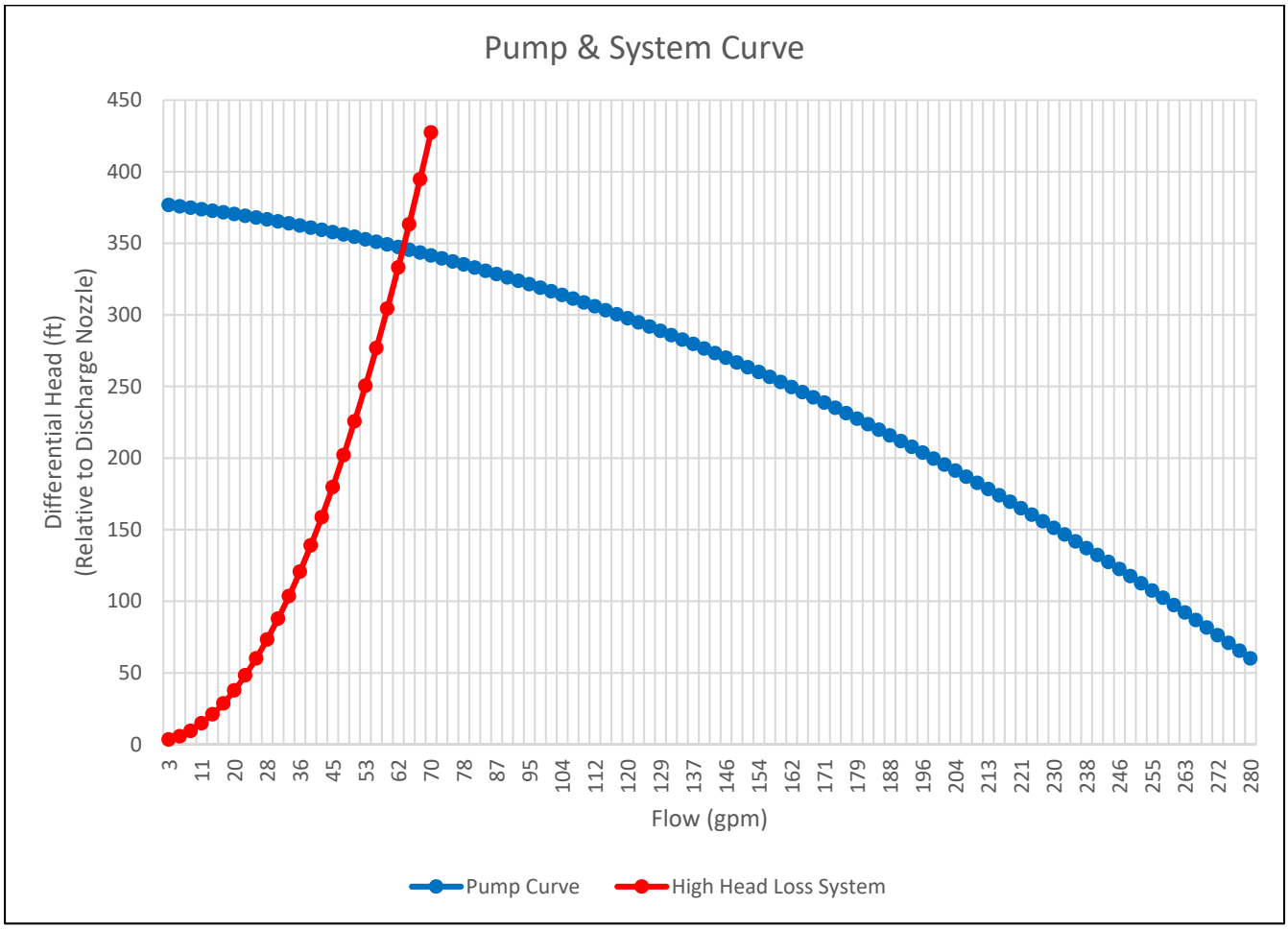

Figure 6-2. AP-07F Pump vs System Curve

6.2 Pump Performance

The calculation determined the maximum differential head and flow requirements of the pump to be 347.5 ft at 61.4 gpm. Pump curve head values can vary by +0%/-5%. The pump curve may be adjusted during (1) testing via (a) weep hole(s) adjustment, and (b) recirculation line orifice resizing and (2) TSCR flow control valve manipulation. Note, head values are relative to the pump discharge elevation of 675.2ft.

6.3 Orifice Sizing

The calculation determined that an orifice diameter of 17/32" is required to provide enough pressure to maintain 5 gpm flow to the TSCR unit during high head loss conditions.

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7.0 REFERENCES

1. 61871-010-RFI-001, *TSCR PUMP*, Rev. 0, U.S. Department of Energy, Richland, WA.
2. ARES Software Verification and Validation No. VV-16-11-020, *Verification and Validation of AFT Fathom Version 9.0 (2016.01.20)*, Rev. 0, (available upon request).
3. Crane, *Technical Paper 410, Flow of Fluids Through Valve, Fittings, and Pipe*, 2011, CRANE Co., Stamford, CN.
4. H-14-111331, *AP Farm TSCR Upgrades HIHTL Layouts General Arrangement*, Rev. 0, U.S. Department of Energy, Richland, WA.
5. H-14-111334, *AP Farm TSCR Upgrades Jumper Assembly AP07F-WT-J-[P1-P2-(A)]*, Rev. 0, U.S. Department of Energy, Richland, WA.
6. H-14-111335, *AP Farm TSCR Upgrades Jumper Assembly AP07F-WT-EPDMJ-[C-D]*, Rev. 0, U.S. Department of Energy, Richland, WA.
7. H-14-111336, *AP Farm TSCR Upgrades 241-AP-07F Dropleg Disch Notes and Parts List*, Rev. 0, U.S. Department of Energy, Richland, WA.
8. H-14-111337, *AP Farm TSCR Upgrades 241-AP-07F Riser Adapter Notes and Parts List*, Rev. 0, U.S. Department of Energy, Richland, WA.
9. H-14-111340, *AP Farm TSCR Upgrades 241-AP-07F HIHTL Strbk Notes and Parts List*, Rev. 0, U.S. Department of Energy, Richland, WA.
10. H-14-111342, *AP Farm TSCR Upgrades Jumper Assembly AP07F-WT-EPDMJ-[A-B]*, Rev. 0, U.S. Department of Energy, Richland WA.
11. H-14-111344, *AP Farm TSCR Upgrades AP-106 Riser 2 Dropleg Notes and Parts List*, Rev. 0, U.S. Department of Energy, Richland, WA.
12. H-14-111357, *Piping AP Farm TSCR Upgrades Hydraulic Diagram*, Rev. 0, U.S. Department of Energy, Richland, WA.
13. H-2-77455, *Piping Pump Pit Details*, Rev. 2, U.S. Department of Energy, Richland, WA.
14. H-2-90534, *Tank Cross Section 241-AP Tanks*, Rev. 4, U.S. Department of Energy, Richland, WA.
15. Lindeburg, *Mechanical Engineering Reference Manual*, 13th Ed., Professional Publication Inc., Belmont, CA.

16. OSD-T-151-00007, *Operating Specification for the Double Shell Storage Tanks*, Rev. 23, Department of Energy, Richland, WA.

17. RPP-22668, *River Bend Transfer Systems Hose Roughness Calculation*, Rev. 0, Washington River Protection Solutions, Richland, WA.

18. RPP-CALC-62574, *Tank Side Cesium Removal (TSCR) Process System Flow Analysis*, Rev. 0, Department of Energy, Richland, WA.

19. RPP-CALC-62576, *Tank Side Cesium Removal Unit Hydraulic Transient Analysis*, Rev. 0, U.S. Department of Energy, Richland, WA.

20. RPP-RPT-60603, *Interface Management Agreement between TF Upgrades Project (Project #T1P190) and the Tank Side Cesium Demonstration Project (Project #TD101)*, Rev. 02, U.S. Department of Energy, Richland, WA.

21. SK-AP-07F-001, *AP Farm TSCR Upgrades AP-107F Pump Sketch*, Rev. 0, Sargent & Lundy, Richland, WA.

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APPENDIX A

FATHOM MODEL

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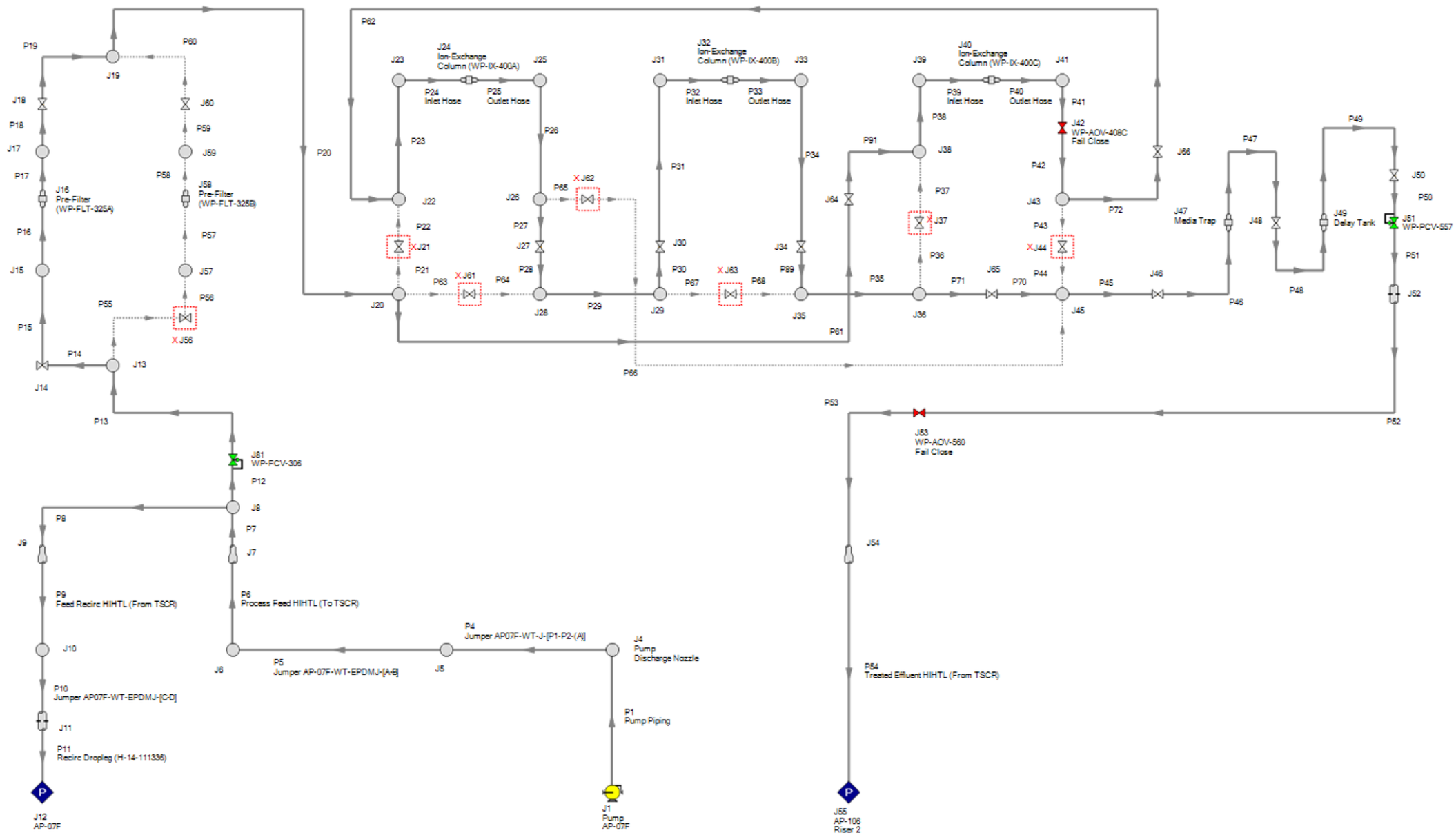

APPENDIX B

HIGH HEAD LOSS MODEL INPUT

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AFT Fathom 9 (Model) 7/18/2019 Page 1	AFT Fathom Model	

General

Title: AFT Fathom Model
Input File: P:\Clients\Atkins Energy Federal EPC, Inc\078906.18.01 - Design of TSCR Upgrades\Calculations\Mechanical\M-002 \Rev 0\Fathom V&V\TSCR Pump Sizing.fth
Scenario: Base Scenario/Dirty

Number Of Pipes= 71
Number Of Junctions= 65

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: User Specified
Fluid= User Specified
Density= 1.25 kg/liter
Viscosity= 5 centipoise
Vapor Pressure= 7.52 psia
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Tee or Wye, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300

Pipes

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness
1	Pump Piping	Yes	2.2	feet	6.065	inches	Standard	0.0018
4	Jumper AP07F-WT-J-[P1-P2-(A)]	Yes	5	feet	2.067	inches	Standard	0.0018
5	Jumper AP-07F-WT-EPDMJ-[A-B]	Yes	45	inches	2	inches	Unspecified	0.00126
6	Process Feed HIHTL (To TSCR)	Yes	330	feet	2	inches	Unspecified	0.00126
7		Yes	3.5	feet	1.61	inches	Standard	0.0018
8		Yes	5.5	feet	1.61	inches	Standard	0.0018
9	Feed Recirc HIHTL (From TSCR)	Yes	335	feet	2	inches	Unspecified	0.00126
10	Jumper AP07F-WT-EPDMJ-[C-D]	Yes	55	inches	2	inches	Unspecified	0.00126
11	Recirc Dropleg (H-14-111336)	Yes	1	feet	2.067	inches	Standard	0.0018
12		Yes	0.5	feet	0.622	inches	Standard	0.0018
13	Pipe	Yes	3.5	feet	0.622	inches	Standard	0.0018
14	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018

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Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness
15	Pipe	Yes	2	feet	0.622	inches	Standard	0.0018
16	Pipe	Yes	3	feet	2.067	inches	Standard	0.0018
17	Pipe	Yes	3	feet	1.049	inches	Standard	0.0018
18	Pipe	Yes	2.5	feet	0.622	inches	Standard	0.0018
19	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
20	Pipe	Yes	7	feet	0.622	inches	Standard	0.0018
21	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
22	Pipe	Yes	1	feet	0.622	inches	Standard	0.0018
23	Pipe	Yes	1	feet	0.622	inches	Standard	0.0018
24	Inlet Hose	Yes	1.5	feet	1.049	inches	Standard	0.0018
25	Outlet Hose	Yes	2	feet	1.049	inches	Standard	0.0018
26	Pipe	Yes	2.5	feet	0.622	inches	Standard	0.0018
27	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
28	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
29	Pipe	Yes	2	feet	0.622	inches	Standard	0.0018
30	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
31	Pipe	Yes	2	feet	0.622	inches	Standard	0.0018
32	Inlet Hose	Yes	1.5	feet	1.049	inches	Standard	0.0018
33	Outlet Hose	Yes	2	feet	1.049	inches	Standard	0.0018
34	Pipe	Yes	3	feet	0.622	inches	Standard	0.0018
35	Pipe	Yes	2	feet	0.622	inches	Standard	0.0018
36	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
37	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
38	Pipe	Yes	1.5	feet	0.622	inches	Standard	0.0018
39	Inlet Hose	Yes	1.5	feet	1.049	inches	Standard	0.0018
40	Outlet Hose	Yes	2	feet	1.049	inches	Standard	0.0018
41	Pipe	Yes	1.5	feet	0.622	inches	Standard	0.0018
42	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
43	Pipe	Yes	1	feet	0.622	inches	Standard	0.0018
44	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
45	Pipe	Yes	4	feet	0.622	inches	Standard	0.0018
46	Pipe	Yes	1	feet	0.622	inches	Standard	0.0018
47	Pipe	Yes	4	feet	0.622	inches	Standard	0.0018
48	Pipe	Yes	8	feet	0.622	inches	Standard	0.0018
49	Pipe	Yes	5	feet	0.622	inches	Standard	0.0018
50	Pipe	Yes	6	feet	0.622	inches	Standard	0.0018
51	Pipe	Yes	1	feet	0.622	inches	Standard	0.0018
52	Pipe	Yes	32	feet	0.622	inches	Standard	0.0018
53	Pipe	Yes	2	feet	0.622	inches	Standard	0.0018
54	Treated Effluent HIHTL (From TSCR)	Yes	211	feet	2	inches	Unspecified	0.00126

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Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness
55	Pipe	Yes	1	feet	0.622	inches	Standard	0.0018
56	Pipe	Yes	1.5	feet	0.622	inches	Standard	0.0018
57	Pipe	Yes	3	feet	2.067	inches	Standard	0.0018
58	Pipe	Yes	3	feet	1.049	inches	Standard	0.0018
59	Pipe	Yes	2.5	feet	0.622	inches	Standard	0.0018
60	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
61	Pipe	Yes	12	feet	0.622	inches	Standard	0.0018
62	Pipe	Yes	11.5	feet	0.622	inches	Standard	0.0018
63	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
64	Pipe	Yes	2	feet	0.622	inches	Standard	0.0018
65	Pipe	Yes	1	feet	0.622	inches	Standard	0.0018
66	Pipe	Yes	9.5	feet	0.622	inches	Standard	0.0018
67	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
68	Pipe	Yes	2.5	feet	0.622	inches	Standard	0.0018
70	Pipe	Yes	2	feet	0.622	inches	Standard	0.0018
71	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
72	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
89	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018
91	Pipe	Yes	0.5	feet	0.622	inches	Standard	0.0018

Pipe	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size
1	inches	1.1974	79.54	gal/min	1, 4	Cylindrical Pipe	Steel - ANSI	6 inch
4	inches	2.226188			4, 5	Cylindrical Pipe	Steel - ANSI	2 inch
5	inches	2.546			5, 6	Cylindrical Pipe	User Specified	
6	inches	3.496	49.00	gal/min	6, 7	Cylindrical Pipe	User Specified	
7	inches	0.06168	49.00	gal/min	7, 8	Cylindrical Pipe	Steel - ANSI	1-1/2 inch
8	inches	0.34952	44.02	gal/min	8, 9	Cylindrical Pipe	Steel - ANSI	1-1/2 inch
9	inches	3.496	44.02	gal/min	9, 10	Cylindrical Pipe	User Specified	
10	inches	2.546			10, 11	Cylindrical Pipe	User Specified	
11	inches	1.50928	44.02	gal/min	11, 12	Cylindrical Pipe	Steel - ANSI	2 inch
12	inches	0.1763804	5.000	gal/min	8, 81	Cylindrical Pipe	Steel - ANSI	1/2 inch
13	inches	0.886744			81, 13	Cylindrical Pipe	Steel - ANSI	1/2 inch
14	inches	1.1			13, 14	Cylindrical Pipe	Steel - ANSI	1/2 inch

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Pipe	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size
15	inches	0.404336			14, 15	Cylindrical Pipe	Steel - ANSI	1/2 inch
16	inches	1.47732			15, 16	Cylindrical Pipe	Steel - ANSI	2 inch
17	inches	0.427668			16, 17	Cylindrical Pipe	Steel - ANSI	1 inch
18	inches	2.564336			17, 18	Cylindrical Pipe	Steel - ANSI	1/2 inch
19	inches	0			18, 19	Cylindrical Pipe	Steel - ANSI	1/2 inch
20	inches	1.504336			19, 20	Cylindrical Pipe	Steel - ANSI	1/2 inch
21	inches	2.2			20, 21	Cylindrical Pipe	Steel - ANSI	1/2 inch
22	inches	0.04			21, 22	Cylindrical Pipe	Steel - ANSI	1/2 inch
23	inches	0.118072			22, 23	Cylindrical Pipe	Steel - ANSI	1/2 inch
24	inches	2.998949			23, 24	Cylindrical Pipe	Steel - ANSI	1 inch
25	inches	0.957768			24, 25	Cylindrical Pipe	Steel - ANSI	1 inch
26	inches	0.2911789			25, 26	Cylindrical Pipe	Steel - ANSI	1/2 inch
27	inches	0.04			26, 27	Cylindrical Pipe	Steel - ANSI	1/2 inch
28	inches	1.1			27, 28	Cylindrical Pipe	Steel - ANSI	1/2 inch
29	inches	0			28, 29	Cylindrical Pipe	Steel - ANSI	1/2 inch
30	inches	1.1			29, 30	Cylindrical Pipe	Steel - ANSI	1/2 inch
31	inches	0.118072			30, 31	Cylindrical Pipe	Steel - ANSI	1/2 inch
32	inches	2.998949			31, 32	Cylindrical Pipe	Steel - ANSI	1 inch
33	inches	0.957768			32, 33	Cylindrical Pipe	Steel - ANSI	1 inch
34	inches	0.3311789			33, 34	Cylindrical Pipe	Steel - ANSI	1/2 inch
35	inches	0			35, 36	Cylindrical Pipe	Steel - ANSI	1/2 inch
36	inches	1.1			36, 37	Cylindrical Pipe	Steel - ANSI	1/2 inch
37	inches	0.04			37, 38	Cylindrical Pipe	Steel - ANSI	1/2 inch
38	inches	0.118072			38, 39	Cylindrical Pipe	Steel - ANSI	1/2 inch
39	inches	2.998949			39, 40	Cylindrical Pipe	Steel - ANSI	1 inch
40	inches	0.957768			40, 41	Cylindrical Pipe	Steel - ANSI	1 inch
41	inches	0.1331069			41, 42	Cylindrical Pipe	Steel - ANSI	1/2 inch
42	inches	0			42, 43	Cylindrical Pipe	Steel - ANSI	1/2 inch
43	inches	0.12			43, 44	Cylindrical Pipe	Steel - ANSI	1/2 inch
44	inches	1.1			44, 45	Cylindrical Pipe	Steel - ANSI	1/2 inch
45	inches	0.444336			45, 46	Cylindrical Pipe	Steel - ANSI	1/2 inch
46	inches	1.1			46, 47	Cylindrical Pipe	Steel - ANSI	1/2 inch
47	inches	0.768672			47, 48	Cylindrical Pipe	Steel - ANSI	1/2 inch
48	inches	1.093008			48, 49	Cylindrical Pipe	Steel - ANSI	1/2 inch
49	inches	0.768672			49, 50	Cylindrical Pipe	Steel - ANSI	1/2 inch
50	inches	1.173008			50, 51	Cylindrical Pipe	Steel - ANSI	1/2 inch
51	inches	0			51, 52	Cylindrical Pipe	Steel - ANSI	1/2 inch
52	inches	1.86168			52, 53	Cylindrical Pipe	Steel - ANSI	1/2 inch
53	inches	0			53, 54	Cylindrical Pipe	Steel - ANSI	1/2 inch
54	inches	1.615	5.000	gal/min	54, 55	Cylindrical Pipe	User Specified	

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Pipe	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size
55	inches	0.404336			13, 56	Cylindrical Pipe	Steel - ANSI	1/2 inch
56	inches	1.1			56, 57	Cylindrical Pipe	Steel - ANSI	1/2 inch
57	inches	1.47732			57, 58	Cylindrical Pipe	Steel - ANSI	2 inch
58	inches	0.427668			58, 59	Cylindrical Pipe	Steel - ANSI	1 inch
59	inches	2.564336			59, 60	Cylindrical Pipe	Steel - ANSI	1/2 inch
60	inches	0			60, 19	Cylindrical Pipe	Steel - ANSI	1/2 inch
61	inches	2.92168			20, 64	Cylindrical Pipe	Steel - ANSI	1/2 inch
62	inches	1.464336			66, 22	Cylindrical Pipe	Steel - ANSI	1/2 inch
63	inches	0.08			20, 61	Cylindrical Pipe	Steel - ANSI	1/2 inch
64	inches	0.04			61, 28	Cylindrical Pipe	Steel - ANSI	1/2 inch
65	inches	1.14			26, 62	Cylindrical Pipe	Steel - ANSI	1/2 inch
66	inches	2.557344			62, 45	Cylindrical Pipe	Steel - ANSI	1/2 inch
67	inches	0.04			29, 63	Cylindrical Pipe	Steel - ANSI	1/2 inch
68	inches	0.04			63, 35	Cylindrical Pipe	Steel - ANSI	1/2 inch
70	inches	0.04			65, 45	Cylindrical Pipe	Steel - ANSI	1/2 inch
71	inches	0.04			36, 65	Cylindrical Pipe	Steel - ANSI	1/2 inch
72	inches	1.464336			43, 66	Cylindrical Pipe	Steel - ANSI	1/2 inch
89	inches	1.1			34, 35	Cylindrical Pipe	Steel - ANSI	1/2 inch
91	inches	1.1			64, 38	Cylindrical Pipe	Steel - ANSI	1/2 inch

Pipe	Type	Special Condition
1	schedule 40	None
4	schedule 40	None
5		None
6		None
7	STD (schedule 40)	None
8	STD (schedule 40)	None
9		None
10		None
11	schedule 40	None
12	STD (schedule 40)	None
13	STD (schedule 40)	None
14	STD (schedule 40)	None

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Pipe	Type	Special Condition
15	STD (schedule 40)	None
16	STD (schedule 40)	None
17	STD (schedule 40)	None
18	STD (schedule 40)	None
19	STD (schedule 40)	None
20	STD (schedule 40)	None
21	STD (schedule 40)	None
22	STD (schedule 40)	None
23	STD (schedule 40)	None
24	STD (schedule 40)	None
25	STD (schedule 40)	None
26	STD (schedule 40)	None
27	STD (schedule 40)	None
28	STD (schedule 40)	None
29	STD (schedule 40)	None
30	STD (schedule 40)	None
31	STD (schedule 40)	None
32	STD (schedule 40)	None
33	STD (schedule 40)	None
34	STD (schedule 40)	None
35	STD (schedule 40)	None
36	STD (schedule 40)	None
37	STD (schedule 40)	None
38	STD (schedule 40)	None
39	STD (schedule 40)	None
40	STD (schedule 40)	None
41	STD (schedule 40)	None
42	STD (schedule 40)	None
43	STD (schedule 40)	None
44	STD (schedule 40)	None
45	STD (schedule 40)	None
46	STD (schedule 40)	None
47	STD (schedule 40)	None
48	STD (schedule 40)	None
49	STD (schedule 40)	None
50	STD (schedule 40)	None
51	STD (schedule 40)	None
52	STD (schedule 40)	None
53	STD (schedule 40)	None
54		None

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Pipe	Type	Special Condition
55	STD (schedule 40)	None
56	STD (schedule 40)	None
57	STD (schedule 40)	None
58	STD (schedule 40)	None
59	STD (schedule 40)	None
60	STD (schedule 40)	None
61	STD (schedule 40)	None
62	STD (schedule 40)	None
63	STD (schedule 40)	None
64	STD (schedule 40)	None
65	STD (schedule 40)	None
66	STD (schedule 40)	None
67	STD (schedule 40)	None
68	STD (schedule 40)	None
70	STD (schedule 40)	None
71	STD (schedule 40)	None
72	STD (schedule 40)	None
89	STD (schedule 40)	None
91	STD (schedule 40)	None

Pipe Fittings & Losses

Pipe	Total K	Area Change	Elbow/Bend Mitre	Elbow/Bend Smooth Flanged	Valve Ball	Valve Three-way	Other Tee
1	1.2		1 (0.9)	1 (0.3)			
4	2.23		1 (1.13)	2 (0.53)		1 (0.57)	
5	2.55		2 (2.28)	1 (0.27)			
6	3.5			11 (3.5)			
7	0.06				1 (0.06)		
8	0.35			1 (0.29)	1 (0.06)		
9	3.5			11 (3.5)			
10	2.55		2 (2.28)	1 (0.27)			
11	1.51		1 (1.13)	1 (0.38)			
12	0.18	1 (0.18)					
13	0.89			2 (0.73)	1 (0.08)		2 (0.08)
14	1.1						1 (1.1)
15	0.4			1 (0.36)			1 (0.04)
16	1.48			1 (0.32)	1 (0.06)		1 (1.1)
17	0.43			1 (0.32)	1 (0.07)		1 (0.04)
18	2.56			1 (0.36)			2 (2.2)
20	1.5			1 (0.36)			2 (1.14)

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Pipe	Total K	Area Change	Elbow/Bend Mitre	Elbow/Bend Smooth Flanged	Valve Ball	Valve Three-way	Other Tee
21	2.2						2 (2.2)
22	0.04						1 (0.04)
23	0.12				1 (0.08)		1 (0.04)
24	3.0	1 (2.32)		3 (0.68)			
25	0.96			3 (0.96)			
26	0.29	1 (0.13)			1 (0.08)		2 (0.08)
27	0.04						1 (0.04)
28	1.1						1 (1.1)
30	1.1						1 (1.1)
31	0.12				1 (0.08)		1 (0.04)
32	3.0	1 (2.32)		3 (0.68)			
33	0.96			3 (0.96)			
34	0.33	1 (0.13)			1 (0.08)		3 (0.12)
36	1.1						1 (1.1)
37	0.04						1 (0.04)
38	0.12				1 (0.08)		1 (0.04)
39	3.0	1 (2.32)		3 (0.68)			
40	0.96			3 (0.96)			
41	0.13	1 (0.13)					
43	0.12						3 (0.12)
44	1.1						1 (1.1)
45	0.44			1 (0.36)			2 (0.08)
46	1.1						1 (1.1)
47	0.77			2 (0.73)			1 (0.04)
48	1.09			3 (1.09)			
49	0.77			2 (0.73)			1 (0.04)
50	1.17			3 (1.09)			2 (0.08)
52	1.86			5 (1.82)			1 (0.04)
54	1.62			5 (1.62)			
55	0.4			1 (0.36)			1 (0.04)
56	1.1						1 (1.1)
57	1.48			1 (0.32)	1 (0.06)		1 (1.1)
58	0.43			1 (0.32)	1 (0.07)		1 (0.04)
59	2.56			1 (0.36)			2 (2.2)
61	2.92			5 (1.82)			1 (1.1)
62	1.46			1 (0.36)			1 (1.1)
63	0.08						2 (0.08)
64	0.04						1 (0.04)
65	1.14						2 (1.14)
66	2.56			4 (1.46)			1 (1.1)

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Pipe	Total K	Area Change	Elbow/Bend Mitre	Elbow/Bend Smooth Flanged	Valve Ball	Valve Three-way	Other Tee
67	0.04						1 (0.04)
68	0.04						1 (0.04)
70	0.04						1 (0.04)
71	0.04						1 (0.04)
72	1.46			1 (0.36)			1 (1.1)
89	1.1						1 (1.1)
91	1.1						1 (1.1)

Pipe Detail Summary

Pipe 1 Detailed Input Data
Name: Pump Piping
Geometry: Cylindrical Pipe
Material: Steel - ANSI 6 inch schedule 40
Inner Diameter= 6.065 inches
Length= 2.2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1974
Elbow/Bend:
Mitre, General, 90 deg., K= 0.90, Quantity= 1
Smooth Flanged, r/D=1, 90 deg., K= 0.30, Quantity= 1

Pipe 4 Detailed Input Data
Name: Jumper AP07F-WT-J-[P1-P2-(A)]
Geometry: Cylindrical Pipe
Material: Steel - ANSI 2 inch schedule 40
Inner Diameter= 2.067 inches
Length= 5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.226188
Elbow/Bend:
Mitre, General, 90 deg., K= 1.13, Quantity= 1
Smooth Flanged, r/D=1.5, 90 deg., K= 0.26, Quantity= 2
Valve:
Three-way, Through flow, K= 0.57, Quantity= 1

Pipe 5 Detailed Input Data
Name: Jumper AP-07F-WT-EPDMJ-[A-B]
Geometry: Cylindrical Pipe
Material: Unspecified
Inner Diameter= 2 inches
Length= 45 inches
Absolute Roughness= 0.00126 inches
Fittings & Losses= 2.546
Elbow/Bend:
Mitre, General, 90 deg., K= 1.14, Quantity= 2
Smooth Flanged, r/D=1.5, 90 deg., K= 0.27, Quantity= 1

Pipe 6 Detailed Input Data
Name: Process Feed HIHTL (To TSCR)
Geometry: Cylindrical Pipe

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Material: Unspecified
Inner Diameter= 2 inches
Length= 330 feet
Absolute Roughness= 0.00126 inches
Fittings & Losses= 3.496
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.27, Quantity= 1
Smooth Flanged, r/D=6, 90 deg., K= 0.32, Quantity= 10

Pipe 7 Detailed Input Data
Name:
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1-1/2 inch STD (schedule 40)
Inner Diameter= 1.61 inches
Length= 3.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.06168
Valve:
Ball, PO=100, K= 0.06, Quantity= 1

Pipe 8 Detailed Input Data
Name:
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1-1/2 inch STD (schedule 40)
Inner Diameter= 1.61 inches
Length= 5.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.34952
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.29, Quantity= 1
Valve:
Ball, PO=100, K= 0.06, Quantity= 1

Pipe 9 Detailed Input Data
Name: Feed Recirc HIHTL (From TSCR)
Geometry: Cylindrical Pipe
Material: Unspecified
Inner Diameter= 2 inches
Length= 335 feet
Absolute Roughness= 0.00126 inches
Fittings & Losses= 3.496
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.27, Quantity= 1
Smooth Flanged, r/D=6, 90 deg., K= 0.32, Quantity= 10

Pipe 10 Detailed Input Data
Name: Jumper AP07F-WT-EPDMJ-[C-D]
Geometry: Cylindrical Pipe
Material: Unspecified
Inner Diameter= 2 inches
Length= 55 inches
Absolute Roughness= 0.00126 inches
Fittings & Losses= 2.546
Elbow/Bend:
Mitre, General, 90 deg., K= 1.14, Quantity= 2
Smooth Flanged, r/D=1.5, 90 deg., K= 0.27, Quantity= 1

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Pipe 11 Detailed Input Data
Name: Recirc Dropleg (H-14-111336)
Geometry: Cylindrical Pipe
Material: Steel - ANSI 2 inch schedule 40
Inner Diameter= 2.067 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.50928
Elbow/Bend:
Mitre, General, 90 deg., K= 1.13, Quantity= 1
Smooth Flanged, r/D=1, 90 deg., K= 0.38, Quantity= 1

Pipe 12 Detailed Input Data
Name:
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.1763804
Area Change:
Contraction to Pipe Area, K= 0.18, Quantity= 1

Pipe 13 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 3.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.886744
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 2
Valve:
Ball, PO=100, K= 0.08, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 2

Pipe 14 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 15 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.404336

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Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 16 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 2 inch STD (schedule 40)
Inner Diameter= 2.067 inches
Length= 3 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.47732
Elbow/Bend:
Smooth Flanged, r/D=6, 90 deg., K= 0.32, Quantity= 1
Valve:
Ball, PO=100, K= 0.06, Quantity= 1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 17 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 3 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.427668
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.32, Quantity= 1
Valve:
Ball, PO=100, K= 0.07, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 18 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.564336
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 2

Pipe 19 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0

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Pipe 20 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 7 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.504336
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 21 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.2
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 2

Pipe 22 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 23 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.118072
Valve:
Ball, PO=100, K= 0.08, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 24 Detailed Input Data
Name: Inlet Hose
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 1.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.998949

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Elbow/Bend:
Smooth Flanged, r/D=1.5, 45 deg., K= 0.23, Quantity= 3
Area Change:
Expansion to Pipe Area, K= 2.32, Quantity= 1

Pipe 25 Detailed Input Data
Name: Outlet Hose
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.957768
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.32, Quantity= 3

Pipe 26 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.2911789
Valve:
Ball, PO=100, K= 0.08, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 2
Area Change:
Contraction to Pipe Area, K= 0.13, Quantity= 1

Pipe 27 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 28 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 29 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)

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Inner Diameter= 0.622 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0

Pipe 30 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 31 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.118072
Valve:
Ball, PO=100, K= 0.08, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 32 Detailed Input Data
Name: Inlet Hose
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 1.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.998949
Elbow/Bend:
Smooth Flanged, r/D=1.5, 45 deg., K= 0.23, Quantity= 3
Area Change:
Expansion to Pipe Area, K= 2.32, Quantity= 1

Pipe 33 Detailed Input Data
Name: Outlet Hose
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.957768
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.32, Quantity= 3

Pipe 34 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)

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Inner Diameter= 0.622 inches
Length= 3 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.3311789
Valve:
Ball, PO=100, K= 0.08, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 3
Area Change:
Contraction to Pipe Area, K= 0.13, Quantity= 1

Pipe 35 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0

Pipe 36 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 37 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 38 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.118072
Valve:
Ball, PO=100, K= 0.08, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 39 Detailed Input Data
Name: Inlet Hose

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Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 1.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.998949
Elbow/Bend:
Smooth Flanged, r/D=1.5, 45 deg., K= 0.23, Quantity= 3
Area Change:
Expansion to Pipe Area, K= 2.32, Quantity= 1

Pipe 40 Detailed Input Data
Name: Outlet Hose
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.957768
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.32, Quantity= 3

Pipe 41 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.1331069
Area Change:
Contraction to Pipe Area, K= 0.13, Quantity= 1

Pipe 42 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0

Pipe 43 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.12
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 3

Pipe 44 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)

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Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 45 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 4 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.444336
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 2

Pipe 46 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 47 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 4 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.768672
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 2
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 48 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 8 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.093008
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 3

Pipe 49 Detailed Input Data
Name: Pipe

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Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.768672
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 2
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 50 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 6 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.173008
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 3
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 2

Pipe 51 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0

Pipe 52 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 32 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.86168
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 5
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 53 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0

Pipe 54 Detailed Input Data
Name: Treated Effluent HIHTL (From TSCR)

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Geometry: Cylindrical Pipe
Material: Unspecified
Inner Diameter= 2 inches
Length= 211 feet
Absolute Roughness= 0.00126 inches
Fittings & Losses= 1.615
Elbow/Bend:
Smooth Flanged, r/D=6, 90 deg., K= 0.32, Quantity= 5

Pipe 55 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.404336
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 56 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 57 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 2 inch STD (schedule 40)
Inner Diameter= 2.067 inches
Length= 3 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.47732
Elbow/Bend:
Smooth Flanged, r/D=6, 90 deg., K= 0.32, Quantity= 1
Valve:
Ball, PO=100, K= 0.06, Quantity= 1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 58 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1 inch STD (schedule 40)
Inner Diameter= 1.049 inches
Length= 3 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.427668
Elbow/Bend:

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Smooth Flanged, r/D=1.5, 90 deg., K= 0.32, Quantity= 1
Valve:
Ball, PO=100, K= 0.07, Quantity= 1
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 59 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.564336
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 2

Pipe 60 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0

Pipe 61 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 12 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.92168
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 5
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 62 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 11.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.464336
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 63 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe

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Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.08
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 2

Pipe 64 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 65 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 1 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.14
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 66 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 9.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 2.557344
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 4
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 67 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 68 Detailed Input Data
Name: Pipe

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Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 70 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 2 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 71 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 0.04
Other:
Tee, Through flow (dead branch), K= 0.04, Quantity= 1

Pipe 72 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.464336
Elbow/Bend:
Smooth Flanged, r/D=1.5, 90 deg., K= 0.36, Quantity= 1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 89 Detailed Input Data
Name: Pipe
Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Pipe 91 Detailed Input Data
Name: Pipe

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Geometry: Cylindrical Pipe
Material: Steel - ANSI 1/2 inch STD (schedule 40)
Inner Diameter= 0.622 inches
Length= 0.5 feet
Absolute Roughness= 0.0018 inches
Fittings & Losses= 1.1
Other:
Tee, Branch flow (dead run), K= 1.10, Quantity= 1

Area Change Table

Area Change	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Type	Geometry
7		Yes	681	feet	951.7	feet		Conical	Contraction
9	Area Change	Yes	681	feet	899.0	feet		Conical	Expansion
54	Area Change	Yes	681	feet				Conical	Expansion

Area Change	Angle	Loss Factor
7	30.	0.173546
9	30.	0.08336683
54	45.	0.8118146

Assigned Pressure Table

Assigned Pressure	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Pressure
12	AP-07F	Yes	677	feet	1.000	atm		1
55	AP-106 Riser 2	Yes	680	feet	1.000	atm		1

Assigned Pressure	Pressure Units	Pressure Type	Balance Energy	Balance Concentration	(Pipe #1) K In, K Out	(Pipe #2) K In, K Out	(Pipe #3) K In, K Out	(Pipe #4) K In, K Out
12	atm	Stagnation	No	No	(P11) 0, 1			
55	atm	Stagnation	No	No	(P54) 0, 1			

Assigned Pressure	(Pipe #5) K In, K Out	(Pipe #6) K In, K Out	(Pipe #7) K In, K Out	(Pipe #8) K In, K Out	(Pipe #9) K In, K Out	(Pipe #10) K In, K Out	(Pipe #11) K In, K Out	(Pipe #12) K In, K Out
12								
55								

Assigned Pressure	(Pipe #13) K In, K Out	(Pipe #14) K In, K Out	(Pipe #15) K In, K Out	(Pipe #16) K In, K Out	(Pipe #17) K In, K Out	(Pipe #18) K In, K Out	(Pipe #19) K In, K Out	(Pipe #20) K In, K Out
12								
55								

Assigned Pressure	(Pipe #21) K In, K Out	(Pipe #22) K In, K Out	(Pipe #23) K In, K Out	(Pipe #24) K In, K Out	(Pipe #25) K In, K Out
12					
55					

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Branch Table

Branch	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Special Condition
4	Pump Discharge Nozzle	Yes	675.2	feet				N/A
5	Branch	Yes	675.2	feet				N/A
6	Branch	Yes	677.2	feet				N/A
8	Branch	Yes	681	feet				N/A
10	Branch	Yes	677.2	feet				N/A
13	Branch	Yes	681	feet				N/A
15	Branch	Yes	681	feet				N/A
17	Branch	Yes	681	feet				N/A
19	Branch	Yes	681	feet				N/A
20	Branch	Yes	687	feet				N/A
22	Branch	Yes	687	feet				N/A
23	Branch	Yes	687	feet				N/A
25	Branch	Yes	687	feet				N/A
26	Branch	Yes	687	feet				N/A
28	Branch	Yes	687	feet				N/A
29	Branch	Yes	687	feet				N/A
31	Branch	Yes	687	feet				N/A
33	Branch	Yes	687	feet				N/A
35	Branch	Yes	687	feet				N/A
36	Branch	Yes	687	feet				N/A
38	Branch	Yes	687	feet				N/A
39	Branch	Yes	687	feet				N/A
41	Branch	Yes	687	feet				N/A
43	Branch	Yes	687	feet				N/A
45	Branch	Yes	687	feet				N/A
57	Branch	Yes	681	feet				N/A
59	Branch	Yes	681	feet				N/A

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Branch	Boundary Flow (+ = in/- = out)	Boundary Flow Units	(Pipe #1) K In, K Out	(Pipe #2) K In, K Out	(Pipe #3) K In, K Out	(Pipe #4) K In, K Out	(Pipe #5) K In, K Out	(Pipe #6) K In, K Out
4			(P1) 0, 0	(P4) 0, 0				
5			(P4) 0, 0	(P5) 0, 0				
6			(P5) 0, 0	(P6) 0, 0				
8			(P7) 0, 0	(P8) 0, 0	(P12) 0, 0			
10			(P9) 0, 0	(P10) 0, 0				
13			(P13) 0, 0	(P14) 0, 0	(P55) 0, 0			
15			(P15) 0, 0	(P16) 0, 0				
17			(P17) 0, 0	(P18) 0, 0				
19			(P19) 0, 0	(P20) 0, 0	(P60) 0, 0			
20			(P20) 0, 0	(P21) 0, 0	(P61) 0, 0	(P63) 0, 0		
22			(P22) 0, 0	(P23) 0, 0	(P62) 0, 0			
23			(P23) 0, 0	(P24) 0, 0				
25			(P25) 0, 0	(P26) 0, 0				
26			(P26) 0, 0	(P27) 0, 0	(P65) 0, 0			
28			(P28) 0, 0	(P29) 0, 0	(P64) 0, 0			
29			(P29) 0, 0	(P30) 0, 0	(P67) 0, 0			
31			(P31) 0, 0	(P32) 0, 0				
33			(P33) 0, 0	(P34) 0, 0				
35			(P35) 0, 0	(P68) 0, 0	(P89) 0, 0			
36			(P35) 0, 0	(P36) 0, 0	(P71) 0, 0			
38			(P37) 0, 0	(P38) 0, 0	(P91) 0, 0			
39			(P38) 0, 0	(P39) 0, 0				
41			(P40) 0, 0	(P41) 0, 0				
43			(P42) 0, 0	(P43) 0, 0	(P72) 0, 0			
45			(P44) 0, 0	(P45) 0, 0	(P66) 0, 0	(P70) 0, 0		
57			(P56) 0, 0	(P57) 0, 0				
59			(P58) 0, 0	(P59) 0, 0				

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Branch	(Pipe #7) K In, K Out	(Pipe #8) K In, K Out	(Pipe #9) K In, K Out	(Pipe #10) K In, K Out	(Pipe #11) K In, K Out	(Pipe #12) K In, K Out	(Pipe #13) K In, K Out	(Pipe #14) K In, K Out	(Pipe #15) K In, K Out
4									
5									
6									
8									
10									
13									
15									
17									
19									
20									
22									
23									
25									
26									
28									
29									
31									
33									
35									
36									
38									
39									
41									
43									
45									
57									
59									

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Branch	(Pipe #16) K In, K Out	(Pipe #17) K In, K Out	(Pipe #18) K In, K Out	(Pipe #19) K In, K Out	(Pipe #20) K In, K Out	(Pipe #21) K In, K Out	(Pipe #22) K In, K Out	(Pipe #23) K In, K Out	(Pipe #24) K In, K Out	(Pipe #25) K In, K Out
4										
5										
6										
8										
10										
13										
15										
17										
19										
20										
22										
23										
25										
26										
28										
29										
31										
33										
35										
36										
38										
39										
41										
43										
45										
57										
59										

Control Valve Table

Control Valve	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Special Condition	Valve Type
51	WP-PCV-557	Yes	687	feet				None	PSV
81	WP-FCV-306	Yes	681	feet				None	FCV

Control Valve	Control Setting	Control Units	Pressure/ Head Type	Inlet Failure Type	Outlet Failure Type	Full Open Loss Type	Full Open Loss
51	50	psig	Static	Close	Fully Open	None	N/A
81	5	gal/min	N/A	Fully Open	N/A	None	N/A

General Component Table

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General Component	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units
16	Pre-Filter (WP-FLT-325A)	Yes	681	feet		

General Component	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units
24	Ion-Exchange Column (WP-IX-400A)	Yes	687	feet		
32	Ion-Exchange Column (WP-IX-400B)	Yes	687	feet		
40	Ion-Exchange Column (WP-IX-400C)	Yes	687	feet		
47	Media Trap	Yes	687	feet		
49	Delay Tank	Yes	687	feet		
58	Pre-Filter (WP-FLT-325B)	Yes	681	feet		

General Component	Database Source	Special Condition	Loss Model	Loss Value	Independent Variable	Ind. Variable Units	Dependent Variable
16		None	Resistance Curve	Variable	Vol. Flow Rate	gal/min	Pressure Loss

General Component	Database Source	Special Condition	Loss Model	Loss Value	Independent Variable	Ind. Variable Units	Dependent Variable
24		None	Resistance Curve	Variable	Vol. Flow Rate	gal/min	Pressure Loss
32		None	Resistance Curve	Variable	Vol. Flow Rate	gal/min	Pressure Loss
40		None	Resistance Curve	Variable	Vol. Flow Rate	gal/min	Pressure Loss
47		None	Resistance Curve	Variable	Vol. Flow Rate	gal/min	Pressure Loss
49		None	K Constant	0			
58		None	Resistance Curve	Variable	Vol. Flow Rate	gal/min	Head Loss

General Component	Dep. Variable Units	Loss Constant a	Loss Constant b	Loss Constant c	Loss Constant d	Loss Constant e
16	psid	4.440892E-16	-0.8	0.28	0	0

General Component	Dep. Variable Units	Loss Constant a	Loss Constant b	Loss Constant c	Loss Constant d	Loss Constant e
24	psid	-2.664535E-15	4.440892E-15	0.6	0	0
32	psid	-1.332268E-15	1.2	0.36	0	0
40	psid	-1.776357E-15	-0.8	0.48	0	0
47	psid	2.88658E-15	-2.220446E-15	0.2	0	0
49						
58	feet	4.440892E-16	-0.8	0.28	0	0

Orifice Table

Orifice	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Orifice Type	Flow Area Type
11	Orifice	Yes	677	feet				Sharp-Edged	Diameter
52	Orifice	Yes	687	feet				Sharp-Edged	Diameter

Orifice	Dimension	Dimension Units	R/D	Restricted Area	Restricted Area Units	Loss Model	Loss Value	Independent Variable	Ind. Variable Units	Dependent Variable
11	0.531	inches				K Constant	529.3999			
52	0.26563	inches				K Constant	65.24963			

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Orifice	Dep. Variable Units	Loss Constant a	Loss Constant b	Loss Constant c	Loss Constant d	Loss Constant e
11						
52						

Pump Table

Pump	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Special Condition	Pump Type
1	Pump AP-07F	Yes	625.9	feet	625.5	feet		None	Pump Curve

Pump	Design Flow Rate	Design Flow Rate Units	Current Configuration	Independent Variable	Ind. Variable Units	Dependent Variable	Dep. Variable Units	Pump Curve Constant a
1				Vol. Flow Rate	gal/min	Head Rise	feet	426.922

Pump	Pump Curve Constant b	Pump Curve Constant c	Pump Curve Constant d	Pump Curve Constant e	Runout Flow Rate	Runout Flow Rate Units	Speed	Control When Exceeded Only
1	-0.3101783	-0.002943075	0	0			100	

Pump	Heat Added To Fluid	Heat Added Units
1	0	Percent

Valve Table

Valve	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Special Condition	Exit Valve
14	Valve	Yes	681	feet				None	No
18	Valve	Yes	681	feet				None	No
21	Valve	Yes	687	feet				Closed	No
27	Valve	Yes	687	feet				None	No
30	Valve	Yes	687	feet				None	No
34	Valve	Yes	687	feet				None	No
37	Valve	Yes	687	feet				Closed	No
42	WP-AOV-408C Fail Close	Yes	687	feet				None	No
44	Valve	Yes	687	feet				Closed	No
46	Valve	Yes	687	feet				None	No
48	Valve	Yes	687	feet				None	No
50	Valve	Yes	687	feet				None	No
53	WP-AOV-560 Fail Close	Yes	681	feet				None	No
56	Valve	Yes	681	feet				Closed	No
60	Valve	Yes	681	feet				None	No
61	Valve	Yes	687	feet				Closed	No
62	Valve	Yes	687	feet				Closed	No
63	Valve	Yes	687	feet				Closed	No
64	Valve	Yes	687	feet				None	No

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Valve	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Special Condition	Exit Valve
65	Valve	Yes	687	feet				None	No
66	Valve	Yes	687	feet				None	No

Valve	Exit Pressure	Exit Pressure Units	Restricted Area	Restricted Area Units	Loss Model	Loss Source	Loss Factor	Percent Open	Open Pct. Data Exists
14					K Constant	N/A	0.078072		No
18					K Constant	N/A	0.078072		No
21					Cv	Cv From Table	32	100	Yes
27					Cv	Cv From Table	32	100	Yes
30					Cv	Cv From Table	32	100	Yes
34					Cv	Cv From Table	32	100	Yes
37					Cv	Cv From Table	32	100	Yes
42					Cv	Cv From Table	32	100	Yes
44					Cv	Cv From Table	32	100	Yes
46					Cv	Cv From Table	32	100	Yes
48					K Constant	N/A	0.078072		No
50					K Constant	N/A	0.078072		No
53					Cv	Cv From Table	32	100	Yes
56					K Constant	N/A	0.078072		No
60					K Constant	N/A	0.078072		No
61					Cv	Cv From Table	32	100	Yes
62					Cv	Cv From Table	32	100	Yes
63					Cv	Cv From Table	32	100	Yes
64					Cv	Cv From Table	32	100	Yes

Valve	Exit Pressure	Exit Pressure Units	Restricted Area	Restricted Area Units	Loss Model	Loss Source	Loss Factor	Percent Open	Open Pct. Data Exists
65					Cv	Cv From Table	32	100	Yes
66					Cv	Cv From Table	32	100	Yes

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Valve	Independent Variable	Ind. Variable Units	Dependent Variable	Dep. Variable Units	Loss Constant a	Loss Constant b	Loss Constant c	Loss Constant d	Loss Constant e
14									
18									
21									
27									
30									
34									
37									
42									
44									
46									
48									
50									
53									
56									
60									
61									
62									
63									
64									

Valve	Independent Variable	Ind. Variable Units	Dependent Variable	Dep. Variable Units	Loss Constant a	Loss Constant b	Loss Constant c	Loss Constant d	Loss Constant e
65									
66									

APPENDIX C

HIGH HEAD LOSS OUTPUTS

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Model Reference Information

General

Title: AFT Fathom Model
Analysis run on: 7/18/2019 8:40:39 AM
Application version: AFT Fathom Version 9 (2016.01.20)
Input File: P:\Clients\Atkins Energy Federal EPC, Inc\078906.18.01 - Design of TSCR Upgrades\Calculations\Mechanical\M-002 \Rev 0\Fathom V&V\TSCR Pump Sizing.fth
Scenario: Base Scenario/Dirty
Output File: P:\Clients\Atkins Energy Federal EPC, Inc\078906.18.01 - Design of TSCR Upgrades\Calculations\Mechanical\M-002 \Rev 0\Fathom V&V\TSCR Pump Sizing_2.out

Execution Time= 0.37 seconds
Total Number Of Head/Pressure Iterations= 359
Total Number Of Flow Iterations= 30
Total Number Of Temperature Iterations= 0
Number Of Pipes= 71
Number Of Junctions= 65
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: User Specified
Fluid= User Specified
Density= 1.25 kg/liter
Viscosity= 5 centipoise
Vapor Pressure= 7.52 psia
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Tee or Wye, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 61.39 gal/min
Total Outflow= 61.39 gal/min
Maximum Static Pressure is 202.8 psia at Pipe 1 Inlet
Minimum Static Pressure is 14.21 psia at Pipe 53 Outlet

Warnings

No Warnings

Pump Summary

CALCULATION SHEET

Project No.	078906.18.01	Calculation No.	078906.18.01-M-002	Rev. 0	Page No. 52 of 68
Title: Tank Side Cesium Removal Process Pump Flow Analysis					
Prepared By: JF Gallegos	Date: 7/18/19	Checked By: KW Dixon		Date: 7/18/19	

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Jct	Results Diagram	Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)	% of BEP (Percent)
1	Show ...	Pump AP-07F	61.39	10.67	215.0	396.8	N/A	100.0	7.699	N/A	N/A

Valve Summary

Jct	Name	Valve Type	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP Stag. (psid)	dH (feet)	P Static In (psig)	Cv	K
14	Valve	REGULAR	5.000	0.8693	0.01833	0.03382	119.9137	41.3130	0.07807
18	Valve	REGULAR	5.000	0.8693	0.01833	0.03382	115.3574	41.3130	0.07807
X21	Valve	REGULAR	0.000	0.0000	N/A	N/A	110.6663	N/A	N/A
27	Valve	REGULAR	5.000	0.8693	0.03054	0.05636	79.6391	32.0000	0.13013
30	Valve	REGULAR	5.000	0.8693	0.03054	0.05636	78.5710	32.0000	0.13013
34	Valve	REGULAR	5.000	0.8693	0.03054	0.05636	62.3933	32.0000	0.13013
X37	Valve	REGULAR	0.000	0.0000	N/A	N/A	61.9050	N/A	N/A
42	WP-AOV-408C Fail Close	REGULAR	5.000	0.8693	0.03054	0.05636	98.5324	32.0000	0.13013
X44	Valve	REGULAR	0.000	0.0000	N/A	N/A	98.6497	N/A	N/A
46	Valve	REGULAR	5.000	0.8693	0.03054	0.05636	60.3875	32.0000	0.13013
48	Valve	REGULAR	5.000	0.8693	0.01833	0.03382	54.0497	41.3130	0.07807
50	Valve	REGULAR	5.000	0.8693	0.01833	0.03382	51.3360	41.3130	0.07807
53	WP-AOV-560 Fail Close	REGULAR	5.000	0.8693	0.03054	0.05636	-0.1075	32.0000	0.13013
X56	Valve	REGULAR	0.000	0.0000	N/A	N/A	120.4935	N/A	N/A
60	Valve	REGULAR	0.000	0.0000	N/A	N/A	115.4870	N/A	N/A
X61	Valve	REGULAR	0.000	0.0000	N/A	N/A	110.6663	N/A	N/A
X62	Valve	REGULAR	0.000	0.0000	N/A	N/A	79.9700	N/A	N/A
X63	Valve	REGULAR	0.000	0.0000	N/A	N/A	79.1507	N/A	N/A
64	Valve	REGULAR	5.000	0.8693	0.03054	0.05636	107.6612	32.0000	0.13013
65	Valve	REGULAR	5.000	0.8693	0.03054	0.05636	61.5740	32.0000	0.13013
66	Valve	REGULAR	5.000	0.8693	0.03054	0.05636	97.9845	32.0000	0.13013
51	WP-PCV-557	PSV	5.000	0.8693	31.87376	58.81751	50.0000	0.7891	214.02020
81	WP-FCV-306	FCV	5.000	0.8693	42.65475	78.71197	163.7297	0.8482	185.20370

CALCULATION SHEET

Project No.	078906.18.01	Calculation No.	078906.18.01-M-002	Rev. 0	Page No. 53 of 68
Title: Tank Side Cesium Removal Process Pump Flow Analysis					
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Jct	Valve State	Open Percentage (Percent)
14	Open	N/A
18	Open	N/A
X21	Closed By User	N/A
27	Open	100.00
30	Open	100.00
34	Open	100.00
X37	Closed By User	N/A
42	Open	100.00
X44	Closed By User	N/A
46	Open	100.00
48	Open	N/A
50	Open	N/A
53	Open	100.00
X56	Closed By User	N/A
60	Open	N/A
X61	Closed By User	N/A
X62	Closed By User	N/A
X63	Closed By User	N/A
64	Open	100.00
65	Open	100.00
66	Open	100.00
51	Open	43.64
81	Open	45.61

Pipe Output Table

Pipe	Name	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	P Static Max (psig)	P Static Min (psig)	Elevation Inlet (feet)	Elevation Outlet (feet)	dP Stag. Total (psid)
1	Pump Piping	61.389	0.6817	188.086884	188.0816	675.2	675.2	0.005253
4	Jumper AP07F-WT-J-[P1-P2-(A)]	61.389	5.8695	187.795425	186.9234	675.2	675.2	0.872010
5	Jumper AP-07F-WT-EPDMJ-[A-B]	61.389	6.2693	186.882538	184.7611	675.2	677.2	2.121413
6	Process Feed HIHTL (To TSCR)	61.389	6.2693	184.761124	164.3973	677.2	681.0	20.363795
7		61.389	9.6745	163.882660	163.3045	681.0	681.0	0.578195
8		56.351	8.8806	163.428528	162.4724	681.0	681.0	0.956125
9	Feed Recirc HIHTL (From TSCR)	56.351	5.7549	162.802292	148.9630	681.0	677.2	13.839339
10	Jumper AP07F-WT-EPDMJ-[C-D]	56.351	5.7549	148.962967	148.1571	677.2	677.0	0.805887
11	Recirc Dropleg (H-14-111336)	56.351	5.3878	0.538107	0.0000	677.0	677.0	0.538107
12		5.000	5.2793	163.857971	163.7297	681.0	681.0	0.128262
13	Pipe	5.000	5.2793	121.074951	120.2588	681.0	681.0	0.816168
14	Pipe	5.000	5.2793	120.258789	119.9137	681.0	681.0	0.345053

CALCULATION SHEET

Project No.	078906.18.01	Calculation No.	078906.18.01-M-002	Rev. 0	Page No. 54 of 68
Title: Tank Side Cesium Removal Process Pump Flow Analysis					
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Pipe	Name	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	P Static Max (psig)	P Static Min (psig)	Elevation Inlet (feet)	Elevation Outlet (feet)	dP Stag. Total (psid)
15	Pipe	5.000	5.2793	119.895401	119.4530	681.0	681.0	0.442353
16	Pipe	5.000	0.4781	119.685852	119.6797	681.0	681.0	0.006136
17	Pipe	5.000	1.8561	116.652634	116.5993	681.0	681.0	0.053293
18	Pipe	5.000	5.2793	116.393631	115.3574	681.0	681.0	1.036208
19	Pipe	5.000	5.2793	115.339096	115.2522	681.0	681.0	0.086862
20	Pipe	5.000	5.2793	115.252228	110.4316	681.0	687.0	4.820618
21	Pipe	0.000	0.0000	110.666336	110.6663	687.0	687.0	0.000000
22	Pipe	0.000	0.0000	95.847107	95.8471	687.0	687.0	0.000000
23	Pipe	5.000	5.2793	95.612396	95.4109	687.0	687.0	0.201437
24	Inlet Hose	5.000	1.8561	95.616653	95.5007	687.0	687.0	0.115915
25	Outlet Hose	5.000	1.8561	80.500748	80.4436	687.0	687.0	0.057089
26	Pipe	5.000	5.2793	80.237946	79.7353	687.0	687.0	0.502654
27	Pipe	5.000	5.2793	79.735291	79.6391	687.0	687.0	0.096251
28	Pipe	5.000	5.2793	79.608505	79.2634	687.0	687.0	0.345053
29	Pipe	5.000	5.2793	79.263443	78.9160	687.0	687.0	0.347447
30	Pipe	5.000	5.2793	78.916000	78.5710	687.0	687.0	0.345053
31	Pipe	5.000	5.2793	78.540405	78.1653	687.0	687.0	0.375161
32	Inlet Hose	5.000	1.8561	78.370956	78.2550	687.0	687.0	0.115915
33	Outlet Hose	5.000	1.8561	63.255032	63.1979	687.0	687.0	0.057089
34	Pipe	5.000	5.2793	62.992245	62.3933	687.0	687.0	0.598905
35	Pipe	5.000	5.2793	62.017742	61.6703	687.0	687.0	0.347447
36	Pipe	0.000	0.0000	61.905010	61.9050	687.0	687.0	0.000000
37	Pipe	0.000	0.0000	107.520294	107.5203	687.0	687.0	0.000000
38	Pipe	5.000	5.2793	107.285568	106.9973	687.0	687.0	0.288299
39	Inlet Hose	5.000	1.8561	107.202972	107.0871	687.0	687.0	0.115915
40	Outlet Hose	5.000	1.8561	99.087067	99.0300	687.0	687.0	0.057089
41	Pipe	5.000	5.2793	98.824265	98.5324	687.0	687.0	0.291828
42	Pipe	5.000	5.2793	98.501892	98.4150	687.0	687.0	0.086862
43	Pipe	0.000	0.0000	98.649750	98.6497	687.0	687.0	0.000000
44	Pipe	0.000	0.0000	61.421383	61.4214	687.0	687.0	0.000000
45	Pipe	5.000	5.2793	61.186665	60.3875	687.0	687.0	0.799188
46	Pipe	5.000	5.2793	60.356930	59.9250	687.0	687.0	0.431915
47	Pipe	5.000	5.2793	54.925014	54.0497	687.0	687.0	0.875316
48	Pipe	5.000	5.2793	54.031376	52.3850	687.0	687.0	1.646338
49	Pipe	5.000	5.2793	52.385036	51.3360	687.0	687.0	1.049040
50	Pipe	5.000	5.2793	51.317677	50.0000	687.0	687.0	1.317670
51	Pipe	5.000	5.2793	18.126244	17.9525	687.0	687.0	0.173723
52	Pipe	5.000	5.2793	2.637156	-0.1075	687.0	681.0	2.744668
53	Pipe	5.000	5.2793	-0.138055	-0.4855	681.0	681.0	0.347447
54	Treated Effluent HIHTL (From TSCR)	5.000	0.5106	0.001847	-0.4435	681.0	680.0	-0.445373

CALCULATION SHEET

Project No.	078906.18.01	Calculation No.	078906.18.01-M-002	Rev. 0	Page No. 55 of 68
Title: Tank Side Cesium Removal Process Pump Flow Analysis					
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AFT Fathom Model

Pipe	Name	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	P Static Max (psig)	P Static Min (psig)	Elevation Inlet (feet)	Elevation Outlet (feet)	dP Stag. Total (psid)
55	Pipe	0.000	0.0000	120.493515	120.4935	681.0	681.0	0.000000
56	Pipe	0.000	0.0000	115.486954	115.4870	681.0	681.0	0.000000
57	Pipe	0.000	0.0000	115.486954	115.4870	681.0	681.0	0.000000
58	Pipe	0.000	0.0000	115.486954	115.4870	681.0	681.0	0.000000
59	Pipe	0.000	0.0000	115.486954	115.4870	681.0	681.0	0.000000
60	Pipe	0.000	0.0000	115.486954	115.4870	681.0	681.0	0.000000
61	Pipe	5.000	5.2793	110.431625	107.6612	687.0	687.0	2.770457
62	Pipe	5.000	5.2793	97.953918	95.6124	687.0	687.0	2.341528
63	Pipe	0.000	0.0000	110.666336	110.6663	687.0	687.0	0.000000
64	Pipe	0.000	0.0000	79.498169	79.4982	687.0	687.0	0.000000
65	Pipe	0.000	0.0000	79.970016	79.9700	687.0	687.0	0.000000
66	Pipe	0.000	0.0000	61.421383	61.4214	687.0	687.0	0.000000
67	Pipe	0.000	0.0000	79.150726	79.1507	687.0	687.0	0.000000
68	Pipe	0.000	0.0000	62.252460	62.2525	687.0	687.0	0.000000
70	Pipe	5.000	5.2793	61.543499	61.1867	687.0	687.0	0.356836
71	Pipe	5.000	5.2793	61.670292	61.5740	687.0	687.0	0.096251
72	Pipe	5.000	5.2793	98.415039	97.9845	687.0	687.0	0.430570
89	Pipe	5.000	5.2793	62.362797	62.0177	687.0	687.0	0.345053
91	Pipe	5.000	5.2793	107.630630	107.2856	687.0	687.0	0.345053

Pipe	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
1	0.005253	0.0000	0.009693	188.0869	188.081635	188.09081	188.085556
4	0.872010	0.0000	1.609144	187.7954	186.923416	188.08556	187.213547
5	2.121413	1.0838	1.914701	186.8825	184.761124	187.21355	185.092133
6	20.363795	2.0592	33.777872	184.7611	164.397324	185.09213	164.728333
7	0.578195	0.0000	1.066959	163.8827	163.304474	164.67088	164.092697
8	0.956125	0.0000	1.764363	163.4285	162.472397	164.09270	163.136566
9	13.839339	-2.0592	29.338093	162.8023	148.962967	163.08119	149.241867
10	0.805887	-0.1084	1.687137	148.9630	148.157074	149.24187	148.435974
11	0.538107	0.0000	0.992983	0.5381	0.000000	0.78257	0.244466
12	0.128262	0.0000	0.236685	163.8580	163.729706	164.09270	163.964432
13	0.816168	0.0000	1.506097	121.0750	120.258789	121.30968	120.493515
14	0.345053	0.0000	0.636736	120.2588	119.913727	120.49352	120.148453

CALCULATION SHEET

Project No. 078906.18.01	Calculation No. 078906.18.01-M-002	Rev. 0	Page No. 56 of 68
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Pipe	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
15	0.442353	0.0000	0.816285	119.8954	119.453049	120.13013	119.687775
16	0.006136	0.0000	0.011323	119.6859	119.679718	119.68777	119.681641
17	0.053293	0.0000	0.098343	116.6526	116.599350	116.68164	116.628357
18	1.036208	0.0000	1.912143	116.3936	115.357422	116.62836	115.592148
19	0.086862	0.0000	0.160288	115.3391	115.252228	115.57382	115.486954
20	4.820618	3.2515	2.895616	115.2522	110.431625	115.48695	110.666336
21	0.000000	0.0000	0.000000	110.6663	110.666336	110.66634	110.666336
22	0.000000	0.0000	0.000000	95.8471	95.847107	95.84711	95.847107
23	0.201437	0.0000	0.371718	95.6124	95.410950	95.84711	95.645676
24	0.115915	0.0000	0.213902	95.6167	95.500748	95.64568	95.529755
25	0.057089	0.0000	0.105347	80.5007	80.443649	80.52975	80.472672
26	0.502654	0.0000	0.927561	80.2379	79.735291	80.47267	79.970016
27	0.096251	0.0000	0.177614	79.7353	79.639053	79.97002	79.873764
28	0.345053	0.0000	0.636736	79.6085	79.263443	79.84322	79.498169
29	0.347447	0.0000	0.641153	79.2634	78.916000	79.49817	79.150726
30	0.345053	0.0000	0.636736	78.9160	78.570953	79.15073	78.805664
31	0.375161	0.0000	0.692294	78.5404	78.165253	78.77513	78.399963
32	0.115915	0.0000	0.213902	78.3710	78.255035	78.39996	78.284042
33	0.057089	0.0000	0.105347	63.2550	63.197948	63.28405	63.226963
34	0.598905	0.0000	1.105175	62.9922	62.393337	63.22696	62.628056
35	0.347447	0.0000	0.641153	62.0177	61.670292	62.25246	61.905010
36	0.000000	0.0000	0.000000	61.9050	61.905010	61.90501	61.905010
37	0.000000	0.0000	0.000000	107.5203	107.520294	107.52029	107.520294
38	0.288299	0.0000	0.532006	107.2856	106.997269	107.52029	107.231995
39	0.115915	0.0000	0.213902	107.2030	107.087067	107.23199	107.116074
40	0.057089	0.0000	0.105347	99.0871	99.029968	99.11607	99.058990
41	0.291828	0.0000	0.538518	98.8243	98.532440	99.05899	98.767151
42	0.086862	0.0000	0.160288	98.5019	98.415039	98.73662	98.649750
43	0.000000	0.0000	0.000000	98.6497	98.649750	98.64975	98.649750
44	0.000000	0.0000	0.000000	61.4214	61.421383	61.42138	61.421383
45	0.799188	0.0000	1.474764	61.1867	60.387478	61.42138	60.622196
46	0.431915	0.0000	0.797024	60.3569	59.925014	60.59165	60.159733
47	0.875316	0.0000	1.615245	54.9250	54.049702	55.15973	54.284420
48	1.646338	0.0000	3.038032	54.0314	52.385036	54.26609	52.619755
49	1.049040	0.0000	1.935821	52.3850	51.336002	52.61975	51.570721
50	1.317670	0.0000	2.431532	51.3177	50.000004	51.55239	50.234722
51	0.173723	0.0000	0.320577	18.1262	17.952518	18.36096	18.187237
52	2.744668	-3.2515	11.064810	2.6372	-0.107511	2.87188	0.127209
53	0.347447	0.0000	0.641153	-0.1381	-0.485501	0.09666	-0.250782
54	-0.445373	-0.5419	0.178141	-0.4435	0.001847	-0.44133	0.004043

CALCULATION SHEET

Project No.	078906.18.01	Calculation No.	078906.18.01-M-002	Rev. 0	Page No. 57 of 68
Title: Tank Side Cesium Removal Process Pump Flow Analysis					
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AFT Fathom Model

Pipe	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
55	0.000000	0.0000	0.000000	120.4935	120.493515	120.49352	120.493515
56	0.000000	0.0000	0.000000	115.4870	115.486954	115.48695	115.486954
57	0.000000	0.0000	0.000000	115.4870	115.486954	115.48695	115.486954
58	0.000000	0.0000	0.000000	115.4870	115.486954	115.48695	115.486954
59	0.000000	0.0000	0.000000	115.4870	115.486954	115.48695	115.486954
60	0.000000	0.0000	0.000000	115.4870	115.486954	115.48695	115.486954
61	2.770457	0.0000	5.112399	110.4316	107.661163	110.66634	107.895889
62	2.341528	0.0000	4.320885	97.9539	95.612396	98.18864	95.847107
63	0.000000	0.0000	0.000000	110.6663	110.666336	110.66634	110.666336
64	0.000000	0.0000	0.000000	79.4982	79.498169	79.49817	79.498169
65	0.000000	0.0000	0.000000	79.9700	79.970016	79.97002	79.970016
66	0.000000	0.0000	0.000000	61.4214	61.421383	61.42138	61.421383
67	0.000000	0.0000	0.000000	79.1507	79.150726	79.15073	79.150726
68	0.000000	0.0000	0.000000	62.2525	62.252460	62.25246	62.252460
70	0.356836	0.0000	0.658479	61.5435	61.186665	61.77822	61.421383
71	0.096251	0.0000	0.177614	61.6703	61.574047	61.90501	61.808765
72	0.430570	0.0000	0.794542	98.4150	97.984467	98.64975	98.219177
89	0.345053	0.0000	0.636736	62.3628	62.017742	62.59752	62.252460
91	0.345053	0.0000	0.636736	107.6306	107.285568	107.86534	107.520294

All Junction Table

Jct	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	Pump AP-07F	-0.2207	188.086884	-0.2168	188.09081	61.389	10.6733	0.00000
4	Pump Discharge Nozzle	188.0816	187.795425	188.0856	188.08556	61.389	10.6733	0.00000
5	Branch	186.9234	186.882538	187.2135	187.21355	61.389	10.6733	0.00000
6	Branch	184.7611	184.761124	185.0921	185.09213	61.389	10.6733	0.00000
7		164.3973	163.882660	164.7283	164.67088	61.389	10.6733	9.86728
8	Branch	163.5611	163.561127	164.0927	164.09270	N/A	N/A	0.00000
9	Area Change	162.4724	162.802292	163.1366	163.08119	56.351	9.7974	4.13484
10	Branch	148.9630	148.962967	149.2419	149.24187	56.351	9.7974	0.00000
11	Orifice	148.1571	0.538107	148.4360	0.78257	56.351	9.7974	529.39990
12	AP-07F	12.6388	-0.244466	12.8833	0.00000	56.351	9.7974	52.69975
13	Branch	120.3892	120.389191	120.4935	120.49352	N/A	N/A	0.00000
14	Valve	119.9137	119.895401	120.1485	120.13013	5.000	0.8693	0.07807
15	Branch	119.4530	119.685852	119.6878	119.68777	5.000	0.8693	0.00000
16	Pre-Filter (WP-FLT-325A)	119.6797	116.652634	119.6816	116.68164	5.000	0.8693	1,558.73572
17	Branch	116.5993	116.393631	116.6284	116.62836	5.000	0.8693	0.00000
18	Valve	115.3574	115.339096	115.5921	115.57382	5.000	0.8693	0.07807

CALCULATION SHEET

Project No. 078906.18.01	Calculation No. 078906.18.01-M-002	Rev. 0	Page No. 58 of 68
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Jct	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
19	Branch	115.3826	115.382629	115.4870	115.48695	N/A	N/A	0.00000
20	Branch	110.6077	110.607666	110.6663	110.66634	N/A	N/A	0.00000
X21	Valve	110.6663	95.847107	110.6663	95.84711	0.000	0.0000	0.00000
22	Branch	95.7428	95.742798	95.8471	95.84711	N/A	N/A	0.00000
23	Branch	95.4109	95.616653	95.6457	95.64568	5.000	0.8693	0.00000
24	Ion-Exchange Column (WP-IX-400A)	95.5007	80.500748	95.5298	80.52975	5.000	0.8693	516.99054
25	Branch	80.4436	80.237946	80.4727	80.47267	5.000	0.8693	0.00000
26	Branch	79.8657	79.865692	79.9700	79.97002	N/A	N/A	0.00000
27	Valve	79.6391	79.608505	79.8738	79.84322	5.000	0.8693	0.13013
28	Branch	79.3938	79.393845	79.4982	79.49817	N/A	N/A	0.00000
29	Branch	79.0464	79.046402	79.1507	79.15073	N/A	N/A	0.00000
30	Valve	78.5710	78.540405	78.8057	78.77513	5.000	0.8693	0.13013
31	Branch	78.1653	78.370956	78.4000	78.39996	5.000	0.8693	0.00000
32	Ion-Exchange Column (WP-IX-400B)	78.2550	63.255032	78.2840	63.28405	5.000	0.8693	516.99054
33	Branch	63.1979	62.992245	63.2270	63.22696	5.000	0.8693	0.00000
34	Valve	62.3933	62.362797	62.6281	62.59752	5.000	0.8693	0.13013
35	Branch	62.1481	62.148144	62.2525	62.25246	N/A	N/A	0.00000
36	Branch	61.8007	61.800694	61.9050	61.90501	N/A	N/A	0.00000
X37	Valve	61.9050	107.520294	61.9050	107.52029	0.000	0.0000	0.00000
38	Branch	107.4160	107.415970	107.5203	107.52029	N/A	N/A	0.00000
39	Branch	106.9973	107.202972	107.2320	107.23199	5.000	0.8693	0.00000
40	Ion-Exchange Column (WP-IX-400C)	107.0871	99.087067	107.1161	99.11607	5.000	0.8693	275.72827
41	Branch	99.0300	98.824265	99.0590	99.05899	5.000	0.8693	0.00000
42	WP-AOV-408C Fail Close	98.5324	98.501892	98.7672	98.73662	5.000	0.8693	0.13013
43	Branch	98.5454	98.545441	98.6497	98.64975	N/A	N/A	0.00000
X44	Valve	98.6497	61.421383	98.6497	61.42138	0.000	0.0000	0.00000
45	Branch	61.3627	61.362705	61.4214	61.42138	N/A	N/A	0.00000
46	Valve	60.3875	60.356930	60.6222	60.59165	5.000	0.8693	0.13013
47	Media Trap	59.9250	54.925014	60.1597	55.15973	5.000	0.8693	21.30202
48	Valve	54.0497	54.031376	54.2844	54.26609	5.000	0.8693	0.07807
49	Delay Tank	52.3850	52.385036	52.6198	52.61975	5.000	0.8693	0.00000
50	Valve	51.3360	51.317677	51.5707	51.55239	5.000	0.8693	0.07807
51	WP-PCV-557	50.0000	18.126244	50.2347	18.36096	5.000	0.8693	214.02025
52	Orifice	17.9525	2.637156	18.1872	2.87188	5.000	0.8693	65.24963
53	WP-AOV-560 Fail Close	-0.1075	-0.138055	0.1272	0.09666	5.000	0.8693	0.13013
54	Area Change	-0.4855	-0.443526	-0.2508	-0.44133	5.000	0.8693	31.37612
55	AP-106 Riser 2	0.1227	-0.002195	0.1248	0.00000	5.000	0.8693	56.85684
X56	Valve	120.4935	115.486954	120.4935	115.48695	0.000	0.0000	0.00000
57	Branch	115.4870	115.486954	115.4870	115.48695	0.000	0.0000	0.00000
58	Pre-Filter (WP-FLT-325B)	115.4870	115.486954	115.4870	115.48695	0.000	0.0000	0.00000

CALCULATION SHEET

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Jct	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
59	Branch	115.4870	115.486954	115.4870	115.48695	0.000	0.0000	0.00000
60	Valve	115.4870	115.486954	115.4870	115.48695	0.000	0.0000	0.00000
X61	Valve	110.6663	79.498169	110.6663	79.49817	0.000	0.0000	0.00000
X62	Valve	79.9700	61.421383	79.9700	61.42138	0.000	0.0000	0.00000
X63	Valve	79.1507	62.252460	79.1507	62.25246	0.000	0.0000	0.00000
64	Valve	107.6612	107.630630	107.8959	107.86534	5.000	0.8693	0.13013
65	Valve	61.5740	61.543499	61.8088	61.77822	5.000	0.8693	0.13013
66	Valve	97.9845	97.953918	98.2192	98.18864	5.000	0.8693	0.13013
81	WP-FCV-306	163.7297	121.074951	163.9644	121.30968	5.000	0.8693	185.20372

Area Change Table

Area Change	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
7		164.3973	163.882660	164.7283	164.67088	61.389	10.6733	9.86728
9	Area Change	162.4724	162.802292	163.1366	163.08119	56.351	9.7974	4.13484
54	Area Change	-0.4855	-0.443526	-0.2508	-0.44133	5.000	0.8693	31.37612

Control Valve Table

Control Valve	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
51	WP-PCV-557	50.0000	18.126244	50.2347	18.36096	5.000	0.8693	214.02025
81	WP-FCV-306	163.7297	121.074951	163.9644	121.30968	5.000	0.8693	185.20372

General Component Table

General Component	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
16	Pre-Filter (WP-FLT-325A)	119.6797	116.652634	119.6816	116.68164	5.000	0.8693	1,558.73572
24	Ion-Exchange Column (WP-IX-400A)	95.5007	80.500748	95.5298	80.52975	5.000	0.8693	516.99054
32	Ion-Exchange Column (WP-IX-400B)	78.2550	63.255032	78.2840	63.28405	5.000	0.8693	516.99054
40	Ion-Exchange Column (WP-IX-400C)	107.0871	99.087067	107.1161	99.11607	5.000	0.8693	275.72827
47	Media Trap	59.9250	54.925014	60.1597	55.15973	5.000	0.8693	21.30202
49	Delay Tank	52.3850	52.385036	52.6198	52.61975	5.000	0.8693	0.00000
58	Pre-Filter (WP-FLT-325B)	115.4870	115.486954	115.4870	115.48695	0.000	0.0000	0.00000

Orifice Table

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Project No. 078906.18.01	Calculation No. 078906.18.01-M-002	Rev. 0	Page No. 60 of 68
Title: Tank Side Cesium Removal Process Pump Flow Analysis			
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Orifice	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
11	Orifice	148.1571	0.538107	148.4360	0.78257	56.351	9.7974	529.39990
52	Orifice	17.9525	2.637156	18.1872	2.87188	5.000	0.8693	65.24963

Pump Table

Pump	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	Pump AP-07F	-0.2207	188.086884	-0.2168	188.09081	61.389	10.6733	0.00000

Valve Table

Valve	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
14	Valve	119.9137	119.895401	120.1485	120.13013	5.000	0.8693	0.07807
18	Valve	115.3574	115.339096	115.5921	115.57382	5.000	0.8693	0.07807
X21	Valve	110.6663	95.847107	110.6663	95.84711	0.000	0.0000	0.00000
27	Valve	79.6391	79.608505	79.8738	79.84322	5.000	0.8693	0.13013
30	Valve	78.5710	78.540405	78.8057	78.77513	5.000	0.8693	0.13013
34	Valve	62.3933	62.362797	62.6281	62.59752	5.000	0.8693	0.13013
X37	Valve	61.9050	107.520294	61.9050	107.52029	0.000	0.0000	0.00000
42	WP-AOV-408C Fail Close	98.5324	98.501892	98.7672	98.73662	5.000	0.8693	0.13013
X44	Valve	98.6497	61.421383	98.6497	61.42138	0.000	0.0000	0.00000
46	Valve	60.3875	60.356930	60.6222	60.59165	5.000	0.8693	0.13013
48	Valve	54.0497	54.031376	54.2844	54.26609	5.000	0.8693	0.07807
50	Valve	51.3360	51.317677	51.5707	51.55239	5.000	0.8693	0.07807
53	WP-AOV-560 Fail Close	-0.1075	-0.138055	0.1272	0.09666	5.000	0.8693	0.13013
X56	Valve	120.4935	115.486954	120.4935	115.48695	0.000	0.0000	0.00000
60	Valve	115.4870	115.486954	115.4870	115.48695	0.000	0.0000	0.00000
X61	Valve	110.6663	79.498169	110.6663	79.49817	0.000	0.0000	0.00000
X62	Valve	79.9700	61.421383	79.9700	61.42138	0.000	0.0000	0.00000
X63	Valve	79.1507	62.252460	79.1507	62.25246	0.000	0.0000	0.00000
64	Valve	107.6612	107.630630	107.8959	107.86534	5.000	0.8693	0.13013
65	Valve	61.5740	61.543499	61.8088	61.77822	5.000	0.8693	0.13013
66	Valve	97.9845	97.953918	98.2192	98.18864	5.000	0.8693	0.13013

CALCULATION SHEET

Project No.	078906.18.01	Calculation No.	078906.18.01-M-002	Rev. 0	Page No. 61 of 68
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Prepared By: JF Gallegos	Date: 7/18/19	Checked By: KW Dixon	Date: 7/18/19		

ATTACHMENT 1

241-AP-107 PUMP AND TANK ELEVATION CALCULATION

CALCULATION SHEET

Project No. 078906.18.01	Calculation No. 078906.18.01-M-002	Rev. 0	Page No. 62 of 68
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Prepared By: JF Gallegos	Date: 7/18/19	Checked By: KW Dixon	Date: 7/18/19

Elevation Calculations

$Elev_{face.of.flange} := 674ft + 3in + \frac{3}{16}in = 674.3 \cdot ft$

AP-07F Riser face of flange elevation (As-Built, H-2-77455, Detail 3, View C).

$Thk_{adapter} := 0.938in + 0.125in = 1.063 \cdot in$

Riser Adapter plate thickness + gasket (H-14-111337, Sh. 3, Detail E).

$Elev_{tankBot} := 623.26ft + \frac{3}{8}in + 8in + \frac{1}{2}in = 624.0 \cdot ft$

Elevation of 241-AP-107 tank bottom (H-2-90534).

$Pump_{length} := 48.5ft$

Pump length from bottom face of pump flange to bottom of pump inlet (SK-AP-07F-001).

$Height_{nozzle} := 10in$

Pump nozzle height above bottom face of pump flange (SK-AP-07F-001).

$Length_{pump} := Pump_{length} + Height_{nozzle} = 49.3 \cdot ft$

Height of pump from inlet to discharge nozzle (SK-AP-07F-001).

$Length_{anti.siphon} := 16.5in$

Elevation difference between bottom face of pump flange and center line of anti-siphon holes in the pump column (SK-AP-07F-001).

$Level_{liquidMax} := 458in$

Maximized authorized waste liquid level for 241-AP-107 (OSD-T-151-00007, Rev. 22 Table 1.1.1).

$Elev_{liquidMax} := Elev_{tankBot} + Level_{liquidMax} = 662.2 \cdot ft$

Highest waste elevation in 241-AP-107.

$Elev_{pumpOut} := Elev_{face.of.flange} + Thk_{adapter} \cdots + Height_{nozzle} = 675.2 \cdot ft$

Calculated elevation of pump discharge nozzle in 241-AP-107.

$Elev_{pumpBot} := Elev_{face.of.flange} \cdots + Thk_{adapter} - Pump_{length} = 625.9 \cdot ft$

Pump inlet elevation (also lowest 241-AP-107 waste level considered).

$Elev_{anti.siphon} := Elev_{face.of.flange} \cdots + Thk_{adapter} - Length_{anti.siphon} = 673.0 \cdot ft$

Antisiphon discharge elevation. This elevation corresponds to the elevation of the holes in the pump column not the end of the discharge piping.

ATTACHMENT 2

EMAIL TO DETERMINE DENSITY AND DYNAMIC VISCOSITY

CALCULATION SHEET

Project No.	078906.18.01	Calculation No.	078906.18.01-M-002	Rev. 0	Page No. 64 of 68
Title: Tank Side Cesium Removal Process Pump Flow Analysis					
Prepared By: JF Gallegos	Date: 7/18/19	Checked By: KW Dixon		Date: 7/18/19	

From: Servin, Mario A
To: Paul Dorsh
Cc: Engeman, Jason K; John Gallegos
Subject: RE: TSCR Pump Sizing
Date: Thursday, October 18, 2018 6:27:00 AM

Paul,

See email below.

Mario A. Servin, PE
TFP Engineering
Washington River Protection Solutions, LLC
Contractor of the Department of Energy
Office: (509) 376-0676
Cell: (562) 335-1041

From: Wagnon, Todd J <todd_j_wagnon@rl.gov>
Sent: Wednesday, October 17, 2018 4:56 PM
To: Servin, Mario A <mario_a_servin@rl.gov>
Cc: Engeman, Jason K <jason_k_engeman@rl.gov>
Subject: RE: TSCR Pump Sizing

Mario,

For a design target the nominal values from Table 3.4 below are generally appropriate.

A better range for viscosity is 2 cP to 5 cP from RPP-RPT-60549. For density, based on the same information a nominal range is from 1.25 to 1.28.

Solids concentration should be considered from 160 ppm to 200 ppm as a nominal range.

Let me know if you have any questions
Todd

Todd Wagnon
Waste Feed Delivery Operations and Planning
2505 Garlick Rm 2332
Office: (509) 376-8406
Cell: (541) 908-2358
Washington River Protection Solutions

From: Servin, Mario A <mario_a_servin@rl.gov>
Sent: Wednesday, October 17, 2018 1:50 PM

To: Wagnon, Todd J <todd_j_wagnon@rl.gov>
Subject: FW: TSCR Pump Sizing

Todd,

See email chain below. ARES would like to close in on the properties of the supernatant range the pump most likely will be operating in to be able to size the pump better. Any thoughts?

Thanks,

Mario A. Servin, PE
TFP Engineering
Washington River Protection Solutions, LLC
Contractor of the Department of Energy
Office: (509) 376-0676
Cell: (562) 335-1041

From: Paul Dorsh <pdorsh@arescorporation.com>
Sent: Tuesday, October 16, 2018 6:54 AM
To: Servin, Mario A <mario_a_servin@rl.gov>; Engeman, Jason K <jason_k_engeman@rl.gov>
Cc: John Gallegos <jgallegos@arescorporation.com>
Subject: RE: TSCR Pump Sizing

That would certainly be closer, but I would think a range of supernatant is needed – and likely what TSCR would encounter. (We could use the high end of the range; then use the delta between the nominal value and the high end of the range to create a low end of supernatant as an initial test)…

Paul

From: Servin, Mario A <mario_a_servin@rl.gov>
Sent: Monday, October 15, 2018 3:51 PM
To: Paul Dorsh <pdorsh@arescorporation.com>; Engeman, Jason K <jason_k_engeman@rl.gov>
Cc: John Gallegos <jgallegos@arescorporation.com>
Subject: RE: TSCR Pump Sizing

Paul,

See table below, this from the TSCR spec, RPP-SPEC-61910. For sizing the pump would it make sense to use the nominal values that TSCR is using for their design?

Table 3-4. Double-Shell Tank Feed Physical Characteristics.

Parameter	Unit	Nominal Value	Range
Density[a]	g/mL	1.27	1.0 – 1.35
Viscosity[b]	cP	3.7	1 – 8
Solids Concentration[c]	ppm	160	0 – 15,000
Solids Particle Size[d]	µm	< 1	< 1 – 550
Waste Temperature[e]	°C	25	20 – 35
Surface Tension[f]	dynes/cm	80	70 – 100

[a] The upper bound value originates from TFC-ENG-STD-26, "Waste Transfer, Dilution, and Flushing Requirements," in which supernatant is defined as having a specific gravity of less than or equal to 1.35 and containing minimal solids.
[b] RPP-RPT-60549, "Supernatant Viscosity Assessment to Support Direct Feed Low Activity Waste Treatment."
[c] Tank-Side Cesium Removal system will be designed to make full throughput at the nominal solids content, but is not required to achieve throughput at the maximum solids content of 15,000 ppm (1.5 wt%).
[d] RPP-RPT-60670, "Solids Removal Requirements in the Direct Feed Low Activity Waste Process."
[e] WRPS-1705804, "Temperature Ranges for Direct Feed Low-Activity Waste Feed."
[f] The surface tension values originate from PNL-10173, *Ammonia in Simulated Hanford Double-Shell Tank Wastes: Solubility and Effect on Surface Tension.*

Mario

From: Paul Dorsh <pdorsh@arescorporation.com>
Sent: Monday, October 15, 2018 2:50 PM
To: Servin, Mario A <mario_a_servin@rl.gov>; Engeman, Jason K <jason_k_engeman@rl.gov>
Cc: John Gallegos <jgallegos@arescorporation.com>
Subject: TSCR Pump Sizing

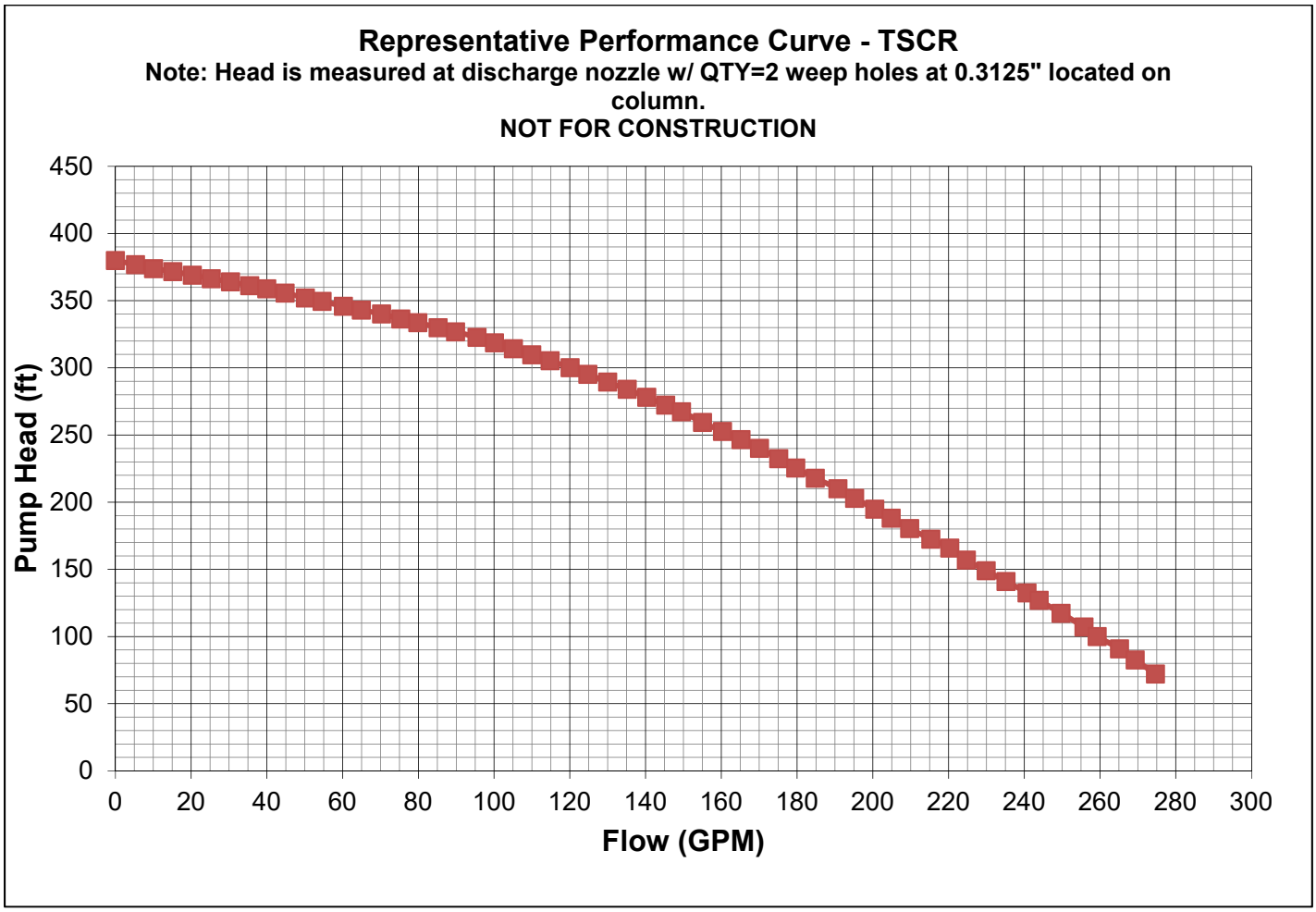
Mario/Jason –

Is it possible for the project to better define the actual supernatant conditions that TSCR will be processing? Right now, we are consider a range from the worst case supernatant (1.37 SpG, 8cP) to water (1.0 SpG, 1 cP). Although the pump can obviously handle the water, using a better supernatant range (as opposed to the water) would likely result in much better control over the range that TSCR would actually see. If designing to this is possible, could you provide the information? I can send a formal RFI to capture any input changes. Thanks.

Paul

ATTACHMENT 3

PUMP CURVE

CALCULATION SHEET

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Prepared By: JF Gallegos	Date: 7/18/19	Checked By: KW Dixon	Date: 7/18/19