AVANTech
INCORPORATED

CALCULATION COVER SHEET

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Jeremiah Rogers 10/24/19

CALCULATION ID NUMBER	RPP-CALC-62496
REVISION NUMBER	3
PROJECT NUMBER	18-13

TITLE	TSCR Filter Sizing

	Name	Initials	Date
Preparer	Jaclyn Siewert	RAW per telecon	10/24/2019
Title	Engineer		
Reviewer	Rob Wilson	RAW	10/24/2019
Title	Sr. Engineer		
Approver	Jeremiah Rogers	JJR	10/24/19
Title	Sr. Engineering Specialist		

Revision Notes	3 – Changed Attachment 1 to Data Sheet DS-1813-04

CALCULATION REVIEW CHECKLIST

CALCULATION ID NUMBER	RPP-CALC-62496
REVISION NUMBER	3

Item	**Yes**	**N/A***
1. Design Inputs such as design bases, regulatory requirements, codes, and standards are identified and documented, verified against customer specifications including edition and addenda.	✓	
2. Effect of design package on compliance with the Safety Analysis Report or Certificate of Compliance identified and documented.	✓	
3. Revision numbers correct on the list of drawings?	✓	
4. Assumptions reasonable?	✓	
5. Appropriate analysis method used?	✓	
6. Correct values used from drawings?	✓	
7. Answers and units correct?	✓	
8. Summary of results matches calculations?	✓	
9. Material properties properly taken from credible references?	✓	
10. Figures match design drawings?	✓	
11. Computer input complete and properly identified?	✓	
12. Documentation of all hand calculations attached?	✓	
13. Reference to Verification / Validation for software?		✓

* N/A, Explain	13. All computer software checked by hand calculation.

	Name	**Initials**	**Date**
Reviewed	Rob Wilson	RW	10/24/2019

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1.0 PURPOSE

This calculation justifies the size and layout of the TSCR Filters (POR655-WP-FLT-325A/B). These backwashable direct flow filters must be sized correctly for effective removal of solids from the TSCR waste stream prior to the ion exchange system. Key design attributes for these vessels are filter surface area, design flux, and air accumulator pressure.

2.0 REFERENCES

2.1. TFC-ENG-STD-02, Rev. A-12, Environmental/Seasonal Requirements for TOC Systems, Structures, and Components. 2017.

2.2. H-14-111268, Rev. 1, TSCR Filter Machined Parts, AVANTech, Inc.

2.3. RPP-SPEC-61910, Rev. 1, Specification for the Tank-Side Cesium Removal Demonstration Project.

2.4. H-14-111331, Rev. B, AP Farm TSCR Upgrades, HIHTL Layout, Hose Chart, Sheet 4.

2.5. H-14-111270, Rev. 1, TSCR Process Enclosure Piping Isometrics, AVANTech, Inc.

2.6. DS-1813-09, Rev. 0, Air Accumulator Tank Data Sheet, AVANTech, Inc.

2.7. Kakac, Sadik; Liu, Hongtan; Pramuanjaroenkij, Anchasa. Heat Exchangers: Selection, Rating, and Thermal Design, 3rd Edition, 2012, pg 383.

2.8. DS-1813-01, Rev. 1, Filter Data Sheet, AVANTech, Inc.

2.9. TR-1813-01, Dead End Filtration Media Testing Results, February 2019, AVANTech, Inc.

2.10. "Safe-T Chem-Acid Transfer Hose." River Bend Transfer Systems, LLC. Specification.

2.11. Walas, S. M., "Chemical Process Equipment: Selection and Design," 1990, p. 671.

2.12. Brown, T. L., et al., "Chemistry: The Central Science," 12th ed., p. 389.

3.0 DESIGN INPUTS AND ASSUMPTIONS

3.1. TUBE LAYOUT

Porous Area per Filter Element = 112.7 in^2/tube
Per Attachment 1, AVANTech Data Sheet DS-1813-04, Line 29.

Tube Pitch, P_t =1.5 in.
Smallest value to accommodate maximum number of filter elements, based on Filter element OD (Ref. 2.2).

Tube Sheet Diameter, D_s = 16.875 in.
Diameter excludes a 0.125-inch bevel around the outermost edge of the tube sheet.
Per Ref. 2.2.

Design Flow Rate = 5 gpm
Per Ref. 2.3, Sec. 3.2.1.

3.2. AIR ACCUMULATOR PRESSURE

Constant air temperature during backwash.
Assumption.

Static pressure in the Filter housing at the end of a backwash = 3 psig
Assumption.

Backwash outlet HIHTL (Hose 4) = 1667 in. length (140 ft)
Per Ref. 2.4, HIHTL Information Table.

Backwash outlet HIHTL = 2 in. ID
Per Ref. 2.10 (ATTACHMENT 2).

Backwash and drain line sizes and lengths taken from 3D CAD model.
Per Ref. 2.5.

Air Accumulator volume, $V_{accumulator}$ = 20 gal.
Per Ref. 2.6.

Filter housing volume, $V_{housing}$ = 49.5 gal.
Per Ref. 2.8.

Atmospheric Pressure = 14.7 psia
Per Ref. 2.1.

4.0 APPROACH/METHODOLOGY

4.1. FILTER DESIGN ORIGIN

The filter design has its origins in the treatment of condensate water at commercial boiling water reactors. It was found that if you operate at a very low flux and maintain pressure drop low (< 2 psid), then filter could be loaded and backwashed over many cycles with a high degree of pressure drop recovery (Ref. 2.9). AVANTech has built upon this concept by supplying multiple low flux backwashable filters to nuclear facilities for the treatment of liquid radwaste. The goal with filter operation is to perform backwashes within a reasonable time, and not necessarily an increase in pressure drop. Maintaining a very low pressure drop minimizes the depth of particle penetration into the filter media, which aids backwash recovery.

4.2. FILTER OPERATION

TSCR uses backwashable dead end filters for removing total undissolved/ suspended solids (TSS) prior to ion exchange. There are two filters in a duplex configuration wherein one filter is online while the other is in a backwash or standby mode. The filter differential pressure (DP) is calculated by the PLC as the difference between the measured pressure values on the feed (WP-PIT-310) and the combined Filter outlet (WP-PIT-313). When a filter has been in operation for 24-hrs or it experiences a DP increase of 2.0 psi, the standby filter is placed in service and the online filter is taken offline, backwashed, refilled with 0.1 M NaOH and then placed in standby. Backwashed liquids and solids are sent through the drain line to AP-108.

4.3. EMPIRICAL TEST RESULTS

A 1/16th scale TSCR filter was recently tested as documented in Ref. 2.9, Media Testing Results. The testing used Hanford 5.6M Na+ simple simulant that was spiked with ferric phosphate ($FePO_4$) solids to a concentration of approximately 400 to 900 ppm. The TSCR test filter platform, shown in **Figure** 1, was designed and mechanically/ operationally configured to mimic the TSCR filter.

Figure 1, TSCR Test Filter Platform

It contained the exact same filter media as TSCR and it was operated at the same pressures and filtration fluxes as those planned for TSCR.

Results shown in **Figure 2** indicate that the differential pressure will rise by approximately 7 in-H_2O (0.25 psi) over a 24-hr period, which is well below the design limiting DP of 55 in-H_2O (2.0 psi), which is listed in the Control Logic Narrative.

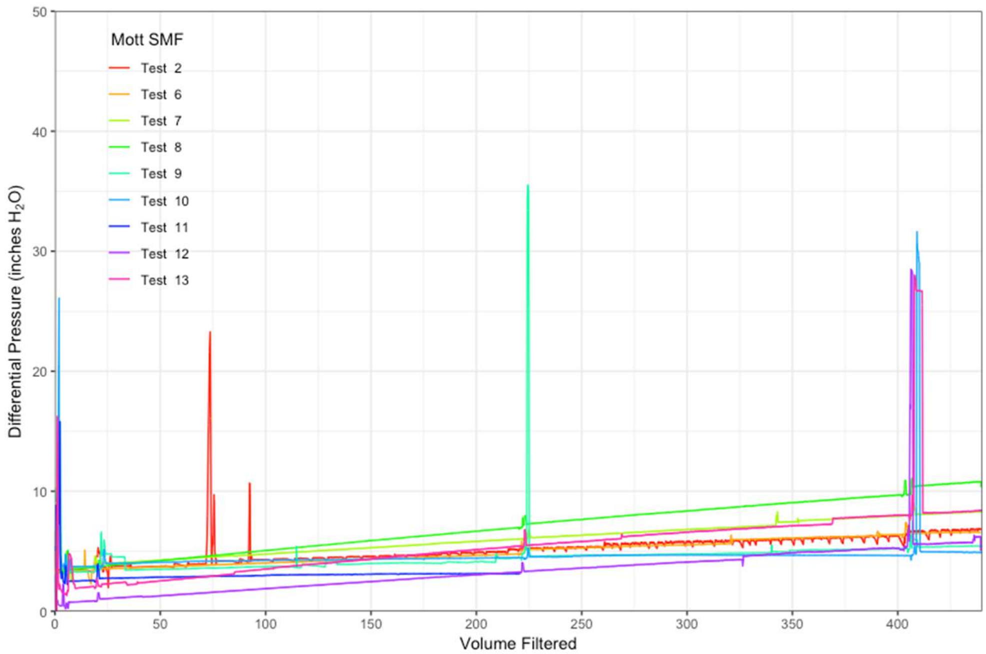

Figure 2, TSCR Filter Differential Pressure (24hr Loading Cycle)

As documented in PNNL LTR-72195-009, *TSS and PSD Analysis of TSCR Filter Performance Samples*, all filtrate samples had a turbidity of less than 10 NTU and therefore did not have a sufficient quantity of solids for particle size distribution nor total suspended solids analyses. Further, the filtrate from the Mott Grade 5 averaged approximately an FIU turbidity of approximately 1 NTU. The lack of filtrate suspended solids and low turbidity mean that a TSCR filter with Mott Grade 5 filter element will adequately protect the functionality of the CST loaded ion exchange columns.

4.4. FILTER SIZING

The approach for sizing the Filters involves testing, manufacturer specifications, and characteristics of the TSCR system process and layout. The complete underpinning behind the sizing of the TSCR filter requires a historical review as follows:

- In the proposal phase of the TSCR project AVANTech proposed the use of a pleated polypropylene filter that has a history of successfully removing iron from condensate and liquid radwaste at commercial nuclear power plants (NPPs).

- AVANTech engineers reviewed the metrics associated with filters used at commercial NPPs, which are shown in the below table, and performed preliminary laboratory testing with simulant. Based on the review and test results the TSCR was sized a flux of 0.006 gpm/ft^2 as shown in Table 4-1.

Table 4-1

Parameter	Condensate Filtration	NPP Liquid Radwaste	AVANTech TSCR
Undissolved Solids (ppm)	<0.10	<10	≈160
Typical Flow (gpm)	5,300	75	5
Typical Filter Area (ft^2)	33,110	2,310	792
Typical Flux (gpm/ft^2)	0.160	0.032	0.006
Flux Turn-down Factor	**1**	**4.9**	**25.4**
Backwash Frequency	Monthly	Daily	Daily

- Plans were made for additional filter testing after contract award. The pleated filters described by the AVANTech proposal was the baseline filter for the Filter Test Plan.

- At this point, the 30% TSCR mechanical design, which had a housing for the pleated polypropylene filters, had already been submitted for review.

- The TSCR project did not want to change the size of the housing, so it constrained the area of alternate test filters, such as the Mott Grade 5 and Pall PMF to a size that would fit in the same housing as proposed for the pleated filters.

- The filter testing was completed as described in Ref. 2.9, and results showed that Mott Grade 5 filter performed better than other media materials and easily completed a 24-hour loading period prior to backwashing.

In summary, the flux of the TSCR filter, which determined the size, was originally based on pleated polypropylene filters used at NPPs. Testing was then performed. It appeared logical that any filter tested should fit inside existing TSCR filter housing. Based on this logic a Mott Grade 5 filter was sized for testing – it worked out that this created a filter arrangement with a flux of 0.065 gpm/ft^2. Empirical results from testing showed that the Mott Grade 5 filter element met all test objectives at a flux of 0.065 gpm/ft^2; therefore, this size was adopted for the full scale TSCR system.

The number of filter elements is calculated using the same methodology as a shell and tube heat exchanger. Testing results support the type of filter element and the design flux at which the TSCR Filters will operate. A tube length of ≈ 36 in. accommodates a high backwash flowrate (due to air purge) and filters the 200 ppm solids that are present in the nominal waste over a 24-hr period loading cycle (Ref. 2.3). Air accumulator pressure calculations are based on expansion of a gas.

5.0 COMPUTATION

5.1. TUBE LAYOUT

The number of tubes (N_t) can be calculated from the tube pitch and desired tube sheet diameter, along with two constants. For a 30° triangular pitch layout, which fits more tubes than a square-pitch layout, the tube layout constant (CL) is sin(60°) or 0.866. The tube count constant (CTP) accounts for the incomplete coverage of the tube sheet diameter by the tubes, and its value is 0.93 for this application (Ref. 2.7).

$$N_t = CTP \times \frac{\pi D_s^2/4}{CL \times P_t^2} = 0.93 \times \frac{\pi(16.875\ in)^2/4}{0.866 \times (1.5\ in.)^2} = 106.75$$

To maintain a Filter capacity of 49.5 gal. and with the presence of a vent tube, the practical number of filter elements on the tube sheet is 98. Dead End Filtration Media Testing was performed to evaluate which of three different filter media has the highest backwash recovery after a 24-hr solids loading cycle. Operating at a filter flux of $6.5\text{x}10^{-2}$ gpm/ft^2, the Mott Media Grade 5 filter elements provided the best results with respect to low differential pressure (DP) rise and high recovery after backwash – as documented in Ref. 2.9. The porous area for the Mott Media Grade 5 filter elements is 112.7 in^2/tube. The total filter area is then calculated as follows:

$$Filter\ Area = (Porous\ Area/tube) \times (Number\ of\ Tubes)$$
$$= (112.7\ in^2/tube) \times (98\ tubes) \times \left(\frac{1\ ft^2}{144\ in^2}\right) = 77\ ft^2$$

At the design service flow rate of 5 gpm, the flux through the Filter will be:

$$Design\ Flux = \frac{Design\ Flow\ Rate}{Filter\ Area} = \frac{5\ gpm}{77\ ft^2} = 0.065\ gpm/ft^2$$

The basis and test results for the calculated design flux are detailed in Ref. 2.9, "Dead End Filtration Media Testing Results."

5.2. AIR ACCUMULATOR PRESSURE

A separate air accumulator tank will hold the required air for backwashing one Filter. The backwash mechanism is a high-velocity reverse-flow pulse. A high initial air pressure is necessary to dislodge the solids from the filter surface. This pressure is the critical value for sizing the air accumulator. It need not be sustained over the entire backwash period, since resistance due to the downstream pipe and hose is much lower than that of the filter. The surge of backwash flow created by the accumulator dump is initially slowed a little by the filter resistance, but quickly rises as solids are removed. The pressure is expected to decrease to approximately 40 psi during the removal of solids from the filter elements. The remaining pressure will be lost via downstream piping resistance. A calculation of the head loss due to piping is found in Appendix A.

At the time of backwash, the Filter outlet valve will open, and the air will expand into the Filter, displacing the liquid and solids on the filter elements. The volume of the air accumulator vessel was initially chosen to be 20 gallons as a reasonable estimate to hold the required amount of compressed air. To determine the minimum required pressure of air in the accumulator, Boyle's Law is employed (Ref. 2.12):

$$P_1V_1 = P_2V_2$$

Where

P_1 = Pressure of compressed air in the air accumulator

V_1 = Air accumulator volume

P_2 = Pressure of expanded air at conclusion of backwash

V_2 = Volume of expanded air

The initial air accumulator volume before backwash (V_1) includes the 20 gal. accumulator tank and connected piping. This volume will be the same regardless of which Filter is being backwashed. It is calculated using the equation below, and lengths and volumes of piping for both filters are listed in Table 5-1.

$$V_1 = \sum \left[\frac{\pi \times (Pipe\ ID^2/4) \times l}{231\ in^3/gal} \right] + V_{accumulator}$$

Table 5-1

Line Size	ID (in.)	Length (in.)[1]	Volume (gal.)
½"	0.622	404.13	0.53
¾"	0.824	56.75	0.13
1"	1.049	139.63	0.52
Total	--	--	**1.18**

[1]Ref. 2.5

$$V_1 = 1.18\ gal. + 20\ gal. = 21.18\ gal.$$

The volume of expanded air should be sufficient to clear the Filter housing, related piping, and hose-in-hose transfer line (HIHTL) in route to AP-108. This mitigates the settling of backwashed solids in the related piping and HIHTL. Simply put, V_2 must be greater than the volume of the system (V_{sys}). V_{sys} is the sum of the volumes of the HIHTL, backwash and drain piping, Filter housing, and air accumulator.

$$V_{sys} = V_{HIHTL} + V_{pipe} + V_{housing} + V_{accumulator}$$

$$V_{HIHTL} = \frac{\pi \times (Hose\ ID^2/4) \times l}{231\ in^3/gal} = \frac{\pi \times [(2\ in.)^2/4] \times (140\ ft \times 12\ in./ft)}{231\ \ in^3/gal} = 22.8\ gal.$$

When the air purge is initiated, the compressed air will expand to fill all accumulator and drain piping up to any closed valves. The 3D CAD model was analyzed to determine the length of pipe that fits this description. For conservatism, pipe lengths for both Filters were included. The volume is calculated by the following equation, and values are listed in Table 5-2.

$$V_{pipe} = \sum \frac{\pi \times (Pipe\ ID^2/4) \times l}{231\ in^3/gal}$$

Table 5-2

Line Size	ID (in.)	Length (in.)[1]	Volume (gal)
½” tube	0.4	478.25	0.26
½”	0.622	1232.50	1.62
¾”	0.824	56.75	0.13
1”	1.049	273.25	1.02
1 ½”	1.61	136.875	1.21
2”	2.067	386.35	5.61
V_{pipe}	--	--	**9.85**

[1]Ref 2.5

$$V_{sys} = 22.8\ gal. + 9.85\ gal. + 49.5\ gal. + 20\ gal. = 102.15\ gal.$$

The pressure of the expanded air after the backwash will be approximately atmospheric. For this calculation, V_1 will include a 3 psi assumed static pressure to equal 17.7 psia. Rearranging Boyle’s Law and substituting V_{sys} for V_2, the minimum pressure of compressed air is calculated as:

$$P_1 = \frac{P_2 V_{sys}}{V_1} = \frac{17.7\ psia \times 98.95\ gal.}{21.18\ gal.} = 85.37\ psia$$

The air accumulator pressure must be greater than 85.37 psia (70.7 psig) to create an air displacement volume of 102.15 gallons to fully flush the line to AP-108.

6.0 CONCLUSIONS

AVANTech engineers used the methodology in Section 4 to size the TSCR Filter vessels. Key design parameters are summarized below:

Filter Surface Area: 77 ft^2

Design Flux: 0.065 gpm/ft^2

Air Accumulator Pressure: 70.7 psig

APPENDIX A. HEAD LOSS CALCULATION

Column→	B	C	D	E	F
Row ↓	**DETERMINE PIPE FLUID VELOCITY**		**Calc-1**		
3	**Parameter**	**Description**	**Value**	**Units**	**Reference**
4	Q	Expected Backwash Flow Rate	160	gal/min	Determined via iterative process with head loss
5	Q	Expected Backwash Flow Rate (ft3/s)	0.3565	ft3/s	=D4/60/7.48
6	D_p	2" Pipe I.D.	2.067	in	Sch. 40 Pipe I.D.
7	ρ	Fluid Density	1.27	g/mL	Ref. 2.3
8	ρ	Fluid Density	79.0	lbs/ft3	=D7*62.24
9	μ	Fluid Viscosity	3.7	cP	Ref. 2.3
10	μ	Fluid Viscosity	0.0025	lbs/ft•s	=D9/1488
11	Δr_p	Pipe Roughness	8.71E-04	---	=1.5*10^-4/(D6/12)
12	g	Gravitational Constant	32.2	ft/s2	Ref. 2.11
13	L_p	Pipe Length	12.65	ft	Ref. 2.5
14	A_p	Area	0.023	ft2	=PI()*0.25*(D6/12)^2
15	v_p	Velocity	15.30	ft/s	=D5/D14
16	**DETERMINE HOSE FLUID VELOCITY**		**Calc-2**		
17	**Parameter**	**Description**	**Value**	**Units**	**Reference**
18	D_h	HIHTL I.D.	2.0	in	Ref. 2.10
19	Δr_h	Hose Roughness	9.00E-04	---	=1.5*10^-4/(D18/12)
20	L_h	Hose Length	140	ft	Ref. 2.4
21	A_h	Area	0.022	ft2	=PI()*0.25*(D18/12)^2
22	v_h	Velocity	16.3	ft/s	=D5/D21
23	**DETERMINE PIPE HEAD LOSS**		**Calc-3**		
24	**Parameter**	**Description**	**Value**	**Units**	**Reference**
25	Re_p	Reynolds Number	83,771	---	=(D8*D6/12*D15)/D10
26	f_p	Friction Factor	0.0223	---	=0.25/(LOG(D11/3.7+5.74/D25^0.9)^2)
27	$h_{L,p}$	Head Loss (ft)	5.954	ft	=(D26*D13*D15^2)/(2*(D6/12)*D12)
28	$h_{L,p}$	Head Loss (psi)	3.27	psi	=(D27*D8)/144
29	**DETERMINE HOSE HEAD LOSS**		**Calc-4**		
30	**Parameter**	**Description**	**Value**	**Units**	**Reference**

31	Re_h	Reynolds Number	86,577	---	=(D8*D18/12*D22)/D10
32	f_h	Friction Factor	0.0223	---	=0.25/(LOG(D19/3.7+5.74/D31^0.9)^2)
33	$h_{L,h}$	Head Loss (ft)	77.80	ft	=(D32*D20*D22^2)/(2*(D18/12)*D12)
34	$h_{L,h}$	Head Loss (psi)	42.70	psi	=(D33*D8)/144
35	**DETERMINE COMBINED HEAD LOSS**		**Calc-5**		
36	**Parameter**	**Description**	**Value**	**Units**	**Reference**
37	h_L	Combined Head Loss	46.0	psi	=D28+D34

Note: Head Loss equations are adapted from AECOM Calculation 31269-21-CALC-0032, LAWPS Process Line Sizing Calculation.

ATTACHMENT 1 – AVANTECH DATA SHEET DS-1813-04

Dead End Filter - Filter Media

No.	By	Chk	App	Date	Description	Doc. No:	DS-1813-04	Rev.: 0
0	DL	N/A	TB	3/27/2019	Initial Release	Project Name:	TSCR	
						Location:	Richland, WA	AVANTech INCORPORATED

GENERAL	1	Tag Number	P&ID Number	N/A	H-14-024857
	2	Service		Waste Processing	
	3	Area Classification		Class 1, Div. 1, Group B	
	4	Ambient Temp Range	Seismic Requirement	68 to 105 °F	N/A
	5	Quality Level	Safety Class	QL-3	GS
PROCESS CONDITIONS	6	Process Description:		Removal of Solids from Tank Waste Supernatant	
	7	Fluid:		Salt Waste Supernatant with Solids (Process) Dilute Sodium Hydroxide and Deionized or Softened Water (Reagent)	
	8	Design Flow:		3 to 7 gpm; 5 gpm (nominal design)	
	9	Density:		1.00 to 1.35 g/mL; 1.27 g/mL (nominal design)	
	10	Viscosity:		1.0 to 8.0 cP; 3.7 cP (nominal design)	
	11	Operating Temp.:		20° to 35°C; 25°C (nominal design)	
	12	Operating Pressure:		Approx. 100 psig (nominal)	
	13	Solids:		Metal oxides and hydroxides	
	14	Solids Concentration:		0 to 15,000 ppm; 200 ppm (nominal design)	
	15	Particle Size Distr:		< 1 - 550 µm; (< 1 µm nominal)	
	16	DP Increase:		2 psid increase over loading cycle (max.)	
FILTER DESIGN	17	Filter Description:		Mott 18" HyPulse LSP	
	18	Rev. A: 60% Review		98 (per filter)	
	19	Configuration:		Dead End Filter - Backwashable	
	20	Element Item Desc.:		Mott Seamless Porous Tube No.: 2316 - G16 – 36 - A00 – 5 - AA, S=0.062"WL, G=2"LG×0.065"WL	
	21	Element Dimensions:		1" OD × 0.875" ID (1/16" Wall) × 35-7/8" Porous Length	
	22	Media Grade:		Mott Grade 5 (seamless)	
	23	Efficiency Rating:		Media Grade 5: 90%> 5 µm, 99%> 8 µm, 99.9%> 13 µm (1/16" thick wall)	
	24	End Connectors:		Open End: 1"OD Tube Connector × 2"LG & Closed end: Blind Solid End Cap (Plain End)	
	25	Interconnectors:		None; butt welded tubes	
	26	Tubesheet DP:		50 psi(d)	
	27	Tubesheet Thickness:		1"	
	28	Design Flux:		93.5 gal/ft2/day (0.065 gal/ft2/min)	
	29	Porous Area:		112.7 in2/tube & 11,084 in2/filter (98 tubes)	
INSPECTION AND TESTING	30	Each Completed tube assembly shall be inspected to verify no weld defects			
	31	Each completed tube assembly shall be 100% leak tested in accordance with Mott procedures			
MATERIALS OF CONSTRUCTION	32	Porous Tubes:		316L SS sintered powdered metal (seamless)	
	33	Tube Connectors:		SA279 or SA 479 316L SS	

NOTES:

1) Tubes are backwashed with both filtrate and dilute NaOH.
2) Motive force for backwashing is compressed air at 60 to 80 psig. Both liquid and air are transferred through the tubes.
3) Porous tube assembly is constructed of two (2) porous sections.
4) Tubes are welded to the tubesheet.
5) The tubesheet is welded to the housing (the tubesheet/ filter assembly is not replaceable)

ATTACHMENT 2 - HIHTL SPECIFICATION

(Safe-T Chem-Acid Transfer Hose)

River Bend Transfer Systems, LLC

Safe-T Chem-Acid Transfer Hose

APPLICATION:

Safe-T Chem-Acid Transfer is a versatile premium high pressure hose developed to handle a wide range of industrial chemicals, acids, sludge and sediments in both suction and discharge service. This strong and durable hose will find many uses in the transfer of a wide range of chemicals at elevated temperatures and higher than normal pressures. Safe-T Chem-Acid Transfer was developed to accomodate the transfer of hazardous chemicals and chemical waste. The hose design will allow it to be used as a hose-in-hose assembly to be used in place of a double wall containment pipe. With state and federal regulatory agencies insisting on safe and dependable handling of chemicals and chemical waste, this hose will exceed the demands of the chemical industry. It is not recommended for refined petroleum products.

CONSTRUCTION:

TUBE: Black Versigard * (EPDM)
REINFORCEMENT: 4-spiral plied synthetic fabric with 2-wire helix
COVER: Black Versigard (Wrapped impression)

TEMPERATURE: -40ºF to 180º (-40º C to 82º)

PACKAGING: Custom Lengths Only (400 ft. Minimum)

NOM. ID	NOM. OD	MAX. WP @ 70º	BEND RADIUS	VACUUM HG	WEIGHT
in.	in.	psig	in.	in.	lb./ft.
1/2	1.25	825	4	29	.55
3/4	1.50	800	5	29	.75
1	1.75	775	6	29	.90
1 1/4	2.00	750	7	29	1.15
1 1/2	2.25	600	7	29	1.31
2	2.75	425	8	29	1.62
2 1/2	3.30	375	10	29	2.10
3	3.75	375	12	29	2.45
4	4.90	250	16	29	3.79
5	5.90	200	30	29	5.86
6	6.91	200	36	29	6.08
6 5/8	7.55	200	38	29	6.73
8	9.00	200	44	29	9.14

Compliant, Contained, Cost Effective

*Versigard is a Registered Trademark of Goodyear Tire and Rubber
Note: Refer to Chemical Resistance Chart for Specific Chemical and Temperature Compatability.