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AVANTech COVER SHEET

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REVISION NUMBER	2
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TITLE	TSCR Delay Tank Sizing

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Revision Notes	2 – Incorporated 90% Comments

CALCULATION REVIEW CHECKLIST

CALCULATION ID NUMBER	RPP-CALC-62498
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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	11., 13. No computer software used in calculation.

	Name	Initials	Date
Reviewed	Rob Wilson	*RW*	6/13/19

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1.0 PURPOSE

This calculation supports the size and configuration of the TSCR Delay Tank (POR655-WP-TK-550). This vessel holds the product stream for enough time to allow for ^{137m}Ba decay before the gamma level is analyzed downstream. The key design parameters are the vessel volume, dimensions, and baffle layout.

2.0 REFERENCES

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

2.2. Drawing H-14-111258 Rev. 1, "Fabrication Drawing Delay Tank ," AVANTech, Inc.

2.3. RPP-CALC-62584 Rev. 2, "Tank-Side Cesium Removal Material and Energy Balance," AVANTech, Inc.

2.4. Baker Tankhead Inc. *Tank Heads: Standard & A.S.M.E. ® Tank Heads For Industry*. "2:1 Semi-Elliptical Tank Heads." 2018. https://www.bakertankhead.com/products/tank-heads.htm

2.5. McCabe, W.L.; Smith, J.C.; Harriott, P. "Unit Operations of Chemical Engineering, 7th edition." 2004. p. 442.

2.6. Mohammadi, K., Investigation of the Effects of Baffle Orientation, Baffle Cut and Fluid Viscosity on Shell Side Pressure Drop and Heat Transfer Coefficient in an E-Type Shell and Tube Heat Exchanger, University of Stuttgart: Institute for Thermodynamics and Thermal Engineering, February 2011. pp. 4-5.

2.7. RPP-CALC-62484 Rev. 1, "TSCR Delay Tank (POR655-WP-TK-550) Pressure Vessel Code, Nozzle Load, & Seismic Calculation," AVANTech, Inc.

2.8. DS-1813-02 Rev. 1, "Delay Tank Data Sheet," AVANTech, Inc.

2.9. U.S. General Services Administration, "P-100 Facilities Standards for the Public Buildings Service," 2010. p. 35.

3.0 DESIGN INPUTS

3.1. VESSEL VOLUME

Design Flow Rate = 5 gpm
Ref. 2.1, Sec. 3.2.1.

Decay Time = 60 minutes
Conservative time estimate of more than 20 half-lives for decay of ^{137m}Ba.

3.2. VESSEL DIMENSIONS

Outside Diameter, OD = 28 in.
Ref. 2.2, Sheet 1.

Vessel Wall Thickness, THK = 3/8 in.
Ref. 2.7.

Straight Flange Length, SF = 1.5 in.
Ref. 2.7.

3.3. INTERNAL BAFFLES

Baffle Spacing = 60% of Vessel ID
Average of recommended range of one-fifth the diameter of the vessel to the vessel ID (Ref. 2.5).

Baffle OD = 27.125 in.
Baffle Length = 21.125 in.
Ref. 2.2, Sheet 2.

4.0 APPROACH/METHODOLOGY

The approach for determining the required volume of the delay tank involves only the flow rate of the process stream and the residence time required for ^{137m}Ba decay to occur. These values are multiplied to give the resulting volume. The height of the Delay Tank is determined by minimizing the footprint, thus resulting in the maximum height that can fit in the Process Enclosure. Because the shell shape in a shell and tube heat exchanger is similar to the shape of the Delay Tank, the approach for determining the baffle layout in the Delay Tank is adopted from that for a heat exchanger, with modifications for this application.

5.0 COMPUTATION

5.1. VESSEL VOLUME

The volume of the Delay Tank is sized based upon the design flow rate of 5 gpm and is calculated as follows:

$$V_T = (Design\ Flow\ Rate) \times (Decay\ Time) = (5\ gpm) \times (60\ min) = 300\ gal.$$

In good engineering practice, the Delay Tank provides sufficient volume to allow ^{137m}Ba decay for all processing rates less than or equal to 6 gpm (Ref. 2.3). While the initial sizing was based on the nominal rate of 5 gpm, the conservative decay time used in this calculation ensures that even at the maximum flow of 6 gpm the minimum decay time will be achieved.

5.2. VESSEL DIMENSIONS

The vessel dimensions were determined based on the size of the Process Enclosure. To minimize the footprint, the maximum height for the 300 gallon tank was limited to the height of the enclosure. For an outside diameter of 28 inches, the dimensions of the Delay Tank are calculated as follows:

$$ID = OD - (2 \times THK) = 28\ in. - (2 \times 0.375\ in.) = 27.25\ in.$$

According to Ref. 2.2, “Fabrication Drawing Delay Tank”, the head style for the Delay Tank is 2:1 Semi-Elliptical. The equation for the volume of this head type is found in Ref. 2.4.

$$Head\ Volume, V_H = 0.000586 \times ID^3 = 0.000586 \times (27.25\ in.)^3 = 11.86\ gal.$$

$$Straight\ Side\ Volume, V_S = V_T - (2 \times V_H) = 300\ gal. - (2 \times 11.86\ gal.) = 276.28\ gal.$$

$$Straight\ Height, H = \frac{4 \times V_S}{ID^2 \times \pi} = \frac{4 \times 276.28\ gal. \times \left(\frac{231\ in.^3}{1\ gal.}\right)}{(27.25\ in.)^2 \times \pi} = 109.43\ in.$$

With a straight flange length (SF) of 1-1/2 inches on each head, the calculated straight side length (L_{SS}) is:

$$L_{SS} = H - (2 \times SF) = 109.43\ in. - (2 \times 1.5\ in.) = 106.43\ in.$$

Rounding up, the straight side length is 106-5/8 inches, as shown in Ref. 2.2, "Fabrication Drawing Delay Tank".

5.3. INTERNAL BAFFLES

Baffles are included in the Delay Tank to prevent static conditions that could inhibit decay of ^{137m}Ba. Spacing between baffles should be 20% to 100% of the inside diameter of the vessel (Ref. 2.5). To create adequate turbulence in the flow while maintaining the desired flow velocity and pressure drop, the spacing will be 60% of the inside diameter:

$$Spacing = ID \times 60\% = 27.25\ in. \times 60\% = 16.4\ in.$$

$$Number\ of\ Baffles = \frac{L_{SS}}{Spacing} = \frac{106.625\ in.}{16.4\ in.} = 6.5$$

Rounding up to the nearest whole number, the Delay Tank will contain 7 baffles. To facilitate gases flowing up through the vessel, the baffles will be sloped upward at 1.5 degrees and will have a 1/8 in. gap along the entire vessel wall. The sloped baffle design will assist with removing any solids buildup on top of the baffles. The basis for this is the minimum slope for water runoff. According to the Facilities Standards for the Public Buildings Service by the U.S. GSA, "in order to provide positive drainage, paved areas…must slope…at a 2 percent grade" (Ref. 2.9). Following this guideline, the minimum slope of the baffle would be:

$$\theta = \sin^{-1}\frac{0.02\ \times Baffle\ Length}{Baffle\ Length} = \sin^{-1}\frac{0.02\ \times 21.125\ in.}{21.125\ in.} = 1.15°$$

The 1.5° slope is above this minimum value. Baffle overlap coverage is crucial to assure adequate decay time is achieved. The single segmental design of the baffles induces turbulence in the flow by forcing the liquid to move side to side as it travels up through the vessel. This will promote plug flow and inhibit short circuiting thus ensuring the desired residence time for ^{137m}Ba decay. Segmental baffles typically have a baffle cut of 20 to 25 percent of the outside diameter of the baffles (Ref. 2.6).

$$Baffle\ Cut = Baffle\ OD - Baffle\ Length = 27.125\ in. - 21.125\ in. = 6\ in.$$

$$Baffle\ Cut\ \% = \frac{Baffle\ Cut}{Baffle\ OD} = \frac{6\ in.}{27.125\ in.} \times 100\% = 22\%$$

6.0 CONCLUSIONS

AVANTech engineers used the methodology in Section 4 to size the Delay Tank. Key design parameters are summarized below. Detailed dimensions and weight metrics are shown in Ref. 2.2, "Delay Tank Fabrication Drawing" and Ref. 2.8, "Delay Tank Data Sheet."

Vessel Volume: 300 gal.
Straight Side Length: 106.625 in.
Baffle Spacing: 16.4 in.
Number of Baffles: 7
Baffle Slope: 1.5°