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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 601865

2. To: (Receiving Organization) ETF Process Engineering		3. From: (Originating Organization) Scott D. Ellingson FDNW		4. Related EDT No.: n/a	
5. Proj./Prog./Dept./Div.: Waste Management Hanford		6. Design Authority/Design Agent/Cog. Engr.: D.E. Scully/S.D. Ellingson		7. Purchase Order No.: n/a	
8. Originator Remarks: The attached design analysis supports pH monitor installation on the ETF evaporator skid (ref:ECN-651583). This analysis provides orifice sizing calculations to assure appropriate flow through the pH monitor.				9. Equip./Component No.: n/a	
				10. System/Bldg./Facility: 2025E	
				12. Major Assem. Dwg. No.: n/a	
				13. Permit/Permit Application No.: n/a	
11. Receiver Remarks: n/a		11A. Design Baseline Document? ☒ Yes ☐ No		14. Required Response Date: n/a	

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	HNF-4940	7	0	Orifice Sizing Design Anal	n/a	2	1	

16. KEY		
Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See VHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)											
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Design Authority	<i>D.E. Scully</i>	8/10/99	56-72						
1	1	Design Agent	<i>S.D. Ellingson</i>	8/10/99	84-39						
		Cog. Eng.									
		Cog. Mgr.									
		QA									
		Safety									
		Env.									

18. Signature of EDT Originator <i>S.D. Ellingson</i> <i>by D.E. Scully</i> 8/10/99		19. Authorized Representative for Receiving Organization Date		20. Design Authority/Cognizant Manager <i>[Signature]</i> 8-10-99		21. DOE APPROVAL (if required) Ctrl No. _____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
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ETF Facility Evaporator Skid Orifice Sizing Design Analysis

S.D. Ellingson for
Waste Management Hanford
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 601865	UC: 502
Org Code: R3111200	Charge Code: 101697
B&R Code: EW3130020	Total Pages: 7

Key Words: Effluent Treatment Facility, ETF, 2025E, Orifice, Evaporator

Abstract:

This document releases and records the design analysis for sizing the orifice plate being installed on the ETF evaporator skid per Engineering Change Notice (ECN) 651583.

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Release Approval Date

Approved For Public Release

FLUOR DANIEL NORTHWEST

CALCULATION IDENTIFICATION AND INDEX

Calc. No. 191-15-M-01

TO Job No. Contract 191, Release 15

Date: 7/16/99

This sheet shows the status and description of the attached Calculation Sheets.

Discipline: MechanicalProject No. & Title: Orifice Addition to the 2025E (ETF) Evaporator SkidCalculations: Orifice Sizing and Selection

These calculations apply to:

Drawing No. H-2-88987, Sheet 1Rev. No. 16Drawing No. H-2-89183, Sheet 1Rev. No. 4Other (Study, CDR) ECN-651583

Rev. No. _____

The status of these calculations is:

☐ Preliminary Calculations☒ Final Calculations☐ Check Calculations on calculations dated: _____☐ Void Calculations (reason voided): _____

Were calculations incorporated into the final drawings?

☒ Yes☐ No

Were calculations verified by independent "check" calculations?

☐ Yes☒ No

Original and Revised Calculation Approvals

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	<i>S. D. Egan</i> 7/28/99		
Checked By	<i>Tim Anderson</i> 7/28/99		
Approved By	<i>OK J. G. L.</i> 7/28/99		
Checked Against Approved Vendor Data			

INDEX

Calculation Sheet
Page No.

Description

<u>1-4</u>	<u>Orifice Sizing</u>
<u>Appx. Pg 1</u>	<u>Swagelok Tubing & Fitting Data</u>

FLUOR DANIEL NORTHWEST, INC.

Calc. No. 191-15-M-01

Revision 0

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DESIGN ANALYSIS

Client WMH

WO/Job No. CONTRACT 191, RELEASE 15

Subject ORIFICE SIZING

Date 7/8/99 By S.D. Egan

Location 2025 E, ETF

Checked By Tim A. 7/28/99

Revised By

GIVEN THE PIPING SYSTEM SHOWN BELOW WITH THE GIVEN PARAMETERS. THE SYSTEM IS FLOWING WATER. REFERENCE ELN- 651583

REQUIRED DETERMINE THE APPROPRIATE ORIFICE TO ASSURE FLOW THROUGH THE PH METER. FLOW SHALL NOT EXCEED 15 GPM THROUGH THE ORIFICE METER PER MANUFACTURERS REQUIREMENTS.

SOLUTION THE FOLLOWING STEPS WILL BE TAKEN TO CONCLUDE A SOLUTION.

- ① DETERMINE AN APPROPRIATE FLOWRATE THROUGH THE TUBING LOOP AND PH METER
- ② DETERMINE THE PRESSURE DROP THROUGH THE TUBING LOOP SUCH THAT ORIFICE SIZE CAN BE DETERMINED. THE ORIFICE MUST PROVIDE THE NECESSARY BACK PRESSURE TO PRODUCE FLOW THROUGH THE TUBING LOOP.
- ③ DETERMINE ORIFICE SIZE.

FOR SOLUTION RESULTS, SEE BOTTOM OF PAGE 4

FLUOR DANIEL NORTHWEST, INC.

Calc. No. 191-15-M-01

Revision 0

Page No. 2 of 4

DESIGN ANALYSIS

Client	WMH	WO/Job No.	CONTRACT 191, RELEASE 15
Subject	ORIFICE SIZING	Date	7/16/99 By S.D. ELLMAN
		Checked	By Tom Christ 7/28/99
Location	2025 E, ETF	Revised	By

THE FOLLOWING REFERENCES WILL BE USED TO PROVIDE A CONCLUSION:

1. CRANE TECHNICAL PAPER No. 410, 19TH PRINTING, 1980
2. SWAGELOK TUBE FITTERS MANUAL, 1993 EDITION
3. SWAGELOK VENDOR CATALOG

① DETERMINE AN APPROPRIATE FLOWRATE THROUGH THE TUBING LOOP:

SINCE THE PH METER MANUFACTURER HAS NO REQUIREMENT FOR MINIMUM FLOW, PICK A FLOWRATE BASED ON A REASONABLE STREAM VELOCITY, BUT NOT TO EXCEED 15 GPM.

CHECK VELOCITY AT 1 GPM FOR 3/8" X .049 TUBING;

$$VF = \frac{QT}{AT} = \left(\frac{1 \text{ GAL}}{\text{MIN}} \right) \left(\frac{1 \text{ MIN}}{60 \text{ SEC}} \right) \left(\frac{1 \text{ FT}^3}{7.48 \text{ GAL}} \right) \left(\frac{4}{\pi} \right) \left(\frac{144}{(.277)^2} \right) = 5.32 \text{ FT/SEC}$$

THIS IS A REASONABLE VELOCITY AND THEREFORE FLOWRATE. USE 1 GPM THROUGH THE TUBING LOOP.

② DETERMINE PRESSURE DROP THROUGH THE TUBING LOOP;

THE FOLLOWING COMPONENTS WILL PROVIDE LOSSES:

1. TOTAL LENGTH OF 3/8" X .049 TUBING = 5 FT
2. QTY (2), 1" X 1/2" REDUCING TEES, SCH 40
3. QTY (1), 3/8" SWAGELOK TEE, BRANCH FLOW
4. QTY (2), 3/8" 90° TUBING BENDS
5. QTY (2), 3/8" WHITEY 4456 BALL VALVES
6. QTY (1), ENTRANCE INTO THE PH METER FLOW CHAMBER
7. QTY (1), EXIT OUT OF THE PH METER FLOW CHAMBER

- THE PRESSURE DROP FOR THE TUBING, TUBING BENDS, AND SWAGELOK TEE CAN BE OBTAINED FROM REFERENCE 2, CHART 3, WITH BENDS AND FITTINGS CONVERTED TO EQUIVALENT LENGTHS. SEE APPENDIX FOR REFERENCE.

$$\text{TOTAL LENGTH} = \text{PIPE} + \text{BENDS} + \text{TEE} = 5' + (2) \cdot .5' + 1.5' = 7.5'$$

$$\text{FROM CHART 3, } \Delta P / 100' @ 1 \text{ GPM } \& .049 \text{ WALL} = 26 \text{ PSI}$$

$$\therefore \Delta P = \frac{7.5}{100} (26 \text{ PSI}) = 1.95 \text{ PSI} \leftarrow$$

FLUOR DANIEL NORTHWEST, INC.

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DESIGN ANALYSIS

Client	WMH	WO/Job No.	CONTRACT 191, RELEASE 15
Subject	ORIFICE SIZING	Date	7/16/99 By S.D. Egan
		Checked	By Tim Lind 7/28/99
Location	2025 E, ETF	Revised	By

② CONTINUED

- PRESSURE DROP FOR THE WHITEY BALL VALVES WILL BE DETERMINED FROM EQ 3-16 OF REF 1, USING A C_v FACTOR FROM REF 3.

$$\Delta P = \frac{Q^2 P}{C_v^2 62.4}$$

WHERE $Q = Q_T = 16 \text{ GPM}$ $P = 61.63 \text{ LBS/FT}^3$, WATER @ 125°F , PG A-6, REF 1 $C_v = 6$ FOR WHITEY BALL VALVES 9456

DONT FORGET QTY 2

$$\Delta P = \frac{(2)(1)^2 (61.63)}{(6)^2 (62.4)}$$

$$\Delta P = .05 \text{ PSI} \leftarrow$$

- PRESSURE DROP FOR THE $1\frac{1}{2}'' \times \frac{1}{2}''$ REDUCING TEE'S WILL BE ASSUMED TO BE BRANCH FLOW FOR $\frac{1}{2}''$ TEE'S. USE EQ 3-14 AND PAGE A-29 OF REF 1. ALSO ASSUME TURBULENT FLOW AND $f = .027$

$$\Delta P = 1.078(10)^{-4} K f v^2 \text{ WHERE } K = (2)60f = (2)(60)(.027) = 3.24 \text{ FOR QTY 2}$$

 $P = 61.63$ AS BEFORE $v = 5.32$ AS BEFORE

$$\Delta P = 1.078(10)^{-4} (3.24) (61.63) (5.32)^2 = .61 \text{ PSI} \leftarrow$$

- PRESSURE DROP FOR THE PH METER CHAMBER ENTRANCE WILL BE BASED ON EQ 3-14 AND PAGE A-29 OF REF 1 AGAIN

$$\Delta P = 1.078(10)^{-4} K f v^2 \text{ WHERE } K = .5 \text{ } P, v \text{ SAME AS BEFORE}$$

$$\Delta P = 1.078(10)^{-4} (.5) (61.63) (5.32)^2 = .09 \text{ PSI} \leftarrow$$

- PRESSURE DROP FOR THE PH METER EXIT WILL BE SIMILAR WITH $K = 1$

$$\Delta P = 1.078(10)^{-4} (1) (61.63) (5.32)^2 = .19 \text{ PSI} \leftarrow$$

$$\text{TOTAL } \Delta P = 1.95 + .05 + .61 + .09 + .19 = 2.89 \text{ PSI}$$

ROUND OFF TO 3 PSI

FLUOR DANIEL NORTHWEST, INC.

Calc. No. 191-15-M-01

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DESIGN ANALYSIS

Client WMH

WO/Job No. CONTRACT 191, RELEASE 15

Subject ORIFICE SIZING

Date 7/16/99

By S.D. Egan

Checked

By Tim Lindt 7/28/99

Location 2025 E, ETF

Revised

By

(3) DETERMINE ORIFICE SIZE:

ORIFICE SIZE WILL BE DETERMINED USING EQ 3-21 AND PAGE A-20 OF REF 1. THE APPROACH WILL BE TO ASSUME A β RATIO (d_1) AND THEN COMPARE THE CALCULATED d_1 WITH THAT ASSUMED.

$$Q = 236 d_1^2 C \left[\frac{\Delta P}{\rho} \right]^{1/2} \Rightarrow d_1 = \left[\frac{Q}{(236)(C) \left[\frac{\Delta P}{\rho} \right]^{1/2}} \right]^{1/2}$$

TO DETERMINE "C", MUST FIRST FIND Re BASED ON FLOW IN d_2 , IE AT $Q = 22-1 = 21$ GPM WITHIN 1" SCH 40 PIPE. USE EQ 3-3 OF REF 1.

$$Re = 123.9 \frac{d_2 v \rho}{\mu} \quad \text{WHERE: } d_2 = 1.049" \\ \rho = 61.63 \text{ LB/FT}^3 \\ \mu = .52 \text{ cP, PG A-3, REF 1}$$

$$Re = (123.9) \frac{(1.049)(7.79)(61.63)}{.52}$$

$$Re = 1.2(10)^5$$

$$v = \frac{Q}{A} = \frac{(21 \text{ GAL})(1 \text{ MIN})}{(60 \text{ SEC})} \left(\frac{1 \text{ FT}^3}{7.48 \text{ GAL}} \right) \left(\frac{4}{\pi} \right) \left(\frac{144}{1.049^2} \right) \\ v = 7.79 \text{ FT/SEC}$$

$$\text{ASSUME } \beta = .75 \Rightarrow d_1 = \beta d_2 = (.75)(1.049) = .78"$$

FIND "C" FROM PG A-20 @ $\beta = .75$ & $Re = 1.2(10)^5$, $C = .745$

$$d_1 = \left[\frac{21}{(236)(.745) \left[\frac{3}{61.63} \right]^{1/2}} \right]^{1/2} = .74" \quad \text{CLOSE ENOUGH!}$$

USE AN ORIFICE OF INTERNAL DIAMETER = $\frac{3}{4}"$

APPENDIX (SECTION A)

FLOW & PRESSURE CHARTS & CONVERSIONS

- Flow & Pressure Charts
- Heads and Equivalent Pressure Conversions
- Pressure Conversions
- Flow Rate Conversions

DETERMINING INSIDE DIAMETER OF TUBING

The I.D. of tubing is set by flow requirements, permissible pressure drop and maximum allowable velocity. To aid in selecting the proper I.D. of tubing for liquid flow, Charts 1 through 10 are provided on the following pages. Charts 11 through 20 are provided for sizing tubing for gas flow.

These charts give pressure drop for 100 feet of tubing for both water and air flow. By using the formula provided, it is also possible to obtain the pressure drop of fluids other than water and gas.

To allow for pressure drops in bends and fittings, the equivalent lengths in Table A can be used when obtaining equivalent length of tubing for pressure drop calculations. To obtain equivalent length of tubing, total all straight lengths and then add lengths for each bend, elbow or tee from Table A.

EQUIVALENT FEET OF STRAIGHT TUBE

Tubing O.D. (In.)	90° Elbow (ft.)	90° Bend (ft.)	180° Bend (ft.)	45° Bend (ft.)	Tee Branch (ft.)
1/4	1	1/2	1	1/2	1
3/8	1-1/2	1/2	1	1/2	1-1/2
1/2	2	1/2	1	1/2	2
5/8	2-1/2	1	2	1/2	2-1/2
3/4	3	1	2	1/2	3
1	4-1/2	1	2	1/2	4-1/2
1-1/4	5	2	4	1	5
1-1/2	6	2	4	1	6
2	9	2	4	1	9

Table A

CHART 3 3/8 Inch O.D. Tubing

A-1

A-8

Calc 191-15-M-01
APPENDIX Pg 1/1

CORRESPONDENCE DISTRIBUTION COVERSHEET

Author

Scott D. Ellingson 373-1151

Addressee

Correspondence No.

Subject: ETF Evaporator Skid Orifice Sizing Calculations

DISTRIBUTION

Approval	Date	Name	Location	w/att
n/a		Scott D. Ellingson	B4-39	X
n/a		Don E. Scully	S6-72	X
n/a		Neal J. Sullivan	S6-72	EDT ONLY