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Project W-320, 241-C-106 Sluicing Piping Calculations, Vol. 7

John W. Bailey

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Project W-320, 241-C-106 Sluicing Piping Calculations, Vol. 7

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W320-27-044

Sluicer Nozzle Force Analysis

**FLUOR DANIEL
NORTHWEST****CALCULATION IDENTIFICATION AND INDEX**Page i of iiDate 1 / 7 / 1997

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline 27, Piping and Vessels WO/Job No. W320/ER9142 Calculation No. W320-27-044Project No. & Name Project W-320 Waste Retrieval for Tank 241-C-106Calculation Item SLUICER NOZZLE FORCE ANALYSIS

These calculations apply to:

Dwg. No. H-2-818551 and H-2-818555Rev. No. 1

Dwg. No. _____

Rev. No. 1

Other (Study, CDR) _____

Rev. No. _____

The status of these calculations is:

☐ Preliminary Calculations☒ Final Calculations supersedes calc. w320-27-033☐ Check Calculations (On Calculation Dated _____)☐ Void Calculation (Reason Voided _____)

Incorporated in Final Drawings?

☒ Yes ☐ No

This calculation verified by independent "check" calculation?

☐ Yes ☒ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature / Date	Rev. 1 Signature / Date	Rev. 2 Signature / Date
Originator	<u>Dennis L. Stone</u> <u>1-17-97</u>		
Checked by	<u>[Signature]</u> <u>01-17-97</u>		
Approved by	<u>[Signature]</u> <u>01-17-97</u>		
Checked Against Approved Vendor Data	<u>R. Ahmed</u> <u>4-11-98</u>		

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Description

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and References2-3Calculations3Conclusion

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FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No.: W-320-27-044

Revision No.: 0

Page No.: 1 of 3

Client: NUMATEC HANFORD COMPANY
Subject: SLUICER NOZZLE FORCE ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location: C TANK FARM - HANFORD 200 EAST AREA

WO/Job No.: W-320/ E09142
Date: 1 / 7 / 97
Checked: 01 / 17 / 97
Revised:

Filename: nozzle.mcd
By: D.L. STONE
By: N.J. JUPLO
By:

OBJECTIVE:

The objective of this calculation is to calculate the hydraulic forces imposed at the sluicer nozzle.

DESIGN INPUTS:

1. Project W320, Tank 241-C-106 Sluicing, Functional Design Criteria (WHC document No. WHC-SD-W320-FDC-001, Rev. 2).
2. Project W-320 Drawing # H-2-818551, Rev.1

ASSUMPTIONS:

None

METHOD of ANALYSIS:

Bernoulli's Momentum equation for steady flow.

Calculations performed by Mathcad 6.0, MathSoft, Inc.

FIGURE 1

REFERENCES:

1. Project W320, Tank 241-C-106 Sluicing, Functional Design Criteria (WHC document No. WHC-SD-W320-FDC-001, Rev. 2).
2. *Engineering Fluid Mechanics*, J.A. Roberson & C.T. Crowe, 4th Edition, 1990
3. Crane Technical Paper No. 410, *Flow of Fluids Through Pipes, Fittings and Valves*, 25th Printing, 1988
4. Project W-320 Drawing # H-2-818551, Rev.1
5. Project W-320 Drawing # H-2-818555, Rev.1

DATA:

Unit Initialization : centipoise $cp := 0.01 \cdot \text{poise}$ $g = 32.174 \cdot \frac{\text{ft}}{\text{sec}^2}$ $\text{gpm} := \frac{\text{gal}}{\text{min}}$

SG := 1.12 Specific Gravity (10% solids loading) (Ref. 1)

Q := 350-gpm Flowrate (Ref. 1)

$\rho_{H_2O} := 62.4 \cdot \frac{\text{lb}}{\text{ft}^3}$ Mass Density of Water at Temperature Shown (Ref. 3)

$d_1 := 2.5\text{-in}$ Bend (Swivel) ID and Nozzle entrance diameter (Ref. 4 & 5)

$d_2 := 1.00\text{-in}$ Nozzle exit diameter (Ref. 4)

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No.: W-320-27-044

Revision No.: 0

Page No.: 2 of 3

Client: NUMATEC HANFORD COMPANY
Subject: SLUICER NOZZLE FORCE ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location: C TANK FARM - HANFORD 200 EAST AREA

WO/Job No.: W-320/ E09142
Date: 1 / 7 / 97
Checked: 01 / 17 / 97
Revised:

Filename: nozzle.mcd
By: D.L. STONE
By: H. J. JUPLO

CALCULATIONS:

$$\rho := SG \cdot \rho_{H_2O} \quad \rho = 69.888 \cdot \frac{\text{lb}}{\text{ft}^3} \quad \text{Mass Density of Process Fluid}$$

$$\gamma := \rho \cdot g \quad \gamma = 69.888 \cdot \frac{\text{lb}}{\text{ft}^3} \quad \text{Fluid Specific Weight}$$

$$A_1 := \frac{\pi \cdot d_1^2}{4} \quad A_1 = 0.034 \cdot \text{ft}^2 \quad \text{Nozzle entrance flow area}$$

$$A_2 := \frac{\pi \cdot d_2^2}{4} \quad A_2 = 0.005 \cdot \text{ft}^2 \quad \text{Nozzle exit flow area}$$

$$V_1 := \frac{Q}{A_1} \quad V_1 = 22.876 \cdot \frac{\text{ft}}{\text{sec}} \quad \text{Nozzle entrance velocity} \quad (\text{Ref. 2, pg. 115})$$

$$V_2 := \frac{Q}{A_2} \quad V_2 = 142.974 \cdot \frac{\text{ft}}{\text{sec}} \quad \text{Nozzle exit velocity} \quad (\text{Ref. 2, pg. 115})$$

Energy dissipated by the Nozzle is found from the conservation of mass and energy as applied in the Bernoulli Equation:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2 \cdot g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2 \cdot g} + z_2 \quad (\text{Ref. 2, pg. 169})$$

$$A_1 \cdot V_1 = A_2 \cdot V_2 = Q$$

$$z_1 = z_2$$

$$\left(\frac{P_1 - P_2}{\gamma} \right) = \left(\frac{V_2^2 - V_1^2}{2 \cdot g} \right)$$

$$\Delta P := \left(\frac{V_2^2 - V_1^2}{2 \cdot g} \right) \cdot \gamma \quad \Delta P = 150.23 \cdot \text{psi}$$

$$\text{Since } P_2 := 0 \cdot \text{psi} \rightarrow P_1 := \Delta P - P_2 \quad P_1 = 150.23 \cdot \text{psi}$$

Momentum equation for forces on a nozzle

$$\sum F = \sum \Delta M$$

$$\sum F_x = 0 = F_{\text{nozzle}} + P_1 \cdot A_1 - P_2 \cdot A_2 + \rho \cdot Q \cdot V_1 - \rho \cdot Q \cdot V_2$$

$$-F_{\text{nozzle}} := \rho \cdot Q \cdot (V_1 - V_2) + P_1 \cdot A_1 - P_2 \cdot A_2 \quad F_{\text{nozzle}} = 532.53$$

208
10/98

(Ref. 2, pg. 221)

FIGURE 2

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No.: W-320-27-044

Revision No.: 0

Page No.: 3 of 3

Client: NUMATEC HANFORD COMPANY
Subject: SLUICER NOZZLE FORCE ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location: C TANK FARM - HANFORD 200 EAST AREA

WO/Job No.: W-320/ E09142
Date: 1 / 7 / 97
Checked: 01/17/97
Revised:

Filename: nozzle.mcd
By: D.L. STONE
By: N.J. JUPLO

For 90° bend:

$$A_1 = \frac{\pi d_1^2}{4} \quad A_1 = 0.034 \cdot \text{ft}^2 \quad \text{Bend entrance flow area} \quad (\text{Ref. 5})$$

$$A_2 = A_1 \quad A_2 = 0.034 \cdot \text{ft}^2 \quad \text{Bend exit flow area}$$

$$V_1 = \frac{Q}{A_1} \quad V_1 = 22.876 \cdot \frac{\text{ft}}{\text{sec}} \quad \text{Bend entrance velocity}$$

$$V_2 = \frac{Q}{A_2} \quad V_2 = 22.876 \cdot \frac{\text{ft}}{\text{sec}} \quad \text{Bend exit velocity}$$

$$P_2 = P_1 \quad P_1 = 150.23 \cdot \text{psi}$$

$$\sum F = \Delta M$$

$$F_{\text{bend}} + P_1 \cdot A_1 - P_2 \cdot A_2 = \rho \cdot V_1 \cdot (V_1 \cdot A_1) + \rho \cdot V_2 \cdot (V_2 \cdot A_2) \quad (\text{Ref. 2, pg. 223})$$

$$\sum F_x = 0 = R_x - P_2 \cdot A_2 + \rho \cdot Q \cdot V_2$$

$$R_x = P_2 \cdot A_2 + \rho \cdot Q \cdot V_2 \quad R_x = 774.2 \quad \text{psi}$$

$$\sum F_y = 0 = -R_y - P_1 \cdot A_1 - \rho \cdot Q \cdot V_1$$

$$-R_y = P_1 \cdot A_1 + \rho \cdot Q \cdot V_1 \quad R_y = 776.19 \cdot \text{lb}$$

$$774 + (532)$$

$$R_{\text{Total}} = R_x + F_{\text{nozzle}}$$

$$R_{\text{Total}} = 242.181 \cdot \text{lb}$$

FIGURE 3

CONCLUSION:

The total force applied at the sluicer nozzle will be 242.181 lbf.

W320-27-045

Pipe Drain Flow and Anti-Siphon
Sizing for Transfer Lines

FLUOR DANIEL NORTHWEST	CALCULATION IDENTIFICATION AND INDEX	Page	i	of	iii
		Date	3 / 5 / 1997		

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline 27, Piping and Vessels WO/Job No. W320/E09141 Calculation No. W320-27-045
 Project No. & Name Project W-320 Waste Retrieval for Tank 241-C-106
 Calculation Item Pipe Drain Flow and Anti-Siphon Sizing for Transfer Lines

These calculations apply to:

Dwg. No. H-2-818498, Sh. 3, H-2-818531, Sh. 2 Rev. No. 0
 Dwg. No. _____ Rev. No. _____
 Other (Study, CDR) _____ Rev. No. _____

The status of these calculations is:

- ☐ Preliminary Calculations
☒ Final Calculations
☐ Check Calculations (On Calculation Dated _____)
☐ Void Calculation (Reason Voided _____)

Incorporated in Final Drawings? ☐ Yes ☒ No

This calculation verified by independent "check" calculation? ☐ Yes ☒ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature / Date	Rev. 1 Signature / Date	Rev. 2 Signature / Date
Originator	<i>Danny L. Evans</i> 3/25/97		
Checked by	<i>Danny L. Evans</i> 3/25/97 <i>William D. Brown</i> 3/25/97		
Approved by	<i>Danny L. Evans</i> 3/25/97		
Checked Against Approved Vendor Data	<i>M. Ahmed</i> 4.11.98		

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		Calculation/Document No.	Revision No.	Calculation/Document No.	Revision No.	Yes	No	Yes	No		
		Dwg. H-2-818495, Sh.1	1				X		X	X	T
		Dwg. H-2-818536, Sh.1	0								
		Dwg. H-2-818498, Sh.2	1								
		Dwg. H-2-818498, Sh. 3	0								
		Dwg. H-2-818427, Sh.1	0								
		Dwg. H-2-818426, Sh.1 & 2	0								
		Dwg. H-2-818434, Sh.1	0								
		Dwg. H-2-818494, Sh.1 & 2	0								
		Dwg. H-2-818508, Sh.1	1							7/2/98	D. Evans
		Dwg. H-2-818505, Sh.1	1								
		Dwg. H-2-818501, Sh.1 & 2	2								
		Dwg. H-2-818501, Sh.1	0								
		Dwg. H-2-818537, Sh.2	1								
		Dwg. H-2-818503, Sh.1	1								
		Dwg. H-2-818515, Sh.1	0/1								
		Dwg. H-2-818551, Sh.2 & 4	1								
		Dwg. H-2-818551, Sh.7	1								
		Dwg. H-2-818549, Sh.1	0				X		X	T	T

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045

Revision No.: 0

Page No. 1 of 25

Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked 3/25/97
Revised

Filename siphon/text.mcd
By D.L. STONE *DS*
By D.L. EVANS *DE*
By

OBJECTIVE:

The objective of this calculation is twofold.

1. To determine if the anti-siphoning holes required to interrupt siphon flow in either the Slurry or Supernate Pipelines are adequately sized.
2. To estimate the time required to drain the lines after termination of flow.

DESIGN INPUTS:

Project W320, Tank 241-C-106 Sluicing, *Functional Design Criteria*
(WSC document No. WHC-SD-W320-FDC-001, Rev. 4)

ASSUMPTIONS:

1. The pressure drops across the de-energized pumps were derived for water and adequately model pressure drops for other system fluids.
2. The valve Cv values used were for water and the resulting pressure drops adequately model those for other system fluids.
3. A fluid temperature of 70°F has been chosen to conservatively approximate the temperature at which siphoning and line draining would most probably take place.

METHOD of ANALYSIS:

Calculations performed using *Mathcad 6.0*, MathSoft, Inc. are shown with sources noted adjacent to formulas.

Methods used in spreadsheet calculations performed by *Microsoft "Excel"* Version 5.0 are either summations, or methods and sources are shown on a previous page, using *Mathcad 6.0*.

Hydraulic calculations are performed by *PIPE-FLO*, v.5, by Engineered Software, Inc.

Ref. 14

The PIPE-FLO program calculates the balanced flow rates and pressures within fluid piping systems using the Darcy-Weisbach equation, which takes into account fluid viscosity and pipe roughness.

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. **W-320-27-045**

Revision No.: **0**

Page No. **2** of **25**

Client **NUMATEC HANFORD COMPANY**

Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Location **C TANK FARM - HANFORD 200 EAST AREA**

WO/Job No. **E09141**

Date **3 / 5 / 97**

Checked **3/25/97**

Revised

Filename **siphon\text.mcd**

By **D.L. STONE** *DS*

By **D.L. EVANS** *DE*

By

(METHOD of ANALYSIS, cont...)

The Darcy-Weisbach equation is as follows: $\Delta P = \rho \cdot f \left(\frac{L}{D} \right) \cdot \frac{v^2}{2 \cdot g}$ where ΔP = pressure drop

ρ = fluid density

f = Darcy friction factor

L = length of pipe

D = pipe diameter

v = mean fluid velocity

g = gravitational constant

For both laminar and non-laminar flow, the friction factor, f , is a function of the Reynolds number, calculated by PIPE-FLO using the equation:

$$R_e = \frac{354 \cdot W}{\mu \cdot d}$$

where

W = flow rate, kg/hr

d = pipe diameter, mm

μ = fluid dynamic viscosity, centipoise

If PIPE-FLO calculates a Reynolds number less than 2100, flow is considered to be laminar and the friction factor is expressed using the equation:

$$f = \frac{64}{R_e}$$

For Reynolds numbers greater than 2100, flow is considered to be turbulent, and the following equation is used:

$$f = \frac{1.325}{\left(\ln \left(\frac{\epsilon}{3.7 \cdot d} + \frac{5.7}{R_e^{0.9}} \right) \right)^2} \quad \epsilon = \text{coefficient of absolute roughness for pipe}$$

PIPE-FLO includes valves and fittings in the calculation using the pipe resistance coefficients (K factors) found in Crane Technical Paper No. 410.

The relationship between the K value and pipe length is: $K = f_T \left(\frac{L}{D} \right)$ where f_T = turbulent friction factor

for which PIPE-FLO uses $f_T = 8 \cdot \left(2.457 \cdot \ln \left(\frac{3.707 \cdot d}{\epsilon} \right) \right)^{-2}$

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045

Revision No.: 0

Page No. 3 of 25

Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked 3/25/97
Revised

Filename siphon/text.mcd
By D.L. STONE DLS
By D.L. EVANS DEE
By

(METHOD of ANALYSIS, cont...)

Calculation of the balanced flow rates in the system is carried out using the Simultaneous Path Adjustment method developed by Don J. Wood of the University of Kentucky. This method uses the Hardy Cross method until the program is close to a solution, then it switches to the linear method to complete the calculations. Information on the Hardy Cross method can be found in Ref 3. The continuity equations and loop pressure drop equations, based on Kirchoff's Laws 1 and 2, provide the independent equations to perform the linear portion of the calculations.

The PIPE-FLO program requires information about fluid properties in order to analyze a piping system. This calculation includes the hydraulic analysis of both the Slurry Transfer Line, estimated to contain at the time of siphoning, a liquid ranging from 10% to 30% solids content, and the Supernate Transfer or "Sluice" Line, containing an estimated 0% to 10% solids content. Mass densities and viscosities corresponding to solids content are calculated on page 9, using relative specific gravities and viscosity adjustment equations specified in the Project Functional Design Criteria (Ref. 1).

Pumps and other components for which headloss varies with flowrate are represented within PIPE-FLO as curves, which have been independently determined and manually input to the program.

Because this calculation addresses only siphoning and drainage scenarios, flow vs. head curves have been developed to account for the headlosses resulting from either forward or reverse flow through the system pumps in non-operational mode. The independent calculation modeling these curves is included as Appendix A of this calculation. Similar curves have been developed to model losses through the Micromotion Mass Flow Meter in the Slurry line, and for the flow monitor located adjacent to the nozzle on the sluice line. The development of these curves is shown on Pages 10 through 14 of this calculation, using manufacturer's graphs shown in Appendix C. Curves developed for input to PIPE-FLO are summarized in spreadsheet form on page 15.

Standard fittings have been input directly to the system model from a table of standard fittings included in the PIPE-FLO program. Purex connectors are modeled as standard 90 degree miter bends. System valves are considered by PIPE-FLO as specialty valves and have been input to the model using manufacturer-specified CV values obtained from vendor data (included in Appendix M.)

The Differential Pressure Calculator in PIPE-FLO uses the formula:
$$K = \frac{891 \cdot d^4}{C_v^2}$$
 to calculate friction loss coefficient, or K value, for input to the model.

Input to the system model is described in terms of Node and Pipe names, elevations, dimensions and components in the Identification and Configuration section of this calculation on pages 16 through 24. Although Node points are normally determined by pipe diameter changes, Nodes have been included at the following additional locations in order to facilitate the objectives of this analysis.

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045

Revision No.: 0

Page No. 4 of 25

Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked ~~8/22~~ 3/25/97
Revised

Filename siphon\text.mcd
By D.L. STONE *DL*
By D.L. EVANS *DL*

(METHOD of ANALYSIS, cont...)

1. Nodes have been placed at the locations of holes drilled in the pipe to provide the inlet of air to prevent siphoning.
2. Nodes have been placed at elevations corresponding to transfer line station points identified in the project profile drawings included in Appendix D.

Pipe Draining

The times required to drain the Slurry and Sluice pipelines have been determined using flow results from the PIPE-FLO program. Pipe drain flows were derived by modeling simulated reservoirs at the pipe high point and at an elevation representing the top of the lower third of the transfer line. The PIPE-FLO models were then run to determine the steady state pipe flows for fluids at various % solids and are included as Appendices F, H, J & L. These drain flows were then used to determine:

- a) The time to void the top 2/3 of the pipe, by using the average steady state drain flow from the two reservoirs.
- b) The time to void the lower third, by using the drain flow from the lower reservoir.

The respective pipe flows and times required to drain the pipes are listed in the conclusion section.

Siphon Flows

Siphon flows have been determined using the PIPE-FLO program, and models included in Appendices E, G, I & K. Flows were derived by modelling reservoirs at locations that maximize the hydraulic head available to drive the siphon. The reservoirs were placed as follows:

Slurry Line: The top reservoir located at the AY-102's maximum liquid level. The lower reservoir located at the lowest liquid level for C-106.

Supernate Line: The top reservoir located at the AY-102's maximum liquid level. The lower reservoir located at the lowest level of the sluice nozzle in C-106.

The siphon models were run to determine steady state flows. Since PIPE-FLO does not provide for two-phase flow analysis, the models did not include openings at the locations of the holes drilled in the pipe to provide the inlet of air to prevent siphoning.

Nodes have been assigned at the locations of these holes and the corresponding siphon flows and fluid pressures are listed in the conclusion section of the calculation.

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045

Revision No.: 0

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Client NUMATEC HANFORD COMPANY

WO/Job No. E09141

Filename siphon/text.mcd

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

By D.L. STONE *DL*

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked 3/25/97

By D.L. EVANS *DL*

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

By

CONCLUSIONS

The following results are taken from the Summary Table (Page 8) and Air Flow calculations, Appendix B.

	Drain Time (min)	Drain Flow (gpm)	Drain Flow (ACFM)	Siphon Flow (gpm)	Siphon Flow (ACFM)	Fluid Pressure at Hole Elev. (psig)	Anti-Siphon Hole Air Flow (SCFM)	<i>then 1 open hole of 2 on each line 2/22/98</i>
<u>Slurry Line</u>								
10% Solids	7.88	150.9	20.17	112	14.97	(-) 6.159	49.33	
30% Solids	8.75	141.5	18.92	81.03	10.83	(-) 6.656	49.54	
<u>Sluice Line</u>								
0% Solids	12.35	86.78	11.6	75.41	10.08	(-) 3.917	11.23	
10% Solids	12.73	84.96	12.43	71.98	9.62	(-) 4.368	11.58	

Drain Times

From the above table the slurry line will free drain in 7.88 min to 8.75 min depending on solids content.

The sluice line will free drain in 12.35 min to 12.73 min depending on solids content.

Hole sizing for Siphon Prevention

Slurry Line

The slurry line normally flows from C-106 to AY-102 and contains two 1/2" diameter holes located approximately 12' above the AY-102 maximum tank liquid level. When power is removed from the pumps, flow will slow, reverse itself, and begin siphoning from AY-102. The siphon may be broken before the siphon flow derived by the model is attained. From the model, maximum stable siphon flow is 112 gpm (14.97 cfm) with a (-) 6.159 psig fluid pressure at the elevation of the anti-siphon holes. With a (-) 6.159 psig, across the holes, the line will aspirate 49.33 cfm of air, from Appendix B. This volume of air will displace all forward flowing fluid and allow the column of fluid in the leg from the tank to settle to some equilibrium level below the holes. The siphon will be broken. The maximum air flow required to support free draining is 14.97 cfm. From Appendix B, 14.97 cfm of air requires a pressure drop of 0.315 psig across the 1/2" anti-siphon holes.

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. **W-320-27-045**Revision No.: **0**Page No. **6** of **25**Client **NUMATEC HANFORD COMPANY**Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106****Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines**Location **C TANK FARM - HANFORD 200 EAST AREA**WO/Job No. **E09141**Date **3 / 5 / 97**Checked **SLZ/97**

Revised

Filename **siphon/text.mcd**By **D.L. STONE** *DLS*By **D.L. EVANS** *DLE*

By

Sluice Line

The sluice line normally flows from AY-102 to C-106 and contains two 1/4" diameter anti-siphon holes located approximately 8' above the AY-102 maximum tank liquid level. When power is removed from the pumps, flow will slow and decay to the modelled siphon rate from AY-102. The siphon may be broken before the flow derived by the model is attained. From the model, maximum stable siphon flow is 75.41 gpm (10.08 cfm) with a (-) 3.917 psig fluid pressure at the drilled hole location. With a (-) 3.917 psig, across the holes, the line will aspirate 11.23 cfm of air, from Appendix B. This volume of air will displace all forward flowing fluid and allow the column of fluid in the leg from the tank to settle to some equilibrium level. The siphon will be broken. The maximum air flow required to support free draining is 10.08 cfm. From Appendix B, 10.08 cfm of air requires a pressure drop of 2.83 psig across the 1/4" anti-siphon holes.

The 1/4" and 1/2" holes are of sufficient size to break the siphon flows and support free draining of the slurry and sluice lines.

REFERENCES

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10. *Control Valve Handbook*, Fisher Controls Company
11. T-M Swivel Joint Catalog.
12. "Mathcad" Version 6.0, MathSoft, Inc.
13. "Excel" Version 5.0, by Microsoft
14. "PIPE-FLO" Version 5.0, by Engineered Software, Inc.

FLUOR DANIEL NORTHWEST

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Calc. No. W-320-27-045

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Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
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Revised

Filename siphon\text.mcd
By D.L. STONE DLS
By D.L. EVANS DLE

(REFERENCES, cont...)

15. Project W-320 Drawings:

- General:
- 15.0 H-2-818495, Sh. 1 Pump and Winch Assembly
 - 15.1 H-2-818536, Sh. 1 Hydraulic Diagram
 - 15.2 H-2-818498, Sh. 2 Shielding Plate
 - 15.3 H-2-818498, Sh. 3 Shielding Plate
 - 15.4 H-2-818427, Sh. 1 Transfer System Plan and Profile
 - 15.5 H-2-818426, Sh. 1 Transfer System Plan and Profile
 - 15.6 H-2-818426, Sh. 2 Transfer System Plan and Profile
 - 15.7 H-2-818434, Sh. 1 Transfer System Plan and Profile
- Slurry Line:
- 15.8 H-2-818494, Sh. 1 Pump and Winch Installation - C-Tank
 - 15.9 H-2-818508, Sh. 1 Jumper Assembly Pit C-06A (Pump Jumper)
 - 15.10 H-2-818505, Sh. 1 Jumper Assembly Pit C-06A (Jumper)
 - 15.11 H-2-818501, Sh. 1 Jumper Assembly Pit C-02A (Distributor Jumper)
 - 15.12 H-2-818501, Sh. 2 Jumper Assembly Pit C-02A (Distributor Jumper)
 - 15.13 H-2-818537, Sh. 1 Distributor Assembly
 - 15.14 H-2-818537, Sh. 2 Distributor Assembly
- Supernate Line:
- 15.15 H-2-818494, Sh. 2 Pump and Winch Installation - AY-Tank
 - 15.16 H-2-818503, Sh. 1 Jumper Assembly Sluice Pit AY-02E (Pump Jumper)
 - 15.17 H-2-818515, Sh. 1 Jumper Assembly Sluice Pit C-06C (Sluicer Jumper)
 - 15.18 H-2-818551, Sh. 2 Sluicer Assembly Details (Swivel)
 - 15.19 H-2-818551, Sh. 4 Piping Sluicer Assembly Feedplate
 - 15.20 H-2-818551, Sh. 7 Sluicer Assembly Details (Nozzle)
 - 15.21 H-2-818549, Sh. 1 Sluicer Installation

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
PIPE DRAINFLOW and ANTI-SIPHON SIZING for TRANSFER LINES
Location C TANK FARM 200 EAST AREA

WO/Job No. EO9141
Date 3/5/1997
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Revision No. 0

Page No. 8 of 25

Filename draintime.xls
By D. L. STONE
D. L. EVANS

SUMMARY OF DRAIN TIMES

(For calculation details, see Page 25)

Pipe #	Pipe ID (in)	Area (in ²)	Length (ft)	Volume (gal)	Volume (ft ³)	Drainflow Highpoint to End (gpm)	Drainflow Lowpoint to End (gpm)	Average Drainflow (ft ³ / min)	Average Time to Drain (min)
Slurry Line 10% Solids									
3.3	4.03	12.73	843.20	557.58	74.54	146.7	150.9	19.89	3.75
3.2	4.03	12.73	468.10	309.54	41.38	146.7	150.9	19.89	2.08
3.1	4.03	12.73	427.61	282.76	37.80		150.9	20.17	1.87
3	3.07	7.39	4.767	1.83	0.24		150.9	20.17	0.012
2.1	4.03	12.73	1.0	0.66	0.09		150.9	20.17	0.004
2	4.03	12.73	34.86	23.05	3.08		150.9	20.17	0.153
1	3.07	7.39	2.32	0.89	0.12		150.9	20.17	0.006
0	5.05	20.01	0.442	0.46	0.06		150.9	20.17	0.003

1782.3					Time to Drain in minutes :					7.88
Slurry Line	30% Solids									
3.3	4.03	12.73	843.20	557.58	74.54	122.7	141.5	17.66	4.22	
3.2	4.03	12.73	468.10	309.54	41.38	122.7	141.5	17.66	2.34	
3.1	4.03	12.73	427.61	282.76	37.80		141.5	18.92	2.00	
3	3.07	7.39	4.767	1.83	0.24		141.5	18.92	0.013	
2.1	4.03	12.73	1.0	0.66	0.09		141.5	18.92	0.005	
2	4.03	12.73	34.86	23.05	3.08		141.5	18.92	0.163	
1	3.07	7.39	2.32	0.89	0.12		141.5	18.92	0.006	
0	5.05	20.01	0.442	0.46	0.06		141.5	18.92	0.003	

Time to Drain in minutes :						8.75			
Sluicer Line		0% Solids							
4.1	4.03	12.73	822.80	544.09	72.73	105.6	86.78	12.86	5.66
4.2	4.03	12.73	468.10	309.54	41.38	105.6	86.78	12.86	3.22
4.3	4.03	12.73	428.70	283.48	37.90		86.78	11.60	3.27
4.4	4.03	12.73	26.27	17.37	2.32		86.78	11.60	0.200
5	2.47	4.79	1.231	0.31	0.04		86.78	11.60	0.004
6	2.07	3.36	0.667	0.12	0.02		86.78	11.60	0.001
7	2.47	4.79	1.203	0.30	0.04		86.78	11.60	0.003
8	2.47	4.79	0.604	0.15	0.02		86.78	11.60	0.002
9	0.96	0.72	0.271	0.01	0.00		86.78	11.60	0.000

1749.8				Time to Drain in minutes :				12.35	
Sluicer Line		10% Solids							
4.1	4.03	12.73	822.80	544.09	72.73	101	84.96	12.43	5.85
4.2	4.03	12.73	468.10	309.54	41.38	101	84.96	12.43	3.33
4.3	4.03	12.73	428.70	283.48	37.90		84.96	11.36	3.34
4.4	4.03	12.73	26.27	17.37	2.32		84.96	11.36	0.204
5	2.47	4.79	1.231	0.31	0.04		84.96	11.36	0.004
6	2.07	3.36	0.667	0.12	0.02		84.96	11.36	0.001
7	2.47	4.79	1.203	0.30	0.04		84.96	11.36	0.004
8	2.47	4.79	0.604	0.15	0.02		84.96	11.36	0.002
9	0.96	0.72	0.271	0.01	0.00		84.96	11.36	0.000

Time to Drain in minutes : 12.73

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045

Revision No.: 0

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Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked 3/25/97
Revised

Filename viscosity.mcd
By D.L. STONE DLS
By D.L. EVANS DLE
By

Calculation of Mass Density and Dynamic Viscosity based on Percent Solids

T := 70-F Operating Temperature (See Assumption 2)
 $\rho_{H_2O} := 62.305 \frac{\text{lb}}{\text{ft}^3}$ Water Density at Temperature Shown (Ref. 6)
 $\mu_T = \mu_{\%}(1 - 0.005(T - 68))$ Temperature adjustment equation from FDC (Ref. 1)

SG := 1.0 Specific Gravity (0% solids loading) (Water) (Ref. 1)
 $\rho := SG \cdot \rho_{H_2O} \quad \rho = 62.305 \frac{\text{lb}}{\text{ft}^3}$ Process Fluid Density
 $\mu_{0\%} := 4 \cdot \text{cp}$ Viscosity at 68 degrees F (0% solids loading)
 $\mu_{0\%70} := \mu_{0\%}(1 - 0.005(70 - 68)) \quad \mu_{0\%70} = 3.96 \cdot \text{cp}$ Viscosity at 0% Solids, 70 degrees F

SG := 1.12 Specific Gravity (10% solids loading) (Ref. 1)
 $\rho := SG \cdot \rho_{H_2O} \quad \rho = 69.782 \frac{\text{lb}}{\text{ft}^3}$ Process Fluid Density
 $\mu_{10\%} := 13 \cdot \text{cp}$ Viscosity at 68 degrees F
 $\mu_{10\%70} := \mu_{10\%}(1 - 0.005(70 - 68)) \quad \mu_{10\%70} = 12.87 \cdot \text{cp}$ Viscosity at 10% Solids, 70 degrees F

SG := 1.2 Specific Gravity (30% solids loading) (Ref. 1)
 $\rho := SG \cdot \rho_{H_2O} \quad \rho = 74.766 \frac{\text{lb}}{\text{ft}^3}$ Process Fluid Density
 $\mu_{30\%} := 105 \cdot \text{cp}$ Viscosity at 68 degrees F
 $\mu_{30\%70} := \mu_{30\%}(1 - 0.005(70 - 68)) \quad \mu_{30\%70} = 103.95 \cdot \text{cp}$ Viscosity at 0% Solids, 70 degrees F (Ref. 1)

FLUOR DANIEL NORTHWEST

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Client NUMATEC HANFORD COMPANY

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141

Date 3 / 5 / 97

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Revised

Filename micromtn.mcd

By D.L. STONE DLS

By D.L. EVANS DLE

By

Calculation of Flow vs Head Curve for Micromotion Mass Flowmeter

(For Vendor Data, see Appendix M)

SG := 1.12

Specific Gravity for 10% Solids at 70°F

$$\rho := SG \cdot \rho_{H2O}$$

$$\rho = 69.782 \cdot \frac{\text{lb}}{\text{ft}^3}$$

Process Fluid Density

(Ref. Pg. 7)

$$\gamma := \rho \cdot g$$

$$\gamma = 69.782 \cdot \frac{\text{lb}}{\text{ft}^3}$$

Specific weight of fluid.

$$\mu := 12.87 \cdot \text{cp}$$

Viscosity at 10% solids

(Ref. Pg. 7)

Volumetric Flowrate

$$Q_{50} := 50 \cdot \frac{\text{gal}}{\text{min}}$$

$$Q_{150} := 150 \cdot \frac{\text{gal}}{\text{min}}$$

$$Q_{250} := 250 \cdot \frac{\text{gal}}{\text{min}}$$

$$Q_{350} := 350 \cdot \frac{\text{gal}}{\text{min}}$$

Mass Flowrate corresponding to Micromotion graph

$$m_{q50} := Q_{50} \cdot \rho$$

$$m_{q150} := Q_{150} \cdot \rho$$

$$m_{q250} := Q_{250} \cdot \rho$$

$$m_{q350} := Q_{350} \cdot \rho$$

$$m_{q50} = 466.422 \cdot \frac{\text{lb}}{\text{min}}$$

$$m_{q150} = 1.399 \cdot 10^3 \cdot \frac{\text{lb}}{\text{min}}$$

$$m_{q250} = 2.332 \cdot 10^3 \cdot \frac{\text{lb}}{\text{min}}$$

$$m_{q350} = 3.265 \cdot 10^3 \cdot \frac{\text{lb}}{\text{min}}$$

Pressure Drop corresponding to Micromotion graph

$$P_{50} := .34 \cdot \text{psi}$$

$$P_{150} := 1.8 \cdot \text{psi}$$

$$P_{250} := 4.5 \cdot \text{psi}$$

$$P_{350} := 8.3 \cdot \text{psi} \quad (\text{Ref. Appendix C})$$

$$h_{50} := \frac{P_{50}}{\gamma}$$

$$h_{150} := \frac{P_{150}}{\gamma}$$

$$h_{250} := \frac{P_{250}}{\gamma}$$

$$h_{350} := \frac{P_{350}}{\gamma}$$

$$h_{50} = 0.702 \cdot \text{ft}$$

$$h_{150} = 3.714 \cdot \text{ft}$$

$$h_{250} = 9.286 \cdot \text{ft}$$

$$h_{350} = 17.128 \cdot \text{ft}$$

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Client NUMATEC HANFORD COMPANY

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141

Date 3 / 5 / 97

Checked 3/25/97

Revised

Filename micromtn.mcd

By D.L. STONE *DL*

By D.L. EVANS *DE*

By

Calculation of Flow vs Head Curve for Micromotion Mass Flowmeter

SG := 1.2

Specific Gravity for 30% Solids at 70°F

$$\rho := SG \cdot \rho_{H_2O}$$

$$\rho = 74.766 \cdot \frac{\text{lb}}{\text{ft}^3}$$

Process Fluid Density

(Ref. Pg. 7)

$$\gamma := \rho \cdot g$$

$$\gamma = 74.766 \cdot \frac{\text{lb}}{\text{ft}^3}$$

Specific weight of fluid.

$$\mu := 103.95 \cdot \text{cp}$$

Viscosity at 30% solids

(Ref. Pg. 7)

Volumetric Flowrate

$$Q_{50} := 50 \cdot \frac{\text{gal}}{\text{min}}$$

$$Q_{150} := 150 \cdot \frac{\text{gal}}{\text{min}}$$

$$Q_{250} := 250 \cdot \frac{\text{gal}}{\text{min}}$$

$$Q_{350} := 350 \cdot \frac{\text{gal}}{\text{min}}$$

Mass Flowrate corresponding to Micromotion graph

$$m_{q50} := Q_{50} \cdot \rho$$

$$m_{q150} := Q_{150} \cdot \rho$$

$$m_{q250} := Q_{250} \cdot \rho$$

$$m_{q350} := Q_{350} \cdot \rho$$

$$m_{q50} = 499.738 \cdot \frac{\text{lb}}{\text{min}}$$

$$m_{q150} = 1.499 \cdot 10^3 \cdot \frac{\text{lb}}{\text{min}}$$

$$m_{q250} = 2.499 \cdot 10^3 \cdot \frac{\text{lb}}{\text{min}}$$

$$m_{q350} = 3.498 \cdot 10^3 \cdot \frac{\text{lb}}{\text{min}}$$

Pressure Drop corresponding to Micromotion graph

$$P_{50} := 1.2 \cdot \text{psi}$$

$$P_{150} := 4 \cdot \text{psi}$$

$$P_{250} := 10 \cdot \text{psi}$$

$$P_{350} := 17.5 \cdot \text{psi}$$

(Ref. Appendix C)

$$h_{50} := \frac{P_{50}}{\gamma}$$

$$h_{150} := \frac{P_{150}}{\gamma}$$

$$h_{250} := \frac{P_{250}}{\gamma}$$

$$h_{350} := \frac{P_{350}}{\gamma}$$

$$h_{50} = 2.311 \cdot \text{ft}$$

$$h_{150} = 7.704 \cdot \text{ft}$$

$$h_{250} = 19.26 \cdot \text{ft}$$

$$h_{350} = 33.705 \cdot \text{ft}$$

FLUOR DANIEL NORTHWEST

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Client NUMATEC HANFORD COMPANY

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Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked 3/25/97

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

Filename monitor.mcd

By D.L. STONE *PLS*

By D.L. EVANS *PLS*

By

Calculation of Headloss Curves for 18" Supernate Line Monitor Tube :

Given / Known Data:

$$d := 2.469 \text{ in}$$

Entrance Pipe Inner Diameter (Ref. 15.7, Sh.7)

$$A := \frac{\pi d^2}{4}$$

Entrance Pipe Flow Area:

$$L_{\text{vein}} := 1 \text{ in}$$

Length of Monitor tube veins

$$P_w := (\pi d) + 4 \cdot (2 \cdot L_{\text{vein}})$$

$$P_w = 15.757 \text{ in}$$

Wetted Perimeter of Piping

Ref. 5, Pg.105

$$A := \left(\frac{\pi d^2}{4} \right) - 4 \cdot \left[\left(1 \cdot \text{in} \right) \cdot \left(\frac{1}{8} \cdot \text{in} \right) \right]$$

$$A = 4.288 \text{ in}^2$$

Flow Area inside Monitor Tube

$$D_e := \frac{4 \cdot A}{P_w}$$

$$D_e = 1.088 \text{ in}$$

Monitor Tube Equivalent diameter

$$Q_i :=$$

Flow Rate

$$v_i := \frac{Q_i}{A}$$

350 GPM
250 GPM
150 GPM
50 GPM
.01 GPM

$$v = \begin{bmatrix} 0 \\ 26.189 \\ 18.706 \\ 11.224 \\ 3.741 \\ 7.483 \cdot 10^{-4} \end{bmatrix} \frac{\text{ft}}{\text{sec}} \text{ Velocity}$$

Monitor Tube Losses at 10% Solids Loading:

$$SG := 1.12$$

Specific Gravity (10% solids loading)

(Ref. 1)

$$\rho_{\text{H}_2\text{O}} := 62.305 \frac{\text{lb}}{\text{ft}^3}$$

Water Density at 70° F

(Ref. 6)

$$\rho := SG \cdot \rho_{\text{H}_2\text{O}} \quad \rho = 69.782 \frac{\text{lb}}{\text{ft}^3}$$

Process Fluid Density

$$\mu_{10\%} := 13$$

Viscosity for 10% solids fluid at 68 degrees F

(Ref. 1)

$$\mu_{10\%70} := \mu_{10\%} \cdot (1 - 0.005 \cdot (70 - 68))$$

Temperature adjustment equation from FDC

(Ref. 1)

$$\mu := \mu_{10\%70} \cdot \text{cp}$$

$$\mu = 12.87 \text{ cp}$$

Viscosity for 10% solids fluid at 50° F

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. **W-320-27-045**
Revision No.: **0**
Page No. **13** of **25**

Client **NUMATEC HANFORD COMPANY**

WO/Job No. **E09141**

Filename **monitor.mcd**

Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**

Date **3/5/97**

By **D.L. STONE** *DL*

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked **3/25/97**

By **D.L. EVANS** *DL*

Location **C TANK FARM - HANFORD 200 EAST AREA**

Revised

(Monitor Tube, cont...)

$$\text{Reynolds}_i := \frac{D_e \cdot v_i \cdot \rho}{\mu}$$

Reynolds_i

Reynolds Number

Ref. 6, Eq 3-3

1.917·10 ⁴
1.369·10 ⁴
8.215·10 ³
2.738·10 ³
0.548

(Out of range for formula)

(Out of range for formula)

$$D_e = 0.091 \cdot \text{ft}$$

$$k_s := .00015 \cdot \text{ft}$$

Roughness factor for pipe Smooth Commercial Pipe

(Ref. 4, Pg.419)

$$f_i := \frac{0.25}{\left(\log \left(\frac{k_s}{3.7 \cdot d} + \frac{5.74}{\text{Reynolds}_i} \right) \right)^2}$$

f_i

Friction Factor (for 4 x 10³ < Re < 10⁶)

Ref. 4, Pg 424

0.0229
0.0243
0.0269
0.0359
0.2401

(Out of range for formula) f_{critical} := 0.045

(Out of range for formula)

$$\frac{k_s}{D_e} = 0.002$$

$$h_{\text{monitor}_i} := (f_i) \cdot \left(\frac{18 \cdot \text{in}}{D_e} \right) \cdot \frac{(v_i)^2}{2 \cdot g}$$

$$h_{\text{monitor}} = \begin{bmatrix} 0 \\ 4.036 \\ 2.182 \\ 0.871 \\ 0.129 \\ 3.455 \cdot 10^{-8} \end{bmatrix} \cdot \text{ft}$$

(Ref 6, Page A-20)

$$h_{\text{monitorC}} := (f_{\text{critical}}) \cdot \left(\frac{18 \cdot \text{in}}{D_e} \right) \cdot \frac{\left(\frac{3.741 \cdot \text{ft}}{\text{sec}} \right)^2}{2 \cdot g}$$

$$h_{\text{monitorC}} = 0.162 \cdot \text{ft}$$

Monitor Tube Losses at 0% Solids Loading (Water):

Given / Known Data:

$$\text{SG} := 1.0$$

Specific Gravity (0% solids loading)

(Ref. 1)

$$\rho_{\text{H}_2\text{O}} := 62.305 \cdot \frac{\text{lb}}{\text{ft}^3}$$

Water Density at 70° F

(Ref. 6)

$$\rho := \text{SG} \cdot \rho_{\text{H}_2\text{O}} \quad \rho = 62.305 \cdot \frac{\text{lb}}{\text{ft}^3}$$

Process Fluid Density

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. **W-320-27-045**

Revision No.: **0**

Page No. **14** of **25**

Client **NUMATEC HANFORD COMPANY**

WO/Job No. **E09141**

Filename **monitor.mcd**

Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**

Date **3 / 5 / 97**

By **D.L. STONE** *DL*

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked **3/25/97**

By **D.L. EVANS** *DL*

Location **C TANK FARM - HANFORD 200 EAST AREA**

Revised

By

(Monitor Tube, cont...)

$$\mu_{0\%} := 4$$

Viscosity for 0% solids fluid at 68 degrees F (Ref. 1)

$$\mu_{0\%70} := \mu_{0\%} (1 - 0.005 \cdot (70 - 68))$$

Temperature adjustment equation from FDC (Ref. 1)

$$\mu := \mu_{0\%70} \cdot \text{cp}$$

$$\mu = 3.96 \cdot \text{cp}$$

Viscosity for 10% solids fluid at 50° F

$$\text{Reynolds}_i := \frac{D_e \cdot v_i \cdot \rho}{\mu}$$

Reynolds_i

Reynolds Number

Ref. 6, Eq 3-3

5.562 · 10 ⁴
3.973 · 10 ⁴
2.384 · 10 ⁴
7.946 · 10 ³
1.589

$$D_e = 0.091 \cdot \text{ft}$$

$$k_s := .00015 \cdot \text{ft}$$

Roughness factor for pipe Smooth Commercial Pipe

(Ref. 4, Pg.419)

$$f_i := \frac{0.25}{\left(\log \left(\frac{k_s}{3.7 \cdot d} + \frac{5.74}{\text{Reynolds}_i} \right) \right)^2}$$

f_i

0.0201
0.0208
0.0222
0.0271
0.8036

Friction Factor (for 4 x 10³ < Re < 10⁶) Ref. 4, Pg 424

$$\frac{k_s}{D_e} = 0.002$$

(Out of range for formula) f_{critical} := 0.045

(Out of range for formula)

$$h_{\text{monitor}_i} := (f_i) \cdot \left(\frac{18 \cdot \text{in}}{D_e} \right) \cdot \frac{(v_i)^2}{2 \cdot g}$$

h_{monitor_i}

(Ref 6, Page A-20)

3.551 · ft
1.871 · ft
0.717 · ft
0.098 · ft
1.156 · 10 ⁻⁷ · ft

$$h_{\text{monitorC}} := (f_{\text{critical}}) \cdot \left(\frac{18 \cdot \text{in}}{D_e} \right) \cdot \frac{\left(\frac{3.741 \cdot \text{ft}}{\text{sec}} \right)^2}{2 \cdot g}$$

$$h_{\text{monitorC}} = 0.162 \cdot \text{ft}$$

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
PIPE DRAINFLOW and ANTI-SIPHON SIZING FOR TRANSFER LINES
Location C TANK FARM 200 EAST AREA

WO/Job No. EO9141
Date 3 / 5 / 1997
Checked 3/25/97
Revised

Calc. No. W-320-27-045
Revision No. 0
Page No. 15 of 25

Filename curves.xls
By D. L. STONE DLS
By D.L. EVANS DLE

SUMMARY OF CURVES for INPUT TO PIPE-FLO MODEL

(Appendix A and Pages 10 - 14)

Immersible Pump 0% Solids
Free Rotor
Positive Flow

Q (gpm)	0	40	80	120	150
H (ft)	0	0.156	0.624	1.4	2.2

Vertical Inline Pump 0% Solids
Free Rotor

Q (gpm)	0	40	80	120	150
H (ft)	0	0.77	3.08	7	10.9

Positive Flow

Immersible Pump 0% Solids
Free Rotor
Reverse Flow

Q (gpm)	0	40	80	120	150
H (ft)	0	0.86	3.45	7.78	12.2

Vertical Inline Pump 0% Solids
Locked Rotor
Reverse Flow

Q (gpm)	0	40	80	120	150
H (ft)	0	1.15	4.59	10.4	16.2

Micromotion 10% Solids
Mass Flow Meter

Q (gpm)	0	50	150	250	350
H (ft)	0	0.702	3.714	9.286	17.128

30% Solids

Q (gpm)	0	50	150	250	350
H (ft)	0	2.311	7.704	19.26	33.705

Monitor Tube 0% Solids

Q (gpm)	0	50	150	250	350
H (ft)	0	0.098	0.717	1.87	3.55

10% Solids

Q (gpm)	0	50	150	250	350
H (ft)	0	0.13	0.87	2.18	4.04

FLUOR DANIEL NORTHWEST

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Client NUMATEC HANFORD COMPANY

WO/Job No. E09141

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

Pipe Drainflow and Anti-Siphon Sizing for Transfer Line

Checked 3/25/97

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

Filename slurrylist.mcd

By D.L. STONE *DS*

By M.D. BROCKETT *MB*

By

SLURRY TRANSFER LINE - Identification and Configuration

Node Name: ~N--0 Elevation: ImPumpSuction := 608.0-ft (Ref. 15.8 & Lawrence Pump Data (Appx. M))

Pipe Name: Pipe 0 L Pipe0 := 5.31-in L Pipe0 = 0.442-ft - Pipe-FLO Pressure Source at 0 psig at 0 ft (conservative)

(5" Suction Diameter) - 1, entrance (exit, for Siphoning)

Node Name: ~N--1 Elevation: ImPumpDischarge := ImPumpSuction + 5.31-in
ImPumpDischarge = 608.443-ft (Ref. 15.0 & Lawrence Pump Data (Appx. M))

Pipe Name: Pipe 1 L vPipe1 := (3 + 4 + 2 · (4.875)) · in (Ref. 15.0)

(3" Line) L hPipe1 := (8.125 + 3) · in (Ref. 11 (Appx. M))

L Pipe1 := L vPipe1 + L hPipe1 L Pipe1 = 2.323-ft

- Immersible Pump Component
1 el, 1 Swivel----> - 3, 3", 90° SR els
- 1, 4 x 3 enlarger - 4" approach

BoosterPumpSuction := 639-ft + 1.281-in

Node Name: ~N--2 Elevation: Reducer 4x3 := ImPumpDischarge + 1.396-ft
Reducer 4x3 = 609.838-ft (Ref. 11, 15.8 & 15.2)

Pipe Name: Pipe 2 L vPipe2 := BoosterPumpSuction - Reducer 4x3 L vPipe2 = 29.268-ft

(4" Line) L hPipe2 := (2 · (10.125) + 12.29 + 18.97 + 15.6) · in L hPipe2 = 5.592-ft

L Pipe2 := L vPipe2 + L hPipe2 L Pipe2 = 34.861-ft

- 1, 4", 45° SR el
2 Swivels----> - 4, 4", 90° SR els
- 2, 4", 90° LR els
- 1, 4", 90° SR el
Jumper Connector----> - 1, 4" miter bend

Node Name: ~N--2.1 Elevation: BoosterPumpSuction = 639.107-ft (Ref. 15.8 & 15.9)

Pipe Name: Pipe 2.1 L Pipe2.1 := 1-ft

(4" Line - Pipe 2.1 modeled to support components not included in this calculation.)

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Client **NUMATEC HANFORD COMPANY**
Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**
Pipe Drainflow and Anti-Siphon Sizing for Transfer Line
Location **C TANK FARM - HANFORD 200 EAST AREA**

WO/Job No. **E09141**
Date **3 / 5 / 97**
Checked
Revised

Filename **slurrylist.mcd**
By **D.L. STONE** *DL*
By **M.D. BROCKETT** *MB*
By

(SLURRY LINE- cont..)

Node Name: ~N--2.2 Elevation: $\text{BoosterPumpSuction} = 639.107 \cdot \text{ft}$ (Ref. 15.9)

Pipe Name: Pipe 3

(3" Line)

$$L_{\text{Pipe3}} := 4 \cdot \text{ft} + 9.2 \cdot \text{in} \quad L_{\text{Pipe3}} = 4.767 \cdot \text{ft}$$

- 90° el 4" LR
- 4x3 reducer, 4" approach
- Pump Backflow Component
- 4x3 enlgr, 4" approach
- 90° el 4" LR

Node Name: ~N--3 Elevation: $\text{BoosterPumpDischarge} := \text{BoosterPumpSuction} + 4.25 \cdot \text{in}$ (Ref. 15.9)

Pipe Name: Pipe 3.1

(4" Line)

$$\text{BoosterPumpDischarge} = 639.461 \cdot \text{ft} \quad (\text{Checkpoint } 1)$$

$$L_{v\text{Pipe3.1}} := (1 \cdot \text{ft} + 2.9 \cdot \text{in}) + (1 \cdot \text{ft} + 5.8 \cdot \text{in}) \quad L_{v\text{Pipe3.1}} = 2.725 \cdot \text{ft} \quad (\text{Ref. 15.10 \& 15.9})$$

$$L_{h\text{Pipe3.1}} := (12 \cdot \text{ft} + 7 \cdot \text{in}) + 2 \cdot \text{ft} \quad L_{h\text{Pipe3.1}} = 14.583 \cdot \text{ft} \quad (\text{Ref. 15.10})$$

$$\text{Jumper} := L_{v\text{Pipe3.1}} + L_{h\text{Pipe3.1}} \quad \text{Jumper} = 17.308 \cdot \text{ft}$$

$$L_{\text{Pipe3.1}} := 410.3 \cdot \text{ft} + \text{Jumper} \quad (\text{Ref. 15.1 \& 15.4})$$

$$L_{\text{Pipe3.1}} = 427.608 \cdot \text{ft}$$

- 2 jmpr conn = miter bend 4"
- 3 90° el 4" LR
- 6, 4" 90° Bends $\frac{1}{d} = 10$
- 2, 4" 45° Bends $\frac{1}{d} = 9$

Node Name: ~N--3.1 Elevation: $\text{Checkpoint } 2 := 650.42 \cdot \text{ft}$ (Ref. 15.1 \& 15.5)

Pipe Name: Pipe 3.2

(4" Line)

$$L_{\text{Pipe3.2}} := 468.1 \cdot \text{ft}$$

$$4, 4" 90° \text{ Bends } \frac{1}{d} = 10$$

Node Name: ~N--3.2 Elevation: $\text{Checkpoint } 3 := 661.63 \cdot \text{ft}$ (Ref. 15.1 \& 15.5)

Pipe Name: Pipe 3.3

(4" Line)

$$L_{\text{Pipe3.3}} := 843.2$$

$$11, 4" 90° \text{ Bends } \frac{1}{d} = 10$$

Node Name: ~N--3.3 Elevation: $\text{SystemHighpoint} := 676.05 \cdot \text{ft}$ (Ref. 15.1)

Pipe Name: Pipe 3.4

(4" Line)

$$L_{\text{Pipe3.4}} := (15.504 + 1.583) \cdot \text{in}$$

$$L_{\text{Pipe3.4}} = 1.424 \cdot \text{ft}$$

- 1 jmpr conn = miter bend 4"
- 1, 90° el 4" LR
- 1, 4 x 3 reducer - 4" approach

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Client NUMATEC HANFORD COMPANY

WO/Job No. E09141

Filename slurrylist.mcd

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

By D.L. STONE

Pipe Drainflow and Anti-Siphon Sizing for Transfer Line

Checked

By M.D. BROCKETT

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

(SLURRY LINE- cont.)

Node Name: ~N-4 Elevation: Micromotion_{in} := SystemHighpoint - 15.375-in (Ref. 15.11)

Micromotion_{in} = 674.769•ft

Pipe Name: Pipe 4

L_{Pipe4.1} := (5.427•ft - 34.562•in) + (2 + 5.292)•in

- 1, 90° el 3" LR

(3" Line)

L_{Pipe4.1} = 3.155•ft

- Micromotion Flowmeter

- 1, 3-way Ball Valve, Cv = 228

Node Name: ~N-4.1 Elevation: Micromotion_{out} := Micromotion_{in} (Ref. 15.11)

Micromotion_{out} = 674.769•ft

Pipe Name: Pipe 5

L_{Pipe5} := (9.958 + 5.292 + 30.844)•in (Ref. 15.11)

(4" Line)

L_{Pipe5} = 3.841•ft

- 1, 4 x 3 enlarger - 4" approach

- 3, 90° el 4" LR

- 1 jmpr conn = miter bend 4"

Node Name: ~N-5 Elevation: Nozzle := SystemHighpoint - (1•ft + 9.375•in) (Ref. 15.11)

Nozzle = 674.269•ft

Pipe Name: Pipe 5.1

L_{5.1} := 7•ft + 8•in L_{5.1} = 7.667•ft (Ref. 15.14)

(4" , Sched. 80 Line)

Node Name: ~N-5.1 Elevation: SiphonHole := 665.8•ft (2, 1/2" holes) (Ref. 15.1)

Pipe Name: Pipe 5.2

L_{Pipe5} := (37 - 7)•ft - 7.75•in L_{Pipe5} = 29.354•ft (Ref. 15.14)

(4" , Sched. 80 Line)

LowerNozzles := 635.91•ft (Ref. 15.1)

Node Name: ~N-6 Elevation: UpperNozzles := LowerNozzles + 7.75•in (Ref. 15.14)

UpperNozzles = 636.556•ft

Distributor Nozzle Pressure Sources:
(Maximum Liquid Level)

H_{UpperNozzles} := 653.66•ft - UpperNozzles

H_{UpperNozzles} = 17.104•ft

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

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Client **NUMATEC HANFORD COMPANY**
Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**
Pipe Drainflow and Anti-Siphon Sizing for Transfer Line
Location **C TANK FARM - HANFORD 200 EAST AREA**

WO/Job No. **E09141**
Date **3 / 5 / 97**
Checked
Revised

Filename **slurrylist.mcd**
By **D.L. STONE *DL***
By **M.D. BROCKETT *MB***
By

(SLURRY LINE- cont..)

Node Name: ~N-6.1

Pipe Name: Pipe 6.1 (2" , Sched. 80 Line) L Pipe5.1 := 0.5·ft - 1, exit (entrance, for Siphoning)

Node Name: ~N-6.2

Pipe Name: Pipe 6.2 (2" , Sched. 80 Line) L Pipe5.2 := 0.5·ft - 1, exit (entrance, for Siphoning)

Node Name: ~N-7 Elevation: LowerNozzles := 635.91·ft (Ref. 15.1 & 15.14)

Pipe Name: Pipe 7 L Pipe7 := 7.75·in L Pipe7 = 0.646·ft
(4" Line)

Distributor Nozzle Pressure Sources: $H_{\text{LowerNozzles}} = H_{\text{UpperNozzles}} + L_{\text{Pipe7}}$ $H_{\text{LowerNozzles}} = 17.75 \cdot \text{ft}$
(Maximum Liquid Level)

Node Name: ~N-7.1

Pipe Name: Pipe 7.1 (4" , Sched. 80 Line) L Pipe6.1 := 6·in L Pipe6.1 = 0.5·ft
- 1 ecc. 4 x 2 reducer (enlarger, for Siphoning)

Node Name: ~N-7.11

Pipe Name: Pipe 7.11 (2" , Sched. 80 Line) L Pipe6.11 := 2·in L Pipe6.11 = 0.167·ft
- 1, exit (entrance, for Siphoning)

Node Name: ~N-7.2

Pipe Name: Pipe 7.2 (4" , Sched. 80 Line) L Pipe6.2 := 6·in L Pipe6.2 = 0.5·ft
- 1 ecc. 4 x 2 reducer (enlarger, for Siphoning)

Node Name: ~N-7.22

Pipe Name: Pipe 7.22 (2" , Sched. 80 Line) L Pipe6.22 := 2·in L Pipe6.22 = 0.167·ft
- 1, exit (entrance, for Siphoning)

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

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Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked
Revised

Filename suprlst.mcd
By D.L. STONE *DLS*
By M.D. BROCKETT *MB*
By

SUPERNATE LINE - Identification and Configuration

Node and Pipe Names, Elevations, Pipe Diameters, Pipe Lengths, Fittings and Pressure Sources

Node Name: ~N-0 Elevation: ImPumpSuction := 635.5 ft (Ref. 15.8 & Lawrence Pump Data (Appx. M))

Pipe Name: Pipe 0 $L_{vPipe0} := 5.31 \text{ in}$ $L_{vPipe0} = 0.442 \text{ ft}$

(5" Suction Diameter)

Submergence := (63.66 - 635.5) ft

Submergence = 18.16 ft

- Pipe-FLO Pressure Source
at 0 psig at 17.77 ft
- Pump entrance

Node Name: ~N-1 Elevation: ImPumpDischarge := ImPumpSuction + 5.31 in

ImPumpDischarge = 635.943 ft

Pipe Name: Pipe 1 $L_{vPipe1} := (3 + 4 + 2 \cdot (4.875)) \text{ in}$ (Ref. 15.0)

(3" Line) $L_{hPipe1} := (8.125 + 3) \text{ in}$ (Ref. 11 (Appx. M))

$L_{Pipe1} := L_{vPipe1} + L_{hPipe1}$ $L_{Pipe1} = 2.323 \text{ ft}$

1 el + 1 Swivel-->

- Immersible Pump (Component curves)
- 3, 3", 90° SR els
- 1, 4 x 3 enlarger - 4" approach

SiphonHole := 661.7 ft

Node Name: ~N-2.1 Elevation: Reducer_{4x3} := ImPumpDischarge + L_{vPipe1}

Reducer_{4x3} = 637.338 ft

Pipe Name: Pipe 2.1 $L_{vPipe2.1} := (\text{SiphonHole} - \text{ImPumpSuction}) - (L_{vPipe0} + L_{vPipe1})$ (Ref. 15.8)

(4" Line)

$L_{hPipe2.1} := 2 \cdot (10.125 \text{ in})$ (Ref. 11 (Appx. M))

$L_{Pipe2.1} := L_{vPipe2.1} + L_{hPipe2.1}$ $L_{Pipe2.1} = 26.049 \text{ ft}$

- 1, 4", 45° SR el
2 Swivels--> - 4, 4", 90° SR els

FLUOR DANIEL NORTHWEST

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Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked
Revised

Filename suprlst.mcd
By D.L. STONE
By M.D. BROCKETT
By

(SUPERNATE LINE- cont.)

Elv PlatetoSuction := 9.313-in (Ref. 15.16)
Elv Plates := 2-(1.5-in) (Ref. 15.3, Pg 2)
Elv PlatetoLap := 15.25-in (Ref. 15.3, Pg 2)
Elv LaptoHole := (102.75 - 8)-in (Ref. 15.3, Pg 2)

Node Name: ~N-2.2 Elevation: SiphonHole := 671.115-ft - (Elv Plates + Elv PlatetoLap + Elv LaptoHole)
SiphonHole = 661.7-ft

Pipe Name: Pipe 2.2 $L_{vPipe2.2} := (Elv\ Plates + Elv\ PlatetoLap + Elv\ LaptoHole) + Elv\ PlatetoSuction$
(4" Line) $L_{vPipe2.2} = 10.193 \cdot ft$

$L_{hPiping} := (12.29 + 18.97) \cdot in$ (Ref. 15.2, Pg 2)

$L_{hJumper} := (17.5 + 46 + 7) \cdot in$ (Ref. 15.16, Pg 3)

$L_{Pipe2.2} := L_{vPipe2.2} + L_{hPiping} + L_{hJumper}$ $L_{Pipe2.2} = 18.673 \cdot ft$

- 4, 4", 90° LR els

- 1, 4", 90° SR el

Jumper Connector--> - 1, 4" miter bend

- 4", 2-way PBM Ball Valve, Cv = 650

BoosterPumpDischarge := (677.073 - 4.404)·ft (Ref. 15.16)

Node Name: ~N-2.3 Elevation: BoosterPumpSuction := BoosterPumpDischarge - 4.25-in (Ref. 15.16)
BoosterPumpSuction = 672.315·ft

Pipe Name: Pipe 2.3 $L_{Pipe3} := 2 \cdot (4 \cdot in)$ $L_{Pipe3} = 0.667 \cdot ft$ - 1, 4 x 3 reducer - 4" approach
(3" Line) - Vertical Inline Pump (Component curves)
- 1, 4 x 3 enlarger - 4" approach

FLUOR DANIEL NORTHWEST

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Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked
Revised

Filename suprlst.mcd
By D.L. STONE *DIS*
By M.D. BROCKETT *MD*
By

(SUPERNATE LINE- cont..)

SystemHighpoint := 677.11-ft

Node Name: ~N-3 Elevation: BoosterPumpDischarge := (677.073 - 4.404)·ft (Ref. 15.16)

BoosterPumpDischarge = 672.669·ft

Pipe Name: Pipe 3 $L_{vPipe3} := (\text{SystemHighpoint} - \text{BoosterPumpDischarge})$ $L_{vPipe3} = 4.441\cdot\text{ft}$

(4" Line) $L_{hPipe3} := (12.9 + 15.25)\cdot\text{in}$ $L_{hPipe3} = 2.346\cdot\text{ft}$ (Ref. 15.16)

$L_{Pipe3} := L_{vPipe3} + L_{hPipe3}$ $L_{Pipe3} = 6.787\cdot\text{ft}$

Jumper Conn--> - 1, 4" miter bend
- 3, 4", 90° LR els
- 1, 4 x 1 Tee, thru Run

Node Name: ~N-4 Elevation: SystemHighpoint := 677.11·ft (Ref. 15.1 & 15.7)

Pipe Name: Pipe 4.1 $L_{Pipe4.1} := 822.8\cdot\text{ft}$ - 10, 4", 90° Bends $l_d = 10$
(4" Line)

Node Name: ~N-5 Elevation: Checkpoint 3 := 661.63·ft (Ref. 15.1 & 15.5)

Pipe Name: Pipe 4.2 $L_{Pipe4.2} := 468.1\cdot\text{ft}$ - 4, 4", 90° Bends $l_d = 10$
(4" Line)

Node Name: ~N-6 Elevation: Checkpoint 2 := 650.39·ft (Ref. 15.1 & 15.4)

Pipe Name: Pipe 4.3 $L_{Pipe4.3} := 428.7\cdot\text{ft}$ 5, 4" 90° Bends $l_d = 10$
(4" Line) 2, 4" 45° Bends $l_d = 9$

FLUOR DANIEL NORTHWEST

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Client NUMATEC HANFORD COMPANY

WO/Job No. E09141

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

Filename suprlst.mcd

By D.L. STONE *DL*

By M.D. BROCKETT

By

SUPERNATE LINE- cont..

Node Name: ~N-10 Elevation: Monitor Top := Modified Swivel - 8-in (Ref. 15.18)
Monitor Top = 621.85-ft

Pipe Name: Pipe 7 L Pipe7 := (12.94 + 1.5)-in L Pipe7 = 1.203-ft - Monitor Component Curve
(2.5" Line)

Node Name: ~N-11 Elevation: Nozzle In := Monitor Top - (18 + 1.5)-in (Ref. 15.20)
Nozzle In = 620.225-ft
- 1, 2.5 x 1 reducer - 7.25" approach

Pipe Name: Pipe 8 L Pipe8 := 7.25-in L Pipe8 = 0.604-ft
(2.5" Line - reducer, only)

Node Name: ~N-12 Elevation: Nozzle Out := Nozzle In - (7.25)-in (Ref. 15.20)
Nozzle Out = 619.621-ft

Pipe Name: Pipe 9 L Pipe9 := 3.25-in L Pipe9 = 0.271-ft - Exit
(1", Schedule 80 Line)

Node Name: ~N-13 Elevation: End := Nozzle Out - 3.25-in (Ref. 15.20)
End = 619.35-ft
- Pipe-FLO Pressure Source,
0 psig at 0 ft submergence

FLUOR DANIEL NORTHWEST

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Client NUMATEC HANFORD COMPANY

WO/Job No. E09141

Filename suprlst.mcd

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

By D.L. STONE

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked

By M.D. BROCKETT

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

By

(SUPERNATE LINE- cont.)

SluicerFlange_{Top} := 638.33·ft (Ref. 15.21)

Modified Swivel := (SluicerFlange_{Top} - 15.813·ft) (Ref. 15.21)

Node Name: ~N-7 Elevation: PitNozzle C106 := 641.42·ft (Checkpoint 1) (Ref. 15.1)

Pipe Name: Pipe 4.4 L_{vPipe4.4} := (PitNozzle C106 - Modified Swivel - 8.4·in) (Ref. 15.18)

(4" Line) L_{Jumper} := (5.464 + 1.33)·ft (Ref. 15.17)

L_{Template} := 15.25·in (Ref. 15.19)

L_{hPipe4.4} := L_{Jumper} + L_{Template}

L_{Pipe4.4} := L_{vPipe4.4} + L_{hPipe4.4} L_{Pipe4.4} = 26.268·ft

- 5, 4", 90° LR els

- 2, 4" miter bend

- 2, 4", 45° SR el

- 1, 4 x 2.5 reducer - 4" approach

Node Name: ~N-8 Elevation: Reducer 4x2.5 := Modified Swivel + 8.4·in (Ref. 15.21 & 15.18)

Reducer 4x2.5 = 623.217·ft

Pipe Name: Pipe 5 L_{vPipe5} := 8.4·in

(2.5" Line) L_{hPipe5} := 6.375·in

L_{Pipe5} := L_{vPipe5} + L_{hPipe5} L_{Pipe5} = 1.231·ft

- 1, 2.5", 90° SR els

- 1, 4" miter bend

Node Name: ~N-9 Elevation: Modified Swivel = 622.517·ft (Ref. 15.21 & 15.18)

Pipe Name: Pipe 6 L_{Pipe6} := 8·in L_{Pipe6} = 0.667·ft (2" Line) - 1, 2 x 2.5 enlarger - 3.5" approach

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045

Revision No.: 0

Page No. 24 of 25

Client NUMATEC HANFORD COMPANY
Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. E09141
Date 3 / 5 / 97
Checked
Revised

Filename suprlst.mcd
By D.L. STONE *DS*
By M.D. BROCKETT
By

(SUPERNATE LINE- cont..)

Node Name: ~N-10 Elevation: Monitor Top := Modified Swivel - 8-in (Ref. 15.18)
Monitor Top = 621.85•ft

Pipe Name: Pipe 7 L Pipe7 := (12.94 + 1.5)•in L Pipe7 = 1.203•ft - Monitor Component Curve
(2.5" Line)

Node Name: ~N-11 Elevation: Nozzle In := Monitor Top - (18 + 1.5)•in (Ref. 15.20)
Nozzle In = 620.225•ft

Pipe Name: Pipe 8 L Pipe8 := 7.25•in L Pipe8 = 0.604•ft - 1, 2.5 x 1 reducer - 7.25" approach
(2.5" Line - reducer, only)

Node Name: ~N-12 Elevation: Nozzle Out := Nozzle In - (7.25)•in (Ref. 15.20)
Nozzle Out = 619.621•ft

Pipe Name: Pipe 9 L Pipe9 := 3.25•in L Pipe9 = 0.271•ft - Exit
(1", Schedule 80 Line)

Node Name: ~N-13 Elevation: End := Nozzle Out - 3.25•in (Ref. 15.20)
End = 619.35•ft - Pipe-FLO Pressure Source,
0 psig at 0 ft submergence

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. **W-320-27-045**
Revision No.: **0**
Page No. **25** of **25**

Client **NUMATEC HANFORD COMPANY**
Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location **C TANK FARM - HANFORD 200 EAST AREA**

WO/Job No. **E09141**
Date **3 / 5 / 97**
Checked **3/25/97**
Revised

Filename **time.mcd**
By **D.L. STONE**
By **D.L. EVANS**

Basic Calculation for Determination of Time to Drain Pipelines

The following calculation exemplifies the method used to estimate the time for each pipe in the two Piping Systems to drain. The Excel spreadsheet shown on Page 8 repeats this calculation for each pipe in the system and sums the results.

EXAMPLE: Pipe 3.1 Pipe Name
 $d := 4.03 \cdot \text{in}$ Pipe Inner Diameter
 $A := \left(\frac{\pi \cdot d^2}{4} \right)$ $A = 0.089 \cdot \text{ft}^2$ Cross sectional Area of Pipe
 $L := 428.91 \cdot \text{ft}$ Pipe Length
 $V := A \cdot L$ $V = 284.207 \cdot \text{gal}$ Pipe Volume

1. _____

The following method is used, and the results for each pipe summed, for the pipeline from the lower station point (1/3 of the distance up the pipe to the transfer line lowpoint) to the end of the line.

$Q_{\text{Lowpoint}} := 122.3 \cdot \frac{\text{gal}}{\text{min}}$ Drain Flowrate from Highpoint, provided by Pipe-Flo
 $T := \frac{V}{Q_{\text{Lowpoint}}}$ $T = 2.324 \cdot \text{min}$ Time required to drain Pipe at the given Flowrate

2. _____

The following method is used, and the results for each pipe summed, for the pipeline from the system highpoint to the lower station point (1/3 of the distance up the pipe to the transfer line lowpoint.)

$Q_{\text{High}} := 122.3 \cdot \frac{\text{gal}}{\text{min}}$ Drain Flowrate from Highpoint, provided by Pipe-Flo
 $Q_{\text{Station}} := 141.5 \cdot \frac{\text{gal}}{\text{min}}$ Drain Flowrate from a Stationpoint, provided by Pipe-Flo
 $Q_{\text{average}} := \frac{Q_{\text{High}} + Q_{\text{Station}}}{2}$ Average Drain Flowrate
 $T := \frac{V}{Q_{\text{average}}}$ $T = 2.155 \cdot \text{min}$ Time required to drain Pipe at the given Flowrate

Appendix A

DESIGN ANALYSIS

Client Project W320

Subject Transfer Line Siphon

Location MO294/200E

WO/Job No. E09141

Date 02/13/97

Checked 03/11/97

Revised 03/13/97

By FM Hauck

By DL Stone

By FM Hauck

BACKGROUND

This calculation is to develop head loss curves for the pumps in the W320 system when the transfer lines are draining following pump operation. Ultimately, the results of this calculation will be used to determine the antisiphon measures required for this system.

METHOD

The head loss curves developed in this calculation are based on data taken from "Centrifugal and Axial Flow Pumps," second edition, by AJ Stepanoff. In Table 13.3, Stepanoff uses actual pump test data for thirteen different specific speed pumps to develop values for pump operation at special conditions. (See Appendix A)

In our case we are specifically interested in the data for flow with both free and locked rotor. Using the "affinity laws" (as explained on page 26 of the text) Stepanoff's data is applied to our specific pumps to determine the head loss through the pump at different capacities.

SCOPE

This calculation develops head loss curves for 1) Lawrence Pump serial nos. 91231-1 and 91231-2, Submersible Pumps for positive and negative flow conditions and 2) Lawrence Pumps, Inc. serial nos. 91232-1 and 91232-2, Vertical Inline Slurry Pumps for negative and positive flow conditions.

SPECIFIC SPEED (Ref. Stepanoff, pg. 27, equation 2.6)

3 x 4 x 13 Submersible Pump

At the pump's BEP, the flow is 540 gpm and the head is 114 feet when operated at 1760 rpm. $N_s = n\sqrt{Q}/H^{.75}$. The resulting specific speed, N_s , is 1172.

3 x 3 x 13 Vertical Inline Pump

At the pump's BEP, the flow is 480 gpm and the head is 448 feet when operated at 3056 rpm. $N_s = n\sqrt{Q}/H^{.75}$. The resulting specific speed, N_s , is 688. Since this pump can be operated at variable speeds, it is important to note that "specific speed" is related to impeller geometry (hydraulics) and will remain the same as the pump speed is adjusted.

DESIGN ANALYSIS

client Project W320

subject Transfer Line Siphon

Location MO294/200E

WO/Job No. E09141

Date 02/13/97

Checked 03/11/97

Revised 03/13/97

By FM Hauck *ml*By DL Stone *DL Stone*By FM Hauck *ml*CALCULATION OF HEAD LOSS

3 X 4 X 13 Submersible Pump

This pump can rotate in a reverse direction so the Table 13.3 in Stepanoff states that a pump at this approximate specific speed in rotor-free, negative flow operation will have a flow of 85% in the reverse direction while rotating at 104% of its normal speed in a reverse direction when subjected to 100% rated head.

Stepanoff states that the affinity laws can be used to relate this data to other operating conditions as follows:

Condition	0	1	2	3	4	5
Flow, GPM	0	40	80	120	150	175
% of 540	0	7.4	14.8	22.2	27.8	32.4

$$H_2 = H_1 \left(\frac{Q_2}{Q_1} \right)^2$$

$$\text{CONDITION 1} \quad H_2 = 100 \left(\frac{7.4}{85} \right)^2 = 0.76\%$$

$$H_2 = 0.76\% (114) = \underline{0.86 \text{ FT}}$$

$$\text{CONDITION 2} \quad H_2 = 100 \left(\frac{14.8}{85} \right)^2 = 3.03\%$$

$$H_2 = 3.03\% (114) = \underline{3.45 \text{ FT}}$$

$$\text{CONDITION 3} \quad H_2 = 100 \left(\frac{22.2}{85} \right)^2 = 6.82\%$$

$$H_2 = 6.82\% (114) = \underline{7.78 \text{ FT}}$$

$$\text{CONDITION 4} \quad H_2 = 100 \left(\frac{27.8}{85} \right)^2 = 10.69\%$$

$$H_2 = 10.69\% (114) = \underline{12.2 \text{ FT}}$$

$$\text{CONDITION 5} \quad H_2 = 100 \left(\frac{32.4}{85} \right)^2 = 14.5\%$$

$$H_2 = 14.5\% (114) = \underline{16.5 \text{ FT}}$$

Lawrence 3 X 4 X 13 Submersible
Free Rotor, Reverse Flow

DESIGN ANALYSIS

Client Project W320

Subject Transfer Line Siphon

Location M0294/200E

WO/Job No. E09141

Date 02/13/97

Checked 03/11/97

Revised 03/13/97

By FM Hauck

By DL Stone

By FM Hauck

The 3 x 4 x 13 Submersible Pump can be subjected to transfer line drain down in a positive flow direction as well as negative. Again, using the information from Stepanoff and the affinity laws, a head loss vs. flow curve has been developed. Table 13.3 in Stepanoff states that with 100% flow in the positive direction there will be a head loss of 25% of the pump rated head at BEP.

$$H_2 = H_1 \left(\frac{Q}{Q} \right)^2$$

$$\text{CONDITION 1 } H_2 = 25 \left(\frac{7.4}{100} \right)^2 = 0.137\%$$

$$H_2 = 0.137\% (114) = \underline{0.156 \text{ FT}}$$

$$\text{CONDITION 2 } H_2 = 25 \left(\frac{14.8}{100} \right)^2 = 0.548\%$$

$$H_2 = 0.548\% (114) = \underline{0.624 \text{ FT}}$$

$$\text{CONDITION 3 } H_2 = 25 \left(\frac{22.2}{100} \right)^2 = 1.23\%$$

$$H_2 = 1.23\% (114) = \underline{1.40 \text{ FT}}$$

$$\text{CONDITION 4 } H_2 = 25 \left(\frac{27.8}{100} \right)^2 = 1.93\%$$

$$H_2 = 1.93\% (114) = \underline{2.20 \text{ FT}}$$

$$\text{CONDITION 5 } H_2 = 25 \left(\frac{32.4}{100} \right)^2 = 2.59\%$$

$$H_2 = 2.59\% (114) = \underline{2.95 \text{ FT}}$$

Lawrence 3 x 4 x 13 Submersible
Free Rotor, Positive Flow

DESIGN ANALYSIS

Client Project W320

Subject Transfer Line Siphon

Location MO294/200E

WO/Job No. E09141

Date 02/13/97

Checked 03/11/97

Revised 03/13/97

By FM Hauck

By DL Stone

By FM Hauck

CALCULATION OF HEAD LOSS--continued

3 x 3 x 13 Vertical Inline

This pump has an anti-reverse rotation clutch on it so that during negative flow it will have a locked rotor. Since locked rotor performance data is not available for a specific speed of 688, the values in Table 13.3 of Stepanoff for a pump specific speed of 1190 is used. This will give us a reasonable estimate of the head losses across this pump. Stepanoff states that with 100% head and 0% rotation, the negative flow will be 164%.

Using the affinity laws:

Condition	0	1	2	3	4	5
Flow, GPM	0	40	80	120	150	175
% of 480	0	8.3	16.6	25	31.2	36.5

$$H_2 = H_1 \left(\frac{Q_2}{Q_1} \right)^2$$

$$\text{CONDITION 1} \quad H_2 = 100 \left(\frac{8.3}{16.6} \right)^2 = 0.26\% \quad H_2 = 0.26\% (448) = \underline{1.15 \text{ FT}}$$

$$\text{CONDITION 2} \quad H_2 = 100 \left(\frac{16.6}{16.6} \right)^2 = 1.02\% \quad H_2 = 1.02\% (448) = \underline{4.59 \text{ FT}}$$

$$\text{CONDITION 3} \quad H_2 = 100 \left(\frac{25}{16.6} \right)^2 = 2.32\% \quad H_2 = 2.32\% (448) = \underline{10.4 \text{ FT}}$$

$$\text{CONDITION 4} \quad H_2 = 100 \left(\frac{31.2}{16.6} \right)^2 = 3.62\% \quad H_2 = 3.62\% (448) = \underline{16.2 \text{ FT}}$$

$$\text{CONDITION 5} \quad H_2 = 100 \left(\frac{36.5}{16.6} \right)^2 = 4.95\% \quad H_2 = 4.95\% (448) = \underline{22.2 \text{ FT}}$$

Lawrence 3 x 4 x 13 Vertical Inline
Locked Rotor, Reverse Flow

DESIGN ANALYSIS

client Project W320

MO/Job No. E09141

Subject Transfer Line Siphon

Date 02/13/97

By FM Hauck *FMH*

Checked 03/11/97

By DL Stone *DL Stone*

Location MO294/200E

Revised 03/13/97

By FM Hauck *FMH*

CALCULATION OF HEAD LOSS -- continued

The 3 x 3 x 13 Vertical Inline pump can be subjected to transfer line drain down in a positive flow direction as well. Again, using the information from Stepanoff and the affinity laws, a head loss vs flow curve has been developed. Table 13.3 in Stepanoff states that with 100% flow in the positive direction there will be a head loss of 25% of the rated head at BEP. Again, it should be noted that for this case we are using data for a pump specific speed of 1270 because data for a specific speed of 688 is not available.

$$H_2 = H_1 \left(\frac{Q_2}{Q_1} \right)^2$$

$$\text{CONDITION 1} \quad H_2 = 25 \left(\frac{8.3}{100} \right)^2 = 0.17\%$$

$$H_2 = 0.17\% (448) = \underline{0.77 \text{ FT}}$$

$$\text{CONDITION 2} \quad H_2 = 25 \left(\frac{16.6}{100} \right)^2 = 0.69\%$$

$$H_2 = 0.69\% (448) = \underline{3.08 \text{ FT}}$$

$$\text{CONDITION 3} \quad H_2 = 25 \left(\frac{25}{100} \right)^2 = 1.56\%$$

$$H_2 = 1.56\% (448) = \underline{7 \text{ FT}}$$

$$\text{CONDITION 4} \quad H_2 = 25 \left(\frac{31.2}{100} \right)^2 = 2.43\%$$

$$H_2 = 2.43\% (448) = \underline{10.9 \text{ FT}}$$

$$\text{CONDITION 5} \quad H_2 = 25 \left(\frac{36.3}{100} \right)^2 = 3.33\%$$

$$H_2 = 3.33\% (448) = \underline{14.9 \text{ FT}}$$

Lawrence 3 x 4 x 13 Vertical Inline
Free Rotor, Forward Flow

DESIGN ANALYSIS

Client Project W320

WO/Job No. E09141

Subject Transfer Line Siphon

Date 02/13/97

By FM Hauck

Checked 03/11/97

By DL Stone

Location M0294/200E

Revised 03/13/97

By FM Hauck

APPENDIX A

2nd
Edition

Centrifugal and Axial

THEORY,

Flow Pumps

DESIGN, AND APPLICATION

A. J. Stepanoff, Ph.D.
Mechville Medalist, A.S.M.E.
Ingersoll-Rand Company

New York • London • Sydney

JOHN WILEY & SONS, INC.

FIG. 2.7. Centrifugal pump characteristics; 3-in. pump at 1750 rpm.

as the square of the speed, and the brake horsepower varies directly as the cube of the speed. The cube of the speed is based on the assumption that efficiency stays constant with speed for each point. The affinity laws are expressed by the following equations

$$\frac{Q_1}{Q_2} = \frac{n_1}{n_2} \quad \frac{H_1}{H_2} = \frac{n_1^2}{n_2^2} \quad \frac{(bhp)_1}{(bhp)_2} = \frac{n_1^3}{n_2^3} \quad (2.5)$$

Figure 2.8 shows three head-capacity curves at speeds n_1 , n_2 , and n_3 . Points connected by the affinity laws are called corresponding points

FIG. 2.8. Head and capacity variations with the speed.

and are connected by curved lines which are square parabolas. These points have the same efficiency and are of the same specific speed.

2.5 SPECIFIC SPEED

In the early stages of pump development it was customary to classify pumps according to their hydraulic-type ratios, such as a ratio of the impeller width at discharge to the impeller outside diameter (b_2/D_2). Ratios of the impeller eye diameter to the impeller outside diameter (D_1/D_2) were also used for the same purpose. Camerer † introduced a new characteristic to describe the hydraulic type of water turbines which was later applied to centrifugal pumps. It is called specific speed and is defined as

$$n_s = \frac{n\sqrt{Q}}{H^{3/4}} \quad (2.6)$$

where n is revolutions per minute, Q is capacity in gallons per minute, and H is head in feet. The physical meaning of specific speed is: revolutions per minute to produce 1 gpm at 1-ft head with an impeller similar to the one under consideration but reduced in size. The physical meaning of specific speed has no practical value and the number is used as a "type" number. The specific speed as a type number is constant for all similar pumps and does not change with the speed for the same pump. Figure 2.3 shows several impellers of different specific speeds. With each specific speed are associated definite proportions of leading impeller dimensions such as b_2/D_2 or D_1/D_2 .

In the study of pump performance and classification of all important design constants, specific speed is a criterion of similarity for centrifugal pumps in the manner that Reynolds number is a criterion for pipe flow. When used as a type number, specific speed is calculated for the best efficiency point. For a multistage pump, specific speed is calculated on the basis of the head per stage. When the specific speed of a double-suction impeller is compared with that of a single-suction impeller the capacity of the first should be divided by 2 or its specific speed should be divided by $\sqrt{2}$. All important pump design and performance characteristics are so closely connected with the specific speed that it is impossible to discuss certain features without reference to it.

From equation 2.6 it follows that, for the same head-capacity requirements, higher specific speed pumps will run at a higher speed and will be of smaller physical dimensions. Also, for the same speed and capacity, higher specific speed pumps will operate at a lower head or, for the same speed and head, a higher specific speed pump will deliver a higher capacity.

† R. Camerer, *Z. ges. Turbinenwes.*, p. 217, 1915.

torque for accelerating the mass of the rotating element of the pump. Although the impeller is filled with water, the acceleration of the impeller is already taken care of by the pumping speed-torque curve, as pumping is produced by water acceleration.

13.6 EFFECT OF SPECIFIC SPEED UPON THE BEHAVIOR OF CENTRIFUGAL PUMPS UNDER SPECIAL OPERATING CONDITIONS

In addition to the complete pump characteristics shown in Fig. 13.2, 13.3, and 13.4, below are listed several references giving the pump performance for the zones A, B, and C which are the most important for water-hammer studies. All pumps are of the single-suction type and specific speeds are tabulated in Table 13.2.

Normal, Tumor

In Table 13.3 are compiled from various sources, test results of several pumps of different specific speeds obtained at $T = 0$ or revolutions per minute $\omega = 0$, and recalculated at $\omega = 100$ or $Q = 100$. A comparison of the figures in the tabulation would indicate that the trend of the specific speed s versus pump behavior under the specified conditions.

In Table 13,3 are compiled from various sources, test results of several pumps of different specific speeds obtained at $N = 0$ or revolutions per minute = 0, and recalculated at 100 or $Q = 100$. A comparison of the figures in the tabulation would indicate the trend of the effect of specific speed on pump behavior under the specified conditions.

umps 8 and 9 have the same impeller, pumps 11 and 12 have the same casing but the impellers are different.

- | Operation | No. of
specimens
tested | Values of head (<i>H</i>), capacity (<i>Q</i>), and torque | | | Remarks |
|---------------|-------------------------------|--|--|--|---------|
| | | Locked | Values of head (<i>H</i>), capacity (<i>Q</i>), and torque | | |
| | | | <i>H</i> = +100
<i>Q</i> = +100
<i>T</i> = 0 | <i>H</i> = +100
<i>Q</i> = +100
<i>T</i> = 0 | |
Negative Flow	Motor-free	Locked	Motor-free	Locked	
Positive Flow					

Appendix B

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045, App B
Revision No.: 0
Page No. 1 of 5

Client NUMATEC HANFORD COMPANY

WO/Job No. E09141

Filename scfm-.mod

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

By D.L. EVANS *DLE*

Airflow vs Pressure Drop Across Anti-Siphoning Holes

Checked

By M.D. BROCKETT *MD*

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

By

OBJECTIVE:

The objective of this calculation is to determine the airflow vs pressure drop across the anti-siphon holes of the W-320 Slurry and Supernate Lines.

DESIGN INPUTS:

Project W-320 Calculation W-320-27-045

Project W-320 Hydraulic Diagram - Drawing H-2-818536, Rev. 0

ASSUMPTIONS:

1. The anti-siphon holes are open.
2. The anti-siphon holes can be modeled as pressure-relieving devices as described in ANSI / API RP 520, Ref. 1, for equipment having a maximum allowable working pressure of 15 psig (applicable to the system during siphoning.)

METHOD of ANALYSIS:

Method used is as described in ANSI / API RP 520, Ref. 1, to determine air flow (SCFM) through anti-siphoning holes.

Calculations performed using *Mathcad 6.0*, MathSoft, Inc. are shown with sources noted adjacent to formulas.

REFERENCES

1. ANSI / API RP 520
2. Project W-320 Calculation W320-27-045, Appendices E, G, I & K.

CONCLUSIONS

All analyses were performed for only one anti-siphoning hole on each line. In all cases the air-flow was less than critical air flow for the available upstream pressure.

The following table shows air flows available through the anti-siphon holes at differential pressures provided by the system siphoning models at anti-siphon hole locations (Ref. 2)

<u>Slurry Line</u>	<u>ΔP</u> <u>psid</u>	<u>Air Flow</u> <u>(SCFM)</u>	<u>Supernate Line</u>	<u>ΔP</u> <u>psid</u>	<u>Air Flow</u> <u>(SCFM)</u>
10% Solids	6.159	49.33	0% Solids	3.917	11.23
30% Solids	6.656	49.54	10% Solids	4.368	11.58

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045, App B

Revision No.: 0

Page No. 2 of 5

Client **NUMATEC HANFORD COMPANY**
Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**
Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines
Location **C TANK FARM - HANFORD 200 EAST AREA**

WO/Job No. **E09141**
Date **3 / 5 / 97**
Checked
Revised

Filename **siphon\text.mcd**
By **D.L. EVANS JPE**
By **M.D. BROCKETT MB**
By

CALCULATIONS

1. Check for Critical Flow

Critical throat pressure is calculated for the most conservative case, only.
Maximum differential pressure from the four siphon models was for the 30% Solids Slurry line.

$P_1 = 14.4$ psia Atmospheric (Dome Air Space) Pressure - Atmospheric at Elev. 640 ft
 $\Delta P = 6.656$ psig Maximum Pressure Drop across Anti-Siphon Hole during Siphon Flow, in psig (Ref. 2)
 $P_2 = P_1 - \Delta P = 7.7$ psia Pipe internal pressure at Anti-Siphon Hole during Siphon Flow, in psia

From the equation: $\frac{P_{cf}}{P_1} = \left[\frac{2}{(k+1)} \right]^{\frac{k}{k-1}}$ in which: $k = 1.4$ (Ref. 1, Equation 1)
 $P_1 = 14.4$ psia

$P_{cf} = P_1 \left[\frac{2}{(k+1)} \right]^{\frac{k}{k-1}}$ $P_{cf} = 7.6$ psia Critical Flow Throat Pressure

Note: $P_2 = 7.7$ psia $>$ $P_{cf} = 7.6$ psia Since the downstream pressure, P_2 , exceeds the Critical Flow Pressure, P_{cf} , Subcritical Flow occurs. (Ref. 1, Sec. 4.3.1)

2. Subcritical Flow Equation for Air Flow through One Anti-Siphon Hole

10% Solids Slurry Line - 1/2" Hole Diameter (Calculation shown for 10% Solids Slurry Line case. All cases are tabulated and graphed.)

From the equation: $A = \frac{V}{4645.2 \cdot F_2 \cdot K_d \cdot \sqrt{\frac{Z \cdot T \cdot M}{P_1 \cdot (P_1 - P_2)}}}$ Effective required discharge area of the Anti-Siphon hole Ref. 1, Pgs 28 & 29, Equation 6

Solving for air flow:

$$V = 4645.2 \cdot K_d \cdot A \cdot \frac{F_2}{\sqrt{\frac{Z \cdot T \cdot M}{P_1 \cdot (P_1 - P_2)}}} = 4645.2 \cdot K_d \cdot A \cdot \frac{F_2 \cdot \sqrt{P_1 \cdot (P_1 - P_2)}}{\sqrt{Z \cdot T \cdot M}}$$

$V = \left(\frac{4645.2 \cdot K_d \cdot A}{\sqrt{Z \cdot T \cdot M}} \right) \cdot \left[F_2 \cdot \sqrt{P_1 \cdot (P_1 - P_2)} \right]$ $V = 49.5$ SCFM Required flow through a Single Anti-Siphon Hole

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. **W-320-27-045, App. B**

Revision No.: **0**

Page No. **3** of **5**

Client **NUMATEC HANFORD COMPANY**

WO/Job No. **E09141**

Filename **siphon.txt.mcd**

Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**

Date **3 / 5 / 97**

By **D.L. EVANS**

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked

By **M.D. BROCKETT**

Location **C TANK FARM - HANFORD 200 EAST AREA**

Revised

By

In which : $k = 1.4$

Ratio of Specific Heats (Air)

$T_{\text{Fahrenheit}} = 80.0 \text{ F}$

Temperature in degrees Fahrenheit

$T := T_{\text{Fahrenheit}} + 460 \quad T = 540.0 \text{ R}$

Temperature in degrees Rankine

$M = 29.0$

Molecular weight of air

$Z = 1.0$

Compressibility factor for the deviation of the actual gas from a perfect gas

$K_d = 0.975$

Effective coefficient of discharge

$r := \frac{P_2}{P_1} \quad r = 0.5$

Ratio of backpressure to upstream relieving pressure
(Pipe internal pressure to Dome Space pressure)

$d = 0.5 \text{ in}$

Diameter of siphon holes

$A := \frac{\pi(d)^2}{4} \quad A = 0.2 \text{ in}^2$

Actual Discharge Area of siphon holes

$$F_2 := \sqrt{\left(\frac{k}{k-1}\right) \cdot (r)^{\frac{2}{k}} \cdot \left[\frac{1-r}{1-r}\right]^{\frac{(k-1)}{k}}}$$

$F_2 = 0.7$ Coefficient of subcritical flow through siphon holes

Collecting variables and regrouping, this equation can be simplified to:

$$V := (4645.2) \cdot (K_d) \cdot (P_1) \cdot (A) \cdot \sqrt{\frac{k}{M \cdot T \cdot Z \cdot (k-1)}} \cdot \left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{k}} - \left(\frac{P_2}{P_1}\right)^{\frac{k+1}{k}} \right] \quad V = 49.5 \text{ SCFM}$$

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. **W-320-27-045, App. B**
Revision No.: **0**
Page No. **4** of **5**

Client **NUMATEC HANFORD COMPANY**

WO/Job No. **E09141**

Filename **siphon.txt.mcd**

Subject **PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106**

Date **3 / 5 / 97**

By **D.L. EVANS**

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked

By **M.D. BROCKETT**

Location **C TANK FARM - HANFORD 200 EAST AREA**

Revised

By

Slurry Line - 1/2" Hole Diameter

$$d := \frac{1}{2} \text{ in} \quad A := \frac{\pi(d)^2}{4} \quad A = 0.196 \text{ in}^2 \quad \text{Actual Discharge Area of a single siphon hole}$$

$\Delta P_i :=$ Differential pressure at Anti-Siphon Hole location during Siphon Flow, in psia (Ref. 2, Pg.5)

0.1
0.3155
0.3
1.0
2.0
3.0
4.0
6.159
6.636

<---- Required to support free draining.
(10% Solids, conserv.)

psi

<---- 10% Solids

<---- 30% Solids

$$P_{2_i} = P_1 - \Delta P_i \quad P_2 = \text{psia}$$

Pipe internal pressure at Anti-Siphon Hole location during Siphon Flow, in psia

0.00
14.30
14.08
13.90
13.40
12.40
11.40
10.40
8.24
7.74

<---- 10% Solids

<---- 30% Solids

$$V_i := (4645.2) \cdot (K_d) \cdot (P_1) \cdot (A) \cdot \sqrt{\frac{k}{M \cdot T \cdot Z \cdot (k-1)} \left[\left(\frac{P_{2_i}}{P_1} \right)^{\frac{2}{k}} - \left(\frac{P_{2_i}}{P_1} \right)^{\frac{k+1}{k}} \right]}$$

Air flow through One Anti-Siphon Hole $V =$ SCFM

0
8.5
14.97
18.71
25.94
35.19
41.17
45.21
49.33
49.54

<---- Volumetric Flow Required to support free draining (10% Solids, conserv.)

<---- 10% Solids

<---- 30% Solids

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

Calc. No. W-320-27-045, App B

Revision No.: 0

Page No. 5 of 5

Client NUMATEC HANFORD COMPANY

WO/Job No. E09141

Filename siphon\text.mcd

Subject PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106

Date 3 / 5 / 97

By D.L. EVANS

Pipe Drainflow and Anti-Siphon Sizing for Transfer Lines

Checked

By M.D. BROCKETT

Location C TANK FARM - HANFORD 200 EAST AREA

Revised

By

Sluice (Supernate) Line - 1/4" Hole Diameter

$$d := \frac{1}{4} \text{ in} \quad A := \frac{\pi \cdot (d)^2}{4} \quad A = 0.049 \text{ in}^2 \quad \text{Actual Discharge Area of a single siphon hole}$$

$\Delta P_i :=$ Differential pressure at Anti-Siphon Hole location during Siphon Flow, in psia (Ref. 2, Pg. 5)

0.1
0.2
0.5
0.75
1.0
2.0
2.83
3.917
4.368

Required to support free draining.
(0% Solids, conserv.)

----- 0% Solids
----- 10% Solids

$$P_{2_i} := P_1 - \Delta P_i \quad P_2 =$$

0.00
14.30
14.20
13.90
13.65
13.40
12.40
11.57
10.48
10.03

Pipe internal pressure at Anti-Siphon Hole location during Siphon Flow, in psia

----- 0% Solids
----- 10% Solids

$$V_i := (4645.2) \cdot (K_d) \cdot (P_1) \cdot (A) \cdot \sqrt{\frac{k}{M \cdot T \cdot Z \cdot (k-1)} \left[\left(\frac{P_{2_i}}{P_1} \right)^{\frac{2}{k}} - \left(\frac{P_{2_i}}{P_1} \right)^{\frac{k+1}{k}} \right]}$$

0
2.12
2.99
4.68
5.67
6.49
8.8
10.08
11.23
11.58

SCFM

Air flow through One Anti-Siphon Hole V = Volumetric Flow Required to support free draining

----- (0% Solids, conserv.)

----- 0% Solids
----- 10% Solids

ΔP	V
0.1	2.12
0.2	2.99
0.5	4.68
0.75	5.67
1	6.49
2	8.80
2.83	10.08
3.917	11.23
4.368	11.58

Siphon Hole ΔP vs Air Flow

Atch. 1, App. B

ΔP	V
0.1	8.50
0.3155	14.97
0.5	18.71
1	25.94
2	35.19
3	41.17
4	45.21
5	47.82
6.159	49.33
6.656	49.54

Appendix C

CMF300 flow rate vs. pressure drop

Finding pressure drop of process fluids with a viscosity near 1 centipoise (μ)

1. The pressure drop charts shown above have several curves, which represent different viscosity (μ) values. For fluids with a viscosity similar to water, use the curve labeled $\mu = 1.0$.
2. Locate the point on the English units or Metric units graph where the vertical line representing the desired flow rate intersects the curve labeled $\mu = 1.0$.
3. From that point, locate the nearest horizontal line, then refer to the left side of the graph, which indicates pressure drop (in psid or bar) at the desired flow rate.
4. Divide the pressure drop indicated on the graph by the specific gravity (S) of the process fluid relative to water:

$$\Delta P_{\text{actual}} = \Delta P_{\text{plotted}} / S_{\text{relative to water}}$$

Finding pressure drop of process fluids with a viscosity above 1 centipoise (μ)

1. The pressure drop charts shown above have several curves, which represent different viscosity (μ) values. Use method a or b, below, to find the process fluid viscosity ($f_{\text{viscosity}}$).
 - a. For fluids with a viscosity between any two values plotted on the English units or Metric units graph, interpolate the approximate $f_{\text{viscosity}}$ location.
 - b. For fluids with a viscosity above the highest value plotted on the graph, find the ratio of actual viscosity to plotted viscosity:

$$f_{\text{viscosity}} = \mu_{\text{actual}} / \mu_{\text{plotted}}$$

2. Multiply the pressure drop indicated on the left side of the graph by the $f_{\text{viscosity}}$ value from step 1:

$$\Delta P = \Delta P_{\text{plotted}} \times f_{\text{viscosity}}$$

3. To find the actual pressure drop, divide the ΔP from step 2 by the specific gravity (S) of the process fluid relative to water:

$$\Delta P_{\text{actual}} = \Delta P / S_{\text{relative to water}}$$

CMF300 flow rate vs. pressure drop

CMF300 flow rate vs. pressure drop

Appendix D

Station Points Table

Slurry Line

		Station Point		Length of Pipe	90 deg Els
		Station Point	Elevation		
Node ~N--3		1610.29	641.42		6
	Pipe 3.1			410.3	
Node ~N--3.1		1200.00	650.39		4
	Pipe 3.2			468.1	
Node ~N--3.2		731.88	661.63		11
	Pipe 3.3			843.2	
Node ~N--3.3		-111.35	675.46		
				1721.6	Line Length

Supernate Line

		Station Point		Length of Pipe	90 deg Els
		Station Point	Elevation		
Node ~N--7		1628.74	641.42		5
	Pipe 4.3			428.7	
Node ~N--6		1200.00	650.39		4
	Pipe 4.2			468.1	
Node ~N--5		731.88	661.63		10
	Pipe 4.1			822.8	
Node ~N--4		-90.91	677.11		
				1719.7	Line Length

PLAN
SCALE: 1"=20'-0"

PARTIAL PLAN-TANK C-106
SCALE: 1"=10'-0"

No elevation given for EOP - Supernate.
Ref. Hydraulic Diagram H-2-818536
EL = 641.42 ft.

PROFILE A
SCALE: HORIZ. 1"=20'-0"
VERT. 1"=5'-0"

NOTES:

1. FOR ADDITIONAL NOTES, SEE H-2-818431, SH1.
2. SEE DWG H-2-818427 SH2 FOR TRANSFER LINE EXCAVATION AND BERM DETAILS.
3. EXCAVATE, BACKFILL AND COMPACT FOR TRANSFER LINES IN ACCORDANCE WITH SPEC. SECTION 02225.
4. REPAIRS TO EXIST C-FARM PERIMETER FENCE SHALL BE IN ACCORDANCE WITH SPEC. SECTION 02831.
5. A LOAD EXCLUSION BOUNDARY SHALL BE ESTABLISHED AROUND C-106 TANK A MINIMUM OF 20 FT FROM OUTSIDE PERIMETER EDGE OF TANK WALL FOR HEAVY CONSTRUCTION OPERATING EQUIPMENT/Cranes. INSIDE TRACKS OR WHEEL LOADS FOR SUCH EQUIPMENT SHALL NOT STRADDLE OR EXTEND INTO THIS LOAD EXCLUSION BOUNDARY AREA.

DESIGNED BY: B. BRINKMAN		DATE: 03-03-78	
DRAWN BY: J. BOOTH		DATE: 03-03-78	
CHECKED BY: SEE DR/AT FORM		DATE: SEE DR/AT FORM	
APPROVED BY: SEE DR/AT FORM		DATE: SEE DR/AT FORM	
PROJECT: H-2-818427		SHEET: 0	
TANK: 241-C-106		SLUICING	
DRAWING LIST: H-2-818427		SHEET: 0	
DATE: 03-03-78		BY: ER4319	
SCALE: 1"=20'		PLOT SCALE: 1"=20'

- NOTES:**
1. FOR ADDITIONAL NOTES, SEE H-2-81B432. (NIC)
 2. SEE DWG H-2-81B427 SH2 FOR TRANSFER LINE EXCAVATION DETAILS. (NIC)
 3. EXCAVATE, BACKFILL AND COMPACT FOR TRANSFER LINES IN ACCORDANCE WITH SPEC, SECTION 02225.
 4. MODIFICATIONS AND REPAIRS TO EXIST AT-FARM PERIMETER FENCE SHALL BE IN ACCORDANCE WITH SPEC, SECTION 02831.

[illegible]

Appendix E

Version: PIPE-FLO ver 5.01

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon Calculation
by: D. L. Stone *DL*
Comments: Slurry Line Siphoning 10% Solids

03/13/97 3:52 pm
Line list: SIPH10%1
Lineup: SIPH10%1
flow rate: gpm
pressure: psig
level & grade: ft

System: SIPH10%1
rev: 03/13/97 3:48 pm

Deviation: 0.000354 %
after: 9 iterations

Slurry Line - Siphon - 10% Solids - configuration 1

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE		FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	>>>	112	~N--0	0	0
Pipe 6.1	<<<	30.55	~N--6.1	0	17.1
Pipe 6.2	<<<	30.55	~N--6.2	0	17.1
Pipe 7.11	<<<	25.45	~N--7.11	0	17.75
Pipe 7.22	<<<	25.45	~N--7.22	0	17.75

Flows IN: 112 gpm

Flows OUT: 112 gpm

NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--0	608		0 (source)	608
~N--1	608.443		-0.189	608.1
~N--2	609.838		2.668	615.3
~N--2.1	639.107		-11.1	616.2
~N--2.2	639.107		-11.09	616.2
~N--3	639.461		-6.676	625.7
~N--3.1	650.42		-9.017	631.8
~N--3.2	661.63		-11.48	637.9
~N--3.3	676.05		-13.01	649.2
~N--4	674.769		-12.27	649.4
~N--4.1	674.769		-10.7	652.7
~N--5	674.269		-10.32	653
~N--5.1	665.8		-6.159	653.1
~N--6	636.556		8.232	653.6
~N--6.1	636.556		8.284 (source)	653.7
~N--6.2	636.556		8.284 (source)	653.7
~N--7	635.91		8.546	653.6
~N--7.1	635.91		8.565	653.6
~N--7.11	635.91		8.597 (source)	653.7
~N--7.2	635.91		8.565	653.6
~N--7.22	635.91		8.597 (source)	653.7

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Pipe 0	~N--1	~N--0	112	* 1.798	(0.189)	0.052
Pipe 1	~N--2	~N--1	112	* 4.864	2.858	7.296
----- Rev. Flow IP ----- dP: 3.284 HL: 6.781						
Pipe 2	~N--2.1	~N--2	112	* 2.825	(13.77)	0.847
Pipe 2.1	~N--2.2	~N--2.1	112	* 2.825	0.006	0.013
Pipe 3	~N--3	~N--2.2	112	* 4.864	4.415	9.469
----- Rev. Flow BP ----- dP: 4.374 HL: 9.031						
Pipe 3.1	~N--3.1	~N--3	112	* 2.825	(2.341)	6.125
Pipe 3.2	~N--3.2	~N--3.1	112	* 2.825	(2.462)	6.126
Pipe 3.3	~N--3.3	~N--3.2	112	* 2.825	(1.528)	11.26
Pipe 3.4	~N--4	~N--3.3	112	* 2.825	0.739	0.244
Pipe 4	~N--4.1	~N--4	112	* 4.864	1.574	3.251
----- Micromotion 10% ----- dP: 1.22 HL: 2.518						
Pipe 5	~N--5	~N--4.1	112	* 2.825	0.375	0.274
Pipe 5.1	~N--5.1	~N--5	112	* 3.128	4.161	0.123
Pipe 5.2	~N--6	~N--5.1	112	* 3.128	14.39	0.470
Pipe 6.1	~N--6.1	~N--6	30.55	* 3.322	0.052	0.107
Pipe 6.2	~N--6.2	~N--6	30.55	* 3.322	0.052	0.107
Pipe 7	~N--7	~N--6	50.9	* 1.422	0.314	0.003
Pipe 7.1	~N--7.1	~N--7	25.45	* 0.711	0.019	0.040
Pipe 7.11	~N--7.11	~N--7.1	25.45	* 2.767	0.031	0.065
Pipe 7.2	~N--7.2	~N--7	25.45	* 0.711	0.019	0.040
Pipe 7.22	~N--7.22	~N--7.2	25.45	* 2.767	0.031	0.065

SYSTEM REPORT

Created: 01/24/97 1:41 pm
 Design file:
 Pipe Specs: 2

Pipes: 20
 Nodes: 21
 Pumps/Comps: 3

Slurry Line - Siphoning - 10% Solids (70F) - configuration 1

SYSTEM NODES

NODE	ELEVATION ft	PIPELINES IN	PIPELINES OUT
~N--0	608	Pipe 0	
~N--1	608.443	Pipe 1	Pipe 0
~N--2	609.838	Pipe 2	Pipe 1
~N--2.1	639.107	Pipe 2.1	Pipe 2
~N--2.2	639.107	Pipe 3	Pipe 2.1
~N--3	639.461	Pipe 3.1	Pipe 3
~N--3.1	650.42	Pipe 3.2	Pipe 3.1
~N--3.2	661.63	Pipe 3.3	Pipe 3.2
~N--3.3	676.05	Pipe 3.4	Pipe 3.3
~N--4	674.769	Pipe 4	Pipe 3.4
~N--4.1	674.769	Pipe 5	Pipe 4
~N--5	674.269	Pipe 5.1	Pipe 5
~N--5.1	665.8	Pipe 5.2	Pipe 5.1
~N--6	636.556	Pipe 6.1 Pipe 6.2 Pipe 7	Pipe 5.2
~N--6.1	636.556		Pipe 6.1
~N--6.2	636.556		Pipe 6.2
~N--7	635.91	Pipe 7.1 Pipe 7.2	Pipe 7
~N--7.1	635.91	Pipe 7.11	Pipe 7.1
~N--7.11	635.91		Pipe 7.11
~N--7.2	635.91	Pipe 7.22	Pipe 7.2
~N--7.22	635.91		Pipe 7.22

PIPELINE	SPEC	FROM_NODE	TO_NODE	PUMP/COMP
Pipe 0	01	~N--1	~N--0	
Pipe 1	01	~N--2	~N--1	Rev. Flow IP
Pipe 2	01	~N--2.1	~N--2	
Pipe 2.1	01	~N--2.2	~N--2.1	
Pipe 3	01	~N--3	~N--2.2	Rev.Flow BP
Pipe 3.1	01	~N--3.1	~N--3	
Pipe 3.2	01	~N--3.2	~N--3.1	
Pipe 3.3	01	~N--3.3	~N--3.2	
Pipe 3.4	01	~N--4	~N--3.3	
Pipe 4	01	~N--4.1	~N--4	Micromotion10%
Pipe 5	01	~N--5	~N--4.1	
Pipe 5.1	02	~N--5.1	~N--5	
Pipe 5.2	02	~N--6	~N--5.1	
Pipe 6.1	02	~N--6.1	~N--6	
Pipe 6.2	02	~N--6.2	~N--6	
Pipe 7	02	~N--7	~N--6	
Pipe 7.1	02	~N--7.1	~N--7	
Pipe 7.11	02	~N--7.11	~N--7.1	
Pipe 7.2	02	~N--7.2	~N--7	
Pipe 7.22	02	~N--7.22	~N--7.2	

PUMP/COMP

PERFORMANCE DATA

Micromotion10%

gpm:	0	50	150	250	350
ft:	0	0.702	3.714	9.286	17.128
eqn:	$0.00113187 Q^{\wedge} 1.63348$				

Rev. Flow IP

gpm:	0	40	80	120	150
ft:	0	0.86	3.45	7.78	12.2
eqn:	$0.000525277 Q^{\wedge} 2.00609$				

Rev.Flow BP

gpm:	0	40	80	120	150
ft:	0	1.15	4.59	10.4	16.2
eqn:	$0.000711089 Q^{\wedge} 2.00264$				

Company: Fluor Daniel Northwest
Project:
by: D. L. Stone

03/17/97 7:20 am
System: SIPH10%1
rev: 03/17/97 7:16 am

PIPELIST REPORT

Created: 01/24/97 1:41 pm
Design file:
Pipe Specs: 2

Pipes: 20
Nodes: 21
Pumps/Comps: 3

Slurry Line - Siphoning - 10% Solids (70F) - configuration 1

SPECIFICATIONS

SPECIFICATION	PIPE MATERIAL Sch / Roughness	FLUID Temp / Pres	VALVE TABLE	DESIGN LIMITS Vel / Pres
01 10% Sch 40 rev: 03/13/97 3:07 pm	Steel Sch 40 0.0018 in Size for: 6 ft/sec	10% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g
02 10% Sch 80 rev: 03/17/97 7:16 am	Steel Sch 80 0.0018 in Size for: 6 ft/sec	10% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	FLUID Temp / Pres	VALVES Total-K
Pipe 0	01	Steel 5 in / 40	0.442	10% solids 70 °F / 0 psi g	1
Pipe 1	01	Steel 3 in / 40	2.323	10% solids 70 °F / 0 psi g	1.112
Pipe 2	01	Steel 4 in / 40	34.861	10% solids 70 °F / 0 psi g	3.303
Pipe 2.1	01	Steel 4 in / 40	1	10% solids 70 °F / 0 psi g	0
Pipe 3	01	Steel 3 in / 40	4.767	10% solids 70 °F / 0 psi g	0.5971
Pipe 3.1	01	Steel 4 in / 40	427.608	10% solids 70 °F / 0 psi g	6.059
Pipe 3.2	01	Steel 4 in / 40	468.1	10% solids 70 °F / 0 psi g	1.956
Pipe 3.3	01	Steel 4 in / 40	843.2	10% solids 70 °F / 0 psi g	5.379
Pipe 3.4	01	Steel 4 in / 40	1.424	10% solids 70 °F / 0 psi g	1.828
Pipe 4	01	Steel 3 in / 40	3.155	10% solids 70 °F / 0 psi g	1.6
Pipe 5	01	Steel 4 in / 40	3.841	10% solids 70 °F / 0 psi g	1.824
Pipe 5.1	02	Steel 4 in / 80	7.667	10% solids 70 °F / 0 psi g	0
Pipe 5.2	02	Steel 4 in / 80	29.354	10% solids 70 °F / 0 psi g	0
Pipe 6.1	02	Steel 2 in / 80	0.5	10% solids 70 °F / 0 psi g	0.5
Pipe 6.2	02	Steel 2 in / 80	0.5	10% solids 70 °F / 0 psi g	0.5
Pipe 7	02	Steel 4 in / 80	0.65	10% solids 70 °F / 0 psi g	0
Pipe 7.1	02	Steel 4 in / 80	0.51	10% solids 70 °F / 0 psi g	4.997
Pipe 7.11	02	Steel 2 in / 80	0.17	10% solids 70 °F / 0 psi g	0.5
Pipe 7.2	02	Steel 4 in / 80	0.51	10% solids 70 °F / 0 psi g	4.997
Pipe 7.22	02	Steel 2 in / 80	0.17	10% solids 70 °F / 0 psi g	0.5

MATERIALS REPORT

Created: 01/24/97 1:41 pm
Design file:
Pipe Specs: 2

Pipes: 20
Nodes: 21
Pumps/Comps: 3

Slurry Line - Siphoning - 10% Solids (70F) - configuration 1

PIPE MATERIALS LIST

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 0	01	Steel 5 in / 40	0.442	1-Exit Projecting
Pipe 1	01	Steel 3 in / 40	2.323	3-Elbow Short - r/d 1 @ 90° 1-Reducer Enlargement 4 X 3
Pipe 2	01	Steel 4 in / 40	34.861	1-Elbow Short - r/d 1 @ 45° 5-Elbow Short - r/d 1 @ 90° 2-Elbow Long - r/d 1.5 @ 90° 1-Mitre Bend @ 90° @ 90°
Pipe 2.1	01	Steel 4 in / 40	1	
Pipe 3	01	Steel 3 in / 40	4.767	1-Reducer Contraction 4 X 3 1-Reducer Enlargement 4 X 3 2-Elbow Long - r/d 1.5 @ 90°
Pipe 3.1	01	Steel 4 in / 40	427.608	2-Mitre Bend @ 90° 3-Elbow Long - r/d 1.5 @ 90° 6-Pipe Bend r/d 10 @ 90° 2-Pipe Bend r/d 8 @ 45°
Pipe 3.2	01	Steel 4 in / 40	468.1	4-Pipe Bend r/d 10 @ 90°
Pipe 3.3	01	Steel 4 in / 40	843.2	11-Pipe Bend r/d 10 @ 90°
Pipe 3.4	01	Steel 4 in / 40	1.424	1-Mitre Bend @ 90° 1-Elbow Long - r/d 1.5 @ 90° 1-Reducer Contraction 4 X 3
Pipe 4	01	Steel 3 in / 40	3.155	1-Fixed K 1.357 1-Elbow Long - r/d 1.5 @ 90°
Pipe 5	01	Steel 4 in / 40	3.841	3-Elbow Long - r/d 1.5 @ 90° 1-Mitre Bend @ 90° 1-Reducer Enlargement 4 X 3
Pipe 5.1	02	Steel 4 in / 80	7.667	

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 5.2	02	Steel 4 in / 80	29.354	
Pipe 6.1	02	Steel 2 in / 80	0.5	1-Entrance Sharp-Edged
Pipe 6.2	02	Steel 2 in / 80	0.5	1-Entrance Sharp-Edged
Pipe 7	02	Steel 4 in / 80	0.65	
Pipe 7.1	02	Steel 4 in / 80	0.51	1-Reducer Enlargement 4 X 2
Pipe 7.11	02	Steel 2 in / 80	0.17	1-Entrance Sharp-Edged
Pipe 7.2	02	Steel 4 in / 80	0.51	1-Reducer Enlargement 4 X 2
Pipe 7.22	02	Steel 2 in / 80	0.17	1-Entrance Sharp-Edged

PIPE MATERIAL	SCHEDULE	SIZE	LENGTH
Steel	40	3 in	10.245 ft
		4 in	1780.03 ft
		5 in	0.442 ft
Steel	80	2 in	1.34 ft
		4 in	38.691 ft

VALVE & FITTING SUMMARY

SPECIFICATION	MATERIAL	SCHEDULE	VALVES & FITTINGS
01 10% Sch 40	Steel	40	
			Size: 3 in
			3-Elbow Short - r/d 1 @ 90°
			2-Reducer Enlargement 4 X 3
			1-Reducer Contraction 4 X 3
			3-Elbow Long - r/d 1.5 @ 90°
			1-Fixed K 1.357
			Size: 4 in
			1-Elbow Short - r/d 1 @ 45°
			5-Elbow Short - r/d 1 @ 90°
02 10% Sch 80	Steel	80	9-Elbow Long - r/d 1.5 @ 90°
			5-Mitre Bend @ 90° @ 90°
			21-Pipe Bend r/d 10 @ 90°
			2-Pipe Bend r/d 8 @ 45°
			1-Reducer Contraction 4 X 3
			1-Reducer Enlargement 4 X 3
			Size: 5 in
			1-Exit Projecting
			Size: 2 in
			4-Entrance Sharp-Edged
			Size: 4 in
			2-Reducer Enlargement 4 X 2

Company: Fluor Daniel Northwest
Project:
by: D. L. Stone

03/17/97 7:23 am
System: SIPH10%1
rev: 03/17/97 7:16 am

PIPELINE REPORT

Pipe 5 rev: 03/13/97 2:50 pm

PIPING MATERIAL: Steel
Schedule: 40
abs roughness: 0.0018 in

PIPE SIZE: 4 in
dia: 4.026 in

LENGTH: 3.841 ft

ELEVATION in: 674.269 ft
out: 674.769 ft

SPECIFICATION: 10% Sch 40

SIZING Criteria: 6 ft/sec

LIMITS Velocity: 6 to 10 ft/sec
Pressure: -14.4 to 300 psi g

FLUID 10% solids at tmp: 70 °F
pres: 0 psi g
den: 69.78 lb/ft³
vsc: 12.87 cpois

PIPELINE RESISTANCE CURVE

Flow gpm	ffp	Vel ft/sec	dP psi
112	.0341	2.825	0.375
0	.0000	0	0.242
33.04	.0494	0.833	0.255
66.08	.0396	1.667	0.290
99.12	.0352	2.5	0.347
132.2	.0326	3.333	0.426
165.2	.0308	4.167	0.526
198.2	.0294	5	0.648
231.3	.0284	5.833	0.792
264.3	.0275	6.667	0.956
297.4	.0268	7.5	1.143
330.4	.0262	8.333	1.35
363.4	.0257	9.167	1.579
396.5	.0252	10	1.829

VALVES and FITTINGS

VALVE / FITTING	K-VALUE	VALVE / FITTING	K-VALUE
Elbow Long - r/d 1.5 90°	3@0.2282	Mitre Bend @ 90°	0.978
Reducer Enlargement 4x3x4	0.1612		

FFT: 0.0163

TOTAL K: 1.824

Avg Percent of Total Loss: 84 %

Appendix F

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone *DLS*
Comments: Slurry Line Drainflow - Highpoint to Endpoint - 10% Solids
Version: PIPE-FLO ver 5.01

03/17/97 12:42 pm
Linelist: DRAN10%1
Lineup: DRAN10%1
flow rate: gpm
pressure: psig
level & grade: ft

System: DRAN10%1
rev: 03/17/97 7:36 am

Deviation: 0.0011 %
after: 4 iterations

Slurry Line - Drain from High to Endpoint - 10% Solids (70F)

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE		FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	>>>	146.7	~N--0	0	0
Pipe 3.3	<<<	146.7	~N--3.3	0	0

Flows IN: 146.7 gpm
Flows OUT: 146.7 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--0	608		0 (source)	608
~N--1	608.443		-0.171	608.1
~N--2	609.838		5.22	620.6
~N--2.1	639.107		-8.276	622
~N--2.2	639.107		-8.267	622
~N--3	639.461		-0.574	638.3
~N--3.1	650.42		-1.098	648.2
~N--3.2	661.63		-1.773	658
~N--3.3	676.05		0 (source)	676

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Line 0	~N--1	~N--0	146.7	* 2.355	(0.171)	0.089
Pipe 1	~N--2	~N--1	146.7	6.372	5.392	12.53
----- Rev. Flow IP ----- dP: 5.645 HL: 11.66						
Pipe 2	~N--2.1	~N--2	146.7	* 3.701	(13.5)	1.402
Pipe 2.1	~N--2.2	~N--2.1	146.7	* 3.701	0.010	0.020
Pipe 3	~N--3	~N--2.2	146.7	6.372	7.693	16.24
----- Rev. Flow BP ----- dP: 7.512 HL: 15.51						
Pipe 3.1	~N--3.1	~N--3	146.7	* 3.701	(0.524)	9.876
Pipe 3.2	~N--3.2	~N--3.1	146.7	* 3.701	(0.674)	9.818
Pipe 3.3	~N--3.3	~N--3.2	146.7	* 3.701	1.773	18.08

System: DRAN10%2
rev: 03/17/97 12:43 pm

Deviation: 0.000921 %
after: 5 iterations

Slurry Line - Drain from Stationpoint to Endpoint - 10% Solids (70F)

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE		FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	>>>	150.9	~N--0	0	0
Pipe 3.1	<<<	150.9	~N--3.1	0	0

Flows IN: 150.9 gpm
Flows OUT: 150.9 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
A System Component is out of range - results may not be valid.				
~N--0	608		0 (source)	608
~N--1	608.443		-0.169	608.1
~N--2	609.838		5.577	621.4
~N--2.1	639.107		-7.883	622.8
~N--2.2	639.107		-7.873	622.9
~N--3	639.461		0.277	640
~N--3.1	650.42		0 (source)	650.4

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
A System Component is out of range - results may not be valid.						
Pipe 0	~N--1	~N--0	150.9	* 2.422	(0.169)	0.094
Pipe 1	~N--2	~N--1	150.9	6.555	5.746	13.26
----- Rev. Flow IP (out of range)----- dP: 5.975 HL: 12.34						
Pipe 2	~N--2.1	~N--2	150.9	* 3.807	(13.46)	1.478
Pipe 2.1	~N--2.2	~N--2.1	150.9	* 3.807	0.010	0.021
Pipe 3	~N--3	~N--2.2	150.9	6.555	8.15	17.18
----- Rev.Flow BP (out of range)----- dP: 7.95 HL: 16.41						
Pipe 3.1	~N--3.1	~N--3	150.9	* 3.807	(0.277)	10.39

Appendix G

Company: Fluor Daniel Northwest
 Project: W-320 Anti-Siphon Calculation
 by: D. L. Stone *DL*
 Comments: Slurry Line Siphoning 30% Solids

Version: PIPE-FLO ver 5.01

03/13/97 3:56 pm
 Linelist: SIPH30%1
 Lineup: SIPH30%1
 flow rate: gpm
 pressure: psig
 level & grade: ft

System: SIPH30%1
rev: 03/13/97 3:47 pm

Deviation: 0.0044 %
after: 12 iterations

Slurry Line - Siphon - 30% Solids (70F) -configuration 1

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE		FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	>>>	81.03	~N--0	0	0
Pipe 6.1	<<<	20.91	~N--6.1	0	17.1
Pipe 6.2	<<<	20.91	~N--6.2	0	17.1
Pipe 7.11	<<<	19.61	~N--7.11	0	17.75
Pipe 7.22	<<<	19.61	~N--7.22	0	17.75

Flows IN: 81.04 gpm

Flows OUT: 81.03 gpm

NET FLOWS IN: 0.010 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--0	608		0 (source)	608
~N--1	608.443		-0.215	608
~N--2	609.838		1.071	611.9
~N--2.1	639.107		-13.7	612.7
~N--2.2	639.107		-13.69	612.7
~N--3	639.461		-11.24	617.8
~N--3.1	650.42		-12.99	625.4
~N--3.2	661.63		-14.65 ***	633.4
~N--3.3	676.05		-14.58 ***	648
~N--4	674.769		-13.84	648.1
~N--4.1	674.769		-11.49	652.6
~N--5	674.269		-11.13	652.8
~N--5.1	665.8		-6.656	653
~N--6	636.556		8.834	653.6
~N--6.1	636.556		8.875 (source)	653.7
~N--6.2	636.556		8.875 (source)	653.7
~N--7	635.91		9.172	653.6
~N--7.1	635.91		9.186	653.6
~N--7.11	635.91		9.211 (source)	653.7
~N--7.2	635.91		9.186	653.6
~N--7.22	635.91		9.211 (source)	653.7

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Line 0	~N--1	~N--0	81.03	* 1.301	(0.215)	0.029
Pipe 1	~N--2	~N--1	81.03	* 3.519	1.285	3.872
----- Rev. Flow IP ----- dP: 1.838 HL: 3.543						
Pipe 2	~N--2.1	~N--2	81.03	* 2.044	(14.77)	0.801
Pipe 2.1	~N--2.2	~N--2.1	81.03	* 2.044	0.009	0.017
Pipe 3	~N--3	~N--2.2	81.03	* 3.519	2.451	5.076
----- Rev. Flow BP ----- dP: 2.451 HL: 4.724						
Pipe 3.1	~N--3.1	~N--3	81.03	* 2.044	(1.746)	7.595
Pipe 3.2	~N--3.2	~N--3.1	81.03	* 2.044	(1.66)	8.011
Pipe 3.3	~N--3.3	~N--3.2	81.03	* 2.044	0.068	14.55
Pipe 3.4	~N--4	~N--3.3	81.03	* 2.044	0.739	0.142
Pipe 4	~N--4.1	~N--4	81.03	* 3.519	2.355	4.538
----- Micromotion30% ----- dP: 2.122 HL: 4.09						
Pipe 5	~N--5	~N--4.1	81.03	* 2.044	0.354	0.183
Pipe 5.1	~N--5.1	~N--5	81.03	* 2.263	4.477	0.158
Pipe 5.2	~N--6	~N--5.1	81.03	* 2.263	15.49	0.606
Pipe 6.1	~N--6.1	~N--6	20.91	* 2.273	0.042	0.080
Pipe 6.2	~N--6.2	~N--6	20.91	* 2.274	0.042	0.080
Pipe 7	~N--7	~N--6	39.21	* 1.095	0.339	0.006
Pipe 7.1	~N--7.1	~N--7	19.61	* 0.548	0.013	0.026
Pipe 7.11	~N--7.11	~N--7.1	19.61	* 2.132	0.025	0.048
Pipe 7.2	~N--7.2	~N--7	19.61	* 0.548	0.013	0.026
Pipe 7.22	~N--7.22	~N--7.2	19.61	* 2.132	0.025	0.048

SYSTEM REPORT

Created: 01/24/97 1:41 pm
 Design file:
 Pipe Specs: 2

Pipes: 20
 Nodes: 21
 Pumps/Comps: 3

Slurry Line - Siphoning - 30% Solids (70F) - configuration 1

SYSTEM NODES

NODE	ELEVATION ft	PIPELINES IN	PIPELINES OUT
~N--0	608	Pipe 0	
~N--1	608.443	Pipe 1	Pipe 0
~N--2	609.838	Pipe 2	Pipe 1
~N--2.1	639.107	Pipe 2.1	Pipe 2
~N--2.2	639.107	Pipe 3	Pipe 2.1
~N--3	639.461	Pipe 3.1	Pipe 3
~N--3.1	650.42	Pipe 3.2	Pipe 3.1
~N--3.2	661.63	Pipe 3.3	Pipe 3.2
~N--3.3	676.05	Pipe 3.4	Pipe 3.3
~N--4	674.769	Pipe 4	Pipe 3.4
~N--4.1	674.769	Pipe 5	Pipe 4
~N--5	674.269	Pipe 5.1	Pipe 5
~N--5.1	665.8	Pipe 5.2	Pipe 5.1
~N--6	636.556	Pipe 6.1 Pipe 6.2 Pipe 7	Pipe 5.2
~N--6.1	636.556		Pipe 6.1
~N--6.2	636.556		Pipe 6.2
~N--7	635.91	Pipe 7.1 Pipe 7.2	Pipe 7
~N--7.1	635.91	Pipe 7.11	Pipe 7.1
~N--7.11	635.91		Pipe 7.11
~N--7.2	635.91	Pipe 7.22	Pipe 7.2
~N--7.22	635.91		Pipe 7.22

SYSTEM PIPES

03/13/97 4:07 pm

PIPELINE	SPEC	FROM_NODE	TO_NODE	PUMP/COMP
Pipe 0	03	~N--1	~N--0	
Pipe 1	03	~N--2	~N--1	Rev. Flow IP
Pipe 2	03	~N--2.1	~N--2	
Pipe 2.1	03	~N--2.2	~N--2.1	
Pipe 3	03	~N--3	~N--2.2	Rev.Flow BP
Pipe 3.1	03	~N--3.1	~N--3	
Pipe 3.2	03	~N--3.2	~N--3.1	
Pipe 3.3	03	~N--3.3	~N--3.2	
Pipe 3.4	03	~N--4	~N--3.3	
Pipe 4	03	~N--4.1	~N--4	Micromotion30%
Pipe 5	03	~N--5	~N--4.1	
Pipe 5.1	04	~N--5.1	~N--5	
Pipe 5.2	04	~N--6	~N--5.1	
Pipe 6.1	04	~N--6.1	~N--6	
Pipe 6.2	04	~N--6.2	~N--6	
Pipe 7	04	~N--7	~N--6	
Pipe 7.1	04	~N--7.1	~N--7	
Pipe 7.11	04	~N--7.11	~N--7.1	
Pipe 7.2	04	~N--7.2	~N--7	
Pipe 7.22	04	~N--7.22	~N--7.2	

PUMP/COMP

PERFORMANCE DATA

Micromotion30%

gpm:	0	50	150	250	350
ft:	0	2.311	7.704	19.26	33.705
eqn:	$0.0100732 Q^{\wedge} 1.36669$				

Rev. Flow IP

gpm:	0	40	80	120	150
ft:	0	0.86	3.45	7.78	12.2
eqn:	$0.000525277 Q^{\wedge} 2.00609$				

Rev.Flow BP

gpm:	0	40	80	120	150
ft:	0	1.15	4.59	10.4	16.2
eqn:	$0.000711089 Q^{\wedge} 2.00264$				

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon Calculation
by: D. L. Stone

03/13/97 4:07 pm
System: SIPH30%1
rev: 03/13/97 3:47 pm

PIPELIST REPORT

Created: 01/24/97 1:41 pm
Design file:
Pipe Specs: 2

Pipes: 20
Nodes: 21
Pumps/Comps: 3

Slurry Line - Siphoning - 30% Solids (70F) - configuration 1

SPECIFICATIONS

SPECIFICATION	PIPE MATERIAL Sch / Roughness	FLUID Temp / Pres	VALVE TABLE	DESIGN LIMITS Vel / Pres
03 30% Sch 40 rev: 03/13/97 3:34 pm	Steel Sch 40 0.0018 in	30% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g
	Size for: 6 ft/sec			
04 30% Sch 80 rev: 03/13/97 3:35 pm	Steel Sch 80 0.0018 in	30% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g
	Size for: 6 ft/sec			

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	FLUID Temp / Pres	VALVES Total-K
Pipe 0	03	Steel 5 in / 40	0.442	30% solids 70 °F / 0 psi g	1
Pipe 1	03	Steel 3 in / 40	2.323	30% solids 70 °F / 0 psi g	1.112
Pipe 2	03	Steel 4 in / 40	34.861	30% solids 70 °F / 0 psi g	3.303
Pipe 2.1	03	Steel 4 in / 40	1	30% solids 70 °F / 0 psi g	0
Pipe 3	03	Steel 3 in / 40	4.767	30% solids 70 °F / 0 psi g	0.5971
Pipe 3.1	03	Steel 4 in / 40	427.608	30% solids 70 °F / 0 psi g	6.059
Pipe 3.2	03	Steel 4 in / 40	468.1	30% solids 70 °F / 0 psi g	1.956
Pipe 3.3	03	Steel 4 in / 40	843.2	30% solids 70 °F / 0 psi g	5.379
Pipe 3.4	03	Steel 4 in / 40	1.424	30% solids 70 °F / 0 psi g	1.828
Pipe 4	03	Steel 3 in / 40	3.155	30% solids 70 °F / 0 psi g	1.51
Pipe 5	03	Steel 4 in / 40	3.841	30% solids 70 °F / 0 psi g	1.824
Pipe 5.1	04	Steel 4 in / 80	7.667	30% solids 70 °F / 0 psi g	0
Pipe 5.2	04	Steel 4 in / 80	29.354	30% solids 70 °F / 0 psi g	0
Pipe 6.1	04	Steel 2 in / 80	0.5	30% solids 70 °F / 0 psi g	0.5
Pipe 6.2	04	Steel 2 in / 80	0.5	30% solids 70 °F / 0 psi g	0.5
Pipe 7	04	Steel 4 in / 80	0.65	30% solids 70 °F / 0 psi g	0
Pipe 7.1	04	Steel 4 in / 80	0.51	30% solids 70 °F / 0 psi g	4.997
Pipe 7.11	04	Steel 2 in / 80	0.17	30% solids 70 °F / 0 psi g	0.5
Pipe 7.2	04	Steel 4 in / 80	0.51	30% solids 70 °F / 0 psi g	4.997
Pipe 7.22	04	Steel 2 in / 80	0.17	30% solids 70 °F / 0 psi g	0.5

MATERIALS REPORT

Created: 01/24/97 1:41 pm
 Design file:
 Pipe Specs: 2

Pipes: 20
 Nodes: 21
 Pumps/Comps: 3

Slurry Line - Siphoning - 30% Solids (70F) - configuration 1

PIPE MATERIALS LIST

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 0	03	Steel 5 in / 40	0.442	1-Exit Projecting
Pipe 1	03	Steel 3 in / 40	2.323	3-Elbow Short - r/d 1 @ 90° 1-Reducer Enlargement 4 X 3
Pipe 2	03	Steel 4 in / 40	34.861	1-Elbow Short - r/d 1 @ 45° 5-Elbow Short - r/d 1 @ 90° 2-Elbow Long - r/d 1.5 @ 90° 1-Mitre Bend @ 90° @ 90°
Pipe 2.1	03	Steel 4 in / 40	1	
Pipe 3	03	Steel 3 in / 40	4.767	1-Reducer Contraction 4 X 3 1-Reducer Enlargement 4 X 3 2-Elbow Long - r/d 1.5 @ 90°
Pipe 3.1	03	Steel 4 in / 40	427.608	2-Mitre Bend @ 90° 3-Elbow Long - r/d 1.5 @ 90° 6-Pipe Bend r/d 10 @ 90° 2-Pipe Bend r/d 8 @ 45°
Pipe 3.2	03	Steel 4 in / 40	468.1	4-Pipe Bend r/d 10 @ 90°
Pipe 3.3	03	Steel 4 in / 40	843.2	11-Pipe Bend r/d 10 @ 90°
Pipe 3.4	03	Steel 4 in / 40	1.424	1-Mitre Bend @ 90° 1-Elbow Long - r/d 1.5 @ 90° 1-Reducer Contraction 4 X 3
Pipe 4	03	Steel 3 in / 40	3.155	1-Elbow Long - r/d 1.5 @ 90° 1-Fixed K 1.267
Pipe 5	03	Steel 4 in / 40	3.841	3-Elbow Long - r/d 1.5 @ 90° 1-Mitre Bend @ 90° 1-Reducer Enlargement 4 X 3
Pipe 5.1	04	Steel 4 in / 80	7.667	

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 5.2	04	Steel 4 in / 80	29.354	
Pipe 6.1	04	Steel 2 in / 80	0.5	1-Entrance Sharp-Edged
Pipe 6.2	04	Steel 2 in / 80	0.5	1-Entrance Sharp-Edged
Pipe 7	04	Steel 4 in / 80	0.65	
Pipe 7.1	04	Steel 4 in / 80	0.51	1-Reducer Enlargement 4 X 2
Pipe 7.11	04	Steel 2 in / 80	0.17	1-Entrance Sharp-Edged
Pipe 7.2	04	Steel 4 in / 80	0.51	1-Reducer Enlargement 4 X 2
Pipe 7.22	04	Steel 2 in / 80	0.17	1-Entrance Sharp-Edged

PIPE MATERIAL	SCHEDULE	SIZE	LENGTH
Steel	40	3 in	10.245 ft
		4 in	1780.03 ft
		5 in	0.442 ft
Steel	80	2 in	1.34 ft
		4 in	38.691 ft

VALVE & FITTING SUMMARY

SPECIFICATION	MATERIAL	SCHEDULE	VALVES & FITTINGS
03 30% Sch 40	Steel	40	
			Size: 3 in
			3-Elbow Short - r/d 1 @ 90°
			2-Reducer Enlargement 4 X 3
			1-Reducer Contraction 4 X 3
			3-Elbow Long - r/d 1.5 @ 90°
			1-Fixed K 1.267
	Size: 4 in		1-Elbow Short - r/d 1 @ 45°
			5-Elbow Short - r/d 1 @ 90°
			9-Elbow Long - r/d 1.5 @ 90°
			5-Mitre Bend @ 90° @ 90°
			21-Pipe Bend r/d 10 @ 90°
04 30% Sch 80	Steel	80	2-Pipe Bend r/d 8 @ 45°
			1-Reducer Contraction 4 X 3
			1-Reducer Enlargement 4 X 3
			Size: 5 in
			1-Exit Projecting
	Size: 2 in		4-Entrance Sharp-Edged
			Size: 4 in
			2-Reducer Enlargement 4 X 2

Company: Fluor Daniel Northwest
Project:
by: D. L. Stone

03/17/97 7:27 am
System: SIPH30%1
rev: 03/13/97 3:47 pm

PIPELINE REPORT

Pipe 5 rev: 03/13/97 3:39 pm

PIPING MATERIAL: Steel
Schedule: 40
abs roughness: 0.0018 in

PIPE SIZE: 4 in
dia: 4.026 in

LENGTH: 3.841 ft

ELEVATION in: 674.269 ft
out: 674.769 ft

SPECIFICATION: 30% Sch 40

SIZING Criteria: 6 ft/sec

LIMITS Velocity: 6 to 10 ft/sec

Pressure: -14.4 to 300 psi g

FLUID 30% solids at tmp: 70 °F

pres: 0 psi g

den: 74.77 lb/ft³

vsc: 103.9 cpois

PIPELINE RESISTANCE CURVE

Flow gpm	ffp	Vel ft/sec	dP psi
81.03	.0872	2.044	0.354
0	.0000	0	0.260
33.04	.2139	0.833	0.283
66.08	.1069	1.667	0.328
99.12	.0713	2.5	0.392
132.2	.0535	3.333	0.477
165.2	.0428	4.167	0.583
198.2	.0356	5	0.709
231.3	.0306	5.833	0.855
264.3	.0484	6.667	1.11
297.4	.0465	7.5	1.327
330.4	.0450	8.333	1.567
363.4	.0436	9.167	1.831
396.5	.0424	10	2.119

VALVES and FITTINGS

VALVE / FITTING	K-VALUE	VALVE / FITTING	K-VALUE
Elbow Long - r/d 1.5 90°	3@0.2282	Mitre Bend @ 90°	0.978
Reducer Enlargement 4x3x4	0.1612		

FFT: 0.0163

TOTAL K: 1.824

Avg Percent of Total Loss: 73 %

Appendix H

<p>03/17/97 1:37 pm Linelist: DRAN30%1 Lineup: DRAN30%1 flow rate: gpm pressure: psig level & grade: ft</p>	<p>Company: Fluor Daniel Northwest Project: W-320 Anti-Siphon and Drainflow by: D. L. Stone Comments: Slurry Line Drainflow - Highpoint to Endpoint - Solids 30% Version: PIPE-FLO ver 5.01</p>
--	---

System: DRAN30%1
rev: 03/17/97 1:34 pm

Deviation: 0.00418 %
after: 8 iterations

Slurry Line - Drain from High to Endpoint - 30% Solids (70F)

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE		FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	>>>	122.7	~N--0	0	0
Pipe 3.3	<<<	122.7	~N--3.3	0	0

Flows IN: 122.7 gpm
Flows OUT: 122.7 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--0	608		0 (source)	608
~N--1	608.443		-0.196	608.1
~N--2	609.838		3.65	616.9
~N--2.1	639.107		-10.82	618.3
~N--2.2	639.107		-10.81	618.3
~N--3	639.461		-5.045	629.7
~N--3.1	650.42		-4.609	641.5
~N--3.2	661.63		-4.084	653.8
~N--3.3	676.05		0 (source)	676

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Line 0	~N--1	~N--0	122.7	* 1.969	(0.196)	0.065
Pipe 1	~N--2	~N--1	122.7	* 5.329	3.846	8.807
----- Rev. Flow IP ----- dP: 4.225 HL: 8.142						
Pipe 2	~N--2.1	~N--2	122.7	* 3.095	(14.47)	1.379
Pipe 2.1	~N--2.2	~N--2.1	122.7	* 3.095	0.013	0.025
Pipe 3	~N--3	~N--2.2	122.7	* 5.329	5.765	11.46
----- Rev. Flow BP ----- dP: 5.626 HL: 10.84						
Pipe 3.1	~N--3.1	~N--3	122.7	* 3.095	0.436	11.8
Pipe 3.2	~N--3.2	~N--3.1	122.7	* 3.095	0.525	12.22
Pipe 3.3	~N--3.3	~N--3.2	122.7	* 3.095	4.084	22.29

Company: Fluor Daniel Northwest
 Project: W-320 Anti-Siphon and Drainflow
 by: D. L. Stone
 Comments: Slurry Line Drainflow - Lowpoint to Endpoint - Solids 30%
 Version: PIPE-FLO ver 5.01

03/17/97 1:47 pm
 Linelist: DRAN30%2
 Lineup: DRAN30%2
 flow rate: gpm
 pressure: psig
 level & grade: ft

System: DRAN30%2
rev: 03/17/97 1:43 pm

Deviation: 0.00184 %
after: 7 iterations

Slurry Line - Drain from Stationpoint to Endpoint - 30% Solids (70F)

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE		FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	>>>	141.5	~N--0	0	0
Pipe 3.1	<<<	141.5	~N--3.1	0	0

Flows IN: 141.5 gpm
Flows OUT: 141.5 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--0	608		0 (source)	608
~N--1	608.443		-0.186	608.1
~N--2	609.838		5.155	619.8
~N--2.1	639.107		-9.164	621.4
~N--2.2	639.107		-9.149	621.5
~N--3	639.461		-1.455	636.7
~N--3.1	650.42		0 (source)	650.4

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Line 0	~N--1	~N--0	141.5	* 2.27	(0.186)	0.085
Pipe 1	~N--2	~N--1	141.5	6.144	5.34	11.69
----- Rev. Flow IP ----- dP: 5.621 HL: 10.83						
Pipe 2	~N--2.1	~N--2	141.5	* 3.568	(14.32)	1.677
Pipe 2.1	~N--2.2	~N--2.1	141.5	* 3.568	0.015	0.029
Pipe 3	~N--3	~N--2.2	141.5	6.144	7.694	15.18
----- Rev.Flow BP ----- dP: 7.481 HL: 14.42						
Pipe 3.1	~N--3.1	~N--3	141.5	* 3.568	1.455	13.76

Appendix I

Company: Fluor Daniel Northwest	03/17/97 3:06 pm
Project: W-320 Anti-Siphon and Drainflow	Linelist: SIPH0%1
by: D. L. Stone <i>DLS</i>	Lineup: SIPH0%1
Comments: Supernate Line Siphoning - Solids 0%	flow rate: gpm
Version: PIPE-FLO ver 5.01	pressure: psi
	level & grade: ft

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone

03/17/97 3:06 pm
Lineup: SIPH0%1
rev: 03/17/97 3:06 pm

System: SIPH0%1
rev: 03/17/97 2:34 pm

Deviation: 0.00207 %
after: 6 iterations

Supernate Line - 0% solids - Siphon Function

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE	FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	<<< 75.41	~N--0	0	18.16
Pipe 9	>>> 75.41	~N-13	0	0

Flows IN: 75.41 gpm
Flows OUT: 75.41 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--0	635.5		7.853 (source)	653.7
~N--1	635.943		7.657	653.6
~N--2.1	637.338		6.71	652.9
~N--2.2	661.7		-3.917	652.6
~N--2.3	672.315		-8.614	652.4
~N--3	672.669		-9.968	649.6
~N--4	677.11		-11.95	649.5
~N--5	661.63		-7.085	645.2
~N--6	650.39		-3.245	642.9
~N--7	641.42		-0.328	640.7
~N--8	623.217		7.386	640.3
~N--9	622.517		7.407	639.6
~N-10	621.85		7.655	639.6
~N-11	620.225		8.242	639.3
~N-12	619.621		8.154	638.5
~N-13	619.35		0 (source)	619.3

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Pipe 0	~N--0	~N--1	75.41	* 1.21	0.197	0.012
Pipe 1	~N--1	~N--2.1	75.41	* 3.275	0.947	0.794
----- Pos Flow 1 ----- dP: 0.240 HL: 0.554						
Pipe 2.1	~N--2.1	~N--2.2	75.41	* 1.902	10.63	0.212
Pipe 2.2	~N--2.2	~N--2.3	75.41	* 1.902	4.697	0.245
Pipe 2.3	~N--2.3	~N--3	75.41	* 3.275	1.354	2.776
----- Pos Flow 2 ----- dP: 1.187 HL: 2.745						
Pipe 3	~N--3	~N--4	75.41	* 1.902	1.983	0.144
Pipe 4.1	~N--4	~N--5	75.41	* 1.902	(4.865)	4.23
Pipe 4.2	~N--5	~N--6	75.41	* 1.902	(3.84)	2.36
Pipe 4.3	~N--6	~N--7	75.41	* 1.902	(2.917)	2.225
Pipe 4.4	~N--7	~N--8	75.41	* 1.902	(7.714)	0.365
Pipe 5	~N--8	~N--9	75.41	* 5.057	(0.021)	0.652
Pipe 6	~N--9	~N--10	75.41	7.216	(0.249)	0.092
Pipe 7	~N--10	~N--11	75.41	* 5.057	(0.587)	0.268
----- Monitor 0% ----- dP: 0.089 HL: 0.207						
Pipe 8	~N--11	~N--12	75.41	* 5.057	0.089	0.809
Pipe 9	~N--12	~N--13	75.41	* 33.66	8.154	19.13

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone

03/17/97 3:06 pm
System: SIPH0%1
rev: 03/17/97 2:34 pm

SYSTEM REPORT

Created: 01/24/97 1:41 pm
Design file:
Pipe Specs: 2

Pipes: 15
Nodes: 16
Pumps/Comps: 3

Supernate Line - 0% Solids - Siphon Function (70F)

SYSTEM NODES

NODE	ELEVATION ft	PIPELINES IN	PIPELINES OUT
~N--0	635.5		Pipe 0
~N--1	635.943	Pipe 0	Pipe 1
~N--2.1	637.338	Pipe 1	Pipe 2.1
~N--2.2	661.7	Pipe 2.1	Pipe 2.2
~N--2.3	672.315	Pipe 2.2	Pipe 2.3
~N--3	672.669	Pipe 2.3	Pipe 3
~N--4	677.11	Pipe 3	Pipe 4.1
~N--5	661.63	Pipe 4.1	Pipe 4.2
~N--6	650.39	Pipe 4.2	Pipe 4.3
~N--7	641.42	Pipe 4.3	Pipe 4.4
~N--8	623.217	Pipe 4.4	Pipe 5
~N--9	622.517	Pipe 5	Pipe 6
~N-10	621.85	Pipe 6	Pipe 7
~N-11	620.225	Pipe 7	Pipe 8
~N-12	619.621	Pipe 8	Pipe 9
~N-13	619.35	Pipe 9	

SYSTEM PIPES

03/17/97 3:06 pm

PIPELINE	SPEC	FROM_NODE	TO_NODE	PUMP/COMP
Pipe 0	03	~N--0	~N--1	
Pipe 1	03	~N--1	~N--2.1	Pos Flow 1
Pipe 2.1	03	~N--2.1	~N--2.2	
Pipe 2.2	03	~N--2.2	~N--2.3	
Pipe 2.3	03	~N--2.3	~N--3	Pos Flow 2
Pipe 3	03	~N--3	~N--4	
Pipe 4.1	03	~N--4	~N--5	
Pipe 4.2	03	~N--5	~N--6	
Pipe 4.3	03	~N--6	~N--7	
Pipe 4.4	03	~N--7	~N--8	
Pipe 5	03	~N--8	~N--9	
Pipe 6	03	~N--9	~N-10	
Pipe 7	03	~N-10	~N-11	Monitor 0%
Pipe 8	03	~N-11	~N-12	
Pipe 9	04	~N-12	~N-13	

PUMP/COMP

PERFORMANCE DATA

Monitor 0%	gpm:	0	50	150	250	350
	ft:	0	0.098	0.717	1.87	3.55
	eqn:	$7.20527e-005 Q^4 + 1.84168$				
Pos Flow 1	gpm:	0	40	80	120	150
	ft:	0	0.156	0.624	1.4	2.2
	eqn:	$9.72278e-005 Q^4 + 2.00063$				
Pos Flow 2	gpm:	0	40	80	120	150
	ft:	0	0.77	3.08	7	10.9
	eqn:	$0.000468926 Q^4 + 2.00674$				

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone

03/17/97 3:07 pm
System: SIPH0%1
rev: 03/17/97 2:34 pm

PIPELIST REPORT

Created: 01/24/97 1:41 pm
Design file:
Pipe Specs: 2

Pipes: 15
Nodes: 16
Pumps/Comps: 3

Supernate Line - 0% Solids - Siphon Function (70F)

SPECIFICATIONS

SPECIFICATION	PIPE MATERIAL Sch / Roughness	FLUID Temp / Pres	VALVE TABLE	DESIGN LIMITS Vel / Pres
03 0%-70F-sch40 rev: 01/31/97 12:53 pm	Steel Sch 40 0.0018 in	0% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g
Size for: 6 ft/sec				
04 0%-70F-sch80 rev: 01/31/97 12:53 pm	Steel Sch 80 0.0018 in	0% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g
Size for: 6 ft/sec				

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	FLUID Temp / Pres	VALVES Total-K
Pipe 0	03	Steel 5 in / 40	0.442	0% solids 70 °F / 0 psi g	0.5
Pipe 1	03	Steel 3 in / 40	2.323	0% solids 70 °F / 0 psi g	1.194
Pipe 2.1	03	Steel 4 in / 40	26.049	0% solids 70 °F / 0 psi g	1.542
Pipe 2.2	03	Steel 4 in / 40	18.673	0% solids 70 °F / 0 psi g	2.771
Pipe 2.3	03	Steel 3 in / 40	0.667	0% solids 70 °F / 0 psi g	0.112
Pipe 3	03	Steel 4 in / 40	6.787	0% solids 70 °F / 0 psi g	1.989
Pipe 4.1	03	Steel 4 in / 40	822.8	0% solids 70 °F / 0 psi g	4.89
Pipe 4.2	03	Steel 4 in / 40	468.1	0% solids 70 °F / 0 psi g	1.956
Pipe 4.3	03	Steel 4 in / 40	428.7	0% solids 70 °F / 0 psi g	2.929
Pipe 4.4	03	Steel 4 in / 40	26.268	0% solids 70 °F / 0 psi g	4.247
Pipe 5	03	Steel 2.5 in / 40	1.231	0% solids 70 °F / 0 psi g	1.485
Pipe 6	03	Steel 2 in / 40	0.667	0% solids 70 °F / 0 psi g	0.01334
Pipe 7	03	Steel 2.5 in / 40	1.203	0% solids 70 °F / 0 psi g	0
Pipe 8	03	Steel 2.5 in / 40	0.604	0% solids 70 °F / 0 psi g	1.961
Pipe 9	04	Steel 1 in / 80	0.271	0% solids 70 °F / 0 psi g	1

MATERIALS REPORT

Created: 01/24/97 1:41 pm
 Design file:
 Pipe Specs: 2

Pipes: 15
 Nodes: 16
 Pumps/Comps: 3

Supernate Line - 0% Solids - Siphon Function (70F)

PIPE MATERIALS LIST

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 0	03	Steel 5 in / 40	0.442	1-Entrance Sharp-Edged
Pipe 1	03	Steel 3 in / 40	2.323	3-Elbow Short - r/d 1 @ 90° 1-Reducer Enlargement 4 X 3 1-Reducer Contraction 5 X 3
Pipe 2.1	03	Steel 4 in / 40	26.049	1-Elbow Short - r/d 1 @ 45° 4-Elbow Short - r/d 1 @ 90°
Pipe 2.2	03	Steel 4 in / 40	18.673	4-Elbow Long - r/d 1.5 @ 90° 1-Elbow Short - r/d 1 @ 90° 1-Mitre Bend @ 90° 1-Fixed K 0.5546
Pipe 2.3	03	Steel 3 in / 40	0.667	1-Reducer Contraction 4 X 3 1-Reducer Enlargement 4 X 3
Pipe 3	03	Steel 4 in / 40	6.787	1-Mitre Bend @ 90° 3-Elbow Long - r/d 1.5 @ 90° 1-Tee Flow Thru Run
Pipe 4.1	03	Steel 4 in / 40	822.8	10-Pipe Bend r/d 10 @ 90°
Pipe 4.2	03	Steel 4 in / 40	468.1	4-Pipe Bend r/d 10 @ 90°
Pipe 4.3	03	Steel 4 in / 40	428.7	5-Pipe Bend r/d 10 @ 90° 2-Pipe Bend r/d 8 @ 45°
Pipe 4.4	03	Steel 4 in / 40	26.268	5-Elbow Long - r/d 1.5 @ 90° 2-Elbow Short - r/d 1 @ 45° 2-Mitre Bend @ 90° 1-Reducer Contraction 4 X 2.5
Pipe 5	03	Steel 2.5 in / 40	1.231	1-Elbow Short - r/d 1 @ 90° 1-Mitre Bend @ 90° 1-Reducer Contraction 2.5 X 2

PIPE MATERIALS LIST

03/17/97 3:07 pm

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 6	03	Steel 2 in / 40	0.667	1-Reducer Enlargement 2.5 X 2
Pipe 7	03	Steel 2.5 in / 40	1.203	
Pipe 8	03	Steel 2.5 in / 40	0.604	1-Reducer Contraction 2.5 X 1
Pipe 9	04	Steel 1 in / 80	0.271	1-Exit Projecting

PIPE SUMMARY

03/17/97 3:07 pm

PIPE MATERIAL	SCHEDULE	SIZE	LENGTH
Steel	40	2 in	0.667 ft
		2.5 in	3.038 ft
		3 in	2.99 ft
		4 in	1797.38 ft
		5 in	0.442 ft
Steel	80	1 in	0.271 ft

VALVE & FITTING SUMMARY

SPECIFICATION	MATERIAL	SCHEDULE	VALVES & FITTINGS
03 0%-70F-sch40	Steel	40	
			Size: 2 in
			1-Reducer Enlargement 2.5 X 2
			Size: 2.5 in
			1-Elbow Short - r/d 1 @ 90°
			1-Mitre Bend @ 90°
			1-Reducer Contraction 2.5 X 2
			1-Reducer Contraction 2.5 X 1
			Size: 3 in
			3-Elbow Short - r/d 1 @ 90°
			2-Reducer Enlargement 4 X 3
			1-Reducer Contraction 5 X 3
			1-Reducer Contraction 4 X 3
			Size: 4 in
			3-Elbow Short - r/d 1 @ 45°
04 0%-70F-sch80	Steel	80	5-Elbow Short - r/d 1 @ 90°
			12-Elbow Long - r/d 1.5 @ 90°
			4-Mitre Bend @ 90°
			1-Fixed K 0.5546
			1-Tee Flow Thru Run
			19-Pipe Bend r/d 10 @ 90°
			2-Pipe Bend r/d 8 @ 45°
			1-Reducer Contraction 4 X 2.5
			Size: 5 in
			1-Entrance Sharp-Edged
			Size: 1 in
			1-Exit Projecting

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone

03/17/97 3:22 pm
System: SIPH0%1
rev: 03/17/97 2:34 pm

PIPELINE REPORT

Pipe 2.2 rev: 03/17/97 2:23 pm

PIPING MATERIAL: Steel
Schedule: 40
abs roughness: 0.0018 in

PIPE SIZE: 4 in
dia: 4.026 in

LENGTH: 18.673 ft

ELEVATION in: 661.7 ft
out: 672.315 ft

SPECIFICATION: 0%-70F-sch40

SIZING Criteria: 6 ft/sec

LIMITS Velocity: 6 to 10 ft/sec
Pressure: -14.4 to 300 psi g

FLUID 0% solids at tmp: 70 °F
pres: 0 psi g
den: 62.31 lb/ft³
vsc: 3.96 cpois

PIPELINE RESISTANCE CURVE

Flow gpm	ffp	Vel ft/sec	dP psi
75.41	.0287	1.902	4.698
0	.0000	0	4.592
33.04	.0356	0.833	4.614
66.08	.0297	1.667	4.674
99.12	.0270	2.5	4.771
132.2	.0254	3.333	4.904
165.2	.0243	4.167	5.072
198.2	.0234	5	5.275
231.3	.0228	5.833	5.514
264.3	.0223	6.667	5.788
297.4	.0218	7.5	6.096
330.4	.0215	8.333	6.44
363.4	.0211	9.167	6.818
396.5	.0209	10	7.231

VALVES and FITTINGS

VALVE / FITTING	K-VALUE	VALVE / FITTING	K-VALUE
Elbow Long - r/d 1.5 90°	4@0.2282	Elbow Short - r/d 1 90°	0.326
Mitre Bend @ 90°	0.978	Fixed K	0.5546

FFT: 0.0163

TOTAL K: 2.771

Avg Percent of Total Loss: 67 %

Appendix J

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone *DL*
Comments: Supernate Line Drainflow - Highpoint to Endpoint -
Version: PIPE-FLO ver 5.01
0% Solids

03/17/97 3:15 pm
Line1st: DRAIN0%1
Lineup: DRAIN0%1
flow rate: gpm
pressure: psig
level & grade: ft

System: DRAIN0%1
rev: 03/17/97 3:13 pm

Deviation: 0.000792 %
after: 4 iterations

Supernate Line - 0% solids - Time required to drain - Configuration 1: Source at Highpoint

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE		FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 4.1	<<<	105.6	~N--4	0	0
Pipe 9	>>>	105.6	~N-13	0	0

Flows IN: 105.6 gpm

Flows OUT: 105.6 gpm

NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--4	677.11		0 (source)	677.1
~N--5	661.63		3.354	669.4
~N--6	650.39		6.353	665.1
~N--7	641.42		8.473	661
~N--8	623.217		16.04	660.3
~N--9	622.517		15.8	659
~N-10	621.85		16.01	658.9
~N-11	620.225		16.5	658.4
~N-12	619.621		16.08	656.8
~N-13	619.35		0 (source)	619.3

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Pipe 4.1	~N--4	~N--5	105.6	* 2.664	(3.354)	7.725
Pipe 4.2	~N--5	~N--6	105.6	* 2.664	(2.999)	4.304
Pipe 4.3	~N--6	~N--7	105.6	* 2.664	(2.12)	4.067
Pipe 4.4	~N--7	~N--8	105.6	* 2.664	(7.571)	0.697
Pipe 5	~N--8	~N--9	105.6	7.084	0.247	1.272
Pipe 6	~N--9	~N--10	105.6	* 10.11	(0.214)	0.172
Pipe 7	~N--10	~N--11	105.6	7.084	(0.488)	0.498
----- Monitor 0% ----- dP: 0.166 HL: 0.384						
Pipe 8	~N--11	~N--12	105.6	7.084	0.423	1.583
Pipe 9	~N--12	~N--13	105.6	* 47.15	16.08	37.44

Company: Fluor Daniel Northwest Project: W-320 Anti-Siphon and Drainflow by: D. L. Stone <i>DLS</i> Comments: Supernate Line Drainflow - Lowpoint to Endpoint - 0% Solids Version: PIPE-FLO ver 5.01	03/17/97 3:21 pm Linelist: DRAIN0%2 Lineup: DRANO%2 flow rate: gpm pressure: psig level & grade: ft
---	--

System: DRAIN0%2
rev: 03/17/97 3:18 pm

Deviation: 0.00235 %
after: 4 iterations

Supernate Line Drainflow - 0% solids - Source at Stationpoint

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE	FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 4.3	<<< 86.78	~N--6	0	0
Pipe 9	>>> 86.78	~N-13	0	0

Flows IN: 86.78 gpm
Flows OUT: 86.78 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--6	650.39		0 (source)	650.4
~N--7	641.42		2.643	647.5
~N--8	623.217		10.31	647.1
~N--9	622.517		10.24	646.2
~N-10	621.85		10.48	646.1
~N-11	620.225		11.03	645.7
~N-12	619.621		10.83	644.7
~N-13	619.35		0 (source)	619.3

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Pipe 4.3	~N--6	~N--7	86.78	* 2.189	(2.643)	2.859
Pipe 4.4	~N--7	~N--8	86.78	* 2.189	(7.666)	0.478
Pipe 5	~N--8	~N--9	86.78	* 5.82	0.070	0.861
Pipe 6	~N--9	~N-10	86.78	8.304	(0.237)	0.119
Pipe 7	~N-10	~N-11	86.78	* 5.82	(0.553)	0.347
----- Monitor 0% ----- dP: 0.116 HL: 0.268						
Pipe 8	~N-11	~N-12	86.78	* 5.82	0.202	1.07
Pipe 9	~N-12	~N-13	86.78	* 38.74	10.83	25.31

Appendix K

Company: Fluor Daniel Northwest	03/17/97 2:53 pm
Project: W-320 Anti-Siphon and Drainflow	Lineist: SIPH10%1
by: D. L. Stone <i>DIS</i>	Lineup: SIPH10%
Comments: Supernate Line Siphoning - Solids 10%	flow rate: gpm
Version: PIPE-FLO ver 5.01	pressure: psi _a
	level & grade: ft

System: SIPH10%1
rev: 03/17/97 2:52 pm

Deviation: 0.007 %
after: 6 iterations

Supernate Line - 10% solids - Siphon Function

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE	FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 0	<<< 71.98	~N--0	0	18.16
Pipe 9	>>> 71.98	~N-13	0	0

Flows IN: 71.98 gpm
Flows OUT: 71.98 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--0	635.5		8.795 (source)	653.7
~N--1	635.943		8.575	653.6
~N--2.1	637.338		7.543	652.9
~N--2.2	661.7		-4.368	652.7
~N--2.3	672.315		-9.629	652.4
~N--3	672.669		-11.03	649.9
~N--4	677.11		-13.25	649.8
~N--5	661.63		-8.214	644.7
~N--6	650.39		-4.153	641.8
~N--7	641.42		-1.109	639.1
~N--8	623.217		7.527	638.8
~N--9	622.517		7.57	638.1
~N-10	621.85		7.843	638
~N-11	620.225		8.477	637.7
~N-12	619.621		8.409	637
~N-13	619.35		0 (source)	619.3

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Pipe 0	~N--0	~N--1	71.98	* 1.155	0.220	0.011
Pipe 1	~N--1	~N--2.1	71.98	* 3.126	1.032	0.736
----- Pos Flow 1 ----- dP: 0.245 HL: 0.505						
Pipe 2.1	~N--2.1	~N--2.2	71.98	* 1.816	11.91	0.232
Pipe 2.2	~N--2.2	~N--2.3	71.98	* 1.816	5.261	0.249
Pipe 2.3	~N--2.3	~N--3	71.98	* 3.126	1.398	2.532
----- Pos Flow 2 ----- dP: 1.211 HL: 2.501						
Pipe 3	~N--3	~N--4	71.98	* 1.816	2.219	0.142
Pipe 4.1	~N--4	~N--5	71.98	* 1.816	(5.032)	5.09
Pipe 4.2	~N--5	~N--6	71.98	* 1.816	(4.062)	2.853
Pipe 4.3	~N--6	~N--7	71.98	* 1.816	(3.043)	2.687
Pipe 4.4	~N--7	~N--8	71.98	* 1.816	(8.636)	0.372
Pipe 5	~N--8	~N--9	71.98	* 4.827	(0.043)	0.611
Pipe 6	~N--9	~N--10	71.98	6.888	(0.273)	0.103
Pipe 7	~N--10	~N--11	71.98	* 4.827	(0.634)	0.316
----- Monitor 10% ----- dP: 0.118 HL: 0.244						
Pipe 8	~N--11	~N--12	71.98	* 4.827	0.068	0.745
Pipe 9	~N--12	~N--13	71.98	* 32.13	8.409	17.63

SYSTEM REPORT

Created: 01/24/97 1:41 pm
Design file:
Pipe Specs: 2

Pipes: 15
Nodes: 16
Pumps/Comps: 3

Supernate Line - 10% Solids - Siphon Function (70F)

SYSTEM NODES

NODE	ELEVATION ft	PIPELINES IN	PIPELINES OUT
~N--0	635.5		Pipe 0
~N--1	635.943	Pipe 0	Pipe 1
~N--2.1	637.338	Pipe 1	Pipe 2.1
~N--2.2	661.7	Pipe 2.1	Pipe 2.2
~N--2.3	672.315	Pipe 2.2	Pipe 2.3
~N--3	672.669	Pipe 2.3	Pipe 3
~N--4	677.11	Pipe 3	Pipe 4.1
~N--5	661.63	Pipe 4.1	Pipe 4.2
~N--6	650.39	Pipe 4.2	Pipe 4.3
~N--7	641.42	Pipe 4.3	Pipe 4.4
~N--8	623.217	Pipe 4.4	Pipe 5
~N--9	622.517	Pipe 5	Pipe 6
~N-10	621.85	Pipe 6	Pipe 7
~N-11	620.225	Pipe 7	Pipe 8
~N-12	619.621	Pipe 8	Pipe 9
~N-13	619.35	Pipe 9	

SYSTEM PIPES

03/17/97 3:04 pm

PIPELINE	SPEC	FROM_NODE	TO_NODE	PUMP/COMP
Pipe 0	05	~N--0	~N--1	
Pipe 1	05	~N--1	~N--2.1	Pos Flow 1
Pipe 2.1	05	~N--2.1	~N--2.2	
Pipe 2.2	05	~N--2.2	~N--2.3	
Pipe 2.3	05	~N--2.3	~N--3	Pos Flow 2
Pipe 3	05	~N--3	~N--4	
Pipe 4.1	05	~N--4	~N--5	
Pipe 4.2	05	~N--5	~N--6	
Pipe 4.3	05	~N--6	~N--7	
Pipe 4.4	05	~N--7	~N--8	
Pipe 5	05	~N--8	~N--9	
Pipe 6	05	~N--9	~N-10	
Pipe 7	05	~N-10	~N-11	Monitor 10%
Pipe 8	05	~N-11	~N-12	
Pipe 9	02	~N-12	~N-13	

PUMP/COMP

PERFORMANCE DATA

Monitor 10%

gpm:	0	50	150	250	350
ft:	0	0.13	0.87	2.18	4.04
eqn:	$0.000130185 Q^{\wedge} 1.7625$				

Pos Flow 1

gpm:	0	40	80	120	150
ft:	0	0.156	0.624	1.4	2.2
eqn:	$9.72278e-005 Q^{\wedge} 2.00063$				

Pos Flow 2

gpm:	0	40	80	120	150
ft:	0	0.77	3.08	7	10.9
eqn:	$0.000468926 Q^{\wedge} 2.00674$				

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone

03/17/97 3:04 pm
System: SIPH10%1
rev: 03/17/97 2:52 pm

PIPELIST REPORT

Created: 01/24/97 1:41 pm
Design file:
Pipe Specs: 2

Pipes: 15
Nodes: 16
Pumps/Comps: 3

Supernate Line - 10% Solids - Siphon Function (70F)

SPECIFICATIONS

SPECIFICATION	PIPE MATERIAL Sch / Roughness	FLUID Temp / Pres	VALVE TABLE	DESIGN LIMITS Vel / Pres
05 10%-sch40 rev: 02/25/97 7:03 am	Steel Sch 40 0.0018 in Size for: 6 ft/sec	10% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g
02 10%-sch80 rev: 02/25/97 7:03 am	Steel Sch 80 0.0018 in Size for: 6 ft/sec	10% solids 70 °F 0 psi g	Standard	6 - 10 ft/sec -14.4 - 300 psi g

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	FLUID Temp / Pres	VALVES Total-K
Pipe 0	05	Steel 5 in / 40	0.442	10% solids 70 °F / 0 psi g	0.5
Pipe 1	05	Steel 3 in / 40	2.323	10% solids 70 °F / 0 psi g	1.194
Pipe 2.1	05	Steel 4 in / 40	26.049	10% solids 70 °F / 0 psi g	1.542
Pipe 2.2	05	Steel 4 in / 40	18.673	10% solids 70 °F / 0 psi g	2.712
Pipe 2.3	05	Steel 3 in / 40	0.667	10% solids 70 °F / 0 psi g	0.112
Pipe 3	05	Steel 4 in / 40	6.787	10% solids 70 °F / 0 psi g	1.989
Pipe 4.1	05	Steel 4 in / 40	822.8	10% solids 70 °F / 0 psi g	4.89
Pipe 4.2	05	Steel 4 in / 40	468.1	10% solids 70 °F / 0 psi g	1.956
Pipe 4.3	05	Steel 4 in / 40	428.7	10% solids 70 °F / 0 psi g	3.227
Pipe 4.4	05	Steel 4 in / 40	26.268	10% solids 70 °F / 0 psi g	4.247
Pipe 5	05	Steel 2.5 in / 40	1.231	10% solids 70 °F / 0 psi g	1.485
Pipe 6	05	Steel 2 in / 40	0.667	10% solids 70 °F / 0 psi g	0.01334
Pipe 7	05	Steel 2.5 in / 40	1.203	10% solids 70 °F / 0 psi g	0
Pipe 8	05	Steel 2.5 in / 40	0.604	10% solids 70 °F / 0 psi g	1.961
Pipe 9	02	Steel 1 in / 80	0.271	10% solids 70 °F / 0 psi g	1

MATERIALS REPORT

Created: 01/24/97 1:41 pm
 Design file:
 Pipe Specs: 2

Pipes: 15
 Nodes: 16
 Pumps/Comps: 3

Supernate Line - 10% Solids - Siphon Function (70F)

PIPE MATERIALS LIST

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 0	05	Steel 5 in / 40	0.442	1-Entrance Sharp-Edged
Pipe 1	05	Steel 3 in / 40	2.323	3-Elbow Short - r/d 1 @ 90° 1-Reducer Enlargement 4 X 3 1-Reducer Contraction 5 X 3
Pipe 2.1	05	Steel 4 in / 40	26.049	1-Elbow Short - r/d 1 @ 45° 4-Elbow Short - r/d 1 @ 90°
Pipe 2.2	05	Steel 4 in / 40	18.673	4-Elbow Long - r/d 1.5 @ 90° 1-Elbow Short - r/d 1 @ 90° 1-Mitre Bend @ 90° 1-Fixed K 0.4952
Pipe 2.3	05	Steel 3 in / 40	0.667	1-Reducer Contraction 4 X 3 1-Reducer Enlargement 4 X 3
Pipe 3	05	Steel 4 in / 40	6.787	1-Mitre Bend @ 90° 3-Elbow Long - r/d 1.5 @ 90° 1-Tee Flow Thru Run
Pipe 4.1	05	Steel 4 in / 40	822.8	10-Pipe Bend r/d 10 @ 90°
Pipe 4.2	05	Steel 4 in / 40	468.1	4-Pipe Bend r/d 10 @ 90°
Pipe 4.3	05	Steel 4 in / 40	428.7	5-Pipe Bend r/d 10 @ 90° 2-Pipe Bend r/d 8 @ 90°
Pipe 4.4	05	Steel 4 in / 40	26.268	5-Elbow Long - r/d 1.5 @ 90° 2-Elbow Short - r/d 1 @ 45° 2-Mitre Bend @ 90° 1-Reducer Contraction 4 X 2.5
Pipe 5	05	Steel 2.5 in / 40	1.231	1-Elbow Short - r/d 1 @ 90° 1-Mitre Bend @ 90° 1-Reducer Contraction 2.5 X 2

PIPE MATERIALS LIST

03/17/97 3:04 pm

PIPELINE	SPEC	MATERIAL Size / Sch	LENGTH ft	VALVES & FITTINGS
Pipe 6	05	Steel 2 in / 40	0.667	1-Reducer Enlargement 2.5 X 2
Pipe 7	05	Steel 2.5 in / 40	1.203	
Pipe 8	05	Steel 2.5 in / 40	0.604	1-Reducer Contraction 2.5 X 1
Pipe 9	02	Steel 1 in / 80	0.271	1-Exit Projecting

PIPE MATERIAL	SCHEDULE	SIZE	LENGTH
Steel	40	2 in	0.667 ft
		2.5 in	3.038 ft
		3 in	2.99 ft
		4 in	1797.38 ft
		5 in	0.442 ft
Steel	80	1 in	0.271 ft

VALVE & FITTING SUMMARY

SPECIFICATION	MATERIAL	SCHEDULE	VALVES & FITTINGS
05 10%-sch40	Steel	40	
			Size: 2 in
			Size: 2.5 in
			Size: 3 in
			Size: 4 in
			Size: 5 in
			Size: 1 in
02 10%-sch80	Steel	80	

1-Reducer Enlargement 2.5 X 2
 1-Elbow Short - r/d 1 @ 90°
 1-Mitre Bend @ 90°
 1-Reducer Contraction 2.5 X 2
 1-Reducer Contraction 2.5 X 1
 3-Elbow Short - r/d 1 @ 90°
 2-Reducer Enlargement 4 X 3
 1-Reducer Contraction 5 X 3
 1-Reducer Contraction 4 X 3
 3-Elbow Short - r/d 1 @ 45°
 5-Elbow Short - r/d 1 @ 90°
 12-Elbow Long - r/d 1.5 @ 90°
 4-Mitre Bend @ 90°
 1-Fixed K 0.4952
 1-Tee Flow Thru Run
 19-Pipe Bend r/d 10 @ 90°
 2-Pipe Bend r/d 8 @ 90°
 1-Reducer Contraction 4 X 2.5
 1-Entrance Sharp-Edged
 1-Exit Projecting

Company: Fluor Daniel Northwest
Project: W-320 Anti-Siphon and Drainflow
by: D. L. Stone

03/17/97 3:23 pm
System: SIPH10%1
rev: 03/17/97 2:52 pm

PIPELINE REPORT

Pipe 2.2 rev: 03/17/97 2:46 pm

PIPING MATERIAL: Steel
Schedule: 40
abs roughness: 0.0018 in

PIPE SIZE: 4 in
dia: 4.026 in

LENGTH: 18.673 ft

ELEVATION in: 661.7 ft
out: 672.315 ft

SPECIFICATION: 10%-sch40

SIZING Criteria: 6 ft/sec

LIMITS Velocity: 6 to 10 ft/sec
Pressure: -14.4 to 300 psi g

FLUID 10% solids at tmp: 70 °F
pres: 0 psi g
den: 69.78 lb/ft³
vsc: 12.87 cpois

PIPELINE RESISTANCE CURVE

Flow gpm	ffp	Vel ft/sec	dP psi
71.98	.0386	1.816	5.263
0	.0000	0	5.142
33.04	.0494	0.833	5.171
66.08	.0396	1.667	5.245
99.12	.0352	2.5	5.362
132.2	.0326	3.333	5.52
165.2	.0308	4.167	5.72
198.2	.0294	5	5.959
231.3	.0284	5.833	6.239
264.3	.0275	6.667	6.559
297.4	.0268	7.5	6.919
330.4	.0262	8.333	7.318
363.4	.0257	9.167	7.756
396.5	.0252	10	8.234

VALVES and FITTINGS

VALVE / FITTING	K-VALUE	VALVE / FITTING	K-VALUE
Elbow Long - r/d 1.5 90°	4@0.2282	Elbow Short - r/d 1 90°	0.326
Mitre Bend @ 90°	0.978	Fixed K	0.4952

FFT: 0.0163

TOTAL K: 2.712

Avg Percent of Total Loss: 61 %

Appendix L

Company: Fluor Daniel Northwest
 Project: W-320 Anti-Siphon and Drainflow
 by: D. L. Stone *DLS*
 Comments: Supernate Line Drainflow - Highpoint to Endpoint - 10% Solids
 Version: PIPE-FLO ver 5.01

03/17/97 3:30 pm
 Linelist: DRAN10%1
 Lineup: DRAIN0%1
 flow rate: gpm
 pressure: psig
 level & grade: ft

System: DRAN10%1
rev: 03/17/97 3:28 pm

Deviation: 0.00272 %
after: 3 iterations

Supernate Line - 0% solids - Time required to drain - Configuration 1: Source at Highpoint

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE	FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 4.1	<<< 101	~N--4	0	0
Pipe 9	>>> 101	~N-13	0	0

Flows IN: 101 gpm

Flows OUT: 101 gpm

NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--4	677.11		0 (source)	677.1
~N--5	661.63		3.07	668
~N--6	650.39		6.035	662.9
~N--7	641.42		8.039	658
~N--8	623.217		16.51	657.3
~N--9	622.517		16.28	656.1
~N-10	621.85		16.51	655.9
~N-11	620.225		17.02	655.4
~N-12	619.621		16.6	653.9
~N-13	619.35		0 (source)	619.3

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
Pipe 4.1	~N--4	~N--5	101	* 2.547	(3.07)	9.142
Pipe 4.2	~N--5	~N--6	101	* 2.547	(2.965)	5.118
Pipe 4.3	~N--6	~N--7	101	* 2.547	(2.004)	4.832
Pipe 4.4	~N--7	~N--8	101	* 2.547	(8.475)	0.704
Pipe 5	~N--8	~N--9	101	6.773	0.237	1.19
Pipe 6	~N--9	~N-10	101	9.663	(0.231)	0.189
Pipe 7	~N-10	~N-11	101	6.773	(0.509)	0.574
----- Monitor 10% ----- dP: 0.215 HL: 0.444						
Pipe 8	~N-11	~N-12	101	6.773	0.415	1.461
Pipe 9	~N-12	~N-13	101	* 45.08	16.6	34.55

Company: Fltior Daniel Northwest Project: W-320 Anti-Siphon and Drainflow by: D. L. Stone <i>DLS</i> Comments: Supernate Line Drainflow - Lowpoint to Endpoint - 10% Solids Version: PIPE-FLO ver 5.01	03/17/97 3:33 pm Linelist: DRAN10%2 Lineup: DRAN10%2 flow rate: gpm pressure: psig level & grade: ft
--	---

System: DRAN10%2
rev: 03/17/97 3:32 pm

Deviation: 0.0033 %
after: 4 iterations

Supernate Line Drainflow - 10% solids - Source at Stationpoint

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used in this calculation.

LINEUP SUMMARIES

PIPELINE	FLOW gpm	PRESSURE SOURCE	SET psi g	LEVEL ft
Pipe 4.3	<<< 84.96	~N--6	0	0
Pipe 9	>>> 84.96	~N-13	0	0

Flows IN: 84.96 gpm
Flows OUT: 84.96 gpm
NET FLOWS: 0 gpm

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
~N--6	650.39		0 (source)	650.4
~N--7	641.42		2.611	646.8
~N--8	623.217		11.18	646.3
~N--9	622.517		11.11	645.5
~N-10	621.85		11.37	645.3
~N-11	620.225		11.95	644.9
~N-12	619.621		11.74	643.9
~N-13	619.35		0 (source)	619.3

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	HL ft
ie 4.3	~N--6	~N--7	84.96	* 2.143	(2.611)	3.578
Pipe 4.4	~N--7	~N--8	84.96	* 2.143	(8.57)	0.508
Pipe 5	~N--8	~N--9	84.96	* 5.698	0.071	0.846
Pipe 6	~N--9	~N-10	84.96	8.13	(0.256)	0.139
Pipe 7	~N-10	~N-11	84.96	* 5.698	(0.582)	0.423
----- Monitor 10% ----- dP: 0.158 HL: 0.327						
Pipe 8	~N-11	~N-12	84.96	* 5.698	0.209	1.036
Pipe 9	~N-12	~N-13	84.96	* 37.93	11.74	24.51

Appendix M

E-21-15

ECONOMY
THROUGH
QUALITY

T-M

SWIVEL JOINTS

T-M MFG. CO. 695 E. ARQUES AVE., SUNNYVALE, CALIF. 94086-3832
A

THREADED AND BORED FOR WELDING

STYLE 100

STYLE 200

STYLE 300

STYLE 400

STYLE 500

STYLE 600

STYLE 700

STYLE 800

D I M E N S I O N S

SIZES	B	C	D	E	G	K	M	N	P	R	V	SIZE
3/8 & 1/2	3 1/2	2	3 3/4	1 7/8	1 1/4	2	3	3 3/8	3 3/8	3 3/8	3 3/8	3/8 & 1/2
3/4 & 1	4 1/4	2 3/8	4 1/4	2 1/4	1 3/4	2 7/8	4 1/8	4 1/8	4 1/8	5	4 1/8	3/4 & 1
1 1/4	4 3/4	2 3/4	4 3/4	2 3/4	2 1/8	3 1/8	4 5/8	4 5/8	5 1/8	5 1/8	5 1/4	1 1/4
1 1/2	5 1/2	3	6	3 1/4	2 1/2	3 1/2	6	5 1/4	5 3/4	5 3/8	5 1/8	1 1/2
2	6 3/8	3 1/2	6 3/8	4 1/4	3 3/8	4 1/8	6 3/8	6	6 3/8	7 3/8	6 1/4	2
2 1/2	6 7/8	4	7 3/8	4	3 3/4	5 1/8	6 7/8	6 3/8	6 7/8	8 1/4	6 3/8	2 1/2
3	7 3/4	4 7/8	9 1/8	4 1/4	4 1/4	5 7/8	8 1/8	7 3/4	7 3/8	10 1/8	7	3
4	9 1/4	5 1/2	10 1/8	5 1/2	5 1/2	7 1/4	10 1/8	9 1/4	8 3/4	11 1/2	8 3/8	4

All dimensions given in inches $\pm 1/16$ "

For sizes larger than 4" refer to section on fabricated joints.

371 Market Street, Lawrence, MA 01843-1595 • Telephone 508-682-5248 • Fax 508-975-4291

INSTALLATION, OPERATION, AND MAINTENANCE MANUAL

TITLE

CUSTOMER: WESTINGHOUSE HANFORD COMPANY

USER: WESTINGHOUSE HANFORD COMPANY

SERVICE: TRANSFER AND SLUICE PUMPS

LOCATION: RICHLAND, WA

PURCHASE ORDER NO: WHC P.O. W-78259-Z4

PUMP SERIAL NO: 91231-1, 91231-2, 91232-1 & 91232-2

PUMP ITEM NO: P-1361, P-0621, P-1361 & P-0621

[illegible]

TIME	DISCHARGE (L/SEC)
1.00	1.00
2.00	2.00
3.00	3.00
4.00	4.00
5.00	5.00
6.00	6.00
7.00	7.00
8.00	8.00
9.00	9.00
10.00	10.00

NOZZLE LOADS:

PUMP TAG NO:	P-0621
PUMP SERIAL NO:	91231-2
PUMP CAPACITY:	350 US GPM
PUMP TDH:	128 FT
PUMP SPEED:	1760 RPM
POWER:	25 HP

PUMP TAG NO.	P-1341
PUMP SERIAL NO.	91231-1
PUMP CAPACITY:	218-350 USG/M
PUMP TDH	120-123 FT
PUMP SPEED	1760 RPM
POWER	31-38 HP

1. FOR LIST OF PHOTOS OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
2. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
3. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
4. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
5. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
6. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
7. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
8. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
9. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.
10. FOR LIST OF NAMES OF SUBJECTS, SEE ATTACHED PHOTOGRAPHIC LIST, PAGES 1-10.

NOTES:

WEIGHTS:	
PLANT	500 LBS.
MOTOR	1800 LBS.
TOTAL	2300 LBS. (APPROXIMATE)

Two-Way Ball Valves

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Page B-157

Engineering Data

Dimensions for SP SERIES

Female NPT • Socket Weld

1/4" thru 4"

Butt Weld

1/2" thru 4"

NOTE: On 2-1/2", 3" & 4" sizes handle travels 45° equally about this center line.

1/4", 3/8", 1/2", 3/4" & 1" valves have 3 bolts
1-1/4", 1-1/2", 2" & 2-1/2" valves have 4 bolts
3" valves have 6 bolts
4" valves have 8 bolts

FEMALE NPT

SOCKET WELD

BUTT WELD

PIPE SIZE (Inch)	FEMALE NPT					SOCKET WELD		APPROX. WT. (LBS.)				
	A Port Dia.	B Length	C Height	D	E Handles	F Dia.	G Depth	Bronze	Iron	S/S	AL	C/S
1/4"	.62"	3.12"	2.16"	1.34"	3.69"	.56"	.81"	2	1 1/2	1 3/4	3/4	1 3/4
3/8"	.62"	3.12"	2.16"	1.34"	3.69"	.69"	.81"	2	1 1/2	1 3/4	3/4	1 3/4
1/2"	.62"	3.12"	2.16"	1.34"	3.69"	.86"	.81"	2	1 1/2	1 3/4	3/4	1 3/4
3/4"	.81"	3.44"	2.28"	1.47"	3.69"	1.06"	.81"	2 1/4	1 3/4	2 1/4	3/4	2 1/4
1"	1.00"	3.88"	2.86"	1.69"	4.31"	1.34"	.94"	3 3/4	3	3 1/2	1 1/4	3 1/2
1 1/4"	1.25"	4.54"	3.78"	1.56"	5.50"	1.69"	1.12"	7 1/2	6 1/4	7 1/4	2 1/2	7 1/4
1 1/2"	1.50"	5.38"	4.03"	1.70"	5.50"	1.92"	1.16"	9 1/2	8	9	3	9
2"	1.94"	5.75"	4.38"	2.03"	5.50"	2.41"	1.12"	12 3/4	11 1/2	12 1/2	4	12 1/2
2 1/2"	2.50"	8.31"	5.31"	2.77"	12.00"	2.94"	1.56"	31 1/2	28 1/2		10	
3"	2.75"	8.62"	6.69"	3.88"	12.00"	3.55"	1.88"	50	45	48	16	48
4"	3.50"	10.50"	7.14"	4.47"	12.00"	4.55"	2.12"	82	75	72	26	72

(NOTE: Male NPT, Solder-Joint, T-Klump, Cherry Burrell, Sil-Breze, and Grooved Ends are available in certain sizes and metals. Call or write us for data.)

PIPE SIZE (Inch)	BUTT WELD					APPROX. WT. (LBS.)			
	A Port Dia.	B Length	C Height	D	E Handle	Iron	S/S	AL	C/S
1/4"	.62"	3.12"	2.16"	1.34"	3.69"	1 3/4	2	3/4	2
3/8"	.81"	3.44"	2.28"	1.47"	3.69"	2	2 1/2	1	2 1/2
1"	1.00"	3.88"	2.86"	1.69"	4.31"	3 1/4	3 3/4	1 1/2	3 3/4
1 1/2"	1.50"	5.38"	4.03"	1.70"	5.50"	8 1/2	9 1/2	3 1/4	9 1/2
2"	1.94"	5.75"	4.38"	2.03"	5.50"	12	13	4 1/4	13
3"	2.75"	8.62"	6.69"	3.88"	12.00"	45 1/2	48 1/2	16	48 1/2
4"	3.50"	10.50"	7.14"	4.47"	12.00"	76	73	26 1/2	73

Sch 40 dimensions shown. Sch 10 and Sch 5 Butt Weld Ends also available.

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316 STAINLESS STEEL (Austenitic Grade)—complies with A351-GR-CF8M.

This metal is exceptionally corrosion-resistant to such reducing solutions as sulphuric and fatty acids. Since it does not pit readily, it is a good choice for handling acetic acid and chloride operations, including sea water.

BRONZE—complies with ASTM Spec. No. B-62 (CDA Alloy No. 836).

The superior properties of this metal recommend it as the ideal choice for all general purpose (non-corrosive) applications. It is versatile and well suited for steam, air, water, oil and gas lines. "UL" listed in sizes up to 2" with F.N.P.T. ends.

IRON—complies with ASTM Grade 32510.

This highly popular material provides almost the same high strength of steel, but it is priced somewhat lower. It features extreme resis-

tance to shock, vibration, fire, and freezing hazards and is recommended for water, air, natural gas and oil services. "UL" listed in sizes up to 4" with F.N.P.T. ends.

CARBON STEEL—complies with A216-WCB.

This is a highly versatile material with extreme strength, making it very useful when valves require unusual resistance to shock, vibration, fire and freezing hazards. It efficiently handles water, air, natural gas and oil and other non-corrosive media.

ALUMINUM—complies with SG-70A-T6.

This material, noted equally for its strength and lightness, becomes an ideal choice for handling such media as nitric, chromic, and most of the organic acids.

For Valve sizes in each of these metals, please see Materials of Construction Chart, Page 5.

C_v factors for 'SP' series Ball Valves

C_v is defined as the number of U.S. gallons of water per minute, at standard conditions (60 F° @ 14.7 PSIA) that will flow through a valve at a 1 PSIG Pressure drop across the Valve.

PIPE SIZE	"SP" SIZE	C _v FACTOR
1/4"	SP-12-25	18
3/8"	SP-12-375	18
1/2"	SP-12	18
3/4"	SP-13	35
1"	SP-14	53
1-1/4"	SP-15	83
1-1/2"	SP-16	120
2"	SP-17	200
2-1/2"	SP-18	330
3"	SP-19	400
4"	SP-20	650
6"	SP-22	1450
8"	SP-24	2050

Nomenclature

- GPM — U.S. Gallons per Minute
- W — Pound per hour*
- Q — Cubic feet per hour @ 60°F and 14.7 PSIA
- G — Specific Gravity
- V — Specific volume of inlet steam
- °F — Inlet gas temperature
- P₁ — Inlet pressure in PSIA
- P₂ — Outlet pressure in PSIA
- ΔP — Pressure drop across the valve in PSI. Must not be greater than half the absolute inlet pressure
- PSIA = PSIG + 14.7

*Pounds per hour may be converted to standard cubic feet per hour by the following formula.

$$Q = \frac{W}{0.0764 G}$$

The Sizing Formulas

(1). LIQUID:

$$C_v = GPM \sqrt{\frac{G}{\Delta P}}$$

$$GPM = C_v \sqrt{\frac{\Delta P}{G}}$$

$$\Delta P = \left[\frac{GPM}{C_v} \right]^2 (G)$$

(2). SATURATED STEAM

$$C_v = \frac{W}{2.1} \sqrt{\frac{1}{\Delta P (P_1 + P_2)}}$$

$$W = 2.1 C_v \sqrt{\Delta P \sqrt{P_1 + P_2}}$$

$$\Delta P = \left[\frac{\bar{V}}{C_v} \right]^2 \left[\frac{0.0159 W}{\bar{V}} \right]^2$$

(3). GAS:

$$C_v = \frac{Q}{1360} \sqrt{\frac{G (460 + ^\circ F)}{\Delta P}} \sqrt{\frac{2}{P_1 + P_2}}$$

$$Q = (1360) C_v \sqrt{\frac{\Delta P}{G (460 + ^\circ F)}} \sqrt{\frac{P_1 + P_2}{2}}$$

$$\Delta P = \left[\frac{Q}{(1360) C_v} \right]^2 \left[\frac{(460 + ^\circ F) G}{P_1} \right]$$

Bolt Configurations

3 Bolts for 1/4", 1/2", 3/4" and 1" Valves

4 Bolts for 1 1/4", 1 1/2", 2" and 2 1/2" Valves

6 Bolts for 3" Valves

6 Bolts for 4", 6" and 8" Valves

Multi-Port Ball Valves

Three, Four, and Five-Way

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3 & 4-way BT

Dimension for

DRAWINGS ARE FOR INFORMATION PURPOSES ONLY...
PLEASE CONSULT FACTORY PRIOR TO
ANY FABRICATION OR INSTALLATION WORK

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Female NPT

PIPE SIZE (inch)	A Port Center Dia.	B Port to Side Center Dia.	C Center to Side Blank Side Center Dia.	D Center to Bottom	E Height	F Handle	3-Way Valve Material
1"	1.06"	1.75"	2.75"	3.80"	6.12"	13	13
1 1/4"	1.08"	2.94"	2.75"	3.80"	6.12"	16	16
1 1/2"	1.62"	3.95"	2.84"	4.75"	12.00"	20	20
2"	1.62"	3.83"	2.84"	4.75"	12.00"	35	35

150# RF Flange (F15)

PORT SIZE	A1 Center Dia.	C1 Center Dia.	I Port to Side Center Dia.	J Center to Bottom	K Height	L Handle	3-Way Valve Material
1"	4.05"	5.10"	5.00"	3.80"	6.12"	13	13
1 1/4"	4.05"	5.10"	5.00"	3.80"	6.12"	16	16
1 1/2"	5.02"	5.17"	6.00"	4.75"	12.00"	20	20
2"	5.02"	5.17"	6.00"	4.75"	12.00"	35	35

*1 Port shown. See flow charts, pages 5 & 6, for other possibilities.
**Weights for Aluminum and for 4 Way stripped upon request.

Cv Factors for MP and BT Series Ball Valves

Cv is defined as the number of U.S. gallons of water per minute, at standard conditions (60°F @ 14.7 PSIA) that will flow through a valve at a 1 PSIG pressure drop across the valve.

Pipe Size	PBM Code	Straight Thru Cv	Side Cv	LL Port Cv
1/2"	12	16	10	8
3/4"	13	16	10	8
1"	14	45	25	22
1 1/4"	15	45	25	22
1 1/2"	16	100	56	46
2"	17	180	100	78
3"	19	228	127	90
4"	20	405	225	175

Nomenclature

- GPM — U.S. Gallons per Minute
- W — Pound per hour*
- Q — Cubic feet per hour @ 60°F and 14.7 PSIA
- G — Specific Gravity
- V̇ — Specific volume of inlet steam
- *F — Inlet gas temperature
- P₁ — Inlet pressure in PSIA
- P₂ — Outlet pressure in PSIA
- ΔP — Pressure drop across the valve in PSI. Must not be greater than half the absolute inlet pressure

PSIA = PSIG + 14.7

*Pounds per hour may be converted to standard cubic feet per hour by the following formula.

$$Q = \frac{W}{0.0764 G}$$

The Sizing Formulas

(1). LIQUID:

$$C_v = \text{GPM} \sqrt{\frac{G}{\Delta P}}$$

$$\text{GPM} = C_v \sqrt{\frac{\Delta P}{G}}$$

$$\Delta P = \left[\frac{\text{GPM}}{C_v} \right]^2 (G)$$

(2). SATURATED STEAM

$$C_v = \frac{W}{2.1 \sqrt{\frac{1}{\Delta P (P_1 + P_2)}}}$$

$$W = 2.1 C_v \sqrt{\Delta P} \sqrt{P_1 + P_2}$$

$$\Delta P = \left[\frac{\bar{V}}{0.0159 W} \right]^2 C_v^2$$

(3). GAS:

$$C_v = \frac{Q}{1360} \sqrt{\frac{G (460 + ^\circ F)}{\Delta P}} \sqrt{\frac{2}{P_1 + P_2}}$$

$$Q = (1360) C_v \sqrt{\frac{\Delta P}{G (460 + ^\circ F)}} \sqrt{\frac{P_1 + P_2}{2}}$$

$$\Delta P = \left[\frac{Q}{(1360) C_v} \right]^2 \left[\frac{(460 + ^\circ F) G}{P_1} \right]$$

equipe

Model CMF300

Mass Flow

and Density Sensor

Direct mass flow and density measurement at flow rates from 0 to 10,000 lb/min (0 to 272,100 kg/hr).

Measurement
Control
Analytical
Utilities

ROSEMOUNT

MICRO MOTION

Model CMF300

Micro Motion's ELITE™ Model CMF300 sensor offers the most accurate mass flow and density measurement for a variety of fluid processes, while exhibiting exceptionally low pressure drop. The flow tubes can accommodate up to 1450 psig (100 bar) and the compact housing safely contains pressure up to 150 psig (10 bar).

The Model CMF300, working with the microprocessor-based ELITE™ Model RFT9739 transmitter, directly measures the mass flow and density of process fluids at flow rates from 0 to 10,000 lb/min (0 to 272,100 kg/hr) and temperatures from -400 to 400°F (-240 to 204°C). The sensor and explosion-proof transmitter can be installed in the same hazardous area.

The Model CMF300 is available in a wide selection of standard fluid connections for virtually any fluid process.

CMF100
CMF150
CMF160
CMF200
CMF300

CMF300 physical specifications

Dimensions in
inches
(mm)

Fittings table

Description of 316L stainless steel fittings	Fitting code	Dim. A Face-to-face	Dim. B Outside diam.
3" ANSI 150 lb weld neck raised face flange	355	33 11/16 (856)	7 1/2 (191)
3" ANSI 300 lb weld neck raised face flange	356	34 7/16 (875)	8 1/4 (210)
3" ANSI 600 lb weld neck raised face flange	357	35 9/16 (894)	8 1/4 (210)
4" ANSI 150 lb weld neck raised face flange	425	34 1/16 (865)	9 (229)
4" ANSI 300 lb weld neck raised face flange	426	35 (889)	10 (254)
4" ANSI 600 lb weld neck raised face flange	427	36 11/16 (932)	10 3/4 (273)
3" sanitary fitting	361	32 (813)	3 9/16 (90)
80 mm DIN PN40 weld neck, DIN 2526, type C facing	391	32 7/8 (835)	7 7/8 (200)
100 mm DIN PN40 weld neck, DIN 2526, type C facing	392	33 7/16 (849)	9 1/4 (235)
80 mm DIN PN40 weld neck, DIN 2512, type N grooved facing	393	32 7/8 (835)	7 7/8 (200)
100 mm DIN PN40 weld neck, DIN 2512, type N grooved facing	394	33 7/16 (849)	9 1/4 (235)
80 mm DIN PN100 weld neck, DIN 2526, type C facing	395	34 9/16 (878)	9 1/16 (230)
100 mm DIN PN100 weld neck, DIN 2526, type C facing	396	35 9/16 (903)	10 7/16 (265)
80 mm DIN PN100 weld neck, DIN 2512, type N grooved facing	397	34 9/16 (878)	9 1/16 (230)
100 mm DIN PN100 weld neck, DIN 2512, type N grooved facing	398	35 9/16 (903)	10 7/16 (265)
80 mm JIS 10K weld neck, JIS facing	400	33 3/8 (848)	7 5/16 (186)
100 mm JIS 10K weld neck, JIS facing	401	33 9/16 (852)	8 1/4 (210)
80 mm JIS 20K weld neck, JIS facing	402	33 3/8 (848)	7 7/8 (200)
100 mm JIS 20K weld neck, JIS facing	403	33 9/16 (852)	10 1/16 (256)
Special - contact factory	999	----	----

Description of Hastelloy® C-22 fittings

3" ANSI 150 lb lap joint flange	550	33 11/16 (856)	7 1/2 (191)
3" ANSI 300 lb lap joint flange	551	34 7/16 (875)	8 1/4 (210)
80 mm JIS 10K lap joint flange, JIS facing	552	33 3/8 (848)	7 5/16 (186)
80 mm DIN PN40 lap joint flange, DIN 2526, type C facing	553	32 7/8 (835)	7 7/8 (200)

Low Rate vs. Pressure Drop

Finding pressure drop of process fluids with a viscosity near 1 centipoise (1 cp)

1. The pressure drop charts shown above have several curves, which represent different viscosity (cp) values. For fluids with a viscosity similar to water, use the curve labeled 1 cp.
2. Locate the point on the English Units or Metric Units graph where the vertical line representing the desired flow rate intersects the curve labeled 1 cp.
3. From that point, locate the nearest horizontal line, then refer to the left side of the graph, which indicates pressure drop (in psi or bar) at the desired flow rate.
4. Divide the pressure drop indicated on the graph by the specific gravity (S) of the process fluid relative to water:

$$\Delta P_{\text{actual}} = \Delta P_{\text{plotted}} / S_{\text{relative to water}}$$

Finding pressure drop of process fluids with a viscosity above 1 centipoise (1 cp)

1. The pressure drop charts shown above have several curves, which represent different viscosity (cp) values. Use method a or b, below, to find the process fluid viscosity ($f_{\text{viscosity}}$).
 - a. For fluids with a viscosity between any two values plotted on the English Units or Metric Units graph, interpolate the approximate $f_{\text{viscosity}}$ location.
 - b. For fluids with a viscosity above the highest value plotted on the graph, find the ratio of actual viscosity to plotted viscosity:

$$f_{\text{viscosity}} = \text{cp}_{\text{actual}} / \text{cp}_{\text{plotted}}$$

2. Multiply the pressure drop indicated on the left side of the graph by the $f_{\text{viscosity}}$ value from step 1:

$$\Delta P = \Delta P_{\text{plotted}} \times f_{\text{viscosity}}$$

3. To find the actual pressure drop, divide the ΔP from step 2 by the specific gravity (S) of the process fluid relative to water:

$$\Delta P_{\text{actual}} = \Delta P / S_{\text{relative to water}}$$

CMF300 performance specifications

Flow

Maximum range

0 to 10,000 lb/min (0 to 272,100 kg/hr)

Rangeability

80:1

Accuracy

$\pm 0.15\% \pm \{(\text{zero stability} / \text{flow rate}) \times 100\}\%$ of rate

Repeatability

$\pm 0.05\% \pm \{1/2(\text{zero stability} / \text{flow rate}) \times 100\}\%$ of rate

Zero stability¹

0.25 lb/min (6.80 kg/hr)

Density

Accuracy

± 0.0005 g/cc

Repeatability

± 0.0002 g/cc

Temperature

Accuracy

$\pm 1^\circ\text{C} \pm 0.5\%$ of reading in $^\circ\text{C}$

Rating

-400° to 400°F (-240° to 204°C)

Pressure influence on sensor²

Flow outputs

$-0.0006\%/psi$ ($-0.009\%/bar$)

Density outputs

$+0.0000002$ g/cc/psi ($+0.0000029$ g/cc/bar)

Pressure ratings

(Based on ASME B31.3)

Flow tubes

1450 psig (100 bar)

Housing

150 psig (10 bar)

Milliamp output rangeability

(for either 4-20 mA or 0-20 mA)

	Minimum span	Range limit
Flow	125 lb/min (3400 kg/hr)	-10,000 to 10,000 lb/min (-272,100 to 272,100 kg/hr)
Density	0.1 g/cc	0 to 5 g/cc
Temperature	36°F (20°C)	-400° to 400°F (-240° to 204°C)

Hazardous area classifications

Intrinsically safe when properly connected to an approved transmitter.

UL and CSA Class I, Div. 1, Groups C and D
Class I, Div. 2, Groups A, B, C, and D
Class II, Div. 1, Groups E, F, and G

CENELEC Exib IIB

SAA Exib IIB

Wetted materials

316L stainless steel
Hastelloy[®] C-22

Housing materials

304L stainless steel

Shipping weight

162 lb (73.5 kg) with 3" ANSI 150 lb weld neck raised face flange

¹ Zero set at process temperature $\pm 36^\circ$ ($\pm 20^\circ\text{C}$).

² Pressure influence can be minimized or eliminated through a variety of techniques. Contact your local sales representative or Micro Motion for more information.

Appendix N

NOTE:
1. FOR GENERAL NOTES, LEGEND AND KEY PLAN, SEE DWG H-2-818518.

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

PROJECT W-32C

HYDRAULIC DIAGRAM

2010-01-01 00:00:00

1001	H-2-81853	ED4310	1001
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1	ENCL 19	1
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6

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LIFTING YORE ASSEMBLY, SEE H-2-81849B, ASSY 5

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DIMENSIONING AND TOLERANCING SHALL BE INTERPRETED PER
ANSI Y14.5-1982
DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
UNSPECIFIED TOLERANCES SHALL BE:
DECIMAL .X ± .1 .XX ± .03 .XXX ± .010
ANGULAR ± 2°
ALL IMPLIED 90° ANGLES SHALL BE PERPENDICULAR WITHIN
THE GREATEST TOLERANCE OF THE LINEAR DIMENSIONS
ALL COAXIAL FEATURES SHALL BE CONCENTRIC WITHIN
.030 DIAMETER, UNLESS OTHERWISE SPECIFIED.

NUMBER	TITLE	NUMBER	TITLE
1	W-320 TANK 241-C-106 SLUICING	2	W-320 TANK 241-C-106 SLUICING
3	W-320 TANK 241-C-106 SLUICING	4	W-320 TANK 241-C-106 SLUICING

W-320-100X GEN DWG REV PER ECN -223, -226, -232 & -428 REV TO INCORP ECNS W-320-155	BAM 9-8 96	REV DATE REV DATE	REV DATE REV DATE
W-320-100X GEN DWG REV PER ECN -223, -226, -232 & -428 REV TO INCORP ECNS W-320-155	BAM 9-8 96	REV DATE REV DATE	REV DATE REV DATE

DESIGNED BY J.R. BYERS	DATE 10/1/84	SAFETY CLASS 3	REV 610535
U.S. DEPARTMENT OF ENERGY RICHLAND OPERATIONS OFFICE ICP KAISER HANFORD COMPANY			
PIPING PUMP AND WINCH ASSEMBLY			
W-320 TANK 241-C-106 SLUICING			
DATE 10/1/84	BY J.R. BYERS	CHKD BY J.R. BYERS	DATE 10/1/84
H-2-818495 1			
2 PLOT SCALE: 1-16 KEH/CAD

4 REDUCER CONNECTION
SCALE: 1/4"

17 NIPPLE-TOP SWIVEL
SCALE: 1/4"

18 NIPPLE-CENTER SWIVEL
SCALE: 1/4"

3 ELBOW CONNECTION
SCALE: 1/4"

5 FLANGE CONNECTION
SCALE: 1/4"

6 WIRE ROPE ASSEMBLY
SCALE: NONE

NOTES:

- ALL PARTS AND MATERIAL AS SPECIFIED OR BUYER APPROVED EQUAL.
- DRAWING FORMAT AND PRESENTATION IS IN ACCORDANCE WITH ANSI/ASME Y14 SERIES.
- ABBREVIATIONS ARE IN ACCORDANCE WITH ASME Y1.1.
- WELDING SYMBOLS ARE IN ACCORDANCE WITH AWS A2.4.
- SURFACE TEXTURE SYMBOLS ARE IN ACCORDANCE WITH ANSI/ASME Y14.36. SURFACE TEXTURE VALUES ARE IN MICROINCHES AND ARE IN ACCORDANCE WITH ANSI/ASME B46.1.
- ALL UNSPECIFIED MACHINED SURFACES SHALL BE 125 V.
- REMOVE ALL BURRS AND BREAK ALL SHARP EDGES TO .06 MAXIMUM.
- ALL UNSPECIFIED MACHINE TOOL RADII SHALL BE .03 MAXIMUM.
- WELDED SURFACES SHALL BE SMOOTH AND UNIFORM IN APPEARANCE WITHOUT ABRUPT CHANGES IN CONTOUR.
- ALL THREADED FASTENERS SHALL BE TIGHTENED TO THE FOLLOWING VALUES:
• 3/4 100 - 120 LB/FT

ELEVATION A-A
ELEVATION B-B

- 1 ASSEMBLY, C-TANK
SCALE: 3/4"=1'-0"
- 2 ASSEMBLY, AY-TANK

[illegible]

NOTES:

- FOR GENERAL NOTES REFER TO DRAWING H-2-818495.
- PUMP SUPPLIED BY OTHERS.
- FOR TECHNICAL SPECIFICATION ON WINCH SYSTEM, SEE PROCUREMENT SPECIFICATION W-320-P24.
- THE TOTAL LIFTED WEIGHT OF THE PUMP/WINCH INSTALLATION AT EACH TANK IS 6650 LBS, WHICH INCLUDES:
 - COMPONENT/ASSEMBLY WEIGHTS
 - WINCH/PUMP ASSEMBLY = 5500 LBS (INCLUDES PUMP WT = 3000 LBS)
 - WINCH PLATE = 720 LBS
 - SHIELD PLATE = 430 LBS
 - TOTAL WT = 6650 LBS
- THE PRELIMINARY SEQUENCE FOR INSTALLING EQUIPMENT AND COMPONENTS FOLLOWING PLACEMENT OF THE COVER BLOCKS WILL INCLUDE THE STEPS SHOWN BELOW. THE FINAL CONFIGURATION AND SEQUENCE OF INSTALLATION SHALL BE IN ACCORDANCE WITH THE WINCH VENDOR'S WRITTEN INSTALLATION INSTRUCTIONS. THE STEPS INCLUDE:
 - WELD LOCK BAR PINS (ITEM 26) ON EMBED
 - PLACE DRIVE ASSEMBLY (ITEM 3 OR 4) THROUGH COVER BLOCK PENETRATION AND ENGAGE DRIVE ASSEMBLY SOCKET WITH WINCH DRIVE NUT.
 - INSTALL SHIM WASHERS (ITEM 27) ONTO LOCK BAR PINS (ITEM 26).
 - INSTALL LOCK BAR ASSEMBLY (ITEM 21) AND ORIENT INTO THE LOCKED POSITION. INSTALL RELEASE PIN (ITEM 28).
 - INSTALL WASHERS (ITEM 31) AND NUTS (ITEM 30) ONTO LOCK BAR PINS (ITEM 26) AND HAND TIGHTEN.
 - INSTALL U-JOINT (ITEM 16) ONTO KEYED END OF DRIVE ASSEMBLY (ITEM 3 OR 4) WITH KEY (ITEM 38). TIGHTEN SET SCREWS ON U-JOINT HUB.
 - INSTALL GEAR REDUCER/MOTOR SUPPORT (ITEM 22) USING WASHERS (ITEM 31) AND NUTS (ITEM 30) ONTO STUDS (ITEM 37). TORQUE NUTS TO TABLE VALUE.
 - INSTALL WORM GEAR DRIVE (ITEM 15) ONTO SUPPORT (ITEM 22) USING BOLTS (ITEM 32). TORQUE TO TABLE VALUE.
 - INSTALL UPPER SHAFT (ITEM 5) WITH KEY (ITEM 39) THROUGH REDUCER (ITEM 15) AND INTO HUB OF U-JOINT (ITEM 16). TIGHTEN SET SCREWS ON U-JOINT HUB.
 - APPLY SUFFICIENT DOWNWARD FORCE ON UPPER SHAFT (ITEM 5) TO DISENGAGE LOCKING PLATE FROM DRIVE NUT OF WINCH ASSEMBLY. DO NOT BOTTOM LOCKING PLATE SPRINGS. LOCK UPPER SHAFT AND KEY (ITEMS 5 AND 39) USING SET SCREWS ON REDUCER HUBS.
 - REMOVE RELEASE PIN (ITEM 28). LOOSEN NUTS (ITEM 30) AND POSITION LOCK BAR ASSEMBLY (ITEM 21) IN THE UNLOCKED POSITION. HAND TIGHTEN NUTS (ITEM 30).

1. INSTALLATION-C TANK

LOOKING NORTH
PUMP ASSEMBLY ROTATED 37°
CCW FOR CLARITY

QTY REQ	PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
1	-010	INSTALLATION C TANK		1	1
1	-020	INSTALLATION AY TANK		2	2
1	-030	DRIVE ASSEMBLY (C-TANK)		3	3
1	-040	DRIVE ASSEMBLY (AY-TANK)		3	4
1	-050	UPPER SHAFT		3	5
1	-060	DRIVE SHAFT (C-TANK)		3	6
1	-070	DRIVE SHAFT (AY-TANK)		3	7
1	H-2-818499-010	ADAPTER PLATE, C-TANK			8
1	H-2-818495-010	PUMP AND WINCH ASSEMBLY, C-TANK			9
1	H-2-818495-020	PUMP AND WINCH ASSEMBLY, AY-TANK			10
1	H-2-818488	WINCH PLATE, C-TANK/AY-FARM			11
1	H-2-818498	SHIELD PLATE, C-TANK/AY-TANK			12
1	H-2-818499-020	ADAPTER PLATE, AY-TANK			13
1	5548HL	SOCKET	PROTO		14
1	121F-10565--H2L010	WORM GEAR DRIVE W/ 2.06CD, 1.5 HP MOTOR W/ 56C FRAME AND BRAKE	MORSE		15
1	D-11B	U-JOINT, BORED FOR Ø1.0 SHAFT W/ KEYWAY	LOVEJOY		16
AR	AR	ROUND Ø1"	ASTM A36 CS		18
AR	AR	ROUND Ø 1-1/2	ASTM A36 CS		19
1	1	PIN, SLOTTED SPRING 1/4 X 1-1/2 L	ANSI B18.8.2/ASTM A-562 (GRADE 1095)		20
1	1	-210			21
1	1	-220			22
1	1	-230			23
2	1	-240			24
2	1	-250			25
2	1	-260			26
2	1	-270			27
1	1	98404A520	QUICK RELEASE PIN, 1/2" x 4" LG	MCMASTER-CARR #95	28
1	1	90312A32	LANYARD, 1/16" DIA WITH NYLON COAT AND TAB x 12" L	MCMASTER-CARR #95	29
6	6	NUT, HEAVY HEX 1/2"-13 UNC-2B	ASTM A 563 GR B		30
6	6	WASHER, 1/2" PLAIN	ASTM F 436 TYPE 3		31
4	4	BOLT, HEX HD, 3/8"-16UNC-2A x 1 1/2" L	ASTM A 307 GR B		32
1	1	SCREW, ROUND HEAD, 1/4-20 UNC-2A x 3/4" L	ASTM A 307 GR B		33
AR	AR	PLATE 3/4" THK	ASTM A 36 CS		35
AR	AR	PLATE 1/2" THK	ASTM A 36 CS		36
4	4	Ø 1/2-13 UNC-2A THREADED STUD	NELSON (TRW)		37
1	1	KEY, BAR 3/8" x 3/8" x 1 1/2" LG	ASTM A 36 CS		38
1	1	KEY, BAR 3/8" x 3/8" x 8" LG	ASTM A 36 CS		39

DRAWING LIST	SHEET	REVISION	TITLE
H-2-818442	1	0	PIPING SWIVELS
H-2-818443	1	0	PIPING FLAT WIRE ROPE
H-2-818444	1	0	PIPING ROSE ASSEMBLY
H-2-818445	1	0	PIPING PUMP & WINCH INSTALL-C TANK & DRAWING LIST
H-2-818446	2	0	PIPING PUMP & WINCH INSTALL-AY TK
H-2-818447	2	0	PIPING WINCH DRIVE ASSEMBLY
H-2-818448	4	0	PIPING WINCH MOTOR ASSEMBLY DETAILS
H-2-818449	4	0	PIPING PUMP AND WINCH ASSEMBLY
H-2-818450	1	0	PIPING WINCH ASSEMBLY
H-2-818451	2	0	PIPING WINCH PARTS LIST AND NOTES
H-2-818452	2	0	PIPING WINCH GEAR HOUSING DETAILS
H-2-818453	3	0	PIPING PUMP WINCH REEL DETAILS
H-2-818454	3	0	PIPING MISCELLANEOUS WINCH DETAILS
H-2-818455	5	0	PIPING PUMP WINCH DETAILS
H-2-818456	6	0	PIPING SHIM WASHERS
H-2-818457	2	0	PIPING SHEAVE ASSEMBLY
H-2-818458	1	0	PIPING SHIELDING PLATE
H-2-818459	1	0	PIPING ADAPTER PLATE C-TANK
H-2-818499	2	0	PIPING ADAPTER PLATE AY-TANK

EXPIRES 1-3-84

DESIGNER	JR BYERS	DATE	3
CHECKED		DATE	6/05/33
APPROVED		DATE	
CONSTRUCTION		DATE	
U.S. DEPARTMENT OF ENERGY			
RESEARCH AND OPERATIONS DIVISION			
ICP KAISER HANDBOOK COMPANY			
PIPING			
PUMP & WINCH INSTALL-C TANK			
& DRAWING LIST			
W-320 TANK 241-C-106 SLUICING			
H-2-818494			
1/24			
1			

ASSEMBLY
SCALE 1 1/2" = 1'-0"

NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH HANDBOOK SPECIFICATION NO. 88-0004, REV. B.
2. JUMPER WEIGHT IS 3750 LB APPROX.
3. JUMPER WEIGHT IS 3750 LB APPROX.
4. ROUTE CABLES APPROXIMATELY AS SHOWN AND SECURE TO SUPPORT SIDE W/IN 31. AVOID IMPACT WRENCH AND LIFTING BALL AREAS.
5. USE (1) COAT OF ANELOCK 400 IN PLACE OF AVERCOT 107 PRIMER AND ANELOCK 23 WHERE REQUIRED BY JUMPER FABRICATION SPECIFICATION.
6. SEE INSTRUCTION SPEC W-30-05, SECTION 13440 FOR FILLING INSTRUCTION AFTER ASSEMBLY.
7. TRIM CABLES FINISHED WITH PN 22 TO 25" LONG. REMOVE HANDLE FROM BALL VALVE (PN 57).
8. TIE EACH END OF TEFION SERIAL WRAPPING (PN 30) WITH NYLON CABLE TIES (PN 31).
9. PRESSURE SENSOR (PN 21) SHALL BE SERIES 40, FOR CLASS 300. FURNISH WITH 100ML OF SILICONE OIL IN A SEPARATE CONTAINER.

COUNT ON SHEET 21		PART/DESCRIPTION		MATERIAL/REFERENCE	
32	2	GASKET, 3" FLANGE, 1/8" THK	COMPRESSED BLUE GARD		
31	AR	CABLE TIE NYLON 6/0 CROSS	PANOUT		
30	AR	CABLE TIE NYLON 6/0 CROSS	PANOUT		
29	1	WIRE ASSY 1/4" x 1/2"	INTERVAL EASTMAN		
28	1	REDUCING BUSHING, 3/4" x 1/2"	APLTON		
27	1	CABLE FITTING, 1/2" MNPT x	GRUUSE-HINDS		
26	3	CABLE FITTING, 3/4" MNPT x	GRUUSE-HINDS		
25	5	CABLE, 3C, #16 AWG	ALPHA		
24	2	CABLE, 3C, #16 AWG	ROCKWELL III		
23	2	CABLE FITTING, 1/2" MNPT x	GRUUSE-HINDS		
22	1	PRESSURE TRANSDUCER, (PD)	CONSTR SPEC		
21	1	PRESSURE SENSOR, 3"	REG VALVE CO, INC		
20	1	PUMP, 1/2" INLET	REG VALVE CO, INC		
19	1	CONDUIT RED BUSHING, 1/2" x 1/2"	APLTON ELECTRIC		
18	1	CABLE, 2 TW SH PR #16 AWG	ROCKWELL III		
17	1	KICK-OFF PL, 4" STD ROUND			
16	1	GASKET, 4" TYPE III			
15	1	NOZZLE, MALE, 4"			
14	1	CONN, VERT, 4"			
13	1	PLATE, 3/8" THK	ASTM A 36		
12	1	PLATE, 1" THK	ASTM A 240 304L		
11	1	PLATE, 1" THK x 11 5/8" DIA	ASTM A 240 304L		
10	1	PLATE, 1/2" THK	ASTM A 36		
9	1	PLATE, 3/8" THK	ASTM A 36		
8	1	PLATE, 3/8" THK	ASTM A 36		
7	1	PLATE, 3/8" THK	ASTM A 36		
6	1	PLATE, 3/8" THK	ASTM A 36		
5	1	PUMP BASE SUB-ASSY			
4	1	LIFTING FRAME SUB-ASSY			
3	1	ASSEMBLY			
2	1				
1	1				

REVISIONS		DATE		BY	
1	1	11/1/80	11/1/80	11/1/80	11/1/80
2	1	11/1/80	11/1/80	11/1/80	11/1/80
3	1	11/1/80	11/1/80	11/1/80	11/1/80
4	1	11/1/80	11/1/80	11/1/80	11/1/80
5	1	11/1/80	11/1/80	11/1/80	11/1/80
6	1	11/1/80	11/1/80	11/1/80	11/1/80
7	1	11/1/80	11/1/80	11/1/80	11/1/80
8	1	11/1/80	11/1/80	11/1/80	11/1/80
9	1	11/1/80	11/1/80	11/1/80	11/1/80
10	1	11/1/80	11/1/80	11/1/80	11/1/80
11	1	11/1/80	11/1/80	11/1/80	11/1/80
12	1	11/1/80	11/1/80	11/1/80	11/1/80
13	1	11/1/80	11/1/80	11/1/80	11/1/80
14	1	11/1/80	11/1/80	11/1/80	11/1/80
15	1	11/1/80	11/1/80	11/1/80	11/1/80
16	1	11/1/80	11/1/80	11/1/80	11/1/80
17	1	11/1/80	11/1/80	11/1/80	11/1/80
18	1	11/1/80	11/1/80	11/1/80	11/1/80
19	1	11/1/80	11/1/80	11/1/80	11/1/80
20	1	11/1/80	11/1/80	11/1/80	11/1/80
21	1	11/1/80	11/1/80	11/1/80	11/1/80
22	1	11/1/80	11/1/80	11/1/80	11/1/80
23	1	11/1/80	11/1/80	11/1/80	11/1/80
24	1	11/1/80	11/1/80	11/1/80	11/1/80
25	1	11/1/80	11/1/80	11/1/80	11/1/80
26	1	11/1/80	11/1/80	11/1/80	11/1/80
27	1	11/1/80	11/1/80	11/1/80	11/1/80
28	1	11/1/80	11/1/80	11/1/80	11/1/80
29	1	11/1/80	11/1/80	11/1/80	11/1/80
30	1	11/1/80	11/1/80	11/1/80	11/1/80
31	1	11/1/80	11/1/80	11/1/80	11/1/80
32	1	11/1/80	11/1/80	11/1/80	11/1/80

U.S. DEPARTMENT OF ENERGY
JUMPER ASSEMBLY
C-06A-B-(A)
PUMP P11
W-320 TANK 241-C-106 SLICING
H-2-818508

1 ASSEMBLY
SCALE: 1" = 1'-0"

NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH HANDBOOK SPECIFICATION HS-BB-0084, REV B.
2. HYDROSTATIC TEST AT 40 PSIG.
3. JUMPER WEIGHT IS 675 LB APPROX.
4. ROUTE CABLES APPROPRIATELY AS SHOWN AND SECURE TO SINK BALL ASSEMBLY.
5. AVOID TYPICAL PN 25. AVOID TAPAL WRENCH AND DO NOT USE ALLEYS.
6. PRESSURE SENSOR PN 190 SHALL BE SERIES 40 FOR CLASS 3000 AND SERIES 400 FOR CLASS 30000. THE PRESSURE SENSOR SHALL BE IN SEPARATE COMPARTMENT FURNISHED WITH 100' OF SPIRAL SLICED WITH 1" SPANATE CONDUIT.
7. INSULATION SHALL BE 1/2" THICK FOAM POLYURETHANE SECTION 12440 FOR FILLING UNDER INSULATION AND 1/2" THICK FOAM POLYURETHANE HANDLING UNDER INSULATION AFTER ASSEMBLY. AFTER FILLING, REMOVE HANDLE FROM BALL VALVE (PN 14).
7. THE EACH END OF THE OPTICAL WRAPPING EPI 240 WITH NIKON LASER CABLES FURNISHING WITH PN 16 TO 25 LONG
8. PRIOR TO INSTALLATION PN 21.
9. USE 1" GANT OF AMERCOAD 400 IN PLACE OF AMERCOAD 187 PRIMER AND SEALANT SECTION.

ITEM NO.	QUANTITY	PART/SUB NUMBER	QUANTITY	ASSEMBLY	DESCRIPTION	MATERIAL/REFERENCE	SHEET NO.
1	1	-010	1	ASSEMBLY	LIFTING FRAME SUB-ASSY		1
2	1	-020	1				2
3	1		1				3
4	1		1				4
5	1		1				5
6	1		1				6
7	1	H-2-32440-1	1	CONN, HORIZ 4"			7
8	1	H-2-32440-2	1	CONN, VERT, 4"			8
9	2	H-2-3997-B	2	GASKET 4 TYPE III			9
10	1	H-2-90761-15	1	LIFTING BAIL			10
11	1		1				11
12	1		1				12
13	1	FE-136'6	1	FLOWMETER, 4"		CONSTRUCTION SPEC W-320-C5	13
14	1	SS-4344	1	BALL VALVE 1/4"		WHITE	14
15	1	PE-1362	1	PRESSURE SENSOR, 4"		RED VALVE CO. INC.	15
16	1	PE-1362	1	PRESSURE TRANSDUCER, 1PD		CONSTRUCTION SPEC	16
17	1	SS-4347	1	STREET TEE, 1/4" NPT		CAJON	17
18	1	CSB196-SG	1	GAS FITTING, 1/2" NPT x		CHOUSE-HINOS	18
19	1	146-5700	1	CABLE 2 TW SH PR 116 AWG W/OVERALL SHEILD PR x 25' L		ROCKBROSSTO	19
20	1		1				20
21	1		1				21
22	1		1				22
23	1		1				23
24	1	RT50T	1	CABLE TIE/ON SPIRAL WRAPPING x 1/8" IN AS REQD		PANDUIT	24
25	1	PL7H-L	1	CABLE TIE, NYLON HYV CROSS SECTION x L, AS REQD		PANDUIT	25
26	1		1	GASKET, 4" FLANGE, 1/8" THK		COMPRESSER FIBER GLASSLOCK BLUE GASK	26
27	1		1				27
28	1		1				28

(CONT ON SHEET 2)

[illegible]

1	GEN DMC REV PER ECM W-320-XXX W-320-414, -395 & -179 REV TO INCORP ECMS	RMS W/AM	REV DATE	ECO APPROVALS	REV
	DESCRIPTION		REVISIONS		
W	REV				
ECO FILE	B505AR1	ECO 0004	W1N95ACD2-12-055		

DATE	2-2-81	BY	81423	REVISIONS	
DESCRIPTION	DRAWING LIST				
PROJECT	H-2-818524				

[illegible]

1
SCALE: 1"= 1'-0"

INF-2477, Rev. 0
Page B-174

1

STATION

ADAPTER FLG SUB-ASSY (2)

DETAIL A

SCALE: 2"=1'-0"

5 PLATE
SCALE: 2"=1'-0"

DETAIL B

SCALE: 2"=1'-0"

DETAIL A

SCALE: 2"=1'-0"

- NOTES:
1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH HANDBOOK SPECIFICATION MS-55-000, REV B.
 2. HYDROSTATIC TEST AT 480 PSIG.
 3. MATERIAL FOR PART 1 AND 15 SHALL BE ASTM A375-30AL.
 4. HEAT TREATING PER DRAWING 15-57331 IS NOT REQUIRED.
 5. PAINTS AND AMERCON 400 IN PLACE OF AMERCON 18.
 6. FABRICATION SPECIFICATION.
 7. DRAIN CLOSURE PLUG MUST BE REMOVED FROM NORMAL OPERATION, WHEN CLOSURE BLOCKS ARE IN PLACE.

QTY REQD	QTY INST	PART / ASM NUMBER	MANUFACTURE DESCRIPTION	MATERIAL / REFERENCE	SHEET NO
1	1	-010	DISTRIBUTION ASSEMBLY		1
2	1	-020	ADAPTER FLG SUB-ASSY		2
1	1	-030	DIST HEAD SUB-ASSY		3
4	4	-001	PLATE, 1/2" THK	ASTM A 36	4
6	1	-003	PLATE, 1 1/2" THK X 51" OD X 28" ID	ASTM A 240 TP304L	6
7	1	-004	PLATE, 1 1/2" THK X 36" OD X 28" ID	ASTM A 240 TP304L	7
8	1	-004	PLATE, 1 1/2" THK X 36" DIA	ASTM A 240 TP304L	8
9					9
1	1	H-2-9187-3	NOZZLE, MALE CONN X 4" SCHED 80		10
2	2	H-2-9185-2	NOZZLE, MALE CONN 2"		11
2	2	H-2-64426-1	TRUNION		12
1	1	H-2-57331-1	DOWNEL LONG	SEE NOTE 3	13
1	1	H-2-57331-2	DOWNEL SHORT	SEE NOTE 3	14
15					15
16					16
17					17
8	2	BAR, 1" DIA X 5" LG	ASTM A 36	ASTM A 276 TP304L	18
19	2	BAR, 2" DIA X 5" LG	ASTM A 36	ASTM A 276 TP304L	19
4		BAR, 3/8" DIA X 6" LG	ASTM A 276 TP304L	ASTM A 276 TP304L	20
AR	AR	P/PC, 4" SCHED 80S	ASTM A 312 GR TP 304L	ASTM A 312 GR TP 304L	21
2	2	P/PC, 2" SCHED 40S	ASTM A 312 GR TP 304L	ASTM A 312 GR TP 304L	22
AR	AR	P/PC, 2" SCHED 80S X 6" LG	ASTM A 312 GR TP 304L	ASTM A 312 GR TP 304L	23
24	2	P/PC, 2" SCHED 80S	ASTM A 312 GR TP 304L	ASTM A 312 GR TP 304L	24
25		TFC, 4" SCHED 80S BW	ASTM A 403 WP-5 304L	ASTM A 403 WP-5 304L	25
26		ROGR, 4" X 2" ECC SCHED 80S BW	ASTM A 403 WP-5 304L	ASTM A 403 WP-5 304L	26
AR	AR	SHEET, 11 GA X 7" WIDE	ASTM A 240 TP304L	ASTM A 240 TP304L	27
28	AR	BAR, 3/8" DIA	ASTM A 276 TP304L	ASTM A 276 TP304L	28
30	1	PLATE, 1 1/4" THK X 6 1/2" DIA	ASTM A 240 TP304L	ASTM A 240 TP304L	30
31	AR	PLATE, 1/4" THK X 3" WIDE	ASTM A 240 TP304L	ASTM A 240 TP304L	31

[illegible]

PLAN

ELEVATION

3 DIST HEAD SUB-ASSY

7 PLATE

8 PLATE

ELEVATION

DETAIL C

IDENT LOCATION

DETAIL D
SCALE: 2\"/>

NOTES:
1. FOR NOTES, SEE SHEET 1.

CONSTRUCTION		605537	
DESIGNED BY	C. D. JONES	DATE	10/1/78
CHECKED BY	R. G. JONES	DATE	10/1/78
U.S. DEPARTMENT OF ENERGY		JOP MATER. MANUFACT. COMPANY	
PIPING		DISTRIBUTOR ASSEMBLY	
PLAN, ELEVATION & DETAILS		PLAN, ELEVATION & DETAILS	
REV. 1		REV. 2	
REV. 3		REV. 4	
REV. 5		REV. 6	
REV. 7		REV. 8	
REV. 9		REV. 10	
REV. 11		REV. 12	
REV. 13		REV. 14	
REV. 15		REV. 16	
REV. 17		REV. 18	
REV. 19		REV. 20	
REV. 21		REV. 22	
REV. 23		REV. 24	
REV. 25		REV. 26	
REV. 27		REV. 28	
REV. 29		REV. 30	
REV. 31		REV. 32	
REV. 33		REV. 34	
REV. 35		REV. 36	
REV. 37		REV. 38	
REV. 39		REV. 40	
REV. 41		REV. 42	
REV. 43		REV. 44	
REV. 45		REV. 46	
REV. 47		REV. 48	
REV. 49		REV. 50	
REV. 51		REV. 52	
REV. 53		REV. 54	
REV. 55		REV. 56	
REV. 57		REV. 58	
REV. 59		REV. 60	
REV. 61		REV. 62	
REV. 63		REV. 64	
REV. 65		REV. 66	
REV. 67		REV. 68	
REV. 69		REV. 70	
REV. 71		REV. 72	
REV. 73		REV. 74	
REV. 75		REV. 76	
REV. 77		REV. 78	
REV. 79		REV. 80	
REV. 81		REV. 82	
REV. 83		REV. 84	
REV. 85		REV. 86	
REV. 87		REV. 88	
REV. 89		REV. 90	
REV. 91		REV. 92	
REV. 93		REV. 94	
REV. 95		REV. 96	
REV. 97		REV. 98	
REV. 99		REV. 100

② INSTALLATION-AY TANK
LOOKING NORTH
PUMP ASSEMBLY ROTATED 82°
CCW FOR CLARITY

U.S. DEPARTMENT OF ENERGY
FOR KENNEDY SPACE CENTER

CONSTRUCTION
PIPELINE
PUMP & WINCH INSTALL-AY TK

W-330 TANK 241-AY-102 SLUCICE PIT

H-2-818494

1/24

1/24

1/24

NO.	DESCRIPTION	DATE	BY	CHKD.
1	DESIGNED	12/2/78	JR	BT
2	REVISED			
3	REVISED			
4	REVISED			
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2. PLOT SCALE: 1/24

1. KPCAD

QTY	DESCRIPTION	MATERIAL REFERENCE	SHEET NO.	PART/DRAW NUMBER		COUNT
				PC-021	PC-022	
1	ASSEMBLY			010		
2	LIFTING FRAME SUB-ASSY			020		
1	PUMP BASE SUB-ASSY			030		
4						
3	ASTM A 36			001		1
3	ASTM A 36			001		1
6	ASTM A 36			002		1
3	ASTM A 36			003		1
7	ASTM A 36			004		4
8	ASTM A 36			005		1
3	ASTM A 240 304L			006		1
10	ASTM A 240 304L			006		1
11						
12	JUMPER FLUSH BLANK HEAD			010-2-81659-1		
13						
14	CONN. VERT. 4"			M-2-32440-2		2
15	NOZZLE, MALE, 2"			M-2-30185-2		
16	KICKOFF PLATE, 2" ROUND			H-2-3194-6		
17	GASKET 4" TYPE III			H-2-3957-8		2
18						
19						
20	PUMP IN-LINE 3" INLET & 3" OUTLET			P-0622		1
21	FLOWMETER, 4"			FC-0621		
22	BALL VALVE 1/4"			SS-4394		2
23	PRESSURE SENSOR, 4"			PC-0621 & PC-0622		
24	CONDUIT RED BUSHING, 3 1/2" x 2 1/2"			RBS350-250		1
25	CONSTR. SPEC W-250-C7					
26	CAJON			CGP7917		1
27	CORD CONNECTOR, 2 1/2"			CGP7917		1
28	CORD FITTING, 1/2" NPT, 1/4" NPT			CGP7917		2
29	CABLE 3C-500 KCM/KW, 600 V, 1/2" NPT, 1/4" NPT			CGP7917		1
30	CABLE 2 TW SH PR #16 AWG W/ OVERALL SHIELD PR x 25 L			CGP7917		2
31	ROCKEESTOS					
32	ROCKEESTOS					
33	ROCKEESTOS					
34	APPLETON					
35						
36	MOUSE ASSY 1/4" ID FLEX x 25 L					

[illegible]

NOTE:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH HANFORD SPECIFICATION HS-BS-0084 REV. B.
2. HYDROSTATIC TEST AT 480 PSIG.
3. JUMPER WEIGHT IS 325 LB APPROX.
4. USE (1) COAT OF AMERLOCK 400 IN PLACE OF AMERCOAT 187 PRIMER AND AMERCOAT 23. WARE REQUIRED BY JUMPER FABRICATION SPECIFICATION.

U.S. DEPARTMENT OF ENERGY		CONSTRUCTION	
HNF-2477, Rev. 0		241-C-06C	
SLUICE PIT		C-06C-6-A	
JUMPER ASSEMBLY		W-220 TANK 241-C-106 SLUICING	
HNF-2477, Rev. 0		B515A	

ITEM	DESCRIPTION	QUANTITY	UNIT
1	ASSEMBLY	1	EA
2	CONNECTION, VERT. 4"	1	EA
3	CONNECTION, HORIZ. 4"	1	EA
4	CONNECTION, VERT. 4"	1	EA
5	CONNECTION, HORIZ. 4"	1	EA
6	CONNECTION, VERT. 4"	1	EA
7	CONNECTION, HORIZ. 4"	1	EA
8	CONNECTION, VERT. 4"	1	EA
9	CONNECTION, HORIZ. 4"	1	EA
10	CONNECTION, VERT. 4"	1	EA
11	CONNECTION, HORIZ. 4"	1	EA
12	CONNECTION, VERT. 4"	1	EA
13	CONNECTION, HORIZ. 4"	1	EA
14	CONNECTION, VERT. 4"	1	EA
15	CONNECTION, HORIZ. 4"	1	EA
16	CONNECTION, VERT. 4"	1	EA
17	CONNECTION, HORIZ. 4"	1	EA
18	CONNECTION, VERT. 4"	1	EA
19	CONNECTION, HORIZ. 4"	1	EA
20	CONNECTION, VERT. 4"	1	EA

SECTION E-E FROM SH 1

SECTION B-B FROM SH 1

SECTION C-C FROM SH 1

SECTION D-D FROM SH 1

VIEW A-A FROM SH 1

DIMENSIONING AND TOLERANCING SHALL BE INTERPRETED PER
ANSI Y14.5M-1982
DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
UNSPECIFIED TOLERANCES SHALL BE:
DECIMAL X ± .1 XX ± .03 XXX ± .010
ANGULAR ± 2°
ALL IMPLIED 90° ANGLES SHALL BE PERPENDICULAR WITHIN
THE GREATEST TOLERANCE OF THE LINEAR DIMENSIONS
ALL COAXIAL FEATURES SHALL BE CONCENTRIC WITHIN
.032 DIAMETER, UNLESS OTHERWISE SPECIFIED.

REVISION	DATE	BY	CHKD	DESCRIPTION
1	7-21-95	C. ALLEN	W. JONES	REV TO ENCORP ECNS

REVISION	DATE	BY	CHKD	DESCRIPTION
1	7-21-95	C. ALLEN	W. JONES	REV TO ENCORP ECNS

DESIGNED BY: TELANDER	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
CHECKED BY: NIXON J. JAMES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
DESIGNED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
CHECKED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
DESIGNED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
CHECKED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
DESIGNED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
CHECKED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
DESIGNED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING
CHECKED BY: C. D. JONES	DATE: 7-21-95	PROJECT: W-300 TANK 241-C-106 SLUICING

11 COUNTERWEIGHT SCALE: 1/2

DIMENSIONING AND TOLERANCING SHALL BE INTERPRETED PER
 ANSI Y14.5M-1982
 DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
 UNSPECIFIED TOLERANCES SHALL BE
 DECIMAL .X 1.1 .XX ± .03 .XXX ± .010
 ANGULAR ± 2°
 ALL LARGEST 90° ANGLES SHALL BE SPECIFIED AS WITHIN
 THE GUARANTEED TOLERANCE OF THE LINEAR DIMENSIONS
 ALL COAXIAL FEATURES SHALL BE CONSIDERED WITHIN
 .002 DIAMETER UNLESS OTHERWISE SPECIFIED

[illegible]

HNF-2477, Rev. 0

W320-27-046

Flushing Nozzle Lifting Force

FLUOR DANIEL NORTHWEST	CALCULATION IDENTIFICATION AND INDEX	Page <u> i </u> of <u> ii </u> Date <u> 3 / 26 / 1997 </u>
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This sheet shows the status and description of the attached Design Analysis sheets.

Discipline	<u>27, Piping and Vessels</u>	WO/Job No.	<u>W320/E09147</u>	Calculation No.	<u>W320-27-046</u>
Project No. & Name	<u>Project W-320 Waste Retrieval for Tank 241-C-106</u>				
Calculation Item	<u>Flushing Nozzle Lifting Force</u>				

These calculations apply to:

Dwg. No.	<u>H-2-818454, Sht. 3, Detail 8</u>	Rev. No.	<u>1</u>
Dwg. No.	<u>H-2-818501, Sht. 1</u>	Rev. No.	<u>1</u>
Other (Study, CDR)	<u>ECN W-320-587 and USQ TF-97-0214</u>		
		Rev. No.	

The status of these calculations is:

☐ Preliminary Calculations
☒ Final Calculations
☐ Check Calculations (On Calculation Dated _____)
☐ Void Calculation (Reason Voided _____)

Incorporated in Final Drawings? ☐ Yes ☒ No

This calculation verified by independent "check" calculation? ☐ Yes ☒ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature / Date	Rev. 1 Signature / Date	Rev. 2 Signature / Date
Originator	<u>Shene Peterson</u> <u>3/26/97</u>		
Checked by	<u>Danny D. Evans</u> <u>3/27/97</u>		
Approved by	<u>Danny D. Evans</u> <u>3/27/97</u>		
Checked Against	<u>M. Ahmed</u> <u>4.11.98</u>		
Approved Vendor Data			

	INDEX
Design Analysis	Description
Page No.	
<u> i </u>	<u>Calculation Identification and Index</u>
<u> ii </u>	<u>Calculation Cross Index</u>
<u> 1 </u>	<u>Objective, Assumptions, References, Conclusion</u>
<u> 2 </u>	<u>Calculations</u>

Subject Calculation No. W320-27-046

Page ii of ii

[illegible]

~~KEH 1975.00 (12/88)~~

DESIGN ANALYSIS

Calc. No. W320-27-046
Revision 0
Page No. 1 of 2

Client	Milamtec Harford Corporation
Subject	Flushing Nozzle Lifting Force
Date	3/11/97
By	AK Peterson
Checked	3/19/97
By	W. J. Brown
Revised	
By	

This calculation is to support USQ TF-97-0214 and ECU W320-587. The goal is to show a potential accident scenario of not blanking off the flushing nozzle after flushing the sluice line, will not dislodge the cover block plug directly above the nozzle.

Assume that the velocity does not significantly change between the nozzle and just prior to striking the bottom of the plug. Also, assume that the fluid stream does not significantly widen in diameter from the nozzle exit to striking the bottom face of the plug. Assume the maximum flow rate from the inline pump is 680 gpm for the worst case. Assume worst case is for 10% solids with a specific gravity of 1.12. Assume all fluid is being pumped through the nozzle.

The calculation will use the formula for an open jet on a horizontal flat plate and compare the resultant force with the weight of the cover block plug.

References:

- (1) H-2-818454, Sheet 3, Detail 8
- (2) H-2-818561, Sheet 1
- (3) H-2-818503, Sheet 1
- (4) HMF-SD-W320-FDC-001, Rev. 4, Sect. 2.2.2
- (5) Vendor Data: Lawrence Pumps Inc, Vertical Inline, RPM 3056 Item P182
- (6) Lawrence Pumps Inc, Submersible/Slurry, RPM 1760, Item P1361
- (7) Mechanical Engineering Reference Manual, 8th ed., Michael Lindberg, P. 3-29
- (8) H-2-818544, Sheet 2

Conclusion:

The force developed in the worst case situation (2/12 lb) is not sufficient to lift the cover block plug (350 lb).

DESIGN ANALYSIS

 Calc. No. W320-27-046

 Revision 0

 Page No. 2 of 2

 Client Numatec Hanford Corporation

 WO/Job No. E09147 / P2XY01

 Subject Flushing Nozzle Lifting Force

 Date 3/11/97 By TK Peterson

 Checked 3/24/97 By D.L. Evans

 Location 241-AV-102 02 E Sluice Pit

Revised

By

Cover block plug weight = 350

Ref. 1

 $\dot{Q} = 680 \text{ gpm, maximum}$

Ref. 5+6

 Nozzle is 2" ϕ schedule 40, 2 1/8" ID

Ref. 2+3

 specific gravity, $S_p G = 1.12$ for 10% solids

Ref. 4

16" from nozzle to bottom face of plug

Ref. 8

$$F = \left(\frac{\dot{V}_p}{g_c} \right) \sqrt{v_o^2 - 2gh}$$

Ref. 7

Open Jet on Horizontal Plate

$$\rho = (1.12)(62.4 \text{ lb/ft}^3)$$

$$\rho = 69.888 \text{ lb/ft}^3$$

$$g = 32.2 \text{ ft/s}^2 \quad g_c = 32.2 \frac{\text{lbm} \cdot \text{ft}}{\text{lb}_f \cdot \text{s}^2}$$

$$h = 1.33 \text{ ft}$$

$$\dot{V} = (680 \text{ gpm}) \left(0.002228 \frac{\text{ft}^3/\text{s}}{\text{gpm}} \right) = 1.515 \text{ ft}^3/\text{s}$$

$$v_o = \frac{1.515 \text{ ft}^3/\text{s}}{\left(\frac{2.0625 \text{ in}}{2(12 \frac{\text{in}}{\text{ft}})} \right)^2 \pi} = 65.3 \text{ ft/s}$$

$$F = \left(\frac{1.515 \text{ ft}^3/\text{s} \times 69.888 \text{ lbm/ft}^3}{32.2 \frac{\text{ft} \cdot \text{lbm}}{\text{lb}_f \cdot \text{s}^2}} \right) \sqrt{(65.3 \text{ ft/s})^2 - 2(32.2 \text{ ft/s}^2)(1.33 \text{ ft})}$$

$$F = 212.55 \text{ lb}_f \text{ of } 1 \text{ ft} < 350 \text{ lb of plug weight}$$

3

FLUID STATICS AND DYNAMICS

Nomenclature

a	acceleration	ft/sec ²
bhp	brake horsepower	hp
A	area	ft ²
c	speed of sound in fluid	ft/sec
C	compressibility, Hazen-Williams constant, or coefficient	ft ² /lbf, -, -
d	depth, diameter	ft
D	diameter, drag	ft, lbf
ehp	electrical horsepower	hp
E	bulk modulus, energy	lbf/ft ² , ft-lbf
f	Darcy friction factor	-
fhp	friction horsepower	hp
F	force	lbf
F _{va}	velocity of approach factor	-
g	local gravitational acceleration	ft/sec ²
g _c	gravitational constant (32.2)	lbfm-ft/lbf-sec ²
G	mass flow rate per unit area	lbfm/sec-ft ²
h	fluid height, head, depth	ft
H	total head	ft
I	moment of inertia	ft ⁴
k	ratio of specific heats	-
K	minor loss coefficient	-
L	length of pipe, lift	ft, lbf
m	mass	lbfm
ṁ	mass flow rate	lbfm/sec
n	rotational speed	rpm
n _s	specific speed	-
N _F	Froude number	-
N _{Re}	Reynolds number	-
N _W	Weber number	-
p	pressure	lbf/ft ²
P	power	ft-lbf/sec
Q	flow rate	gpm
r	radius	ft
r _A	hydraulic radius	ft
R	specific gas constant	ft-lbf/lbfm-°R

s	length	ft
S.G.	specific gravity	-
t	time	sec
T	absolute temperature	°R
v	velocity	ft/sec
V	volume	ft ³
Ṡ	volumetric flow rate	ft ³ /sec
w	weight	lbf
whp	water horsepower	hp
x	x-coordinate	ft
y	distance, y-coordinate	ft
z	height above datum	ft

Symbols

β	contact angle, beta ratio	°
γ	specific weight	lbf/ft ³
ε	specific roughness	ft
η	efficiency	-
θ	angle	°
μ	absolute viscosity	lbf-sec/ft ²
ν	kinematic viscosity	ft ² /sec
ρ	density	lbfm/ft ³
τ	shear stress	lbf/ft ²
T	surface tension	lbf/ft
v	specific volume	ft ³ /lbfm
φ	angle, deflection angle	°
ω	rotational speed	rad/sec

Subscripts

a	atmospheric
A	added
b	blade
c	centroid, contraction
d	discharge
D	drag
e	equivalent, entrance
E	English, extracted
f	friction, flow
i	inside, inlet

3. F and x are positive to the right. F and y are positive upward.
4. F is the force on the fluid. The force on the walls or support has the same magnitude but opposite direction.
5. The fluid is assumed to flow horizontally from left to right and is assumed to possess no y -component of velocity.

The *momentum* possessed by a moving fluid is defined as the product of mass (in slugs) and velocity (in ft/sec). The g_c term in equation 3.146 is needed to convert pounds-mass into slugs.

$$\text{momentum} = \frac{mv}{g_c} \quad 3.146$$

Impulse is defined as the product of a force and the length of time the force is applied.

$$\text{impulse} = F\Delta t \quad 3.147$$

The *impulse-momentum principle* states that the impulse applied to a moving body is equal to the change in momentum. This is expressed by equation 3.148.

$$F\Delta t = \frac{m\Delta v}{g_c} \quad 3.148$$

Solving for F and combining m and Δt yields equation 3.149.

$$F = \frac{m\Delta v}{g_c \Delta t} = \frac{\dot{m}\Delta v}{g_c} \quad 3.149$$

Since F is a vector, it can be broken into its components

$$F_x = \frac{\dot{m}\Delta v_x}{g_c} \quad 3.150$$

$$F_y = \frac{\dot{m}\Delta v_y}{g_c} \quad 3.151$$

If the fluid flow is directed through an angle ϕ ,

$$\Delta v_x = v(\cos \phi - 1) \quad 3.152$$

$$\Delta v_y = v \sin \phi \quad 3.153$$

There are several fluid applications of the impulse-momentum principle.

A. JET PROPULSION

$$\dot{m}_2 = \dot{m}_1 + \dot{m}_{\text{fuel}} = \frac{\dot{V}_1 \rho_1 + \dot{V}_{\text{fuel}} \rho_{\text{fuel}}}{g_c} \quad 3.154$$

$$F_x = \frac{\dot{V}_2 \rho_2 v_{2x} - \dot{V}_1 \rho_1 v_{1x}}{g_c} \quad 3.155$$

$$F_y = \frac{\dot{V}_2 \rho_2 v_{2y} - \dot{V}_1 \rho_1 v_{1y}}{g_c} \quad 3.156$$

Figure 3.27 Jet Propulsion

B. OPEN JET ON VERTICAL FLAT PLATE

$$\Delta v_y = 0 \quad 3.157$$

$$\Delta v_x = -v \quad 3.158$$

$$F_x = \frac{-\dot{m}v}{g_c} = \frac{-\dot{V}\rho v}{g_c} \quad 3.159$$

Figure 3.28 Open Jet on Vertical Plate

C. OPEN JET ON HORIZONTAL FLAT PLATE

As the jet travels upwards, its velocity decreases since gravity is working against it. By the time the liquid has reached the plate, the velocity has become

$$v_y = \sqrt{v_0^2 - 2gh} \quad 3.160$$

$$\Delta v_x = 0 \quad 3.161$$

$$\Delta v_y = -\sqrt{v_0^2 - 2gh} \quad 3.162$$

$$F = \left(\frac{-\dot{m}}{g_c} \right) \sqrt{v_0^2 - 2gh} \quad 3.163$$

$$= \left(\frac{\dot{V}\rho}{g_c} \right) \sqrt{v_0^2 - 2gh}$$

Figure 3.29 Open Jet on Horizontal Plate

D. OPEN JET ON SINGLE STATIONARY BLADE

v_2 may not be the same as v_1 if friction is present. If no information is given, assume that $v_2 = v_1$.

$$\Delta v_x = v_2 \cos \phi - v_1 \quad 3.164$$

$$\Delta v_y = v_2 \sin \phi \quad 3.165$$

Sluice

SLUICE

**LAWRENCE
PUMPS INC.**

371 MARKET STREET, LAWRENCE, MA 01843-9966

- TOTAL DYNAMIC HEAD
- ◇ EFFICIENCY
- BHP AT 1.12 SP.GR.

Viscosity: 14.17 cps ---

IMPELLER: C55607

CASING: C55608/23-171

TEST NO.: T3549

TEST DATE: 04/22/96

TESTED BY: FVX

ACCEPTED BY:

SV 4/30/96

TOTAL HEAD - FEET

N.P.S.H.R. - FEET

BRAKE HORSEPOWER

EFFICIENCY-PERCENT

CAPACITY-GALLONS PER MINUTE (U.S.)

CUSTOMER: WESTINGHOUSE HANFORD
USER NAME: WESTINGHOUSE HANFORD
P.O. NUMBER: MZ4-XVV-78259
ITEM NUMBER: P-1362

SERIAL NUMBER: 91232-1
PUMP TYPE: VERTICAL INLINE
PUMP SIZE: 3X3X13
SERVICE: RADIOACTIVE SLURRY

IMPELLER TESTED (IN): 13.00
IMPELLER PLOTTED (IN): 13.00
RATED FLOW (GPM): 350
RATED HEAD (FT): 512

SPEED (RPM): 3056
IMP DIA. MIN (IN): 9.00
IMP DIA. MAX (IN): 13.00
IMP EYE AREA (IN²):

SLUICE

**LAWRENCE
PUMPS INC.**

371 MARKET STREET, LAWRENCE, MA 01843-9966

- TOTAL DYNAMIC HEAD
- ◇ EFFICIENCY
- BHP AT 1.12 SP.GR.

Viscosity: 1417 cps ---

IMPELLER: C55662

CASING: C55663/26-200

TEST NO.: T3553

TEST DATE: 04-25-96

TESTED BY: JDA

ACCEPTED BY:

SV 4/30/96

CUSTOMER: WESTINGHOUSE HANFORD	SERIAL NUMBER: 91231-1	IMPELLER TESTED (IN): 11.25	SPEED (RPM): 1760
USER NAME: WESTINGHOUSE HANFORD	PUMP TYPE: SUBMERSIBLE/SLURRY	IMPELLER PLOTTED (IN): 11.25	IMP DIA. MIN (IN): 7.50
P.O. NUMBER: MZA-XVV-78259	PUMP SIZE: 3X4X13	RATED FLOW (GPM): 350	IMP DIA. MAX (IN): 13.00
ITEM NUMBER: P-1361	SERVICE: RADIOACTIVE SLURRY	RATED HEAD (FT): 128	IMP EYE AREA (IN ²):

W320-27-047

W-320 Pit Volumes and In-Out Areas

CALCULATION IDENTIFICATION AND INDEX

Page i of i

Date

03/12/97

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline: PIPING/ VESSALS WO/Job No.: EO9142/ W-320

Calculation No.: W320-27-047

Project No. & Name: PROJECT W-320, TANK 241-C-106 SLUICING

Calculation Item: W-320 PIT VOLUMES AND IN-OUT AREAS,
241-C-106 (Pits 06A and 06C), 241-AY-102 (Pits 02A and 02E)

These calculations apply to:

Dwg. No. None

Rev. No. N/A

Dwg. No. None

Rev. No. N/A

Other (Study, CDR): None

Rev. No. N/A

The status of these calculations is:

☐ Preliminary Calculations

☒ Final Calculations

☐ Check Calculations (On Calculation Dated)

☐ Void Calculation (Reason Voided)

Incorporated in Final Drawings?

☐ Yes ☒ No

This calculation 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	Michael R. Custer <i>Michael R. Custer 3/13/97</i>		
Checked by	<i>Samuel D. 02/01/97</i>		
Approved by	<i>Samuel D. 4/1/97</i>		
Checked Against Approved Vendor Data	<i>A. Ahmed 4.11.98</i>		

INDEX

Design Analysis
Page No.

Description

i	Calculation Identification and Index
1	OBJECTIVE; CRITERIA; DATA; ASSUMPTIONS; METHODS; REFERENCES
2-4	SUMMARY - VOLUME AND AREA INFORMATION
ATTACH. A	ESTIMATED EQUIPMENT VOLUMES/ PENETRATION AND GAP AREAS (17 SHEETS)

DESIGN ANALYSIS

Calc. No.: W320-27-047

Revision: 0

Page No.: 1 of 4

Client: NUMATEC HANFORD CORPORATION
Subject: W-320 PIT VOLUMES AND IN-OUT AREAS

WO/Job No. E09142/ W-320

Date: 03/12/97

By: M. R Custer *MRC*

Checked: *04/01/97*

By: *N. J. JUPLO*

Location: TANK 241-C-106 and 241-AY-102, 200E

Revised:

By:

OBJECTIVE:

The objective of this calculation is to determine the net volumes and air flow areas in and out of pits 06A and 06C at Tank 241-C-106 and pits 02A and 02E AT TANK 241-ay-102.

CRITERIA:

1. N/A

DATA:

1. N/A

ASSUMPTIONS:

1. N/A

METHODS:

1. N/A

REFERENCES:

1. H-2-818448, Sh 1
2. H-2-818450, Sh 1
3. H-2-818453, Sh 1 thru 3
4. H-2-818454, Sh 1 thru 2
5. H-2-818490, Sh 1 thru 2
6. H-2-818494, Sh 1 thru 2
7. H-2-818496, Sh 1 thru 6
8. H-2-818500, Sh 1
9. H-2-818501, Sh 1
10. H-2-818502, Sh 1
11. H-2-818503, Sh 1
12. H-2-818505, Sh 1
13. H-2-818508, Sh 1
14. H-2-818515, Sh 1
15. H-2-818518, Sh 1
16. H-2-818524, Sh 1 and 2
17. H-2-818526, Sh 1 and 2
18. H-2-818537, Sh 1
19. H-2-818542, Sh 1
20. H-2-818543, Sh 1
21. H-2-818544, Sh 1 and 2
22. H-2-818545, Sh 1
23. H-2-818549, Sh 1

DESIGN ANALYSIS

Client: NUMATEC HANFORD CORPORATION
 Subject: W320 PIT VOLUME AND IN-OUT AREAS

WO/Job No. E09142/ W-320

Date: 03/12/97

By: M.R Custer *MRC*

Checked: 04/01/97

By: N. J. JUPLO

Location: 241-C-106 AND 241-AY-102

Revised:

By:

SUMMARY - VOLUMES AND IN-OUT AREAS: (Refer to Attachment A)■ **TANK 241-C-106, PUMP PIT (PIT 06A)**• **PIT FREE VOLUME**a. PIT VOLUME = $14.5 \text{ ft} \times 11.0 \text{ ft} \times 6.4 \text{ ft} = 1020 \text{ cu ft}$

b. INSTALLED EQUIPMENT VOLUME = 41 cu ft

FREE VOLUME = 979 cu ft• **VENTILATION FLOW PATH AREA, PIT TO TANK**

a. 6" HIGH CAPACITY DRAIN = 28.3 sq in (Winch)

b. OTHER PENETRATIONS = NONE

TOTAL FLOW AREA, PIT TO TANK = 28.3 sq in• **VENTILATION FLOW PATH AREA, PIT TO ATMOSPHERE**

a. WINCH DRIVE PORT = 9.5 sq in

b. COVER BLOCK GAPS (NORTH SIDE) = 9.0 sq in

c. COVER BLOCK GAPS (SOUTH SIDE) = 12.0 sq in

TOTAL FLOW AREA, PIT TO ATMOSPHERE:**Maximum = 30.5 sq in****Minimum = 9.5 sq in**■ **TANK 241-C-106, SLUICE PIT (PIT 06C)**• **PIT FREE VOLUME**a. PIT VOLUME = $9.0 \text{ ft} \times 8.5 \text{ ft} \times 7.6 \text{ ft} = 581 \text{ cu ft}$

b. INSTALLED EQUIPMENT VOLUME = 5.0 cu ft

FREE VOLUME = 576 cu ft• **VENTILATION FLOW PATH AREA, PIT TO TANK**

a. 6" HIGH CAPACITY DRAIN = 28.3 sq in (Sluicer)

b. OTHER PENETRATIONS = NONE

TOTAL FLOW AREA, PIT TO TANK = 28.3 sq in

DESIGN ANALYSIS

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WO/Job No. E09142/ W-320

Date: 03/12/97

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Location: 241-C-106 AND 241-AY-102

Revised:

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- VENTILATION FLOW PATH AREA, PIT TO ATMOSPHERE

- a. COVER BLOCKS (NORTH SIDE) = 10.0 sq in

- b. COVER BLOCKS (SOUTH SIDE) = 7.5 sq in

- TOTAL FLOW AREA, PIT TO ATMOSPHERE:

- MAXIMUM = 17.5 sq in

- MINIMUM = 0.0 sq in, however assume 1.0 sq in (Due to incomplete sealing)

- TANK 241-AY-102, PUMP PIT (PIT 02A)

- PIT FREE VOLUME

- a. PIT VOLUME = 12.0 ft x 8.0 ft x 5.0 ft = 480 cu ft

- b. INSTALLED EQUIPMENT VOLUME = 7.7 cu ft

- FREE VOLUME = 472 cu ft

- VENTILATION FLOW PATH AREA, PIT TO TANK

- a. 6" HIGH CAPACITY DRAIN = 28.3 sq in (Distributor)

- b. OTHER PENETRATIONS = NONE

- TOTAL FLOW AREA, PIT TO TANK = 28.3 sq in

- VENTILATION FLOW PATH AREA, PIT TO ATMOSPHERE

- a. VALVE HANDLE - 1/16 in gap @ 3 in. HOLE = 0.9 sq in x 2 = 1.8 sq in

- b. COVER BLOCKS GAPS (EAST/ WEST SIDES) = 107.0 sq in

- c. 3" DIA. PENETRATION (DRAIN SEAL) = 0.6 sq in

- TOTAL FLOW AREA, PIT TO ATMOSPHERE:

- MAXIMUM = 108.2 sq in

- MINIMUM = 1.2 sq in

- TANK 241-AY-102, SLUICE PIT (PIT 02E)

- PIT FREE VOLUME

- a. PIT VOLUME = 8.0 ft x 6.0 ft x 7.0 ft = 336 cu ft

- b. INSTALLED EQUIPMENT VOLUME = 43.0 cu ft

- FREE VOLUME = 293 cu ft

DESIGN ANALYSIS

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Subject: W320 PIT VOLUME AND IN-OUT AREAS

WO/Job No. E09142/ W-320

Date: 03/12/97

By: M.R Custer *MRC*Checked: *04/01/97*By: *H.J. SUPLO*

Location: 241-C-106 AND 241-AY-102

Revised:

By:

- VENTILATION FLOW PATH AREA, PIT TO TANK
 - a. 6" HIGH CAPACITY DRAIN = 28.3 sq in (Winch)
 - b. OTHER PENETRATIONS = NONE
- TOTAL FLOW AREA, PIT TO TANK = 28.3 sq in**
- VENTILATION FLOW PATH AREA, PIT TO ATMOSPHERE
 - a. WINCH DRIVE PORT = 9.5 sq in
 - b. COVER BLOCK GAP (NORTH SIDE) = 9.1 sq in
 - c. COVER BLOCK GAP (NORTH SIDE) = 10.3 sq in

TOTAL FLOW AREA, PIT TO ATMOSPHERE:

MAXIMUM = 28.9 sq in

MINIMUM = 9.5 sq in

ATTACHMENT A

CALCULATION W320-27-047, Revision 0
(TOTAL PAGES = 18, COVER PAGE + 17)

**FLUOR DANIEL
NORTHWEST**

DESIGN ANALYSIS

Client NUMATEC HANFORD CORP.
Subject
Location:

WO/Job No.
Date: 03/12/97
Checked: 04/04/97
Revised:

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By: MRC
By: H. J. JUFLO
By:

TANK 241-AY-102, Pump PIT 02A

- 1) RISERS: a) R- (4")
b) R- (4")

2) FLOOR DRAIN

General Ref. dngs
AY-02A, H-2-818542
AY-02E, H-2-818543
AY-02A, H-2-818544, SH 1 & 2
AY-02E, H-2-818545

2) JUMPER ASSEMBLIES:

- a) H-2-818501 w/ U-11 connector
b) H-2-818502 w/ U-3 & U-8 connectors

3) EQUIPMENT:

a) DISTRIBUTOR (H-2-818537)

4) COVER BLOCKS (H-2-818454, SH. 2)

TANK 241-AY-102, SLUICE PIT 02E

- 1) RISERS:
a) R- (34")

2) JUMPER ASSEMBLIES:

- a) H-2-818503 SH. 1

2.8"

3) EQUIPMENT:

a) WINCH ASSEMBLY (H-2-818494-2)

b) SLUICE BOOSTER PUMP

c) PIT COOLING FAN COIL UNIT/SUPPORT

✓ 1) COOLING FAN COIL UNIT (ISPEC C7, FC-0621)

✓ 2) COOLING FAN COIL SUPPORT (H-2-818490, SH 1 & 2)

4) COVER BLOCKS (H-2-818454, SH 2)

**FLUOR DANIEL
NORTHWEST**

DESIGN ANALYSIS

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By: N. J. JUPLO
By:

TANK 241-C-106, Pump PIT 06A

- 1) RISERS: a) R-5 (4") R-7 —
b) R-6 (12")
c) R-9 (36")
d) FLOOR DRAIN

2) JUMP ASSEMBLIES:

- a) H-2-818505
b) H-2-818508

3) EQUIPMENT:

- a) SLURRY BOOSTER PUMP (H-2-818500)
b) WINCH ASSEMBLY (H-2-818494)
c) EXISTING PUMP, PTX141 (R-6)

- 4) COVER BLOCK (GAPS/PENETRATIONS): H-2-818448, SH 5
a) ELECT. ACCESS SLOT

TANK 241-C-106, SLURGE PIT 06C

- 1) RISERS: R-3 (12"), R-4 (4"), FLOOR DRAIN

2) JUMPER ASSEMBLIES:

- a) H-2-818515
b) H-2-818516

3) EQUIPMENT:

- a) SLURGE ASSEMBLY (H-2-818549)

- 4) COVER BLOCK (GAPS/PENETRATIONS): H-2-818448, SH 2

Ref dwgs

AT 06A H-2-818524 SH 1, 2
PT 06C H-2-818526 SH 1, 2

**FLUOR DANIEL
NORTHWEST**

DESIGN ANALYSIS

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By: W. J. JUPLO
By:

ESTIMATED VOLUMES:

1. DISTRIBUTOR: (241-AY-102, PIT 02A)
 - a) ADAPTER PLATE, $\pi \left[\frac{(51''^2 - 28''^2)}{4} \right] (1.5'') = 2140.6 \text{ in}^3$
 - b) ADAPTER PLATE LUGS, $\left[\frac{(8+4)}{2} (12) (.5) \right] 4 + \left(\frac{3}{2} \right) \pi (4'') = 156.6 \text{ in}^3$
 - c) TRUNIONS, $2 \left[(4\frac{1}{2}'')^2 \pi \times 5'' \right] = 125.7 \text{ in}^3$
 - d) DOWELS, (TOTAL LENGTH, 18'')
FOR 1 PLATE, $18'' (2\frac{1}{2}'')^2 \pi (2) = 113.1 \text{ in}^3$
 - e) R ⑦, $\pi \left[\frac{(36^2 - 28^2)}{4} \right] (1.5'') = 603.2 \text{ in}^3$
 - f) R ⑧, $\pi \left[\frac{(36^2 - 47\frac{1}{8}^2)}{4} \right] (1.5'') = 1498.8 \text{ in}^3$
 - g) CHAMBER BETWEEN ⑦ & ⑧, $5'' (36\frac{1}{2}'')^2 \pi = 5089.4 \text{ in}^3$
 - h) 4" Ø NOZZLE & PIPE, $11.5'' (4\frac{1}{2}'')^2 \pi = 144.5 \text{ in}^3$
 - i) 2" Ø NOZZLE & PIPE, $10.3 (2\frac{1}{2}'')^2 \pi = 32.4 \text{ in}^3$

$$\text{TOTAL VOLUME} = \frac{9904.3 \text{ in}^3}{1778} = 5.7 \text{ FT}^3$$

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

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By:

ESTIMATED VOLUMES: (CONT.)

2. WINCH ASSEMBLY: (241-C-106, PIT 06A/241-AV-102, PIT 02E), EACH

- ADAPTER PLATE (C-Fram), 56" dia, 1 1/2" thick
- Winch PLATE (45" dia, 1 1/2" thick)
- Winch Assembly

a) Volume = $\left(\frac{56}{2}\right)^2 \pi \times 1.5" = 3695 \text{ in}^3$

b) Volume = $\left(\frac{45}{2}\right)^2 \pi \times 1.5" = 2386 \text{ in}^3$

c) Winch Assembly:

1) 1" BASE PLATE: $23.17" \times 22.25" \times 1" = 515.0 \text{ in}^3$

2) Gear box: $13.30" \times 27.25" \times 31.42" = 11,387.0 \text{ in}^3$

3) Sheave w/cable: $\left(\frac{28.0}{2}\right)^2 \pi (3.75") = 2309.0 \text{ in}^3$

4) Idler sheave: $\left(\frac{5}{2}\right)^2 \pi (2.5") = 49.1 \text{ in}^3$

5) HANFORD WHEEL: $\left(\frac{4}{2}\right)^2 \pi (6") = 75.4 \text{ in}^3$

6) DRIVE GUIDE: $\left(\frac{5}{2}\right)^2 \pi (8") = 157.0 \text{ in}^3$

7) Pillow Block/support: $16" \times 2.75" \times 13.25" = 583.0 \text{ in}^3$
sheave

8) DRAW SHAFT: $82.88" \times \left(\frac{1}{2}\right)^2 \pi = 65.6 \text{ in}^3$

9) LIFTING LUGS:
ADAPTER PLATE = $\left[2\left(\frac{5}{2}\right)(12")\left(\frac{8.44}{2}\right) + \left(\frac{5}{2}\right)^2 \pi \times 3"\right] 2 = 162.8 \text{ in}^3$

WINCH PLATE = $\left[2\left(\frac{5}{2}\right)(7")\left(\frac{4.13}{2}\right) + \left(\frac{5}{2}\right)^2 \pi \times 2"\right] 3 = 139.0 \text{ in}^3$

TOTAL VOLUME = $21,523.0 \text{ in}^3 = 12.5 \text{ ft}^3$

**FLUOR DANIEL
NORTHWEST**

DESIGN ANALYSIS

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By:

ESTIMATED VOLUMES: (CONT.)

3.a) Booster Pump: (241-C-106, PIT 06A/241-AY-102 PIT 02E) EACH

1) Motor portion: $60" \times \left(\frac{26"}{2}\right)^2 \pi = 31,856.0 \text{ m}^3$

2) Pump portion (lower): $9" \times \left(\frac{31"}{2}\right)^2 \pi = 3118.0 \text{ m}^3$

3) Pump portion (upper):

$\frac{\pi (20^2 - 18.5^2)}{4} (40") + \left(\frac{7.5}{2}\right)^2 \pi (40") = 3581 \text{ m}^3$

TOTAL VOLUME = $\frac{38565 \text{ m}^3}{1728} = \underline{\underline{22.3 \text{ ft}^3}}$

$A = \frac{\pi (d^2 - d_1^2)}{4}$

3.b) EXISTING PUMP PTX146 (R-6)

VOLUME IN PIT = $10" \phi \times 44", \left(\frac{10"}{2}\right)^2 \pi (44") = 3455.8 \text{ m}^3$

BASE FB, $\approx 1\frac{1}{2}" \times 28" \phi = 923.6 \text{ m}^3$

W4 X13 LUGS (2), $20" \times 3.83 (2) = 153.2 \text{ m}^3$

TOTAL VOLUME = $\frac{4532.6}{1728} = 2.6$

2.6 ft³

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By: *N.J. JUPLO*
By:

ESTIMATED VOLUMES: (CONT.)

4. SLUICER ASSEMBLY:

a) FEED PLATE ASSEMBLY:

④ $1'' [13'' \times 13.5''] + (2\frac{1}{2}'')\pi + (5.5''/2)\pi = 545.6 \text{ in}^3$

$$\textcircled{44} 1.75'' \left[(13'' \times 13.5'') + \frac{\pi (21''^2 - 11.6''^2)}{4} \right] = 728.3 \text{ in}^3$$

3" connector, $4 \left[\frac{3.5^2}{2} \pi \right]$ $= 38.4 \text{ in}^3$
 3" pipe $\left[\left(\frac{3.5^2}{2} \pi \right) (7.5 + 4) \right]$ $= 110.6 \text{ in}^3$

① 4" NO33EL, 4" $[(4.5/2)\pi]$
4" PIPE, $[(4.5/2)\pi(9.82 + 2.5)]$

(61) 12" PIPE w/ HOLES (82.4 m³)
 12" PIPE CHAMBER VOLUME = $\frac{(12.75/2)^2 \pi (16-2.75)}{1691.7 \text{ in}^3} = 1691.7 \text{ in}^3$

④ 3" R, 13.0" x 13.25" x 3" = 516.8 in³

(20) TUBING, 4340, D x 4" ID, $\pi (4.75"/2)^2 \times 44" = 779.7 \text{ in}^3$

$$= 292.5 \text{ m}^3$$

(62) COUNTERWT, $5 \left[4 \times 13.0 \times 3 \right] = 49.9 \text{ m}^3$

$$\textcircled{12} \text{ RAIL, } (1.38/2) \pi [9.4'' + 2(12'')] = 49.9 \text{ m}$$

④ 4" R 4" (12.5" X 13") = 150.0 in

Time: $4'' \text{OD} \times 3'' \text{ID}$ $2'-6''$ long, $(\frac{1}{2})^2 \pi \times 30$

(59) TUBING, 4 O.D. x 3 I.D., 2-6 (10 ft), (4 ft) 100
= 6040.0 in³

$$\text{TOTAL VOLUME} = \frac{6040.0 \text{ m}^3}{1728} = 3.5 \text{ A}^3$$

$$\begin{array}{r} 647-10 \\ \underline{638-4} \\ 9-6 \\ -2-0 \\ \hline 716 \end{array}$$

**FLUOR DANIEL
NORTHWEST**

DESIGN ANALYSIS

Client NUMATEC HANFORD CORP.

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By: N.J. JUPLO

By:

EQUIPMENT VOLUMES: (CONT.)

5. PIT COOLING FAN COIL/SUPPORT: (241-AY-02E)

a) COOLING FAN COIL, $13.25" \times 18.5" \times 36"$ (VOLUME) = 8824.5 in^3

b) (37) 1" PIPING, $(95.17' + 97.17') (1.32/2)'' \pi$ = 263.2 in^3

c) SUPPORT STRUCTURE,

(29) C4 X S4, $1.54 \text{ m}^2 (131.6 \text{ in})$ = 202.7 in^3

(A = 1.54 m^2)

(30) $\angle 2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ (8" LG), 1.19 m^2 (8") = 9.5 m^3

(31) $\angle 1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{4}$ (6" LG), 0.68 m^2 (6") = 4.1 m^3

(32) PL $1\frac{1}{2} \times 4 \times \frac{1}{4}$ THK (6), = 9.0 m^3

(33) PL $12\frac{1}{2} \times 4 \times \frac{1}{2}$ THK (1) = 25.0 m^3

d) 1" PIPE-FITTINGS:

(38) 8, 1" SCH. 40, 90° LR, $8(2.4'') ([(\pi/32/2)'' \pi])$ = 26.3 m^3

(39) 4, 1" SCH. 40, 45° LR, $4(2.4/2) ([(\pi/32/2)'' \pi])$ = 6.6 m^3

e) PINS: TOTAL LGTH = $8' (1\frac{1}{2}') \pi$ = 6.3 m^3

TOTAL VOLUME = $9377 \text{ in}^3 = \underline{\underline{5.4 \text{ ft}^3}}$

**FLUOR DANIEL
NORTHWEST**

DESIGN ANALYSIS

Client NUMATEC HANFORD CORP.
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By: N. J. SUPLO
By:

ESTIMATE VOLUMES: (CONT.)

6. JUMPER ASSEMBLIES (241-AY-102, PIT O2A)

a) H-2-818501: AY-02A-U11-A-C)

$$\left. \begin{matrix} (19) \\ (21) \\ (22) \end{matrix} \right\} 4", (4.5/2)^2 \pi [(65"-12") + (21"-2") + (19"-12") + (15"-6") + 6" + 9.4"(3) + 4.7"] = 1954.6 \text{ m}^3$$

$$(5)(6) \text{ Volume } 6" \phi \times 6" \text{ long, } (6/2)^2 \pi (6)(2) = 339.3 \text{ m}^3$$

$$(10) 2" \text{ PIPE, } (2.38/2)^2 \pi (20") = 89.0 \text{ m}^3$$

$$(11) 4" \phi \times 10", (4/2)^2 \pi (10") + 5.0(\text{misc}) = 130.7 \text{ m}^3$$

$$\text{TOTAL VOLUME} = \frac{2513.3 \text{ m}^3}{1728} = \underline{\underline{1.5 \text{ ft}^3}}$$

b) H-2-818502: AY-02A-U13-UB-B

$$(32) 2" \text{ PIPE, } [(33"-3") + \frac{6\pi}{4}(43"-3") + \frac{6\pi}{4}(76"-33")](2.38/2)^2 \pi = 544.6 \text{ m}^3$$

$$(31) 4" \text{ PIPE, } (12") \times (4.5/2)^2 \pi = 198.9 \text{ m}^3$$

$$(33) 2" \text{ PIPE (6450), } (2.38/2)^2 \pi (2") = 8.9 \text{ m}^3$$

$$(18) 23 \times 4.1 (A=1.21 \text{ m}^2)(21.5") = 26.0 \text{ m}^3$$

$$(19) 22 \times 2 \times 1/4 (A=0.83 \text{ m}^2)(2") = 1.9 \text{ m}^3$$

$$(20) \rightarrow (25), 18 \text{ m}^3 + 3.3 + 5.3 + 4.6 + 5.1 + 1.9 = 38.2 \text{ m}^3$$

$$(5)(7), (3/2)^2 \pi (4") \times 2 = 56.5$$

$$\text{TOTAL VOLUME} = \frac{867 \text{ m}^3}{1728} = \underline{\underline{0.50 \text{ ft}^3}}$$

$$\text{PIT O2A, TOTAL VOLUME} = \underline{\underline{2.0 \text{ ft}^3}}$$

FLUOR DANIEL NORTHWEST

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DESIGN ANALYSIS

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By: H. J. DUPLO
By:

ESTIMATES VOLUMES: (Cont.)

7. JUMPER ASSEMBLIES (241-AY-102, PIT 02E)

a) H-2-818503, SH. 1: AY-02E-U2-A-(B)

55	4x13 ($A=3.8312$), $3.83(60 \times 2)$	=	459.6 in ³
56	23x4.1 ($A=1.2112$), $1.21(73 \times 24)$	=	117.4
57	3x1/2 x (30.5"π)	=	143.7
58	2 1/2 x 3/8 x 2" (4)	=	7.6
59	1 1/2 x 5/8 (2)	=	19.9
60	3/4 x 2 1/8 (4)	=	4.6
61	1/2 x 16" (2)	=	6.3
62	3/8 x 3x6"	=	6.8
63	3/8 x 6" x 6.5"	=	14.6
64	3/8 x 4" x 5"	=	7.5
65	3/8 x 3/8	=	2.9
66	5.5 x 6 x 3/8	=	12.4
67	1 3/8 x 7 3/4 x 3/8	=	4.0
68	10" x 6.5 x 3/8	=	24.4
69	1" x 8 1/2 x 8 1/2	=	72.3
70	4" PIPE, $(4.5 \times 2) \pi [46" - 2(2) + \frac{12}{4} \pi + (8-6) + \frac{12}{4} \pi + (45" - 6) + \frac{12}{4} \pi + (12" - 6)]$	=	1897.0
71	2" PIPE, $(2.38 \times 2) \pi [24"]$	=	106.8
72	4", 300# RF, 10" x 1.5" (4)	=	471.2
73	2", 300# RF, 6.5" x 1.5" (4)	=	199.1
74	(5" x 6" + 6" x 4")	=	230.9
75	6" x 10" [JUMPER FLUSH BOWLHEAD]	=	282.7
76	6" x 8" (2) [CONN. VERT, 4"]	=	452.4
77	3" x 4" [NOZZLE, MALE, 2"]	=	28.2
78	MISCELL	=	200.0

TOTAL VOLUME = 4772 in³ = 2.8 ft³

HEADER1.XLS

FLUOR DANIEL NORTHWEST

DESIGN ANALYSIS

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By: H.J. JUPLO

By:

ESTIMATED VOLUMES: (cont.)

8. JUMPER ASSEMBLIES (241-C-106, PIT-66A)

a) H-2-818505: C-06A-A-A

12D Down 4" (1Hm, 1Vrt), 6"Ø x 8' (2)	= 452.4 m ³
13 Flaremate 4", 5"Ø x 6"	= 117.8
15 Press. Sensor, 6"Ø x 4"	= 113.1
35 C6 x 8.2 (A=2.4m ²), 2.4 (50")	= 120.0
39 1/4 x 6 x 8' (2)	= 24.0
40 2 1/4 x 1 1/2 x 3' (4)	= 7.5
45 4" sch 40, (4.5') ² π [(91'-4"(2) - (6")(3) + 12π(3)]	= 3073.9
46 2" sch 40, (2.38') ² π (27")	= 120.0
48 Flange 4", 300# RF, 10"Ø x 1.5' (4)	= 471.2
○ miscell	= 200.0

TOTAL VOLUME = $\frac{4700 \text{ m}^3}{1728} = \underline{\underline{2.7 \text{ ft}^3}}$

b) H-2-818508: C-06A-B-(A)

43 64 x 13 (A=3.83m ²), 3.8' (56") ²	= 429.0 m ³
44 BAR 3 x 1/2", (31") π (3") (5")	= 146.0
45 2 1/2 x 3/8 x 2' (4)	= 7.5
46 (1 1/2"Ø x 5") (2)	= 17.7
47 (1/2 x 3 x 5) (2)	= 15.0
50 4" PIPE, sch 40, (4.5/2) ² π (6")	= 95.4
51 2" PIPE, sch 40, (2.38/2) ² π (10")	= 44.5
53 Reduc EL (90) sch 40, [(12"π/4) (2) (3/2) ² π]	= 133.2
54 2" 300# RF, 6.5"Ø x 1.5' (2)	= 99.6
55 3" PLUG, (3.5/2) ² π (3")	= 28.9

(cont. pg 11)

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ESTIMATED VOLUMES: (cont.)

8. b) H-2-018508: C-06A-B-(A)

⑤ 4, $(3/8 \times 17/8 \times 7.75) 4$	=	16.0
⑦ 2x, $3/8 \times 6.5 \times 10$	=	48.8
⑧ 1x, $1/2 \times 9.5$	=	14.3
⑨ 1x, $1/2 \times 7 \times 7$	=	24.5
⑪ 4x, $3/4 \times 8 \times 3.5$	=	6.2
⑭ Conn. vent 4"	=	452.4
⑮ Nozzle Mate 4", $(4.5/2)^2 \pi (6")$	=	95.4
⑰ R $1/2 \times 9 \times 6$	=	31.8
⑳ → 32 6" x 6" x 6" (misc.)	=	216.0

$$\text{TOTAL VOLUME} = \frac{1922}{1728} = \underline{\underline{1.1 \text{ ft}^3}}$$

$$\text{PIT OGA, TOTAL VOLUME} = \underline{\underline{3.8 \text{ ft}^3}}$$

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ESTIMATES VOLUMES; (cont.)

9. JUMPER Assemblies: (PIT OGC)

a) H-2-818515; C-OGC-6-A

$$\begin{aligned} \textcircled{1} & 4" \text{ conn. } 2, \left[\left(\frac{6 \frac{1}{2}}{2} \right)^2 \pi \times 8 \right] 2 & = 452.4 \text{ in}^3 \\ \textcircled{2} & \text{ LIFTING BAIL, } \frac{1}{2} \times 33 \times 6 & = 6.5 \\ \textcircled{3} & \frac{1}{4} \times 6 \times 6 & = 9.0 \\ \textcircled{4} & 4" \text{ PIPE SCH. 40, } \left(\frac{4.5}{2} \right)^2 \pi \left[56 + \frac{12}{4} \pi (2) \right] & = 1190.4 \end{aligned}$$

$$\text{TOTAL VOLUME} = \frac{1658 \text{ in}^3}{1728} = \underline{\underline{1.0 \text{ ft}^3}}$$

b) H-2-818516; C-OGC-8-B

$$\begin{aligned} \textcircled{1} & 3" \text{ conn. } (2), \left[\left(\frac{5 \frac{1}{2}}{2} \right)^2 \pi \times 6 \right] 2 & = 235.6 \\ \textcircled{2} & \text{ BAIL & = 6.5} \\ \textcircled{3} & \frac{1}{4} \times 5 \times 5 & = 6.3 \\ \textcircled{4} & 3" \text{ PIPE SCH. 40, } \left(\frac{3.5}{2} \right)^2 \pi \left[39 + \frac{9}{4} \pi (2) \right] & = 511.2 \end{aligned}$$

$$\text{TOTAL VOLUME} = \frac{759.6 \text{ in}^3}{1728} = \underline{\underline{0.4 \text{ ft}^3}}$$

$$\text{PIT OGC, TOTAL VOLUME} = \underline{\underline{1.4 \text{ ft}^3}}$$

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AIR FLOW AREAS: (PIT TO TANK)

1. 241-C-106, PIT 06A (H-2-818522, SH. 1)

<u>PENETRATION No.</u>	<u>SIZE</u>	
R-5	4"Ø	SEALED (SHIELD PLUG w/GASKET)
R-6	12"Ø	(EXISTING PUMP PTXIAN IN PLACE)
R-7	12"Ø	SEALED (FLANGE CAP)
R-9	36"Ø	(WINCH/PUMP ASSEMBLY w/6"Ø HOLE)
FLOOR DRAIN (Sump)	-	PUMP HOSE DRAIN TO 6" WINCH HOLE

2. 241-C-106, PIT 06C (H-2-818523, SH. 1)

<u>PENETRATION No.</u>	<u>SIZE</u>	
R-3	12"Ø	(SLUICER w/6"Ø HOLE)
R-4	4"Ø	SEALED (SHIELD PLUG w/GASKET)
FLOOR DRAIN (Sump)	-	PUMP HOSE DRAIN TO 6" SLUICER HOLE

3. 241-AY-102, PIT 02A (H-2-818542)

<u>PENETRATION No.</u>	<u>SIZE</u>	
RISER	42"Ø	(DISTRIBUTOR w/6"Ø HOLE)
FLOOR DRAIN	4"Ø	SEALED

4. 241-AY-102, PIT 02E (H-2-818543, SH. 1#2)

<u>PENETRATION No.</u>	<u>SIZE</u>	
RISER	34"Ø	(WINCH/PUMP ASSEMBLY w/6"Ø HOLE)
FLOOR DRAIN	4"Ø	SEALED

**FLUOR DANIEL
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AIR FLOW AREAS: PIT TO AIR

1. 241-C-106, PIT 06A (H-2-818448 SAT / THURS)

a) 3 - 8" Ø CAMERA PORTS,

CONDITION / in²

SEALED (SHIELD PLUG W/GASKET)

** b) 1 - 3" VALVE PORT,

SEALED (SHIELD PLUG W/GASKET)

c) 1 - 6" Ø WINCH PORT SLEEVE:
 $A = (6/2)^2 \pi - (1/2)^2 \pi - (3" \times 6") =$

9.5 in²

d) 2 - SLOTS (ELECTRICAL)

SEALED

* e) 2 - COVER BLOCK GAPS (NORTH SIDE)
 $A = (6.75" \times 6") (2)$

9 in² (MAX), (IF NOT TAPED)

* f) 2 - COVER BLOCK GAPS (SOUTH SIDE)
 $A = (6.75" \times 8") (2)$

12 in² (MAX), (IF NOT TAPED)

g) EXIST. 12" RISER

SEALED

h) PUMP PENETRATION

SEALED (SHIELD PLUG W/GASKET)

(*) DURING SLUICING OPERATION, THESE GAPS WOULD BE
TAPED ELIMINATING THIS AREA FOR AIR TO FLOW.

(**) ALWAYS OPEN

$$\text{MAX. } 9 + 12 + 9.5 = 30.5 \text{ in}^2$$

$$\text{MIN. } 0 + 0 + 9.5 = 9.5 \text{ in}^2$$

**FLUOR DANIEL
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AIR FLOW AREAS): PIT TO AIR

2. 241-C-106, PIT OLC (H-2-SIS #50 SH-1 thru 3)
CONDITION/IN²
SEALED (SHIELD PLUG w/GASKET)
- a) 3" Ø VALVE PORT, II
SEALED
10 IN² (IF NOT TAPED)
- b) 8" Ø CAMERA PORT
SEALED
7.5 IN² (IF NOT TAPED)
- c) 12" Ø SLUICER PORT.
SEALED
10 IN² (IF NOT TAPED)
- * d) I-COVER BLOCK GAP (NORTH END),
MAX. GAP WIDTH = 1 1/4" X 8"
SEALED (SHIELD PLUG w/GASKET)
- e) SLOT PLUG (ELECT. CABLES ETC)
7.5 IN² (IF NOT TAPED)
- * f) I-COVER BLOCK GAP (SOUTH END),
MAX GAP WIDTH = 1 1/4" X 6"

* DURING SLUICING OPERATION THESE GAPS WOULD BE
TAPED ELIMINATING THIS AREA FOR AIR TO FLOW.

$$\begin{aligned}\text{MAX.} &= 10.0 + 7.5 = 17.5 \text{ m}^2 \\ \text{MIN.} &= 0 \text{ BUT ASSUME} = 1.0 \text{ m}^2 \\ &\text{(DUE TO INCOMPLETE SEALING)}\end{aligned}$$

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AIR FLOW AREAS: PIT TO AIR

3. 241-AY-102, PIT 02A (H-2-818453, SHTS 1 thru 3)

CONDITION / m²

a) (1) - 14" Ø PENETRATION

SEALED (SHIELD PLUG W/GASKET)

b) (2) - 3" Ø PENETRATIONS

ASSUME 1/16" GAP AROUND PERIMETER
OF 3" HOLE = $0.30 \text{ m}^2 \times 2 = 0.6 \text{ m}^2$

c) (1) - 8 1/2" Ø PENETRATION

SEALED (SHIELD PLUG)

d) (1) - 6 1/2" Ø PENETRATION

TEE WRENCH /

* e) 2 - COVER BLOCK GAPS
(EAST/WEST), 1/2" X 107" (2)
= 107 m²

OPEN / 107 m² (TOTAL)

f) NEW PENETRATION (EON FOR DRAIN
SEAL)
(3" Ø CORE - 2 7/8" Ø INSTALLED DEVICE)
A = 0.6 m²

A_{GAP} = 0.6 m²

* DURING BLUICING OPERATION THESE GAPS WOULD BE
TAPED ELIMINATING THIS AREA FOR AIR TO FLOW,
ALSO THE GAP AT THE PERIMETER WOULD BE SEALED.

NOTE: CURRENTLY THE TOP OF THE COVER BLOCKS IS
COVERED WITH 3/4" LEAD SHEETING.

$$\begin{aligned} \text{MAX} &= 0.6 + 107 + 0.6 = 108.2 \text{ m}^2 \\ \text{MIN} &= 0.6 + 0 + 0.6 = 1.2 \text{ m}^2 \end{aligned}$$

$$= \pi (r^2 - d_1^2) / 4$$

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AIR FLOW AREAS: PIT TO AIR

4. 241-AY-102, PITOZE (H-2-818454, SHT. 1 TRF4)

CONDITION/IN²

a) 36"Ø PUMP PENETRATION

SEALED (SHIELD PLUG W/GASKET)

b) 12"Ø VALVE OPERATING PART

SEALED (SHIELD PLUG W/GASKET)

c) (2)-8"Ø CAMERA PORTS

SEALED (SHIELD PLUG W/GASKET)

** d) 6"Ø WINCH DRIVE PART

$$(6\frac{1}{2})^2\pi - (1\frac{1}{2})^2\pi - (3" \times 6") =$$

$$9.5 \text{ in}^2$$

e) (3)- SLOTS (ELECT WIRING ETC)

SEALED

* f) 1- COVER BLOCK GAP
(NORTH SIDE), 1.25" X 7.25"

$$9.1 \text{ in}^2 \text{ MAX. (IF NOT TAPED)}$$

* g) 1- COVER BLOCK GAP
(SOUTH SIDE), 1.25 X 8.25"

$$10.3 \text{ in}^2 \text{ MAX. (IF NOT TAPED)}$$

* DURING SLUICING OPERATION, THESE GAPS WOULD BE TAPED
ELIMINATING THIS AREA FOR AIR FLOW.

** ALWAYS OPEN

$$\begin{aligned} \text{MAX} &= 9.5 + 9.1 + 10.3 = 28.9 \text{ m}^2 \\ \text{Min} &= 9.5 + 0 + 0 = 9.5 \text{ m}^2 \end{aligned}$$

DISTRIBUTION SHEET

To	From	Page 1 of 1			
Distribution	JW Bailey	Date 24 July 1998			
Project Title/Work Order		EDT No. 622235			
Project W-320 Tank 106-C, HNF-2477, Piping Calculations, Vol. 7		ECN No. n/a			
Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
JW Bailey	S2-48				
W-320 Project Files	RI-29				