

NEW RIVER CLASS FERRY

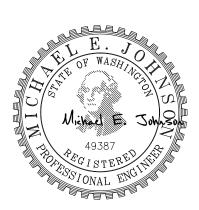
Piping System and Mechanical Calculations

Prepared for: NCDOT • Raleigh, North Carolina

Ref:

16101-200-505-1 Rev. -

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PREPARED BY

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REVISIONS

REV	DESCRIPTION	DATE	APPROVED
-	Initial issue	08/2/17	LGB 51201
			MEJ 49387

GENERAL NOTES

1. P.E. stamp applies to the EBDG engineered sections of this report as shown in the following table:

Professional Engineer	Applicable Appendices
Lydia Benger	Appendices B,D,G,H,I,J,K, and L
Michael Johnson	Appendices A,C, E and F

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1 PURPOSE

This report documents the calculations used to devleop of the machinery and piping systems for the NEW RIVER CLASS FERRY, a design for the North Carolina Department of Transportation. The subject vessel is a 183 foot 7 inch long by 46 foot wide by 11 foot deep passenger and vehicle ferry intended for service within the Outer Banks of North Carolina, and the associated rivers.

The calculations relating to each specific system are presented in separate appendices. Each appendix provides the following information:

- Description of the system
- Calculation procedures
- Given and assumed parameters
- Formulas and software used
- Calculation results
- References used in preparing the calculations

2 REGULATORY FRAMEWORK

The NEW RIVER CLASS FERRY will be inspected by the US Coast Guard under the provisions of 46 CFR Subchapter H. Piping and mechanical system designs shall comply with the applicable regulations.

Appendix A

Shaft Arrangement, Dwg. 16101-200-243-1

1 DESCRIPTION

This appendix documents the shafting calculations used to determine minimum shaft diameters for the shafting arrangement.

2 PROCEDURE

Calculations were performed in accordance with [1].

3 REGULATORY FRAMEWORK

The NEW RIVER CLASS FERRY will be USCG inspected under the provisions of 46 CFR Subchapter H.

4 GIVEN AND ASSUMED PARAMETERS

- Maximum propeller input speed is 670 RPM [2]
- Chosen reduction gear ratio is 2.5:1
- Main engines are rated 600 HP at 1800 RPM [3]
- Full power will be delivered to propeller at 1675 RPM or higher

5 FORMULAS

(not used)

6 CALCULATIONS

6.1 Line shaft between reduction gear and cycloidal propeller

The minimum calculated shaft diameter is 3.74in. The chosen line shaft diameter is 4.5 inches to maintain commonality with similar vessels in the NCDOT fleet.

6.2 Line shafts between engine and reduction gear

The minimum calculated shaft diameter is 2.77 in. A 3-inch nominal shaft diameter was chosen pending final equipment selections and detail design.

7 **REFERENCES**

- [1] American Bureau of Shipping, *Rules for Building and Classing Steel Vessels Under 90 Meters (295 feet) in Length 2017*, Houston, Texas, 2016.
- [2] L. Erdman (2017, Apr. 7), 16101: NC Ferry VSP's, lee.erdman@voith.com, 4/7/2017.
- [3] Caterpillar, "C18 Performance Data [EM0268]," 3/8/17.

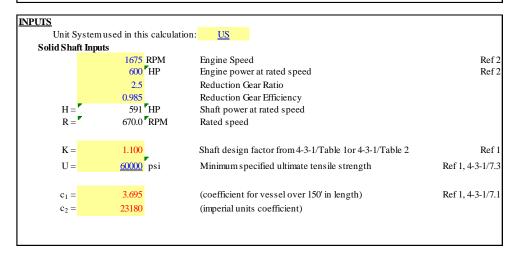
LINE SHAFT BETWEEN REDUCTION GEAR AND PROPELLER

APPROACH

Calculation of required shaft diameter according to ABS Rules for Building and Classing Steel Vessels Under 90 m, for line shaft between reduction gear and cycloidal propeller

ASSUMPTIONS

- 1 Shafting is ABS Grade 2, mininmum
 - 2 Engine is rated for 600 HP @ 1800 RPM, max power delivered to propller at 1675 RPM or higher
 - 3 98.5% Gear efficiency assumed



CALCULATION OF SOLID SHAFT DIAMETER

The minin	num diameter of propulsion sh	hafting is to be determined by the following equation:	
D = 100-	$\mathbf{K} \cdot \sqrt[3]{\frac{\mathbf{H}}{\mathbf{R}} \cdot \frac{\mathbf{c}_{1}}{\mathbf{U} + \mathbf{c}_{2}}}$		
H =	591.0 HP		
K =	1.100		
R =	670.00 RPM		
U =	60000 psi		
$c_1 =$	3.695		
$c_2 =$	23180		
	-		
D =	3.74 [°] in	= 94.90 mm	

<u>NOTES</u>

Chosen shaft diameter = 4.5in OD

REFERENCES

ABS Rules for Building and Classing Steel Vessels Under 90m (295ft) 2017
 CAT C18 Performance Data, EM0268

Ref 1, 4-3-1/7.1

LINE SHAFTS BETWEEN ENGINE AND REDUCTION GEAR



ASSUMPTIONS 1 Shafting is ABS Grade 2, minimum

2 Engine is rated for 600 HP @ 1800 RPM, max power delivered to propller at 1675 RPM or higher

INPUTS

<u>vruis</u>			
Unit System	used in this calculation	ion: <u>US</u>	
Solid Shaft Inpu	its		
	1675 RPM	Engine Speed	Ref 2
	600 HP	Engine power at rated speed	Ref 2
	1	Reduction Gear Ratio (no reduction)	
	1	Reduction Gear Efficiency (no reduction)	
H =	600 HP	Shaft power at rated speed	
R =	1675.0 RPM	Rated speed	
K =	1.100	Shaft design factor from 4-3-1/Table 1or 4-3-1/Table 2	Ref 1
U =	60000 psi	Minimum specified ultimate tensile strength	Ref 1, 4-3-1/7.1
$c_1 =$	3.695	(coefficient for vessel over 150' in length)	Ref 1, 4-3-1/7.1
$c_2 =$	23180	(imperial units coefficient)	

CALCULATION OF SOLID SHAFT DIAMETER The minimum diameter of propulsion shafting is to be determined by the following equation: $D = 100 \cdot \text{K} \cdot \sqrt[3]{\frac{\text{H}}{\text{R}} \cdot \frac{\text{c}_{1}}{\text{U} + \text{c}_{2}}}$ $H = \frac{6000^{\text{T}}\text{HP}}{2}$

	D=	2.77	in	1	=	70.28 mm		
	c ₂ =	23180						
	$c_1 =$							
L	U =		psi					
L	R =							
L	K =	1.100	_					
н		000.0						

<u>NOTES</u>

Chosen shaft diamger = 3in

REFERENCES

ABS Rules for Building and Classing Steel Vessels Under 90m (295ft) 2017
 CAT C18 Performance Data, EM0268

Ref 1, 4-3-1/7.1

Appendix B

Cooling System, Dwg. 16101-200-256-1

1 DESCRIPTION

This appendix documents the first principles calculations used in designing the cooling system. These calculations are used to identify steady state frictional losses throughout the piping system and to validate system design.

2 PROCEDURE

Calculations are presented in the following sequence:

- Pipe size calculations
- Main engine cooling system pressure calculations
- Generator engine cooling system pressure calculations

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

- The cooling system is to be constructed of Schedule 40 carbon steel pipe.
- Pressure drop through each cooler is assumed to be constant across the coolant flow range available from each engine. From [1], [2], and [3], the pressure drop through each of the various keel coolers are as follows:

Cooler	Pressure Drop
Main Engine JW	3.5 psi at 78 gpm
Main Engine SCAC	2.5 psi at 97 gpm
Generator JW	2.5 psi at 86 gpm
Generator SCAC	2.5 psi at 40 gpm

- Each main engine is supplied with an engine mounted, full flow, gear oil cooler which contributes an additional 5 psi drop to the main engine after cooler circuit.
- The fluid in the system is assumed to be a fresh water glycol mixture with a viscosity of 0.9199 cp and a density of 64.75 lbs/cu ft.
- Piping system lengths, routing, fittings, etc. are estimated based on [4] and [5].
- References [6], [7], [8] and [9] provide pump data used to construct the engine cooling models.

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Pipe Size Calculations

Pipe sizes are based on the nominal velocity limits found in Marine Engineering, Chapter 20, Table 3, [10]. The following table shows the flow rates of cooling water occurring in the system, and the resulting pipe sizes.

Pipe Segment	Flow Rate	Pipe Size	ID	Design Vel	locity (ft/s)	V
	gpm	(NPS)	in	Nominal	Limit	ft/s
Main Engine JW Circuit	102	2 1/2" SCH 40	2.47	7.86	15.00	6.65
Main Engine SCAC Circuit	104	2 1/2" SCH 40	2.47	7.86	15.00	6.78
Generator JW Circuit	75	2" SCH 40	2.07	7.19	15.00	6.96
Generator SCAC Circuit	44	2" SCH 40	2.07	7.19	15.00	4.09

5.2 Main Engine Cooling System Pressure Calculations

As shown in the attached pipeflo model of the off-engine jacket water circuit piping for the main engine, the calculated pressure drop is 12.7 feet H2O resulting in a flow rate of 91.8 gpm. As shown in Figure 5-1, this is comfortably within the operating range of the pump.

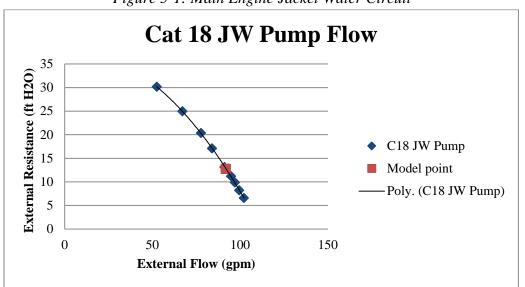


Figure 5-1: Main Engine Jacket Water Circuit

As shown in the attached pipeflo model of the off-engine aftercooler circuit piping for the main engine, the calculated pressure drop is 21.8 feet H2O resulting in a flow rate of 94.9 gpm. As shown in Figure 5-2, this is comfortably within the operating range of the pump.

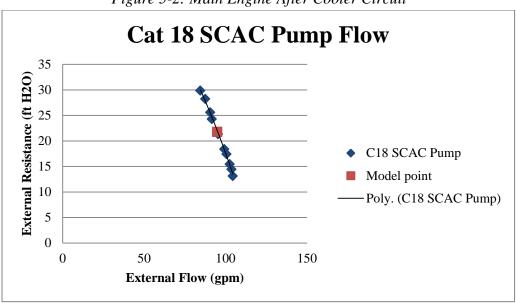
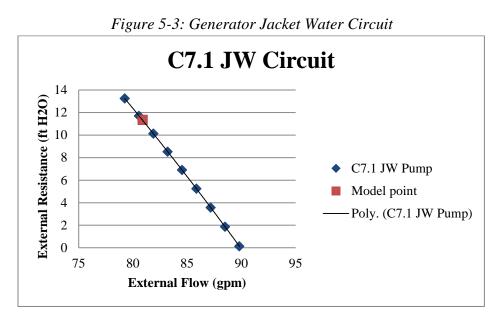


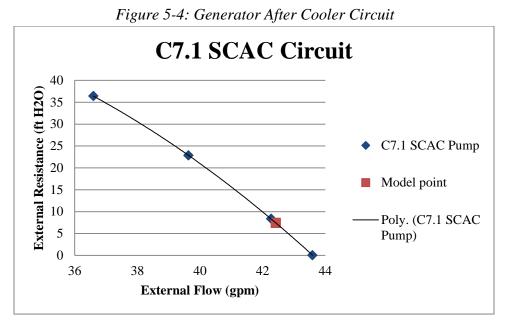
Figure 5-2: Main Engine After Cooler Circuit

5.3 Generator Engine Cooling System Pressure Calculations

As shown in the attached pipeflo model of the off-engine jacket water circuit piping for the generator engine, the calculated pressure drop is 11.3 ft H2O psi resulting in a flow rate of 80.9 gpm. As shown in Figure 5-3, this is comfortably within the operating range of the pump.



As shown in the attached pipeflo model of the off-engine aftercooler circuit piping for the generator engine, the calculated pressure drop is 7.4 ft H2O resulting in a flow rate of 42.4 gpm. As shown in Figure 5-4, this is comfortably within the operating range of the pump.

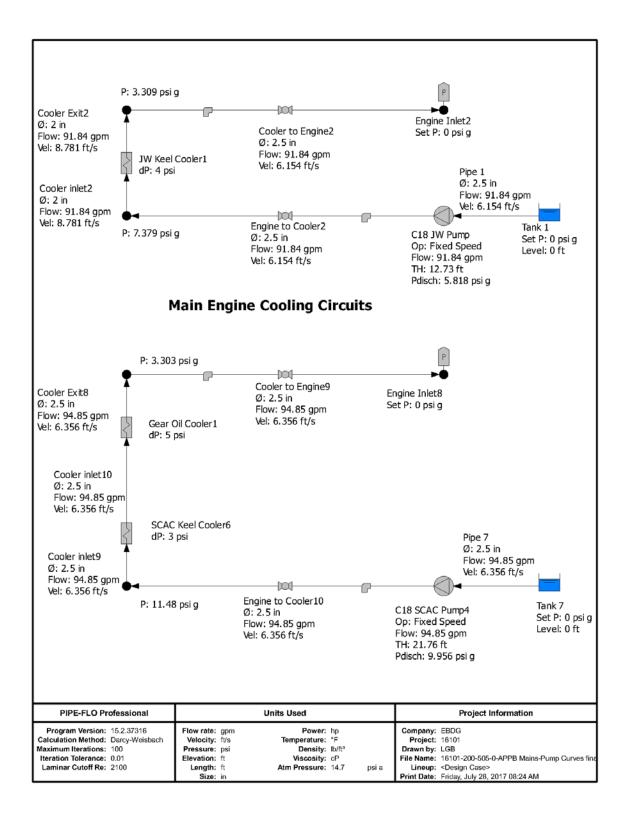


6 **REFERENCES**

- [1] Fernstrum, Elliott Bay Passenger Ferry Quote#JFQ030917-2, 3/9/17.
- [2] Fernstrum, Elliott Bay Passenger Ferry Quote#JFQ071217-1, 7/12/17.
- [3] J. Friendshuh, "Email: RE: RWF QUOTE JFQ071217-1 16101 Passenger Ferry Gen Set," joef@fernstrum.com, 7/14/17.
- [4] Elliott Bay Design Group, "NCDOT New River Class Ferry: Profiles and Arrangements," 16101-200-101-1, Seattle, WA.
- [5] Elliott Bay Design Group, "NCDOT New River Class Ferry: Cooling System Schematic," 16101-200-256-1, Seattle, WA.
- [6] Caterpillar, "C18 Marine IMO II & EPA Tier III SCAC engine Jacket Water Pump data EM0326," 3/8/17.
- [7] Caterpillar, "C18 Marine IMO II EPA Tier III SCAC Engine SCAC pump Data EM0328," 3/8/17.
- [8] Caterpillar, "C7.1 Maine Genset Data Jacket Water Pump Performance EM5101," 7/10/17.
- [9] Caterpillar, "C7.1 Marine Genset Data Auxiliary Pump Performance Data EM5100," 1/11/2017.

[10] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.

MAIN ENGINE COOLING PIPE-FLO MODEL



			List Report				
File Name: 16101-200-505-0.APPB Mains-Pump Curves final.pipe Lineup: <design case=""> Proceent Name: PIPE_ET (D Professione)</design>	fains-Pump Curves final.		Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 May Harchisone: 400		Company: EBDG Project: 16101 by: 1.08		
Version: 15.2.37316		Percent Tolerance: 0.0 Allowable Deviation: 1	Percent Tolerance: 0.01 Ilowable Deviation: 1 %	Date: Date: Atmospheric Pressure:	Date: Friday, July 28, sure: 14.7 psi a	Date: Friday, July 28, 2017 08:26 AM isure: 14.7 psi a	
			Pipe Specifications	s			
Specification Name Valve Table	Material Schedule	Absolute F Hazen Willia	Absolute Roughness Sizin Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure	Reynolds Number
Sch 40 Steel standard	Steel A53-B36.10 Schedule:40	1.800E-03 in 140	03 in 0.0 0	Min: Max:	th's full	psi g Dsi a	
			Fluid Zones		l		
Fluid Zone Name Table Name	Te	femperature F Pressure Relativ	Fluid State Relative Molecular Mass	Density Viscosity	Vapor Critica	Vapor Pressure Specif Critical Pressure Spe	Specific Heat Capacity (cp) Specific Heat Ratio (k)
50% ethlyene glycol 50% Dowtherm SR-1		120 °F 0 psig	Liquid 27.24	65.98 lb/ft ³ 1.653 cP	1.2	1.284 psia 691.3 psia	
			Centrifugal Pump	50			
Pump Name	Test Speed Operating Speed	Suction Elevation Suction Pressure	Discharge Elevation Discharge Pressure	Total Head dP	Flow Rate Power	Efficiency NF BEP Efficiency NF	NPSHa Design NPSH NPSHr Margin Ratio
C18 JW Pump Fixed Speed	1946 rpm 1946 rpm	5 ft -0.01439 psig	5 ft 5.818 psig	12.73 ft 5.832 psi	91.84 gpm -	- 29.2	29.24 ft
Company: CAT C18 JW Pump Curve: Manual Pump Type:		Size: Diameter: 2.5 in POR: from	- to -				
C18 SCAC Pump4 Fixed Speed	2160 rpm 2160 rpm	5 ft -0.01529 psig	5 ft 9.956 psig	21.76 ft 9.971 psi	94.85 gpm -	- 29.24 %	24 ft
Company: CAT C18 SCAC Pump Curve: Manual Pump Type:		Size: Diameter: 2.5 in POR: from	t t				
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total de Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	e V&F Friction Factor re V&F Resistance K e V&F dP de V&F Head Loss
Cooler Exit2 Sch 40 Steel 50% ethlyene glycol	2 in 2.067 in 0.5 ft	JW Keel Cooler1 0 ft Node 6 0 ft	91.84 gpm 8.781 ft/s 89848 0.02198	3.344 psig 2.795 psig 7.298 ft 6.099 ft	0.03502 psi 0.07643 ft	3.309 psig 2.76 psig 7.221 ft 6.023 ft	0.01899 0.00 0 psi 0 ft
Cooler Exit8 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 0.5 ft	Gear Oil Cooler1 0 ft Node 18 0 ft	94.85 gpm 6.356 ft/s 77688 0.02186	3.318 psig 3.031 psig 7.242 ft 6.615 ft	0.01529 psi 0.03336 ft	3.303 psig 3.016 psig 7.209 ft 6.581 ft	0.01821 0.00 0 ft
Cooler inlet10 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 5 ft	SCAC Keel Cooler6 0 ft Gear Oil Cooler1 0 ft	94.85 gpm 6.356 ft/s 77688 0.02186	8.471 psig 8.184 psig 18.49 ft 17.86 ft	0.1529 psi 0.3336 ft	8.318 psig 8.031 psig 18.15 ft 17.53 ft	0.01821 0.00 0 psi 0 ft
PIPE-FLO Professional	Version: 15.2.37316	16	List Report		Friday, July 28, 2017 08:26 AM	117 08:26 AM	Page 1

			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device er Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Cooler inlet2 Sch 40 Steel 50% ethlyene glycol	2 in 2.067 in 0.5 ft	Node 7 0 ft JW Keel Cooler1 0 ft	91.84 gpm 8.781 ft/s 89848 0.02198	7.379 psig 6.83 psig 16.1 ft 14.91 ft	0.03502 psi 0.07643 ft	7.344 psig 6.795 psig 16.03 ft 14.83 ft	0.01899 0.00 0 psi 0 ft
Cooler inlet9 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 0.25 ft	Node 19 0 ft SCAC Keel Cooler6 0 ft	94.85 gpm 6.356 ft/s 77688 0.02186	11.48 psig 11.19 psig 25.05 ft 24.42 ft	7.643E-03 psi 0.01668 ft	11.47 psig 11.18 psig 25.04 ft 24.41 ft	0.01821 0.00 0 psi 0 ft
Cooler to Engine2 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 25 ft	Node 6 0 ft Engline intet2 5 ft	91.84 gpm 6.154 ft/s 75219 0.02196	3.309 psig 3.039 psig 7.221 ft 6.633 ft	3.309 psi 2.221 ft	0 psig -0.2697 psig 5 ft 4.411 ft	0.01821 1.11 0.2983 psi 0.6509 ft
Cooler to Engine9 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 23 ft	Node 18 0 ft 5 ft	94.85 gpm 6.356 ft/s 77688 0.02186	3.303 psig 3.016 psig 7.209 ft 6.581 ft	3.303 psi 2.209 ft	0 psig -0.2877 psig 5 ft 4.372 ft	0.01821 1.07 0.309 psi 0.6745 ft
Engine to Cooler10 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 15 ft	C18 SCAC Pump4 5 ft Node 19 0 ft	94.85 gpm 6.356 ft/s 77688 0.02186	9.956 psig 9.668 psig 26.73 ft 26.1 ft	-1.523 psi 1.675 ft	11.48 psig 11.19 psig 25.05 ft 24.42 ft	0.01821 1.07 0.309 psi 0.6745 ft
Engine to Cooler2 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 15 ft	C18 JW Pump 5 ft Node 7 0 ft	91.84 gpm 6.154 ft/s 75219 0.02196	5.818 psig 5.548 psig 17.7 ft 17.11 ft	-1.561 psi 1.594 ft	7.379 psig 7.109 psig 16.1 ft 15.52 ft	0.01821 1.11 0.2985 psi 0.6515 ft
Pipe 1 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 0.5 ft	Tank 1 5 ft C18 JW Pump 5 ft	91.84 gpm 6.154 ft/s 75219 0.02196	0 psig -0.2697 psig 5 ft 4.411 ft	0.01439 psi 0.0314 ft	-0.01439 psig -0.2841 psig 4.969 ft 4.38 ft	0.01821 0.00 0 psi 0 ft
Pipe 7 Sch 40 Steel 50% ethlyene glycol	2.5 in 2.469 in 0.5 ft	Tank 7 5 ft C18 SCAC Pump4 5 ft	94.85 gpm 6.356 ft/s 77688 0.02186 Tent/s	0 psig -0.2877 psig 5 ft 4.372 ft	0.01529 psi 0.03336 ft	-0.01529 psig -0.303 psig 4.967 ft 4.339 ft	0.01821 0.00 0 psi 0 ft
Tank Name Fluid Zone	Bottom Elevation S Liquid Level E	Surface Pressure Bottom Pressure	Hydraulic Grade	Pipeline Name Pen	Connecting Pipelines Penetration Height Pipeline F	low Rate	Pressure at Penetration
Tank 1 50% ethlyene glycol	5 ft 0 ft	0 psig 0 psig	5 Å	Pipe 1	0 ft	91.84 gpm	0 psig
Tank 7 50% ethlyene glycol	5 ft 0 ft	0 psig 0 psig	ي ج	Pipe 7	tt O	94.85 gpm	0 psi g
PIPE-FLO Professional	Version: 15.2.37316	37316	List Report		Friday, July 28, 2017 08:26 AM	7 08:26 AM	Page 2

NEW RIVER CLASS FERRY

EBDG – NC, PLLC 16101-200-505-1

Job: 16101 Rev. -

		Fixed (Fixed dP Devices		
Fixed dP Device Name	Inlet Elevation Inlet Pressure	Outlet Elevation Outlet Pressure	dP Head Loss	Flow Rate	
Gear Oil Cooler1	0 ft 8.318 psig	0 ft 3.318 psig	5 psi 10.91 ft	94.85 gpm	
JW Keel Cooler1	0 ft 7.344 psig	0 ft 3.344 psig	4 psi 8.73 ft	91.84 gpm	
SCAC Keel Cooler6	0 ft 11.47 psig	0 ft 8.471 psig	3 psi 6.547 ft	94.85 gpm	
			Nodes		
Node Name		Elevation	Pressure	Hydraulic Grade	
Node 18		0 ft	3.303 psi g	6.581 ft	
Node 19		0 ft	11.48 psi g	24.42 ft	
Node 6		0 ft	3.309 psi g	6.328 ft	
Node 7		0 ft	7.379 psi g	15.21 ft	
		Pressure	Pressure Boundaries		
Pressure Boundary Name		Elevation	Pressure	Hydraulic Grade	Flow Rate
Engine Inlet2		5 ft	0 psig	4.411 ft	91.84 gpm
Engine Inlet8		5 ft	0 psig	4.372 ft	94.85 gpm

	Fixed d	Gear O	JW Kee	SCAC H	Noboli
DG _	NC	ΡΓΓ	C		

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List Report

Version: 15.2.37316

PIPE-FLO Professional

File Name:	16101-200-	505-0-APPB Mains-Pump	Bill of Materials R Curves final pipe	Company:	EBDG			
Lineup: Program Name:	<design ca<br="">PIPE-FLO F</design>	se>	ou too manppo	Project: by:	16101 LGB			
Version:	15.2.37316		0		Friday, July 28, 2017 08:	25 AM	_	_
			Centrifugal P	umps				
Centrifugal Purr Operation	np Name							
C18 JW Pump			CAT C18 JW Pump		Test Speed:	1946 rpm		
Fixed Speed		Type: Size:			Impeller Diameter: POR; from	2.5 in	to	
			Manual Pump		Port. Iron		10	
C18 SCAC Pump	p4	Company:	CAT C18 SCAC Pump		Test Speed:	2160 rpm		
Fixed Speed		Type:			Impeller Diameter:	2.5 in		
		Size: Curve:	Manual Pump		POR: from		to	
			Tanks					
Tank Name								
Tank 1								
Tank 7			C' 1 10 0					
	News		Fixed dP Dev	lices				
Fixed dP Device			Fixed dP					
Gear Oil Cooler1			5 psi					
JW Keel Cooler1			4 psi					
SCAC Keel Cool	er6		3 psi Pipelines	»				
Pipeline		Specification	Size	Length	Valves and Fittin	as		
Cooler Exit2		Sch 40 Steel	2 in	0.5 ft		5-		
Cooler Exit8		Sch 40 Steel	2.5 in	0.5 ft				
Cooler inlet10		Sch 40 Steel	2.5 in	5 ft				
Cooler inlet2		Sch 40 Steel	2 in	0.5 ft				
Cooler inlet9		Sch 40 Steel	2.5 in	0.25 ft				
Cooler to Engine	2	Sch 40 Steel	2.5 in	25 ft	1 x Ball 4 x Elbow - Long r 1 x Reducer - Enla			in - 3
Cooler to Engine	9	Sch 40 Steel	2.5 in	23 ft	1 x Ball 4 x Elbow - Long r	adius, r/d 1.	5 (90°)	
Engine to Cooler	10	Sch 40 Steel	2.5 in	15 ft	1 x Ball 4 x Elbow - Long r	adius, r/d 1.	5 (90°)	
Engine to Cooler	2	Sch 40 Steel	2.5 in	15 ft	1 x Ball 4 x Elbow - Long r 1 x Reducer - Cor			n - 3 ir
Pipe 1		Sch 40 Steel	2.5 in	0.5 ft				
Pipe 7		Sch 40 Steel	2.5 in	0.5 ft				
			Pipeline Material					
Specification		Material	Size	Total Lengt	h Valves & Fittings			
Sch 40 Steel		Steel A53-B36.10 Schedule: 40	2 in	1.00 ft				
Sch 40 Steel		Steel A53-B36.10 Schedule: 40	2.5 in	84.75 ft	4 x Ball 16 x Elbow - Long r 1 x Reducer - Contr 1 x Reducer - Enlar	action (2.5 i	n x 2 in	

PIPE-FLO Professional

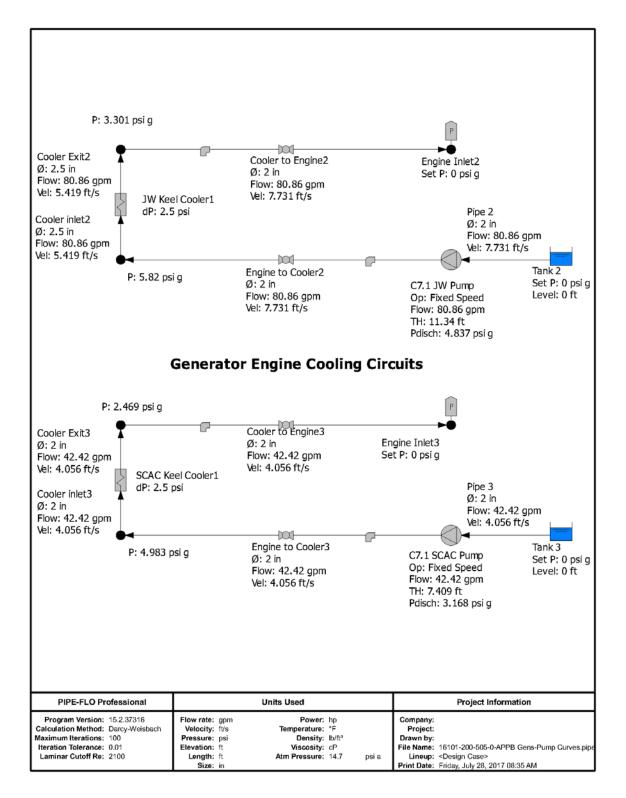
Version: 15.2.37316

Bill of Materials Report

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GENERATOR ENGINE COOLING PIPE-FLO MODEL



				List Report					
File Name: 16101-200-505-0.APPB Gens-Pump Curves.pipe Lineup: <design case=""> Progem Name: PIPE-FLO Professional Version: 15.2.37316</design>	ens-Pump Curves.pip		Calculation Method: Darc Laminar Cutoff Re: 2100 Max Iterations: 100 Percent Tolerance: 0.01 Allowable Deviation: 1	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Iterations: 100 Percent Tolerance: 0.01 Allowable Deviation: 1 %	Co Atmospheric P	Company: Project: by: Date: Friday, Pressure: 14.	panry: oject: by: Friday, July 28, 2017 08:36 AM ssure: 14.7 psia	8:36 AM	
				Pipe Specification	IS				
Specification Name	Material	ğ	Absolute Roughness		Sizing Criteria			Design Limits	
Valve Table	Schedule	Haze	Hazen Williams C Factor		,	Velocity		Pressure	Reynolds Number
Sch 40 Steel standard	Steel A53-B36.10 Schedule:40		1.800E-03 in 140	in 0.0	2 2	Min: Max:	ft/s ft/s	psig Dsi a	
				Fluid Zones		l			
Fluid Zone Name		Temperature	Flui	Fluid State	Density	- (Vapor Pressure		Specific Heat Capacity (cp)
Fresh Water		120 °F		Liquid	61.7 Ib/ft		1.695 psi a		1.014 BTU/lb°F
AVAICI		n paig		Centrifugal Pumps			a lad bala		:
Pump Name	Test Speed Operating Speed	Suction Elevation ed Suction Pressure	vation ssure	Discharge Elevation Discharge Pressure	Total Head dP	Flow Rate Power	Efficiency BEP Efficiency	cy NPSHa ancy NPSHr	a Design NPSH r Margin Ratio
C7.1 JW Pump Fixed Speed	3600 rpm 3600 rpm	5 -0.02356	ft psig	5 ft 4.837 psig	11.34 ft 4.86 psi	80.86 gpm -	• 1	30.29 ft %	1
Compary: CAT C7.1 JW Curve: Manual Pump Type:		Size: Diameter: 2 in POR: from	Size: neter: 2 in POR: from	1 1 1					
C7.1 SCAC Pump Fixed Speed	1800 rpm 1800 rpm	5 -6.812E-03	ft psig	5 ft 3.168 psig	7.409 ft 3.175 psi	42.42 gpm -	1	30.33 ft 	1
Compary: CAT C7.1 SCAC Curve: Manual Pump Type:		Size: Diameter: 2 in POR: from	Size: meter: 2 in POR: from	· to Pipelines					
Pipeline Name	Size	Inlet Device	ice	Flow Rate	Inlet Total Pressure	Total dP		Outlet Total Pressure	V&F Friction Factor
Specification Fluid Zone	Inside Diameter Length	ar Inlet Elevation Outlet Device Outlet Elevation	rtion vice ation	Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	-	Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Resistance K V&F dP V&F Head Loss
Cooler Exti2 Sch 40 Steel Fresh Water	2.5 in 2.469 in 0.5 ft	JW Keel Cooler ¹ 0 ft Node 6	er.	80.86 gpm 5.419 ft/s 184664	3.311 psig 3.115 psig 7.727 ft	9.516E-03 psi 0.02221 ft		3.301 psig 3.106 psig 7.705 ft	0.01821 0.00 0 psi
Casta Euto	ii e	SCACKool Covier	-	40.40	T 1/2//	0 0100 00		7.249 T	0.01000
Cooler Exit3 Sch 40 Steel Fresh Water	2.067 in 0.5 ft	SCAC NOSI COO 0 ft Node 8		42.42 gpm 4.056 ft/s 115722 0.02142	2.476 psig 2.367 psig 5.524 ft	6.812E-U3 psi 0.0159 ft		2.469 psig 2.36 psig 5.763 ft 5.508 ft	0.00 0.00 0 ft 0 ft
Cooler inlet2 Sch 40 Steel Fresh Water	2.5 in 2.469 in 0.5 ft	Node 7 0 ft JW Keel Cooler1 0 ft	er1	80.86 gpm 5.419 ft/s 184664 0.02003	5.82 psig 5.625 psig 13.58 ft 13.13 ft	9.516E-03 psi 0.02221 ft		5.811 psig 5.615 psig 13.56 ft 13.11 ft	0.01821 0.00 0 psi 0 ft
PIPE-FLO Professional	Version: 15.2.37316	7316		List Report		Friday, July 2	Friday, July 28, 2017 08:36 AM	W	Page 1

l ist Report

	Inlet Device Inlet Elevation Outlet Elevation Node 9 0 ft Node 6 0 ft 0 ft Fegine Inla? 5 ft C7.1 JW Pump C7.1 JW Pump	Flow Rate Fluid Velocity Reynolds Number Preprinds Number 40.65 ft 115722 0.02142 80.06 gpm 7.731 ft 220579 0.02039 4.055 ft 115722 0.02039 0.02039 80.00 220579 0.02039 0.02039 220579 0.02039 220579 0.02039 27731 ft 220579 0.02039 27731 ft 220579 0.02039 27731 ft 220579 0.02039 27731 ft 220579 0.02039 27731 ft 220579 0.02039 27731 ft 220579 0.02039 27731 ft 220579 0.02039 27056 ft 2006 ft 2007 2007 2007 2007 2007 2007 2007 200	Inlet Total Pressure Inlet Static Pressure Inlet Static Pressure Inlet Static Pressure 4.884 psig 4.874 psig 7.705 ft 7.705 ft 7.	Total dP Total Head Loss 6.812E-03 6.812E-03 9.0159 10.0159 2.301 2.469 psi 0.7634 0.7635	Contracted	
2,067 in 0.5 ft 0.5 ft 15 ft 15 ft 15 ft 15 ft 2,067 in 15 ft 15 ft 2,067 in 15 ft 2,067 in 15 ft	Node 9 0 ft 0 ft 0 ft 0 ft 0 ft 5 ft 5 ft 1 Node 8 5 ft 5 ft 5 ft 5 ft 0 ft 5 ft 0 ft 5 ft 0 ft 5 ft 0 ft 0 ft 0 ft 0 ft 0 ft 0 ft 0 ft 0	42.42 gpm 4.056 ft/s 1/5722 0.15722 0.05142 80.86 gpm 7.731 ft/s 220579 0.02039 4.2.42 gpm 4.056 ft/s 115722 0.02142 80.06 gpm	4.983 psi g 4.874 psi g 11.63 ft 11.57 ft 3.301 psi g 7.705 ft 6.776 ft 6.776 ft 5.506 psi g 4.439 psi g 16.29 ft 16.29 ft 16.29 ft 16.29 ft 16.29 ft 3.166 psi g	6.812E-03 psi 0.0159 ft 3.301 psi 2.705 ft 2.469 psi 0.7634 ft -0.9835 psi	4.976 psig 4.867 psig 4.867 psig 11.361 ft 11.36 ft 5 ft 4.011 ft 4.0105 psig 5.422 psig 5.422 psig 5.422 psig 5.422 psig 5.422 psig	0.01899 0.00 0 fst 0 ft 0.01899 1.14 0.423 psi 1.056 ft 0.1227 psi 0.1227 psi 0.2865 ft
2.067 in 15 ft 15 ft 2.067 in 15 ft 15 ft 2.067 in 15 ft 15 ft 2.067 in 2.067 in 2.067 in 2.067 in	Node 6 0 ft Fighte inlat2 Fighte inlat2 Fighte inlat3 5 ft 5 ft 5 ft Mode 5 Fighte inlat3 5 ft Mode 5 Fighte inlat3	80.86 gpm 7.731 fbs 220579 0.02039 42.42 gpm 4.056 fbs 115722 0.02142 80.06 gpm	3.301 psig 2.903 psig 6.7705 ft 6.7705 ft 5.776 ft 5.508 psig 4.439 psig 16.29 ft 16.29 ft 16.29 ft 16.29 ft 16.29 ft 3.168 psig	3.301 psi 2.705 ft 2.469 psi 0.7634 ft -0.9835 psi	0 psig 0.398 psig 5 ft 4.071 ft 4.071 ft 0 psig 0 psig 5.82 psig 5.82 psig 13.58 ft 13.58 ft 13.58 ft 12.66 ft	0.01899 1.14 0.4523 psi 1.056 ft 1.056 ft 0.1899 0.1227 psi 0.2865 ft
gine3 2.067 in 15 ft 2.067 in 2.067 in 15 ft 2.067 in 15 ft 15 ft 2.067 in 2.067 in 15 ft	Node 8 0 ft 5 ft Node 7 5 ft Node 7	42.42 gpm 4.056 ft/s 115722 0.02142 80.86 gpm	2.469 psig 2.36 psig 5.763 ft 5.5763 ft 4.439 psig 16.29 ft 16.29 ft 16.29 ft 3.168 psig	2.469 psi 0.7634 ft -0.9835 psi	0 psig -0.1095 psig 5 ft 4.744 ft 5.82 psig 5.422 psig 13.58 ft 12.66 ft	0.01899 1.12 0.1227 psi 0.2865 ft
2.067 in 15 ft 15 ft 2.067 in 15 ft 15 ft 2.067 in 2.067 in 2.067 in 15 ft	7.1 JW Pump 5 ft Note 7	80.86 gpm	4.837 psig 4.439 psig 16.29 ft 15.36 ft 3.168 psig	-0.9835 psi	5.82 psig 5.422 psig 13.58 ft 12.66 ft	
2.067 in 15 ft 2.067 in 15 ft 2.067 in	0 ft	220579 0.02039	DSi	2.705 ft	Ľ	0.01899 1.14 0.4521 psi 1.055 ft
2 in 2.067 in	C7.1 SCAC Pump 5 ft Node 9 0 ft	42.42 gpm 4.056 ft/s 115722 0.02142	n a bar	-1.815 psi 0.7634 ft	4.983 psig 4.874 psig 11.63 ft	0.01899 1.12 0.1227 psi 0.2865 ft
Fresh Water 0.5 ft C7.	Tank 2 5 ft C7.1 JW Pump 5 ft	80.86 gpm 7.731 ft/s 220579 0.02039	0 psig -0.398 psig 5 ft 4.071 ft	0.02356 psi 0.05498 ft	-0.02356 psig -0.4216 psig 4.945 ft 4.016 ft	0.01899 0.00 0 ft
Pipe 3 2 in Sch 40 Steel 2.067 in Fresh Water 0.5 ft C7.1	Tank 3 5 ft C7.1 SCAC Pump 5 ft	42.42 gpm 4.056 ft/s 115722 0.02142	0 psig -0.1095 psig 5 ft 4.744 ft	6.812E-03 psi 0.0159 ft	-6.812E-03 psig -0.1164 psig 4.984 ft 4.728 ft	0.01899 0.00 0 psi 0 ft
Tank Name Bottom Elevation Surface Pressure Fluid Zone Liquid Level Bottom Pressure		Hydraulic Grade	Pipeline Name Pen	Connecting Penetration Height	Connecting Pipelines Height Pipeline Flow R a te Pi	Pressure at Penetration
Tank 2 5 ft 0 p Fresh Water 0 ft 0 p	psi g psi g	5 ft	Pipe 2	0 ft	80.86 gpm	0 psig
Tank 3 5 ft 0 p Fresh Water 0 ft 0 p	psi g psi g	5 ft Fixed dP Devices	Pipe 3	1 U	42.42 gpm	0 psig
Fixed dP Device Name Inlet Elevation Inlet Pressure	Outlet Elevation Outlet Pressure	ation isure	dP Head Loss	Flow Rate		
JW Keel Cooler1 0 ft 5.811 psi g	0 ft 3.311 psig	ß	2.5 psi 5.835 ft	80.86 gpm		
SCAC Keel Cooler1 0 ft 4.976 psi g PIPE-FLO Professional Version: 15.2.37316	0 ft 2.476 psig	g List Report	2.5 psi 5.835 ft	42.42 gpm Friday July 28, 2017 08:36 AM	17 08:36 AM	Page 2

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16101-200-505-1

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Rev. -

	Nodes			
Node Name	Elevation	Pressure	Hydraulic Grade	
Node 6	0 ft	3.301 psi g	7.012 ft	
Node 7	0 ft	5.82 psi g	12.89 ft	
Node 8	0 ft	2.469 psi g	5.508 ft	
Node 9	0 ft	4.983 psi g	11.37 ft	
	Pressure Boundaries	ıdaries		
Pressure Boundary Name	Elevation	Pressure	Hydraulic Grade	Flow Rate
Engine Inlet2	5 ft	0 psig	4.071 ft	80.86 gpm
Engine Inlet3	5 ft	0 psig	4.744 ft	42.42 gpm

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List Report

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PIPE-FLO Professional

			Bill of Mat	erials Re	port						
Lineup: Program Name:	16101-200-505-0-APPB Gen <design case=""> PIPE-FLO Professional 15.2.37316</design>	s-Pump Cur	ves.pipe		Company: Project: by: Date:		ly 28, 20 [.]	17 08:3	5 AM		
			Centr	ifugal Pu	nps						
Centrifugal Pum Operation	np Name										
C7.1 JW Pump Fixed Speed	Co	ompany: C/ Type: Size: Curve: M	AT C7.1 JW anual Pump			Tes Impeller D			3600 m 2 in 	m to	
C7.1 SCAC Pum Fixed Speed	p Ca	Type: Size:	AT C7.1 SCAC anual Pump	Tanks		Tes Impeller D			1800 rp 2 in 	om to	
Tank Name				Tanko							
Tank 2											
Tank 3											
			Fixed	d dP Devi	ces						
Fixed dP Device	Name	Fi	xed dP								
JW Keel Cooler1		2	2.5 psi								
SCAC Keel Coole	er1	2	2.5 psi								
			F	Pipelines							
Pipeline	Specifi			Size	Length	Va	lves and	Fitting	S		
Cooler Exit2	Sch 40			2.5 in	0.5 ft						
Cooler Exit3	Sch 40			2 in	0.5 ft						
Cooler inlet2	Sch 40			2.5 in	0.5 ft						
Cooler inlet3	Sch 40	Steel		2 in	0.5 ft						
Cooler to Engine	2 Sch 40	Steel		2 in	15 ft	4 :	< Ball < Elbow - < Reduce	Long ra r - Cont	idius, r/d raction (i	1.5 (90° 2 in x 2.5) 5 in - 3 in)
Cooler to Engine	3 Sch 40	Steel		2 in	15 ft		k Ball k Elbow -	Long ra	adius, r/d	1.5 (90°)
Engine to Cooler.	2 Sch 40	Steel		2 in	15 ft	4 :	< Ball < Elbow - < Reduce) 5 in - 3 in)
Engine to Cooler	3 Sch 40	Steel		2 in	15 ft		< Ball < Elbow -	Long ra	adius, r/d	1.5 (90°)
Pipe 2	Sch 40	Steel		2 in	0.5 ft						
Pipe 3	Sch 40	Steel		2 in	0.5 ft						
			Pipeline N	Aaterial S							
Specification	Material		Size		Total Lengt		ves & Fit	tings			
Sch 40 Steel	Steel A53-B3 Schedule: 4		2 in		62.00 ft	1 x	Elbow -	- Contra	action (2	in x 2.5 i	
Sch 40 Steel	Steel A53-B3 Schedule: 44		2.5 ir	n	1.00 ft						

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Bill of Materials Report

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Appendix C

Exhaust System, Dwg. 16101-200-259-1

1 DESCRIPTION

This appendix documents the calculations used in designing the diesel engine exhaust systems. These calculations estimate frictional losses through the exhaust piping to verify that system backpressure is below the engine manufacturers' published requirements.

2 PROCEDURE

Calculations are presented in the following sequence:

- Main engine exhaust piping ΔP calculations
- Generator exhaust piping ΔP calculations
- Emergency generator exhaust piping ΔP calculations

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy-Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

• Main engine exhaust gas characteristics are taken from [1] [2] as follows:

Caterpillar C18, 600 hp at 18	00 RPM
Exhaust Gas Flow Rate at Stack	3,066 ft ³ /min
Exhaust Gas Temperature at Stack	703.0 °F
Maximum Allowable Backpressure	27 inches H ₂ O

• Generator exhaust gas characteristics are taken from [3] [4] as follows:

Caterpillar C7.1, 150 ekW at 1	800 RPM
Exhaust Gas Flow Rate at Stack	1,042 ft ³ /min
Exhaust Gas Temperature at Stack	712.9 °F
Maximum Allowable Backpressure	60 inches H ₂ O

• Emergency generator exhaust gas characteristics are taken from [5] as follows:

Caterpillar C4.4 ACERT, 66 ekW	at 1800 RPM
Exhaust Gas Flow Rate at Stack	8.5 kg/min
Exhaust Gas Temperature at Stack	759 °F
Maximum Allowable Backpressure	60 inches H ₂ O

- For the purpose of calculating piping friction losses, exhaust gas pressure is assumed to be standard atmospheric pressure, 14.7 PSIA, plus half the maximum allowable backpressure value listed for the system analyzed.
- In calculating frictional losses through pipe, exhaust gas is assumed to have the same density and dynamic viscosity as air at assumed system pressure and stack temperature noted above for the system analyzed.
- System pipe lengths, routing and fittings are estimated based on the routing shown in [6].
- Selected main engine silencer is an 8 inch Harco VRSA-8 with estimated backpressure of 7.9 in H₂0. Backpressure estimated with vendor provided calculation tool [7].
- Selected generator silencer is a 5 inch Harco VRSA-5 with estimated backpressure of 5.9 in H₂0. Backpressure estimated with vendor provided calculation tool [7].
- Selected emergency generator silencer is a 4 inch Harco VRS-4 SISO with estimated backpressure of 9.7 in H₂0. Backpressure estimated with vendor provided calculation tool [7]. In conjunction with the side-inlet, side-outlet silencer, the selected emergency generator spark arrestor is a Harco 5AA. Backpressure of spark arrestor estimated at 18 inH20 based on testing agency guidelines [8].

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Main Engine Exhaust Piping ΔP Calculation

As shown in the attached PIPE-FLO results, the estimated main engine exhaust piping backpressure is approximately 16.2 in H_2O , 60% of the stated vendor design value.

5.2 Generator Exhaust Piping ΔP Calculation

As shown in the attached PIPE-FLO results, the estimated generator exhaust piping backpressure is approximately 16.5 in H_2O , 28% of the stated vendor maximum.

5.3 Emergency Generator Exhaust Piping ΔP Calculation

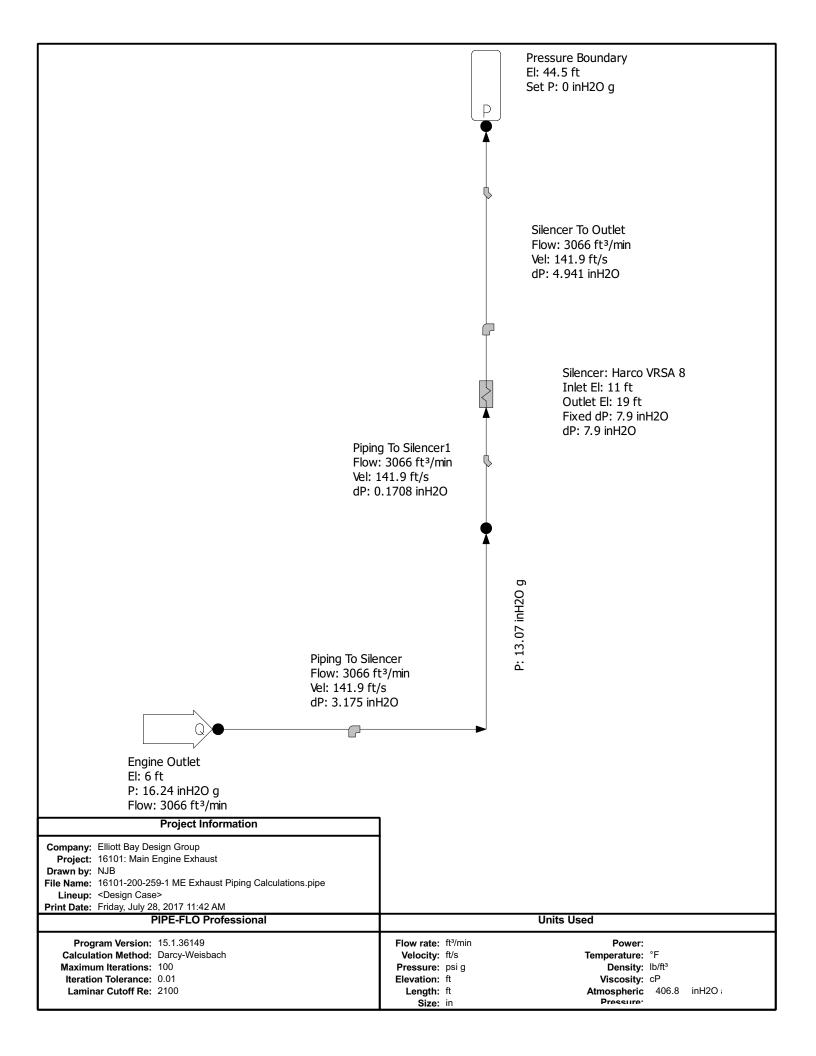
Exhaust gas volumetric flow rate is first determined using the given mass flow rate from the engine technical data [5].

Exhaust gas temperature at stack	404° C (759° F)
Assumed exhaust gas pressure at stack	14.7 psia
Air density at stack temp. and press.	0.519 kg/m^3
Given mass flow rate	8.5 kg/min
Volumetric flow rate	16.38 m ³ /min (578 ft³/min)

As shown in the attached PIPE-FLO results, the estimated emergency generator exhaust piping backpressure is approximately 14 in H_2O , 23% of the stated vendor maximum.

6 REFERENCES

- [1] Caterpillar, "EM0268; C18 600HP at 1800 rpm Systems Data," March 8, 2017.
- [2] Caterpillar, EM0268; C18 600HP at 1800 rpm Performance Data, March 8, 2017.
- [3] Caterpillar, "EM5070; C7.1 150ekW at 1800 rpm Performance Data," July 10, 2017.
- [4] Caterpillar, "EM5070; C7.1 150ekW at 1800 rpm Systems Data," July 10, 2017.
- [5] Caterpillar, "LEHM0240-00; C4.4 ACERT Marine Generator Set Package Specifications," 2016.
- [6] Elliott Bay Design Group, "Exhaust Arrangement; 16101-200-259-1," Rev -, Seattle, WA, 7/28/17.
- [7] Harco Manufacturing, "Silencer Back Pressure Calculator," [Online]. Available: http://harcomfg.com/. [Accessed July 2017].
- [8] USFS, "Spark Arrester Guide," 2017.



			List Report				
File Name: 16101-200-259-1 ME E Lineup: <design case=""> Progam Name: PIPE-FLO Professional Version: 15.1.36149</design>	16101-200-259-1 ME Exhaust Piping Calculations.pipe <design case=""> PIPE-FLO Professional 15.1.36149</design>	Calculation Meth Laminar Cutoff Max Iteratio Iteration Toleran Atmospheric Press	od: Darcy-Weisbach Re: 2100 ns: 100 ice: 0.01 ire: 406.8 inH2O a Pipe Specifications	Company: Project: by: Date:	: Elliott Bay Design Group : 16101: Main Engine Exhaust : NJB : Friday, July 28, 2017 11:43 AM	p haust :43 AM	
Specification Name Valve Table	Material Schedule H	Absolute Roughness Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure		Reynolds Number
Steel, Sch 10 standard	Steel A53-B36.10 Schedule:10	1.800E-03 in 140	0.0	to ft/s	þ	psig	to
Steel, Sch 20 standard	Steel A53-B36.10 Schedule:20	1.800E-03 in 140	0.0	to ft/s	to	psi g	to
Steel, Sch 40 standard	Steel A53-B36.10 Schedule:40	1.800E-03 in 140	0.0 Fluid Zones	to ft/s	to	psig	þ
Fluid Zone Name Table Name	Temperature	Pressure Flui	Fluid State	Density Viscosity	Vapor Pressure Critical Pressure	Sp Rels	Specific Heat Ratio (k) Relative Molecular Mass
Engine Exhaust (Air at 703F) Air				0.03522 lb/ft ³ 0.03181 cP	6.005E+06 inH2O a 15151 inH2O a		1.373 28.96
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Elevation ter Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number	Total Head Loss V&F Head Loss	Inlet Pressure Outlet Pressure	Total dP V&F dP	Pipe Friction Factor V&F Friction Factor V&F Resistance K
Silencer To Outlet Steel, Sch 20 Engine Exhaust (Air at 703F)	8 in 8.125 in 29 ft Inlet Device: Silencer: Harco	19 ft 44.5 ft co VRSA 8	3066 ft³/min 141.9 ft/s 158328 Outlet Device:	066 ft ^{3/} min 704.4 ft 1.9 ft/s 465.8 ft 158328 Outlet Device: Pressure Boundary	4.941 inH20 (0 inH20 (4.941 inH2C 3.153 inH2C	0.0178 0.01402 1.49
Piping To Silencer Steel, Sch 20 Engine Exhaust (Air at 703F)	8 in 8.125 in 34 ft Inlet Device: Engine Outlet	6 ft 1 ft	3066 ft ³ /min 141.9 ft/s 158328 Outlet Device: Node	464 ft 184.3 ft Node 1	16.24 inH2O (13.07 inH2O (3.175 inH2C 1.248 inH2C	0.0178 0.01402 0.59
Piping To Silencer1 Steel, Sch 20 Engine Exhaust (Air at 703F)	8 in 8.125 in 2 ft Inlet Device: Node 1	11 A 11 A 11 A 11 A 12 A 12 A 12 A 12 A	3066 ft³/min 141.9 ft/s 158328 Outlet Device: Fixed dP Devices	066 ft ³ /min 25.23 ft 1.9 ft/s 8.776 ft 158328 Outlet Device: Silencer: Harco VRSA 8 Devices	13.07 inH20 12.9 inH20	0.1708 inH2C 0.05941 inH2C	0.0178 0.01402 0.03
Fixed dP Device Name	Inlet Elevation Inlet Pressure	Outlet Elevation Outlet Pressure		dP F Head Loss	Flow Rate		
Silencer: Harco VRSA 8	11 ft 12.9 inH2Og	19 ft 4.941 inH2Og	Nodos	7.9 inH2O 1167 ft	3066 ft³/min		
Node Name		Elevation	Pressure	Hydraulic Grade	rade		
Node 1		11 ft	13.07 inH2O g	Og 1628 ft			

Friday, July 28, 2017 11:43 AM

List Report

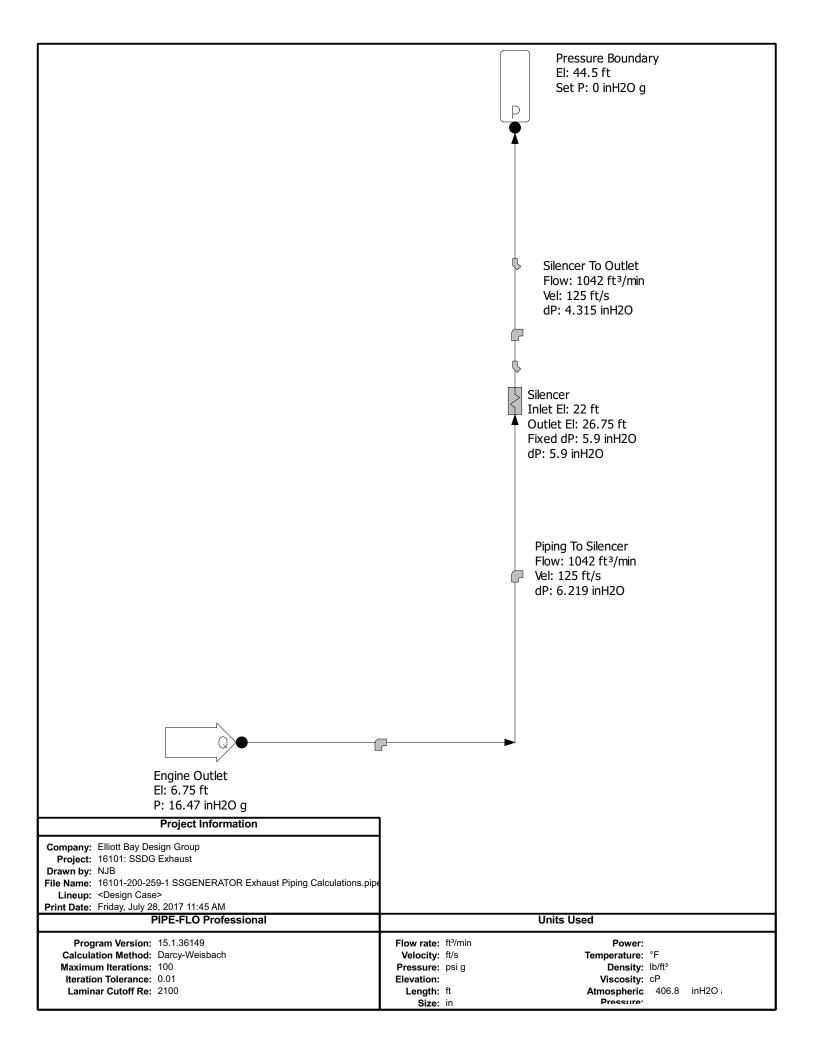
PIPE-FLO Professional

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List Report

	B	ill of Materials Repo	ort				
File Name: 16101-200-259-1 ME Exhaust Piping Calculations.pipe Lineup: <design case=""> Program Name: PIPE-FLO Professional Version: 15.1.36149</design>		ations.pipe	Project: 1610 by: NJB	tt Bay Design Group D1: Main Engine Exhaust ay, July 28, 2017 11:43 AM			
Pipelines							
Pipeline	Specification	Size	Length	Valves and Fittings			
Silencer To Outlet	Steel, Sch 20	8 in	29 ft	1 x Exit - Projecting 2 x Elbow - Long radius, r/d 1.5 (45°) 1 x Mitre Bend @ 45°			
Piping To Silencer	Steel, Sch 20	8 in	34 ft	3 x Elbow - Long radius, r/d 1.5 (90°)			
Piping To Silencer1	Steel, Sch 20	8 in	2 ft	1 x Mitre Bend @ 0°			
Pipeline Material Summary							
Specification	Material	Size	Fotal Length	Valves & Fittings			
Steel, Sch 20	Steel A53-B36.10 Schedule: 20	8 in	65.00 ft	2 x Elbow - Long radius, r/d 1.5 (45°) 3 x Elbow - Long radius, r/d 1.5 (90°) 1 x Exit - Projecting 1 x Mitre Bend @ 0° 1 x Mitre Bend @ 45°			



			List Report				
File Name: 16101-200-259-1 SSGE Lineup: <design case=""> Progam Name: PIPE-FLO Professional Version: 15.1.36149</design>	16101-200-259-1 SSGENERATOR Exhaust Piping Calcul: <design case=""> PIPE-FLO Professional 15.1.36149</design>	Calculation Meth Laminar Cutoff Max Iteratic Iteration Tolerat Atmospheric Press	od: Darcy-Weisbach Re: 2100 ons: 100 cne: 0.01 ure: 406.8 inH2O a Pipe Specifications	Company: Project: by: Date:	any: Elliott Bay Design Group ect: 16101: SSDG Exhaust by: NJB ate: Friday, July 28, 2017 11:47 AM	47 AM	
Specification Name Valve Table	Material Schedule Ha	Absolute Roughness Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure		Reynolds Number
Steel, Sch 10 standard	Steel A53-B36.10 Schedule:10	1.800E-03 in 140	0.0	to ft/s	to	psi g	to
Steel, Sch 20 standard	Steel A53-B36.10 Schedule:20	1.800E-03 in 140	0.0	to ft/s	to	psig	to
Steel, Sch 40 standard	Steel A53-B36.10 Schedule:40	1.800E-03 in 140	0.0 Fluid Zones	to ft/s	to	psi g	to
Fluid Zone Name Table Name	Temperature	Pressure	Fluid State	Density Viscositv	Vapor Pressure Critical Pressure	Sp Reis	Specific Heat Ratio (k) Relative Molecular Mass
Engine Exhaust (Air at 713F) Air				0.03505 lb/ft³ 0.03199 cP	6.202E+06 inH2O a 15151 inH2O a		1.372 28.96
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Elevation er Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number	Total Head Loss V&F Head Loss	Inlet Pressure Outlet Pressure	Total dP V&F dP	Pipe Friction Factor V&F Friction Factor V&F Resistance K
Piping To Silencer Steel, Sch 40 Engine Exhaust (Air at 713F)	5 in 5.047 in 54 ft Inlet Device: Engine Outlet	6.75 ft 22 ft	1042 ft ^{3/} min 125 ft/s 85730 Outlet Device: Silencer	907.9 ft 278.5 ft : Silencer	16.47 inH2O (10.25 inH2O (6.219 inH2C 1.877 inH2C	0.02018 0.0155 1.15
Silencer To Outlet Steel, Sch 40 Engine Exhaust (Air at 713F)	5 in 5.047 in 20 ft Inlet Device: Silencer	26.75 ft 44.5 ft	1042 ft³/min 125 ft/s 85730 Outlet Device	042 ft ^{3/} min 622.7 ft 125 ft/s 389.6 ft 85730 Outlet Device: Pressure Boundary	4.315 inH2O (0 inH2O (4.315 inH2C 2.625 inH2C	0.02018 0.0155 1.60
		Fi	Fixed dP Devices				
Fixed dP Device Name	Inlet Elevation Inlet Pressure	Outlet Elevation Outlet Pressure	т	dP Head Loss	Flow Rate		
Silencer	22 ft 10.25 inH2O g	26.75 ft 4.315 inH2O g		5.9 inH2O 875.8 ft	1042 ft³/min		
Pressure Boundary Name	l	Pres Elevation	Pressure Boundaries	e Hvdraulic Grade	Grade Flow Rate	ate	
Pressure Boundary		44.5 ft	0 inH2O a	Da		nim	
			Flow Demands	l			
Flow Demand Name		Elevation	Pressure	Hydraulic Grade	Grade Flow Rate	Flow Direction	rection
Engine Outlet		6.75 ft	16.47 inH2O g	20g 2208 ft		Flo	Flow in

Friday, July 28, 2017 11:47 AM

List Report

PIPE-FLO Professional

Page 1

Bill of Materials Report

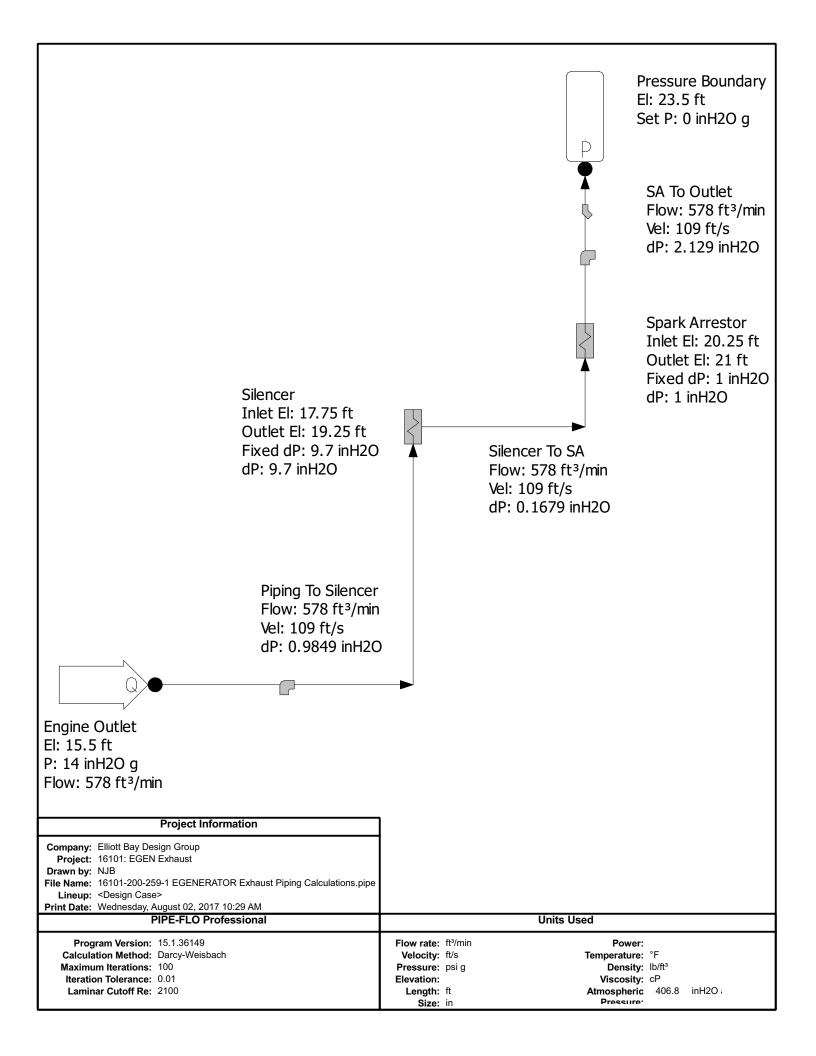
Pipeline	Specifi	ication Size	Len	igth Valves and F
		Pipelines		
•	15.1.36149			Friday, July 28, 2017 11:45
Program Name:	PIPE-FLO Professional		bv:	NJB
Lineup:	<design case=""></design>		Project:	16101: SSDG Exhaust
File Name:	16101-200-259-1 SSGENER	ATOR Exhaust Piping Calculations.pir	Company:	Elliott Bay Design Group

	[Date: Friday, July 28, 2017 11:45 AM			
	Pipelines				
Specification	Size	Length	Valves and Fittings		
Steel, Sch 40	5 in	54 ft	3 x Elbow - Long radius, r/d 1.5 (90°) 2 x Elbow - Standard 45°		
Steel, Sch 40	5 in	20 ft	2 x Mitre Bend @ 15° 1 x Elbow - Standard 45° 1 x Exit - Projecting 1 x Mitre Bend @ 45°		
	Pipeline Material Summary				

Specification	Material	Size	Total Length	Valves & Fittings
Steel, Sch 40	Steel A53-B36.10 Schedule: 40	5 in	74.00 ft	3 x Elbow - Long radius, r/d 1.5 (90°) 3 x Elbow - Standard 45° 1 x Exit - Projecting 2 x Mitre Bend @ 15° 1 x Mitre Bend @ 45°

Piping To Silencer

Silencer To Outlet



			List Report				
File Name: 16101-200-259-1 EGEN Lineup: <design case=""> Procam Name: PIPE-FLO Professional</design>	16101-200-259-1 EGENERATOR Exhaust Piping Calcula <design case=""> PIPE-FLO Professional</design>	culat Calculation Method: Laminar Cutoff Re: Max Iterations:	Darcy-Weisbach 2100 100	Company: Project: bv:	 my: Elliott Bay Design Group ect: 16101: EGEN Exhaust bv: NJB 	۵	
		Iteration Tolerance: 0.01 Atmospheric Pressure: 406.8	0.01 406.8 inH2O a	Dat		, 2017 10:29 AM	
		Pip	e Specifications				
Specification Name Valve Table	Material Schedule	Absolute Roughness Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure		Reynolds Number
Steel, Sch 10 standard	Steel A53-B36.10 Schedule:10	1.800E-03 in 140	0.0	to ft/s	s to	psi g	to
Steel, Sch 20 standard	Steel A53-B36.10 Schedule:20	1.800E-03 in 140	0.0	to ft/s	s to	psi g	to
Steel, Sch 40 standard	Steel A53-B36.10 Schedule:40	1.800E-03 in 140	0.0 Fluid Zones	to ft/s	s to	psi g	to
Fluid Zone Name Table Name	Temperature	Pressure Flui	Fluid State	Density Viscosity	Vapor Pressure Critical Pressure	Sp Rels	Specific Heat Ratio (k) Relative Molecular Mass
Engine Exhaust (Air at 713F) Air	713 °F	14.97 inH2C G		0.03505 lb/ft³ 0.03199 cP	6.202E+06 inH2O a 15151 inH2O a		1.372 28.96
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diamete Length	Inlet Elevation neter Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number	Total Head Loss V&F Head Loss	Inlet Pressure Outlet Pressure	Total dP V&F dP	Pipe Friction Factor V&F Friction Factor V&F Resistance K
Piping To Silencer Steel, Sch 40 Engine Exhaust (Air at 713F)	4 in 4.026 in 5 ft Inlet Device: Engine Outlet	15.5 ft 17.75 ft let	578 ft ³ /min 109 ft/s 59614 Outlet Device: Silencer	143.9 ft 84.16 ft Silencer	14 inH2O (13.01 inH2O (0.9849 inH2C 0.5669 inH2C	0.02174 0.01629 0.46
Silencer To SA Steel, Sch 40 Engine Exhaust (Air at 713F)	4 in 4.026 in 2 ft Inlet Device: Silencer	19.25 ft 20.25 ft	578 ft ³ /min 23.92 109 ft/s 0 59614 Outlet Device: Spark Arrestor	23.92 ft 0 ft Spark Arrestor	3.302 inH2O(3.134 inH2O(0.1679 inH2C 0 inH2C	0.02174 0.01629 0.00
SA To Outlet Steel, Sch 40 Engine Exhaust (Air at 713F)	4 in 4.026 in 3 ft Inlet Device: Spark Arrestor	21 ft 23.5 ft	578 ft³/min 109 ft/s 59614 Outlet Device:	578 ft ³ /min 313.6 ft 109 ft/s 277.7 ft 59614 Outlet Device: Pressure Boundary Devices	2.129 inH20{ 0 inH20{	2.129 inH2C 1.871 inH2C	0.02174 0.01629 1.50
Fixed dP Device Name	Inlet Elevation Inlet Pressure	Outlet Elevation Outlet Pressure		dP Head Loss	Flow Rate		
Silencer	17.75 ft 13.01 inH2Og	19.25 ft 3.302 inH2O g	~	9.7 inH2O 1440 ft	578 ft³/min		
Spark Arrestor	20.25 ft 3.134 inH2Og	21 ft 2.129 inH2O g Pres	ssure Boundaries	1 inH2O 148.4 ft	578 ft³/min		
Pressure Boundary Name		Elevation	Pressure	Hydraulic Grade	Grade Flow Rate	tate	
Pressure Boundary		23.5 ft	0 inH2Og)g -161 ft	t 578 ft³/min	³/min	
PIPE-FLO Professional	Ľ	List Report		Wednesday, August 02, 2017 10:29 AM)2, 2017 10:29 AM		Page 1

	Flow Demands	nands			
Flow Demand Name	Elevation	Pressure	Hydraulic Grade	Flow Rate	Flow Direction
Engine Outlet	15.5 ft	14 inH2Og	1909 ft		Flow in

List Report

Wednesday, August 02, 2017 10:29 AM

		Bill of Materials Report	
	16101-200-259-1 EGENERATOR Exhau <design case=""></design>		 Hy: Elliott Bay Design Group ct: 16101: EGEN Exhaust
•	PIPE-FLO Professional	b	by: NJB
Version:	15.1.36149	Dat	te: Wednesday, August 02, 2017 10:29 AM
		Pipelines	
Pipeline	Specification	Size	Length Valves and Fittings
Piping To Silence	er Steel, Sch 40	4 in	5 ft 2 x Elbow - Long radius, r/d 1.5 (90°)
Silencer To SA	Steel, Sch 40	4 in	2 ft
SA To Outlet	Steel, Sch 40	4 in	3 ft 1 x Elbow - Standard 45° 1 x Exit - Projecting 1 x Mitre Bend @ 45°
		Pipeline Material Summary	
Specification	Material	Size Total Leng	gth Valves & Fittings
Steel, Sch 40	Steel A53-B36.10 Schedule: 40	4 in 10.00 ft	ft 2 x Elbow - Long radius, r/d 1.5 (90°) 1 x Elbow - Standard 45°

1 x Exit - Projecting 1 x Mitre Bend @ 45°

Appendix D

Fuel Oil System, Dwg. 16101-200-261-1

1 DESCRIPTION

This appendix documents the first principles calculations used in designing the fuel oil system. These calculations are used to identify steady state frictional losses throughout the piping system and to validate system design.

2 PROCEDURE

Calculations are presented in the following sequence:

- Pipe size calculations
- Engine fuel pump supply pressure calculations
- Engine fuel pump return pressure

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

- The fuel oil system is to be constructed of Schedule 40 carbon steel pipe.
- Maximum fuel flow rate to each main engine is 3.34 gpm, from [1].
- Maximum fuel flow rate to each generator is 1.1 gpm, from [2].
- The main engines and generators have the following fuel system design constraints [1], [2]:

Parameter	Maximum
Allowable supply line restriction to main engine	4.37 psi
Allowable return line restriction from main engine	3.93 psi
Allowable supply line restriction to generator engine	1.47 psi
Allowable return line restriction from generator engine	1.47 psi

Table 5-1: Fuel System Design Constraints

- Piping system lengths, routing, fittings, etc. are estimated based on the Profiles and Arrangements, and Fuel Oil Diagram [3] [4].
- Each main engine fuel supply utilizes a Racor 751000MAXM duplex fuel filter with a pressure drop of 3.5 psi at a flowrate of 6.0 gpm, from [5].
- Each generator engine fuel supply utilizes a Racor 1000MAM fuel filter with a pressure drop of 0.5 psi at a flowrate of 3.0 gpm, from [5]
- The system is normally arranged such that an engine and generator pair consumes fuel from the nearest tank. The model assumes a worst case wherein both main engines and one generator are utilizing one tank.

• Tank and engine elevations were estimated from [3] and all elevations are in reference to the vessel's baseline:

Elevation Point	Elevation
Fuel tank low fuel level	3.5 feet
Fuel tank high fuel level	7.5 feet
Main Engine fuel inlet	3.75 feet
Main Engine fuel outlet	5.8 feet
Generator fuel inlet	4.25 feet
Generator fuel outlet	4.25 feet

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Pipe Size Calculations

Pipe sizes are based on the nominal velocity limits found in Marine Engineering, Chapter 20, Table 3, [6]. The following table shows the flow rates of fuel occurring in the system, and the resulting pipe sizes.

Pipe Segment	Flow Rate	Pipe/Tube Size	ID	Design Ve	locity (ft/s)	V
ripe Segment	gpm	(NPS)	in	Nominal	Limit	ft/s
Fill Rate	50	2" Sch 80	1.940	6.96	12.00	5.29
Supply Main (1 me, 1 gen)	4.44	2" Sch 40	2.070	2.88	7.00	0.41
Return main (1 me, 1 gen)	4.44	2" Sch 40	2.070	7.19	12.00	0.41
Main Engine - Supply	3.34	3/4" Sch 40	0.820	1.81	7.00	1.97
Generator - Supply	1.10	3/4" Sch 40	0.820	1.81	7.00	0.65
Main Engine - Return	3.34	3/4" Sch 40	0.820	4.53	12.00	1.97
Generator - Return	1.10	1" Sch 40	1.050	5.12	12.00	0.40

Table 5-3: Fuel Oil System Pipe Sizes and Velocities

5.2 Engine Fuel Suction Pressure Calculations

The attached system model confirms that the piping systems are compatible with the main engines' fuel supply allowable line restriction requirements. As listed above, the maximum fuel line restriction is 4.37 psi. The attached model shows the calculated pressure loss to be 2.5 psi.

The attached system model confirms that the piping systems are compatible with the generator engines' fuel supply allowable line restriction requirements. As listed above, the maximum fuel line restriction is 1.47 psi. The attached model shows the calculated pressure loss to be 0.6 psi.

5.3 Engine Fuel Return Pressure Calculations

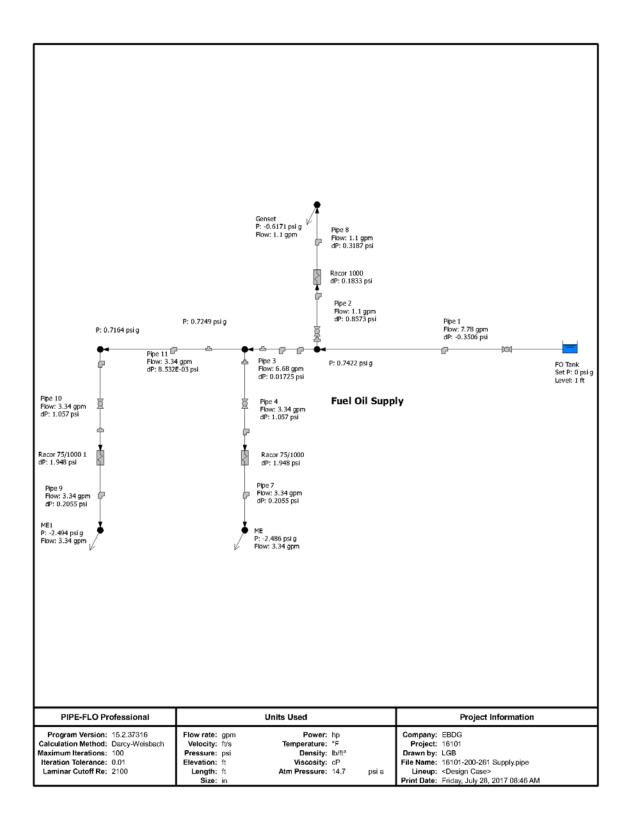
The attached model of the fuel system's return piping confirms that the backpressure at the main engines does not exceed the listed maximum value of 3.93psi. The return line restriction at the main engines was found to be 1.163 psi.

The generators fuel return line restriction is calculated to be 1.35 psi which is below the stated maximum of 1.47 psi. Note, however, that this assumes the generator is installed on a foundation that is approximately 16" above the engine room grating. This is also considering the scenario wherein both main engines are returning to the same tank. Particular attention should be paid toward generator selection and installation with respect to fuel oil return during detail design.

6 **REFERENCES**

- [1] Caterpillar, "C18 Systems Data," EM0270, 12/19/2016.
- [2] Northern Lights, "ISM Toyota Mitsubishi Marine Genset Specs; Model M944T3," Feb 2016.
- [3] Elliott Bay Design Group, "NCDOT Pedestrian Ferry: Profiles and Arrangements," 16109-003-101-1, Seattle, WA.
- [4] Elliott Bay Design Group, "NCDOT Pedestrian Ferry: Fuel Oil Diagram," 16109-003-261-1, Seattle, WA.
- [5] Parker Racor, "Racor Products Catolog: Marine Fuel Filtration Products: 79/1000MAV".
- [6] Parker Racor, "Racor Products Catolog:Marine Fuel Filtration Products: 1000MA".
- [7] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.

FUEL OIL SUPPLY PIPE-FLO MODEL



NCDOT

Fie Name: 16:101-200-261 Supplyable Calculation Method: Derroy Method: <thderroy method:<="" th=""> <</thderroy>							
Clip Specific Calibor Assoluts Roughness Calibor Selected a Assoluts Roughness Calibor Selected a Assoluts Roughness Calibor Selected a Assoluts Roughness Assoluts Roughness Assoluts Roughness Assoluts Roughness <td>200-261 Supply.pipe n Case> LO Professional 316</td> <td>Calculation Laminar C. Max Ite Percent To Allowable Do</td> <td>0 2 3 9</td> <td>Atmospheric</td> <td>Company: EBDG Project: 16101 by: LGB Date: Fridsy July 28, 2017 08:47 AM Pressure: 14.7 psi a</td> <td>8, 2017 08:47 AM a</td> <td></td>	200-261 Supply.pipe n Case> LO Professional 316	Calculation Laminar C. Max Ite Percent To Allowable Do	0 2 3 9	Atmospheric	Company: EBDG Project: 16101 by: LGB Date: Fridsy July 28, 2017 08:47 AM Pressure: 14.7 psi a	8, 2017 08:47 AM a	
certion Name Material Absolute Roughness abie Schedule Hazen Williams C Factor 65 Sch 40 Steel A53-835.10 13005 1400 Fluid Steel 65 Sch 40 Steel A53-835.10 13005 1400 Fluid Steel 65 Sch 40 Steel A53-835.10 13005 1400 Fluid Steel 66 Sch 40 Steel A53-835.10 13005 1400 Fluid Steel 67 Sch 40 Steel A53-835.10 13005 110005 110005 68 Sch 40 0.0050 1.5 0.00508 1.5 0.00508 63 Sch 40 0.015 0.016 1.5 0.0130 1.35 0.00508 63 Sch 40 0.016 0.016 0.016 0.00508 0.0130 63 Sch 40 0.016 0.016 0.00508 0.0133 0.0133 63 Sch 40 0.025 0.025 0.0133 0.0133 0.0133 0.0133 63 Sch 40 0.025 0.025 0.02634			Pipe Specification:	S			
63 Sch 40 Steel AS3-836.10 1800E-03 1400 140 and Schedule:40 16mperature Fluic and France Relative Relative Asx 0 psi 0 1.5 ft Asx 0 psi 0.75 in Node 5 Asx 0 psi 1.5 ft 1.5 ft Asx 0.75 in Node 5 1.5 ft Asx 0.75 in Node 5 1.5 ft Asx 0.75 in Node 5 1.5 ft Asx 1.0 ft 1.6 ft 1.5 ft Asx 1.0 ft 1.5 ft 1.5 ft Asx 1.0 ft 1.6 ft 1.5 ft <	Material Schedule	Absolute Hazen Willia		Sizing Criteria	Velocity	Design Limits Pressure	Reynolds Number
Mame Temperature Fluid Airs Descure Relation N Airs Size Init Elevation Cistion Lis ft Init Elevation Cistion Lis ft Init Elevation Cistion Lis ft Ist ft Cistion Cistin Sist ft Sist ft Cistion Cistin Sist ft Sist ft Cistin Lis ft Ist ft Ist ft Cistin Cistin Sist ft Sist ft Cistin Cistin Sist ft Sist ft Cistin Sist ft Sist ft Sist ft Cistin Sist ft Sist ft Sist ft Cistin Sist ft Sist ft Sist ft Sist ft Sist ft <td>Steel A53-B36.10 Schedule:40</td> <td>1.800E-</td> <td></td> <td>Min: Max:</td> <td>n: ft/s x: ft/s</td> <td>psig psig</td> <td></td>	Steel A53-B36.10 Schedule:40	1.800E-		Min: Max:	n: ft/s x: ft/s	psig psig	
Constraine Temperature Fluir Aix $0 = 5$ $1 = 5$ Lid Aix $0 = 5$ $0 = 5$ Lid Aix $0 = 5$ $0 = 5$ Lid Aix $0 = 5$ $0 = 5$ Lid Aix $0 = 5$ $1 = 5$ Lid Aix $0 = 5$ $1 = 5$ $1 = 5$ $1 = 5$ Aix $0 = 75$ $0 = 75$ $0 = 75$ $0 = 75$ $1 = 5$ 653 Sch 40 $0 = 75$ $1 = 3.6$ $1 = 5$ $1 = 5$ $0 = 75$ $1 = 7$ $1 = 7$ $1 = 5$ $1 = 5$ $1 = 5$ $0 = 75$ $1 = 75$ $1 = 75$ $1 = 75$ $1 = 5$ $1 = 5$ $0 = 5$ $1 = 75$ $1 = 75$ $1 = 75$ $1 = 5$ $1 = 5$ $0 = 5$ $1 = 75$ $1 = 75$ $1 = 75$ $1 = 5$ $1 = 5$ $0 = 5$ $1 = 75$ $1 = 75$ $1 = 5$ $1 = 5$ $1 = 5$ $0 = 5$ $1 = 75$ <			Fluid Zones				
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Name Size Inter Device ation Langth Inter Device 65 Sh4 40 2 In Cutat Elevation 63 Sh4 40 2 In FO Task 63 Sh4 40 2 In FO Task 63 Sh4 40 2 In FO Task 63 Sh4 40 2 In Node 5 63 Sh4 40 2 In Node 5 63 Sh4 40 0 75 in Node 5 63 Sh 40 0 75 in </td <td></td> <td>50 °F 0 psig</td> <td></td> <td>56.38 lb/ft² 10.19 cP</td> <td>0.217 319</td> <td>0.2171 psia 3199 psia</td> <td></td>		50 °F 0 psig		56.38 lb/ft ² 10.19 cP	0.217 319	0.2171 psia 3199 psia	
Name Size Intel Device action Length Outlet Elevation 65 Sch 40 2 lin FO Tavk 65 Sch 40 0.75 lin Node 6 65 Sch 40 0.75 lin Node 1 65 Sch 40 0.75 lin Node 5 65 Sch 40 0.75 lin Node 5 65 fin 0.75 lin Sch 4 10 fin Node 5 1 10 fin 0.75 lin Sch 4 10 fin 0.75 li			Pipelines				
Action Inside Diameter Length Unter Elevation Cuttor Elevation Outlot Elevation 63 Sch 40 2.067 in 2.5 ft 63 Sch 40 2.067 in 2.5 ft 63 Sch 40 0.75 in Node 5 63 Sch 40 0.75 in Node 5 63 Sch 40 0.824 in 1.5 ft 63 Sch 40 0.75 in Node 5 63 Sch 40	Size		Flow Rate	Inlet Total Pressure	Total dP	Outlet Total Pressure	V&F Friction Factor
2 in 2 in 2 in 2 in 2 in to the formation of the formati	Inside Diame Length		Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Resistance K V&F dP V&F Head Loss
63 Sch 40 2.067 in 2.5 ft 0 30 ft 1.5 ft Node 6 1.5 ft Node 6 63 Sch 40 0.75 in Node 6 63 Sch 40 0.824 in 1.5 ft 63 Sch 40 0.824 in 1.5 ft 63 Sch 40 2.067 in Node 6 63 Sch 40 2.067 in 1.5 ft 63 Sch 40 0.75 in Node 1 63 Sch 40 0.75 in Node 1 63 Sch 40 0.824 in 1.5 ft 63 Sch 40 0.824 in 1.5 ft 63 Sch 40 0.824 in 1.5 ft 63 Sch 40 0.75 in Node 5 63 Sch 40 0.75 in 3.5 ft	2 II.	FO Tank	7.78 gpm	0.3915 psi a	-0.3506 psi	0.7422 psi a	0.01899
30 ft Node 1 1.5 ft 1.5 ft 63 Sdh 40 0.75 in Node 6 63 Sdh 40 0.824 in 1.5 ft 65 Sdh 40 0.75 in Node 6 1.5 ft 1.5 ft 1.5 ft 63 Sdh 40 0.75 in Node 1 1.5 ft 1.5 ft 1.5 ft 1.5 ft 1.6 ft 1.5 ft 1.6 ft 1.6 ft 3.5 ft 1.6 ft 3.5 ft 1.6 ft	2.067 in	2.5 ft	0.7439 ft/s	0.3882 psig		0.7388 psig	1.58
63 Sch 40 0.75 in 0.824 in 3.75 (100 1 Node 6 63 Sch 40 0.824 in 3.65 (100 1 1.6 ft 3.6 ft 3.5 ft 8.6 75 (100 1 63 Sch 40 2.075 in 1.5 ft Node 5 1.6 ft 1.5 ft 1.6 ft 1.5 ft 1.6 ft 1.5 ft 63 Sch 40 2.5 ft Node 1 1.5 ft 1.6 ft 1.6 ft 63 Sch 40 0.75 in Node 1 1.5 ft 1.6 ft 1.6 ft 1.6 ft 63 Sch 40 0.75 in Node 1 1.6 ft Node 1 1.6 ft <	30 ft	1.5 ft	1055 0.06068	3.5 ft 3.491 ft	0.1044 ft	3.396 ft 3.387 ft	5.307E-03 psi 0.01355 ft
63 Sch 40 0.824 in 1.5 ft 63 Sch 40 10 ft Raco779100 1 63 Sch 40 2 in Node 5 63 Sch 40 2.067 in 1.5 ft 63 Sch 40 2.057 in 1.5 ft 63 Sch 40 0.75 in Node 5 63 Sch 40 0.75 in Node 1 63 Sch 40 0.824 in 1.5 ft 63 Sch 40 0.75 in Node 5 63 Sch 40 0.75 in 8000 75100	0.75 in	Node 6	3.34 gpm	0.7164 psig	1.057 psi	-0.3404 psi g	0.02398
10 ft Record/10001 53 Sch 40 3.5 ft 3.5 ft 55 ft 1.5 ft 3.5 ft 0.66 53 Sch 40 2.5 ft 1.5 ft 0.66 1.5 ft 0.65 1.6 0.65 1.6 0.65 1.6 0.65 1.6 0.66 1.6<	0.824 in	1.5 ft	2.009 ft/s	0.6918 psi g		-0.365 psi g	2.94
23 Sch 40 2 in Node 5 1.5 ft 1.5 ft 1.66 ft 15 ft 1.5 ft 1.66 ft 1.66 ft 1.66 ft 1.66 ft 15 ft Node 1 Node 1 1.66 ft 1.66 ft 1.66 ft 63 Sch 40 0.75 in Node 1 1.6 ft 1.6 ft 1.6 ft 63 Sch 40 0.824 in 1.6 ft 3.5 ft 1.6 ft 1.6 ft 63 Sch 40 0.75 in Node 5 1.5 ft 1.6 ft 1.6 ft 63 Sch 40 0.75 in Node 5 1.5 ft 1.6 ft 1.5 ft 63 Sch 40 0.25 in Node 5 1.6 ft 1.5 ft 1.6 ft 63 Sch 40 0.25 in Node 5 1.6 ft 1.6 ft 1.6 ft 63 Sch 40 0.25 in Ruco 75/1000 3.5 ft 1.6 ft 63 Sch 40 0.824 in 3.5 ft ME	10 ft	Racor 75/1000 1 3.5 ft	1136 0.05634	3.33 ft 3.267 ft	0.6993 ft	2.63 ft 2.568 ft	0.07219 psi 0.1844 ft
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10 IT Record 100 3.5 ft 3.5 ft 1.5 f	0.824 in	1.5 ft	0.6618 ft/s		1 0000 0	-0.1178 psig	2.94
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453 Sd1 40 2.067 in 10 ft 1.5 ft Nois 5 1.5 ft 0 70 ft 0.75 in Nois 5 1.5 ft 0 63 Sd1 40 0.75 in Nois 5 1.5 ft 1.5 ft 63 Sd1 40 0.75 in Nois 5 1.5 ft 1.5 ft 1 453 Sd1 40 0.824 in 1.5 ft 3.5 ft 3.5 ft 1 453 Sd1 40 0.824 in 3.5 ft 3.5 ft ME	2 in	Node 1	6.68 gpm	0.7422 psi g	0.01725 psi	0.7249 psig	0.01899
10 ft Node 5 1.5 ft 1.5 ft 1.5 ft 1.5 ft 1.5 ft 1.5 ft 1.5	2.067 in	1.5 ft	0.6387 ft/s	0.7397 psi g		0.7224 psi g	2.85
453 Sch 40 0.75 in Node 5 0.824 in 1.5 ft 10 ft Raxx 751000 0.75 in Raxx 751000 0.75 in Raxx 751000 0.75 in Raxx 751000 0.824 in 3.5 ft ME	10 ft	Node 5 1.5 ft	905.7 0.07067	3.396 ft 3.389 ft	0.04406 ft	3.352 ft 3.345 ft	7.070E-03 psi 0.01806 ft
453 Sch 40 0.824 in 1.5 ft 10 ft Raxx751000 3.5 ft 0.75 in Raxx751000 0.75 in Raxx751000 3.5 ft 3.5 ft Me	0.75 in	Node 5	3.34 gpm	0.7249 psi g	1.057 psi	-0.3319 psi g	0.02398
10 ft Raxx75/000 3.5 ft 453 Sch 40 0.824 in 3.5 ft 3.5 ft Me	0.824 in	1.5 ft	2.009 ft/s	0.7003 psi g		-0.3565 psig	2.94
0.75 in Ruoor 75/100 453 Sch 40 0.824 in 3.5 ft 3 ft ME	10 ft	Racor 75/1000 3.5 ft	1136 0.05634	3.352 ft 3.289 ft	0.6993 ft	2.652 ft 2.589 ft	0.07219 psi 0.1844 ft
A53 Sch 40 0.824 in 3.5 ft ME 3 ft ME	0.75 in	Racor 75/1000	3.34 gpm	-2.28 psig	0.2055 psi	-2.486 psi g	0.02398
3.ft ME	0.824 in	3.5 ft	2.009 ft/s	psi		-2.51 psig	1.92
3.75 ft 0	3 ft	ME 3.75 ft	1136 0.05634	-2.324 ft -2.387 ft	0.2748 ft	-2.599 ft -2.662 ft	0.04713 psi 0.1204 ft
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			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device eter Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade r Inlet Hydraulic Grade	e Total dP re Total Head Loss ide	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 8 ASTM A53 Sch 40 Fuel 3	0.75 in 0.824 in 3 ft	Racor 1000 3.5 ft Genset 4.25 ft	1.1 gpm 0.6618 ft/s 374.1 0.1711	-0.2984 psig -0.3011 psig 2.738 ft 2.731 ft	0.3187 psi 0.06393 ft	-0.6171 psig -0.6198 psig 2.674 ft 2.667 ft	0.02398 1.92 5.112E-03 psi 0.01306 ft
Pipe 9 ASTM A53 Sch 40 Fuel 3	0.75 in 0.824 in 3 ft	Racor 75/1000 1 3.5 ft ME1 3.75 ft	3.34 gpm 2.009 ft/s 1136 0.05634 Tanks	-2.289 psig -2.313 psig -2.346 ft -2.409 ft	0.2055 psi 0.2748 ft	-2.494 psig -2.519 psig -2.621 ft -2.684 ft	0.02398 1.92 0.04713 psi 0.1204 ft
Tank Name Fluid Zone	Bottom Elevation Liquid Level	Surface Pressure Bottom Pressure	Hydraulic Grade	Pipeline Name	Connectin Penetration Height	Connecting Pipelines Height Pipeline Flow Rate Pre	Pressure at Penetration
Fo Tank Fuel 3	2.5 ft 1 ft	0 psig 0.3915 psig	3.5 ft	Pipe 1	0 ft	7.78 gpm	0.3915 psig
Curve dP Device Name	Inlet Elevation		Curve dP Devices Outlet Elevation	ŝŝ	Flow Rate	l	
Description	Inlet Pressure		Outlet Pressure	Head Loss			
Racor 1000 Racor 1000	3.5 ft -0.1151 psig		3.5 ft -0.2984 psi g	0.1833 psi 0.4683 ft	1.1 gpm		
Racor 75/1000 Racor 75/1000	3.5 ft -0.3319 psig		3.5 ft -2.28 psig	1.948 psi 4.976 ft	3.34 gpm		
Racor 75/1000 1 Racor 75/1000	3.5 ft -0.3404 psig		3.5 ft -2.289 psi g Nodes	1.948 psi 4.976 ft	3.34 gpm		
Node Name		u	Elevation P	Pressure H	Hydraulic Grade		
Node 1			1.5 ft 0.74:	0.7422 psi g	3.388 ft		
Node 5			1.5 ft 0.72	0.7249 psi g	3.328 ft		
Node 6		l	1.5 ft 0.716 Flow Demands	0.7164 psig ands	3.298 ft		
Flow Demand Name		Ξ		issure	Hydraulic Grade	Flow Rate Flow Direction	rection
Genset		4	4.25 ft -0.61	-0.6171 psi g 2	2.667 ft	1.1 gpm Flov	Flow out
ME		3	3.75 ft -2.4	-2.486 psig -2	-2.662 ft	3.34 gpm Flov	Flow out
ME1		n	3.75 ft	2.494 psi g	-2.684 ft	3.34 gpm Flov	Flow out

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File Name: 16101-200 Lineup: <design ca<br="">Program Name: PIPE-FLO</design>	ase>		Company: Project: by:	
Version: 15.2.37316	3	Teeke	Date:	Friday, July 28, 2017 08:46 AM
Tank Name		Tanks		
FO Tank				
		Curve dP Devi	ces	
Curve dP Device Name	Curve	Description		
Racor 1000	Racor	1000		
Racor 75/1000	Racor	75/1000		
Racor 75/1000 1	Racor	75/1000		
Dinalina	Seculiantian	Pipelines Size	Longth	Values and Eithings
Pipeline	Specification		Length	Valves and Fittings
Pipe 1	ASTM A53 Sch 40	2 in	30 ft	4 x Pipe Bend - r/d 1 (90°) 1 x Ball
Pipe 10	ASTM A53 Sch 40	0.75 in	10 ft	1 x Ball 1 x Reducer - Contraction (0.75 in x 2 in - 0 in 1 x Tee - Flow Thru Branch 3 x Pipe Bend - r/d 1.5 (90°)
Pipe 11	ASTM A53 Sch 40	2 in	15 ft	4 x Pipe Bend - r/d 1.5 (90°) 1 x Tee - Flow Thru Run
Pipe 2	ASTM A53 Sch 40	0.75 in	10 ft	1 x Reducer - Contraction (0.75 in x 2 in - 0 in 1 x Ball 3 x Pipe Bend - r/d 1.5 (90*) 1 x Tee - Flow Thru Branch
Pipe 3	ASTM A53 Sch 40	2 in	10 ft	2 x Pipe Bend - r/d 1 (90°) 3 x Elbow - Standard 90° 1 x Tee - Flow Thru Run
Pipe 4	ASTM A53 Sch 40	0.75 in	10 ft	1 x Ball 1 x Reducer - Contraction (0.75 in x 2 in - 0 in 3 x Pipe Bend - r/d 1.5 (90*) 1 x Tee - Flow Thru Branch
Pipe 7	ASTM A53 Sch 40	0.75 in	3 ft	4 x Pipe Bend - r/d 1 (90°)
Pipe 8	ASTM A53 Sch 40	0.75 in	3 ft	4 x Pipe Bend - r/d 1 (90°)
Pipe 9	ASTM A53 Sch 40	0.75 in	3 ft	4 x Pipe Bend - r/d 1 (90°)
		Pipeline Material S	ummary	
Specification	Material	Size	Total Length	Valves & Fittings
ASTM A53 Sch 40	Steel A53-B36.10 Schedule: 40	0.75 in	39.00 ft	3 x Ball 12 x Pipe Bend - r/d 1 (90°) 9 x Pipe Bend - r/d 1.5 (90°) 3 x Reducer - Contraction (0.75 in x 2 in - 0 in) 3 x Tee - Flow Thru Branch
ASTM A53 Sch 40	Steel A53-B36.10 Schedule: 40	2 in	55.00 ft	1 x Ball 3 x Elbow - Standard 90° 6 x Pipe Bend - r/d 1 (90°) 4 x Pipe Bend - r/d 1.5 (90°) 2 x Tee - Flow Thru Run

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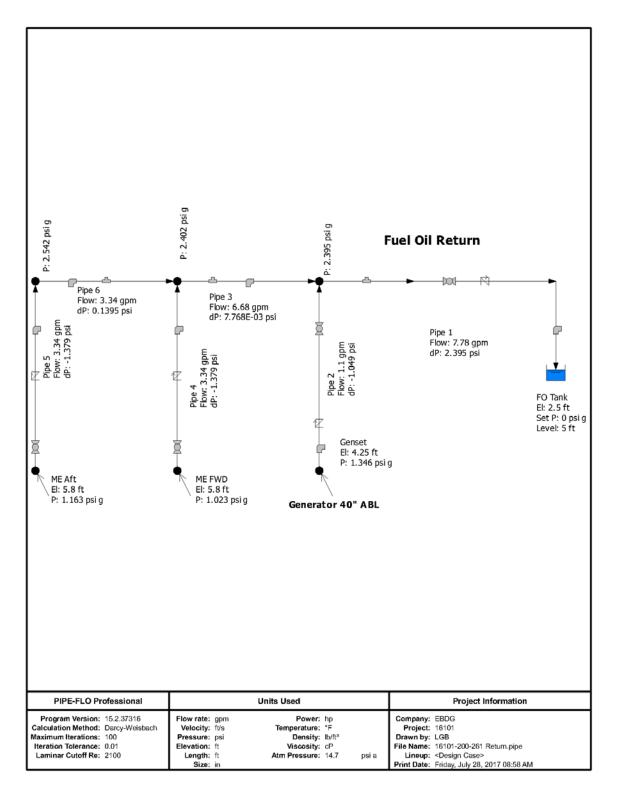
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pipe	۵	Calculatic Laminar Nax Percent Allowable	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Iterations: 000 Percent Tolerance: 0.01 Allowable Deviation: 1 %	Weisbach	Company: Project: by: Date: Atmospheric Pressure:	Company: EBDG Project: 16101 by: LGB Date: Friday, July 28, Pressure: 14.7 psi a	pany: EBDG oject: 16101 by: LGB Date: Fitdey, July 28, 2017 08:59 AM sure: 14.7 psia	-		
			Pipe Spec	ifications						
	Material	Absolut	Absolute Roughness	Sizing	Sizing Criteria	Viete etter	Design Limits	Limits		
	acriedure					velocity	LISSALE	8	Reynolds Number	
	Steel A53-B36.10 Schedule:40	1.800	1.800E-03 in 140	0.0	Min: Max:	c ft/s	psi g psi g	51 51		
	SSteel ASTM-A-269 Schedule:.065		6E-05 in 100	0.0	Min: Max:	tt/s tt/s	psi g psi g	0 0		
			Fluid Zones	Cones			·			
	F	Temperature Pressure Rel	Fluid State Relative Molecular Mass	355	Density Viscosity	Vapo Critic	Vapor Pressure Critical Pressure	Specific H Specific	Specific Heat Capacity (cp) Specific Heat Ratio (k)	
		50°F 0 psig	Liquid 1		56.38 lb/ft ² 10.19 cP	0.2	0.2171 psia 3199 psia			
			Pipelines	ines						
	Size Inside Diameter Length	Inlet Device r Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	ate ocity lumber n Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	ressure Pressure y Grade iic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss	
	2 in 2.067 in 30 ft	Node 1 1.5 ft FO Tank 7.5 ft	7.78 gpm 0.7439 ft/s 1055 0.06068	bm /s	2.395 psig 2.391 psig 7.616 ft 7.608 ft	2.395 psi 0.1162 ft	0 psig -3.367E-03 psig 7.5 ft 7.491 ft	0 psig 03 psig 5 ft 01 ft	0.01899 2.94 9.910E-03 psi 0.02531 ft	
	1 in 1.049 in 10 ft	Genset 4.25 ft Node 1 1.5 ft	1.1 gpm 0.4083 ft/s 293.9 0.2178	m /s	1.346 psig 1.345 psig 7.688 ft 7.685 ft	-1.049 psi 0.07141 ft	2.395 psi 2.394 psi 7.616 ft 7.614 ft	psig psig ft	0.02249 2.64 2.681E-03 psi 6.848E-03 ft	
	2 in 2.067 in 3 ft	Node 2 1.5 ft Node 1 1.5 ft	6.68 gpm 0.6387 ft/s 905.7 0.07067	ws 2	2.402 psig 2.4 psig 7.636 ft 7.63 ft	7.768E-03 psi 0.01984 ft	2.395 psig 2.392 psig 7.616 ft 7.61 ft	psig ft ft	0.01899 1.90 4.713E-03 psi 0.01204 ft	

File Name: 16101-200-261 Return.pipe Lineup: Obesign Case> Progem Name: PIPE-FLO Professional Version: 15.2.37316		Calculation Method: Laminar Cutoff Re: Max Iterations: Percent Tolerance: Allowable Deviation:	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Herations: 100 Percent Tolerance: 0.01 Allowable Deviation: 1 %	Atmospheric	Company: EBDG Project: 16101 by: LGB Date: Friday Pressure: 14	pany: EBDG oject: 16101 by: LGB Date: Friday, July 28, 201 isure: 14.7 psi a	201
			Pipe Specifications	SII (
Specification Name	Material	Absolute		Sizing Criteria			
Valve Table	Schedule	Hazen Willi	Hazen Williams C Factor			Velocity	
ASTM A 53 Sch 40 standard	Steel A53-B36.10 Schedule:40	1.800E-03 140	IE-03 in 0.0 140	-	Min: Max:	ft/s ft/s	
ASTM-A-269 0.065 Wall standard	SSteel ASTM-A-269 Schedule: 065	60 15	6E-05 in 0.0 100		Min: Max:	ft/s ft/s	
			Fluid Zones				
Fluid Zone Name Table Name	Tem	Temperature Pressure Relat	Fluid State Relative Molecular Mass	Density Viscosity		Vapor Press Critical Press	ress ress
Fuel 3 Fuel 3 Max		50°F 0psig	Liquid 1	56.38 lb/ft ⁹ 10.19 cP		0.2171 psi 3199 psi	psi psi
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade r Inlet Hydraulic Grade		Total dP Total Head Loss	<u>er</u> o <u>er</u> o
Pipe 1 ASTM A 53 Sch 40	2 in 2 067 in	Node 1 1 5 #	7.78 gpm 0.7430 #/e	2.395 psig 2.301 psig	6	2.395 psi	٩ ٩
Fuel 3	30 ft	5 ft 7.5 ft	0.06068	7.616 ft 7.608 ft	0.1	0.1162 ft	·
Pipe 2	i.	Gensel	1.1 gpm	1.346 psi a	5	-1.049 psi	
ASTM A 53 Sch 40 Fuel 3	1.049 in 10 ft	4.25 ft Node 1	0.4083 ft/s 293.9	1.345 psig 7.688 ft	0.07	0.07141 ft	
0.000 -		1.5 ft	0.2178				
Pipe 3 ASTM A 53 Sch 40		Node 2 1.5 ft	6.68 gpm 0.6387 ft/s		7.768	7.768E-03 psi	
706 0	ц	1.5 ft	7.cms 0.07067	7.63 ft	0.0	0.01964 T	
Pipe 4	0.75 in	ME FWD	3.34 gpm	1.023 psig	4	-1.379 psi	
Fuel 3	10 ft	0.0 IL Node 2 1.5 ft	2:003 145 1136 0.05634	0.3301 Parg 8.414 ft 8.351 ft	0.7	0.7776 ft	
Pipe 5	0.75 in	MEAN	3.34 gpm	1.163 psig	4	-1.379 psi	
ASTM A 53 Sch 40 Fuel 3	0.824 in 10 ft	5.8 ft Node 3 1.5 ft	2.009 ft/s 1136 0.05634	1.138 psig 8.77 ft 8.707 ft	0.7	0.7776 ft	
Pipe 6	,i	Node 3	3.34 gpm	2.542 psi g	0.1	0.1395 psi	
ASTM A 53 Sch 40 Fuel 3	1.049 in 15 ft	1.5 ft Node 2	1.24 ft/s 892.3	2.533 psig 7.992 ft	0.3	0.3564 ft	
		1.5 ft	0.07173				

0.02398 4.19 0.1028 psi 0.2627 ft

0.02398 4.19 0.1028 psi 0.2627 ft

2.402 psi g 2.378 psi g 7.636 ft 7.573 ft 2.542 psi g 2.517 psi g 7.992 ft 7.93 ft

0.02249 2.61 0.02441 psi 0.06234 ft

2.402 psig 2.393 psig 7.636 ft 7.612 ft

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			Tanks	s			
Tank Name Fluid Zone	Bottom Elevation Liquid Level	Surface Pressure Bottom Pressure	Hydraulic Grade	Pipeline Name	Connecti Penetration Height	Connecting Pipelines Height Pipeline Flow Rate	Pipelines Pipeline Flow Rate Pressure at Penetration
FO Tank Fuel 3	2.5 ft 5 ft	0 psig 1.958 psig	7.5 ft	eig Tool	4 12	7.78 4000	0 Det
		l	Nodes	l	2	IIIdB ozra	6 101
Node Name			Elevation	Pressure	Hydraulic Grade		
Node 1			1.5 ft	2.395 psi g	7.61 ft		
Node 2			1.5 ft	2.402 psi g	7.605 ft		
Node 3			1.5 ft	2.542 psi g	7.949 ft		
			Flow Demands	nands			
Flow Demand Name		-	Elevation	Pressure	Hydraulic Grade	Flow Rate Flo	Flow Direction
Genset			4.25 ft	1.346 psi g	7.685 ft	1.1 gpm	Flow in
ME Aft			5.8 ft	1.163 psi g	8.707 ft	3.34 gpm	Flow in
ME FWD			5.8 ft	1.023 psi g	8.351 ft	3.34 gpm	Flow in

Bottom Liqui	21			
Tank Name Fluid Zone	FO Tank Fuel 3	Node Name	Node 1	Node 2
NC I				

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File Name: 16101-20 Lineup: <design Program Name: PIPE-FL Version: 15.2.373</design 	Case> O Professional	-		
Tank Name		Tanks		
FO Tank				
		Pipelines		
Pipeline	Specification	Size	Length	Valves and Fittings
Pipe 1	ASTM A 53 Sch 40	2 in	30 ft	1 x Swing Check - Vertical 1 x Tee - Flow Thru Branch 3 x Pipe Bend - r/d 1.5 (90°) 1 x Ball
Pipe 2	ASTM A 53 Sch 40	1 in	10 ft	1 x Reducer - Contraction (1 in x 2 in - 1.5 in) 1 x Swing Check - Vertical 1 x Ball 4 x Elbow - Long radius, r/d 1.5 (90°)
Pipe 3	ASTM A 53 Sch 40	2 in	3 ft	2 x Pipe Bend - r/d 1 (90°) 1 x Tee - Flow Thru Branch
Pipe 4	ASTM A 53 Sch 40	0.75 in	10 ft	1 x Swing Check - Angled 1 x Reducer - Enlargement (0.75 in x 2 in - 3 in) 4 x Pipe Bend - r/d 1.5 (90°) 1 x Ball
Pipe 5	ASTM A 53 Sch 40	0.75 in	10 ft	1 x Swing Check - Angled 1 x Reducer - Enlargement (0.75 in x 2 in - 3 in) 4 x Pipe Bend - r/d 1.5 (90°) 1 x Ball
Pipe 6	ASTM A 53 Sch 40	1 in	15 ft	1 x Tee - Flow Thru Branch 4 x Elbow - Long radius, r/d 1.5 (90°)
	I	Pipeline Material S	ummary	
Specification	Material	Size	Total Length	Valves & Fittings
ASTM A 53 Sch 40	Steel A53-B36.10 Schedule: 40	0.75 in	20.00 ft	2 x Ball 8 x Pipe Bend - r/d 1.5 (90°) 2 x Reducer - Enlargement (0.75 in x 2 in - 3 in) 2 x Swing Check - Angled
ASTM A 53 Sch 40	Steel A53-B36.10 Schedule: 40	1 in	25.00 ft	1 x Ball 8 x Elbow - Long radius, r/d 1.5 (90°) 1 x Reducer - Contraction (1 in x 2 in - 1.5 in) 1 x Swing Check - Vertical 1 x Tee - Flow Thru Branch
ASTM A 53 Sch 40	Steel A53-B36.10 Schedule: 40	2 in	33.00 ft	1 x Ball 2 x Pipe Bend - r/d 1 (90°) 3 x Pipe Bend - r/d 1.5 (90°) 1 x Swing Check - Vertical 2 x Tee - Flow Thru Branch

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Appendix E

Machinery Ventilation System, Dwg. 16101-200-513-1

1 DESCRIPTION

This appendix documents the calculations used in designing the machinery ventilation system. The required ventilation rate was calculated for each machinery or void space in the hold, and ducting calculations performed to determine required fan performance. Louver sizes for the emergency generator room are also determined.

2 PROCEDURE

Calculations are presented in the following sequence:

1) Space Airflow Calculation	Flow rates are calculated based on advised air changes per hour based upon space type or airflow per occupant [1]. For spaces containing diesel engines or oil fired machinery, airflow is based upon equipment combustion air intake and heat dissipation.
2) Duct/Trunk Size Calculation	Duct and trunk sizes are calculated based on nominal velocity limits given in [2]. These calculations are developed in conjunction with a preliminary duct layout in which flows through branches are determined.
3) Fan Pressure Calculation	Fan total and static pressures are calculated based on the frictional losses through the ducting established in the preceding step.

3 REGULATORY FRAMEWORK

The NEW RIVER CLASS ferries will be inspected by the US Coast Guard under the provisions of 46 CFR Subchapter H.

4 GIVEN AND ASSUMED PARAMETERS

- A maximum outdoor air temperature of 95°F is assumed for hold ventilation calculations. The maximum expected dry bulb temperature over a 20-year period is 95.2 °F. Per ASHRAE climatic data [3], the 0.4% outdoor air design temperature is 88.1 °F, which represents a temperature that is exceeded fewer than 40 hours per year.
- The machinery and void hold spaces will be fitted with flow-through ventilation systems utilizing 100% outdoor air.
- Compartment volumes are estimated based on the arrangement shown in [4]
- The following main propulsion engine parameters at 100% MCR are used in the calculations [5].

Parameter	Value
Combustion Air Intake	1,375 cfm
Engine Heat Rejection to Engine Room	1,534 btu/min

• The following diesel generator parameters at 100% MCR are used in the calculations for the ship service generators [6].

Parameter	Value
Combustion Air Intake	511 cfm
Generator Engine Heat Rejection	538 btu/min

- SSDG alternator heat rejection is estimated using 8% of rated generator capacity at full power or 683 btu/min
- The following parameters from [7] are used to size louvers for the emergency generator:

Parameter	Value
Max allowable duct restriction	0.5 in H ₂ O
Total Radiator Airflow, unrestricted	10171 cfm
Total Radiator Airflow, 0.5 inH2O restriction	9841 cfm

• The following oil cooler parameters at full capacity are used in the calculations for the cycloidal propellers [8].

Parameter	Value
Oil Cooler Rejection to Thruster Room	569 btu/min

- Engine Room ventilation calculation assumes:
 - Maximum temperature rise of 22.5 °F
 - Two main engines and one ship service generator operating at full power.
- Heat radiated from hot exhaust piping is estimated using data from [9], which assumes 1 3/4 inches to 2 3/4 inches of insulation and a 610°F temperature difference between exhaust and ambient.
- Lighting heat loads are not considered for these calculations, as lighting is intended to be high efficiency LEDs with minimal contribution to the heat load.

5 CONCLUSIONS

5.1 Engine Room

A minimum ventilation supply rate of 12,320 cfm and ventilation exhaust rate of 10,100 cfm are required to provide cooling and combustion air in the engine room.

Two supply fans, each providing 6,300 cfm, will supply air to the engine room via a pair of ventilation supply plenums on the main deck. Air will exhaust through the exhaust uptake to the

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01 deck. The calculated total pressure loss is 2.02 inches H_2O . The corresponding static pressure for a 24-inch supply fan is 1.8 inches H_2O .

5.2 Voids

A minimum ventilation rate of 800 cfm is required to maintain six air changes per hour in each void.

One supply fan, providing 1,000 cfm, will supply air to each void via a ventilation supply plenum on the main deck. Air will exhaust through the exhaust plenums on the main deck. The calculated total pressure is 1.33 inches H_2O . The corresponding static pressure for a 12-inch supply fan is 1.24 inches H_2O .

5.3 Thruster Rooms

A minimum ventilation rate of 900 cfm is required to provide cooling and maintain six air changes per hour in each thruster room.

One supply fan, providing 1,000 cfm, will supply air to each thruster room via a ventilation supply plenum on the main deck. Air will exhaust through the exhaust plenums on the main deck. The calculated total pressure is 1.21 inches H_2O . The corresponding static pressure for a 12-inch supply fan is 1.12 inches H_2O .

5.4 Emergency Generator Room

Louvers 39 inches wide by 60 inches tall were selected to keep the emergency generator room restriction below 0.5 inches H_2O .

REFERENCES

- The Society of Naval Architects and Marine Engineers, "Technical and Research Bulletin 4-16: Calculations for Merchant Ship Heating, Ventilation and Air Conditioning Design," New York, NY, 08/1980.
- [2] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.
- [3] ASHRAE, Climatic Design Condtions Hattaras Billy Mitchel AP, NC, USA, ASHRAE, 2009.
- [4] Elliott Bay Design Group, "New River Class Ferry: Profiles and Deck Arrangements," 16101-200-101-1, Rev -, Seattle, WA, 2017.
- [5] Caterpillar, "EM0268; C18 600HP at 1800 rpm Performance Data," March 8, 2017.
- [6] Caterpillar, "EM5070; C7.1 150ekW at 1800 rpm Performance Data," July 10, 2017.

- [7] Caterpillar, LEHM02040-00 C4.4 ACERT Marine Generator Set Package, 2016.
- [8] Rexroth Bosch Group, "Oil/Air Coolers Types KOL and KOLP, 10kW".
- [9] International Organization for Standardization, "ISO 8861: Shipbuilding Engine-room ventilation in diesel-engined ships Design requirements and basis of calculations," 1988.

Engine Room Ventilation

Approach

The minimum required airflow to the Engine Room is calculated based on i) airflow necessary to dissipate heat given off by running equipment, and ii) minimum airflow of 6 air change per hour into the space.

Space and Equipment Loads	
Main Engines	
Main Engine Heat Rejection, $qe = 1,534.00 btu/min$	Cat C18 600 BHP @ 1800 rpm
Main engine Air Consumption, $Qe = 1,375.00 cfm$	
Number of Engines Operating, $Ne = 2.00$	
Engine Heat Rejection = 3,068.00 btu/min	
Generators	
Generator Total Heat Rejection, $qe = 1,221.00 btu/min$	CAT C7.1 150 ekW @ 1800 rpm
Generator Engine Air Consumption, $Qe = 511.00 \ cfm$	
Number of Engines Operating, $Ne = 1.00$	
Engine Heat Rejection = $1,221.00$ btu/min	
Exhaust Piping	
Piping Diameter = 8.00 in	
Piping Length = 103.00 ft	
Heat Emmission Factor = 0.20 kW/m	ISO 8861, Figure 3
3.47 btu/min/ft	
Estimated Exhaust Heat Rejection = 357.39 btu/min	
Main Deck Solar Load	
Deck Temperature (Ts) = $145.00 \circ_{\rm F}$	
Inside Temperature (Ti) = $117.50 _{\circ \text{F}}$	
Area = $2,216.00 \text{ ft}^2$	
Heat Transfer Coefficient (U) = $0.12 \text{ btuh/ft}^2 \text{ F}$	
Heat Gain (q) = 121.88 btu/min	q=U x A * (Ts -Ti)/60
	1
Side Shell	
Temperature (T0) = $95.00 {}^{\circ}\text{F}$	
Inside Temperature (Ti) = $117.50 {}_{\circ}F$	
Area = 359.00 ft^2	
Heat Transfer Coefficient (U) = $1.34 \text{ btuh/ft}^2 \text{ F}$	
Heat $Gain(q) = -180.26$ btu/min	q=U x A * (To -Ti)/60
Side Shell	
Temperature (To) = $95.00 \circ_{\rm F}$	
Inside Temperature (Ti) = $117.50 \circ_{\rm F}$	
Area = 205.00 ft^2	
Heat Transfer Coefficient (U) = $1.34 \text{ btuh/ft}^{2} \text{F}$	
Heat Gain (q) = -102.94 btu/min	q=U x A * (To -Ti)/60
Wattad Chall	
Wetted Shell Water Temperature (Tw) = $86.00 _{\text{F}}$	
Inside Temperature (Ti) = $117.50 _{\text{F}}$	
Area = $2,303.00 \text{ ft}^2$	
Heat Transfer Coefficient (U) = $0.80 \text{ btuh/ft}^{2}\text{ F}$	
Heat Gain (q) = -968.47 btu/min	q=U x A * (Tw - Ti)/60
	1 · · · · · · · · · · · · · · · · · · ·
Total Heat Load = 3,516.61 btu/min	

Ь	nlet Air Conditions	
Summer Air In Temperature (TIN) =	95.00 °F	
Humidity Ratio	0.022 <i>lb/lb dry air</i>	
Air In Enthalpy (hIN) =	46.78 Btu / lb	[5], Ch. 1, Eqn 32
Air In Specific Volume (rIN) =	14.47 ft^3 / lb dry air	
Ex	haust Air Conditions	
Max Temperature (TOUT) =	117.50 °F	
Air Out Enthalpy (hOUT) =	52.40 Btu / lb	[5], Ch. 1, Eqn 32
Air out Specific Volume (rOUT) =	15.06 <i>ft³ / lb dry air</i>	[5], Ch. 1, Eqn 28
	Other Givens	
Volume of Space $(V) =$	$22,500 ft^3$	[2]
Minutes per air change (MA) =	10.00 min	6 ACH
Calculated Airflow base	d on Total Heat Load and Air (Consumption
Total Heat Rejection (Qe) =	3.517 Btu / min	.
D Enthalpy (Dh) =	5.62 Btu / lb	Dh = hOUT - hIN
Required CFM (Heat Load) =	9,060 <i>cfm</i>	CFM = (Qe / Dh x rIN)
consumption air (Qc)=	3,261 <i>cfm</i>	
cooling + combustion air =	12,321 cfm	
5	, ,	
	w based on minimum air exch	anges:
Volume of Space (V) =	22,500 ft^3	
Air exchanges / min (AC)=	10 min/AC	
Required CFM(Air Exchange) =	2,250 cfm	CFM = V/MA
Calc	ulated Exhaust Airflow	
inlet air (V)=	12,321 cfm	(maximum of required airflows)
inlet air specific volume (rIN)=	14.47 ft3/lb	(maximum of required diffiows)
exhaust air specific volume (rOUT)=	15.06 <i>ft3/lb</i>	
expansion =	4.06%	
consumption air (Qc)=	2,750 cfm	
exhaust air =	10,071 <i>cfm</i>	CFM = V / rIN * rOUT - Qc
	, . ,	
	Results	
Total intake air=	12,300 cfm	(based on heat load and air consumption)
total exhaust air $=$	10,100 cfm	

Engine Room Total Pressure Calculation Input Variables

Supply Air Temperature $(T_{IN}) =$	88	°F
Humidity Ratio	0.0217	lb/lb dry air
Air In Specific Volume $(r_{IN}) =$	14.29	ft3 / Ib dry air
Supply air specific weight	0.070	lb/cu ft
Supply air viscosity	3.89E-07	lb-s/sq ft ²
Supply air density	0.0022	slugs/cu ft
Max Temperature (T _{OUT}) =	115.0	°F
Air out Specific Volume (r _{OUT}) =	14.99	ft³ / Ib dry air
Exhaust air specific weight	0.067	lb/cu ft
Exhaust air viscosity	4.02E-07	lb-s/sq ft ²
Exhaust air density	0.0021	slugs/cu ft
Supply air flow rate	12600	cfm
Exhaust air flow rate	10400	ft/min

Description	height	width	w/h	eqiv	hyd diam	area	length	qty	q	v	Re	f	к	h L
	(in)	(in)		dia (in)	(in)	(sq ft)	(ft)		(cfm)	(ft/min)				(ft)
Run A														
Inlet Demister (two in parallel), 0.4" H20	18	25	1.39	22.49	20.93	3.13	I	1	3150	1008	1.64E+05	0.018	6.900	30.24
Inlet to Structural Trunk- 90 deg sharp	9	72	8.00	24.11	16.00	4.50		1	6300	1400	1.74E+05	0.018	1.300	10.99
Structrual Trunk, Net Area	12.00	72.00	0.17	-	20.57	6.00	9	1	6300	1050	1.67E+05	0.018	0.094	0.45
Add' 1 HL for misc losses in trunk	12.00	72.00	0.17	-	20.57	6.00	9	1	6300	1050	1.67E+05	0.018	1.000	4.76
Deck cutout, outlet to plenum	12	64	5.33	27.24	20.21	5.33		1	6300	1181	1.85E+05	0.018	1.500	9.03
Abrupt contraction - Plenum to Duct			-	-	24.00	3.14		1	6300	2005	3.73E+05	0.016	0.500	8.67
Fire Damper	24	24	1.00	25.53	24.00	3.14		1	6300	2005	3.73E+05	0.016	0.520	9.02
Fan			-	-	24.00	3.14		1	6300	2005	3.73E+05	0.016	0.000	0.00
Ducting			-	-	24.00	3.14	4	1	6300	2005	3.73E+05	0.016	0.033	0.56
Rect to Round Transition, 12" long	20	24	1.20	23.28	21.82	3.33		1	6300	1890	3.20E+05	0.017	0.060	0.92
Divide Flow, Equal Areas	10	24	2.40	16.10	14.12	1.67		1	3550	2130	2.33E+05	0.018	0.100	1.96
Ducting	10	24	2.40	16.10	14.12	1.67	2	1	3550	2130	2.33E+05	0.018	0.031	0.60
60 degree Direct take-off	8	8	1.00	8.51	8.00	0.44		1	750	1688	1.05E+05	0.021	1.500	18.42
Ducting	8	8	1.00	8.51	8.00	0.44	8	1	750	1688	1.05E+05	0.021	0.255	3.14
Elbow	8	8	1.00	8.51	8.00	0.44		1	750	1688	1.05E+05	0.021	0.300	3.68
Outlet, abrupt discharge w/ screen	8	8	1.00	8.51	8.00	0.44	1	1	750	1688	1.05E+05	0.021	1.600	19.65
		• • • • • • • • •									Seg	ment tota	pressure	122.10
Description	height	width	h/w		hyd diam	area	length	qty	q	v	Re	f	К	h L
	(in)	(in)			(in)	(sq ft)	(ft)		(cfm)	(ft/min)				(ft)
Exhaust Vent			•											
Deck Cutout to Trunk (two in parallel)	32.00	62.00	0.52	l	42.21	13.78	r	1	5200	377	1.14E+05	0.018	0.750	0.46
Deck Cutout to Trunk (two in parallel) Structrual Trunk	32.00 58.00	62.00 58.00	0.52	-	42.21 58.00	13.78 23.36	10	1	5200 10400	377 445	1.14E+05 1.85E+05	0.018	0.750 0.034	0.46
· · · · · · · · · · · · · · · · · · ·				-			10 10							
Structrual Trunk	58.00	58.00	1.00		58.00	23.36		1	10400	445	1.85E+05	0.017	0.034	0.03
Structrual Trunk Add' 1 HL for misc losses in trunk	58.00 58.00	58.00 58.00	1.00 1.00	-	58.00 58.00	23.36 23.36		1	10400 10400	445 445	1.85E+05 1.85E+05	0.017 0.017	0.034	0.03 0.85
Structrual Trunk Add' 1 HL for misc losses in trunk Deck penetration	58.00 58.00 44	58.00 58.00 64	1.00 1.00 1.45	- 56.20	58.00 58.00 52.15	23.36 23.36 19.56	10	1 1 1	10400 10400 10400	445 445 532	1.85E+05 1.85E+05 2.15E+05	0.017 0.017 0.016	0.034 1.000 0.200	0.03 0.85 0.24
Structrual Trunk Add' 1 HL for misc losses in trunk Deck penetration Structrual Trunk, Net Area (less exhaust)	58.00 58.00 44 49.50	58.00 58.00 64 49.50	1.00 1.00 1.45 1.00	- 56.20 -	58.00 58.00 52.15 49.50	23.36 23.36 19.56 17.02	10 10	1 1 1 1	10400 10400 10400 10400	445 445 532 611	1.85E+05 1.85E+05 2.15E+05 2.17E+05	0.017 0.017 0.016 0.016	0.034 1.000 0.200 0.040	0.03 0.85 0.24 0.06
Structrual Trunk Add 1 HL for misc losses in trunk Deck penetration Structrual Trunk, Net Area (less exhaust) Add 1 HL for misc losses in trunk	58.00 58.00 44 49.50 49.50	58.00 58.00 64 49.50 49.50	1.00 1.00 1.45 1.00 1.00	- 56.20 - -	58.00 58.00 52.15 49.50 49.50	23.36 23.36 19.56 17.02 17.02	10 10	1 1 1 1 1	10400 10400 10400 10400 10400	445 445 532 611 611	1.85E+05 1.85E+05 2.15E+05 2.17E+05 2.17E+05	0.017 0.017 0.016 0.016 0.016	0.034 1.000 0.200 0.040 1.000	0.03 0.85 0.24 0.06 1.61

			FT	in H2O
sup	ply air total	pressure	122.10	1.643
exha	ust air total	pressure	8.07	0.109
		Total	130.17	1.752
	15% desi	ign margin	149.69	2.015

Supply Fan Static Pressure	
Fan Dia (in)	24.00
Fan area (ft2)	3.14
flowrate (cfm)	6300
velocity (fpm)	2005
fan velocity pressure	0.2229
Static Pressure for fan selection (in H20)	1.792

8/3/17

Job: 16101

Rev. -

Void Ventilation

Approach

The minimum required airflow to the Engine Room is calculated based on i) airflow necessary to dissipate heat given off by running equipment, and ii) minimum airflow of 6 air change per hour into the space.

	Space and Equipment Loads	
Main Deck Solar Load		
Deck Temperature (Ts) =	145.00 °F	
Inside Temperature (Ti) =	115.00 °F	
Area =	901.00 ft ²	
Heat Transfer Coefficient (U) =	0.12 btuh/ft ² °F	
Heat $Gain(q) =$	54.06 btu/min	q=U x A * (Ts - Ti)/60
Side Shell		
Temperature $(T0) =$		
Inside Temperature (Ti) =		
Area =	138.00 ft^2	
Heat Transfer Coefficient $(U) =$		
Heat $Gain(q) =$	-63.94 btu/min	q=U x A * (To -Ti)/60
Side Shell	05.00	
Temperature (To) =		
Inside Temperature (Ti) =		
Area =	********************	
	1.34 btuh/ft ² °F	
Heat $\operatorname{Gain}(q) =$	-130.33 btu/min	q=U X A * (10 - 11)/60
Wetted Shell		
Water Temperature (Tw) =	86.00 °F	
Inside Temperature (Tit) =		
Area =		
Heat Transfer Coefficient $(U) =$		
Heat $\operatorname{Gain}(q) =$		q=U x A * (Tw - Ti)/60
$\operatorname{Heat} \operatorname{Gain}(\mathbf{q}) = $		q=0 XX (1w - 1)/00
Total Heat Load =	-517.68 htu/min	

NEW RIVER CLASS FERRY

	Inlet Air Conditions									
Summer Air In Temperature (TIN) =	95.00 °F									
Humidity Ratio	0.022 <i>lb/lb</i> dry air									
Air In Enthalpy (hIN) = $-$	46.78 <i>Btu / lb</i>	[5], Ch. 1, Eqn 32								
Air In Specific Volume (rIN) =	$14.47 ft^3 / lb dry air$	[5], Ch. 1, Eqn 22								
The in Speenic Volume (In V) =	17.77 Ji 7 ib ary air	[5], Ch. 1, Eqn 20								
	Exhaust Air Conditions									
Max Temperature (TOUT) =	115.00 °F									
Air Out Enthalpy (hOUT) =	51.77 Btu / lb	[5], Ch. 1, Eqn 32								
Air out Specific Volume (rOUT) =	14.99 ft ³ / lb dry air	[5], Ch. 1, Eqn 28								
Other Givens										
Volume of Space $(V) =$		[2]								
Minutes per air change (MA) = $_$	10.00 min	6 ACH								
Calcul	Calculated Airflow based on Total Heat Load									
Total Heat Rejection (Qe) =	(518) <i>Btu / min</i>									
D Enthalpy (Dh) =	4.99 <i>Btu / lb</i>	Dh= hOUT - hIN								
	(1,500) cfm	CFM = (Qe / Dh x rIN)								
consumption air (Qc)=	- cfm									
cooling + combustion air =	(1,500) cfm									
	Airflow based on minimum a	ir exchanges:								
Volume of Space (V) = Air exchanges / min (AC)=	$8,054 ft^{3}$ 10 min/AC									
Required CFM(Air Exchange) =	805 cfm	CFM = V/MA								
Required CFM(All Exchange) –	803 <i>CJM</i>	CFM = V/MA								
	Calculated Exhaust Airflow	v								
inlet air (V)=	805 cfm	(maximum of required airflows)								
inlet air specific volume (rIN)=	14.47 <i>ft3/lb</i>									
exhaust air specific volume (rOUT)=	14.99 <i>ft3/lb</i>									
expansion =	3.61%									
consumption air $(Qc)=$	- cfm									
exhaust air =	834 cfm	CFM = V / rIN * rOUT - Qc								
m - 11 - 1	Results									
Total intake air=	800 cfm	(minimum airflow)								
total exhaust air =	834 cfm									

Void Total Pressure Calculation														
Input Variables							-							
Supply Air Temperature (T _{IN}) =	88	۶°F												
Humidity Ratio	0.0217	lb/lb dry ai	r											
Air In Specific Volume (r _{IN}) =	14.29	ft ³ / Ib dry	air											
Supply air specific weight	0.070	lb/cu ft												
Supply air viscosity	3.89E-07	' lb-s/sq ft ²												
Supply air density	0.0022	slugs/cu ft												
Max Temperature (T _{OUT}) =	115.0	۴												
Air out Specific Volume (r _{OUT}) =	14.99	ft ³ / Ib dry	air											
Exhaust air specific weight	0.067	lb/cu ft												
Exhaust air viscosity	4.02E-07	' lb-s/sq ft ²												
Exhaust air density	0.0021	slugs/cu ft												
Supply air flow rate	1000) cfm												
Exhaust air flow rate	9 1000) cfm												
	1			-						1	1			r
Description	height	width	w/h	eqiv	hyd diam	area	length	qty	q	v	Re	f	к	h L
	(in)	(in)		dia (in)	(in)	(sq ft)	(ft)		(cfm)	(ft/min)				(ft)
Supply Ducting				1			1							
Inlet Demister	12	12	1.00	12.76	12.00	1.00		1	1000	1000	9.30E+04	0.021	8.600	37.09
Inlet to Structural Trunk- 90 deg sharp	15	24	1.60	20.05	18.46	2.50		1	1000	400	5.72E+04	0.022	1.300	0.90
Structrual Trunk, Net Area	15	24	0.63	-	18.46	2.50	3	1	1000	400	5.29E+04	0.022	0.043	0.03
Add' 1 HL for misc losses in trunk	15	24	0.63	-	18.46	2.50		1	1000	400	5.29E+04	0.022	1.000	0.69
Abrupt contraction - trunk to pipe			· · ·		12.00	0.79		1	1000	1273	1.18E+05	0.020	0.600	4.20
Elbow r/d = 1				-	12.00	0.79		2	1000	1273	1.18E+05	0.020	0.300	4.20
Fan			· ·	-	12.00	0.79		1	1000	1273	1.18E+05	0.020	0.000	0.00
Ducting					12.00	0.79	17	1	1000	1273	1.18E+05	0.020	0.339	2.37
Tee, straight branch 12x10					10.00	0.55		2	500	917	7.11E+04	0.022	2.090	15.15
Ducting				10.00	10.00	0.55	9	1	500	917	7.11E+04	0.022	0.236	0.86
Balancing Damper, Butterfly					10.00	0.55		1	500	917	7.11E+04	0.022	0.190	0.69
Terminal w/ Screen (wire mesh)			-	-	10.00	0.55		1	500	917	7.11E+04	0.022	1.600	5.80
											Seg	ment tota	i pressure	71.97
Description	the Sector		1.4	1	hard at any		L			1	D .			
Description	height	width	h/w		hyd diam (in)	area (sq ft)	length	qty	q (cfm)	v (ft/min)	Re	f	к	h ∟ (ft)
Exhaust Vant	(in)	(in)			(in)	(sq it)	(ft)		(cim)	(it/min)				(it)
Exhaust Vent	40	20	0.50	r · · · · · ·	40.00	4.00			1000	700	6.88E+04	0.004	0.900	0.04
Deck Cutout to Structural Trunk Structrual Trunk, Net Area	10 14	20	0.50	-	13.33 17.68	1.39 2.33	10	1	1000	720 429	6.88E+04 5.43E+04	0.021	0.900	2.01 0.12
Add' 1 HL for misc losses in trunk	14	24	0.58	-	17.68	2.33	10	1	1000	429	5.43E+04	0.022	1.000	0.12
Exhaust Louver with insect screen	14	16	1.13	-	16.94	1.20	10	1	1000	833	1.01E+05	0.022	3.600	10.78
Exhaust Louver with insect screen	10	10	1.13	-	10.94	1.20			1000	033		ment tota		A REAL PROPERTY AND A REAL
											ડસ્	ineni iola	i pressure	13.71
									r	1				
													FT	in H2O
											oply air total			0.969
										exh	aust air total	· · · · · · · · · · · · · · · · · · ·	13.71	0.184
												Total	85.67	1.153
											15% des	ign margin	98.52	1.326
										Su	pply Fan Sta	tic Pressu	ire	
												E	an Dia (in)	12.0
													area (ft2)	
													rate (cfm)	
													city (fpm)	
												fan velocit		
										Static	Pressure for fa			1.236

Thruster Room Ventilation

Approach

The minimum required airflow to the Engine Room is calculated based on i) airflow necessary to dissipate heat given off by running equipment, and ii) minimum airflow of 6 air change per hour into the space.

	Space and Equipment Loads	
Cycloidal Propeller		
Heat Rejection, $qe =$	569.00 btu/min	Oil Cooler 10kW
Main Deck Solar Load		
Deck Temperature (Ts) =	145.00 °F	
Inside Temperature (Ti) =	115.00 °F	
L	760.00 ft^2	
Heat Transfer Coefficient (U) =	0.12 btuh/ft ² °F	
Heat $Gain(q) =$	45.60 btu/min	q=U x A * (Ts - Ti)/60
Side Shell and Ballast Tanks		
Temperature (T0) =	95.00 °F	
Inside Temperature (Ti) =	115.00 °F	
Area =	240.00 ft^2	
Heat Transfer Coefficient $(U) =$	1.39 btuh/ft ² °F	
Heat $Gain(q) =$	-111.20 btu/min	q=U x A * (To -Ti)/60
Side Shell		
Temperature (To) =	95.00 °F	
Inside Temperature (Ti) =	*****	
Area =		
Heat Transfer Coefficient (U) =	1.34 btuh/ft ² °F	
Heat $Gain(q) =$	-107.12 btu/min	q=U x A * (To -Ti)/60
Wetted Shell		
Water Temperature (Tw) =	86.00 °F	
Inside Temperature (Ti) =	115.00 °F	
Area =		
Heat Transfer Coefficient $(U) =$	0.80 btuh/ft ² °F	
Heat $Gain(q) =$	-294.23 btu/min	q=U x A * (Tw -Ti)/60
Total Heat Load =	102.05 btu/min	

NEW RIVER CLASS FERRY

	Inlat	Air Conditions								
Summer Air In Temperature (TIN) =	95.00									
Humidity Ratio	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	lb/lb dry air								
Air In Enthalpy (hIN) = \int	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Btu / lb	[5], Ch. 1, Eqn 32							
Air In Specific Volume (rIN) =		ft ³ / lb dry air	[5], Ch. 1, Eqn 32 [5], Ch. 1, Eqn 28							
All III Specific Volume (IIIV) –	14.47	ji ^o / ib ary air	[5], Cn. 1, Eqn 28							
	Fxhaus	t Air Conditions								
Max Temperature (TOUT) =	115.00									
Air Out Enthalpy (hOUT) =	51.77	Btu / lb	[5], Ch. 1, Eqn 32							
Air out Specific Volume (rOUT) =			[5], Ch. 1, Eqn 28							
r · · · · · · · · · · · · · · · · · · ·		,								
	O	ther Givens								
Volume of Space $(V) =$	8,517	ft ³	[2]							
Minutes per air change (MA) =	10.00	min	6 ACH							
	Calculated Airflow based on Total Heat Load and Air Consumption									
	ow based on '	Total Heat Load a	nd Air Consumption							
Total Heat Rejection $(Qe) =$	102	Btu / min								
D Enthalpy (Dh) =		Btu / lb	Dh = hOUT - hIN							
Required CFM (Heat Load) =	296	cfm	$CFM = (Qe / Dh \ x \ rIN)$							
consumption air (Qc)=		cfm								
cooling + combustion air =	296	cfm	(50% combustion air from cooling air)							
Calculated Airflow based on minimum air exchanges:										
Volume of Space (V) =	8,517		in exchanges.							
Air exchanges / min (AC)=		min/AC								
Required CFM(Air Exchange) =	852	cfm	CFM = V/MA							
		5								
	Calculate	ed Exhaust Airflow	v							
inlet air (V)=	852	U	(maximum of required airflows)							
inlet air specific volume (rIN)=	14.47									
exhaust air specific volume (rOUT)=	14.99	ft3/lb								
expansion =	3.61%									
consumption air (Qc)=	-	cfm								
exhaust air =	882	cfm	CFM = V / rIN * rOUT - Qc							
Tradelindel a sta	000	Results								
Total intake air=	900	U	(minimum airflow)							
total exhaust air =	900	сјт								

Thruster Room Total Pressure Calculation Input Variables

niables			
	Supply Air Temperature (T _{IN}) =	88 °	F
	Humidity Ratio	0.0217 lt	b/lb dry air
	Air In Specific Volume (r _{IN}) =	14.29 ft	t³ / Ib dry air
	Supply air specific weight	0.070 lt	o/cu ft
	Supply air viscosity	3.89E-07 lt	b-s/sq ft ²
	Supply air density	0.0022 s	lugs/cu ft
	Max Temperature (T _{OUT}) =	115.0 °	F
	Air out Specific Volume (r_{OUT}) =	14.99 ft	t³ / Ib dry air
	Exhaust air specific weight	0.067 lb	o/cu ft
	Exhaust air viscosity	4.02E-07 lt	o-s/sq ft ²
	Exhaust air density	0.0021 s	lugs/cu ft
	Supply air flow rate	1000 c	:fm
	Exhaust air flow rate	1000 c	;fm

1.00 1.60 0.63 - - - - - - - - - - - - - - - - - - -	dia (in) 12.76 20.05 - - - 10.00 8.00 - - - - - - - - - - - - -	(in) 12.00 18.46 18.46 18.46 12.00 12.00 12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 10 10 10 10 10 10 10 10 10	(sq ft) 1.00 2.50 2.50 2.50 0.79 0.79 0.79 0.79 0.79 0.79 0.79 0.35 0.3	(ft) 3 6 10 10 10	1 1 1 2 1 1 2 1 1 1 1 1 1 1	(cfm) 1000 1000 1000 1000 1000 1000 1000 1000 1000 250 250 250 250 250 250 250	(ft/min) 1000 400 400 1273 1275 1276 1716	9.30E+04 5.72E+04 5.29E+04 5.29E+04 1.18E+05 1.18E+05 1.18E+05 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re 6.88E+04	0.021 0.022 0.022 0.020 0.020 0.020 0.020 0.021 0.021 0.024 0.024 0.024 0.024 0.024 0.024 0.024 0.024 0.024	к 0.900	(ft) 37.09 0.90 0.03 0.69 4.20 4.20 4.20 0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft) 2.01 0.12
1.60 0.63 - - - - - - - - - - - - - - - - - - -	20.05 - - - 10.00 - 8.00 - - - - - - - - - - - - -	18.46 18.46 18.46 12.00 12.00 12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 12.00 13.33 17.68	2.50 2.50 2.50 0.79 0.79 0.79 0.79 0.79 0.79 0.35 0.35 0.35 0.35 0.35	6 10 10 10	1 1 1 2 1 1 2 1 1 2 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 750 750 250 250 250 250 250 250	400 400 400 1273 1273 1273 1273 955 955 716 716 716 716 716 716	5.72E+04 5.29E+04 5.29E+04 1.18E+05 1.18E+05 1.18E+05 1.18E+05 1.18E+05 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 8.44E+04 8.44E+04 8.88E	0.022 0.022 0.022 0.020 0.020 0.020 0.020 0.021 0.021 0.024 0.024 0.024 0.024 0.024 f	1.300 0.043 1.000 0.300 0.300 0.300 0.207 2.090 0.361 0.190 1.600 pressure K	0.90 0.03 0.69 4.20 4.20 0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
1.60 0.63 - - - - - - - - - - - - - - - - - - -	20.05 - - - 10.00 - 8.00 - - - - - - - - - - - - -	18.46 18.46 18.46 12.00 12.00 12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 12.00 13.33 17.68	2.50 2.50 2.50 0.79 0.79 0.79 0.79 0.79 0.79 0.35 0.35 0.35 0.35 0.35	6 10 10 10	1 1 1 2 1 1 2 1 1 2 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 750 750 250 250 250 250 250 250	400 400 400 1273 1273 1273 1273 955 955 716 716 716 716 716 716	5.72E+04 5.29E+04 5.29E+04 1.18E+05 1.18E+05 1.18E+05 1.18E+05 1.18E+05 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 8.44E+04 8.44E+04 8.88E	0.022 0.022 0.022 0.020 0.020 0.020 0.020 0.021 0.021 0.024 0.024 0.024 0.024 0.024 f	1.300 0.043 1.000 0.300 0.300 0.300 0.207 2.090 0.361 0.190 1.600 pressure K	0.90 0.03 0.69 4.20 4.20 0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
0.63 0.63 - - - - - - - - - - - - - - - - - - -		18.46 18.46 12.00 12.00 12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 10.00 1	2.50 2.50 0.79 0.79 0.79 0.79 0.79 0.79 0.79 0.35 0.35 0.35 0.35 0.35 0.35 0.35	6 10 10 10	1 1 2 1 1 2 1 2 1 1 1 1 1 1	1000 1000 1000 1000 1000 750 750 250 250 250 250 250 250	400 400 1273 1273 1273 1273 955 955 716 716 716 716 716 716 V (ft/min)	5.29E+04 5.29E+04 1.18E+05 1.18E+05 1.18E+05 1.18E+05 8.88E+04 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 4.44E+04 8.88E 8.8	0.022 0.022 0.020 0.020 0.020 0.021 0.021 0.024 0.024 0.024 0.024 0.024 0.024 f	0.043 1.000 0.600 0.300 0.000 0.119 0.200 0.207 2.090 0.361 0.190 1.600 pressure K 0.900	0.03 0.69 4.20 0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33
0.63 - - - - - - - - - - - - - - - - - - -		18.46 12.00 12.00 12.00 12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00	2.50 0.79 0.79 0.79 0.79 0.79 0.79 0.35 0.35 0.35 0.35 0.35 0.35 0.35	6 10 10 10	1 1 2 1 1 2 1 2 1 1 1 1 1	1000 1000 1000 1000 750 250 250 250 250 250	400 1273 1273 1273 1273 955 955 716 716 716 716 716 716	5.29E+04 1.18E+05 1.18E+05 1.18E+05 1.18E+05 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re	0.022 0.020 0.020 0.020 0.021 0.021 0.024 0.024 0.024 0.024 0.024 0.024 ment total	1.000 0.600 0.300 0.119 0.200 0.207 2.090 0.361 0.190 1.600 pressure K	0.69 4.20 4.20 0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
- - - - - - - - - - - - - - - - - - -	- - - - - - - - - - - -	12.00 12.00 12.00 12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00	0.79 0.79 0.79 0.79 0.79 0.35 0.35 0.35 0.35 0.35 0.35 0.35	10 10	1 2 1 2 1 1 1 1 1 1 4 ty	1000 1000 1000 750 250 250 250 250 250	1273 1273 1273 1273 955 955 716 716 716 716 716 716	1.18E+05 1.18E+05 1.18E+05 1.18E+05 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re	0.020 0.020 0.020 0.021 0.021 0.024 0.024 0.024 0.024 0.024 0.024 f	0.600 0.300 0.000 0.119 0.200 0.207 2.090 0.361 0.190 1.600 pressure K 0.900	4.20 4.20 0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
	- - 10.00 - - -	12.00 12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00	0.79 0.79 0.79 0.79 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35	10 10	2 1 2 1 2 1 1 1 1 1 4 ty	1000 1000 750 750 250 250 250 250 250 250	1273 1273 1273 955 955 716 716 716 716 716 716	1.18E+05 1.18E+05 1.18E+05 8.88E+04 4.44E+04 4.44E+04 4.44E+04 5eg Re	0.020 0.020 0.021 0.021 0.024 0.024 0.024 0.024 0.024 ment total	0.300 0.000 0.119 0.200 0.207 2.090 0.361 0.190 1.600 pressure K	4.20 0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
		12.00 12.00 12.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00	0.79 0.79 0.79 0.35 0.35 0.35 0.35 0.35 area (sq ft) 1.39	10 10	1 1 2 1 2 1 1 1 1 1	1000 1000 750 250 250 250 250 250 (cfm)	1273 1273 955 955 716 716 716 716 716 V (ft/min)	1.18E+05 1.18E+05 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re	0.020 0.020 0.021 0.024 0.024 0.024 0.024 0.024 ment total	0.000 0.119 0.200 0.207 2.090 0.361 0.190 1.600 pressure K 0.900	0.00 0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
	10.00 8.00 - -	12.00 12.00 8.00 8.00 8.00 8.00 8.00 13.33 17.68	0.79 0.79 0.35 0.35 0.35 0.35 0.35 area (sq ft)	10 10	1 2 1 1 1 1 1	1000 750 250 250 250 250 250 q (cfm)	1273 955 955 716 716 716 716 716 (f/min)	1.18E+05 8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re	0.020 0.021 0.021 0.024 0.024 0.024 0.024 ment total	0.119 0.200 0.207 2.090 0.361 0.190 1.600 pressure K	0.84 1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
- h/w 0.50 0.58	8.00	12.00 12.00 8.00 8.00 8.00 8.00 hyd diam (in) 13.33 17.68	0.79 0.35 0.35 0.35 0.35 0.35 area (sq ft)	10 10	2 1 2 1 1 1 1 qty	750 750 250 250 250 250 250 (cfm)	955 955 716 716 716 716 716 716 716	8.88E+04 8.88E+04 4.44E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re	0.021 0.021 0.024 0.024 0.024 0.024 0.024 ment total	0.200 0.207 2.090 0.361 0.190 1.600 pressure K	1.57 0.82 9.25 0.80 0.42 3.54 64.33 h L (ft) 2.01
- h/w 0.50 0.58	8.00	12.00 8.00 8.00 8.00 8.00 hyd diam (in) 13.33 17.68	0.79 0.35 0.35 0.35 0.35 area (sq ft)	10 Iength	1 2 1 1 1 1	750 250 250 250 250 250 (cfm)	955 716 716 716 716 716 716 v (ft/min)	8.88E+04 4.44E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re	0.021 0.024 0.024 0.024 0.024 ment total	0.207 2.090 0.361 0.190 1.600 pressure K	0.82 9.25 0.80 0.42 3.54 64.33 h L (ft)
- h/w 0.50 0.58	8.00	8.00 8.00 8.00 hyd diam (in) 13.33 17.68	0.35 0.35 0.35 0.35 area (sq ft) 1.39	10 Iength	2 1 1 1	250 250 250 250 q (cfm)	716 716 716 716 716 (t/min)	4.44E+04 4.44E+04 4.44E+04 4.44E+04 Seg Re	0.024 0.024 0.024 0.024 ment total	2.090 0.361 0.190 1.600 pressure K 0.900	9.25 0.80 0.42 3.54 64.33 h L (ft) 2.01
- h/w 0.50 0.58		8.00 8.00 hyd diam (in) 13.33 17.68	0.35 0.35 0.35 area (sq ft) 1.39	length	1 1 1 qty	250 250 250 q (cfm)	716 716 716 716 (ft/min)	4.44E+04 4.44E+04 4.44E+04 Seg Re	0.024 0.024 0.024 ment total	0.361 0.190 1.600 pressure K 0.900	0.80 0.42 3.54 64.33 h L (ft) 2.01
- h/w 0.50 0.58		8.00 8.00 hyd diam (in) 13.33 17.68	0.35 0.35 area (sq ft) 1.39	length	1 1 qty	250 250 q (cfm)	716 716 v (ft/min)	4.44E+04 4.44E+04 Seg Re	0.024 0.024 ment total	0.190 1.600 pressure K 0.900	0.42 3.54 64.33 h L (ft) 2.01
- h/w 0.50 0.58		8.00 hyd diam (in) 13.33 17.68	0.35 area (sq ft) 1.39	-	1 qty	250 q (cfm)	716 v (ft/min)	4.44E+04 Seg Re	0.024 ment total f	1.600 pressure K 0.900	3.54 64.33 h L (ft) 2.01
h/w 0.50 0.58		hyd diam (in) 13.33 17.68	area (sq ft) 1.39	-	qty	q (cfm)	v (ft/min)	Seg Re	ment total f	K 0.900	64.33 h L (ft) 2.01
0.50 0.58		(in) 13.33 17.68	(sq ft) 1.39	-		(cfm)	(ft/min)	Re	f	к 0.900	h L (ft) 2.01
0.50 0.58		(in) 13.33 17.68	(sq ft) 1.39	-		(cfm)	(ft/min)	Re	f	к 0.900	h L (ft) 2.01
0.50		(in) 13.33 17.68	(sq ft) 1.39	-		(cfm)	(ft/min)			0.900	(ft) 2.01
0.50		(in) 13.33 17.68	(sq ft) 1.39	-		(cfm)	(ft/min)			0.900	(ft) 2.01
0.58		13.33 17.68	1.39		4			6.88E+04	0.021		2.01
0.58		17.68			4			6.88E+04	0.021		
0.58		17.68			1	1000	720				
	-			10	1	1000	429	5.43E+04	0.022	0.149	
0.58		17.68	2.33	10	1	1000	429	5.43E+04	0.022	1.000	0.79
1.13	-	16.94	1.20		1	1000	833	1.01E+05	0.020	3,600	10.7
1.10		10.54	1.20			1000	000		ment total		
								Ocg	ment total	pressure	10.1
										FT	in H2O
									_		-
								oply air total			0.866
							exha	ust air total	· · · · · · · · · ·		0.184
									Total		1.050
								15% desi	gn margin	89.75	1.208
							Su	pply Fan Stat	tic Pressu	re	
											12
									i di i	uica (itZ)	
									£1.0	ata lafr-1	
										ate (cfm)	
										city (fpm)	12
								Su	Supply Fan Stat	Fa	Supply Fan Static Pressure Fan Dia (in) Fan area (ft2)

8/3/17

Input Variables														
Supply Air Temperature $(T_{IN}) =$	88	°F												
Humidity Ratio	0.0217	lb/lb dry ai	r											
Air In Specific Volume (r _{IN}) =	14.29	ft3 / Ib dry	air											
Supply air specific weight	0.070	lb/cu ft												
Supply air viscosity	3.89E-07	lb-s/sq ft ²												
Supply air density	0.0022	slugs/cu ft												
Max Temperature (T _{OUT}) =	115.0	°F												
Air out Specific Volume (r _{OUT}) =	14.99	ft3 / Ib dry	air											
Exhaust air specific weight	0.067	lb/cu ft												
Exhaust air viscosity	4.02E-07	lb-s/sq ft ²												
Exhaust air density	0.0021	slugs/cu ft												
Supply air flow rate	9841	cfm												
Exhaust air flow rate		cfm												
Description	height	width	h/w	1	hyd diam	area	length	qty	q	v	Re	f	к	h L
	(in)	(in)			(in)	(sq ft)	(ft)	17	(cfm)	(ft/min)				(ft)
gen Room Inlet														
	60	39	1.54	- 1	47.27	9.75		1	9841	1009	3.42E+05	0.015	3.600	15.82
nlet louver with insect screen	00												0.520	0.00
	60	39	1.54	-	47.27	16.25		1	9841	606	2.22E+05	0.016	0.520	0.82
nlet louver with insect screen Fire Damper				-		16.25		1	9841	606		0.016 ment total		
				-		16.25		1	9841	606				
Fire Damper				- eqiv		16.25 area	length	1 qty	9841 q	606				
ïre Damper	60	39	1.54		47.27		length (ft)				Seg	iment total	pressure	15.82
Fire Damper	60 height	39 width	1.54	eqiv	47.27 hyd diam	area			q	v	Seg	iment total	pressure	15.82 h L
Fire Damper Description Radiator Outlet	60 height	39 width	1.54	eqiv	47.27 hyd diam	area			q	v	Seg	iment total	pressure	15.82 h L
Fire Damper Description Radiator Outlet Exhaust louver, duct connected	60 height (in)	39 width (in)	1.54 w/h	eqiv dia (in)	47.27 hyd diam (in)	area (sq ft)		qty	q (cfm)	v (ft/min)	Seg Re	f	pressure K	15.82 h L (ft)
Fire Damper Description Radiator Outlet Exhaust louver, duct connected Fire Damper	60 height (in) 60 60	39 width (in) 39 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27 30.00	area (sq ft) 9.75 16.25 4.91	(ft)	qty	q (cfm) 9841	v (ft/min) 1009 606 2005	Seg Re 3.42E+05 2.05E+05 4.31E+05	f 0.015 0.016 0.016	K 3.100 0.520 0.000	15.82 h L (ft) 13.62 0.82 0.00
Fire Damper Description Radiator Outlet Exhaust louver, duct connected Fire Damper Fan	60 height (in)	39 width (in) 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27	area (sq ft) 9.75 16.25		qty	q (cfm) 9841 9841	v (ft/min) 1009 606	Seg Re 3.42E+05 2.05E+05 4.31E+05 2.73E+05	f 0.015 0.016 0.016 0.016	K 3.100 0.520 0.000 0.008	15.82 h L (ft) 13.62 0.82 0.00 0.02
Fire Damper Description Radiator Outlet Exhaust louver, duct connected Fire Damper Fan	60 height (in) 60 60	39 width (in) 39 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27 30.00	area (sq ft) 9.75 16.25 4.91	(ft)	qty	q (cfm) 9841 9841 9841	v (ft/min) 1009 606 2005	Seg Re 3.42E+05 2.05E+05 4.31E+05 2.73E+05	f 0.015 0.016 0.016	K 3.100 0.520 0.000 0.008	15.82 h L (ft) 13.62 0.82 0.00 0.02
ire Damper escription adiator Outlet xhaust lower, duct connected ire Damper an	60 height (in) 60 60	39 width (in) 39 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27 30.00	area (sq ft) 9.75 16.25 4.91	(ft)	qty	q (cfm) 9841 9841 9841	v (ft/min) 1009 606 2005	Seg Re 3.42E+05 2.05E+05 4.31E+05 2.73E+05	f 0.015 0.016 0.016 0.016	K 3.100 0.520 0.000 0.008	15.82 h L (ft) 13.62 0.82 0.00 0.02
Fire Damper Description Radiator Outlet Exhaust lower, duct connected Fire Damper Fan	60 height (in) 60 60	39 width (in) 39 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27 30.00	area (sq ft) 9.75 16.25 4.91	(ft)	qty	q (cfm) 9841 9841 9841	v (ft/min) 1009 606 2005 807	Seg Re 3.42E+05 2.05E+05 4.31E+05 2.73E+05 Seg	f 0.015 0.016 0.016 0.016 0.016	pressure K 3.100 0.520 0.000 0.008 pressure FT	15.82 h L (ft) 13.62 0.00 0.02 14.47 in H2O
Fire Damper Description Radiator Outlet Exhaust lower, duct connected Fire Damper Fan	60 height (in) 60 60	39 width (in) 39 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27 30.00	area (sq ft) 9.75 16.25 4.91	(ft)	qty	q (cfm) 9841 9841 9841	v (ft/min) 1009 606 2005 807 807	Seg Re 3.42E+05 2.05E+05 4.31E+05 2.73E+05 Seg pply air total	f 0.015 0.016 0.016 0.016 ment total	K 3.100 0.520 0.000 0.008 pressure	15.82 h L (ft) 13.62 0.82 0.00 0.02 14.47
Fire Damper Description Radiator Outlet Exhaust louver, duct connected Fire Damper Fan	60 height (in) 60 60	39 width (in) 39 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27 30.00	area (sq ft) 9.75 16.25 4.91	(ft)	qty	q (cfm) 9841 9841 9841	v (ft/min) 1009 606 2005 807 807	Seg Re 3.42E+05 2.05E+05 4.31E+05 2.73E+05 Seg	f 0.015 0.016 0.016 0.016 ment total	pressure K 3.100 0.520 0.000 0.000 pressure FT 15.82 14.47	15.82 h L (ft) 13.62 0.00 0.02 14.47 in H2O
	60 height (in) 60 60	39 width (in) 39 39	1.54 w/h 0.65 0.65	eqiv dia (in) 51.16 51.16	47.27 hyd diam (in) 47.27 47.27 30.00	area (sq ft) 9.75 16.25 4.91	(ft)	qty	q (cfm) 9841 9841 9841	v (ft/min) 1009 606 2005 807 807	Re 3.42E+05 2.05E+05 4.31E+05 2.73E+05 Seg	f 0.015 0.016 0.016 0.016 ment total	pressure K 3.100 0.520 0.000 0.008 pressure FT 15.82 14.47 30.29	15.82 h L (ft) 13.62 0.00 0.02 14.47 in H2O 0.213

Appendix F

Accomodations HVAC

1 DESCRIPTION

This appendix presents calculations performed to estimate heating, ventilation, and air conditioning requirements for the NEW RIVER CLASS FERRY design. The resulting heating and cooling loads were used to estimate electrical requirements for the vessel.

2 **PROCEDURE**

Heating and cooling load calculations were performed using the procedures outlined in [1], modified as follows:

- Passenger Lounge ventilation rate calculated using requirements from [2].
- Low-e glass is specified for the Crew Lounge and Passenger lounge. Glass solar factors (GSF) for these spaces were modified for geographic location and use of low-e coated glass using the RLF method from [3].

3 REGULATORY FRAMEWORK

The NEW RIVER CLASS ferries will be US Coast Guard under the provisions of 46 CFR Subchapter H.

4 GIVEN AND ASSUMED PARAMETERS

- The Pilothouse, Crew Lounge, Passenger Lounge, and EOS will be air-conditioned using air-cooled split heat pump units.
- The Pilothouse, Crew Lounge, Passenger Lounge, and EOS will utilize split heat pumps as primary heat, with electric strip heaters for backup.
- The hold spaces of existing vessels are not heated, except for the Engine Room. The Engine Room will be fitted with two (2) five-kilowatt unit heaters per NCDOT request.
- Single pane windows are assumed for the Pilothouse. Low-e coated dual pane insulating glass is assumed for exterior windows in the Crew Lounge and Passenger Lounge. Dual pane A-60 windows are assumed in the EOS.
- Bulkhead insulation in air-conditioned or heated passenger and crew spaces is assumed to have a maximum overall heat transfer coefficient of U = 0.12 BTU/hr/ft²/°F. This corresponds to 3 inches of fiberglass insulation plus 1" stiffener wrap on unlined decks or bulkhead or 2" of fiberglass insulation plus 1" stiffener wrap on decks with furred sheet metal linings, Table 18, Type 92 or Table 17 Type 55 in [4] respectively.
- The following environmental conditions, taken from [5] and [6] were used to determine the HVAC loads:

Environmental Condition	Summer	Winter
Outside Air Dry Bulb Temperature (°F)	95	27
Outside Air Relative Humidity (%)	75	-
Sea Water Temperature (°F)	86	32
Air Conditioned Spaces Temperature (°F)	74	70

Environmental Condition	Summer	Winter
Air Conditioned Spaces Humidity (%)	55	-

• Space areas estimated from [7].

5 CONCLUSIONS

Calculations are presented below. Heating and cooling loads for each space are estimated as follows:

Space	Winter Heat Load	Summer I (BT					
	Qw (BTUH)	Sensible, Qs	Latent, Ql	Total, Qt			
Pilothouse	12,605	24,874	2,312	27,186			
Crew Lounge	7,936	20,966	4,520	25,486			
Passenger	29,562	44,444	16,000	60,444			
Lounge							
EOS	14,170	22,388	3,200	25,588			

REFERENCES

- The Society of Naval Architects and Marine Engineers, "Technical and Research Bulletin 4-16: Calculations for Merchant Ship Heating, Ventilation and Air Conditioning Design," New York, NY, 12/2015.
- [2] ASHRAE, ASHRAE Standard 62.1-2016 Ventilation for Acceptable Indoor Air Quality, Atlanta, GA: ASHRAE, 2016.
- [3] AHSRAE, 2009 ASHRAE Handbook: Fundamentals, Atlanta, GA, 2009.
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- [5] AHSRAE, ASHRAE Handbook Fundamentals, Hatteras Billy Mitchell AP, NC, USA WMO#723139, 2009.
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GLASS SOLAR FACTOR FOR LOW-E WINDOWS

Calculation of fenestration load using RLF method from ASHRAE Fundamentals, Ch 17

 $CF_{fen} = U(\Delta t$ -0.46*DR) + PXI x SGHC x IAC X FF_s

 $q_{fen} = A \times CF_{fen}$

Given/Assumed

1) Glass u value taken from SNAME T&R 4-16

2) Cooling design temperature, To =95F, Ti = 74

3) DR from ASHRAE data for Hatteras Billy Mitchell AP

4) Latitude is 35.2 degrees, using Peak Irradiance from ASHRAE Fundamentals, Table 10, 35 degrees

5) Assume no interior shading, IAC = 1

6) Assume no exterior shading (no shading modifications to PXI)

7) SHGC assumes use of Low-e coated window glass with a SHGC of less than .47

8) FFs taken from ASHRAE Fundamentas Table 13, single family detached column (see descriptions on page 17.1)

9) Worst combination of PXI and FFs, West Facing, used for calculation

U=	0.60 BTU/h-SF-°	F fenestration NFRC heating U-factor
$\Delta t =$	21 °F	cooling design temperautre difference
DR=	12 °F	cooling daily range
PXI=	237 btu/h-SF	peak exterior irradiance
SHGC=	0.47	rated or estimated solar heat gain coefficient
IAC=	1	interior shading attenuation coefficient
$FF_s =$	0.56	fenstration solar load factor
Cffen=	71.67 BTUH/sf	fenestration cooling load
		-

Use Cf_{fen}= 75 BTUH/sf

ROOM LOAD CALCULATIONS

Pilothouse (SB)					Deck	Area.	144	ft^2			Vo	lume:	1152	ft ³
SI			leight:		ft			,0		1152				
Lighting Load Calculatio	n			•		0								
Description							Area (ft	2)	LC, (Btu/hı	/ft ²⁾		qs (btuh)		qt (btuh)
Lighting					144			7	1,008		1,00			
										Lighti	ng Totals:	1,008		1,00
Equipment Load Calculat	ion											<u> </u>		
Description				qs (btuh)	ql (b	tuh)		0	ty	Use	Factor	q _s (btuh)	q ₁ (btuh)	q _t (btuh)
Coffee Maker (commercial)				6,500	2,0						0.5	3,250	1,000	4,25
Electronics				7,000	2,0	00		1			1	7,000	1,000	
Liectronics				7,000							1	7,000		7,00
									Ec	quipme	ent Totals:	10250	1000	1125
Personnel Load Calculati	on													
Description	Gender	Туре		q _s (btuh)	q ₁ (b	tuh)			(Count		q _s (btuh)	q ₁ (btuh)	q _t (btuh)
SEATED AT REST	male	1-P1		240	A. (160						240	160	- 40
SEATED AT REST	mixed	1-P2		210		140				0				
				210		110			Р		nel Totals:	240	160	40
X7									1	cison	iel lotais.	240	100	+0
Ventilation Requirement		_		L				-	_		_			
Туре		Description		Rate	U			Qty			OA (cfm)		EX (cfm)	
By Occupancy		× •		15	5 cfm/person			1 people				15		
Rate of Change	AC, Pil	ot House		1	l ach			1152 ft ³				19		
Sanitary Fixtures				50	50 cfm/fixture			0 fixture						
												20		
			Hea	ting Outside	Air T	emp	27	°F		Cool	ng Outsid	e Air Temp	95	
			He	ating Inside	Air Te	emp	70 °F					esign Temp:	74	°F
Heating and Cooling Loa	d Calcı	lation				ł	Heating	[Cool	ing Seaso	n	
Description	Load	Insul		Area (ft ²)	Т	ΔΤ	U or	$q_w \left(\text{btuh} \right)$	T (°F)	ΔT	U or	q _s (btuh)	q ₁ (btuh)	qt (btuh)
	Key	Туре			$(^{\circ}F)$		GSF				GSF			
Pilot House Top	Over	C-2		243.0	27	43	0.120	1,254	95	21	0.120	612		61
Crew Lounge	Belw	C-2		144.0	70	0	0.120		74	0	0.120			
Exterior - Weather (Solar) Exterior - Weather	Fwd	C-2 C-2		0.0	27	43	0.120	227	95	21	0.120	116		11.
Exterior - Weather Exterior - Windows (Solar)	Fwd Fwd	001-H1	☆↔	46.0	27 27	43	0.120	237	95 125	21 51	0.120	116		11
Exterior - Windows (Solar) Exterior - Windows (Shaded)	rwa Fwd	001-H1 001-H2	₩↔I	22.0	27	43	1.130	1,069	95	21	160	3,520	1	3,520
Exterior - Windows (Shaded)		001-H2				43	1.130	· · · · · · · · · · · · · · · · · · ·		21	1.130			52
Exterior - Weather	Aft	C-2		46.0	27	43	0.120	237	95	21	0.120	116	1	110
Exterior - Weather (Solar)	Port	C-2		56.9	27	43	0.120	294	125	51	0.120	348		348
Exterior - Weather	Port	C-2		101.1	27	43	0.120	522	95	21	0.120	255		25
Exterior - Windows (Solar)	Port	001-H1	☆↔	30.1	27	43	1.130	1,463	125	51	160	4,816		4,81
	Port		W↔I	39.9	27	43	1.130	1,939	95	21	1.130	947		94
Exterior - Weather (Shaded)	Stbd	C-2		180.0	27	43	0.120	929	95	21	0.120	454		454
Exterior - Windows (Shaded)	Stbd	001-H2	W↔I	52.0	27	43	1.130	2,527	95	21	1.130			1,23
	Lght											1,008	1.005	1,00
LIGHTS		1										10,250	1,000	11,25
EQUIPMENT	Eqpt													400
EQUIPMENT PERSONNEL	Pers							1.0.5 -	0.5			240	160	
EQUIPMENT					27	43	e Totals:	1,066 12,605	95	21	Totals:	240 437 24,874	1,152 2,312	1,589

Crew Lounge	inge					Area:	240	ft ²			blume: 1920 ft ³			
St			Height:		ft			10	iune.	1720	n			
Lighting Load Calculatio	n					0								
Description			_		_		Area (ft2	2)	LC, (Btu/h	r/ft ²⁾		qs (btuh)		qt (btuh)
Lighting								240	LC, (Dtu/II	/ IL	7	1,680		qt (btui)
					240			,	1,000		1,00			
										Light	ing Totals:	1,680		1,68
	•									Lignu	ing Totals:	1,080		1,08
Equipment Load Calculat	lion	_		as (htub)	-1.4	4-1-)		0	4	T.L.	E t	(1 + 1)	(1 + 1)	(1, 1)
Description				qs (btuh)	ql (b	· ·		-	ty		Factor	q _s (btuh)		q _t (btuh)
Coffee Maker (commercial)				6,500	2,000			1			0.5	3,250	1,000	4,25
Electronics				6,000				1	l		1	6,000		6,00
Microwave				3,000				1	l		0.3	900		90
Refrigerator				1,670				1	l		1	1,670		1,67
									Ec	quipm	ent Totals:	11820	1000	1282
Personnel Load Calculati	on									-				
Description	Gender	Туре		q _s (btuh)	q ₁ (b	tuh)				Count		q _s (btuh)	q ₁ (btuh)	q _t (btuh)
SEATED AT REST	male	1-P1		240	- <u>1</u> 1 (U	160				4		960	640	1,600
SEATED AT REST	mixed 1-P2			210						0		,,,,,		1,000
SEATED AT REST INDEED IT I INTER IT I I I I I I I I I I I I I I I I I I			210	J 140				D	-	nel Totals:	960	640	160	
Vantilation Deminor									1	cison	IICI TOTALS.	900	040	100
Ventilation Requirement				D .				0					I	
Туре		escription		Rate	U			Qty	people			OA (cfm)		
By Occupancy	High Oc	cupancy		12	12 cfm/person			4			48			
Sanitary Fixtures				50	cfm/fi	xture		1 fixture				50		
											Chosen:	50		
				eating Outsic				°F			0	e Air Temp		°F
		_	I	Heating Insid	le Air			°F	(esign Temp:		°F	
Heating and Cooling Loa		1	-				<u>Ieating</u>		TE (0TE)	4.77		ing Seaso		
Description	Load	Insul		Area (ft ²)	T	ΔT	U or	$q_w (\text{btuh})$	T (°F)	ΔT	U or	q _s (btuh)	q ₁ (btuh)	q _t (btuh)
Exterior - Weather (Solar)	Key Over	Type C-2		64.0	(°F) 27	43	GSF 0.120	330	130	56	GSF 0.120	430		430
Pilot House	Over	C-2 C-2		144.0	70	45	0.120	550	74	0	0.120	430		43
Passenger Lounge	Belw	C-2 C-2		24.0	70	0	0.120		74	0	0.120			
Engine Room	Belw	C-2		72.0	45	25	0.120	216	115	41	0.120	354		35-
Exterior - Weather	Belw	C-2		144.0	27	43	0.120	743	95	21	0.120	363		363
Exterior - Weather (Solar)	Fwd	C-2		81.0	27	43	0.120	418	115	41	0.120	399		39
Exterior - Windows (Solar)	Fwd		☆↔	9.0	27	43	0.610	236	115	41	75.000	675		67
Exterior - Windows (Shaded)	Aft	002-H2	W↔I	6.0	27	43	0.610	157	95	21	0.610			7
Exterior - Weather	Aft	C-2		84.0	27	43	0.120	433	95	21	0.120	212		212
Exterior - Weather (Solar)	Port	C-2		195.0	27	43	0.120	1,006	115	41	0.120	959		95
Exterior - Windows (Solar)	Port	002-H1	\$\ ₽	15.0	27	43	0.610	393	115	41	75.000	1,125		1,12
Exterior - Weather	Stbd	C-2	—	128.0	27	43	0.120	660	95	21	0.120	323		32
Uptakes Exterior - Windows (Shaded)	Stbd Stbd	C-2 002-H2	W↔I	70.0	27 27	43 43	0.120	361 315	115 95	41 21	0.120			34
Exterior - windows (Snaded)	Siba	002-H2		12.0	27	43	0.610	515	95	21	0.610	154		15
LIGHTS	Lght											1,680		1,68
	Eqpt											11,820	1,000	12,82
EOUIPMENI														· · · · · · · · · · · · · · · · · · ·
EQUIPMENT PERSONNEL												960	640	1.00
PERSONNEL Ventilation	Pers OA				27	43		2,666	95	21		960 1,092	640 2,880	1,600 3,972

* This calculation sheet assumes sun on forward and port sides

Passenger Lounge					Deck	Area.	640	ft ²			Vo	lume:	5120	ff ³
St	ace No:					leight:		ft			10	iune.	5120	n
Lighting Load Calculatio				1										
Description		_	_		_		Area (ft.	2)	LC, (Btu/h	(ft ²)	_	qs (btuh)	1	qt (btuh)
Lighting							Alea (IL	<u>640</u>	LC, (Diu/II	/11	7	4,480		4,48
								040			,	4,400		4,40
										T 1.1.7		4 490		4 40
										Light	ing Totals:	4,480		4,48
Equipment Load Calculat	tion													
Description				T	-			Q	ty	Use	Factor	q _s (btuh)	q ₁ (btuh)	q _t (btuh)
				•				1	Е	quipm	ent Totals:	0	0	
Personnel Load Calculati	on												· · · · ·	1
Description										Count		q _s (btuh)	q1 (btuh)	q _t (btuh)
SEATED AT REST	male	1-P1		240	· · · ·	160				0		4s (ottal)	qi (oturi)	qi (otali)
SEATED AT REST	mixed	1-P2		240		140				32		6,720	4,480	11,20
SEATED AT REST	mixed	1-F2		210		140			г	-	a al Tatala	,		,
		_		_				_	F	erson	nel Totals:	6720	4480	1120
Ventilation Requirement								1				1	1	1
Туре		escription	_	Rate	Uı			Qty				OA (cfm)		
per ASHRAE 62.1		People OA			cfm/pe			32				160		
		Area OA	Rate	0.06	cfm/cf	f		640				38		
			Sum	L								198		
											Chosen:	200		
			He	ating Outsic	le Air'	Temp		°F			0	e Air Temp		°F
			H	leating Insid	le Air'	Temp	70	°F		(esign Temp:		°F
Heating and Cooling Loa							leating					ing Seaso		
Description	Load	Insul		Area (ft ²)	T	ΔT	U or	$q_w (\text{btuh})$	T (°F)	ΔT	U or	$q_s \text{ (btuh)}$	q ₁ (btuh)	qt (btuh)
Enterior Weather	Key	Туре		640.0	(°F)	42	GSF	2 202	05	21	GSF	1 612		1.61
Exterior - Weather Crew Lounge	Over Over	C-2 C-2		640.0 96.0	27 70	43	0.120	3,302	95 74	21	0.120	1,613		1,613
EOS	Belw	C-2 C-2		210.0	70	0	0.120		74	0	0.120			
Engine Room	Belw	C-2		317.0	45	25	0.120	951	115	41	0.120	1,560		1,56
Voids	Belw	C-2		209.0	27	43	0.120	1,078	115	41	0.120	1,028		1,028
Exterior - Weather	Fwd	C-2		84.0	27	43	0.120	433	95	21	0.120	212		21
Exterior - Windows (Shaded)		002-H2	W↔I			43	0.610			21	0.610			7
Exterior - Weather	Aft	C-2		84.0	27	43	0.120	433	95	21	0.120	212		212
Exterior - Windows (Shaded)	Aft	002-H2	W↔I	6.0	27	43	0.610		95	21	0.610			7
Exterior - Weather	Port Port	C-2 C-2		423.0 180.0	27 27	43	0.120	2,183 929	95 115	21	0.120	1,066		1,06
Engine Room EOS	Port Port	C-2 C-2		162.0	70	43	0.120	929	74	41 0	0.120	886		88
	Port	002-H2	W↔I	0.0	27	43	0.120		95	21	0.120			
Exterior - Weather (Solar)	Stbd	C-2		506.0	27	43	0.120	2,611	125	51	0.120			3,09
Exterior - Windows (Solar)	Stbd	002-H2	W↔I	254.0	27	43	0.610		125	51	75.000	· · · · · · · · · · · · · · · · · · ·		19,05
LIGHTS	Lght											4,480		4,48
EQUIPMENT	Eqpt													
PERSONNEL	Pers											6,720	4,480	11,20
Ventilation	OA				27	43		10,664	95	21		4,368	11,520	15,88
						Spac	e Totals:	29,562			Totals:	44,444	16,000	60,44

* This calculation sheet assumes sun on starboard side only

EOS					Deck	Area:	360	ft ²			Vo	olume:	2880	ft ³
S	pace No:	:		1		Height:		ft			70		2000	-
Lighting Load Calculation	n					0								
Description							Area (fť	2)	LC, (Btu/h	r/ff ²⁾		qs (btuh)		qt (btuh)
Lighting							1 1104 (14	360	Le, (Dan	., 10	7	2,520		2,520
2.5												2,020		2,02
										Link	ma Tatala	2.520		2.520
										Light	ing Totals	2,520		2,520
Equipment Load Calcula	tion													
Description				qs (btuh)	ql (b	otuh)		Q	ty	Use	Factor	q _s (btuh)	q1 (btuh)	q _t (btuh)
Switchboard / Electronics				10,000				1	l		1	10,000		10,000
				1	I			1	E.	l minm	ent Totals	10000	0	1000
	•								E	quipine	In Totals	1 10000		10000
Personnel Load Calculat		m		a +>						9				
Description	Gender			q _s (btuh)	q1 (t					Count		q _s (btuh)	q ₁ (btuh)	q _t (btuh)
SEATED AT REST	male	1-P1		240		160				2		480	320	800
SEATED AT REST	mixed	1-P2		210		140				0				
									F	Person	nel Totals	480	320	800
Ventilation Requirement	ts													
Туре	1	escription		Rate	U	nit		Qty				OA (cfm)		
By Occupancy		A			cfm/p				people			30		
Rate of Change					ach			2880	· ·			48		
Sanitary Fixtures					cfm/fi	vturo			fixture					
Sandary Fixtures				50	ciiivii	Ature		0	IIXture		Chosen:	50		
			11.		1. A.L.	T	27	°F	1	Cert				°F
				ating Outsic Heating Insic				°F			0	e Air Temp esign Temp:		°F
Heating and Cooling Loa	d Colar	lation	<u> </u>	reating msic	le All		Heating					ling Seaso		1
Description	Load	Insul	<u> </u>	Area (ft ²)	Т	ΔT	U or	qw (btuh)	T (°F)	ΔT	U or	q _s (btuh)	q ₁ (btuh)	q _t (btuh)
Description	Key	Туре		Area (π)	(°F)		GSF	q _w (btuil)	1(1)		GSF	q _s (oturi)	qi (oturi)	qt (Dtull)
Exterior - Weather	Over	C-2		96.0	27	43	0.120	495	95	21	0.120	242		242
Passenger Lounge	Over	C-2		264.0	70	0	0.120		74	0	0.120			
EOS Floor	Belw	0-D4	I↓I	360.0	32	38	0.695	9,508	86	12	0.801	3,460		3,460
Engine Room	Fwd	C-2		123.0	55	15	0.120	221	115	41	0.120	605		605
Engine Room - Windows	Fwd	002-H2	W↔I	24.0	55	15	0.610		115	41	0.610			600
Void	Aft	C-2		147.0	55	15	0.120	265	115	41	0.120	723		723
Engine Room	Port	C-2	W -	210.0		15					0.120			1,033
Engine Room - Windows	Port	002-H2	w↔l	30.0	55	15			115	41	0.610			750
Exterior - Weather (solar)	Stbd	C-2		144.0	27	43	0.120	743	125	51	0.120	881		881
		1												
LIGHTS	Lght											2,520		2,520
EQUIPMENT	Eqpt											10,000		10,000
PERSONNEL	Pers											480	320	800
Ventilation	OA				27	43		2,666	95	21		1,092	2,880	3,972
						Spac	e Totals:	14,770			Totals:	22,388	3,200	25,58

* This calculation sheet assumes sun on starboard side only

Appendix G

Fire Main System, Dwg. 16101-200-521-1

1 DESCRIPTION

This appendix documents the calculations used in designing the fire main piping system. These calculations establish pump capacity in accordance with regulatory requirements and minimum pipe sizes based upon nominal velocity limits. Estimated losses through the system piping are calculated to establish the total dynamic head (TDH) and net positive suction head (NPSH) requirements for the fire pumps.

2 PROCEDURE

Calculations are presented in the following sequence:

- Fire main pipe nominal velocity calculations
- Fire pump TDH and NPSH calculations

Minimum fire pump capacity, pressure, and nozzle size is based upon the requirements found in

46 CFR Subchapter H, [1].

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

- Fire main system is to be constructed of Class 200 copper nickel pipe.
- Piping system lengths, routing, fittings, etc. are estimated based on the Profiles and Arrangements, and Fire Main System Schematic [2] [3].
- In accordance with [1], the required pressure at the two most remote fire hydrants is 50 psi and the required nozzle orifice size is 5/8".
- The theoretical discharge from a 5/8" orifice at 50 psi is assumed to be 82 gpm, or 164 gpm for two nozzles.
- To maintain fleet commonality, the client prefers the fire pump be a Goulds 3796 2x2-10, 3550 rpm, 8.5 inch impeller.
- The following elevations above baseline are assumed for the system calculation

Waterline	4.5 ft
Pump inlet/outlet	2.5 ft
01 Deck Stations	24 ft

• The fluid medium is seawater with the following properties:

Specific weight	64.04 lb/cu ft
Viscosity	1.206 cP
Temperature	60 °F
Vapor pressure	0.2513 psia

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Pipe Size Calculations

Pipe sizes are based on the nominal velocity limits found in Marine Engineering, Chapter 20, Table 3, [4]. The following table shows the flow rates of fuel occurring in the system, and the resulting pipe sizes.

Pipe Segment	Flow Rate	Pipe Size	ID	Design Ve	locity (ft/s)	V
	gpm	(NPS)	in	Nominal	Limit	ft/s
Firemain Suction	164	3" CL 200 CUNI	3.310	5.46	12.00	5.96
Firemain Discharge	164	3" CL 200 CUNI	3.310	9.10	12.00	5.96
Firemain Branch (1 hydrant)	82	1-1/2" CL 200 CUNI	1.756	6.63	12.00	10.58
Firemain Branch (2 hydrants)	164	2" CL 200 CUNI	2.209	7.43	12.00	13.37
Firemain Overboard	164	3" CL 200 CUNI	3.310	9.10	12.00	5.96

Table 5-1: Nominal Pipe Velocity

Note that the velocity limit of 12 feet per second is exceeded in a 2" line with a 164 gpm flowrate, and it is likely this limit will be exceeded in some cases with the client's preferred fire pump. This is acceptable; however, as the fire system is infrequently used and minimal pipe wear is anticipated over the life of the vessel.

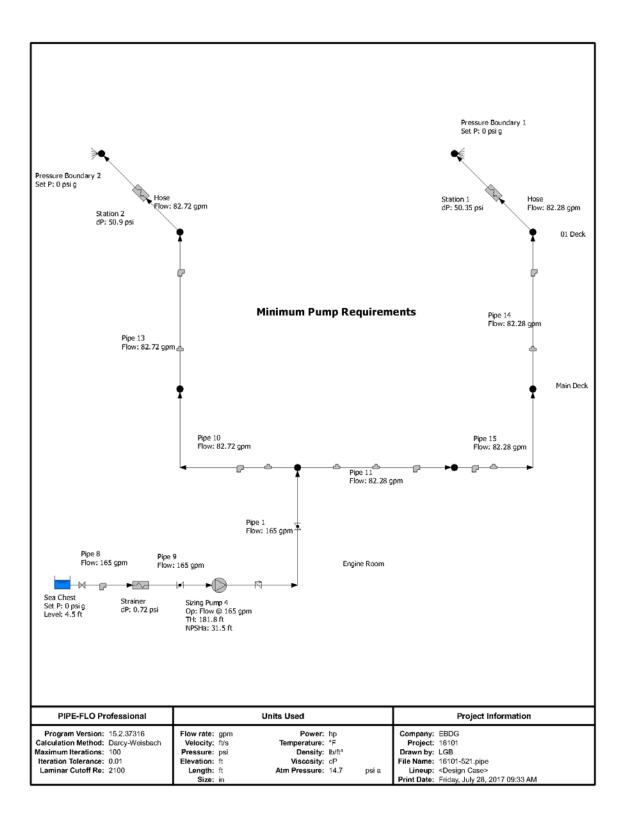
5.2 Fire Pump TDH and NPSHa Calculation

From the enclosed system model, the minimum fire main pump operating point is 165 gpm at a total dynamic head of 182 feet H2O while discharging from the two most remote fire stations with a pitot pressure of 50 psig. The system provides NPSH of 31.5 feet H2O. The client's preferred pump is also modeled. This pump will provide a 192 gpm at 237 feet H2O while discharging from the two most remote fire stations; this exceeds the minimum regulatory requirements.

6 REFERENCES

- [1] USCG, "46 CFR, Chapter I, Subchapter H, Part 76 Fire Protection Equipment," 7/21/2017.
- [2] Elliott Bay Design Group, "NCDOT New River Class Ferry: Profiles and Arrangements," 16101-200-101-1, Seattle, WA.
- [3] Elliott Bay Design Group, "NCDOT New River Class Ferry: Fire Main System Schematic," 16101-200-521-1, Seattle, WA.
- [4] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.

FIRE MAIN PIPE-FLO MODEL



		l		List Report		l			
File Name: 16101-521,pipe Lineup: <design case=""> Progent Name: PIPE-FLO Professional Version: 15.2.37316</design>		Calcu Lami Perc	Calculation Method: Darcy Laminar Cutoff Re: 2100 Max Iterations: 100 Percent Tolerance: 0.01 Allowable Deviation: 1 9	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max terations: 100 Percent Tolerance: 0.01 Niowable Deviation: 1 %	Atmospheric	Company: EBDG Project: 16101 by: LGB Date: Friday, Pressure: 14	0G 01 ay, July 28, 2(14.7 osi a	pany: EBDG oject: 16101 by: LGB the: Friday, July 28, 2017 09:15 AM tsure: 14.7 beia	
				Pipe Specifica	tions				
Specification Name Valve Table	Material Schedule	Abs	Absolute Roughness Hazen Williams C Factor		Sizing Criteria	Velo	Velocity	Design Limits Pressure	Reynolds Number
CuNi Class 200 standard	Copper Nickel MIL-T-16420K Schedule:Class 200	T-16420K	6E-05 in 150		0.0	Min: Max:	ft/s ft/s	psig psig	
				Fluid Zone	ŝ				
Fluid Zone Name Table Name	-	Temperature Pressure	Fluic Relative N	Fluid State Relative Molecular Mass	Density Viscosity		Vapor Pressure Critical Pressure		Specific Heat Capacity (cp) Specific Heat Ratio (k)
Seawater Seawater 3.5% Salinity		60 °F 0 psig	Lie	Liquid 29	64.04 lb/ft ² 1.206 cP		0.2513 psia 3199 psia	si a Si a	
				Sizing Pumps	ps				
Pump Name		Suction Elevation Suction Pressure		Discharge Elevation Discharge Pressure	tion Total Head ure dP		Flow Rate	NPSHa	
Sizing Pump 4		2.5 ft -0.4351 psig	5	2.5 ft 80.41 psig	181.8 ft 80.84 psi		165 gpm	31.5 ft	
				Fipelines					
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device r Inlet Elevation Outlet Device Outlet Elevation	ce tion stion	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Per Inlet Energy Grade Stor Inlet Hydraulic Grade	Total dP e Total Head Loss de		Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Loos	4 6 in	Modo 1		Marine DC CD	EA 07 main	14 61	ina	50 32 mai a	0.01076
CUNI Class 200	1.756 in	24 ft		10.9 ft/s	64.15 psig	0.4		49.53 psi q	0.00
Seawater	150 ft	Station 1 24 ft		126044 0.01736	170.1 ft 168.2 ft	32.86	ŧ	137.2 ft 135.4 ft	0 psi
		a de la		00100			100	10 10 10 10 10 10 10 10 10 10 10 10 10 1	0 01075
HOSE CUNI Class 200	11.756 in	24 H		02.72 gpm 10.96 #/s	64.82 psig	14.75	bsi	50.07 psig	C/6L0.0
Seawater	150 ft	Station 2 24 ft		126707 0.01734	171.6 ft 169.7 ft	33.17	¥	138.4 ft 136.6 ft	0 psi 0 ft
Pipe 1	3 in	Sizing Pump 4	4	165 gpm	80.41 psig	4.587	psi	75.82 psig	0.01702
CuNi Class 200	3.31 in	2.5 ft		6.152 ft/s	80.14 psig			75.56 psig	2.47
Seawater	10 ft	Node 2 11 ft		134088 0.01705	183.3 ft 182.7 ft	1.815	Ŧ	181.5 ft 180.9 ft	0.6455 psi 1.451 ft
Pipe 10	2 in	Node 2		82.72 gpm	75.82 psi g	2.71	psi	73.11 psig	0.01869
CuNi Class 200	2.209 in	11 ft		6.925 ft/s	75.49 psig			72.78 psig	2.18
Seawater	20 ft	Node 6 14 ft		100723 0.01811	181.5 ft 180.7 ft	3.093	Ŧ	178.4 ft 177.6 ft	0.7237 psi 1.627 ft
Pipe 11	3 in	Node 2		82.28 gpm	75.82 psi g	0.4522 psi	psi	75.37 psi g	0.01702
CuNi Class 200	3.31 in	11 ft		3.068 ft/s	75.75 psig			75.3 psig	2.31
Seawater	65 ft	Node 9		66868	181.5 ft	1.017 ft	ŧ	180.5 ft	0.1506 psi
		11 ft		0.01967	181.3 ft			180.3 ft	0.3385 ft
PIPE-FLO Professional	Version: 15.2.37316	7316		List Report		Friday, July	Friday, July 28, 2017 09:15 AM	9:15 AM	Page 1

Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device eter Inlet Elevation Outlet Device Outlet Elevation	FIL FIL	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 13 CuNi Class 200 Seawater	1.5 in 1.756 in 20 ft	Node 6 14 ft Node 3 24 ft	82.72 gpm 10.96 ft/s 126707 0.01734	73.11 psig 72.28 psig 178.4 ft 176.5 ft	7.458 psi 6.77 ft	65.65 psig 64.82 psig 171.6 ft 169.7 ft	0.01975 1.26 1.044 psi 2.347 ft
Pipe 14 CuNi Class 200 Seawater	1.5 in 1.756 in 20 ft	Node 8 14 ft Node 1 24 ft	82.28 gpm 10.9 ft/s 126044 0.01736	72.16 psig 71.34 psig 176.3 ft	7.193 psi 6.173 ft	64.97 psig 64.15 psig 170.1 ft 168.2 ft	0.01975 0.97 0.7969 psi 1.792 ft
Pipe 15 CuNi Class 200 Seawater	2 in 2.209 in 40 ft	Node 10 11 11 14 14 14 14	82.28 gpm 6.888 ft/s 100196 0.01813	75.37 psig 75.04 psig 180.5 ft	3.204 psi 4.204 ft		0.01869 1.76 0.5779 psi 1.3 ft
Pipe 4 CuNi Class 200 Seawater	1.5 in 1.756 in 0.01 ft	Station 1 24 ft Pressure Boundary 1 24 ft		9.742E-04 psig -0.8203 psig 24 ft 22.16 ft	9.742E-04 psi 2.191E-03 ft		0.01975 0.00 0 psi 0 ft
Pipe 7 CuNi Class 200 Seawater	1.5 in 1.756 in 0.01 ft	Station 2 24 ft Pressure Boundary 2 24 ft	82.72 gpm 10.96 ft/s 126707 0.01734	9.835E-04 psig -0.8289 psig 24 ft 22.14 ft	9.835E-04 psi 2.211E-03 ft	0 psig -0.8299 psig 24 ft 22.13 ft	0.01975 0.00 0 psi 0 ft
Pipe 8 CuNi Class 200 Seawater	3 in 3.31 in 5 ft	Sea Chest 0 ft Strainer 2.5 ft	165 gpm 6.152 ft/s 134088 0.01705	2.001 psig 1.74 psig 4.5 ft 3.912 ft	1.484 psi 0.8362 ft	0.5176 psig 0.256 psig 3.664 ft 3.076 ft	0.01702 1.11 0.291 psi 0.6544 ft
Pipe 9 CuNi Class 200 Seawater	3in 3.31 in 2 ft	Strainer 2.5 ft Stering Pump 4 2.5 ft	165 gpm 6.152 ft/s 134088 0.01705	-0.2024 psig -0.464 psig 2.045 ft 1.457 ft	0.2327 psi 0.5231 ft	-0.4351 psig -0.6967 psig 1.522 ft 0.9335 ft	0.01702 0.77 0.2003 psi 0.4504 ft
Tank Name Fluid Zone	Bottom Elevation Liquid Level	Surface Pressure Bottom Pressure	lanks Hydraulic Grade	Pipeline Name Pe	Connecting Pipelines Penetration Height Pipeline F	Tow Rate	Pressure at Penetration
Sea Chest	0 ft 1.5 ft	0 psig 2.001 psig	4.5 ft	Pipe 8	0 ft	165 gpm	2.001 psi g
Curve dP Device Name Description	Inlet Elevation Inlet Pressure		Outlet Elevation Outlet Pressure	dP Head Loss	Flow Rate		
Station 1 5/8* Nozzle	24 ft 50.36 psig		24 ft 9.742E-04 psi g	50.35 psi 113.2 ft	82.28 gpm		
Station 2 5/8" Nozzle	24 ft 50.9 psig	24 ft sig 9.835E-04 psi	24 ft 04 psig	50.9 psi 114.4 ft	82.72 gpm		
Strainer Eaton Model 72 3"	2.5 ft 0.5176 psig		2.5 ft -0.2024 psi g	0.72 psi 1.619 ft	165 gpm		
PIPE-FLO Professional	Version: 15.2.37316	37316	l iet Renort		Friday Judy 28, 2017 09-15 AM	17 09-15 AM	Darra 7

NEW RIVER CLASS FERRY

8/3/17

	Nodes			
Node Name	Elevation	Pressure	Hydraulic Grade	
Node 1	24 ft	64.97 psig	168.2 ft	
Node 2	11 ft	75.82 psi g	181 ft	
Node 3	24 ft	65.65 psi g	169.7 ft	
Node 6	14 ft	73.11 psig	177.1 ft	
Node 8	14 ft	72.16 psig	175 ft	
Node 9	11 ft	75.37 psi g	180 ft	
	Pressure Boundaries	ndaries		
Pressure Boundary Name	Elevation	Pressure	Hydraulic Grade	Flow Rate
Pressure Boundary 1	24 ft	0 psig	22.15 ft	82.28 gpm
Pressure Boundary 2	24 ft	0 psig	22.13 ft	82.72 gpm

Page 3

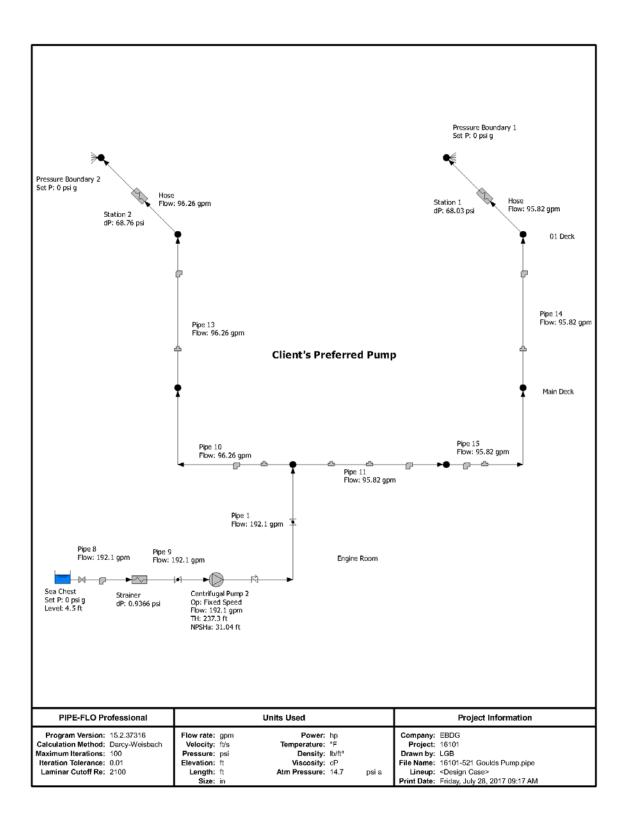
Friday, July 28, 2017 09:15 AM

List Report

Version: 15.2.37316

PIPE-FLO Professional

File Name: 16101-521. Lineup: <design ca<br="">rogram Name: PIPE-FLO F Version: 15.2.37316</design>	ise> Professional	Sizing Pumps	Date:		09:15 AM
Sizing Pump Name Operation				Desi Flow Rate	gn Point Total Head
Sizing Pump 4 Flow @ 165 gpm				165 gpm	181.8 ft
Tank Name		Tanks			
Sea Chest					
Current of District Marrier	Curran D	Curve dP Devic	es		
Curve dP Device Name		escription			
Station 1	5/8" Noz				
Station 2	5/8" Noz				
Strainer	Eaton Mo	Pipelines			
Pipeline	Specification	Size	Length	Valves and Fi	ttings
Hose	CuNi Class 200	1.5 in	150 ft		
Hose	CuNi Class 200	1.5 in	150 ft		
Pipe 1	CuNi Class 200	3 in	10 ft	1 x Butterfly 1 x Swing Che	ck - Angled
Pipe 10	CuNi Class 200	2 in	20 ft		ng radius, r/d 1.5 (90°) Contraction (2 in x 3 in - 0 in) Thru Branch
Pipe 11	CuNi Class 200	3 in	65 ft	1 x Tee - Flow 1 x Tee - Flow 4 x Elbow - Lo	
Pipe 13	CuNi Class 200	1.5 in	20 ft	1 x Tee - Flow	Contraction (1.5 in x 2 in - 2 in) Thru Run ng radius, r/d 1.5 (90°)
Pipe 14	CuNi Class 200	1.5 in	20 ft	1 x Tee - Flow	Contraction (1.5 in x 2 in - 3 in) Thru Run ng radius, r/d 1.5 (90°)
Pipe 15	CuNi Class 200	2 in	40 ft		Thru Run Contraction (2 in x 3 in - 3 in) ng radius, r/d 1.5 (90°)
Pipe 4	CuNi Class 200	1.5 in	0.01 ft		
Pipe 7	CuNi Class 200	1.5 in	0.01 ft		
Pipe 8	CuNi Class 200	3 in	5 ft	2 x Elbow - Lo 1 x Gate - Wee 1 x Entrance -	
Pipe 9	CuNi Class 200	3 in	2 ft	1 x Butterfly	
		peline Material Su			
Specification	Material	Size	Total Length		
CuNi Class 200	Copper Nickel MIL-T-16420K Schedule: Class 200	1.5 in	340.02 ft	1 x Reducer - C	g radius, r/d 1.5 (90°) ontraction (1.5 in x 2 in - 2 in) ontraction (1.5 in x 2 in - 3 in) hru Run
CuNi Class 200	Copper Nickel MIL-T-16420K Schedule: Class 200	2 in	60.00 ft	1 x Reducer - C	
CuNi Class 200	Copper Nickel MIL-T-16420K Schedule: Class 200	3 in	82.00 ft	2 x Butterfly 6 x Elbow - Long 1 x Entrance - S 1 x Gate - Wedg 1 x Swing Ched 1 x Tee - Flow T 1 x Tee - Flow T	ge Disc k - Angled 'hru Branch



Appendix H

Sanitary Drains System, Dwg. 16101-200-528-1

1 DESCRIPTION

This appendix documents the first principles calculations used in selecting the zero discharge pump for the sanitary drains system. These calculations are used to establish minimum pipe sizes based upon nominal velocity limits and to identify steady state frictional losses to establish the total dynamic head (TDH) and net positive suction head (NPSH) requirements for the zero discharge pumps.

2 PROCEDURE

Calculations are presented in the following sequence:

- Pipe size calculations
- Zero discharge pump TDH and NPSH calculations

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

- The zero discharge system is to be constructed of Schedule 80 CPVC pipe.
- Piping system lengths, routing, fittings, etc. are estimated based on the Profiles and Arrangements, and Sanitary Drains Schematic, [1] [2].
- A pressure of 10 psig is assumed at the zero discharge connection on the Main Deck.
- The zero discharge tanks are 2 feet above baseline, the pump suction and discharge are 2.5 feet above baseline, and the zero discharge connection on the Main Deck is assumed to be 11 feet above baseline, [1].
- The fluid used for all calculations is fresh water with the following properties:

Temperature:	60 degrees F
Specific Weight:	62.37 lb/cuft
Dynamic viscosity:	1.105 cP
Vapor Pressure:	0.2564 psia

- A single pump shall be capable of emptying the two 500 gallon tanks in 10 minutes or less, so the minimum flowrate is 100 gpm.
- To maintain fleet commonality the client prefers an MP Pumps Flomax 10 2x2, 3450 rpm with a 5.5 inch impeller for the zero discharge pump.

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Pipe Size Calculations

Pipe sizes are based on the nominal velocity limits found in Marine Engineering, Chapter 20, Table 3, [3]. The following table shows the flow rates of zero discharge effluent occurring in the system, and the resulting pipe sizes.

Pipe Segment	Flow Rate	Pipe Size	ID	Design Ve	locity (ft/s)	V
	gpm	(NPS)	in	Nominal	Limit	ft/s
Pump suction	100	2" SCH 80	1.94	4.18	15.00	10.57
Pump discharge	100	2" SCH 80	1.94	6.96	15.00	10.57

Table 5-1: Zero Discharge System Pipe Sizes and Velocities

While the expected velocities exceed the nominal velocities , the expected velocities are still well below the maxium limit.

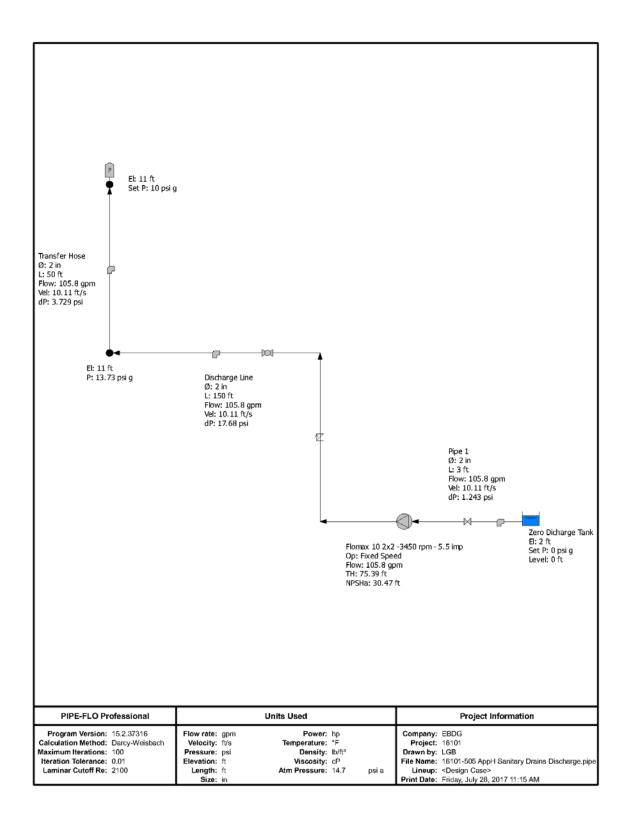
5.2 Zero Discharge Pump TDH and NPSH Calculation

From the enclosed system model, the zero discharge pump shall be sized for 105 gpm at 75 feet H2O TDH. The system has 30.5 NPSH available. The system model considers the client's preferred pump; this operating point is on the pump curve of the client's preferred pump.

6 **REFERENCES**

- [1] Elliott Bay Design Group, "NCDOT New River Class Ferry: Profiles and Arrangements," 16101-200-101-1, Seattle, WA.
- [2] Elliott Bay Design Group, "NCDOT New River Class Ferry: Sanitary Drains Schematic," 16101-200-528-1, Seattle, WA.
- [3] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.

ZERO DISCHARGE PIPE-FLO MODEL



			List Report		l			
File Name: 16101-505 AppH Sanitary Drains Discharge.pipe Lineup: <design case=""> Progen Name: PIPE-FLO Professional Version: 15.2.37316</design>	itary Drains Discharge.pip		Calculation Method: Darcy-Weisbach Laminar Cutoff Re. 2100 Max Iterations: 100 Percent Tolerance: 0.01 Allowable Deviation: 1 % Allowable Deviation: 2 %	Company: Project: by: Date: Atmospheric Pressure:	Company: EBDG Project: 16101 by: LGB Date: Friday, July 28, 2017 11:16 AM Presure: 14.7 psia	8, 2017 11:16 AM	- 1	
Specification Name Valve Table	Material Schedule	Absolute Roughness Hazen Williams C Factor		Sizing Criteria	Velocity	Design Limits Pressure		Reynolds Number
Carbon Steel SCH 80 standard	Steel A53-B36.10 Schedule:80	1.800E-03 in 140	0.0 0.0	Min: Max:	8/U B/VS	psig psig		
Plastic Pipe standard	PVC PIPE D1785 Schedule:40	6E-05 140	6E-05 in 0.0 140 Eluid Zonos	Min: Max:	ft/s ft/s	psi g psi g		
Fluid Zone Name Table Name		Temperature F Pressure Relativ	Fluid State Relative Molecular Mass	Density Viscosity	Vapor Critical	Vapor Pressure Sp Critical Pressure	pecific Heat Capacity (c Specific Heat Ratio (k)	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Water Water		60 °F 0 psig	Liquid 18 Centrifiugal Pumos	62.37 lb/ft ⁹ 1.105 cP	0.256 319	0.2564 psia 3199 psia	;	
Pump Name	Test Speed Operating Speed	Suction Elevation ed Suction Pressure	Discharge Elevation Discharge Pressure	Total Head dP	Flow Rate Power B	Efficiency BEP Efficiency	NPSHa NPSHr	Design NPSH Margin Ratio
Flomax 10 2x2 -3450 rpm - 5.5 imp Fixed Speed	3450 rpm 3450 rpm	2.5 ft -1.243 psig	2.5 ft 31.41 psig	75.39 ft 32.65 psi	105.8 gpm -	%	30.47 ft 6.922 ft	1
Company: Flomax Curve: Manual Pump Type:		Size: 10 2x2 Diameter: 5.5 in POR: from	- 1 2					
			Pipelines					
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device sr Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade		V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Discharge Line Plastic Pipe Water	2 in 2.067 in 150 ft	lomax 10 2x2 - 3450 rpm - 5.5 im 2.5 ft Pressure Boundary 11 ft	105.8 gpm 10.11 ft/s 146322 0.01683	31.41 psig 30.72 psig 75.02 ft 73.43 ft	17.68 psi 32.32 ft	13.73 psig 13.04 psig 42.7 ft 41.11 ft	5 1 53	0.01899 5.68 3.908 psi 9.024 ft
Pipe 1 Plastic Pipe Water	2 in 2.067 in 3 ft	Zero Dicharge Tank 2 ft bomax 10 2x2 -3450 rpm - 5.5 im 2.5 ft	105.8 gpm 10.11 ft/s 146322 0.01683	0 psig -0.6883 psig 2 ft 0.4108 ft	1.243 psi 2.369 ft	-1.243 psig -1.931 psig -0.3894 ft -1.959 ft	5 5	0.01899 1.20 0.8245 psi 1.903 ft
Transfer Hose Plastic Pipe Water	2 in 2.067 in 50 ft	Pressure Boundary 11 ft Pressure Boundary 1 11 ft	105.8 gpm 10.11 ft/s 146322 0.01683	13.73 psig 13.04 psig 42.7 ft 41.11 ft	3.729 psi 8.61 ft	10 psig 9.312 psig 34.09 ft 32.5 ft	רס ום	0.01899 0.53 0.366 psi 0.845 ft
Tank Name Fluid Zone	Bottom Elevation S Liquid Level B	Surface Pressure Hyc Bottom Pressure	IanKs Hydraulic Grade	Pipeline Name Penetr	Connecting Pipelines Penetration Height Pipeline F	l Pipelines Pipeline Flow Rate		Pressure at Penetration
PIPE-FLO Professional	Version: 15.2.37316	7316	List Report	Ľ	Friday, July 28, 2017 11:16 AM	17 11:16 AM		Page 1

0 psig 2 ft				
_				
	Pip	e1 0.ft	105.8 gpm	0 psig
No	les			
Elevation	Pressure	Hydraulic Grade		
11 ft	13.73 psi g	41.11 ft		
Pressure E	oundaries			
Elevation	Pressure	Hydraulic Grade	Flow Rate	
	Noc Elevation 11 ft Pressure B	Nodes Pressure 13.73 psig ressure Boundaries Pressure	Nodes Preseure 13.73 psi g ressure Boundaries Preseure	Nodes Hpe 1 UIT Presure Hydraulic Grade 13.73 psi g 41.11 ft ressure Boundarles Hydraulic Grade FI

Page 2

Friday, July 28, 2017 11:16 AM

List Report

Version: 15.2.37316

PIPE-FLO Professional

		Bill of Materia	ls Report		
File Name: 16101-3 Lineup: <design Program Name: PIPE-FI Version: 15.2.37</design 	LO Professional		Date:		
		Centrifug	al Pumps		
Centrifugal Pump Name Operation	•				
Flomax 10 2x2 -3450 rpn Fixed Speed	Type: Size:	10 2x2 Manual Pump		Test Speed: 3450 rpm Impeller Diameter: 5.5 in POR: from to	
		Tan	ks		
Tank Name					
Zero Dicharge Tank					
		Pipel	ines		
Pipeline	Specification	Siz	e Length	Valves and Fittings	
Discharge Line	Plastic Pipe	2 ii	n 150 ft	8 x Elbow - Standard 90° 1 x Swing Check - Vertical 3 x Ball	
Pipe 1	Plastic Pipe	2 ii	n 3ft	1 x Gate - Knife 1 x Elbow - Long radius, r/d 1.5 (90°) 1 x Entrance - Inward	
Transfer Hose	Plastic Pipe	2 ir	n 50 ft	2 x Pipe Bend - r/d 4 (90°)	
		Pipeline Mate	rial Summary		
Specification	Material	Size	Total Lengti	h Valves & Fittings	
Plastic Pipe	PVC PIPE D1785 Schedule: 40	2 in	203.00 ft	3 x Ball 1 x Elbow - Long radius, r/d 1.5 (90°) 8 x Elbow - Standard 90° 1 x Entrance - Inward 1 x Gate - Knife 2 x Pipe Bend - r/d 4 (90°)	

1 x Swing Check - Vertical

PIPE-FLO Professional

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Bill of Materials Report

Friday, July 28, 2017 11:16 AM

Page 1

Appendix I

Bilge System, Dwg. 16101-200-529-1

8/3/17

1 DESCRIPTION

This appendix documents the calculations used in designing the bilge piping system. These calculations establish minimum bilge pipe sizes and required pump capacity in accordance with regulatory requirements. Estimated losses through the bilge system are calculated to establish the total dynamic head (TDH) and net positive suction head (NPSH) requirements for the bilge pump.

2 **PROCEDURE**

Calculations are presented in the following sequence:

- Bilge pipe size and pump capacity calculations
- Bilge pipe nominal velocity calculations
- Bilge pump TDH and NPSH calculation

Bilge pipe size and capacity are based on the regulatory requirements found in [1].

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

- Bilge system is to be constructed of Schedule 80 carbon steel pipe.
- Piping system lengths, routing, fittings, etc. are estimated based on the Profiles and Arrangements, and Bilge and Ballast System Schematic [2] [3].
- The fluid medium is seawater with the following properties:

Specific weight	64.04 lb/cu ft
Viscosity	1.206 cP
Temperature	60 °F
Vapor pressure	0.2513 psia

• The following elevations above baseline are assumed for the system calculation

Overboard Discharge	9.5 ft
Pump inlet/outlet	2.5 ft
Lazarette Bilge Suction	4.0 ft
Thruster Bilge Suction	3.0 ft
Void Bilge Suction	1.0 ft
Engine Room Bilge Suction	0.0 ft

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Bilge Pipe Size and Pump Capacity Calculation

From the attached spreadsheet, the minimum internal bilge main diameter is 3.02 inches ± 0.25 inches. 3 inch schedule 80 steel pipe has an inside diameter of 2.9 inches, and is minimum acceptable size for the bilge main. The minimum bilge piping diameter for the hull compartments ranges from 2.0 inches to 2.45 inches. The acceptable minimum NPS pipe size ranges from 2 inches to 2.5 inches schedule 80 steel pipe.

The minimum bilge pump capacity to maintain a nominal velocity of 400 feet per minute in the bilge main is 149 gpm.

5.2 Bilge Pipe Nominal Velocity Calculation

Pipe sizes are checked against the nominal velocity limits found in Marine Engineering, Chapter 20, Table 3, [4]. The following table shows the flow rates of bilge water occurring in the system.

Pipe Segment	Flow Rate	Pipe Size	ID	Design Vel	locity (ft/s)	V
	gpm	(NPS)	in	Nominal	Limit	ft/s
Bilge Main	149	3" Schedule 80 Steel	2.900	5.11	15.00	7.05
Engine Room Bilge Branch	149	2.5" Schedule 80 Steel	2.320	4.57	15.00	11.01
All other Bilge Branches	149	2" Schedule 80 Steel	1.940	4.18	15.00	15.75
Overboard Discharge	149	3" Schedule 80 Steel	2.900	8.51	15.00	7.05

Table 5-1: Nominal Pipe Velocity

Note that it is necessary to throttle the pump discharge when pumping individual compartments beyond the void, so the velocity in those smaller lines is not likely to exceed the 15 feet per second limit.

5.3 Bilge Pump TDH and NPSH Calculation

From the enclosed system model, the bilge pump is required to produce about 40 feet H2O TDH at the required flowrate of 149 gpm. Calculated NPSH available for the bilge system ranges from about 6 feet to 12 feet in the void and engine room, respectively.

Note that it is necessary to throttle the pump discharge when pumping an individual compartment beyond the void to prevent pump cavitation.

6 **REFERENCES**

[1] USCG, "46 CFR, Chapter I, Subchapter F, 56.50-50," 7/21/2017.

[2] Elliott Bay Design Group, "NCDOT New River Class Ferry: Profiles and Arrangements," 16101-200-101-1, Seattle, WA.

[3] Elliott Bay Design Group, "NCDOT New River Class Ferry: Bilge and Ballast System

Schematic," 16101-200-529-1, Seattle, WA.

[4] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.

BILGE PIPE SIZING AND PUMP CAPACITY BILGE SYSTEM SIZING CALCULATIONS

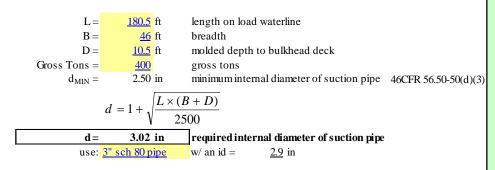
APPROACH

Size bilge pipes and bilge pumps per the requirements of 46CFR Subchapter F, 56.50-50.

ASSUMPTIONS

- 1. Unit System used in this calculation: US.
- 2. Bilge piping is schedule 80.

CALCULATION OF PIPE SIZE FOR SUCTION TO EACH MAIN BILGE PUMP 46CFR 56.50-50(d)(1)



CALCULATION OF PIPE SIZE FOR SUCTION OF EACH BRANCH

46CFR 56.50-50(d)(2)

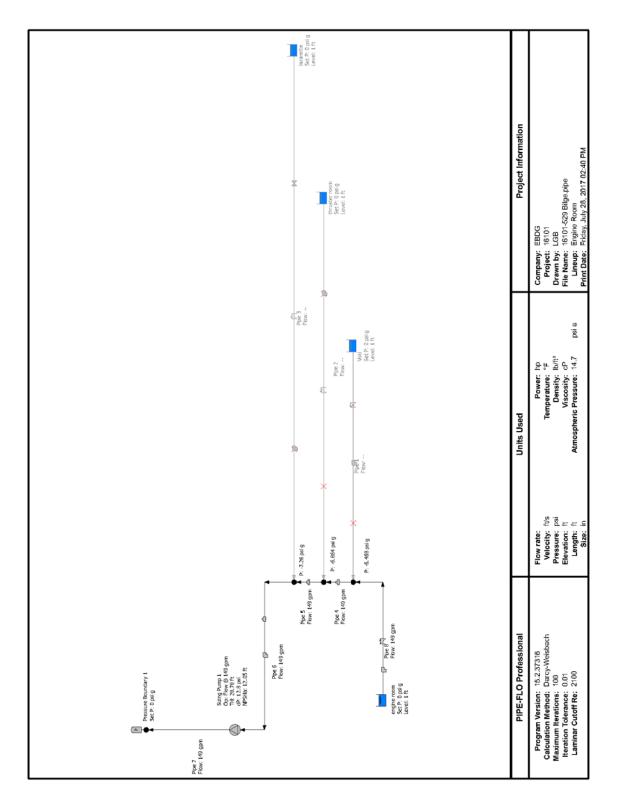
$B = \begin{array}{ccc} 46 \text{ ft} & \text{breadth} \\ D = \begin{array}{ccc} 10.5 \text{ ft} & \text{molded depth to bulkhead deck} \\ d_{\text{MIN}} = \begin{array}{ccc} 2 \text{ in} & \text{minimum internal diameter of branch suction pipe} \\ d_{\text{MAX}} = \begin{array}{ccc} 4 \text{ in} & \text{maximum internal diameter of branch suction pipe} \end{array}$	c =	see table	ft	compartment length
$d_{MIN} = 2$ in minimum internal diameter of branch suction pipe	B =	46	ft	breadth
	D =	10.5	ft	molded depth to bulkhead deck
$d_{MAX} = \frac{4}{10}$ in maximum internal diameter of branch suction pipe	$d_{MIN} =$	2	in	minimum internal diameter of branch suction pipe
a _{MAA} – The maximum internal dufficter of branch suction pipe	$d_{MAX} =$	4	in	maximum internal diameter of branch suction pipe
d = see table in required internal diameter of branch suction pipe	d =	see table	in	required internal diameter of branch suction pipe
id = see table in actual diameter of branch suction pipe	id =	see table	in	actual diameter of branch suction pipe

$$d = 1 + \sqrt{\frac{c \times (B+D)}{1500}}$$

Compartment	с	d	pipe selected	id	PASS
	(ft)	(in)		(in)	
Lazarette A	<u>11.8</u>	2.000	<u>2" sch 80 pipe</u>	<u>1.939</u>	PASS
Thruster Room A	<u>32</u>	2.098	<u>2" sch 80 pipe</u>	<u>1.939</u>	PASS
Void A	<u>20</u>	2.000	<u>2" sch 80 pipe</u>	<u>1.939</u>	PASS
Eninge Room	<u>56</u>	2.452	<u>2¹/2" sch 80 pipe</u>	2.323	PASS
Void B	<u>20</u>	2.000	<u>2" sch 80 pipe</u>	1.939	PASS
Thruster Room B	<u>32</u>	2.098	<u>2" sch 80 pipe</u>	1.939	PASS
Lazarette B	11.8	2.000	<u>2" sch 80 pipe</u>	1.939	PASS

CALCULATION OF PUMP CAPACITY 46CFR 56.50-55(c) d = 3.02 in required diameter of main bilge suction a = 7.16 in² required cross sectional area of main bilge suction v = 400 ft / min required pump suction velocity V = 149 gpm required pump capacity

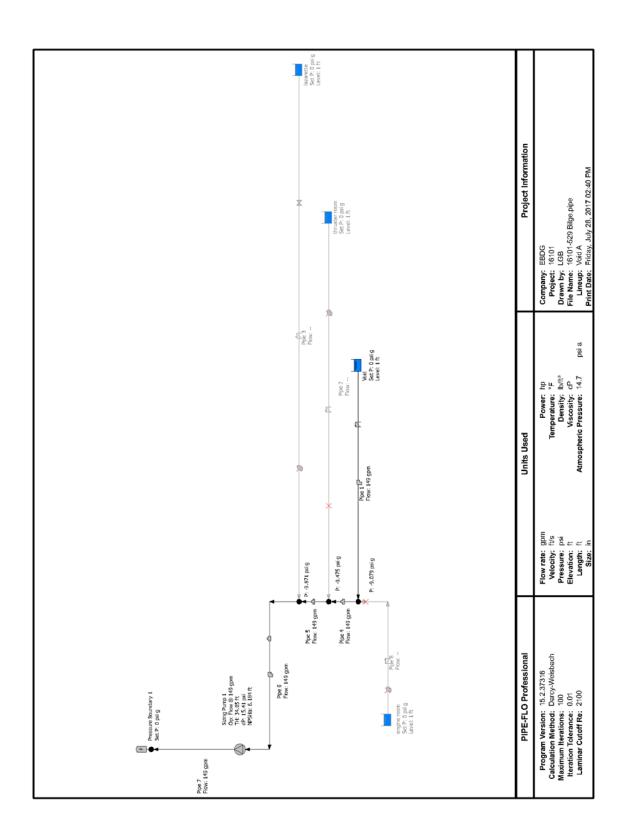
BILGE SYSTEM PIPE-FLO MODEL



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5	LL.	Head	· ·	4.50			4	
ö	20	÷					-	
~	~	÷.						

		l	List Report	l	l		
File Name: 16101-529 Bilge.pipe Lineup: Engine Room Progam Name: PIPE-FLO Professional Version: 15.2.31316		Calculati Lamina May	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Iterations: 100 Percent Tolerance: 0.01		Company: EBDG Project: 16101 by: LGB Date: Friday July 28, 2017 02:44 PM	8. 2017 02:44 PM	
		Allowable	Allowable Deviation: 1 % Bine Specifica	Atmospheric Pressure:	ssure: 14.7 psia	53	
			hecilic	IOIIS			
Specification Name Valve Table	Material Schedule	Absolu Hazen V	Absolute Roughness S Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure	Reynolds Number
Steel A53 sch 80	Steel A53-B36.10	1.80	.u	0.0 Min:	n: ft/s	psig	
standard	Schedule:80		140 Eluid Zono	Max:		psi g	
						l	
Fluid Zone Name Table Name		Temperature Pressure Re	Fluid State Relative Molecular Mass	Density Viscosity	Vapor Critical	Vapor Pressure Specific Critical Pressure Specifi	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Sea Water Seawater 3.5% Salinity		60°F 0psig	Liquid 29	64.04 Ib/ft ³ 1.206 cP	0.251 319	0.2513 psia 3199 psia	
			Sizing Pumps	ps			
Pump Name		Suction Elevation Suction Pressure	on Discharge Elevation re Discharge Pressure	ion Total Head ure dP	Flow Rate	ate NPSHa	
Sizing Pump 1		2.5 ft -9.084 psig	2.5 ft 3.715 psig	28.78 ft 12.8 psi	149 gpm	pm 12.05 ft	
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device er Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Dipe Friction Factor	Inlet Total Pressure Inlet Static Pressure er Inlet Energy Grade stor Inlet Hvdraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hvdraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 1	2 in	Void					
Steel A53 sch 80	1.939 in	4	:	:		:	4.50
Sea Water	3 #	Node 1 2.5 ft			ı		
Pipe 2	2 in	thruster room	:				:
Steel A53 sch 80	1.939 in	3 ft	:	:		•	4.78
Sea Water	30 #	2.5 ft			I		1 1
Pipe 3	2 in	lazarette	:	:			:
Steel A53 sch 80	1.939 in	4 ft	:	:		:	5.47
Sea Water	62 ft	Node 3	I	1	I	:	I
		1 0.7					
Pipe 4	ain ain	Node 1	149 gpm	-6.468 psig	0.396 psi	-6.864 psi g	0.01754
Sidel Abd SCh 8U See Meter	U # 20	Node 7	138204	-12 04 fb	0 8005 1	-1.2 03 A	0.100 ison 1.000
000 1100	-	2.5 ft	0.02008		1 0000.0		0.8567 ft
Pipe 5	3 in	Node 2	149 gpm		0.396 psi	-7.26 psi g	0.01754
Steel A53 sch 80	2.9 in	2.5 ft	7.237 ft/s			-7.622 psig	1.05
Sea Water	0.5 ft	Node 3	138204	-12.93 ft 13 75 6	0.8905 ft	-13.83 ft	0.381 psi
		1 0.7	0007000	11 67.61-		- 14.04 1	11 /000'0
PIPE-FLO Professional	Version: 15.2.37316	7316	List Report		Friday, July 28, 2017 02:44 PM	17 02:44 PM	Page 1

		l	Pipelines		l	l	
Dineline Name	Size	Inlet Device	Flow Rate	Inlet Total Pressure	Total dD	Outlet Total Pressure	1
Pipeline Name Specification Fluid Zone	size Inside Diameter Length	ĒOÕ	Flow Kate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet lotal Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	Outlet lotal Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	e V&F Friction Factor e V&F Resistance K • V&F dP ie V&F Head Loss
Pipe 6 Steel A53 sch 80 Sea Water	3 in 2.9 in 45 ft	Node 3 2.5 ft Sizing Pump 1 2.5 ft	149 gpm 7.237 ft/s 138204 0.02008	-7.26 psig -7.622 psig -13.83 ft -14.64 ft	1.823 psi 4.1 ft	-9.084 psig -9.446 psig -17.92 ft -18.74 ft	0.01754 1.30 0.4699 psi 1.057 ft
Pipe 7 Steel A53 sch 80 Sea Water	3 in 2.9 in 20 ft	Sizing Pump 1 2.5 ft Pressure Boundary 1 0.5.9	149 gpm 7.237 ft/s 138204	3.715 psig 3.353 psig 10.85 ft	3.715 psi 1.352 ft	0 psig -0.362 psig 9.5 ft 8.686 ft	0.01754 0.00 0 psi
Pipe 8 Steel A53 sch 80 Sea Water	2.5 in 2.323 in 20 ft	engine room 0 ft Node 1 2.5 ft	149 gpm 149 gpm 11.28 fts 172532 0.02033 Tanks	0.4447 psig 0.4447 psig -0.4345 psig 1 ft -0.9771 ft	6.913 psi 13.04 ft	-6.468 psig -7.348 psig -12.04 ft -14.02 ft	0.01847 4.50 3.954 psi 8.892 ft
Tank Name Fluid Zone	Bottom Elevation Liquid Level	Surface Pressure Bottom Pressure		Pipeline Name Pen	Connecting Pipelines Penetration Height Pipeline F	low Rate	Pressure at Penetration
Void	 4 #	0 psi g	:	Pipe 1	4 0	:	0.4447 psi g
engine room	0 ft 1 ft	0 psig 0.4447 psig	- t	Pipe 8	0 ft	149 gpm	0.4447 psi g
lazarette Sea Water	4 1 1 1	0 psig	:	Pipe 3	0 ft	:	0.4447 psi g
thruster room Sea Water	3 ft ft	0 psig	: soboli	Pipe 2	ų		0.4447 psi g
Node Name		Ee		Pressure Hydra	Hydraulic Grade		
Node 1		a	2.5 ft -6.468	-6.468 psi g -13	-13.44 ft		
Node 2 Node 3			2.5 ft6.864 2.5 ft -7.26 Pressure Boundaries	psig psig	-13.75 ft -14.64 ft		
Pressure Boundary Name		ă	Elevation Pre	sure	Hydraulic Grade	Flow Rate	
Pressure Boundary 1			9.5 .#	0 psig 8.66	8.686 11	149 gpm	
PIPE-FLO Professional	Version: 15.2.37316	2.37316	List Report		Friday, July 28, 2017 02:44 PM	17 02:44 PM	Page 2



List Report

Specification Name Valve Table S		Allowable E	Percent Tolerance: 0.01 Allowable Deviation: 1 %	Atmospheric Pres	Date: Friday, July 28, 2017 02:46 PM sure: 14.7 psi a	8, 2017 02:46 PM a	
			Pipe Specifications	10			
	Material Schedule	Absolute Hazen Will	Absolute Roughness Sizing Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure	Reynolds Number
Steel A53 sch 80 Standard S	Steel A53-B36.10 Schedule:80	1.800E	1.800E-03 in 0.0 140	Min: Max:	ths files	psi g Dsi g	
			Fluid Zones		l	D and	
Fluid Zone Name Table Name		Temperature Pressure Rela	Fluid State Relative Molecular Mass	Density Viscosity	Vapor F Critical	Vapor Pressure Specific H Critical Pressure Specific	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Sea Water Seawater 3.5% Salinity		60 °F 0 psig	Liquid 29	64.04 lb/f ² 1.206 cP	0.251(319(0.2513 psia 3199 psia	
Pump Name	l	Suction Elevation		Total Head	Flow Rate	ate NPSHa	
Sizing Pump 1		2.5 ft -11.69 psig	urscharge Fressure 2.5 ft 3.715 psig	ar 34.65 ft 15.41 psi	149 gpm	om 6.184	
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device ier Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 1	2 in	Vold	149 anm	0.4447 psi a	9.524 nsi	-9.079 nsi a	0.01928
Sierel A53 sch 80 Sea Water	1.939 in 3 ft	1 ft Node 1 2.5 ft	16.19 ft/s 206700 0.02071	-1.367 psig 2 ft -2.073 ft	19.91 ft	-10.89 psig -17.91 ft -21.99 ft	4.50 8.16 psi 18.35 ft
Pipe 2	2 ii	thruster room				:	:
Steel A53 sch 80	1.939 in	3 ft Mode 3	:	:		:	4.78
oca walei	11 00	2.5 ft			1	: :	
Pipe 3	2 in	lazarette	:	:		:	:
Steel A53 sch 80 Sea Water	1.939 in 62 ft	4 ft Node 3	11	: :	ı	: :	5.47
		2.5 ft				:	
Pipe 4	3 in	Node 1	149 gpm	-9.079 psi g	0.396 psi	-9.475 psig	0.01754
Steel A53 sch 80 Sea Water	2.9 In 0.5 ft	2.5 ft Node 2 2.5 4	7.237 11/s 138204 0.00009	-9.441 psig -17.91 ft 40.72 4	0.8905 ft	-9.837 psig -18.8 ft 40.62 4	1.05 0.381 psi 0.8557 4
			00070	1 0.01-		11 20.01	11 20000
Pipe 5 Steel A53 sch 80	3 in 2.9 in	2.5 ft	149 gpm 7.237 ft/s	-9.475 psig -9.837 psig	0.396 psi	-9.871 psi g -10.23 psi g	0.01754
Sea Water	0.5 ft	Node 3	138204		0.8905 ft	-19.7 ft	0.381 psi
		2.5 11	0.02008	-19.62 ft		-20.51 ft	0.8567 ft

NEW RIVER CLASS FERRY

8/3/17

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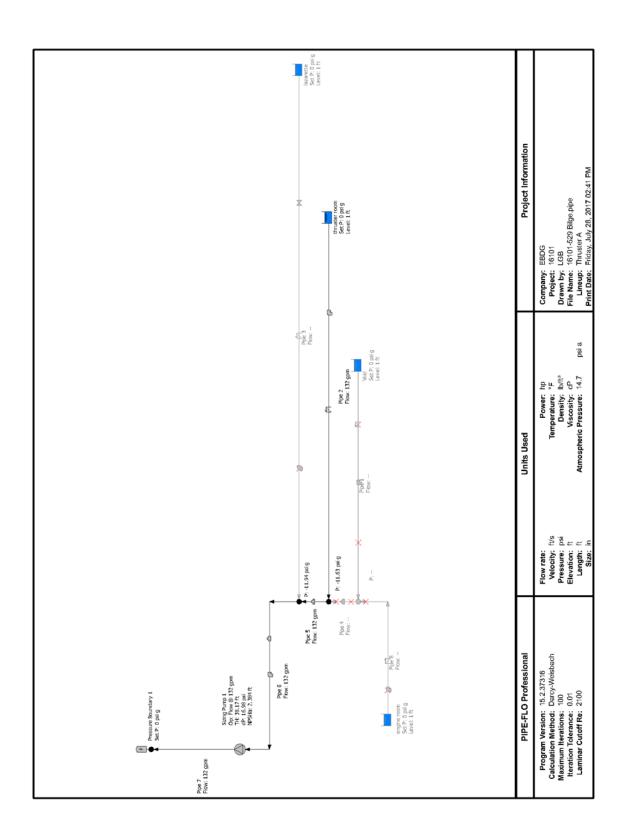
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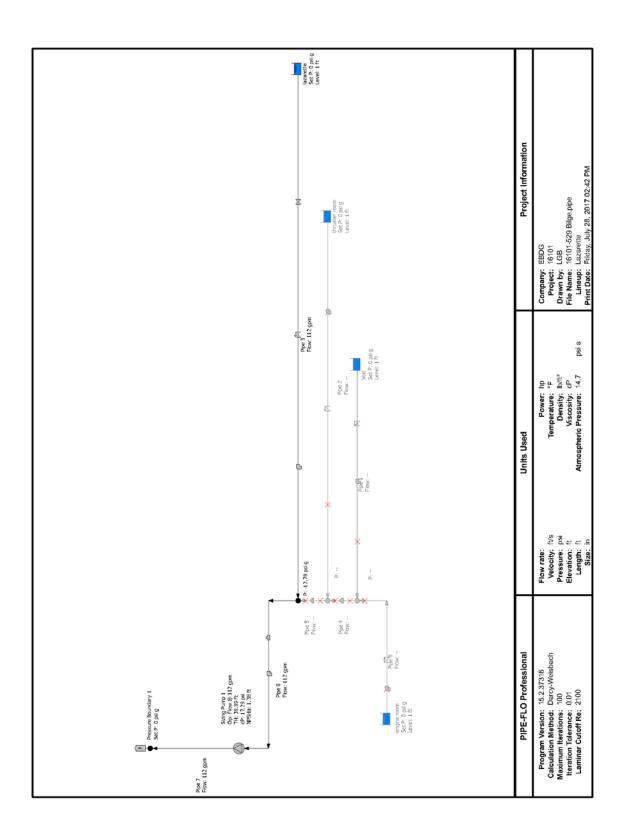
			Pipelines				
Pineline Name	Size	Inlet Device	Flow Rate	Inlet Total Pressure	Total dP	Outlet Total Pressure	V&F Friction Factor
Specification Fluid Zone	Inside Diameter Length	ĒOĞ	Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total	Outliet Static Pressure Outliet Energy Grade Outliet Hydraulic Grade	
Pipe 6 Steel A53 sch 80	3 in 2.9 in	Node 3 2.5 ft	149 gpm 7.237 ft/s	-9.871 psig -10.23 psig	1.823 psi	-11.69 psig -12.06 psig	0.01754
Sea Water	45 ft	Sizing Pump 1 2.5 ft	138204 0.02008	-19.7 ft -20.51 ft	4.1 ft	-23.79 ft -24.61 ft	0.4699 psi 1.057 ft
Pine 7	10	Skine Pumo 1	149 mm	3.715 nei n	3.715 nei	0 neio	0.01754
Steel A53 sch 80	2.9 in	2.5 ft	7.237 ft/s	3.353 psi g		-0.362 psig	0.00
Sea Water	20 ft	Pressure Boundary 1	138204	10.85 ft	1.352 ft	9.5 ft	0 psi
		1 0.0	000770			1 0000	-
Pipe 8	2.50 II	engine room	:	:		:	:
Steel A53 sch 80	2.323 IN 20.6	0 ft Node 1	1	1		:	4.50
269 Malei	11 07	25 ft			ı		
			Tanks				
Tank Name Fluid Zone	Bottom Elevation Liquid Level	Surface Pressure Bottom Pressure	Hydraulic Grade	Pipeline Name Pe	Connecting Pipelines Penetration Height Pipeline F	low Rate	Pressure at Penetration
Void	4 4 4 4	0 psi g 0.4447 psi g	2 ft	- -		046	2000 CAMP 0
				L adi-	1 0	149 gpm	U.4447 psi g
engine room	0 ft 1 ft	0 psig		Ì			
				Pipe 8	0 ft		0.4447 psi g
lazarette Sea Water	44 ft 1 ft	0 psig 	:	Pipe 3	0 ft	:	0.4447 psi g
thruster room	3 ft	0 psig	:				
Sea water		1		Pipe 2	U U		0.4447 psi g
			Nodes				
Node Name		Elev	Elevation Pre	Pressure Hydr	Hydraulic Grade		
Node 1		2	2.5 ft -9.079	-9.079 psi g	-20.36 ft		
Node 2		2	2.5 ft 9.475	-9.475 psi g	-19.62 ft		
Node 3		2	2.5 ft9.871	-9.871 psi g	-20.51 ft		
			Pressure Boundaries	38			
Pressure Boundary Name		Ele	Elevation Pre	Pressure Hydr	Hydraulic Grade	Flow Rate	
Pressure Boundary 1		σ	9.5 /t	0 psig	8.686 ft	149 gpm	
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By:	LGB
Page:	I-13

				List Report					
File Name: 16:101-559 Bilge pipe Lineup: Thruster A Progem Name: PIPE-FLO Professional Version: 15.2.37316		Calcul Lami Perc Allowa	Calculation Method: Darroy Laminar Cutoff Re: 2100 Max Iterations: 100 Percent Tolerance: 0.01 Allowable Deviation: 1 ?	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Iterations: 100 Percent Tolerance: 0.01 Mowable Deviation: 1 % Dipo Shacifications	Corr Pr Atmospheric Pre:	Company: EBDG Project: 16101 by: LGB Date: Friday, July 28, 2017 02:47 PM Pressure: 14.7 psia	ly 28, 2017 02:4 [:] psi a	Md 2	
Specification Name Valve Table	Material Schedule	Abs	Absolute Roughness Hazen Williams C Factor		Sizing Criteria	Velocity		Design Limits Pressure	Revnolds Number
Steel A53 sch 80 standard	Steel A53-B36.10 Schedule:80	-	1.800E-03 in 140	0.0	Min: Max:			psi g psi g	
				Fluid Zones					
Fluid Zone Name Table Name		Temperature Pressure	Fluid State Relative Molecular Mass	tate ecular Mass	Density Viscosity	Vap Criti	Vapor Pressure Critical Pressure	Specific H Specific	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Sea Water Seawater 3.5% Salinity		60 °F 0 psig	Liquid 29	Sizina Dumbe	64.04 lb/ft ² 1.206 cP	00	0.2513 psia 3199 psia		
Pump Name		Suction Elevation Suction Pressure		Discharge Elevation	Total Head dP	Flow	Flow Rate	NPSHa	
Sizing Pump 1		2.5 ft -13.38 psig		2.5 ft 3.591 psig Pipelines	38.17 ft 16.98 psi	132	udő :	2.384 ft	
Pipeline Name	Size	Inlet Device		Flow Rate	Inlet Total Pressure	Total dP	Outlet To	Outlet Total Pressure	V&F Friction Factor
Specification Fluid Zone	Inside Diameter Length	er Inlet Elevation Outlet Device Outlet Elevation		Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	-	Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Resistance K V&F dP V&F Head Loss
Pipe 1	2 in	Void		1	:	ı			1
Steel A53 sch 80 Sea Water	1.939 in 3 ft	1 ft Node 1		: •	: 1	·			4.50
		2.5 ft						:	
Pipe 2 Steel A53 sch 80 Som Mitter	2 in 1.939 in 30 #	thruster room 3 ft Norie 3		132 gpm 14.34 ft/s 143117	0.4447 psig -0.9769 psig 4 fr	12.07 psi	-11.63 -13.05 -73.65		0.01928 4.78 6.799 pei
000 11010	1 00	2.5 ft		0.02087	0.8035 ft	11 00:17	9 89 9	-26.84 ft	15.26 ft
Pipe 3	2 in	lazarette		:	:	1		:	:
Steel A53 sch 80	1.939 in	4 4		;	;			;	5.47
Sea Water	11 29	2.5 ft			: :	1			: 1
Pipe 4	3in	Node 1		:	:				:
Steel A53 sch 80	2.9 in	2.5 ft		;	:			;	1.05
Sea Water	0.5 ft	Node 2 2.5 ft			: :	ı			
Dine 5	e.	Node 2		132 Anm	-11 63 nei n	0.311 nei	1	-11 04 nei n	0.01754
Steel A53 sch 80	2.9 in	2.5 ft		6.412 ft/s	-11.91 Dsid		-12.22	22 DSig	1.05
Sea Water	0.5 ft	Node 3		122436	-23.65 ft	0.6992 ft	-24	-24.35 ft	0.299 psi
		2.5 ft		0.02033	-24.29 ft		-24	-24.99 ft	0.6723 ft
PIPE-FLO Professional	Version: 15.2.37316	37316	_	List Report		Friday, July 28, 2017 02:47 PM	2017 02:47 PM		Page 1
						i			

			Pipelines		l		
Discline Name	Sire	Inlet Device	Elour Data	Inlet Total Braceura	Total AD	Outlet Total Braceuro	V&E Eriction Eactor
Pipeline Name Specification Fluid Zone	size Inside Diameter Length	ter Inlet Elevation Outlet Elevation Outlet Elevation	Flow Kate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet lotal Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	
Pipe 6 Steel A53 sch 80 Sea Water	3 in 2.9 in 45 ft	Node 3 2.5 ft Sizing Pump 1 2.5 ft	132 gpm 6.412 ft/s 122436 0.02033	-11.94 psig -12.22 psig -24.99 ft	1.444 psi 3.248 ft	-13.38 psig -13.67 psig -27.6 ft -28.23 ft	0.01754 1.30 0.3688 psi 0.8292 ft
Pipe 7 Steel A 53 sch 80 Sea Water	3 in 2.9 in 20 ft	Stzing Pump 1 2.5 ft Pressure Boundary 1 0.5.0	132 gpm 6.412 ft/s 122436 0.02033	3.591 psig 3.307 psig 10.57 ft 0.38 ft	3.591 psi 1.075 ft	0 psig -0.2841 psig 9.5 ft 8.861 ft	0.01754 0.00 0 psi
Pipe 8 Steel A53 sch 80 Sea Water	2.5 in 2.323 in 20 ft	enghe room 0 ft Node 1 2.5 ft		-			4.50
Tank Name Fluid Zone	Bottom Elevation	Surface Pressure H Bottom Pressure		Pipeline Name Pen	Connecting Pipelines Penetration Height Pipeline F	low Rate	Pressure at Penetration
Void	1 ft 1 ft	0 psi g 	:	Pipe 1	ų U	:	0.4447 psi g
engine room	0 ft 1 ft	0 psig	:	Pipe 8	0 ft	:	0.4447 psi g
lazarette Sea Water	4 1 1 1 1	0 psig	:	Pipe 3	0 ft	:	0.4447 psi g
thruster room Sea Water	α 4 4	0 psig 0.4447 psig	4 ft Nodes	Pipe 2	4 0	132 gpm	0.4447 psi g
Node Name		Elevation		Pressure Hydra	Hydraulic Grade		
Node 1		2.5	ft				
Node 2 Node 3		2.5	ft ft Pressure Bour	osi g osi g	-25.57 ft -24.99 ft		
Pressure Boundary Name		Elev	Elevation Pre	aure	Hydraulic Grade	Flow Rate	
Pressure Boundary 1		4. 0	5.5 ft ft 0	0 psi g	8.861 11	132 gpm	
PIPE-FLO Professional	Version: 15.2.37316	37316	List Report		Friday, July 28, 2017 02:47 PM	17 02:47 PM	Page 2



		l	I	List Report		l	_		
Fije Name: 16101-529 Bilge.pipe Lineup: Lazarette Progam Name: PIPE-FLO Professional Version: 15.2.37316		Calcu Lam Perc	alculation Method: Darc Laminar Cutoff Re: 2100 Max Iterations: 100 Percent Tolerance: 0.01 Ilowable Deviation: 1	M- ~ %	Com Pr Atmospheric Pres	Fid EBC	0G 01 33, July 28, 2017 0: 14.7 psi a	2:47 PM	
Specification Name	Material	ä	Pipe S Absolute Roughness	pecific	ations Šizing Criteria	l	l	Design Limits	l
Valve Table	Schedule	Haze	Hazen Williams C Factor			Velocity	Į,	Pressure	Reynolds Number
Steel A53 sch 80 standard	Steel A53-B36.10 Schedule:80		1.800E-03 in 140	in 0.0	Min: Max:		ft/s ft/s	psi g psi g	
				Fluid Zones					
Fluid Zone Name Table Name		Temperature Pressure	Flui Relative N	Fluid State Relative Molecular Mass	Density Viscosity	≈ 2	Vapor Pressure Critical Pressure		Specific Heat Capacity (cp) Specific Heat Ratio (k)
Sea Water Seawater 3.5% Salinity		60°F 0 psig	Ľ	Liquid 29	64.04 lb/ft ^a 1.206 cP		0.2513 psia 3199 psia		
			l	Sizing Pumps			l		
Pump Name		Suction Elevation Suction Pressure	ation ssure	Discharge Elevation Discharge Pressure	Total Head dP	Flo	Flow Rate	NPSHa	
Sizing Pump 1		2.5 ft -13.83 psig	D	2.5 ft 3.464 psig Pipelines	38.89 ft 17.29 psi	£	112 gpm	1.38 ft	
Pipeline Name	Size		ce	Flow Rate	Inlet Total Pressure	Total dP	Outlet	Outlet Total Pressure	V&F Friction Factor
Specification Fluid Zone	Inside Diameter Length	er Inlet Elevation Outlet Device Outlet Elevation	tion tice	Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	-	Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Resistance K V&F dP V&F Head Loss
Pipe 1	2 in	Vold			:				:
Steel A53 sch 80	1.939 in			;	:			;	4.50
Sea Water	3 #	2.5 ft							
Pipe 2	2 in	thruster room	_						
Steel A53 sch 80	1.939 in	3 ft		:	•			;	4.78
Sea Water	30 ft	2.5 ft			: :	1		: :	1 1
Dine 3	ci c	la zarette		112 anm	0.4447 nei n	13.22 nei		12 78 nei n	0.010.08
Steel A53 sch 80	1.939 in	4		12.17 ft/s	-0.5787 DSi g			-13.8 Dsig	5.47
Sea Water	62 ft	Node 3		155372 0.02444	5 ft 2 2 600 ft	31.23 ft		-26.23 ft -26.23 ft	5.598 psi 12.50 ft
Dine 4	e e	Node 1				'			
Steel A53 sch 80	2.9 in	2.5 ft		:	;			;	1.05
Sea Water	0.5 ft	Node 2			:	1		;	1
		2.5 ft		;	:			;	;
Pipe 5	3 in	Node 2		ı	;	,		;	1
Steel A53 sch 80 See Weier	2.9 in 0.5 ft	2.5 ft Node 3			:	1			1.05
OCG MAGICI	1 0.0	4 4 6				ı			
		-							
PIPE-FLO Professional	Version: 15.2.37316	37316		List Report		Friday, July 28, 2017 02:47 PM	i, 2017 02:47 F	W	Page 1

			Pipelines		l		
Pipeline Name	Size	Inlet Device	Flow Rate	Inlet Total Pressure	Total dP	Outlet Total Pressure	V&F Friction Factor
Specification Fluid Zone	Inside Diameter Length	ĒĢģ	FI Rey Pipe	Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total Head Loss	Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	
Pipe 6	3 in	Node 3	112 gpm	-12.78 psig	1.054 psi	-13.83 psig	0.01754
Steel A53 sch 80	2.9 in	2.5 ft	5.44 ft/s	-12.98 psig		-14.04 psi g	1.30
Sea Water	45 11	Sizing Pump 1 2.5 ft	103885 0.02071	-26.23 ft -26.69 ft	2.371 ft	-28.6 ft -29.06 ft	0.2655 psi 0.597 ft
0100 J	e	Cising Dump 4	110 mm	o las hat p	ion MAK P	o aoi o	0.04764
Steel A53 sch 80	110 110	2.5 ft	5.44 #/s	3.259 Dailo	ind tota	-0.2045 nsi o	000
Sea Water	20 ft	Pressure Boundary 1	103885	10.29 ft	0.7884 ft	9.5 ft	0 psi
		9.5 ft	0.02071	9.828 ft		9.04 ft	0 ft
Pipe 8	2.5 in	engine room		:	1		:
Steel A53 sch 80	2.323 in	0 #	:			:	4.50
Sea Water	20 ft	Node 1		:	ı	:	1
		2.5 ft		:		:	
			Tanks				
Tank Name Fluid Zone	Bottom Elevation	Surface Pressure Bottom Pressure	Hydraulic Grade	Pineline Name Pen	Connecting Pipelines	Iow Rate	Pressure at Penetration
Allon Tollin			-			- 1	
Void	t t	0 psig					
				Pipe 1	0 ft		0.4447 psi g
engine room	0 ft	0 psig	:				
		1		Pipe 8	0 ft	ı	0.4447 psi g
lazarette		0 psig	5 ft				
Sea Water	1 ft	0.4447 psi g		Pipe 3	0 ft	112 gpm	0.4447 psi g
thruster room	3 ft	0 psig					
sea water		1		Pipe 2	1 O		0.4447 psi a
			Nodes				
Node Name		Ele	Elevation Pre	Pressure Hydra	Hydraulic Grade		
Node 1			2.5 ft				
Node 2			2.5 ft				
Node 3			2.5 ft -12.78	-12.78 psi g	-27.61 ft		
			Pressure Boul	,			
Pressure Boundary Name		Ξ	Elevation Pre	Pressure Hydra	Hydraulic Grade	Flow Rate	
Pressure Boundary 1			9.5 ft 0	0 psig 9.	9.04 ft	112 gpm	
PIPE-FLO Professional	Version: 15.2.37316	2.37316	List Report		Fridav July 28, 2017 02:47 PM	17 02:47 PM	Page 2
							9

		Bill of Materials Re	eport		
Lineup: Program Name:	16101-529 Bilge.pipe Engine Room PIPE-FLO Professional		Company: Project: by:	16101 LGB	47 00 40 PM
Version:	15.2.37316	Sizing Pump		Friday, July 28, 20	17 02:43 PM
Sizing Pump Na	me	j ·j			Jesign Point
Operation				Flow Rate	Total Head
Sizing Pump 1 Flow @ 149 g	pm	Teele		149 gpm	28.78 ft
Tank Name		Tanks			
Void					
engine room					
lazarette					
thruster room					
		Pipelines			
Pipeline	Specification	Size	Length	Valves and	d Fittings
Pipe 1	Steel A53 sch 80	2 in	3 ft	1 x Stop Cl	- Long radius, r/d 1.5 (90°) heck - Angled ar - Enlargement (2 in x 3 in - 3.5 in)
Pipe 2	Steel A53 sch 80	2 in	30 ft	3 x Elbow	heck - Angled - Long radius, r/d 1.5 (90°) r - Enlargement (2 in x 3 in - 3.5 in)
Pipe 3	Steel A53 sch 80	2 in	62 ft	1 x Gate - 5 x Elbow -	heck - Angled Wedge Disc - Long radius, r/d 1.5 (90*) er - Enlargement (2 in x 3 in - 3.5 in)
Pipe 4	Steel A53 sch 80	3 in	0.5 ft	1 x Tee - F	low Thru Branch
Pipe 5	Steel A53 sch 80	3 in	0.5 ft	1 x Tee - F	low Thru Branch
Pipe 6	Steel A53 sch 80	3 in	45 ft		Long radius, r/d 1.5 (90°) 3 Iow Thru Branch
Pipe 7	Steel A53 sch 80	3 in	20 ft		
Pipe 8	Steel A53 sch 80	2.5 in	20 ft	3 x Elbow -	heck - Angled - Long radius, r/d 1.5 (90°) ar - Enlargement (2.5 in x 3 in - 3.5 in)
		Pipeline Material S	ummary		
Specification	Material	Size	Total Length	Valves & Fit	tings
Steel A53 sch 80	Steel A53-B36.10 Schedule: 80	2 in	95.00 ft	1 x Gate - W	- Enlargement (2 in x 3 in - 3.5 in)
Steel A53 sch 80	Steel A53-B36.10 Schedule: 80	2.5 in	20.00 ft		ong radius, r/d 1.5 (90°) - Enlargement (2.5 in x 3 in - 3.5 in) eck - Angled
Steel A53 sch 80	Steel A53-B36.10 Schedule: 80	3 in	66.00 ft		ong radius, r/d 1.5 (90°) w Thru Branch

PIPE-FLO Professional

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Bill of Materials Report

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Appendix J

Ballast System, Dwg. 16101-200-529-1

1 DESCRIPTION

This appendix documents the calculations used in designing the ballast piping system. These calculations establish ballast pipe sizes and required pump capacity based upon a desired ballast loading and unloading rate. Estimated losses through the ballast system are calculated to establish the total dynamic head (TDH) and net positive suction head (NPSH) requirements for the bilge pump.

2 PROCEDURE

Calculations are presented in the following sequence:

- Ballast pipe nominal velocity calculations
- Ballast pump TDH and NPSH calculation

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

- Ballast system is to be constructed of copper nickel class 200.
- Piping system lengths, routing, fittings, etc. are estimated based on the Profiles and Arrangements, and Bilge and Ballast System Schematic [2] [3].
- The fluid medium is seawater with the following properties:

Specific weight	64.00 lb/cu ft
Dynamic viscosity	2.51E-5 lb-s/sq ft
Temperature	60 °F
Vapor pressure	0.26 psia

• The following elevations above baseline are assumed for the system calculation

Waterline	4.5 ft
Overboard Discharge	9.5 ft
Pump inlet/outlet	2.5 ft
Tank Suction/Discharge	2.0 ft

- Desired ballast loading rate is 400 gpm split between two pumps. To calculate the worst case loading condition, the ballast tanks are approaching full capacity.
- Desired ballast unloading rate is 400 gpm split between two pumps. To calculate the worst case unloading condition, the ballast tanks are approaching empty.
- Desired ballast trimming rate is 200 gpm with one pump. To calculate the worst case trimming condition, the source tank is approaching empty and the destination tank is approaching full capacity.

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Ballast Pipe Size and Nominal Velocity Calculation

Pipe sizes are based on the nominal velocity limits found in Marine Engineering, Chapter 20, Table 3, [3]. The following table shows the flow rates of sea water occurring in the system, and the resulting pipe sizes.

Pipe Segment	Flow Rate	Pipe Size	ID	Design Ve	locity (ft/s)	V
	gpm	(NPS)	in	Nominal	Limit	ft/s
Ballast Pump Suction (1 pump)	200	4" CL 200 CUNI	4.282	6.21	12.00	4.34
Ballast Pump Discharge (1 pump)	200	4" CL 200 CUNI	4.282	10.35	12.00	4.34
Ballast Loading (1 tank)	100	3" CL 200 CUNI	3.310	9.10	12.00	3.63
Ballast Unloading (1 tank)	100	3" CL 200 CUNI	3.310	5.46	12.00	3.63
Ballast Main Suction (2 pumps)	400	4" CL 200 CUNI	4.282	6.21	12.00	8.68
Ballast Main Discharge (2 pumps)	400	4" CL 200 CUNI	4.282	10.35	12.00	8.68

Table 5-1: Nominal Pipe Velocity

5.2 Ballast Pump TDH and NPSH Calculations

Three different conditions are considered in the attached system model.

- Loading ballast water with 2 pumps in operation
- Unloading ballast water with 2 pumps in operation
- Trimming ballast water with 1 pump in operation

For loading ballast water, the enclosed system model predicts that each ballast pump is required to produce 13.4 feet H2O TDH at the required flowrate of 200 gpm. Calculated NPSH available for each ballast pump in this condition is approximately 32 feet H2O.

For unloading ballast water, the enclosed system model predicts that each ballast pump is required to produce 17 feet H2O TDH at the required flowrate of 200 gpm. Calculated NPSH available for each ballast pump in this condition is approximately 28 feet H2O.

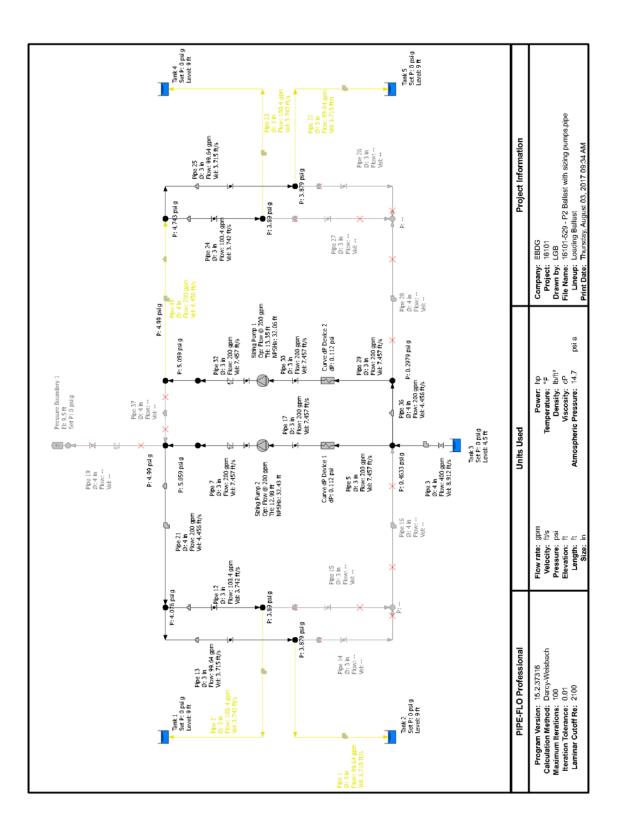
For trimming ballast water from one end to the other, the enclosed system model predicts that the ballast pump is required to produce 17.3 feet H2O TDH at the required flowrate of 200 gpm. Calculated NPSH available for the ballast pump in this condition is approximately 28 feet H2O.

The Ballast pumps are selected for 200 gpm at 20 feet H2O TDH.

6 REFERENCES

- [1] USCG, "46 CFR, Chapter I, Subchapter F, 56.50-50," 7/21/2017.
- [2] Elliott Bay Design Group, "NCDOT New River Class Ferry: Profiles and Arrangements," 16101-200-101-1, Seattle, WA.
- [3] Elliott Bay Design Group, "NCDOT New River Class Ferry: Bilge and Ballast System Schematic," 16101-200-529-1, Seattle, WA.
- [4] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.

BALLAST SYSTEM PIPE-FLO MODEL



EBDG - NC, PLLC
16101-200-505-1

1 :04

			List Report				
File Name: 16:101-559 - P2 Ballast with sizing pumps.pipe Lineup: Loading Ballast Progen Name: PIPE-FLO Professional Version: 15.2.37316	vith sizing pumps. pipe	Calculation Method: Da Laminar Cutoff Re: 21 Max Iterations: 10 Percent Tolerance: 0.0 Allowable Deviation: 1	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max teretions: 100 Percent Tolerance: 0.01 Mowable Deviation: 1 %	Atmospheric	Company: EBDG Project: 16101 by: LGB Date: Thursday, Augu Pressure: 14.7 psi a	pany: EBDG oject: 16101 by: LGB me: Thursday, August 03, 2017 09:34 AM ssure: 14.7 psia	
			Pipe Specification	c.			
Specification Name	Material Soboduto	Absolute Roughness		Sizing Criteria	Valacity	Design Limits	Demolds Mumber
Valve lable	screaue		TIS C FACTOF		velocity	LISSALE	Reymolds Number
Copper Nickel Class 200 standard	Copper Nickel MIL-T-16420K Schedule:Class 200		6E-05 in 0.0 150	M	Min: ft/s Max: ft/s	psig psig	
			Fluid Zones				
Fluid Zone Name Table Name	Temperature		Fluid State Relative Molecular Mass	Density Viscosity	Vapor Critica	Vapor Pressure Specific Critical Pressure Speci	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Sea Water Seawater 3.5% Salinity	60 °F 0 psi		Liquid 29	64.04 lb/ft ³ 1.206 cP	0.25		
			Sizing Pumps				
Pump Name	ŝ	Suction Elevation Suction Pressure	Discharge Elevation Discharge Pressure	Total Head dP	Flow Rate	Rate NPSHa	
Sizing Pump 1	0-	2.5 ft -0.1885 psig	2.5 ft 5.749 psig	13.35 ft 5.937 psi	200 gpm	gpm 32.06 ft	
Sizing Pump 2).0-	2.5 ft -0.02309 psig	2.5 ft 5.749 psig Pibolinos	12.98 ft 5.772 psi	200 9	gpm 32.43 ft	
			ripellites				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Ir Length O	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP • V&F Head Loss
Pipe 1	3 in	Tank 2	99.64 gpm	3.879 psi g	-0.1234 psi	4.003 psi g	0.01702
Copper Nickel Class 200	3.31 in	2 ft	3.715 ft/s	3.784 psig		3.907 psig	2.21
Sea Water	85 ft	Node 1 4 ft	80970 0.01889	12.72 ft 12.51 ft	1.723 ft	11 ft 10.79 ft	0.2108 psi 0.4739 ft
Messages: Reversed flow							
Pipe 12	3 in	Node 7	100.4 gpm	4.076 psi g	0.1862 psi	psi	0.01702
Copper Nickel Class 200	3.31 in	4	3.742 ft/s	3.979 psig			1.79
Sea Water	2 ft	Node 2 4 ft	81561 0.01887	13.16 ft 12.95 ft	0.4186 ft	12.75 ft 12.53 ft	0.1729 psi 0.3889 ft
Pipe 13	3 in	Node 7	99.64 gpm	4.076 psi g	0.1966 psi	3.879 psig	0.01702
Copper Nickel Class 200	3.31 in	4	3.715 ft/s	3.98 psig		psi	1.79
Sea Water	4 ft	Node 1 4 ft	80970 0.01889	13.16 ft 12.95 ft	0.442 ft	12.72 ft 12.51 ft	0.1704 psi 0.3832 ft
Pipe 14	3 in	Node 1	:	:			:
Copper Nickel Class 200	3.31 in	4		:		:	1.79
Sea Water	4 ft	Node 8		:	ı	:	ı
		11 11		:		:	ı
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		l	Pipelines		l		
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 15 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Node 2 Node 8 A ft					1.79
Pipe 16 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Node 8 4 ft Node 4 2.5 ft			1 1		0.45
Pipe 17 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Curve dP Device 1 2.5 ft Sking Pump 2 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	0.317 psig -0.06732 psig 3.213 ft 2.349 ft	0.3401 psi 0.7647 ft	-0.02309 psig -0.4074 psig 2.448 ft 1.584 ft	0.01702 0.77 0.2943 psi 0.6618 ft
Pipe 19 Copper Nickel Class 200 Sea Water	4 in 4.282 in 15 ft	Node 5 2.5 ft Pressure Boundary 1 9.5 ft				1111	2.53
Pipe 2 Copper Nickel Class 200 Sea Water Messages: Reversed flow	3 31 in 3.31 in 85 ft	Taink 1 2 ft Node 2 4 ft	100.4 gpm 3.742 ft/s 81561 0.01887	3.89 psig 3.793 psig 12.55 ft 12.53 ft	-0.113 psi 1.746 ft	4.003 psig 3.906 psig 11 ft 10.78 ft	0.01702 2.21 0.2138 psi 0.4808 ft
Pipe 20 Copper Nickel Class 200 Sea Water	3 in 3.31 in 3 ft	Sizing Valve 5 2.5 ft Node 5 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	5.059 psig 4.674 psig 13.87 ft 13.01 ft	0.06864 psi 0.1543 ft	4.99 psig 4.606 psig 13.72 ft 12.86 ft	0.01702 0.00 0 psi 0 ft
Pipe 21 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Node 5 2.5 ft Node 7 4 ft	200 gpm 4.456 fus 125637 0.01725	4.99 psig 4.853 psig 13.72 ft 13.41 ft	0.9142 psi 0.5556 ft	4.076 psig 3.939 psig 13.16 ft 12.86 ft	0.01607 1.41 0.194 psi 0.4363 ft
Pipe 22 Copper Nickel Class 200 Sea Wäter Messanes: Reversed flow	3 in 3.31 in 85 ft	Tank 5 2 ft Node 9 4 ft	99.64 gpm 3.715 ft/s 80970 0.01889	3.879 psig 3.784 psig 12.72 ft 12.51 ft	-0.1234 psi 1.723 ft	4.003 psig 3.907 psig 11 ft 10.79 ft	0.01702 2.21 0.2108 psi 0.4739 ft
Pipe 23 Copper Nickel Class 200 Sea Water Messages: Reversed flow	3.1 in 3.31 in 85 ft	Tank 4 2 ft Node 10 4 ft	100.4 gpm 3.742 ft/s 81561 0.01887	3.89 psig 3.793 psig 12.53 ft 12.53 ft	-0.113 psi 1.746 ft	4.003 psig 3.906 psig 11 ft 10.78 ft	0.01702 2.21 0.2138 psi 0.4808 ft
Pipe 24 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Sizing Valve 8 2.5 ft Node 10 4 ft	100.4 gpm 3.742 ft/s 81561 0.01887	4.743 psig 4.646 psig 13.16 ft 12.95 ft	0.8533 psi 0.4186 ft	3.89 psig 3.793 psig 12.75 ft 12.53 ft	0.01702 1.79 0.1729 psi 0.3889 ft
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NEW RIVER CLASS FERRY

Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 25 Copper Nickel Class 200 Sea Water	3 in 3.31 in 4 ft	Sizing Valve 8 2.5 ft Node 9 4 ft	99.64 gpm 3.715 ft/s 80970 0.01889	4.743 psig 4.648 psig 13.16 ft 12.95 ft	0.8637 psi 0.442 ft	3.879 psig 3.784 psig 12.72 ft 12.51 ft	0.01702 1.79 0.1704 psi 0.3832 ft
Pipe 26 Copper Nickel Class 200 Sea Water	3.31 in 4 ft	Node 9 4 ft Node 11 2.5 ft					1.79
Pipe 27 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	2.5 ft			1 1		1.1.1
Pipe 28 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Node 15 2.5 ft Node 11 2.5 ft			1 1		0.45
Pipe 29 Copper Nickel Class 200 Sea Water	3 in 3.31 in 1.5 ft	Node 15 2.5 ft Curve dP Device 2 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	0.2979 psig -0.08645 psig 3.17 ft 2.306 ft	0.03432 psi 0.07717 ft	0.2636 psig -0.1208 psig 3.093 ft 2.228 ft	0.01702 0.00 0 psi 0 ft
Pipe 3 Copper Nickel Class 200 Sea Water	4 in 4.282 in 10 ft	Tank 3 0 ft Node 4 2.5 ft	400 gpm 8.912 ft/s 251273 0.01509	2.001 psig 1.452 psig 4.5 ft 3.266 ft	1.538 psi 0.9582 ft	0.4633 psi g -0.08556 psi g 3.542 ft 2.308 ft	0.01607 0.35 0.194 psi 0.4363 ft
Pipe 30 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Curve dP Device 2 2.5 ft Stering Pump 1 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	0.1516 psig -0.2328 psig 2.841 ft 1.977 ft	0.3401 psi 0.7647 ft	-0.1885 psig -0.5729 psig 2.076 ft 1.212 ft	0.01702 0.77 0.2943 psi 0.6618 ft
Pipe 32 Copper Nickel Class 200 Sea Water	3.31 in 3.1 in 3.1	Sizing Pump 1 2.5 ft Sizing Valve 7 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	5.749 psig 5.364 psig 15.43 ft 14.56 ft	0.69 psi 1.551 ft	5.059 psig 4.674 psig 13.87 ft 13.01 ft	0.01702 1.62 0.6213 psi 1.397 ft
Pipe 33 Copper Nickel Class 200 Sea Water	3 in 3.31 in 3 ft	Sizing Valve 7 2.5 ft Node 16 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	5.059 psig 4.674 psig 13.87 ft 13.01 ft	0.06864 psi 0.1543 ft	4.99 psig 4.606 psig 13.72 ft 12.86 ft	0.01702 0.00 0 psi 0 ft
Pipe 35 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Sizing Valve 8 2.5 ft Node 16 2.5 ft	200 gpm 4.456 ft/s 125637 0.01725	4.99 psig 4.853 psig 13.72 ft 13.41 ft	0.2471 psi 0.5556 ft	4.743 psig 4.606 psig 13.16 ft 12.86 ft	0.01607 1.41 0.194 psi 0.4363 ft
messages: reversed now Pipe 36 Copper Nickel Class 200 Sea Water PIPE-FLO Professional	4 in 4.282 in 5 ft Version: 15,2.37316	Node 4 2.5 ft Node 15 2.5 ft	200 gpm 4.456 ft/s 125637 0.01725 List Report	0.4633 psig 0.3261 psig 3.542 ft 3.233 ft 7 1	0.1654 psi 0.2979 0.1607 0.372 ft 3.17 2.817 Thursday, August 03, 2017 09:34 AM	0.2979 psig 0.1607 psig 3.17 ft 2.811 ft 2017 09:34 AM	0.01607 0.96 0.1323 psi 0.2974 ft Page 3

Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	e Total dP re Total Head Loss ade	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	 V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 37 Copper Nickel Class 200 Sea Water	4.282 in 5 ft	Node 16 2.5 ft Node 5 2.5 ft			1 1		: 0 96: 1 1
Pipe 5 Copper Nickel Class 200 Sea Water	3 in 3.31 in 1.5 ft	2.5 ft Curve dP Device 1 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	0.4633 psig 0.079 psig 3.542 ft 2.678 ft	0.03432 psi 0.07717 ft	0.429 psig 0.04468 psig 3.465 ft 2.6.5 ft	0.01702 0.00 0 psi
Pipe 7 Copper Nickel Class 200 Sea Watter	3 in 3.31 in 3 ft	2.5.1 li Steing Pump 2 2.5 ft 2.5 ft 2.5 ft	200 9pm 200 9pm 7.457 ft/s 162530 0.01642 Tanks	5.749 psig 5.364 psig 15.43 ft 14.56 ft	0.69 psi 1.551 ft	5.059 psig 4.574 psig 13.87 ft 13.01 ft	0.01702 1.62 0.6213 psi 1.397 ft
Tank Name Fluid Zone	Bottom Elevation Su Liquid Level Bo	Surface Pressure H	Hydraulic Grade	Pipeline Name	Connectin Penetration Height	Connecting Pipelines Height Pipeline Flow Rate F	Pressure at Penetration
Tank 1	2 ft 9 ft	0 psi g 4.003 psi g	11 ft	Pipe 2	ų 6	100.4 gpm	4.003 psi g
Tank 2	2 ft 9 ft	0 psig 4.003 psig	11 ft	Pipe 1	0 ft	99.64 gpm	4.003 psi g
Tank 3	0 ft 4.5 ft	0 psig 2.001 psig	4.5 ft	Pipe 3	0 ft	400 gpm	2.001 psi g
Tank 4	2 ft 9 ft	0 psig 4.003 psig	11 ft	Pipe 23	<i>ਜ</i> 0	100.4 gpm	4.003 psi g
Tank 5	2 ft 9 ft	0 psig 4.003 psig	11 ft Create do Devise	Pipe 22	υų	99.64 gpm	4.003 psi g
Curve dP Device Name Description	Inlet Elevation Inlet Pressure		Curve or Devices Outlet Elevation Outlet Pressure	dP Head Loss	Flow Rate		
Curve dP Device 1 Eaton model 72	2.5 ft 0.429 psig	2.5 ft 0.317 psi g	ft psi g	0.112 psi 0.2518 ft	200 gpm		
Curve dP Device 2 Eaton model 72	2.5 ft 0.2636 psig	2.5 ft 0.1516 psi	0	0.112 psi 0.2518 ft	200 gpm		
Node Name		Elevation	Nodes	Pressure H	Hydraulic Grade		
Node 1		4	ft	3.879 psi g	12.51 ft		
Node 10		4	ft	3.89 psi g	12.53 ft		
Node 11			2.5 ft				
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NCDOT

	Nor	Nodes		
Node Name	Elevation	Pressure	Hydraulic Grade	
Node 15	2.5 ft	0.2979 psig	2.583 ft	
Node 16	2.5 ft	4.99 psi g	13.13 ft	
Node 2	4 ft	3.89 psig	12.53 ft	
Node 4	2.5 ft	0.4633 psi g	2.739 ft	
Node 5	2.5 ft	4.99 psig	13.13 ft	
Node 7	4 ft	4.076 psi g	12.92 ft	
Node 8	4 ft			
Node 9	4 ft	3.879 psi g	12.51 ft	
Sizing Valve 5	2.5 ft	5.059 psi g	13.01 ft	
Sizing Valve 7	2.5 ft	5.059 psi g	13.01 ft	
Sizing Valve 8	2.5 ft	4.743 psi g	12.92 ft	
	Pressure E	Pressure Boundaries		
Pressure Boundary Name	Elevation	Pressure	Hydraulic Grade	Flow Rate
Pressure Boundary 1	9.5 ft	0 psig	:	:

By:	LGB
Page:	J-10

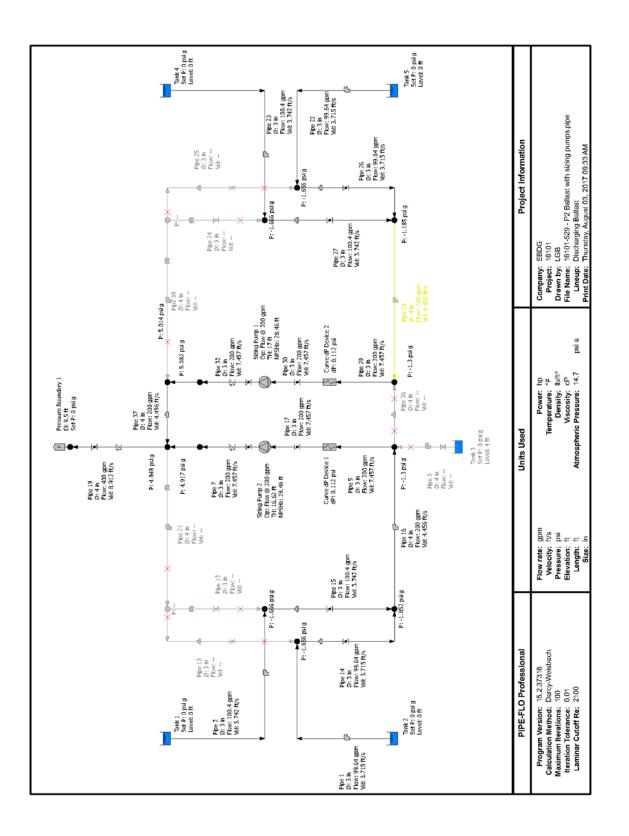
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List Report

Version: 15.2.37316

PIPE-FLO Professional



		l	List Report		l		
File Name: 16:101-529 - P2 Ballast wit Lineup: Discharging Ballast Progem Name: PIPE-FLO Professional Version: 15.2.37316	P2 Ballast with sizing pumps.pipe Ballast ofessional	Calculation Laminar (Max I Percent 7 Allowable I	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Heretions: 100 Percent Tolerance: 0.01 Allowable Deviation: 1 %	Atmospheric	Company: EBDG Project: 16101 by: LGB Date: Thursday, Augu Pressure: 14.7 psi a	pany: EBDG oject: 16101 by: LGB mai: Thursday, August 03, 2017 09:33 AM saure: 14.7 psia	
			Pipe Specification	SI			
Specification Name Valve Table	Material Schedule	Absolute Hazen Wil	Absolute Roughness Sizin Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure	Reynolds Number
Copper Nickel Class 200 standard	Copper Nickel MIL-T-16420K Schedule:Class 200		6E-05 in 0.0 150	Min: Max:	t: ft/s	psig psig	
			Fluid Zones				
Fluid Zone Name Table Name	Ter	femperature Pressure Rela	Fluid State Relative Molecular Mass	Density Viscosity	Vapor Critical	Vapor Pressure Specific Critical Pressure Speci	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Sea Water Seawater 3.5% Salinity		60°F 0 psig	Liquid 29	64.04 lb/ft ³ 1.206 cP	0.251 319	0.2513 psia 3199 psia	
			Sizing Pumps				
Pump Name		Suction Elevation Suction Pressure	Discharge Elevation Discharge Pressure	Total Head dP	Flow Rate	ate NPSHa	
Sizing Pump 1		2.5 ft -1.786 psig	2.5 ft 5.772 psig	17 ft 7.558 psi	200 gpm	pm 28.46 ft	
Sizing Pump 2		2.5 ft -1.786 psig	2.5 ft 5.607 psig	16.62 ft 7.393 psi	200 gpm	pm 28.46 ft	
			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 1 Copper Nickel Class 200 Sea Water	3 in 3.31 in 85 ft	Tank 2 2 ft Node 1 4 ft	99.64 gpm 3.715 ft/s 80970 0.01889	0 psig -0.09538 psig 2 ft 1.786 ft	1.656 psi 1.723 ft	-1.556 psig -1.751 psig 0.2774 ft 0.06294 ft	0.01702 2.21 0.2108 psi 0.4739 ft
Pipe 12 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Node 7 4 ft Node 2 4 ft	: : : :		11		
Pipe 13 Copper Nickel Class 200 Sea Water	3 in 3.31 in 4 ft	Node 7 4 ft Node 1 4 ft			1 1		
Pipe 14 Copper Nickel Class 200 Sea Water	3 in 3.31 in 4 ft	Node 1 4 ft Node 8 4 ft	99.64 gpm 3.715 ft/s 80970 0.01889	-1.656 psig -1.751 psig 0.2774 ft 0.06294 ft	0.1966 psi 0.442 ft	-1.852 psig -1.948 psig -0.1646 ft -0.3791 ft	0.01702 1.79 0.1704 psi 0.3832 ft
Pipe 15 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Node 2 4 ft Node 8 4 ft	100.4 gpm 3.742 ft/s 81561 0.01887	-1.666 psig -1.763 psig 0.2541 ft 0.03646 ft	0.1862 psi 0.4186 ft	-1.852 psig -1.949 psig -0.1646 ft -0.3822 ft	0.01702 1.79 0.1729 psi 0.3889 ft
PIPE-FLO Professional	Version: 15.2.37316	9	List Report	F	Thursday, August 03, 2017 09:33 AM	2017 09:33 AM	Page 1

Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Elevation Outlet Elevation	Pipelines Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 16 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Node 8 Node 4 2.5 ft	200 gpm 4.456 ft/s 125637 0.01725	-1.852 psig -1.989 psig -0.1646 ft -0.4731 ft	-0.5523 psi 0.2581 ft	-1.3 psig -1.437 psig -0.427 ft -0.7313 ft	0.01607 0.45 0.06173 psi 0.1388 ft
Pipe 17 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Curve of Device 1 2.5 ft String Pump 2 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	-1.446 psig -1.83 psig -0.7517 ft -1.616 ft	0.3401 psi 0.7647 ft	-1.786 psig -2.171 psig -1.516 ft -2.381 ft	0.01702 0.77 0.2943 psi 0.6618 ft
Pipe 19 Copper Nickel Class 200 Sea Water	4 in 4.282 in 15 ft	Node 5 2.5 ft Pressure Boundary 1 9.5 ft	400 gpm 8.912 ft/s 251273 0.01509	4.848 psig 4.299 psig 13.4 ft 12.17 ft	4.848 psi 3.901 ft		0.01607 2.53 1.387 psi 3.118 ft
Pipe 2 Copper Nickel Class 200 Sea Water	3.1 in 85 ft	Tank 1 2 ft Node 2 4 ft	100.4 gpm 3.742 ft/s 81561 0.01887	0 psig -0.09678 psig 2 ft 1.782 ft	1.666 psi 1.746 ft	-1.666 psig -1.763 psig 0.2541 ft 0.03646 ft	0.01702 2.21 0.2138 psi 0.4808 ft
Pipe 20 Copper Nickel Class 200 Sea Water	3 in 3.31 in 3.11	Sizing Valve 5 2.5 ft Node 5 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	4.917 psig 4.532 psig 13.56 ft 12.69 ft	0.06864 psi 0.1543 ft	4.848 psig 4.464 psig 13.4 ft 12.54 ft	0.01702 0.00 0 psi 0 ft
Pipe 21 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Node 5 2.5 ft Node 7 4 ft			i i		14 14 - 1
Pipe 22 Copper Nickel Class 200 Sea Water	3 in 3.31 in 85 ft	Tank 5 2 ft Node 9 4 ft	99.64 gpm 3.715 ft/s 80970 0.01889	0 psig -0.09538 psig 2 ft 1.786 ft	1.656 psi 1.723 ft	-1.656 psig -1.751 psig 0.2774 ft 0.06294 ft	0.01702 2.21 0.2108 psi 0.4739 ft
Pipe 23 Copper Nickel Class 200 Sea Water	3 in 3.31 in 85 ft	Tank 4 2 ft Node 10 4 ft	100.4 gpm 3.742 ft/s 81561 0.01887	0 psig -0.09678 psig 2 ft 1.782 ft	1.666 psi 1.746 ft	-1.666 psig -1.763 psig 0.2541 ft 0.03646 ft	0.01702 2.21 0.2138 psi 0.4808 ft
Pipe 24 Copper Nickel Class 200 Sea Water	3.in 3.31 in 2 ft	Sizing Valve 8 2.5 ft Node 10 4 ft			i i		
Pipe 25 Copper Nickel Class 200 Sea Water	3 in 3.31 in 4 ft	Sizing Valve 3 2.5 ft Node 9 4 ft					
Pipe 26 Copper Nickel Class 200 Sea Water	3 in 3.31 in 4 ft	Node 9 4 ft Node 11 2.5 ft	99.64 gpm 3.715 ft/s 80970 0.01889	-1.656 psig -1.751 psig 0.2774 ft 0.06294 ft	-0.4705 psi 0.442 ft	-1.185 psig -1.28 psig -0.1646 ft -0.3791 ft	0.01702 1.79 0.1704 psi 0.3832 ft
PIPE-FLO Professional	Version: 15.2.37316	9	List Report	f	Thursday, August 03, 2017 09:33 AM	2017 09:33 AM	Page 2

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			Pipelines				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 27 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Node 10 4 ft Node 11 2.5 ft	100.4 gpm 3.742 ft/s 81561 0.01887	-1.666 psig -1.763 psig 0.2541 ft 0.03646 ft	-0.4809 psi 0.4186 ft	-1.185 psig -1.282 psig -0.1646 ft -0.3822 ft	0.01702 1.79 0.1729 psi 0.3889 ft
Pipe 28 Copper Nickel Class 200 Sea Water Messanes - Romered flow	4 in 4.282 in 8 ft	Node 15 2.5 ft Node 11 2.5 ft	200 gpm 4.456 ft/s 126637 0.01725	-1.185 psig -1.322 psig -0.1646 ft -0.4731 ft	0.1148 psi 0.2581 ft	-1.3 psig -1.437 psig -0.4227 ft -0.7313 ft	0.01607 0.45 0.06173 psi 0.1388 ft
Pipe 29 Copper Nickel Class 200 Sea Water	3 in 3.31 in 1.5 ft	Node 15 2.5 ft Curve dP Device 2 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	-1.3 psig -1.684 psig -0.4227 ft -1.287 ft	0.03432 psi 0.07717 ft	-1.334 psig -1.718 psig -0.4999 ft -1.364 ft	0.01702 0.00 0 psi 0 ft
Pipe 3 Copper Nickel Class 200 Sea Water	4 in 4.282 in 10 ft	Tank 3 0 ft Node 4 2.5 ft			: :		0.35
Pipe 30 Copper Nickel Class 200 Sea Water	3.31 in 2.11	Curve dP Device 2 2.5 ft Sizing Pump 1 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	-1.446 psig -1.83 psig -0.7517 ft -1.616 ft	0.3401 psi 0.7647 ft	-1.786 psig -2.171 psig -1.516 ft -2.381 ft	0.01702 0.77 0.2943 psi 0.6618 ft
Pipe 32 Copper Nickel Class 200 Sea Water	3.31 in 3.31 in 3 ft	Sizing Pump 1 2.5 ft Sizing Valve 7 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	5.772 psig 5.388 psig 15.48 ft 14.61 ft	0.69 psi 1.551 ft	5.082 psig 4.698 psig 13.93 ft 13.06 ft	0.01702 1.62 0.6213 psi 1.397 ft
Pipe 33 Copper Nickel Class 200 Sea Water	3.31 in 3.31 in 3.11	Sizing Valve 7 2.5 ft Node 16 2.5 ft	200 gpm 7.457 ft/s 162530 0.01642	5.082 psig 4.698 psig 13.93 ft 13.06 ft	0.06864 psi 0.1543 ft	5.014 psig 4.629 psig 13.77 ft 12.91 ft	0.01702 0.00 0 psi 0 ft
Pipe 35 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Sizing Valve 8 2.5 ft Node 16 2.5 ft			1 1		1.41
Pipe 36 Copper Nickel Class 200 Sea Water	4 in 4.282 in 5 ft	Node 4 2.5 ft Node 15 2.5 ft					
Pipe 37 Copper Nickel Class 200 Sea Water	4 in 4.282 in 5 ft	Node 16 2.5 ft Node 5 2.5 ft	200 gpm 4.456 ft/s 125637 0.01725	5.014 psig 4.876 psig 13.77 ft 13.46 ft	0.1654 psi 0.372 ft	4.848 psig 4.711 psig 13.4 ft 13.09 ft	0.01607 0.96 0.1323 psi 0.2974 ft
Pipe 5 Copper Nickel Class 200 Sea Water PIPE-FLO Professional	3 in 3.31 in 1.5 ft Version: 15.2.37316	Node 4 2.5 ft Curve of Device 1 2.5 ft 5	200 gpm 7.457 ft/s 162530 0.01642 List Report	-1.3 psig -1.684 psig -0.4227 ft -1.287 ft Th	0.03432 psi -1.334 -1.718 0.07717 ft -0.4999 -1.364 Thursday, August 03, 2017 09:33 AM	-1.334 psig -1.718 psig -0.4999 ft -1.364 ft 017 09:33 AM	0.01702 0.00 0 psi 0 ft Page 3

Pipeline Name Specification Size Length Length Fluid Zone Inside Diameter Length Pipe 7 3:31 in 3:31 i	ter Inlet Elevation Inlet Elevation Outlet Elevation Saling Pump 2 Saling Pump 2 Surface Pressure Bottom Pressure 0 psi g 0 psi g 0 psi g 0 psi g 0 psi g 0 psi g	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor 200 gpm (62530 0.01642 Tanks Hydrautic Grade 2 ft 2 ft 2 ft 2 ft 2 ft 2 ft 2 ft 2 ft	Inlet Total Pressure Inlet Static Pressure Inlet Hydraulic Grade 5.6.07 psi g 5.222 psi g 15.11 ft 14.24 ft 14.24 ft 14.24 ft Pipe 2 Pipe 2 Pipe 3	re Total dP Outlet 1 re Total Head Loss Outlet (H) ade Total Head Loss Outlet (H) 0.69 psi 0.44 1.551 ft 1.1551 ft 1.1 Commecting Pipelines Penetration Height Pipelines 0 ft 99.64 0 ft 99.64 0 ft 100.4	ctal Pressu tatic Pressu Pressu Francy Grad (17) psig 3.56 ft 2.69 ft 2.69 ft 10w Rate 10w Rate 10m Rate 1 gpm	re V&F Friction Factor re V&F Resistance K V&F dP V&F dP 0.01702 1.6213 psi 1.397 ft 1.397 ft 1.397 ft 1.397 ft 1.397 ft 1.397 ft 1.397 ft 1.397 ft 1.397 ft 1.397 ft 0 psi g 0 psi g 0 psi g
Nickel Class 200 and an	String Pump 2 2.5 ft String Valve 5 2.5 ft 2.5 ft 2.5 ft 2.5 ft 0 psi g 0 psi	99m 178 20 20 20 20 20 20 20 20 20 20 20 20 20	5.607 psig 5.222 psig 1.5.11 ft 1.4.24 ft Pipe 2 Pipe 1 Pipe 3 Pipe 23	0.69 psi 1.551 ft Connecting Penetration Height 0 ft 0 ft 0 ft 0 ft		0.01702 1.62 0.6213 psi 1.397 ft 1.397 ft 1.397 gsi g 0 psi g 1.779 psi g
nne Bottom Elevation Iquid Level 0 ft 0 ft 4 ft 2 ft 0 ft 2 ft 0 ft 0 ft 0 ft 0 ft 0 ft 0 ft 0 ft 0	Irface Pressure ottom Pressure 0 psi g 0 psi g 		ipeline Name Pipe 2 Pipe 3 Pipe 23	Penetration Height 0 ft 0 ft 0 ft 0 ft 0 ft	low Rate gpm gpm	ressure at Penetration 0 psi g 1.779 psi g 0 psi g
200 200 04 20 20 25 25 25 25 25 25 25 25 25 25 25 25 25 2	0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	e e e e	Pipe 2 Pipe 1 Pipe 23	0 H H H H 0 H 0 H 0 H		0 paig 0 paig 1.779 paig
00 04 00 00	0 0 0 1 1 0 0 0 1 1 0 0 0 1 1 1 1 1 1 1		Pipe 1 Pipe 3 Pipe 23		99.64 gpm 	0 psig 1.779 psig 0 psig
04 00 00	0 psig 0 psig 0 psig psig psis		Pipe 3 Pipe 23		- 100.4 gpm	1.779 psig
0 0 0 0 0	0 psig 0 psig 0 psig		Pipe 23		100.4 gpm	0 psig
0.0	0 psig					
	5 10 1 0		Pipe 22	0 ft	99.64 gpm	0 psig
Curve dP Device Name Curve dP Device Name		Curve dP Devices	ę	Flow Rate		
		Outlet Pressure	Head Loss			
Curve dP Device 1 2.5 ft Eaton model 72 -1.334 psi g		2.5 ft -1.446 psig	0.112 psi 0.2518 ft	200 gpm		
Curve dP Device 2 2.5 ft Eaton model 72 -1.334 psi g		2.5 ft -1.446 psig	0.112 psi 0.2518 ft	200 gpm		
Node Name	Ele	0	Pressure	Hydraulic Grade		
Node 1		4 ft -1.656 psi g		0.06294 ft		
Node 10		4 ft -1.666 psi g		0.03646 ft		
Node 11		2.5 ft -1.185 psi g	psi g	-0.4115 ft		
Node 15		2.5 ft -1.3	-1.3 psi g	-1.009 ft		
Node 16		2.5 ft 5.014	5.014 psi g	13.19 ft		
Node 2		4 ft -1.666	-1.666 psi g	0.03646 ft		
Node 4		2.5 ft -1.3	-1.3 psig	-1.009 ft		
Node 5		2.5 ft 4.848	4.848 psig	12.6 ft		
Node 7		4 ft		1		
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EBDG – NC, PLLC

16101-200-505-1

Job: 16101

Rev. -

	Nodes			
Node Name	Elevation	Pressure	Hydraulic Grade	
Node 8	4 ft	-1.852 psig	-0.4115 ft	
Node 9	4 ft	-1.656 psig	0.06294 ft	
Sizing Valve 5	2.5 ft	4.917 psig	12.69 ft	
Sizing Valve 7	2.5 ft	5.082 psi g	13.06 ft	
Sizing Valve 8	2.5 ft		1	
	Pressure Boundaries	ndaries		
Pressure Boundary Name	Elevation	Pressure	Hydraulic Grade	Flow Rate
Pressure Boundary 1	9.5 ft	0 psig	8.266 ft	400 gpm

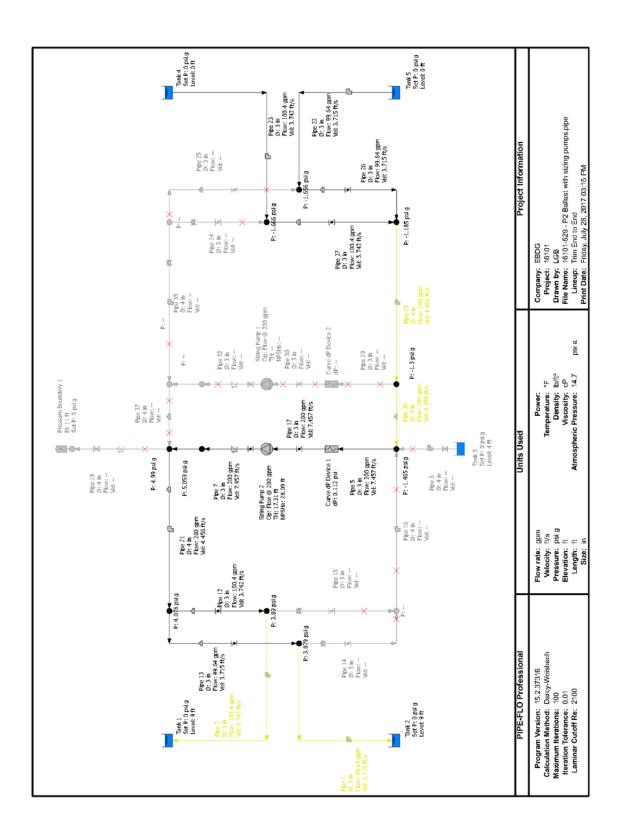
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List Report

Version: 15.2.37316

PIPE-FLO Professional



EBDG - NC, PLLC
16101-200-505-1

			5	List Report					
File Name: 16101-529 - P2 Ballast with sizing pumps.pipe Lineup: Trim End to End Proceam Name: PIPE-FLO Professional	th sizing pumps.pipe	Calcul Lami	ulation Method: Darc ninar Cutoff Re: 2100 Max Iterations: 100	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Iterations: 100	Com	Company: EBDG Project: 16101 bv: LGB			
Version: 15.2.37316		Perc	Percent Tolerance: 0.01 Allowable Deviation: 1 %	0.01	Date: Atmospheric Pressure:	Date: Friday, July 28, sure: 14.7 psia	Date: Friday, July 28, 2017 03:15 PM seure: 14.7 psi a		
			Pipe	Pipe Specifications					
Specification Name Valve Table	Material Schedule	Abs Hazer	Absolute Roughness Hazen Williams C Factor		Sizing Criteria	Velocity	Design Limits Pressure		Reynolds Number
Copper Nickel Class 200 standard	Copper Nickel MIL-T-16420K Schedule:Class 200	-16420K	6E-05 in 150	0.0	Min: Max:	th's fu's	psi g psi g		
				Fluid Zones					
Fluid Zone Name Table Name	μ.	Temperature Pressure	Fluid State Relative Molecular Mass	ste cular Mass	Density Viscosity	Vap Criti	Vapor Pressure Sp Critical Pressure	pecific He Specific H	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Sea Water Seawater 3.5% Salinity		60°F 0 psig	Liquid 29		64.04 lb/ft ³ 1.206 cP	0.2	0.2513 psia 3199 psia	1	
			0)	Sizing Pumps					
Pump Name		Suction Elevation Suction Pressure		Discharge Elevation Discharge Pressure	Total Head dP	Flow	Flow Rate NF	NPSHa	
Sizing Pump 1		2.5 ft 		2.5 ft 		I		1	
Sizing Pump 2		2.5 ft -1.952 psig		2.5 ft 5.749 psig Ploelines	17.31 ft 7.7 psi	200	200 gpm 28.09	09 ft	
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation		Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure outlet Energy Grade Outlet Hydraulic Grade		V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 1 Copper Nickel Class 200 Sea Water	3 in 3.31 in 85 ft	Tank 2 2 ft Node 1 4 ft	0.07	99.64 gpm 3.715 ft/s 80970 0.01889	3.879 psig 3.784 psig 12.72 ft 12.51 ft	-0.1234 psi 1.723 ft	4.003 psig 3.907 psig 11 ft 10.79 ft	0.0	0.01702 2.21 0.2108 psi 0.4739 ft
Messages: Reversed flow									
Pipe 12 Copper Nickel Class 200 Sea Water	3.31 in 2.11	Node 7 4 ft Node 2 4 ft		100.4 gpm 3.742 ft/s 81561 0.01887	4.076 psig 3.979 psig 13.16 ft 12.95 ft	0.1862 psi 0.4186 ft	3.89 ps 3.793 ps 12.75 ft 12.53 ft	psig psig #	0.01702 1.79 0.1729 psi 0.3889 ft
Pipe 13 Copper Nickel Class 200 Sea Water	3.31 in 4.11	Node 7 4 ft Node 1 4 ft	0,0,	99.64 gpm 3.715 ft/s 80970 0.01889	4.076 psig 3.98 psig 13.16 ft 12.95 ft	0.1966 psi 0.442 ft	3.879 ps 3.784 ps 12.72 ft 12.51 ft	psig Ոլ Ոլ	0.01702 1.79 0.1704 psi 0.3832 ft
Pipe 14 Copper Nickel Class 200 Sea Water	3 in 3.31 in 4 ft	Node 1 4 ft Node 8 4 ft		:::		1 1	1 1 1		1.79 -
PIPE-FLO Professional	Version: 15.2.37316		<u> </u>	 List Report	1	Friday, July 28, 2017 03:15 PM			- Page 1

Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 15 Copper Nickel Class 200 Sea Water	3 in 3,31 in 2 ft	Node 2 4 ft Node 8					 1.79
000 +1010	- 4	4 fi					
Pipe 16	4 in	Node 3	:	:		:	:
Copper Nickel Class 200	4.282 in	4 ft	:	•		:	0.45
Sea Water	8 ft	Node 4		•	ı	•	ı
		2.5 ft		:		:	
Pipe 17	3 in	Curve dP Device 1	200 gpm	-1.612 psig	0.3401 psi	-1.952 psig	0.01702
Copper Nickel Class 200	3.31 in	2.5 ft	7.457 ft/s	-1.996 psig			0.77
Sea Water	2 11	seng Pump 2 2.5 ft	162530 0.01642	-1.124 ft -1.988 ft	0.7647 ft	-1.888 tt -2.753 ft	0.2943 psi 0.6618 ft
Dine 19	4 in	Node 5	:	:		:	:
Copper Nickel Class 200	4.282 in	2.5 ft	:	:		:	2.53
Sea Water	15 ft	Pressure Boundary 1		:	ı	:	ı
		1					
Pipe 2 Conser Nickel Class 200	3 in 3 24 in	Tank 1 3 A	100.4 gpm 3 742 #Ie	3.89 psig 3.703 psig	-0.113 psi	4.003 psi g	0.01702
Sea Water	85 ft	Node 2	81561		1.746 ft		0.2138 psi
		4 ft	0.01887	12.53 ft		10.78 ft	0.4808 ft
Messages: Reversed flow							
Pipe 20	3 in	Sizing Valve 5	200 anm	5.059 nsi o	0.06864 nsi	4.99 nsi a	0.01702
Copper Nickel Class 200	3.31 in	2.5 ft	7.457 ft/s	4.674 psi g		4.606 psig	0.00
Sea Water	3 ft	Node 5	162530	13.87 ft	0.1543 ft	13.72 ft	0 psi
		2.5 ft	0.01642	13.01 ft		12.86 ft	0 ft
Pipe 21	4 in	Node 5	200 gpm	4.99 psig	0.9142 psi	4.076 psig	0.01607
Copper Nickel Class 200	4.282 in	2.5 ft	4.456 ft/s	4.853 psig		3.939 psig	1.41
Sea Water	8 ft	Node 7 4 ft	125637 0.01725	13.72 ft 13.41 ft	0.5556 ft	13.16 ft 12.86 ft	0.194 psi 0.4363 ft
Pipe 22	3 in	Tank 5	99.64 gpm	0 psig	1.656 psi	-1.656 psig	0.01702
Copper Nickel Class 200	3.31 in	2 fi	3.715 ft/s	-0.09538 psig		-1.751 psig	2.21
Sea Water	85 ft	Node 9 4 ft	80970 0.01889	2 ft 1.786 ft	1.723 ft	0.2774 ft 0.06294 ft	0.2108 psi 0.4739 ft
Pine 23	3 in	Tank 4	100.4 apm	0 psi a	1.666 psi	-1.666 psi a	0.01702
Copper Nickel Class 200	3.31 in	2 ft	3.742 ft/s	-0.09678 psi g		-1.763 psi g	2.21
Sea Water	85 ft	Node 10	81561	2 ft	1.746 ft		
		4 ft	0.01887	1.782 ft		0.03646 ft	0.4808 ft
Pipe 24	3 in	Sizing Valve 8	:	:	ł		;
Copper Nickel Class 200	3.31 in	2.5 ft	;	;		;	1.79
Sea Water	2 11	N006 1U			ı		
36	i e	Ciston Makan 0					
Conner Nickel Class 200	110 2.24 in	o ania fuizio	: :	: :	1	: :	1 70
Sea Water	4 11	Node 9			ı		n 1
		4 11		:		:	

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		l	Pipelines		l		
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Pipe 26 Copper Nickel Class 200 Sea Water	3 in 3.31 in 4 ft	Node 9 4 ft 2.5 ft	99.64 gpm 3.715 ft/s 80970 0.01889	-1.656 psig -1.751 psig 0.2774 ft 0.06294 ft	-0.4705 psi 0.442 ft	-1.185 psig -1.28 psig -0.1646 ft -0.3791 ft	0.01702 1.79 0.1704 psi 0.3832 ft
Pipe 27 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Node 10 4 ft Node 11 2.5 ft	100.4 gpm 3.742 ft/s 81561 0.01887	-1.666 psig -1.763 psig 0.2541 ft 0.03646 ft	-0.4809 psi 0.4186 ft	-1.185 psig -1.282 psig -0.1646 ft -0.3822 ft	0.01702 1.79 0.1729 psi 0.3889 ft
Pipe 28 Copper Nickel Class 200 Sea Water Messanes: Reversed flow	4 in 4.282 in 8 ft	Node 15 2.5 ft Node 11 2.5 ft	200 gpm 4.456 ft/s 126637 0.01725		0.1148 psi 0.2581 ft	-1.3 psig -1.437 psig -0.4227 ft -0.7313 ft	0.01607 0.45 0.06173 psi 0.1388 ft
Pipe 29 Copper Nickel Class 200 Sea Water	3 in 3.31 in 1.5 ft	Node 15 2.5 ft Curve dP Device 2 2.5 ft					1 00.0
Pipe 3 Copper Nickel Class 200 Sea Water	4 in 4.282 in 10 ft	Tank 3 0 ff 2.5 ft			1 1		0.35
Pipe 30 Copper Nickel Class 200 Sea Water	3 in 3.31 in 2 ft	Curve dP Device 2 2.5 ft String Pump 1 2.5 ft		1 : : 1	i i		
Pipe 32 Copper Nickel Class 200 Sea Water	3.31 in 3.31 in 3.ft	Sizing Pump 1 2.5 ft Sizing Valve 7 2.5 ft			: :		1.62
Pipe 33 Copper Nickel Class 200 Sea Water	3 in 3.31 in 3.1	Sizing Valve 7 2.5 ft Node 16 2.5 ft			1 1		
Pipe 35 Copper Nickel Class 200 Sea Water	4 in 4.282 in 8 ft	Sizing Valve 8 2.5 ft Node 16 2.5 ft			: :		141
Pipe 36 Copper Nickel Class 200 Sea Water Messages: Reversed flow	4 in 4.282 in 5 ft	Node 4 2.5 ft Node 15 2.5 ft	200 gpm 4.456 ft/s 1.25637 0.01725	-1.3 psig -1.437 psig -0.4227 ft -0.7313 ft	0.1654 psi 0.372 ft	-1.465 psig -1.603 psig -0.7947 ft -1.103 ft	0.01607 0.96 0.1323 psi 0.2974 ft
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Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device r Inlet Elevation Outlet Device Outlet Elevation	FI Reyr	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hvdraulic Grade	re Total dP rre fe Total Head Loss ade	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hvdraulic Grade	V&F Friction Factor V&F Resistance K V&F dP e V&F Head Loss
Pipe 37 Copper Nickel Class 200 Sea Water	4 in 4.282 in 5 ft	Node 16 2.5 ft Node 5					
Pipe 5 Copper Nickel Class 200 Sea Water	3 in 3.31 in 1.5 ft	2.5 ft Node 4 2.5 ft Curve dP Device 1	 200 gpm 7.457 ft/s 162530		0.03432 psi 0.07717 ft	 -1.5 psig -1.884 psig -0.8719 ft	
Pipe 7 Copper Nickel Class 200 Sea Water	3.31 in 3.31 in 3.11	2.5 ft Sizing Pump 2 2.5 ft Sizing Valve 5 2.5 ft 2.5 ft	0.01642 200 gpm 7.457 ft/s 162530 0.01642	-1.659 ft 5.749 psig 5.364 psig 15.43 ft 14.56 ft	0.69 psi 1.551 ft	-1.736 ft 5.059 psig 4.674 psig 13.87 ft 13.01 ft	0 ft 0.01702 1.62 0.6213 psi 1.397 ft
			Tanks				
Tank Name Fluid Zone	Bottom Elevation Su Liquid Level Bo	Surface Pressure Bottom Pressure	Hydraulic Grade	Pipeline Name	Connectin Penetration Height	Connecting Pipelines Height Pipeline Flow Rate F	Pressure at Penetration
Tank 1	2 ft 9 ft	0 psig 4.003 psig	1 ft	Pipe 2	ц 0	100.4 gpm	4.003 psi g
Tank 2	2 ft 9 ft	0 psig 4.003 psig	11 ft	Pipe 1	0 ft	99.64 gpm	4.003 psig
Tank 3	0ft 4ft	0 psig	:	Pipe 3	Ф Ф	1	1.779 psig
Tank 4	2 ft 0 ft	0 psig 0 psig	2 ft	Pipe 23	یر 0	100.4 gpm	0 psig
Tank 5	2 ft 0 ft	0 psig 0 psig	2 ft	Pipe 22	ti O	99.64 gpm	0 psig
Curve dP Device Name Description	Inlet Elevation Inlet Pressure		CUIVE OF DEVICES Outlet Elevation Outlet Pressure	dP Head Loss	Flow Rate		
Curve dP Device 1 Eaton model 72	2.5 ft -1.5 psig		2.5 ft -1.612 psig	0.112 psi 0.2518 ft	200 gpm		
Curve dP Device 2 Eaton model 72	2.5 ft -	2	2.5 ft 		:		
Node Name		Ē	Nodes Elevation Pre	Pressure	Hydraulic Grade	l	l
Node 1				3.879 psi g	12.51 ft		
Node 10			4 ft -1.666		0.03646 ft		
Node 11			2.5 ft -1.185	-1.185 psig	-0.4115 ft		

	Nodes	ŵ		
Node Name	Elevation	Pressure	Hydraulic Grade	
Node 15	2.5 ft	-1.3 psig	-0.7313 ft	
Node 16	2.5 ft			
Node 2	4 ft	3.89 psi g	12.53 ft	
Node 4	2.5 ft	-1.465 psig	-1.381 ft	
Node 5	2.5 ft	4.99 psig	13.13 ft	
Node 7	4 ft	4.076 psi g	12.92 ft	
Node 8	4 ft			
Node 9	4 ft	-1.656 psi g	0.06294 ft	
Sizing Valve 5	2.5 ft	5.059 psi g	13.01 ft	
Sizing Valve 7	2.5 ft	:	:	
Sizing Valve 8	2.5 ft	ı		
	Pressure Boundaries	undaries		
Pressure Boundary Name	Elevation	Pressure	Hydraulic Grade	Flow Rate
Pressure Boundary 1	11 ft	0 psig		:

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		Bill o	f Materials Repo	ort		
Lineup:	16101-529 - P2 Ballast with Discharging Ballast PIPE-FLO Professional	sizing pumps.pipe		Company: Project:		
	15.2.37316					03, 2017 09:41 AM
			Sizing Pumps			and the state
Bizing Pump Nar Operation	me				Flow Rate	Design Point Total Head
Sizing Pump 1 Flow @ 200 gp	pm				200 gpm	1 7 ft
Sizing Pump 2 Flow @ 200 gp	pm				200 gpm	16.62 ft
			Tanks			
fank Name						
Fank 1 Fank 2						
rank 2 Fank 3						
Fank 4						
Fank 5						
			Curve dP Devices	5		
Curve dP Device	e Name	Curve Des	cription			
Curve dP Device	1	Eaton mod	el 72			
Curve dP Device	2	Eaton mod				
Pipeline	C	fication	Pipelines Size	Length	Valves and	d Fittings
Pipe 1		er Nickel Class 200	3 in	85 ft		- Long radius, r/d 1.5 (90°)
Pipe 12	Сорре	er Nickel Class 200	3 in	2 ft	1 x Butterfl	y
Pipe 13	Сорре	er Nickel Class 200	3 in	4 ft	1 x Butterfl	low Thru Branch y Iow Thru Branch
Pipe 14	Coppe	er Nickel Class 200	3 in	4 ft	1 x Butterfl	
Pipe 15	Coppe	er Nickel Class 200	3 in	2 ft	1 x Butterfl	
Pipe 16	Coppe	er Nickel Class 200	4 in	8 ft		- Long radius, r/d 1.5 (90°)
Pipe 17		er Nickel Class 200	3 in	2 ft	1 x Butterfl	• • • •
Pipe 19		er Nickel Class 200	4 in	15 ft		Check - Vertical tounded
Pipe 2	Сорре	er Nickel Class 200	3 in	85 ft	6 x Elbow - 1 x Entranc	- Long radius, r/d 1.5 (90°) ce - Inward
Pipe 20	Coppe	er Nickel Class 200	3 in	3 ft		
Pipe 21	Coppe	er Nickel Class 200	4 in	8 ft		- Long radius, r/d 1.5 (90°) Iow Thru Branch
Pipe 22	Coppe	er Nickel Class 200	3 in	85 ft	6 x Elbow - 1 x Entrand	- Long radius, r/d 1.5 (90°) ce - Inward
Pipe 23	Сорре	er Nickel Class 200	3 in	85 ft	6 x Elbow - 1 x Entranc	- Long radius, r/d 1.5 (90°) ce - Inward
Pipe 24	Coppe	er Nickel Class 200	3 in	2 ft	1 x Butterfl 1 x Tee - Fl	y Iow Thru Branch
Pipe 25	Сорре	er Nickel Class 200	3 in	4 ft	1 x Butterfl 1 x Tee - Fl	y Iow Thru Branch
Pipe 26	Coppe	er Nickel Class 200	3 in	4 ft	1 x Butterfl 1 x Tee - Fl	y Iow Thru Branch
Pipe 27	Сорре	er Nickel Class 200	3 in	2 ft	1 x Butterfl 1 x Tee - Fl	y Iow Thru Branch
Pipe 28	Coppe	er Nickel Class 200	4 in	8 ft	2 x Elbow ·	- Long radius, r/d 1.5 (90°)
Pipe 29	Conn	er Nickel Class 200	3 in	1.5 ft		

		Pipelines		
Pipeline	Specification	Size	Length	Valves and Fittings
Pipe 3	Copper Nickel Class 200	4 in	10 ft	1 x Elbow - Long radius, r/d 1.5 (90°) 3 1 x Gate - Wedge Disc
Pipe 30	Copper Nickel Class 200	3 in	2 ft	1 x Butterfly
Pipe 32	Copper Nickel Class 200	3 in	3 ft	1 x Swing Check - Vertical 1 x Butterfly
Pipe 33	Copper Nickel Class 200	3 in	3 ft	
Pipe 35	Copper Nickel Class 200	4 in	8 ft	2 x Elbow - Long radius, r/d 1.5 (90°) 1 x Tee - Flow Thru Branch
Pipe 36	Copper Nickel Class 200	4 in	5 ft	1 x Tee - Flow Thru Branch
Pipe 37	Copper Nickel Class 200	4 in	5 ft	1 x Tee - Flow Thru Branch
Pipe 5	Copper Nickel Class 200	3 in	1.5 ft	
Pipe 7	Copper Nickel Class 200	3 in	3 ft	1 x Swing Check - Vertical 1 x Butterfly
	Pip	eline Material S	Summary	
Specification	Material	Size	Total Length	Valves & Fittings
Copper Nickel Class 200	Copper Nickel MIL-T-16420K Schedule: Class 200	3 in	383.00 ft	12 x Butterfly 24 x Elbow - Long radius, r/d 1.5 (90°) 4 x Entrance - Inward 2 x Swing Check - Vertical 8 x Tee - Flow Thru Branch
Copper Nickel Class 200	Copper Nickel MIL-T-16420K Schedule: Class 200	4 in	67.00 ft	1 x Butterfly 9 x Elbow - Long radius, r/d 1.5 (90°) 1 x Exit - Rounded 1 x Gate - Wedge Disc 1 x Swing Check - Vertical 4 x Tee - Flow Thru Branch

PIPE-FLO Professional

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Appendix K

Lube Oil and Waste Oil System, Dwg. 16101-200-529-2

1 DESCRIPTION

This appendix documents the first principles calculations used in designing the lube oil and waste oil system. These calculations are used to identify steady state frictional losses and to verify compliance with manufacturer-stated performance limits.

2 PROCEDURE

Calculations are presented in the following sequence:

- Pipe size calculations
- Frictional loss and pump ΔP calculations

Frictional losses through the piping system are calculated by constructing a model using PIPE-FLO Professional software utilizing the Darcy Weisbach method.

3 GIVEN AND ASSUMED PARAMETERS

- The Waste Oil system is to be constructed of Schedule 80 carbon steel pipe.
- Piping system lengths, routing, fittings, etc. are estimated based on the Profiles and Arrangements, and Lube Oil and Waste Oil Schematic [1] [2].
- A pressure of 10 psig is assumed at the waste oil discharge on the Main Deck.
- The waste oil tank is 2 feet above baseline, the pump suction and discharge are 4 feet above baseline, and the waste oil discharge on the Main Deck is assumed to be 12 feet above baseline, [1].
- The fluid used for all calculations is SAE 30 Lube Oil with the following properties:

Temperature:	50 degrees F
Specific Weight:	55.99 lb/cuft
Dynamic viscosity:	479.4 cP
Vapor Pressure:	0.2173 psia

4 FORMULAS

(not used)

5 CALCULATIONS

5.1 Pipe Size Calculations

Pipe sizes are based on the nominal velocity limits found in Marine Engineering, Chapter 20, Table 3, [3]. The following table shows the flow rates of lube oil occurring in the system, and the resulting pipe sizes.

		•				
Pipe Segment	Flow Rate	Pipe Size	ID	Design Ve	locity (ft/s)	V
	gpm	(NPS)	in	Nominal	Limit	ft/s
Pump suction	16	1 1/2" SCH 80	1.50	1.22	4.00	2.83
Pump discharge	16	1 1/2" SCH 80	1.50	2.45	6.00	2.83

Table 5-1: Waste Oil System Pipe Sizes and Velocities

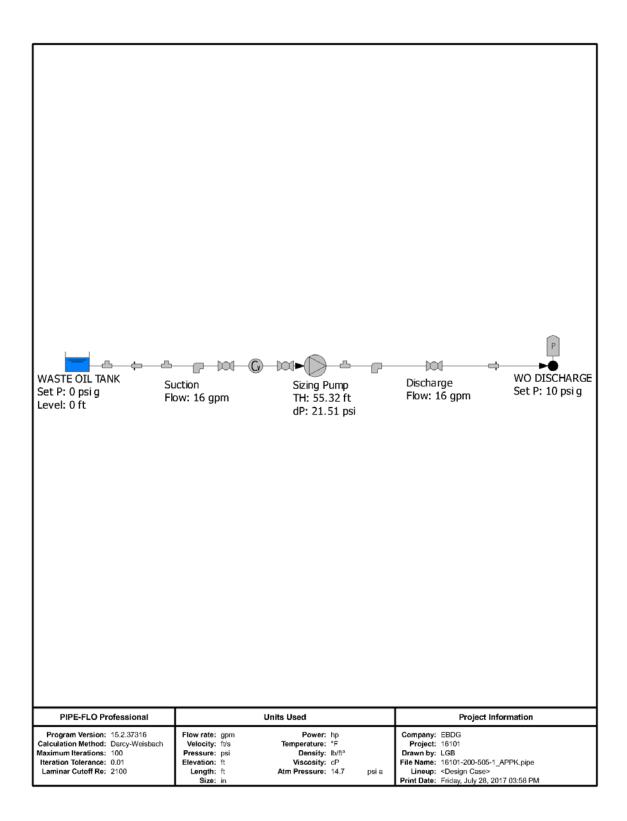
5.2 Frictional Loss and Pump ΔP Calculation

From the enclosed system model, the waste oil pump must provide at a minimum 20 psig when operating at a flow rate of 16 gpm.

6 **REFERENCES**

- [1] Elliott Bay Design Group, "NCDOT New River Class Ferry: Profiles and Arrangements," 16101-200-101-1, Seattle, WA.
- [2] Elliott Bay Design Group, "NCDOT New River Class Ferry: Lube Oil and Waste Oil Piping Schematic," 16101-200-529-2, Seattle, WA.
- [3] R. L. Harrington, Marine Engineering, Jersey City, NJ: SNAME, 1992.

WASTE OIL SYSTEM PIPE-FLO MODEL



EBDG – NC, PLLC
16101-200-505-1

			List Report	port				
File Name: 16101-200-505-1_APPK.pipe Lineup: <design case=""> Pronam Name: DIDF_FI O Professionel</design>	PK.pipe	Calcu Lami	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Heredione: 100	-Weisbach	Con	Company: EBDG Project: 16101 hv: 1.GR		
Version: 15.2.37316	2	Pero	Percent Tolerance: 0.01 Allowable Deviation: 1 %	_	Date: Date: Atmospheric Pressure:	Date: Friday, July 28, 2017 03:59 PM ssure: 14.7 psi a	28, 2017 03:59 PM ia	
			Pipe Spec	cifications				
Specification Name Valve Table	Material Schedule	Abs	Absolute Roughness Hazen Williams C Factor	Sizing	Sizing Criteria	Velocity	Design Limits Pressure	Reynolds Number
Steel A53-B36.10	Steel A53-B36.10		1.800E-03 in	0.0	Min:	n: ft/s	bsi g	
standard	Schedule:80		140 Fluid Zones	Zones	Max:	l	b isd	
Fluid Zone Name Table Name		Temperature Pressure	Fluid State Relative Molecular Mass	ass	Density Viscosity	Vapor Critica	Vapor Pressure Specific Critical Pressure Specif	Specific Heat Capacity (cp) Specific Heat Ratio (k)
SAE 30 Lube Oil SAE 30 Lube		50 °F 40 psig	Liquid 1		55.99 lb/ft ³ 479.4 cP	0.21	0.2173 psia 3199 psia	
			Sizing	Sizing Pumps				
Pump Name		Suction Elevation Suction Pressure	ation Discharge Elevation sure Discharge Pressure	Elevation Pressure	Total Head dP	Flow Rate	tate NPSHa	
Sizing Pump		4 ft -4.501 psig	g 17.01 psig	f psig	55.32 ft 21.51 psi	16 gpm	pm 25.66 ft	
			adıa	sauli				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device ter Inlet Elevation Outlet Device Outlet Elevation	ce Flow Rate ion Fluid Velocity ice Reynolds Number tion Pipe Friction Factor	Rate elocity Number on Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Discharge	1.5 in	Sizing Pump	16 gpm	mdg	17.01 psig	7.011 psi	10 psig	0.02054
Steel A53-B36.10 SAE 30 Lube Oil	1.5 In 10 ft	4 Π WO DISCHARGE 11 Π	2.905 TVS 3E 63.12 1.014	87 or ot	15.915 psig 47.75 유 47.61 유	11.03 ft	9.949 psig 36.72 ft 36.59 ft	2.99 0.1526 psi 0.3924 ft
Suction Steel A53-B36.10	1.5 in 1.5 in	WASTE OIL TANK 2 ft	NK 16 gpm 2.905 ft/s	gpm ñ/s	0 psig -0.05099 psig	4.501 psi	-4.501 psig -4.552 psig	0.02054 8.13
SAE 30 Lube Oil	8 ft	Sizing Pump 4 ft			2 ft 1.869 ft	9.576 ft	-7.576 ft -7.707 ft	0.4146 psi 1.066 ft
			Tar	Tanks				
Tank Name Fluid Zone	Bottom Elevation Liquid Level	Surface Pressure Bottom Pressure	Hydraulic Grade	Ā	Pipeline Name Pen	Connecting Penetration Height	Connecting Pipelines Height Pipeline Flow Rate Pr	Pressure at Penetration
WASTE OIL TANK SAE 30 Lube Oil	2 ft 0 ft	0 psig 0 psig	2 ft		Suction	0 ft	16 gpm	0 psig
			Pressure Boundaries	Boundaries				
Pressure Boundary Name			Elevation	Pres	Pressure Hydra	Hydraulic Grade	Flow Rate	
WO DISCHARGE			11 ft	10	10 psig 36.	36.59 ft	16 gpm	
PIPE-FLO Professional	Version: 15.2.37316	.37316	List Report	ort		Friday, July 28, 2017 03:59 PM	17 03:59 PM	Page 1

	Bi	II of Materials Rep	port		
File Name: 16101-20 Lineup: <design Program Name: PIPE-FLO Version: 15.2.373</design 	Case> O Professional		Company: Project: by: Date:	16101	04:00 PM
		Sizing Pumps	3		
Sizing Pump Name Operation				Des Flow Rate	sign Point Total Head
Sizing Pump Flow @ 16 gpm				16 gpm	55.32 ft
		Tanks			
Tank Name					
WASTE OIL TANK					
		Pipelines			
Pipeline	Specification	Size	Length	Valves and F	ittings
Discharge	Steel A53-B36.10	1.5 in	10 ft	1 x Exit - Proj	ong radius, r/d 1.5 (90°) jecting v Thru Branch
Suction	Steel A53-B36,10	1.5 in	8 ft	1 x Entrance 1 x Strainer 1 x Tee - Flov	
		Pipeline Material Su	mmary		
Specification	Material	Size	Total Length	Valves & Fittin	ngs
Steel A53-B36.10	Steel A53-B36.10 Schedule: 80	1.5 in	18.00 ft	5 x Ball 4 x Elbow - Loi 1 x Entrance - 1 x Exit - Proje 1 x Strainer	

1 x Strainer 2 x Tee - Flow Thru Branch 1 x Tee - Flow Thru Run

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Appendix L

Potable and Sanitary Water System, Dwg. 16101-200-533-1

1 DESCRIPTION

This appendix documents the calculations used in designing the potable water system. These calculations were used to determine flow demand and pipe sizes for the potable water piping and to size the potable water pressure tank and pump.

2 PROCEDURE

Calculations are presented in the following sequence:

- Demand water supply calculation
- Potable water tank sizing calculation
- Potable water pump requirements

System sizing is based on the guidance found in Appendix A of [1] and estimated usage factors.

Water system pressure tank is sized in accordance with [2].

3 GIVEN AND ASSUMED PARAMETERS

- The potable water system is Steel Schedule 40 at the tank connection and Copper Seamless Hard Drawn Type K beyond the tank shut off valve. These calculations assume
- The system is supplied with two pumps. One pump will pressurize the system in normal operation and the second pump will be on standby. Pump will cycle on at 40 psig and off at 60 psig.
- Water closets flush using 1.28 gallons per flush, low-volume, flush-o-meter valves.
- Fixture count, system pipe lengths, routing and fittings are estimated based on the Profiles and Deck Arrangements [3] and Potable and Sanitary Water Piping Schematic [4].
- The highest potable and sanitary water outlet is on the bridge deck at the window washing system, 38 feet ABL.
- The pump inlet and outlet elevation is 2.5 feet.
- Required residual pressure at the highest outlet is 15 psi.
- The water tank is assumed to have 5 feet of water.
- Friction losses from the outlet of the pump to the highest outlet of the system are assumed to be 20 psi.

4 FORMULAS

The following formulas, taken from [2], are used to estimate the size of the potable water pressure tank:

Eq 1: Supplemental Drawdown (gal) = (Peak demand (gpm) – pump capacity(gpm)) × Peak Demand Time (min)

Eq 2: Total Pressure Tank Volume = $\frac{Minimum Drawdown + Supplemental Drawdown}{Acceptance Factor}$

Eq 3: Acceptance Factor =
$$1 - \frac{P1(tank \ precharge) + 14.7}{P2(cutout) + 14.7}$$

5 CALCULATIONS

5.1 Demand Water Supply Calculations

			Water Supply Fixture		Flow Rate	Usage	Total
Level	Item	Qty	Units, Table A-2	Item Totals	(gpm)	Factor	Flow
Bridge Deck	Window Wash**	1	1	1	1.5	0.5	0.8
	Hose Bib*	2	2.5	3.5	2.5	0.1	0.5
	Total, Main Deck:			4.5			1.3
01 Deck	Service Sink	1	1.5	1.5	2.5	0.1	0.3
	Lavatory	1	1	1	1.5	1	1.5
	Hose Bib	1	1	1	2.5	0.1	0.3
	Head	1	5	5	1.5	1	1.5
	Total, 01Deck:			8.5			3.5
Main Deck	Service Sink	1	1.5	1.5	2.5	0.1	0.3
	Lavatory	2	1	2	1.5	1	3.0
	Hose Bib	2	1	2	1.5	1	3.0
	Head	2	5	10	1.5	1	3.0
	Total, Main Deck:			15.5			9.3
Hold	Hose Bib	3	1	3	2.5	0.1	0.8
	Total, Hold			3			0.8
Total WSFU fo	r Vessel		31.5				14.8
Supply demand	l, from [1], Ch A-3, line	1	40	GPM			
Excluding wate	er closets, from [1], Ch	A-3, Line 2	20	GPM			
* First hose bil	o is 2.5 WSFU, additiona	al are 1.0					
**Window was	sh WSFU is estimated a	s similar to a sink	C				

Demand flow from Chart A-3, Line 1 is 40 gpm, from [1]. However, varying the usage factors to simulate different system loads results in instantaneous demands ranging from 8 to 16 gpm. A pump sized for flows in this range with a maximum head of 50 psi coupled with a suitable pressure tank to prevent pump cycling will suffice.

5.2 Pressure Tank Sizing Calculation

Per [2], Table IV.1.2, the minimum draw-down for an 8 gpm pump is 8 gallons. The minimum pressure tank volume is calculated as follows:

	Item	Qty		Note / Reference
(1)	Pump Capacity	8	gpm	
(2)	Minimum Drawdown	8	gallons	
(4)	Peak Demand Estimation	16	gpm	
(5)	Peak Demand Time		minutes	
(6)	P1 pressure tank precharge	40	psi	
(7)	P2 cutout pressure	60	psi	
(9)	Supplemental Drawdown	0.64	gallons	Eq. 1: [(4) - (1)] * (5)
(10)	Total Required Drawdown	8.64	gallons	Eq. 2: $(2) + (9)$
(11)	Acceptance Factor	0.27		Eq. 3: 1 - [[(6) + 14.7]/[(7) + 14.7]]
(12)	Total Calculated Tank Size	32	gallons	Eq. 4 (10)/(11)

Table 5-2: Pressure Tank Sizing

5.3 Friction Loss

In order to determine the pump head requirements, the piping system between the potable water supply tank and potable water pressure tank are modeled using Pipe-Flo Professional 15 utilizing the Darcy-Weisbach friction loss method.

The pressure tank is set to 50 psi to represent 15 psi at the highest potable water outlet and 20 psi friction losses in the piping.

Based upon the attached model, at a flow rate of 16 gpm the velocity in the water suction line is 3.0 ft/sec, head loss is 1.5 ft, and the pump total head requirement is 113.5 ft.

The potable water pump will operate between 40 and 60 psi against a pressure tank, and should be selected with a shutoff head exceeding 60 psi and an NPSHr well below the NPSHa of the system for the flow rate at 40 psi. System NPSHa at various flow rates are as follows:

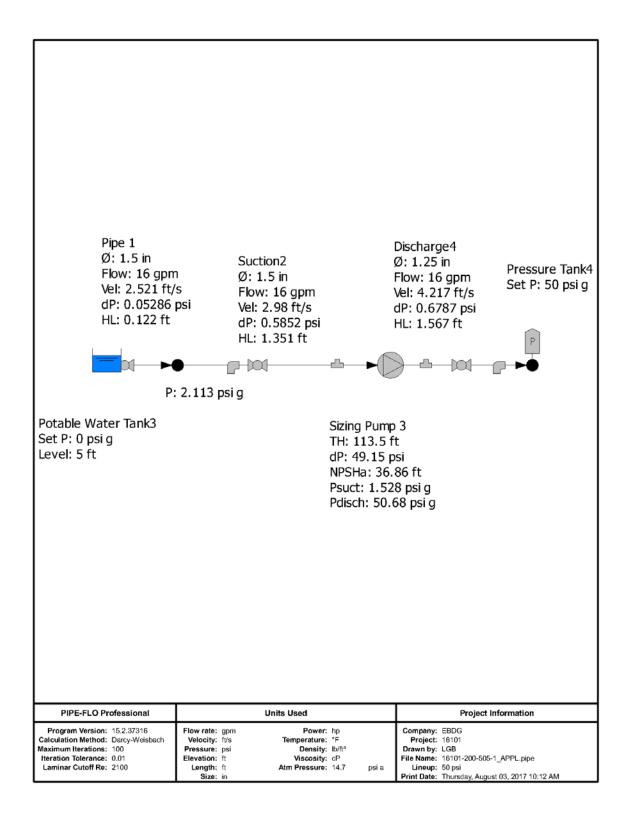
Flow Rate, (gpm)	System NPSHa, ft	Velocity, ft/s
4	38.23	1.05
8	37.94	2.11
12	37.49	3.16
16	36.86	4.22
20	36.08	5.27

Table 5-3: System NPSHa

6 REFERENCES

- [1] IAPMO/ANSI UPC 1 2009: Uniform Plumbing Code, Ontario, CA: International Association of Plumbing and Mechanical Officials, 04/2009.
- [2] Water Systems Council, Wellcare Information For You About Sizing a Pressure Tank, Washington, DC.
- [3] EBDG, "16101-200-101-1 Profiles and Deck Arrangements," 7/28/17.
- [4] EBDG, "16101-200-533-1 Potable and Sanitary Water Piping Schematic," 7/21/17.

Potable and Sanitary Water Pipe-Flo Model



			List Report				
File Name: 16101-200-505-1_APPL.pipe Lineup: 50 psi Progam Name: PIPE-FLO Professional	APPL.pipe onal	Calculati Laminar Max	Calculation Method: Darcy-Weisbach Laminar Cutoff Re: 2100 Max Iterations: 100		Company: EBDG Project: 16101 by: LGB		
Version: 15.2.37316		Percent Allowable	Percent Tolerance: 0.01 Allowable Deviation: 1 %	Date: Atmospheric Pressure:	Date: Thursday, Augu sure: 14.7 psia	Date: Thursday, August 03, 2017 10:12 AM ssure: 14.7 psi a	
			Pipe Specificatio	suc			
Specification Name Valve Table	Material Schedule	Absolu Hazen W	Absolute Roughness Sizi Hazen Williams C Factor	Sizing Criteria	Velocity	Design Limits Pressure	Reynolds Number
Copper Tube, K - Discharge standard	Copper Tube H23 Schedule:K		6E-05 in 8.0 140	8.0 ft/s Min:	ti fi/s fi/s	15 psig 80 psig	
Copper Tube, K - Suction standard	Copper Tube H23 Schedule:K		6E-05 in 4.0 140	4.0 ft/s Min: Max:	r: ft/s c: ft/s	psig psig	
Steel ASTM A53 standard	Steel A53-B36.10 Schedule:40		1.800E-03 in 0.0 140	Min: Max:	t: ft/s c: ft/s	psig psig	
			Fluid Zones				
Fluid Zone Name Table Name		Temperature Pressure Re	Fluid State Relative Molecular Mass	Density Viscosity	Vapor F Critical I	Vapor Pressure Specifi Critical Pressure Spec	Specific Heat Capacity (cp) Specific Heat Ratio (k)
Potable Water Water		60°F 60 psig	Liquid 18	62.37 lb/ft ² 1.105 cP	0.2564 3199	0.2564t psia 3199 psia	
			Sizing Pumps				
Pump Name		Suction Elevation Suction Pressure	on Discharge Elevation re Discharge Pressure	n Total Head e dP	Flow Rate	ate NPSHa	
Sizing Pump 3		2.5 ft 1.528 psig	2.5 ft 50.68 psig Pinelines	113.5 ft 49.15 psi	16 gpm	m 36.86 ft	
	ľ		Lipdings				
Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device later Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade or Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	e V&F Friction Factor re V&F Resistance K e V&F dP de V&F Head Loss
Discharge4	1.25 in	Sizing Pump 3	16 gpm	50.68 psi g	0.6787 psi	50 psig	0.02152
Copper Tube, K - Discharge Potable Water	1.245 in 5 ft	2.5 ft Pressure Tank4 2.5 ft	4.217 ft/s 36750 0.02255	50.56 psig 119.5 ft 119.2 ft	1.567 ft	49.88 psig 117.9 ft 117.7 ft	4.58 0.5487 psi 1.267 ft
Pipe 1 Steel ASTM A53 Potable Water	1.5 in 1.61 in 2 ft	Potable Water Tank3 2.5 ft Sizing Pump 5 2.5 ft	16 gpm 2.521 ft/s 28419 0.02647	2.166 psig 2.123 psig 7.5 ft 7.401 ft	0.05286 psi 0.122 ft	2.113 psig 2.07 psig 7.378 ft 7.279 ft	0.02018 0.84 0.03597 psi 0.08305 ft
Suction2 Copper Tube, K - Suction Potable Water	1.5 in 1.481 in 20 ft	Steing Pump 5 2.5 ft Steing Pump 3 2.5 ft	16 gpm 2.98 ft/s 30894 0.02343	2.113 psig 2.053 psig 7.378 ft 7.24 ft	0.5852 psi 1.351 ft	1.528 psig 1.468 psig 6.027 ft 5.889 ft	0.0206 5.99 0.3582 psi 0.827 ft
			Tanks				
Tank Name Fluid Zone	Bottom Elevation Liquid Level	Surface Pressure Bottom Pressure	Hydraulic Grade	Pipeline Name Pene	Connecting Pipelines Penetration Height Pipeline F	low Rate	Pressure at Penetration
Potable Water Tank3 Potable Water	2.5 ft 5 ft	0 psig 2.166 psig	7.5 ft				
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			Tanks				
Tank Name	Bottom Elevation	Surface Pressure	Hydraulic Grade		Connectir	Connecting Pipelines	
Fluid Zone	Liquid Level	Bottom Pressure		Pipeline Name	Penetration Height	Pipeline Flow Rate	Pipeline Name Penetration Height Pipeline Flow Rate Pressure at Penetration
Potable Water Tank3 Potable Water	2.5 ft 5 ft	0 psig 2.166 psig	7.5 ft				
				Pipe 1	0 ft	16 gpm	2.166 psi g
			Nodes				
Node Name			Elevation	Pressure	Hydraulic Grade		
Sizing Pump 5			2.5 ft	2.113 psig	7.26 ft		
			Pressure Boundaries	ndaries			
Pressure Boundary Name			Elevation	Pressure	Hydraulic Grade	Flow Rate	
Pressure Tank4			2.5 ft	50 psig	117.7 ft	16 gpm	

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		Bill of	f Materials Repo	ort		
Lineup: Program Name:					16101 LGB	st 03, 2017 10:12 AM
veraion.	10.2.01010		Sizing Pumps	Date.	Thorsoul, raga	100,2011 10:1274
Sizing Pump Na Operation	me				Flow Rate	Design Point Total Head
Sizing Pump 3 Flow @ 16 gpr	m				16 gpm	113.5 ft
			Tanks			
Tank Name						
Potable Water Ta	ink3					
			Pipelines			
Pipeline		Specification	Size	Length	Valves a	nd Fittings
Discharge4		Copper Tube, K - Discharge	1.25 in	5 ft		Flow Thru Branch v - Standard 90°
Pipe 1		Steel ASTM A53	1.5 in	2 ft	1 x Entra 1 x Ball	ince - Inward
Suction2		Copper Tube, K - Suction	1.5 in	20 ft	6 x Elboy	ince - Inward v - Standard 90° Flow Thru Branch her
		Pipe	line Material Sum	imary		
Specification	N	laterial	Size	Total Length	n Valves & I	Fittings
Copper Tube, K -		copper Tube H23 ichedule: K	1.25 in	5.00 ft		- Standard 90° Iow Thru Branch
Copper Tube, K -		opper Tube H23 chedule: K	1.5 in	20.00 ft	1 x Entran 1 x Straine	- Standard 90° ce - Inward r flow Thru Branch
Steel ASTM A53	-	iteel A53-B36.10 ichedule: 40	1.5 in	2.00 ft	1 x Ball 1 x Entran	ce - Inward

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