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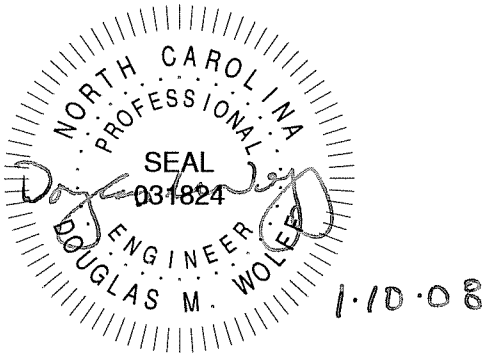

New Sound Class Ferry Design

HVAC Calculations

Prepared for: NC DOT Ferry Division • Raleigh, NC

Ref: 07069-001-514-1 Rev - **January 10, 2008**

Elliott Bay Design Group
Architectural & Engineering Services for the Marine Industry

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
-	Initial issue	1/10/08	DMW 031824

PURPOSE

The purpose of these calculations is to determine the preliminary air flow and power requirements of the vessel's heating, ventilation and air-conditioning (HVAC) system components.

PROCEDURE

Engine room air flow requirements were determined by establishing a ratio of air flow per installed brake horsepower. This ratio was then used to calculate the air flow required at each fan discharge. Passenger cabin air flow was determined by applying a nominal ratio of airflow/person to the 300 person capacity. The required air flow for the pilothouse was determined by assuming a number of air changes/hour.

With the air flows established, assumptions were made for duct sizes, lengths, number of bends, reductions in duct size, etc. These assumptions were modeled in spreadsheets representing each duct. The spreadsheets were then used to calculate flow losses and fan static pressure. Where necessary the duct sizes were increased to reduce flow losses.

Heating and cooling loads for the passenger cabin, pilothouse, top deck and below deck crew quarters were determined using the AHSRAE GRP 158 Cooling and Heating Load Calculation Manual. Internal and external load factors, along with correction factors, were determined using the ASHRAE methodology and modeled in spreadsheets to represent specific power demands for individual spaces. Individual spaces were then grouped to create cooling and heating load zones, for which heating and cooling coils were sized in accordance with manufacturer recommendations.

GIVEN AND ASSUMED PARAMETERS

Design conditions for HVAC calculations are as follows:

Ambient conditions:

Summer air:	90° F at 80% RH
Summer water:	85° F
Winter air:	30° F at 60% RH
Winter water:	46° F

Inside conditioned air:

Summer:	72° F at 50% RH
Winter:	68° F at 50% RH

Assumptions for airflow ratios and heat loss coefficients are shown in the attached calculations. Ducting lengths and fittings were estimated based on the vessel's preliminary arrangement drawing. Final selection of HVAC components, such as chillers, pumps, air handling units

(heating and cooling), fan coil duct units and ventilation fans shall be based on final vessel design data.

CONCLUSION

Based on the preliminary air flow and duct loss calculations the following values of flow and static pressure were determined for the ventilation supply fans:

Ventilation Fan	Static Pressure (in H_2O)	Flow Rate (CFM)	HP
Engine Room supply fan #1 (stbd ducting)	2.259	6000	2.5
Engine Room supply fan #2 (port ducting)	2.409	6000	2.5
Engine Room exhaust fan	1.149	12000	5.0
Pilothouse and Top Deck (Zone 1)	0.798	2000	1.0
Passenger cabin (Zone 2A) including aft control station	1.954	3650	5.0
Passenger cabin (Zone 2B)	1.954	3650	5.0
Below deck crew quarters supply fan	1.133	2000	3.0
Bow thruster room supply fan	0.2	3000	0.5
Tank room supply fan	1.133	2500	1.0
Crew head exhaust fan	n/a	200	42 Watts
Passenger head exhaust fan	n/a	400	68 Watts

Based on the preliminary heat loss calculations heater sizes and quantities were determined to be as follows:

Heater	Quantity	Power ea. (kW)
Pilothouse window defogger system	1	4.5
Pilothouse main heat (duct heater)	2	3.0
Top deck main heat (duct heater)	1	3.0
Top house head convection heater	1	0.5
Passenger cabin pre-heater	2 (1 per air handler)	15.0
Passenger toilet space convection heaters	2 (1 per head)	2.25
Below deck crew quarters pre-heater	1	8.0
Crew stateroom convection heat	3 (1 per SR)	0.5
Crew head convection heat	3 (1 per head)	0.5
Below deck crew quarters duct heater	1	2.5
Bow thruster room convection heater	1	1.125
Tank room convection heater	2	1.125
Engine Room convection heater	2	1.125
Emergency generator convection heater	1	0.5
HVAC fan room (1)	1	1.125
HVAC fan room (2)	1	1.125

Based on the preliminary cooling load calculations, AC zone components sizes were determined to be as follows:

Cooling	Carrier Unit Type	CFM Required (ea. unit)	AC (tons ea. unit)
Pilothouse (Qty 2 – duct fan coil unit)	42DFA	1000	2.5
Top Deck (Qty 1 – duct fan coil unit)	42DFA	1000	1
Passenger cabin (port), Zone 2A (Qty 1 – air handling unit)	39LA	3650	21
Passenger cabin (stbd), Zone 2B (Qty 1 – air handling unit)	39LA	3650	21
Aft control station, Zone 2C included in Zone 2A	n/a	50	1.25
Below deck crew quarters, Zone 3 (Qty 1 – air handling unit)	39LA	2000	6.5

Based on the preliminary cooling load calculations, AC main chiller requirements were determined to be as follows:

Cooling	Carrier Unit Type	AC (tons ea. unit)
Chilled water unit (Qty 2 – reciprocating liquid chiller)	90YNH7-DUAL	60

REFERENCES

1. Technical Specification, 07069-001-832-1.
2. Profiles and Deck Arrangements, 07069-001-101-1.
3. Marine Engineering, SNAME, Harrington, 1992.

Appendix A

HVAC Calculations

Givens: Air conditioning shall be a chilled water system. Piping shall be 316. Pumps shall be Flomax. Provide two Carrier Compressors – each one will be capable of 100% service alone. Dual chillers provides for backup.

Ambient conditions:

Summer air: 90 degrees at 80% rh	Seawater Temp
Summer water: 85 degrees	Summer: 85 degrees
Winter air: 30 degrees at 60% rh	Winter: 46 degrees

Inside conditioned air:

Summer 72 degrees at 50% rh
Winter 68 degrees

Provide 10% makeup air. Provide at least two A/C outlets in the pilothouse.

Conditioned Spaces	Length (in)	Width (in)	Height (in)	Surface Area (in^2) Roof/Ceiling	Floor	Wall (Port)	Wall (Stbd)	Wall (Fwd)	Wall (Aft)	Room Volume
Lower Deck										
Crew Quarters	378	470	90	177660	177660	34020	34020	42300	42300	9253.125
Crew Head (Qty 2)	96	36	90	3456	3456	8640	8640	3240	3240	180
Galley	180	138	90	24840	24840	16200	16200	12420	12420	1293.75
										0
Passenger Deck										0
Seating Area	875	546	88	477750	477750	77000	77000	48048	48048	24329.86111
Passenger Head (Qty 2)	175	140	88	24500	24500	15400	15400	12320	12320	1247.685185
										0
Pilot House / Top House										0
Pilot House	212	432	88	91584	91584	18656	18656	38016	38016	4664
Hall	312	72	86	22464	22464	26832	26832	6192	6192	1118
Office	110	94	86	10340	10340	9460	9460	8084	8084	514.6064815
Head	110	36	86	3960	3960	9460	9460	3096	3096	197.0833333
Aft Control Station	88	81	88	7128	7128	7744	7744	7128	7128	363

NOTES:	Description	U-Factor
Assumption - Roof No. 1 and Wall Group G are approximately same U-Factor	Table 3.8, Roof (No 1)	0.213
Adjacent Conditioned Spaces are Considered Balanced	Table 3.9, Outside Wall (above wa	0.213
	Table 3.9, Inside Wall	0.213
	Table 3.9, Outside Wall (below wal	0.213
	Table 3.14, Glass (1/4" Gap, Doub	0.58
	Table 3.8, Roof (w/ Suspended Ce	0.092

Load Calculation	ASHRAE Ref.1	Glass q=U*A*TD	Structure q=U*A*TD	External LoadsTotal q			
Pilot House / Top House					**Pilot House kW**		**Total kW**
Pilot House Roof	Table 3.8, Roof (No 1)		5147.784	5147.784	18231.28622	**5.287073004**	**58.1514043**
Pilot House Walls (P,S,F)	Table 3.14, Glass (50% Single Glass), Table 3.9, Outside Wall (50% Group G)	4336.982222	928.112	5265.094222			
Pilot House Walls (A)	Table 3.14, Glass (50% Single Glass), Table 3.9, Inside Wall (50% Group G)	1068.408	0	1068.408			

Hall Roof	Table 3.8, Roof (No 1)		1262.664	1262.664	**Hall, Office, Top House Head**	
Hall Walls (S,A)	Table 3.9, Outside Wall (Group G)		1508.182	1508.182	5584.481	**1.61949949**
Office	Table 3.8, Roof (No 1)		581.1941667	581.1941667		
Office Walls (P)	Table 3.9, Outside Wall (Group G)		531.7308333	531.7308333		
Top House Head	Table 3.8, Roof (No 1)		222.585	222.585		
					Aft Control Station	
Aft Control Station Walls (P,S,F,A)	Table 3.14, Glass (50% Glass), Table 3.9, Outside Wall (50% Group G)	2276.242222	835.9303333	3112.172556	3112.172556	**0.902530041**
Passenger Deck						
Seating Area Roof	Table 3.8, Roof (No 1)		9619.325542	9619.325542	**Passenger Deck**	
Seating Area Walls (P,S,F,A)	Table 3.14, Glass (50% Single Glass), Table 3.9, Outside Wall (50% Group G)	19139.29111	7028.739667	26168.03078	101103.8494	**29.32011632**
Lower Deck					**Crew Quarters**	
Crew Quarters Roof	Table 3.8, Roof (No 1 w/ Suspended Ceiling)		2497.11	2497.11	39256.38	**11.3843502**
Crew Quarters Floor	Table 3.8, Roof (No 1 w/ Suspended Ceiling)		2497.11	2497.11		
Crew Quarters Walls	Table 3.9, Outside Wall (Group G)		4967.16	4967.16		

Ventilation	**Number of Occupants**	**Air Changes (CFM**	**Makeup Air**	**q=4.5*CFM*delta(**	**delta(h)**	
Top House Head		32.84722222	16.42361111	1478.125	20	**0.42865625**
Passenger Head - Qty 2		415.8950617	41.58950617	3743.055556	20	**1.085486111**
Crew Quarters Head - Qty 2		60	60	5400	20	**1.566**
Crew Quarters Galley		810	405	3645	20	**1.05705**
Top House Deck	15	2121.703704	75	6750	20	**1.9575**
Passenger Deck	225	6841.493056	684.1493056	61573.4375	20	**17.85629688**
Lower Deck	15	837.65625	225	20250	20	**5.8725**

Additional Heating Loads	**Area (Ft^2)**	**Makeup Air**	**q=U*A*TD**	**q Makeup Air**	
Bowthruster Room					
Roof	793.125	634.5	0	4911.03	**1.4241987**
Floor	793.125		0	0	
Walls	1603.875		0	0	
Engine Room / EOS			0	0	
Roof	1455	1164	0	9009.36	**2.6127144**
Floor	1455		0	0	
Walls	918		0	0	
Tank Room			0	0	
Roof	1566.666667	1253.333333	0	9700.8	**2.813232**
Floor	1566.666667		0	0	
Walls	665.8333333		0	0	
Emergency Generator Room				0	
Roof	87.80555556	70.24444444	74.81033333	543.692	**0.198442312**
Floor	87.80555556		0	0	
Walls	77.20833333		65.7815	0	
HVAC Fan Room (1)				0	
Roof	793.125	0	6419.55375	0	**2.589247836**
Floor	793.125		0		
Walls	619.9375		2508.887063		
HVAC Fan Room (2)					
Roof					
Floor					
Walls					

NOTE: VALUES ARE INCLUDED IN OVERALL HEAT LOAD REQUIREMENTS

Air conditioning shall be a chilled water system. Piping shall be 316. Pumps shall be Flomax. Provide two Carrier Compressors – each one will be capable of 100% service alone. Dual chillers provides for backup.

Ambient conditions:

Summer air: 90 degrees at 80% rh
Summer water: 85 degrees
Winter air: 30 degrees at 60% rh

Seawater Temp
Summer: 85 degrees
Winter: 46 degrees

Inside conditioned air:

Summer 72 degrees at 50% rh
Winter 68 degrees

Provide 10% makeup air. Provide at least two A/C outlets in the pilothouse.

Conditioned Spaces				Surface Area (in^2)						Room Volume
	Length (in)	Width (in)	Height (in)	Roof/Ceiling	Floor	Wall (Port)	Wall (Stbd)	Wall (Fwd)	Wall (Aft)	
Lower Deck										9253.125
Crew Quarters	378	470	90	177660	177660	34020	34020	42300	42300	180
Crew Head (Qty 2)	96	36	90	3456	3456	8640	8640	3240	3240	1293.75
Galley	180	138	90	24840	24840	16200	16200	12420	12420	0
										0
Passenger Deck										24329.86111
Seating Area	875	546	88	477750	477750	77000	77000	48048	48048	1247.685185
Passenger Head (Qty 2)	175	140	88	24500	24500	15400	15400	12320	12320	0
										0
Pilot House / Top House										4664
Pilot House	212	432	88	91584	91584	18656	18656	38016	38016	1118
Hall	312	72	86	22464	22464	26832	26832	6192	6192	514.6064815
Office	110	94	86	10340	10340	9460	9460	8084	8084	197.0833333
Head	110	36	86	3960	3960	9460	9460	3096	3096	363
Aft Control Station	88	81	88	7128	7128	7744	7744	7128	7128	0

NOTES:

Assumption - Roof No. 1 and Wall Group G are approximately same U-Factor

Adjacent Conditioned Spaces are Considered Balalanced

Assume Glass is Double pane with 0.25" air gap - no shading

Description	U-Factor Correction	U-Factor	CLTD
Table 3.8, Roof (No 1)	4.875	0.213	14
Table 3.9, Outside Wall (above waterline)	4.875	0.213	14
Table 3.9, Inside Wall	-2.625	0.213	14
Table 3.9, Outside Wall (below waterline)	8.625	0.213	14
Table 3.14, Glass	4.875	0.58	14
Table 3.8, Roof (w/ Suspended Ceiling)	4.875	0.092	15

Load Calculation	ASHRAE Ref.1	Glass q=A*SC*SHGF*CLF	+ q=U*A*CLTD Outside Structure q=U*A*CLTD	External LoadsTotal q			Total Cooling (Tons) Required
Pilot House / Top House					**Pilot House AC**	**Tons**	**55.00526197**
Pilot House Roof	Table 3.8, Roof (No 1)		2556.9585	2556.9585	55469.79189	**4.622297758**	
Pilot House Walls (P,S,F)	Table 3.14, Glass (80% Glass), Table 3.9, Outside Wall (20% Group G)	36148.98007	184.4012	36333.38127			
Pilot House Walls (A)	Table 3.14, Glass (80% Glass), Table 3.9, Inside Wall (20% Group G)	16451.52432	127.9278	16579.45212			
Hall Roof	Table 3.8, Roof (No 1)		627.1785	627.1785	**Hall, Office, Top House Head AC**		
Hall Walls (S,A)	Table 3.9, Outside Wall (Group G)		922.006	922.006	13005.16697	**1.083720564**	
Office	Table 3.8, Roof (No 1)		288.6852604	288.6852604			
Office Walls (P)	Table 3.9, Outside Wall (Group G)		264.1163021	264.1163021			
Top House Head	Table 3.8, Roof (No 1)		110.5603125	110.5603125			
					Aft Control Station AC		
Aft Control Station Walls (P,S,F,A)	Table 3.14, Glass (80% Glass), Table 3.9, Outside Wall (20% Group G)	14280.44141	166.0861583	14446.52757	14446.52757	**1.203829143**	
Passenger Deck							
Seating Area Roof	Table 3.8, Roof (No 1)		9556.040505	9556.040505	**Passenger Deck AC**		
Seating Area Walls (P,S,F,A)	Table 3.14, Glass (80% Glass), Table 3.9, Outside Wall (20% Group G)	120074.0074	1396.499592	121470.507	497415.4477	**41.44962926**	
Lower Deck					**Crew Quarters AC**		
Crew Quarters Roof	Table 3.8, Roof (No 1 w/ Suspended Ceiling)		2255.911875	2255.911875	79752.61305	**6.645785245**	
Crew Quarters Floor	Table 3.8, Roof (No 1 w/ Suspended Ceiling)		2255.911875	2255.911875			
Crew Quarters Walls	Table 3.9, Outside Wall (Group G)		5108.2725	5108.2725			**Due to passengers / crew**

Ventilation	Number of Occupants	Air Changes (CFM)	Makeup Air	Q (sensible)	Q (latent)	q (latent) - gained	q (sensible) - gained
Top House Head		32.84722222	16.42361111	319.275	1200.303194		
Passenger Head - Qty 2		415.8950617	207.9475309	823.4722222	15197.63735		
Crew Quarters Head - Qty 2		60	60	1188	4385.04		
Crew Quarters Galley (Makeup for Hood Exhaust)		810	405	8019	29599.02		
Top House Deck	5	2121.703704	75	1485	5481.3	1250	1000
Passenger Deck	225	6841.493056	3375	13546.15625	246658.5	46125	43875
Lower Deck	15	837.65625	225	4455	16443.9	3075	2925

Internal Loads	Lighting Load kW	Watts/ ft^2	Q (sensible)
Top House/Pilot House Deck	0.8	0.897559759	56.7424
Passenger Deck	2.3	0.693249608	163.1344
Lower Deck	0.6	0.486322188	42.5568

Additional Heating Loads	Area (Ft^2)	Room Volume	Air Change CFM	HP/kW	Ratio Method Factor	CFM
Bowthruster Room				503	6	**3018**
Roof	793.125	6345	1269			
Floor	793.125		0			
Walls	1603.875		0			
Engine Room / EOS			0	2000	6	**12000**
Roof	1455	11640	2328	350	7.8	**2730**
Floor	1455		0			
Walls	918		0			
Tank Room			0			
Roof	1566.666667	12533.33333	**2506.666667**			
Floor	1566.666667		0			
Walls	665.8333333		0			
Emergency Generator Room			0	100	7.8	**780**
Roof	87.80555556	702.4444444	140.4888889			
Floor	87.80555556		0			
Walls	77.20833333		0			
HVAC Fan Room (1)	n/a		0			
Roof						
Floor						
Walls						
HVAC Fan Room (2)	n/a					
Roof						
Floor						
Walls						

Flaktwoods Fan (kW) 460V /3 Ph (for informational purposes)	
	0.3
	3.12
	0.9
	0.1

Space	**CFM**	(avg)
Top Deck	2155	2000
Passenger Deck	7257	7250
Below Deck	1708	1700
Pilot House	925	900
Aft Control Station	24.2	25

Pilot House & Top Deck

ITEM DESCRIPTION	dimensions	area (ft^2)	Qty	flow (ft^3/min)	v (ft/min)	length (ft)	h_v (in H_2O)	K	ΔP (in H_2O) per 100 ft	ΔP (in H_2O)	
Main Run											
inlet louver w/screen (50%) free area	24" x 24"	2		2000	1000.00		0.062	3.000		0.187	
contraction 1: 0.3	22" diam	2.64		2000	757.58		0.036	0.330		0.012	estimated K value
pre-heater / air exchanger	22" diam	2.64		2000	757.58		0.036	2.300		0.082	estimated K value
circular duct	20" diam	2.64		2000	757.58	30			0.280	0.084	
90° elbow (r/d = 1)	20" diam	2.18	3	2000	917.43		0.052	0.330		0.052	
circular duct	20" diam	2.18		2000	917.43	30			0.13	0.039	
heater / AC coil	20" diam	2.18		2000	917.43		0.052	2.300		0.121	estimated K value
longest run branch (assumed to have greatest losses) ends at aft control station											
fire damper (10% blockage)	20" diam	2.18		2000	917.43		0.052	0.200		0.010	
circular duct	20" diam	2.18		2000	917.43	5			0.22	0.011	
tee w/ splitter (run)	20" diam	2.18		2000	917.43		0.052	0.000		0.000	
circular duct	18" diam	1.76		1600	909.09	25	2		0.22	0.055	
tee w/ splitter (branch)	18" diam	2.76		1600	579.71		0.021	0.330		0.007	
tee w/ splitter (run)	15" diam	1.22		1200	983.61		0.060	0.000		0.000	
circular duct	15" diam	1.22		1200	983.61	12			0.13	0.016	
tee w/ splitter (run)	15" diam	1.22		800	655.74		0.027	0.000		0.000	
circular duct	14" diam	1.07		800	747.66	12			0.13	0.016	
tee w/ splitter (run)	14" diam	1.07		800	747.66		0.035	0.000		0.000	
tee w/ splitter (run)	14" diam	1.07		400	373.83		0.009	0.000		0.000	
circular duct	14" diam	1.07		400	373.83	8			0.13	0.010	
tee w/ splitter (run)	12" diam	0.785		200	254.78		0.004	0.000		0.000	
circular duct	8" diam	0.349		200	573.07	8			0.13	0.010	
terminal	8" diam	0.349		200	573.07		0.020	2.000		0.041	estimated K value
										0.712	**total inlet losses**

most restrictive exhaust exit is through the cold air return ducting
it is assumed that one 200 cfm fans draw exhaust from each toilet space. Therefore the remainder of the flow to the upper deck cabin is returned through ducting to recirculation

cold air return (inlet)	20" diam	2.18		2000	917.43		0.052	2.000		0.105	
circular duct	20" diam	2.18		2000	917.43	115			0.22	0.253	
fire damper (10% blockage)	20" diam	2.18		2000	917.43		0.052	0.200		0.010	
90° elbow (r/d = 1)	20" diam	2.18	3	2000	917.43		0.052	0.330		0.052	
exit	20" diam	2.18	1	2000	917.43		0.052	1.100		0.058	
										0.420	**total exit losses = total cabin pressure**
										1.133	**total supply fan pressure required**

The previous duct sizes can be re-used as they yield no significant increase in flow velocity or in total fan pressure

Use fan rated for **2000** **1.133** in H_2O s.p.

NOTES
K values and unit losses for ducting taken from Ref 1
Ducting components taken from Ref 2
Duct lengths estimated from Ref 3
Estimated K values taken from Ref 4

Pilot House & Top Deck

ITEM DESCRIPTION	dimensions	area (ft^2)	Qty	flow (ft^3/min)	v (ft/min)	length (ft)	h_v (in H_2O)	K	ΔP (in H_2O) per 100 ft	ΔP (in H_2O)	
Main Run											
inlet louver w/screen (50%) free area	24" x 24"	2		2000	1000.00		0.062	3.000		0.187	
contraction 1: 0.3	20" diam	2.18		2000	917.43		0.052	0.330		0.017	estimated K value
circular duct	20" diam	2.64		2000	757.58	10			0.280	0.028	
90° elbow (r/d = 1)	20" diam	2.18	2	2000	917.43		0.052	0.330		0.035	
circular duct	20" diam	2.18		2000	917.43	5			0.13	0.007	
heater / AC coil	20" diam	2.18		2000	917.43		0.052	2.300		0.121	estimated K value
longest run branch (assumed to have greatest losses) ends at aft control station											
fire damper (10% blockage)	20" diam	2.18		2000	917.43		0.052	0.200		0.010	
circular duct	20" diam	2.18		2000	917.43	5			0.22	0.011	
tee w/ splitter (run)	20" diam	2.18		2000	917.43		0.052	0.000		0.000	
circular duct	18" diam	1.76		1820	1034.09	4	2		0.22	0.009	
tee w/ splitter (run)	18" diam	1.76		1820	1034.09		0.067	0.000		0.000	
circular duct	15" diam	1.22		1460	1196.72	12			0.13	0.016	
tee w/ splitter (run)	15" diam	1.22		1460	1196.72		0.089	0.000		0.000	
circular duct	14" diam	1.07		1100	1028.04	28			0.13	0.036	
tee w/ splitter (run)	14" diam	1.07		1100	1028.04		0.066	0.000		0.000	
tee w/ splitter (run)	14" diam	1.07		920	859.81		0.046	0.000		0.000	
circular duct	14" diam	1.07		920	859.81	8			0.13	0.010	
tee w/ splitter (run)	12" diam	0.785		740	942.68		0.055	0.000		0.000	
circular duct	8" diam	0.349		370	1060.17	10			0.13	0.013	
tee w/ splitter (run)	8" diam	0.349		370	1060.17		0.070	0.000		0.000	
circular duct	8" diam	0.349		370	1060.17	10			0.13	0.013	
terminal	8" diam	0.349		370	1060.17		0.070	2.000		0.140	estimated K value
										0.513	**total inlet losses**

most restrictive exhaust exit is through the cold air return ducting
it is assumed that one 200 cfm fans draw exhaust from each toilet space. Therefore the remainder of the flow to the upper deck cabin is returned through ducting to recirculation

cold air return (inlet)	18" diam	1.76		1800	1022.73		0.065	2.000		0.130	
circular duct	18" diam	1.76		1800	1022.73	45			0.22	0.099	
fire damper (10% blockage)	18" diam	1.76		1800	1022.73		0.065	0.200		0.013	
90° elbow (r/d = 1)	18" diam	1.76	2	1800	1022.73		0.065	0.330		0.043	
exit	20" diam	2.18	1	1800	825.69		0.043	1.100		0.047	
										0.286	**total exit losses = total cabin pressure**
										0.798	**total supply fan pressure required**

The previous duct sizes can be re-used as they yield no significant increase in flow velocity or in total fan pressure

Use fan rated for **2000** **0.798** in H_2O s.p.

NOTES
K values and unit losses for ducting taken from Ref 1
Ducting components taken from Ref 2
Duct lengths estimated from Ref 3
Estimated K values taken from Ref 4

Passenger Cabin - split into two (2) zones (2 fans and separate temperature controllers), Stbd / Port, Port zone feeds aft control station

ITEM DESCRIPTION	dimensions	area (ft^2)	Qty	flow (ft^3/min)	v (ft/min)	length (ft)	h_v (in H_2O)	K	ΔP (in H_2O) per 100 ft	ΔP (in H_2O)	
One Zone											
inlet louver w/screen	36" x 40"	5		3650	730.00		0.033	3.000		0.100	
contraction 1: 0.35	22" diam	2.64		3650	1382.58		0.119	0.380		0.045	
pre-heater / air exchanger	22" diam	2.64		3650	1382.58		0.119	2.300		0.274	estimated K value
circular duct	22" diam	2.64		3650	1382.58	10			0.280	0.028	
contraction 1: 0.3	22" to 20" diam	2.18		3650	1674.31		0.175	0.330		0.058	
90° elbow (r/d = 1)	20" diam	2.18	2	3650	1674.31		0.175	0.330		0.115	
circular duct	20" diam	2.18		3650	1674.31	5			0.13	0.007	
heater / AC coil (zone)	20" diam	2.18		3650	1674.31		0.175	2.300		0.402	estimated K value
longest run branch (assumed to have greatest losses) ends at aft control station											
fire damper (10% blockage)	20" diam	2.18		3650	1674.31		0.175	0.200		0.035	
circular duct	20" diam	2.18		3650	1674.31	5			0.22	0.011	
tee w/ splitter (run)	20" diam	2.18		3650	1674.31		0.175	0.000		0.000	
circular duct	18" diam	1.76		3042	1728.41	4			0.22	0.009	
tee w/ splitter (run)	18" diam	1.76		3042	1728.41		0.186	0.000		0.000	
circular duct	15" diam	1.22		2434	1995.08	28			0.13	0.036	
tee w/ splitter (run)	15" diam	1.22		2434	1995.08		0.248	0.000		0.000	
circular duct	14" diam	1.07		1826	1706.54	28			0.13	0.036	
tee w/ splitter (run)	14" diam	1.07		1826	1706.54		0.182	0.000		0.000	
tee w/ splitter (branch)	12" diam	0.785		1218	1551.59		0.150	0.330		0.050	
circular duct	12" diam	0.785		1218	1551.59	8			0.13	0.010	
tee w/ splitter (branch)	10" diam	0.545		853	1565.14		0.153	0.330		0.050	
tee w/ splitter (run)	10" diam	0.545		853	1565.14		0.153	0.000		0.000	
tee w/ splitter (branch)	4" diam	0.087		50	574.71		0.021	0.330		0.007	
90° elbow (r/d = 1)	4" diam	0.087		50	574.71		0.021	0.330		0.007	
circular duct	4" diam	0.087		50	574.71	15			0.16	0.024	
terminal	4" diam	0.087		50	574.71		0.021	2.000		0.041	estimated K value
										1.345	**total inlet losses**

most restrictive exhaust exit is through the cold air return ducting

it is assumed that two 400 cfm fans draw exhaust from each toilet space. Therefore the remainder of the flow to the passenger cabin is returner through ducting to reheater air exchanger

cold air return (inlet)	18" diam	1.76		2850	1619.32		0.163	2.000		0.327	
circular duct	18" diam	1.76		3042	1728.41	64			0.22	0.141	
fire damper (10% blockage)	18" diam	1.76		2850	1619.32		0.163	0.200		0.033	
90° elbow (r/d = 1)	18" diam	1.76	2	2850	1619.32		0.163	0.330		0.108	
exit	20" diam	2.18	1	2850	1307.34		0.107	1.100		0.117	
										0.608	**total exit losses = total cabin pressure**
										1.954	**total supply fan pressure required**

The previous duct sizes can be re-used as they yield no significant increase in flow velocity or in total fan pressure

Use fan rated for **3650** **1.954** in H_2O s.p.

NOTES

K values and unit losses for ducting taken from Ref 1
Ducting components taken from Ref 2
Duct lengths estimated from Ref 3
Estimated K values taken from Ref 4

Engine Room (0.2 in WG)

ITEM DESCRIPTION	dimensions	area (ft^2)	Qty	flow (ft^3/min)	v (ft/min)	length (ft)	h_v (in H_2O)	K	ΔP (in H_2O) per 100 ft	ΔP (in H_2O)	
fan #1											
inlet louver w/screen (50%) free area	36" x 40"	5		6000	1200.00		0.090	3.600		0.323	
fire damper (10% blockage)	36" x 40"	5		6000	1200.00		0.090	0.200		0.018	
contraction 1: 0.35	22" diam	2.64		6000	2272.73		0.322	0.380		0.122	
circular duct	22" diam	2.64		6000	2272.73	26			0.280	0.073	
90° elbow (r/d = 1)	22" diam	2.64	2	6000	2272.73		0.322	0.330		0.213	
exit	20" diam	2.18	1	5000	2293.58		0.328	1.100		0.361	
										1.110	**total**
fan#2											
inlet louver w/screen (50%) free area	36" x 40"	5		6000	1200.00		0.090	3.600		0.323	
fire damper (10% blockage)	36" x 40"	5		6000	1200.00		0.090	0.200		0.018	
contraction 1: 0.35	22" diam	2.64		6000	2272.73		0.322	0.380		0.122	
circular duct	20" diam	2.18		6000	2752.29	36			0.320	0.115	
tee w/ splitter (branch)	20" diam	2.18		5000	2293.58		0.328	0.330		0.108	
90° elbow (r/d = 1)	22" diam	2.64	2	6000	2272.73		0.322	0.330		0.213	
exit	20" diam	2.18	2	5000	2293.58		0.328	1.100		0.361	
										1.260	**total**
exhaust losses											
casing	158" x 63"	33.7		12000	356.08	40				negligible	
fire damper (10% blockage)	36" x 40"	5		12000	2400.00		0.359	0.200		0.072	
louver w/ mesh (50 % free area)	36" x 40"	5		12000	2400.00		0.359	3.000		1.077	
										1.149	

total inlet loss = main loss + branch 1 loss

total inlet loss	**2.370**	**total**

total fan pressure = total inlet loss + exhaust loss

total fan pressure fan#1	**2.259**
total fan pressure fan#2	**2.409**

NOTES

K values and unit losses for ducting taken from Ref 1 **total**
Ducting components taken from Ref 2
Duct lengths estimated from Ref 3
Estimated K values taken from Ref 4

Appendix B

HVAC Equipment List

HVAC EQUIPMENT LIST

System Component	Component Function	Space Served	Qty	Manufacturer	Model No.	Power	Cooling Capacity	Heating Load (ea.)	Heating Load (total)	HP	RPM
Main Chiller	Cooling	All (Cooling)	2 (1 is backup)	Carrier	90YNH7-DUAL	208/230-3-60	60 Ton	-	-	-	-
BTR Supply Fan	Ventilation	Bow Thruster Room	1	Flaktwoods	50JM/20/4/3/14	208-3-60	-	-	-	0.5	-
Space Heater	Heating	Bow Thruster Room	1	Indeeco	932U01500V	120-1-60	-	1125 Watts	1125 Watts	-	-
Space Heater	Heating	Crew Head (ea.)	3 (total)	Indeeco	930U00500B	120-1-60	-	0.5 kW	1.5 kW	-	-
Air Handler #3	Cooling/Heating	Crew Quarters (Zone 3)	1	Carrier	SIZE 06 39MN	208-3-60	25 GPM @ 40F	10 kW	10 kW	3	1500
Space Heater	Heating	Crew Staterooms (ea.)	3 (total)	Indeeco	930U00500B	120-1-60	-	0.5 kW	1.5 kW	-	-
Space Heater	Heating	Emergency Generator Room	1	Indeeco	930U00500B	120-1-60	-	0.5 kW	0.5 kW	-	-
ER Exhaust Fan	Ventilation	Engine Room	1	Flaktwoods	100JM/40/6/6/13	208-3-60	-	-	-	5	-
ER Supply Fan #1	Ventilation	Engine Room	1	Flaktwoods	56JM/20/2/3/8	208-3-60	-	-	-	2.5	-
ER Supply Fan #2	Ventilation	Engine Room	1	Flaktwoods	56JM/20/2/3/9	208-3-60	-	-	-	2.5	-
Space Heater	Heating	Engine Room	2	Indeeco	932U01500V	120-1-60	-	1125 Watts	2.25 kW	-	-
Fan Coil Unit	Cooling	EOS	1	Carrier	42DFA, SIZE 800 CFM	208-3-60	10 GPM @ 40F	-	-	0.125	-
Space Heater	Heating	HVAC Room #1	1	Indeeco	932U01500V	120-1-60	-	1125 Watts	1125 Watts	-	-
Space Heater	Heating	HVAC Room #2	1	Indeeco	932U01500V	120-1-60	-	1125 Watts	1125 Watts	-	-
Air Handler #1	Cooling/Heating	Passenger (Zone 2A)	1	Carrier	SIZE 08 39MN	208-3-60	25 GPM @ 40F	15 kW	15 kW	5	1400
Air Handler #2	Cooling/Heating	Passenger (Zone 2B)	1	Carrier	SIZE 08 39MN	208-3-60	25 GPM @ 40F	15 kW	15 kW	5	1400
Space Heater	Heating	Passenger Head (ea.)	2	Indeeco	932U01500V	120-1-60	-	1125 Watts	2.25 kW	-	-
Ventilation Fan	Ventilation	Passenger Head (ea.)	2 (total)	Fantech	FADE 10-4	120-1-60	-	-	68 Watts	-	-
Fan Coil w/ Heater	Cooling/Heating	Pilot House	2 (total)	Carrier	42DFA08LLDF6AYYY	208-1-60	10 GPM @ 40F	3 kW	6 kW	0.125	-
Pilot House Window Defogger	Heating	Pilot House	15	Seaclear Industries	Model HS	120-1-60	-	0.3 kW	4.5 kW	-	-
TR Supply Fan	Ventilation	Tank Room	1	Flaktwoods	31JM/16/2/5/28	208-3-60	-	-	-	1	-
Space Heater	Heating	Tank Room	2	Indeeco	932U01500V	120-1-60	-	1125 Watts	2.25 kW	-	-
Fan Coil w/ Heater	Cooling/Heating	Top Deck (Hall, Office)	1	Carrier	42DFA08LLDF6AYYY	208-1-60	10 GPM @ 40F	3 kW	3 kW	0.125	-
Space Heater	Heating	Top Deck Head	1	Indeeco	930U00500B	120-1-60	-	0.5 kW	1.5 kW	-	-
Ventilation Fan	Ventilation	Top Deck Head	1	Panasonic	FV-20VQ3	120-1-60	-	42 Watts	42 Watts	-	-
Chilled Water Circ Pump	Cooling	All	2 (1 is backup)	TACO	FI SERIES 1206	208-3-60	100 GPM @ 50 TDH	-	-	3	3500
Chiller Sea-water Cooling Pump	Cooling	Chillers	2 (1 is backup)	TACO	KV SERIES 2508	208-3-60	195 GPM @ 20 TDH	-	-	1.5	1160

CARRIER MARINE HVAC POC:	**PHONE NO.**
SCOTT OGATA	315-432-3322