

# Ship HVAC Systems

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# AGENDA

- § Main components and suppliers
- § Different ventilated spaces in ship
- § Dimensioning of HVAC plant
- § HVAC Power consumption and space reservations

# Ship HVAC Systems

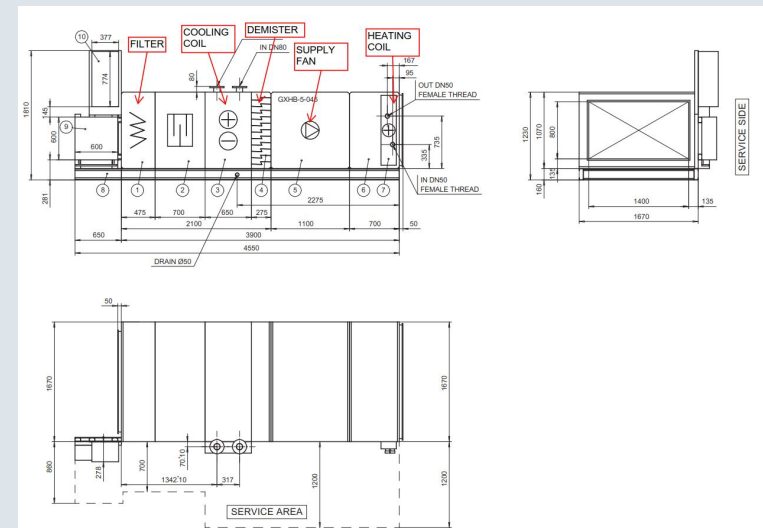
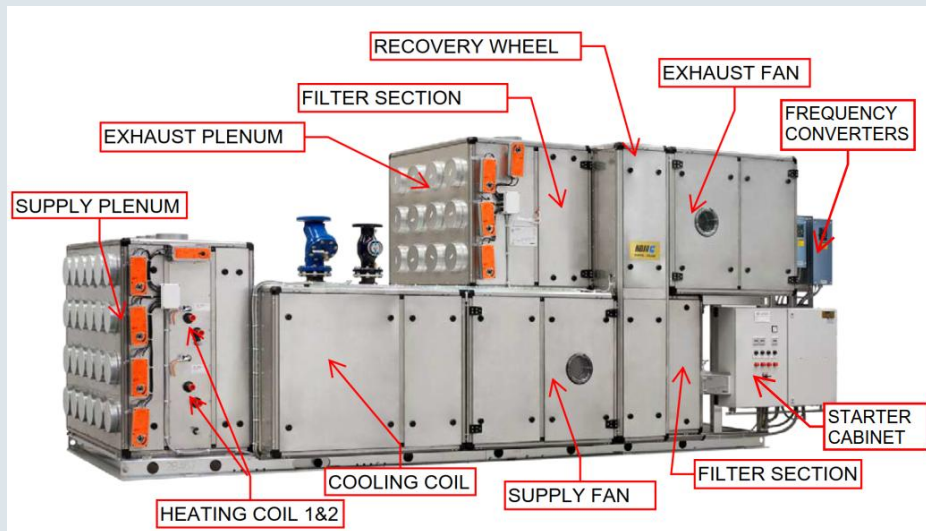
- § Rules and Regulations for ship HVAC systems
  - § IMO, SOLAS (Chapter II-2)
    - § Fire Safety
    - § SRtP (Safe Return to Port)
    - § WTI (Water tight integrity)
  - § Classification societies rules
    - § RINA, Lloyds, DNV, Bureau Veritas, etc.
  - § Flag state rules
  - § ILO
  - § USCG & USPH
  - § Ship technical specification
  - § Standards (ISO7547, ISO8861, ISO 9943, VDI2052)

# Main Components

- § Air Handling Units (AHUs)
- § Fan-coil units
  - § Cabin fan-coil units (CFCU)
  - § Public fan-coil units (AFCU)
  - § Technical Fan-coil units (TFCU)
- § Separate Fans
- § Hoods
- § Air Terminal devices and Dampers
- § AC Chillers

# Air Handling Unit (AHU)

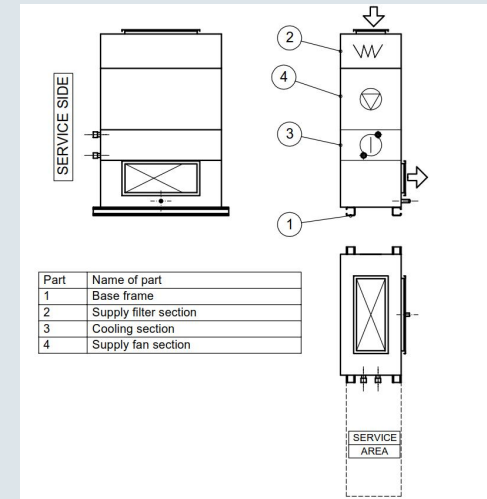
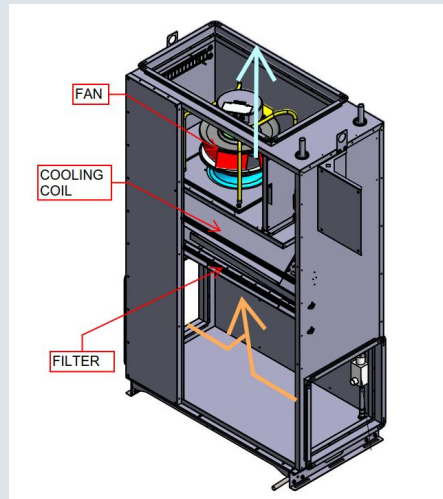
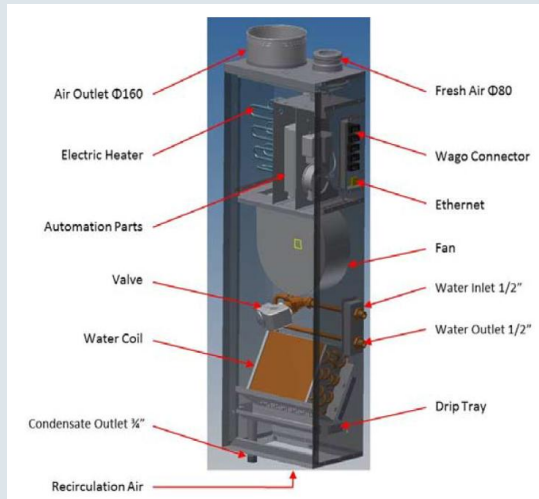
- § AHUs are used to provide Fresh Air, Cool and Heat spaces
- § Supply air filtered, cooled & dried and heated (if needed)
- § Exhaust air filtered, energy recovered
- § Manufacturers EuroClima, Fläktwoods, Koja, Novenco, System Air, Roggechiani





# Fan Coil unit (FCU)

- § CFCUs control individually each cabin temperature (Cooling & Heating)
- § AFCUs cool public spaces heat loads (AHU provides only fresh air)
- § TFCUs cover heat loads of technical spaces (El. rooms etc.)
- § Manufacturers Koja, EuroClima, Halton, Kampmann, System Air, Roggechiani



# Separate Fans

- § Separate fans used to supply untreated air and exhaust contaminated air from spaces
- § Axial fans used mainly on machinery spaces ventilation and smoke extraction where high capacities are needed
- § centrifugal fans used mainly in public spaces
- § Manufacturers Fläktwoods, Koja, Nicotra Gebhardt, Novenco, Witt & Sohn



# Hoods & Canopies

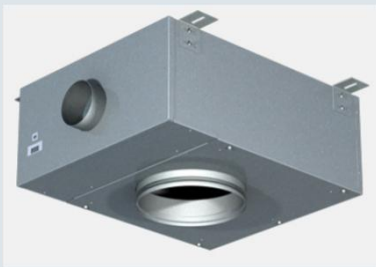
- § Hoods & Canopies used to exhaust contaminated air from galleys
- § Hoods placed above galley equipment (Greasy exhaust air) [SOLAS chp. II-2, pt.C, Reg. 9;7.5],  
Canopies moisture producing equipment (Dishwasher etc.) [USPH etc.]
- § Hoods equipped grease filters (Options automatic washing, UV-lights)
- § Canopies with direct exhaust without filtering
- § Manufacturers Halton, Seaking, Wagener, Vianen





# Air terminal devices and Dampers

- § Air terminal devices (ATDs)
  - § Plenum boxes for diffusers with options for CAV or VAV with or without electric heating
  - § Diffusers and valves used to distribute and control air flow to space
- § Dampers
  - § Fire and smoke dampers used to prevent fire/smoke spread acc. to rules and regulations
  - § VAV and CAV dampers use to control air flow to spaces
- § Manufacturers Climecon, Fläktwoods, Halton, Lindab



# AC Chillers

- § AC Chillers
  - § Generates the cooling water for AC and other systems
  - § Scroll, Screw or Centrifugal chillers
  - § Capacities ranging from 50 - 20000kW, max. size in cruise ships ~8000kW
  - § COP varying from 3 – 12, depending the system and ambient conditions
- § Manufacturers Carrier, Daikin, Engie, York

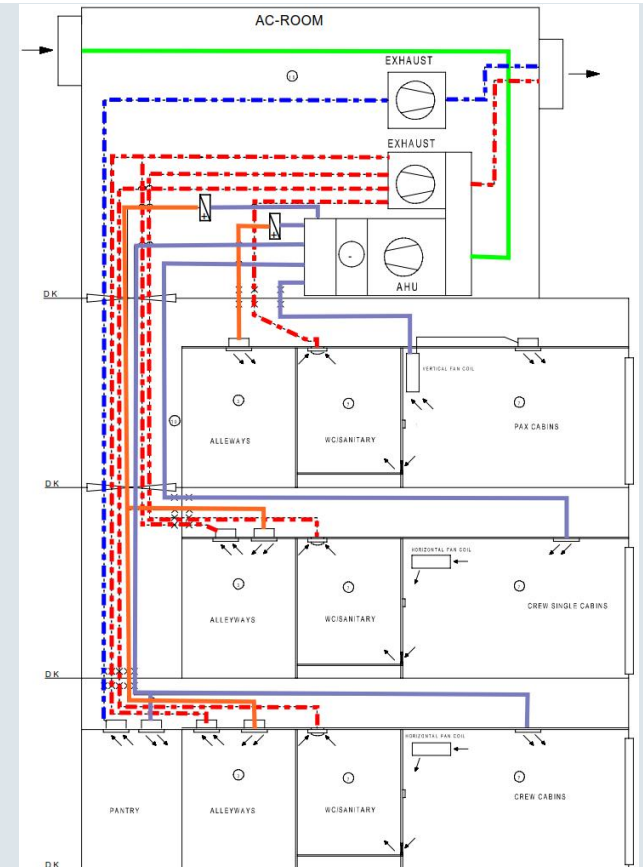


## HVAC spaces served

- § HVAC systems are divided to four different categories depending the space served (Following list is based on SOLAS II-2 Reg. 9 Chp. 7 [>36 pass. and >4000GT])
  - § Cabin system AHUs (Cabins, corridors, offices etc.)
  - § Public system AHUs (Restaurants, Casino, Theater etc.)
  - § Staircase system AHUs (Staircase, lift lobbies etc.)
  - § Service system AHUs (Galley, Laundries)
  - § Mechanical ventilation Systems (Machinery spaces)

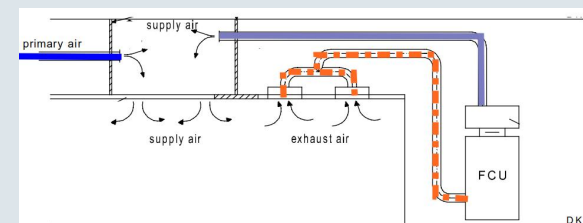
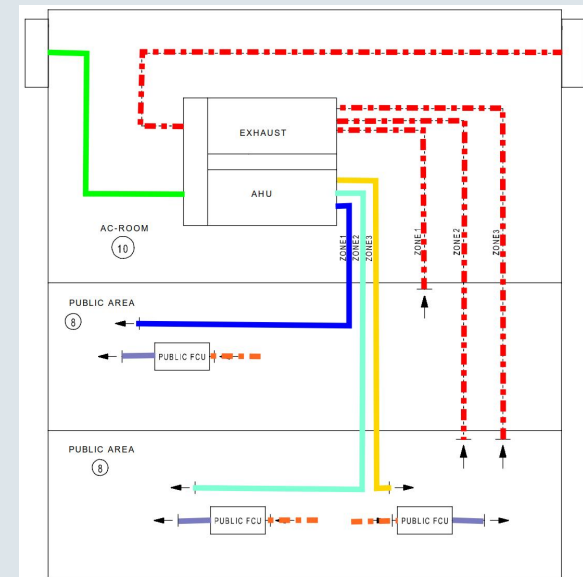
# Cabin system

- § Serves Cabins, Corridors, Offices, Technical spaces and other small spaces where constant fresh air flow is needed.
- § High pressure system (2500-3000Pa)
- § Depending ship specification cabins equipped with Fan-coils (CFCU) or with ATDs with electrical re-heating
- § Air distributed with spiral seam ducting, supply ducting pre-insulated, exhaust without insulation (Ø80-250mm), air speed <15m/s.



# Public system

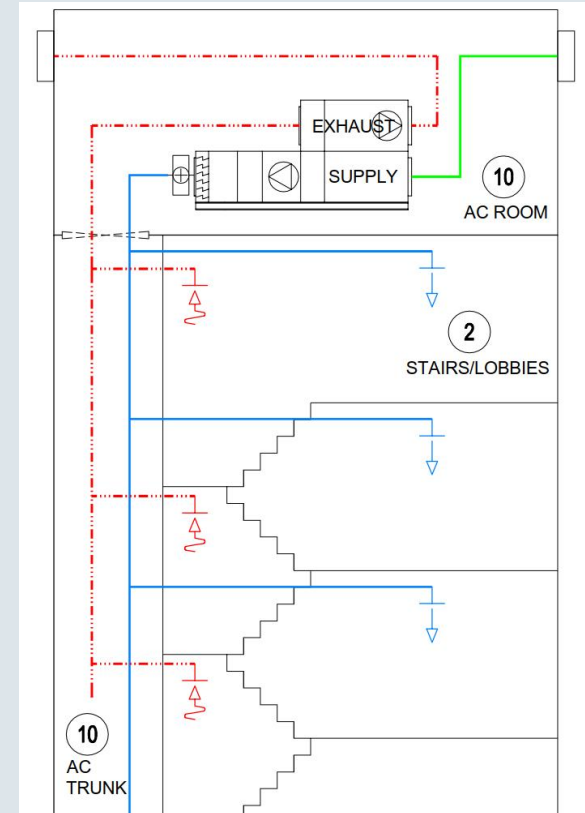
- § Serves public spaces (e.g. Restaurant, Theater, Casino)
- § Low pressure system (<2000Pa)
- § Supply air separated acc. to spaces served (separate heating zones), fresh air amount controlled with VAV-dampers
- § Depending ship specification, public areas are equipped with local fan-coils units or space is supplied only with AHU air
- § Air supplied with rectangular ducting, air speed <10m/s.
- § Air is distributed inside space through open ceiling construction, exhausts located above heat sources





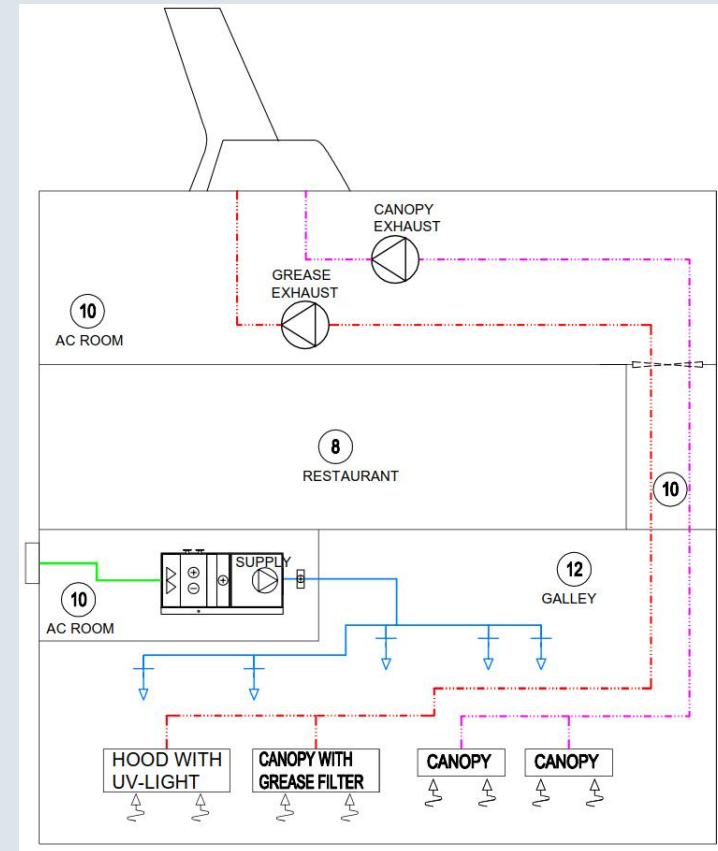
# Stairs system

- § Serves only Staircases (Solas Cat. 2 spaces)
- § Low pressure system (<2000Pa)
- § Air supplied with rectangular ducting, air speed <10m/s.
- § Depending ship specification AHUs with recovery wheel or with re-circulation construction



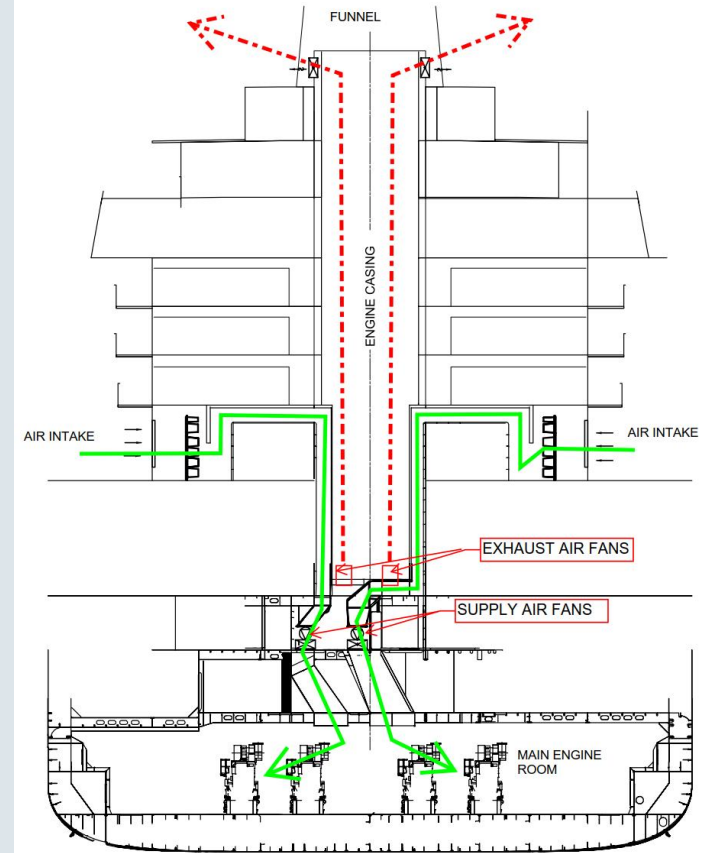
# Service system

- § Serves Galleys, Laundries and other spaces where treated supply air is needed and exhaust air contaminated
  - § Supply air temperatures ~20°C / RH70-90%
- § Low pressure system (<2000Pa)
- § Air supplied with rectangular ducting, air speed <10m/s.
- § Exhaust with separate fans
- § Hoods above cooking equipment (grease), canopies over moisture producing equipment (dishwashers etc.)
- § ~5% more exhaust than supply to keep contaminated air in space



# Mechanical ventilation system

- § Serves spaces where treated air is not needed
- § Machinery spaces (Main engine room, thruster rooms, etc.)
- § High air volumes (Calculation based ISO8861)
- § Ambient air temperature <math><45^{\circ}\text{C}</math>

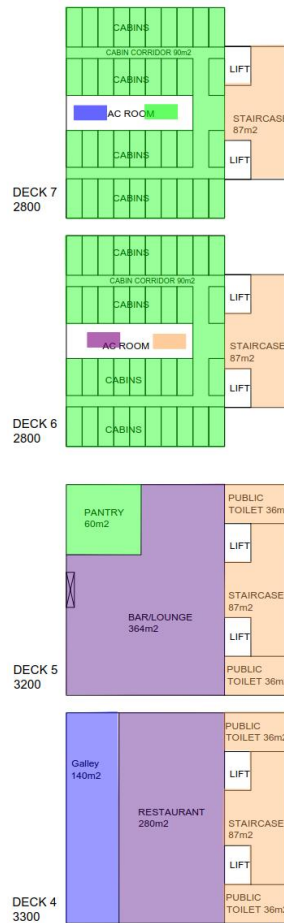


## HVAC system selection

- § Following factors should be considered when selecting the HVAC system
  - § Which ship is the system selected (Cruise ship, Yacht, Ferry, Merchant ship, Naval)
  - § Cost of the HVAC system
  - § Space efficiency of the HVAC system
  - § Energy consumption of HVAC system
  - § Comfort level and air quality
- § Ship specification and rules applied defines the HVAC system installed for ship
  - § Ambient conditions for dimensioning
    - § Baltic Sea Ferry; Ambient conditions summer 28°C / 75% RH (78kJ/kg) and inside temperature 23 °C / 50% RH
    - § Cruise Ship; Ambient conditions summer 32°C / 85% RH (98kJ/kg) and inside temperature 22 °C / 55% RH

# HVAC system example

- § Cruise ship example
- § Example of one vertical zone HVAC systems
  - § Cabin system (Green)
  - § Public system (Purple)
  - § Stairs system (Orange)
  - § Service system (Blue)





# HVAC system example

- § Example of capacity estimation for HVAC system (Cruise Ship)
- § Ship specification defines that fan-coils will be used to cover heat loads in cabins so only 75m<sup>3</sup>/h of fresh air per cabin is needed. For type spaces following air change table has been given.
- § Space volume calculated with interior heights, not steel to steel
- § Based on the given are arrangements and specification AHUs capacities would be following

Space	pcs	A (m <sup>2</sup> )	h (m)	x/h	m <sup>3</sup> /h
Cabins	76				5700
Cabin Corridor		180	2,1	3	1134
Pantry		60	2,1	10	1260
CABIN AHU					8094
Space	pcs	A (m <sup>2</sup> )	h (m)	x/h	m <sup>3</sup> /h
Bar / Lounge D5		364	2,6	12	11357
Restaurant D4		280	2,7	12	9072
PUBLIC AHU					20429
Space	pcs	A (m <sup>2</sup> )	h (m)	x/h	m <sup>3</sup> /h
Public toilet D5		72	2,5	6	1080
Public toilet D4		72	2,6	6	1123
Staircase D7		87	2,1	6	1096
Staircase D6		87	2,1	6	1096
Staircase D5		87	2,7	6	1409
Staircase D4		87	2,8	6	1462
STAIRS AHU					7267
Space	pcs	A (m <sup>2</sup> )	h (m)	x/h	m <sup>3</sup> /h
Galley		140	2,3	45	14490
SERVICE AHU					14490

Guideline for air change rates (Times per hour)		
	Supply	Exhaust
Cabins and equal spaces	6	6
Cabin corridors	3	3
Galleys	45	50
Pantries	10	10
Main Laundry	20	20
Staircases	6	6
Public Toilets	6	6
Public Spaces	12	12

# HVAC system selection

- § Following standards are used for more accurate calculations for specific capacities per space
  - § ISO7547 Air conditioning and ventilation of accommodation spaces (Most used)
  - § ISO8861 Engine room ventilation in diesel-engined ships (Most used)
  - § ISO9943 Ventilation and Air treatment of Galleys and Pantries with cooking appliances
  - § VDI2052 Ventilation equipment for kitchens (Defining exhaust amount per galley equipment)
  - § ASHRAE
  - § Eurovent

# HVAC Power Consumption

- § Main items influencing HVAC system energy consumption
  - § Specified ambient conditions (Outdoor and indoor) have impact on the HVAC plant cooling power consumption (AC chillers capacity dimensioning) and needed air volumes
  - § AC rooms locations around the ship (Pressure losses in ducting)
  - § Selected HVAC system (Is fan-coil used in Cabins, Public Space etc.)
- § How to calculate power consumption
  - § Fan Power = Air flow (m<sup>3</sup>/s) x Fan total pressure(Pa) / Fan efficiency ( $P = \frac{q \cdot \Delta p \cdot 10^{-3}}{n}$ )
  - § Cooling power = Air flow (m<sup>3</sup>/s) x Density (kg/m<sup>3</sup>) x Enthalpy (kJ/kg) ( $P = q \cdot \rho \cdot \Delta h$ )

# HVAC Power Consumption



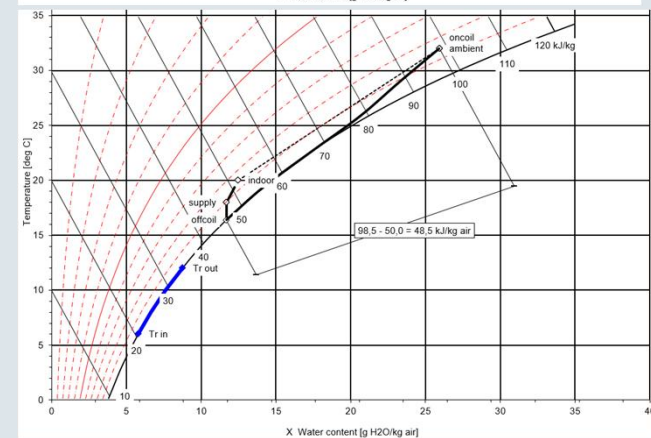
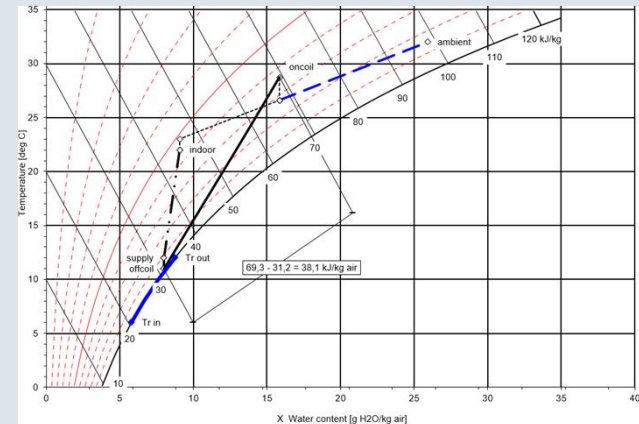
- § Fan Power calculation
  - § AHU fan efficiency used 68% and Separate fans 70%
  - § Supply pressure higher due to AHU internal pressure losses and length of ducting
  - § Air volumes 2% more supply Cabin, Public and Stairs
  - § Galley 4% more exhaust than supply
- § The calculated fan power consumption is 67kW
- § Fan motor, +10% margin to fan power consumption, installed motor capacity 86kW

Cabin AHU	m3/h	P total (Pa)	Eff.	Fan Power (kW)	El-Motor (kW)
Supply	8256	2200	68 %	7,4	9,2
Exhaust	8094	1800	68 %	6,0	9,2
Public AHU	m3/h	P total (Pa)	Eff.	Fan Power (kW)	El-Motor (kW)
Supply	20838	1700	68 %	14,5	16,7
Exhaust	20429	1500	68 %	12,5	16,7
Stairs AHU	m3/h	P total (Pa)	Eff.	Fan Power (kW)	El-Motor (kW)
Supply	7412	1700	68 %	5,1	6,4
Exhaust	5063	1400	68 %	2,9	4,5
Exhaust toilets	2203	1200	70 %	1,0	1,3
Service AHU	m3/h	P total (Pa)	Eff.	Fan Power (kW)	El-Motor (kW)
Supply	14490	1700	68 %	10,1	12,9
Exhaust Fan	15070	1200	70 %	7,2	9,2
				Total	Total
				66,7	86,1

# HVAC Power Consumption

- § HVAC system cooling power demand
- § Ambient cond. Outside 32°C / 85% RH, inside 22 °C / 55% RH
- § Supply air temperature to space from Cabin, Stairs and Public AHUs is 12°C, recovery wheel efficiency 60% ( $\Delta h=38\text{kJ/kg}$ )
- § Service unit supply air temperature 20 degrees ( $\Delta h=49\text{kJ/kg}$ )
- § AC chiller capacity need for AHUs is 705kW

System	m3/h	$\rho$ (kg/m3)	$\Delta h$ (kJ/kg)	kW
Cabin AHU	8256	1,21	38	105
Public AHU	20838	1,21	38	266
Stairs AHU	7412	1,21	38	95
Service AHU	14490	1,21	49	239
			Total	705





# HVAC system weight & space reservation

- § HVAC system weight and space reservation
  - § HVAC system weight is ~15-16kg / interior m<sup>2</sup>
  - § HVAC space reservation (AC rooms and Trunks) ~7% of total interior area
- § Defining space needed AC rooms following factors can be used
  - § For AHUs with supply & exhaust unit ~3m<sup>2</sup> per 1000m<sup>3</sup>/h of capacity, for service AHUs (supply unit only) 4 times unit foot print and for separate fans ~1m<sup>2</sup> per 1000m<sup>3</sup>/h of capacity.
  - § From the figures above calculated AC room area is 151m<sup>2</sup>
  - § Each cabin is 15m<sup>2</sup> totalling 1140m<sup>2</sup>, other areas 1516m<sup>2</sup>. Total indoor area 2656m<sup>2</sup> -> AC room is 5,7% of total interior area.
  - § AC trunks size, velocity ~4m/s of combined air volume per deck. Example D4 total air volume 52000m<sup>3</sup>/h -> ~3,6m<sup>2</sup> of AC trunk needed between AC room and D4.
  - § Weight based on above figures ~40ton

Type of unit	m <sup>3</sup> /h	m <sup>2</sup>
Cab., Pub., St. AHUs	36505	110
Service	14490	24
Separate Fans	17273	17
	Total	151

# HVAC system weight & space reservation

§ Alternatively you need to calculate it based on the actual dimensions of unit/materials

FUTURE MARINE DIMENSIONS				Air handling unit Future Marine					
Quick selection chart									
Unit size	Width (mm)	Height (mm)	Face Area (m <sup>2</sup> )	Air flow rate at different face velocities (m <sup>3</sup> /s)					
				2 m/s	2,3 m/s	2,6 m/s	2,9 m/s	3,2 m/s	3,5 m/s
0603	790	470	0,21	0,4	0,5	0,5	0,6	0,7	0,7
0605	790	670	0,34	0,7	0,8	0,9	1,0	1,1	1,2
0606	790	790	0,42	0,8	1,0	1,1	1,2	1,4	1,5
0906	1070	790	0,60	1,2	1,4	1,6	1,7	1,9	2,1
0909	1070	1070	0,86	1,7	2,0	2,2	2,5	2,8	3,0
1206	1350	790	0,78	1,6	1,8	2,0	2,3	2,5	2,7
1208	1350	990	1,02	2,0	2,4	2,7	3,0	3,3	3,6
1209	1350	1070	1,12	2,2	2,6	2,9	3,3	3,6	3,9
1210	1350	1190	1,27	2,5	2,9	3,3	3,7	4,1	4,4
1212	1350	1350	1,46	2,9	3,4	3,8	4,2	4,7	5,1
1506	1670	790	0,99	2,0	2,3	2,6	2,9	3,2	3,4
1509	1670	1070	1,42	2,8	3,3	3,7	4,1	4,5	5,0
1512	1670	1350	1,85	3,7	4,3	4,8	5,4	5,9	6,5
1515	1670	1670	2,34	4,7	5,4	6,1	6,8	7,5	8,2
1808	1990	990	1,56	3,1	3,6	4,1	4,5	5,0	5,5
1809	1990	1070	1,71	3,4	3,9	4,4	5,0	5,5	6,0

Cabin and Stairs AHU

Service

Public AHU

# HVAC system weight & space reservation

- § Alternatively you need to calculate it based on the actual dimensions of unit/materials from suppliers
- § AHUs 7850kg, Fans ~550kg, Hoods 1600kg, Dampers 1800kg, Dampers 700kg,

**FUTURE MARINE DIMENSIONS CABIN**  
Quick selection

There must be at least one unit width free space available in service side for AHU service and maintenance.

Unit size	Unit width (mm)	Unit height (mm)	Total length *) (mm)	Total height (mm)	Total width **) (mm)	E (mm)	Weight (kg)
1206	1350	790	4250	1740	1830	1950	2000

**FUTURE MARINE DIMENSIONS PUBLIC**  
Quick selection

There must be at least one unit width free space available in service side for AHU service and maintenance.

Unit size	Unit width (mm)	Unit height (mm)	Total length *) (mm)	Total height (mm)	Total width **) (mm)	E (mm)	Weight (kg)
1206	1350	790	3850	1740	1830	2000	1800
1809	1990	1070	4550	2300	2310	2400	2800

**FUTURE MARINE DIMENSIONS SERVICE**  
Quick selection

There must be at least one unit width free space available in service side for AHU service and maintenance.

Unit size	Unit width (mm)	Unit height (mm)	Total length *) (mm)	Total height (mm)	Total width **) (mm)	E (mm)	Weight (kg)
1210	1350	1190	3300	1350	1670		1250



# THANK YOU !

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