Volume XXI 2018
ISSUE no.1
MBNA Publishing House Constanta 2018

Scientific Bulletin of Naval Academy

SBNA PAPER • OPEN ACCESS

Contributions to the study of functional parameters in exploitation of the heat, ventilation and air conditioning system for special ships

To cite this article: O N Volintiru, T M Stefanescu, E Dragomir and A Pruiu, Scientific Bulletin of Naval Academy, Vol. XXI 2018, pg. 256-261.

ISSN: 2392-8956; ISSN-L: 1454-864X

doi: 10.21279/1454-864X-18-I1-039

Contributions to the study of functional parameters in exploitation of the heat, ventilation and air conditioning system for special ships

O N Volintiru[1], T M Stefanescu[1], E Dragomir[1] and A Pruiu[2]

[1]Romanian Navy, Constanta, Romania
[2]Naval Academy "Mircea cel Batran", Constanta, Romania
Email: octaviannarcis@yahoo.com

Abstract. Under normal operating conditions, as a result of heat gains onboard ships from engine rooms and crew, the increase in humidity as well as due to the various releases of gases from onboard systems, room air deteriorates, requiring replacement and its processing through the HVAC (heat, ventilation and air conditioning) system. Another feature of the HVAC system for special ships is operating under heavy conditions such as CBRN tightness where operating parameters record extreme values in cooling engine rooms. In the paper, I will present contributions to the study of functional parameters in exploitation of the HVAC system on board special ships under different load operating conditions.

Keywords: HVAC, special ships, engine room, ventilation, heat, air conditioning

1. Introduction

For special ships, the heating, ventilation and air conditioning system is complex, vital and of large size, impacting each compartment of the ship. The HVAC system is divided into zones and is integrated with the chilled water system of the ship. In the figure below is represented the HVAC system schematic for a military ship.

At the same time, the heating, ventilation and air conditioning system can also be used to cool the engine rooms by opening intermediate flaps when the ship is in a tight condition.

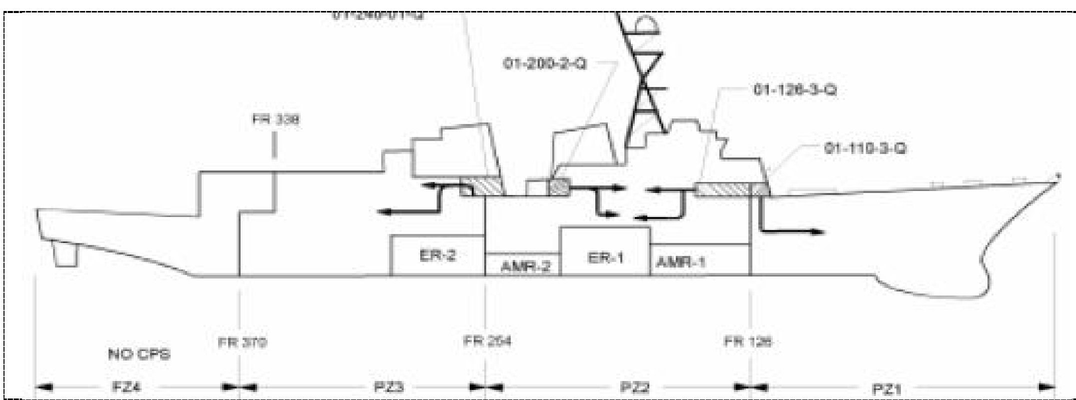

Figure 1. HVAC system divided into zones [2]

2. Auxiliary engine room for special ships

Each of the engine rooms (Forward Auxiliary Machinery Room, Aft Auxiliary Machinery Room, Forward Engine Room, Aft Engine Room) are ventilated with 2 supply fans and 2 exhaust fans. When the special ship is weathertight against the contaminated atmosphere, the air in the engine rooms is recirculated through chilled water coolers by supply fans. At the same time, cold air can be introduced directly from the inside of the ship via flaps. The extraction capacity is greater than the air intake capacity in the machine rooms in order to ensure smoke and gas extraction and to cool the exhaust gas gallery (for F.A.M.R. compartment: intake capacity with 2 supply fan of 28746 $\left[\frac{m^3}{h}\right]$, extraction capacity with two exhaust fan of 32716 $\left[\frac{m^3}{h}\right]$).

The Forward Auxiliary Machinery Room (F.A.M.R.) comprises the following aggregates:

- 2 Paxman Ventura diesel generators;
- 2 air conditioning plants;
- 2 fin stabilizers.

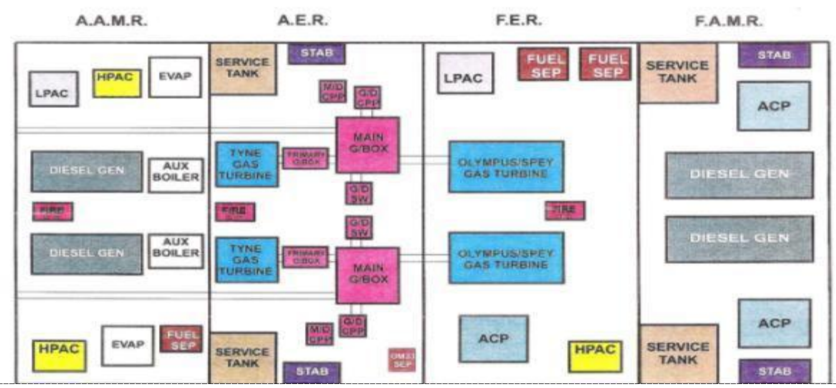

Figure 2. Special ship engine rooms

2.1. Paxman Ventura 16YJ diesel generator

Design of the first Paxman Ventura engine started in 1958, leading on to the engine's launch in 1960. Type 22 frigates had onboard four 16 cylinder Paxman Venturas for electrical power. Paxman Ventura engines were used for fast patrol boats of the Royal Australian Navy. Also, the engines were used for rail traction.

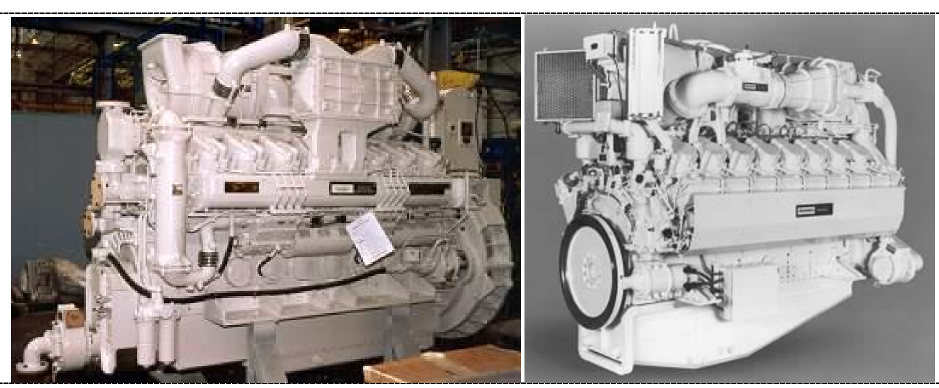

Figure 3. Paxman Ventura diesel generator [5]

Table 1. Diesel engine characteristics

Cylinder number	16 V
Diesel engine max power	1000 [kW]
Nominal speed	1200 [rpm]
Weight	8910 [kg]
Lenght with generator	5000 [mm]
Wide	1800 [mm]
Hight	2500 [mm]

2.2. Energy balance for Paxman Ventura diesel generator

For one Paxman Ventura diesel generator we have formulas for heat flux:

$$\dot{Q_{rad}} = (0.02 \ldots 0.04) \cdot \dot{Q_d} \, [kW] \tag{1}$$

$$\dot{Q_d} = \frac{1}{\eta_e} \cdot P_e = \frac{1000}{0.45} = 2222 \, [kW] \tag{2}$$

$$\dot{Q_{rad}} = 0.03 \cdot 2222 = 66.66 \, [kW] \tag{3}$$

- $\dot{Q_{rad}}$ – radiant heat flux;
- $\dot{Q_d}$ – dissipated heat flux;
- P_e – engine effective power;
- η_e – effective efficiency.

2.3. Air flow calculation for Forward Auxiliary Machinery Room

Mass air flow calculation for engine room:

$$\dot{Q_{rad}} = \dot{m_{air}} \cdot c_{air} \cdot \Delta t \, [kW] \tag{4}$$

$$\dot{m_{air}} = \frac{\dot{Q_{rad}}}{c_{air} \cdot \Delta t} \left[\frac{Kgair}{s}\right] \tag{5}$$

- $\dot{m_{air}} \left[\frac{Kgair}{s}\right]$ - air masis flow;
- $c_{air} = 1 \left[\frac{KJ}{KgK}\right]$- specific air heat;
- Δt =[5…10] $[K]$ - temperature difference.

$$m_{air} = \frac{66.66}{1 \cdot 7} \left[\frac{Kgair}{s}\right] \tag{6}$$

$$m_{air} = 9.52 \left[\frac{Kgair}{s}\right] \tag{7}$$

Volumic air flow calculation for engine room

$$\rho = \frac{P}{RT} \tag{8}$$

$$\rho = \frac{100}{0.286 \cdot 300} \tag{9}$$

$$\rho = 1.16 \left[\frac{Kgair}{m^3}\right] \tag{10}$$

- $P \left[\frac{KN}{m^2}\right]$ - air pressure;
- $R = 0.286 \left[\frac{KJ}{KgK}\right]$ - gas constant;
- $T = 300\ [K]$ – air temperature;
- $\rho = 1.16 \left[\frac{Kgair}{m^3}\right]$ – air densisty.

$$\dot{V} = \frac{m_{air}}{\rho} \tag{11}$$

$$\dot{V} = \frac{9.52}{1.16} \tag{12}$$

$$\dot{V} = 8.20 \left[\frac{m^3}{s}\right] \tag{13}$$

Volumic air flow calculation for engine room fan:

$$P_{fan} = \frac{\dot{V} \cdot \Delta P}{\eta_{fan}} [kW] \tag{14}$$

$$\Delta P = \frac{80 \cdot 100}{10200} = 0.78 \left[\frac{kN}{m^2}\right] \tag{15}$$

$$\dot{V} = \frac{0.75 \cdot 9}{0.78} = 8.65 \left[\frac{m^3}{s}\right] \tag{16}$$

- $P_{fan} = 9\ [kW]$– fan effective power;
- $\dot{V}$ – volumic air flow;
- η_{fan} = [0.65…0.75] – fan efficiency;
- ΔP – pressure difference.

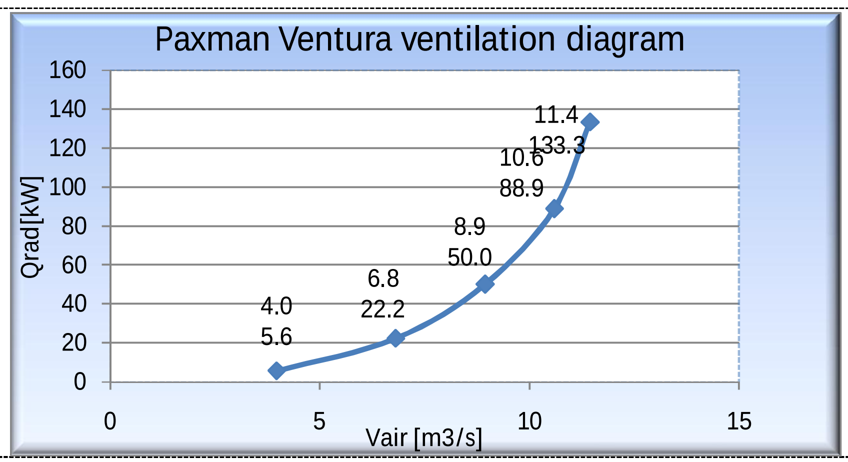

Figure 4. Paxman Ventura diesel generator ventilation diagram

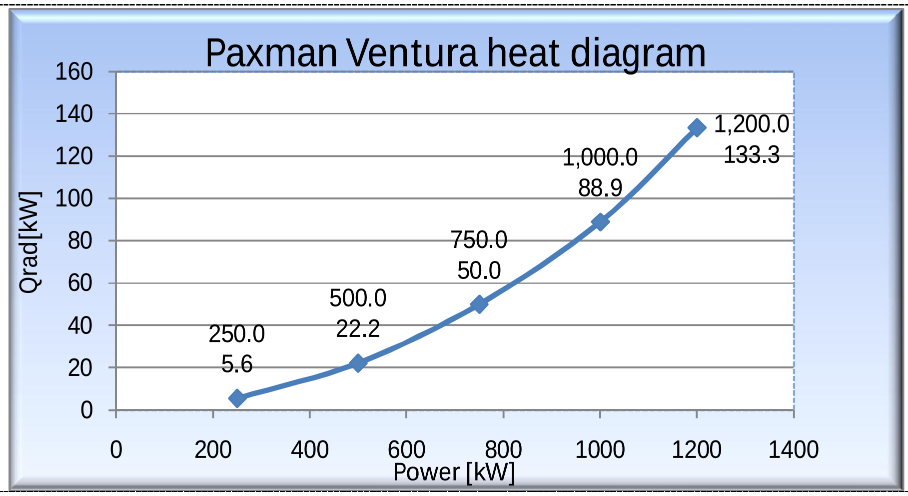

Figure 5. Paxman Ventura diesel generator heat diagram

3. Ventilation cooling simulation in machinery space

Ansys offers a complete range of simulation solutions, engineering kits offer almost any field of simulation engineering, and a pre-rendering machine is required. For simulate ventilation system working for engine room was used a machinery space geometry of *L x l x h = 9 x 15 x 6 [m]*.

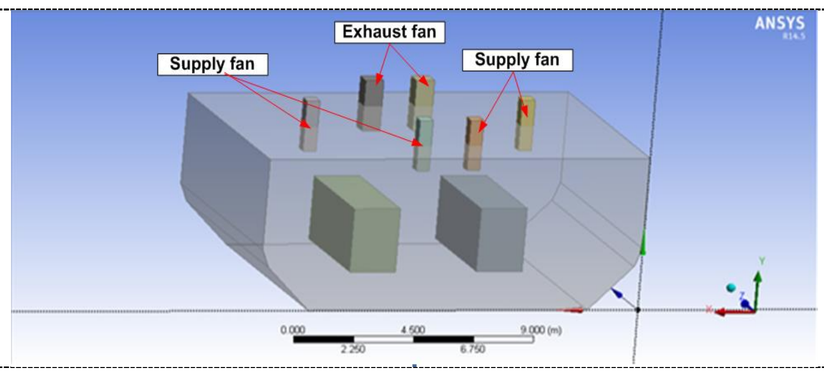

Figure 6. Forward Auxiliary Machinery Room – Ansys geometry

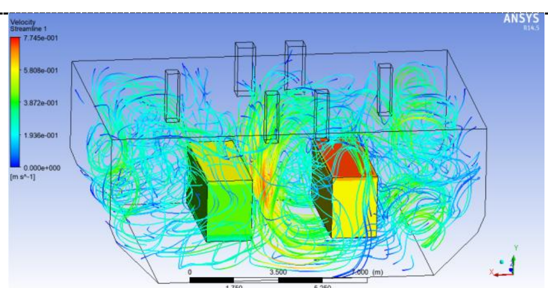

Figure 7. Air velocity in the machinery room

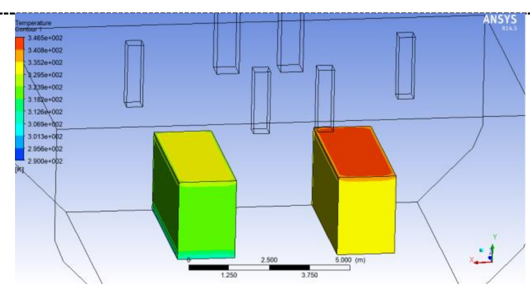

Figure 8. Temperature contour for diesel generators

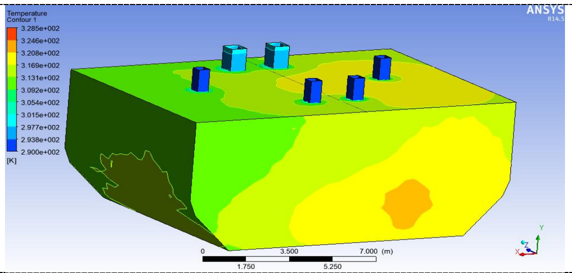

Figure 9. Temperature contour for machinery space – top view

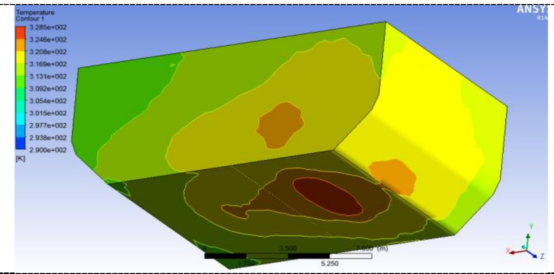

Figure 10. Temperature contour for machinery space – bottom view

Ansys simulation gave the following values:

- air velocity in machinery room: from 0 to 0.774 $\left[\frac{m}{s}\right]$;
- temperature contour for diesel generators: from 289.98 to 346.48 $[K]$;
- temperature contour for machinery room: from 290 to 328.48 $[K]$.

4. Conclusions

In order to eliminate thermal flows in the compartments of the ship, it is necessary to calculate the following sizes:

- calculation of the air flow introduced into engine compartments;
- calculation of the air flow extracted from engine compartments;
- the calculation of the airflow required to evacuate the heat flow from the engine rooms.

To improve the energy usage required for air supply fans must consider the heaviness of warm drive machine works, to be specific the number of engines to run at the same time and the amount of steam boilers burners running at the same time.

The Ansys software displayed all information results from physical data to related calculations identified with geometry, mesh and mesh quality in order to give a large vision for HVAC simulation for ship machinery rooms. Ambient conditions require adjusting the air flow which ventilates the engine room and supplies the necessary air for engines, and engine room air temperature control.

References

[1] Volintiru O N, *Research Report: Considerații privind regulile societăților de clasificare și ale NATO pentru ventilarea compartimentelor navelor speciale,* Military Technical Academy, Bucharest, Octomber 2017;

[2] Serbanescu I, *Consideration Regarding Maritime Ship Engine Room Ventilation System,* January 2016;

[3] Det Norske Veritas AS (DNV) – *Naval and Naval Support Vessel*, January 2015;

[4] Lloyd's Register – *Military Design and Special Features*, January 2015;

[5] Naval Surface Warfare Center Carderock Division, *21 Century HVAC System for Future Naval Surface Combatants – Concept Development Report* , USA, September 2007;

[6] ISO 8861, *Engine room ventilation in diesel-engine ships,* January 2001;

[7] Standard 02 – 102 (NES 102), *Requirements for air conditioning and ventilation, part 1* - (*ftp://ftp.iks-jena.de/mitarb/lutz/standards/dstan/02/102/01000200.pdf)* , UK, September 2000;

[8] http://www.paxmanhistory.org.uk/paxeng34.htm;

[9] www.ansys.com.