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MAIN REQUIREMENTS FOR VENTILATION OF DIFFERENT ROOMS ON THE SHIPS

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ABSTRACT

The ventilation system is vital for the good functionality of the vessels and its purpose is to ensure the requested environmental condition for equipment and people. In addition, the ventilation system is ensuring the safety of the vessels by reducing the concentration of flammable and toxic gases which can escape from the equipment, systems, and storage tanks. Also, in case of fire, the ventilation system must be able to extract the smoke from the engine rooms and public atriums spaces of passenger vessels. The paper is a short overview of the main requirements and recommendations for ventilation systems of different compartments on the vessel and different types of vessels. The requirements related to the safety of the vessel and people on board are stated in Class and IMO/Administration rules and regulations while the calculation of the air flow necessary to remove the heat radiated inside the room is indicated in ISO standards.

Keywords: ventilation, ships, hazardous, air changes, air cooling efficiency.

1. INTRODUCTION

All compartments on the vessels are provided with ventilation systems. There are rooms where natural ventilation is considered enough and other rooms where mechanical ventilation is requested by Classification societies or Administration. In the case of mechanical ventilation there could be two alternatives:

- If it is necessary to have a positive pressure inside the served room (e.g., engine rooms where it is recommended to have 50Pa positive pressure) the ventilation system is provided with a supply fan and natural exhaust. However, in case the exhaust system has a big pressure drop, also the exhaust system should be provided with a fan in order to keep the positive pressure inside the room at the desired value.

- The rooms where toxic or flammable gases can escape from the systems installed inside are provided with exhaust fans and natural air supply in order to ensure a negative pressure inside the room related to other spaces so that the gases will not pass to adjacent spaces. If the pressure drop across the air supply system is increasing over the desired value, a supply fan will be also installed. The supply and exhaust fans will be balanced to keep the requested negative pressure inside the room.

The rooms where equipment with heat dissipation is installed should be provided with a ventilation system that is able to remove the heat radiated in the worst environmental conditions and equipment loading. The ventilation systems are calculated and designed according to dedicated standards. The requested temperature inside the room is a different function than the room's destination. The temperature should be kept between 0˚C and 45˚C in technical and machinery spaces and in control stations: e.g., in the wheelhouse and engine control room the temperature should not increase over 27˚C. In the case of rooms where flammable toxic gases can escape the air flow, the ventilation system should be high enough in order to extract the gases. In this case, the air flow is requested by Class and IMO rules in order to keep the safety of the vessel and people on board.

In order to control the smoke spreading, smoke dampers are requested in common ventilation systems which are supplying the control stations for cargo vessels and passenger vessels carrying less than 36 passengers. If passenger vessels are designed for carrying more than 36 passengers, smoke dampers are requested also near the penetration of each deck according to SOLAS requirements.[1]

There are IMO requirements regarding the height of the ventilation openings on the weather deck. [2] In this respect, some rooms like the engine room and emergency generator room should have openings located high enough (4.5 m in position 1 and 2.3 m in position 2) so that the closing devices are not necessary, in order to keep continuous ventilation under any weather conditions.

2. General requirements for the ventilation system

2.1 Ventilation for Machinery Spaces

The ventilation system for machinery spaces shall assure the air needed for removing the heat radiated inside and the air needed for combustion. The air flow needed should be calculated considering that the machinery inside is running at full power under heavy weather conditions [3]. The ventilation system should be arranged to assure an uninterrupted air supply for cooling and combustion but also it should be arranged so that the accumulation of flammable gases is not permitted, as is exemplified in figure 1.

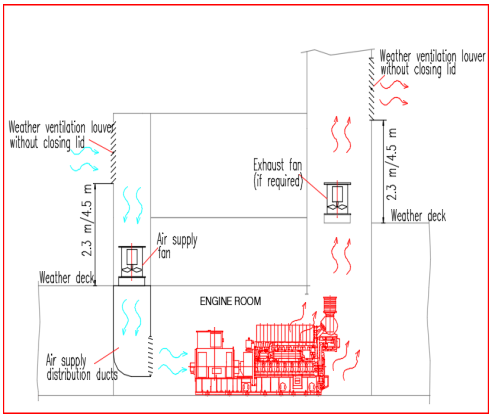

Fig.1 Typical arrangement for ventilation of engine room

The ventilation system for machinery spaces is provided with air supply fans and sometimes additional exhaust fans. According to ISO standard [4], the ventilation system for the engine room should assure a slight overpressure of up to 50Pa inside the room.

In the case of a ship with unrestricted services, engine room temperature should be kept between 0˚C and 45˚ RH60% [5]. For ships that are not certified for unrestricted services, the Classification Society can approve an increased temperature inside the engine room [6].

The air flow needed for ventilating the engines room should be calculated according to ISO standard 8861 [4] but also the equipment makers have some requirements and recommendations and in order to get a good efficiency of the ventilation, detailed CFD analyses could be necessary [7]. In order to improve the ventilation system in case of high temperatures and outside dry air, additional systems like adiabatic cooling can be analysed. [8]

2.2 Ventilation of gas, ammonia and methanol hazardous spaces

In order to reduce the pollution with nitrogen oxides (NOx), sulphur oxides (SOx), and particles from the diesel engines, diesel engines were replaced for some vessels with gas fuelled engines. In these cases, the ventilation system should be adapted according to class requirements for the safe operation of equipment in an area with gas installation. Therefore, according to Classification Societies rules [9] [10] the gas tank connection space and fuel preparation room should be provided with extraction-type ventilation with a rate of at least 30 air changes per hour. The system should be designed so that the capacity requested for ventilation will remain available in case of failure of a fan or a group of fans that have a common electrical supply.

Last time, the Classification Societies also elaborated "tentative rules" and rules for using other carbon-neutral fuels like ammonia and methanol. These are applicable for the conversion of the existing vessels and also for new buildings. [11] The ventilation of the spaces that contain equipment handling ammonia should be provided with a leakage detection and extraction ventilation system with a capacity of minimum 30 air changes per hour for continuous running [12]. In the case of gas detection, the ventilation system should have an extraction capacity of minimum 45 air changes per hour. In this respect, additional "catastrophe" fans are installed for all spaces which can have ammonia leakages. The two fans, regular and catastrophe, will be arranged according to figure 2, with power supply and control so that one failure will not affect both ventilation systems.[13]

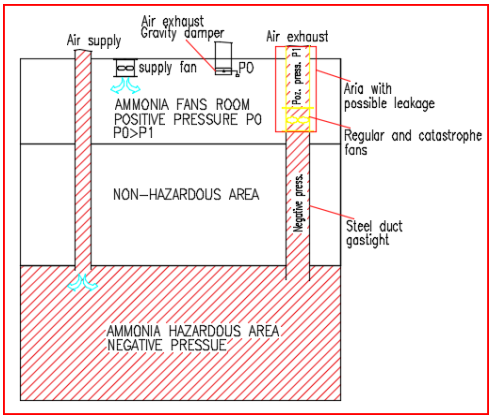

Fig.2 Ventilation principle for ammonia hazardous spaces

The ventilation pipes that pass through rooms with lower hazard zone should have a negative pressure inside related to the rooms as indicated in figure 2.

In methanol fuelled ships, the fuel preparation room should be provided with an exhaust fan with the capacity to ensure a minimum of 30 air changes per hour during normal operation.[14]

2.3 Ventilation for separator room or separators located inside the diesel engine room

Even if the fuel oil separators are installed in a dedicated room or in a space open to the engine room, that area should be provided with ventilation. The purpose of this system is to ensure that flammable gases from separators will not go to other areas inside the engine room.

2.4 Ventilation for Control stations (Engine control room and Wheelhouse)

In general, the engine control rooms are provided with ventilation and air conditioning systems which must keep the temperature below + 27°C, considering the heat dissipation from the equipment installed inside and the moderate fresh air exchange rate [15]. For redundancy purposes, in case of failure of the main air conditioning system, a backup air conditioning system or ventilation with fresh air is provided [16].

The capacity of the ventilation and air conditioning system should be calculated according to ISO standard 8862, Air-conditioning and ventilation of machinery control rooms on board ships – Design conditions and basis of calculation [15] for the outside temperature of + 35°C @70%RH and 45°C inside the adjacent engine room. According to ISO standards, the ventilation system must provide a minimum of 28.8m^3/h/person fresh air for a minimum of 3 persons.

The wheelhouse should be provided with a ventilation and air conditioning system calculated according to ISO standard 8864 [17]. The calculation method is based in general on the requirements from ISO 7547 [18] valid for accommodation spaces. Therefore, the ventilation and air conditioning system for the wheelhouse is designed similarly to the system for other accommodation spaces, considering a minimum of 5 persons inside the room.

The ventilation system must ensure a small positive pressure inside the room [17].
If the ventilation for the engine control room, wheelhouse and other manned control stations is connected to the ventilation system serving other rooms, the ventilation duct connected to the engine control room and wheelhouse should be provided with a smoke damper that can be closed from the served room as is indicated in figure 3. In addition, it is recommended that the arrangement of the ventilation ducts to be done without recirculation to different rooms, in order to avoid the spread of disease from one room to another one [19].

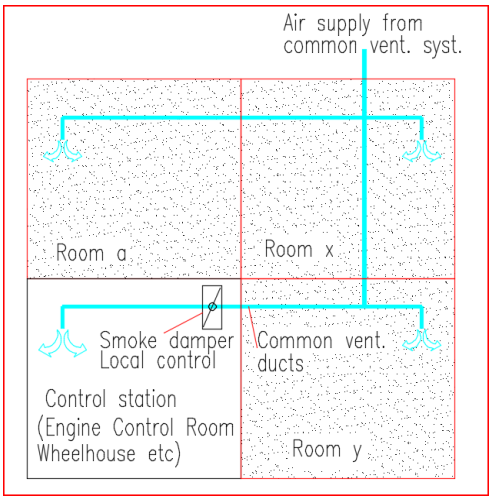

Fig.3 Control of smoke spread to control stations using a smoke damper-controlled from the room

2.5 Emergency generator room

The emergency generator room should be provided with proper ventilation in order to assure enough fresh air for combustion and cooling purposes.

According to class requirements, the ventilation is to be able to immediately supply the emergency generator room [20] when the generator is started. Therefore, the ventilation openings must be arranged so that the weathertight closing appliances are not necessary (according to Load Line and Class regulations) [2]. In case it is not practicable to install the ventilation opening high enough due to the ship size and arrangement, the ventilation system can be provided with closing appliances but they should be opened automatically or manually/remotely from a safe position outside the room. The height above the deck is indicated in table 1 related to the location ("position") on the vessel according to Load line rules indicated in figure 4.

Table 1 Height requirements for ventilation ducts openings on the open decks [7] [2]

Position	**I**	**II**
Ventilators without closures	4500	2300
Ventilators with closures	900	760

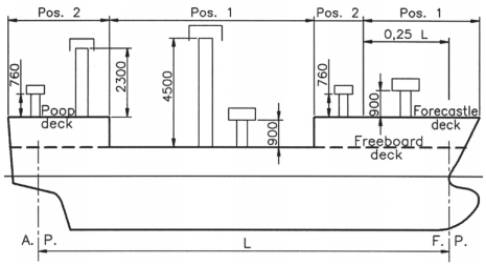

Fig.4 Definition of Position I and II according to Load line rules (data processed form reference [2] and [21])

The location of the inlet ventilation duct should be chosen so that the smoke extraction system from other rooms will not release smoke close to the ventilation inlet of the emergency generator.

In general, the emergency generator is air-cooled and provided with an air-water heat exchanger, with the fan installed on the engine. Therefore, when the diesel generator is started the fan is automatically switched and ventilation is started.

In addition to the main ventilation system provided for running the emergency diesel generator, a small fan is provided to cool-down the room when the emergency generator is not running.

2.6. Paint store, chemical stores, and other flammable liquids stores

The compartments where flammable liquids are stored must be provided with a ventilation system separated from other ventilation systems to avoid the transfer of flammable gases to other rooms. The ventilation ducts should be arranged to be able to remove both flammable vapors, heavier and lighter than air.

The ventilation ducts are to be led to the open deck. It should be noted that the equipment installed inside these rooms should be provided with explosion protection certificates. In addition, the hazardous area is extended inside the ventilation ducts and 3 m from the mechanical ventilation outlet, and 1 m from the ventilation inlet on the open deck. Figure 5 presents a typical example of ventilation with extended hazardous areas.

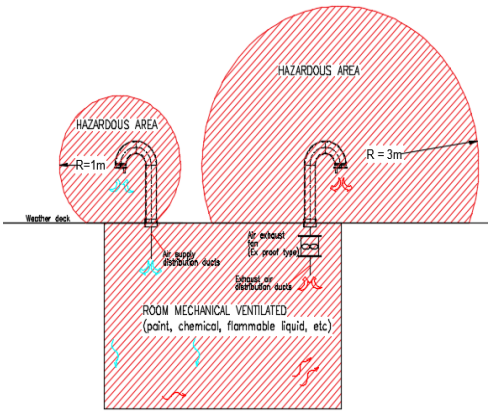

Figure 5. Typical arrangement. Ventilation of paint store, chemical store, other flammable liquid store, oxygen-acetylene storage rooms, with extended hazardous areas.

2.7 Oxygen-acetylene storage rooms

A ventilation system independent from other ventilation systems should be provided for the oxy-acetylene storage room. The room is considered hazardous therefore all equipment installed inside and at 3 m from mechanical ventilation outlets and 1 m from inlets should be provided with explosion protection certificates.

The recommendation is to have a ventilation system that ensures a minimum of 6 air changes per hour if the temperature cannot be controlled by natural ventilation and the temperature inside must be kept below 40˚C [3].

2.8 CO_2 rooms

In general, the CO_2 room is located above the main deck with direct access from the open deck. These compartments should be provided with independent mechanical ventilation and if there is no access from the open deck the exhaust ventilation system should assure at least 6 air changes per hour [16]. The exhaust duct should be led to the bottom where CO_2 can accumulate.

2.9. Refrigerating machinery - special requirements for ammonia (R717)

Refrigerating machinery compartments where ammonia bottles are installed are gastight and separated from accommodation and other machinery spaces used for essential services [3]. These compartments are provided with independent mechanical extraction ventilation which should assure at least 30 air changes per hour [3]. The ventilation fans are provided with start and stop control from outside the refrigerated room.

In case equipment using ammonia is allowed in the engine room, the area where ammonia equipment is located should be provided with a separate extraction ventilation hood with a minimum capacity of 30 air changes per hour. [3]

2.10. Battery rooms

The rooms where batteries with charging power above 0.2kW are installed must be provided with a ventilation system to prevent the accumulation of ignitable gases. Ventilation is not required in the case of gastight battery type NiCd-, NiMH-, or Li- [16].

Based on the battery capacity/type and charging current, the Classification Societies provide information and guidelines for the calculation of the cross-section of the air ducts and air flow needed for the ventilation system.

The electrical motor of the fan must be installed outside of the exhaust ventilation ducts and outside of the battery compartment or it should have an ATEX certificate for the hazardous zone where it is installed [3]. Also, in case the fan is installed at a distance less than 3 m from the exhaust outlet, it should be of safe type [22].

The ventilation system should be designed so that the fan will start automatically when starting the charging.

2.11 Galley ventilation

The galley is provided with a mechanical ventilation system with fresh air supply and exhaust fan, an exhaust hood with a removable grease trap, and fire dampers located in the lower and upper part of the exhaust duct. Both fire dampers should be remotely operated and in addition, the ones installed close to the galley hood should be automatic type. In the case of cargo ships with gross tonnage below 4000 and for small passenger vessels that carry a maximum of 36 passengers, a part of air inlets can be supplied from a common air conditioning system [1] but in this case, an automatic fire damper should be installed close to the ventilation unit. The exhaust air flow must be higher than the supply air flow to ensure a depression inside the galley related to adjacent spaces.

In the summer time, according to ISO standard [23], the cooling power for the ventilation system should be calculated so that the air inlet temperature should be 10˚C below external environmental conditions, considered +35°C and 70%RH. In the winter time, the heating power should be calculated so that the air inlet temperature is +20°C in case of the external temperature of -20°C, considering the low speed of the fans.[23]

The air inlets should be arranged so that the discomfort to the crew is reduced at the minimum possible. In the area with crew activity, the air velocity should be below 0.5 m/s.[23]

3. Additional general requirements for the ventilation system depending on the vessel type

3.1. Livestock Carriers

All enclosed spaces containing livestock should be provided with mechanical ventilation with a capacity of not less than 20 air changes per hour. The partially enclosed spaces containing livestock with a breadth greater than 20 m should be provided with mechanical ventilation with the capacity of not less than 15 air changes per hour [24][25]. In case the clear height of the space is below 2.3 m, the air flow rate requested should be 50% higher. The ventilation system should be provided with at least two independent fans designed so that the requested capacity is maintained in case one fan fails [25].

3.2. Oil Tankers and FLS Tankers

Enclosed spaces located in the cargo area shall be provided with mechanical ventilation. All these spaces and openings of ventilation ducts are considered hazardous areas. Ventilation inlets and outlets for other spaces, especially for machinery spaces, should be located as far as possible.

The ventilation of the Cargo Pump Room should be designed so that accumulation of flammable vapors can be minimized. The system is provided with exhaust fans which will assure a minimum of 20 air changes per hour [25]. For the safety of the personnel who should not enter the room if the ventilation is not in operation, the fan will start automatically any time when the light is started [25].

In the case of oil recovery ships, the cargo pump room should be provided with an exhaust ventilation system that must ensure a minimum rate of 8 air changes per hour [26].

3.3. Liquefied Gas Carriers

All spaces containing cargo handling equipment and all other spaces where cargo flammable vapors can accumulate shall be provided with mechanical ventilation that can be controlled from outside the space. The ventilation system shall run continuously in order to avoid the accumulation of flammable vapors. The system is provided with pressure or flow monitoring devices which should indicate any issue with the requested ventilation capacity.

The ventilation systems should be designed so that the requested capacity is maintained with one failed fan.

The exhaust ventilation openings from a hazardous area should be located at a distance of at least 10 m in the horizontal direction against other openings from non-hazardous spaces [27]. In case the distance of 10 m is not practicable, the non-hazardous area should be protected by air locks.

3.4. Passenger Ships

In the case of passenger ships, the main additional requirements are related to the safety of the vessel and passengers, taking into consideration the big number of persons who cannot quickly and safely leave the ship. Therefore, any penetration of the watertight or fire integrity division should be carefully analysed in order to keep the fire and watertight integrity of that division in case of collision, explosion, fire, etc. The ventilation systems together with other essential systems are designed and analysed in different emergency scenarios so that the vessel is able to safely return to port [25], [1].

Other additional requirements for passenger vessels are related to the control of smoke spread and, in this respect, additional smoke dampers are requested in common ventilation systems. The smoke extraction system for public atriums spaces is another special requirement. The system should have the capacity to remove the smoke in a maxi-

mum of 10 minutes, according to MSC/Circ 1034 [28].

In the case of passenger and cargo vessels for inland navigation, at least two separate gas-tight engine rooms with dedicated independent ventilation should be provided. In the case of a cargo vessel, it is also accepted that the equipment that assures the propulsion and steering to be provided with combustion air taken from outside the room [29].

3.5. Ro-Ro cargo spaces

The ventilation of the cargo spaces, where vehicles that have internal combustion engines can be driven, is calculated and arranged according to ISO standard 9785 [30]. The air flow is calculated according to air changes requested and based on the number and characteristics of the engines which can run at the same time inside the cargo space.

The ventilation system should assure a minimum of 10 air changes per hour, but during loading and unloading the air flow should be increased to 20 air changes per hour, according to SOLAS requirements [1] and DNVGL interpretation [31].

The ventilation inlet and outlets should be located in the crew working area and in areas with high emission of exhaust gases. Also, the arrangement should consider that the exhaust gases can easier accumulate in the lower parts, below vehicles.

3.6. Ships operating in polar water

According to Classification Societies requirements [32], the air intake ventilation openings should be located on both sides of the ship, in order to have the redundancy for air supply in machinery spaces and accommodation spaces. Considering the low temperature of the outside air, the accommodation air intake should be provided with heating devices. Heating devices can be provided also for machinery spaces for cold starting of the engines.

4. CONCLUSIONS

The ventilation system for different rooms on the vessel has different requirements depending on the destination of the served room, the installed equipment, and the risk to have leakage of flammable or toxic gases.

The calculation of the air flow needed to remove the heat radiating inside the room is done according to ISO standards. The other requirements are related to the safety of the vessel and people on board and are stated in Class and IMO/Administration rules and regulations.

As described above, the ventilation systems represent a major component for the safety and functionality of modern vessels and can influence the arrangement and equipment of different types of ships.

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