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Aspects of NBC ventilation systems in military ships

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Abstract. On a warship, every sailor plays a critical role. To fight in a chemically or biologically contaminated environment, the shipboard fighting force needs to function at its optimal level. An enemy's purpose in using NBC (Nuclear, Biological, Chemical) weapons against a ship is to degrade or cease ship operations. The NBC ventilation system can be used onboard a ship by introducing an over-pressurized environment into a vessel by blowing purified air, in a sufficient quantity to overcome dynamic air pressure being exerted due to air flow speed, whilst maintaining the correct physiological comfort (oxygen and carbon dioxide levels and relative humidity) for long periods.[4]
Keywords: ventilation, NBC, flow

1. Introduction

It is essential in a modern warship, to maintain sophisticated electronic equipment temperature and humidity within close limits to ensure proper functioning. Ventilation and air conditioning are required in a warship to provide adequate fresh air, maintain tolerable living and working conditions for personnel, and cool certain items of electrical equipment within the ship in a variety of climates. Although the atmospheric conditions are the major factors to be considered, the ship`s machinery will generate vast quantities of wild heat which must be disposed of noxious fumes and odours from the equipment and personnel must also be removed rapidly. In addition, there is the possibility in wartime that the ship may be subject to nuclear, biological or chemical attack. It then becomes necessary to seal the ship into an airtight box called the citadel. This will cause further problems in that the fresh air supplied must be filtered before being brought into the ship. [1]

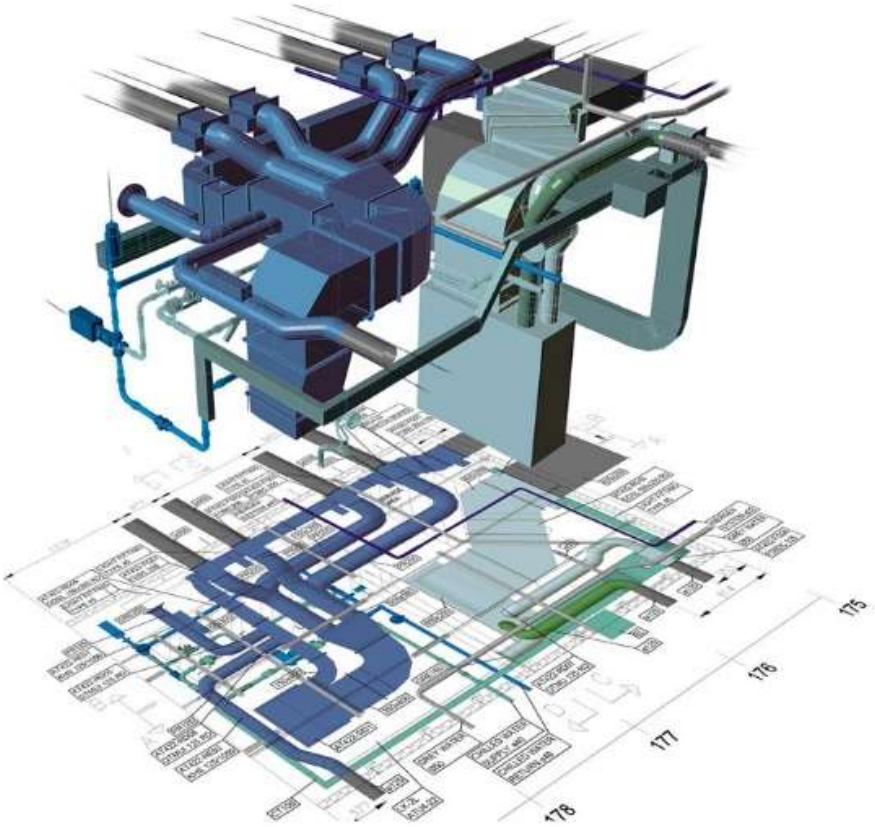

Figure 1. Ship ventilation system [2]

2. Types of ventilation systems onboard ship

Ventilation systems are designed to exhaust large quantities of wild heat, moisture, noxious fumes and odours from within the ship, and to supply fresh air to personnel. Fresh air supplied to a compartment will collect heat from personnel and equipment and is exhausted warmer than when it entered. The heat thus extracted is by one heat exchange. It is for this reason that it is said the ship can never be cooler or less humid than the air outside. There are three ventilation systems fitted to ships to supply fresh air:

- the single system;
- the group system;
- the air filtration unit.

The single system is as the name implies, designed to serve a single compartment and has individual air treatment unit. The group system has a large air treatment unit and serves more than one compartment. The air filtration unit is a specialised unit which supplies fresh air in a special ventilation condition or CBRN condition. In CBRN conditions, ventilation systems are designed to supply air at a rate of 0,85 m^3 per man per minute and to maintain a temperature of no more than 6 ◦C above the ambient. In cold climates, heaters are fitted within the system to achieve this.

Figure 2. NBC air filtration unit for ship ventilation system [3]

3. Special NBC ventilation system

The systems are designed to meet certain requirements and may take the form of one of the following:

- Fan Supply and Fan Exhaust
- Fan Supply and Natural Exhaust
- Natural Supply and Fan Exhaust
- Natural Supply and Natural Exhaust.

The word fan is used to indicate the mechanical means by which air is supplied or exhausted and natural where no mechanical means is used. Fan supply and fan exhaust systems are used where it is necessary to remove large quantities of wild heat, moisture or noxious fumes, coupled with the requirement to provide fresh air to personnel working in those compartments like machinery spaces, galleys, laundries, heads and bathrooms. Fan supply and natural exhaust systems are used where the supply of fresh air is the primary consideration like in some storerooms and workshops. Natural supply and fan exhaust are used where the primary objective is to remove noxious gases or flammable vapours from the paint stores and spirit rooms' inflammable stores. Natural Supply and Natural Exhaust are provided for minor unoccupied compartments, stores and lobbies. Where the compartment ventilation is by fan supply and exhaust, the exhaust volume is designed to be greater than the supply to ensure that unwanted fumes are exhausted from the compartment and are not allowed to spread into adjacent compartments (a slight vacuum is created). In CBRN condition, also, is used air conditioning that can be summarised as the control of temperature, humidity, purity and flow of air within a designed boundary. Achieving all these elements to close limits requires complete equipment and control systems. The system fitted to ships is a compromise with the main aim of ensuring ship staff remain efficient for long periods and that of an environment for weapon equipment which will ensure satisfactory and reliable operation. Air conditioning systems fitted in ships are based on what is termed the group system. A mixture of fresh (33%) and recirculated (67%) air is filtered and either cooled or heated in an air treatment unit and circulated to a group of compartments. In certain circumstances, the cooled air may be reheated to give greater control of temperature and humidity. To achieve air conditioning, the boundary must be maintained. This involves strict control of doors and hatches giving access to the weather decks. To maintain a balanced airflow, an equal amount of conditioned air is bled off into adjacent compartments like galleys, heads and bathrooms.

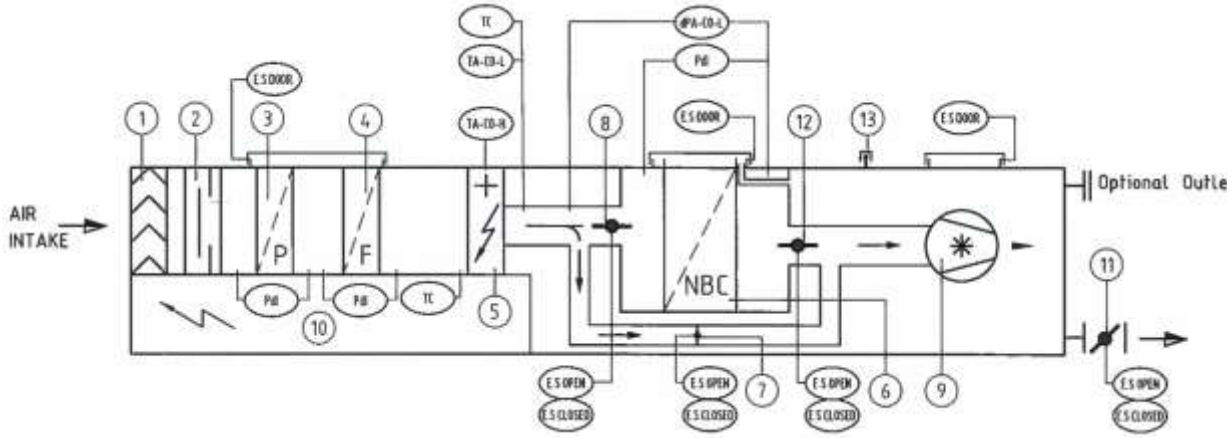

Figure 3. Air treatment unit – ATU and air filter unit AFU [5]

4. Gastight citadel in NBC environment

The citadel is required to provide an adequate clean supply of oxygen and maintain a tolerable temperature and an internal pressure greater than that outside. The gastight citadel is defined as those compartments grouped together with an unbroken gastight boundary within which recirculation of air and normal passage for personnel is possible without the risk of contamination. It comprises the greater part of the ship and in new construction can be divided into zones. The advent of air conditioning coupled with the increased threat of CBRN attack has led post-war ship design to exclude side scuttles and to minimise external openings. By stopping ventilation and closing external doors, hatches and ventilation openings. The ship is quickly brought to a gastight condition. It should now be apparent that air conditioning can be restarted under CBRN special conditions because they recirculate a proportion of their designed air flow back through air conditioned compartments. Thus the temperature, humidity and purity can be kept at the correct levels. There is still a need to admit fresh air though to keep oxygen and carbon dioxide at the levels necessary for physical and mental alertness. The admission of fresh air is through air filtration units. Like the personal CBRN respirator, they will quickly filter out all known CBRN agents. In addition to providing fresh air, the units will build up a positive pressure in the citadel which, if a leak occurs in the boundary will prevent the ingress of contaminated air. The citadel is maintained at a pressure of 5 millibars.

An air filtration unit consists of three filters. These are:

- pre-particulate filter;
- fine filter (particulate filter);
- gas filter.

The pre-filter is located behind the blast valves. The pre-filter is a washable filter and filters the air on large particles. In this way the lifetime of the fine filter will be increased. The fine filter is located behind the pre-filter and filters the air from small particles. This filter increases the lifetime of the High Efficiency Particles (HEPA) part of the NBC filters. The fine filter is a non-washable filter which must be replaced when clogged. A gas filter is designed to remove all known chemical agents in the form of gases or vapours by absorption in a charcoal filling. Renewal of the filter is done by replacing the filter casing completely with charcoal. Should this be necessary, the work is normally undertaken by the dockyard. Where AFUs are grouped together in filter compartments, an arrangement consisting of an air inlet chamber, pressure chamber and plenum chamber (Figure 4) is used. As will, all equipment filled on ships the AFUs are subject to periodical maintenance. The maintenance for these units is in the form of two types of tests. The first is a pressure test and the

second is a gas test. In the pressure test, the resistance of the flow of air is measured across each of the filters by taking a set of readings from pipes filled into the unit and comparing them with the specifications. For the gas test, a gas is released outside the inlet to the unit and the amount of gas entering the citadel is measured.

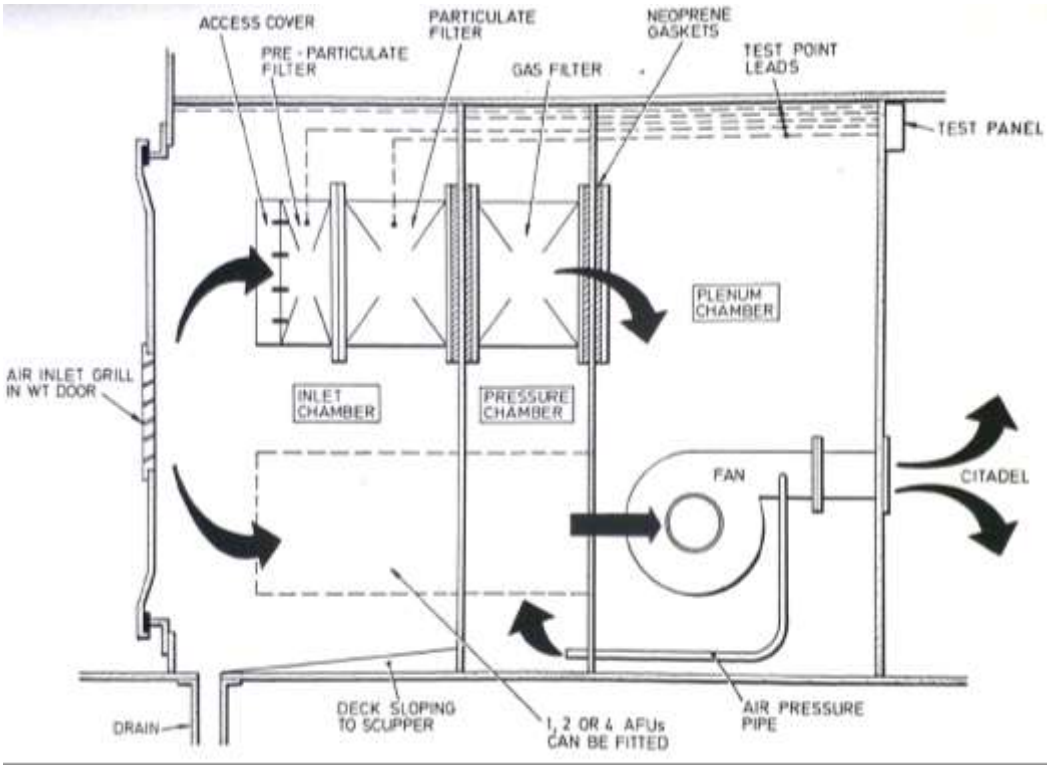

Figure 4. Air filter unit

5. Conclusions

The ventilation system for ships sailing in a contaminated environment must be efficient to ensure the clean air necessary for the breathing of the crew and the safe operation of the aggregates on board. In normal atmosphere but also in contaminated atmosphere (atmosphere with dangerous substances - CBRN substances), all air conditioners are intended to work with the help of filtration units (AFU - air filtration unit) all the time. From the filter units, the air is introduced into the ship and then with the help of the treatment units (ATU - air treatment unit) it is recirculated throughout the ship.For ships with a special character, the artificial microclimate system is complex, vital and sized for each compartment of the ship.

The objectives of the NATO regulations regarding the ventilation installation are as follows:

1. the ambient conditions must be controlled in accordance with the requirements of the personnel on board;
2. the ambient conditions must be controlled in accordance with the requirements of the aggregates on board;
3. ventilation must be able to be provided for navigation in areas with hazardous conditions.

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