

summer design air conditions. It will generally be found that the resulting quantity will change the air in these spaces in about $\frac{3}{8}$ to 1 min, depending on concentration of equipment. All of the exhaust should be arranged so as to remove air from the space through hoods fitted over the cooking equipment and these hoods should contain grease filters over ranges and griddles and should be made readily accessible for frequent cleaning.

The mechanical supply when fitted should blow air directly on the personnel but away from the equipment and so as not to interfere with the flow of exhaust air to the hoods.

Generally, no heat is required for these spaces in winter except that the supply air temperature should not be too low. Usually a preheater delivering air at about 45 to 60 F should be provided.

Laundries

The problems in the ventilation of laundries are somewhat similar to those for galleys. Heat removal is necessary and best accomplished by the installation of mechanical exhaust through hoods fitted over the heat-producing equipment.

The supply for these spaces may be all mechanical, or part mechanical and part natural. The mechanical supply should be distributed through adjustable blast-type terminals at relatively high velocities directed to blow cool air on the torsos of the operating personnel. Experience indicates that this quantity should be sufficient to change the air in the spaces in from 1 to 4 min.

The exhaust should be at least one air change per minute and at least equal to 120 per cent of the total supply so as to insure an indraft of air through the access openings to the space. All exhaust openings within the space should be fitted to be readily accessible for frequent cleaning and lint removal.

No winter heating is required except that the supply air should be delivered at about 40 to 60 F.

Storerooms and Cargo Spaces

The ventilation of these spaces should be predicated upon the kind and type of stores or cargo to be carried.

For materials which would not be adversely affected by summer temperatures, no ventilation is required. Also, storerooms or cargo spaces below the water line in which temperatures would not normally exceed 100 F with the sea water assumed as 85 F maximum, may not require ventilation for certain cargoes. As spaces in these two categories are frequently damp some means of moisture removal must be provided. Chemical dessicants are satisfactory where it is essential to prohibit openings through watertight structure. In other cases a supply of dry air is provided from a central silica gel dehumidification system and distributing ducts, with recirculation used to accelerate the drying process.

Where storage spaces must be ventilated to obtain a change of air in about 15 to 30 min, in some cases the ventilation is determined by the maximum temperature which the cargo or stores can withstand without damage.

Spaces in which inflammable liquids are carried, or where inflammable vapors may be generated, require special consideration. They should be fitted with mechanical exhaust with terminals so located as to remove explosive or combustible vapors. The supply to these spaces may be natural and arranged so that good distribution, free from pockets, is assured.

If stores and cargo, which require some special and constant temperature or humidity control, are carried, special air conditioning equipment must be installed to suit the particular requirements.

SHIP INSULATION

In order to properly limit one of the major ventilation heat loads which is that made necessary by heat transmission, and to prevent condensation, it is necessary to use insulation judiciously. The principal sources of heat in a ship are the power plant and sun load. The confinement or exclusion of this heat in the structure of a ship is not easy, principally because of the complex structural nature of the beams, stiffeners, bulkheads, decks and hull. The continuous metal paths offer easy means of heat flow throughout the structure.

Insulation like any other component hull part of the ship cannot be used indiscriminately because of weight and space limitations. Therefore higher heat transmission coefficients are accepted for insulated structures of certain classes of vessels, than would be considered satisfactory ashore. On passenger and cargo vessels, the structure is frequently covered with a metal sheathing in order to improve appearance. Such sheathing reduces the resistance to heat flow because the necessary supports form a metallic contact that bypasses the insulation.

Hull insulation may be either sheathed fill or blanket and board type and should possess certain desirable physical characteristics, namely:

1. *Fireproofness.* The material must be incombustible and when subjected to high temperatures by fires within compartments and it must not give off smoke or harmful gases. If cements are used to secure the material they too must satisfy the same combustible restrictions. When the exposed surface of the insulation is to be finished with paint, the paint should be fire retardant. Insulation properly used will retard the spread of fires within ships. Government regulations govern the construction and insulation of bulkheads to prevent the spread of fire on vessels.

2. *Density.* A 6,000 ton warship may have from 13 to 25 tons of hull insulation, depending on the type of insulation. It is obviously desirable to minimize this dead weight commensurate with other considerations.

3. *Thermal Conductivity.* It is important that the conductivity of insulation used be 0.33 Btu per hour per square foot per degree Fahrenheit.

4. *Ruggedness.* As any exposed or internally applied material is subjected to rough usage aboard ship it must be able to withstand much pounding from the seas and vibration from the ship's machinery.

5. *Vermiproof.* For sanitary reasons it is essential that insulation harbor no vermin.

6. *Applicability.* Because of the necessity of speeding construction of vessels and minimizing costs, insulating materials must lend themselves to easy and ready application. Generally, when cements are used the application is slow and laborious.

For duct insulation—mineral wool or spun glass are the most commonly used materials. Corrugated asbestos is not recommended because the presence of moisture tends to disintegrate it. Semi-rigid insulation is