automatically controlled, and preheaters are designed and installed to minimize the possibility of freezing of condensate.

The usual combinations or variations of duct type and convection or radiant heaters are used, depending on basic design requirements, such as weight and space limitations, and economic justification for refinements.

VENTILATION FOR VARIOUS TYPES OF SPACE

In the paragraphs which follow the most important considerations are given for the treatment of the various spaces, but the resulting quantities of air should, in all cases, be checked with those shown in Table 1.

Machinery Spaces

The prime purpose of machinery space ventilation is to maintain a habitable temperature for the operating personnel. Of secondary importance is the necessity for maintaining temperature conditions satisfactory for the successful operation of machinery. It is more practicable to use *spot cooling* of personnel at working areas than to attempt to obtain uniform ambient temperature. The permissible temperature rise at working stations is usually about 15 deg, while the over-all temperature rise is usually between 30 and 50 deg.

These spaces must be exhausted adequately, preferably by mechanical means. Every attempt should be made to remove air at or close to heat sources. The capacity of the mechanical exhaust systems should take into consideration the expansion of the supply air, and should be sufficient to insure an indraft through access openings to the space.

Normally, heat is not required for machinery spaces except for those fitted with electrically operated equipment, which may remain inactive during periods while in port. Such spaces should be equipped so as to be heated to about 50 F during such periods.

Living Spaces

The minimum quantity of air required for any space which is fitted for sleeping or office work, including hospital space, should be that which will limit the temperature rise over the outside air conditions to not more than 10 deg (a rise of 7 deg is more satisfactory if practicable), or a minimum of 30 cfm per person, whichever is the greater. For spaces fitted for eating, recreation, or manual work the rise may be taken at 10 deg with not less than 20 cfm per person. The same requirement applies to mechanical exhaust, although natural exhaust may be used where only a short run of duct exists.

Heat should be furnished to maintain the following temperatures:

Staterooms, Berthing, Messing and Office Spaces	70 F
Working Spaces and Shops	60 F
Hospital Spaces	75 to 78 F

Toilets, Washrooms, Showers and Baths

Spaces for these purposes should be fitted with mechanical exhaust ventilation for odor and steam removal. Generally, the surrounding living or working spaces are exhausted through them. Air requirements on merchant vessels are commonly estimated on the basis of a 4 min rate of change. Where the amount of available air is limited by outside air requirements of air conditioning systems, rates of change as high as one change in 6 min

are used for private bathrooms. On naval vessels, the minimum total quantity of exhaust is that which changes the air within the compartment in 6 min, plus 25 cfm for each toilet fixture, plus 50 cfm for each shower head.

Heat is obtained by use of convector radiators which should maintain a temperature of 70 F.

Galleys, Bakeries, Laundries, and Food Handling Spaces

The problem of the ventilation of spaces fitted for cooking and food preparation is primarily one of heat and smoke or fume removal. Complete mechanical exhaust is always provided, and the mechanical supply is made equivalent to at least 50 per cent of the exhaust. Sufficient natural supply to provide an indraft is required. The exhaust quantities should be predicated on restricting the ambient temperature rise to about 15 deg above the outside summer design air conditions. The resulting quantity will change the air in these spaces in about $^3/_8$ to 1 min. All of the exhaust should be arranged to remove air from the space through hoods fitted over the heat producing equipment. The mechanical supply should blow air directly on the personnel, but away from the equipment, so as not to interfere with the flow of exhaust air to the hoods.

The problem of ventilating laundries is somewhat similar to that for galleys. Experience indicates that the quantity of mechanical supply ventilation should be sufficient to change the air in the spaces in 1 to 4 min. The total exhaust (including tumbler dryers) should be equivalent to at least one air change per minute and at least equal to 120 per cent of the supply so as to insure an indraft of air. Generally, no heat is required for these spaces in winter, but preheaters are provided to temper the supply to between 45 and 60 F.

Storerooms and Cargo Spaces

The ventilation provided for these spaces depends on the type of vessel, location of space, and nature of cargo.

On merchant vessels ventilation is required for all closed spaces. Even if ventilation is not necessary to preserve the stores or cargo, it is required to prevent the accumulation of toxic or combustible gases and putrid odors. One air change in 15 to 30 min is common practice, except where inflammable liquids or proximity to hot spaces requires additional ventilation. Mechanical supply and natural exhaust are usually used. However, where inflammable gases may exist, natural supply and mechanical exhaust are provided.

It is the practice on naval vessels to omit ventilation where it is not necessary to preserve the stores, except for those spaces which hold inflammable liquids. The latter are provided with mechanical exhaust systems and natural supply. As spaces below the waterline are frequently damp, those which are unventilated may require chemical desiccants for removing moisture.

Refrigerated stores and cargo spaces requiring constant temperature and humidity control require special treatment.

AIR CONDITIONING SPACE TREATMENT

The extent of the application of air conditioning to new American passenger ships is fairly well established. All passenger staterooms, except steerage and third class, are usually air conditioned. This includes state-