outside) at working stations is usually 15 deg, while the overall 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 the heat sources. The capacity of the mechanical exhaust systems should be greater than the supply, taking into consideration the expansion of the supply air, to insure an indraft through access openings to the space.

Heat is not required for machinery spaces, except for those fitted with electrically operated equipment, which may remain inactive during periods while in port when heating to about 50 F will be required.

Living Spaces

The minimum quantity of ventilation air required for any sleeping or office space, including hospital space, should be that which will limit the temperature rise over the outside air to not more than 10 deg (a rise of 7 deg is more satisfactory), or a minimum of 30 cfm per person, whichever is the greater.

In 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. Usually, the surrounding living or working spaces are exhausted through them. Air requirements on merchant vessels are commonly estimated on the basis of a complete air change in 4 min. Where the available air is limited by outside air requirements of air conditioning systems, a lesser quantity (one change in 6 min) is used for private bathrooms. 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 15 deg above the outside summer design air conditions. The resulting quantity will change the air in these spaces in about 23 sec 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 tempered mechanical supply should blow air directly on the personnel, but away from the equipment, to minimize interference with the flow of exhaust air to the hoods.

The problem of ventilating laundries is somewhat similar to that for galleys. The exhaust should be about 20 per cent greater than supply to insure air indraft. Supply air is generally heated to a temperature of from

45 to 60 F. Ventilation should be sufficient to change the air in the spaces in 1 to 4 min.

Storerooms and Cargo Spaces

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

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 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.

Many ships are fitted with dehumidification facilities for eliminating damage to the dry cargo by preventing condensation and dampness. The dehumidification load consists of moisture removed from the ventilation air passed through the dehumidifier, plus the moisture on, or given off by, the cargo, packaging, dunnage, battens, and other materials in the ship's holds. The most severe outside condition requires a moisture removal of 90 grains (140–50) per pound of dry air, with 88 F cooling water. The largest cargo ships are provided with equipment for removing about 250 lb of water per hour.

The dehumidification systems generally utilize silica gel or lithium chloride with inhibitor (see Chapter 37). In most cases central drying equipment is provided. On large passenger ships consideration is given to the use of two dehumidifying units, because the cargo-carrying spaces are usually concentrated at the extreme ends of the vessel. A simple duct system distributes the dry air to the hold supply ventilation system. These ventilation systems use outside air when weather conditions are favorable. Recirculation and dehumidification are used only when necessary, *i.e.*, when the weather dew-point approaches or exceeds the temperature in the hold. Two control stations are generally provided, one in machinery space and one in chart or wheelhouse. These stations are arranged so that either may change the cargo conditioning system controls from use of outside air to use of conditioned air.

SHIP REFRIGERATION

The kind of refrigeration equipment chosen for a particular vessel depends on the same factors which would govern selection on land.

Small tonnage systems use reciprocating or radial (Freon) compressors. Ships requiring in excess of approximately 125 tons of refrigeration generally use centrifugal compressors. Steam jet refrigeration has proven satisfactory on several large foreign liners and is being seriously considered in this country for similar applications. The two essential prerequisites of the steam jet (low-cost steam and condenser cooling water) are available.

The type of equipment used for the refrigerated cargo space will determine the equipment to be used for air conditioning. This consideration can reduce materially the overall cost, because a stand-by unit is always provided for cargo refrigeration.

AIR CONDITIONING SPACE TREATMENT FOR SHIPS

The application of air conditioning to new American passenger ships is well established. All passenger staterooms, except steerage and third