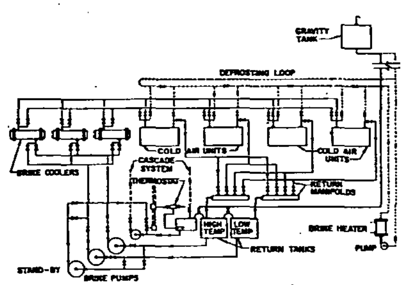

* *Return tanks may be omitted by venting through system gravity tank.*

Fig. 9 .... Two-Temperature Brine System*

by two circulating loops from which, by setting valves at the refrigerators, one can selectively utilize the desired brine.

Brine returns from each cooling unit should run individually to the central plant return-valve twin manifold where room temperatures may be remotely controlled by brine flow. By controlling return flow the systems are under pumping pressure to the return valve and air binding will be at a minimum.

The returning brine is diverted to its respective collector tank from which the brine pump takes its suction. Two types of systems are in use, one in which the return brine streams are in view of the operator, providing the so-called open system, and the closed system in which a static head is maintained on the enclosed return tank and system by a vented overhead gravity tank. These same brine systems may be used with plants using a refrigerant other than Refrigerant 12.

A simple two-temperature brine system can also be had by providing a closed high temperature brine loop or cooling unit with a recirculating pump, the selective brine temperature being maintained by a thermostatically operated pilot valve which will feed low temperature brine to the loop or cooler as required. The central plant thus becomes essentially a one-temperature installation.

With the use of brine for distribution there results an additional temperature differential between the primary evaporating refrigerant and the compartment air temperature. With a room temperature of -10 F and Refrigerant 12, compounded effect is desirable by the cascading of the refrigerant plant. In this operation the high temperature brine is circulated through the condenser in lieu of sea water, thus reducing head pressure and compression ratios over that of single-stage compression.

To facilitate staging by this method a cascading brine pump is suggested which will recirculate its own allotment of brine at a predetermined temperature thermostatically maintained by a pilot feed valve which will control the addition of low temperature brine.

For defrosting with hot brine an independent small pipe loop is suggested, it having its own pump and heater. In this operation the cold brine valves are closed at the refrigerator, and the cooling coils are placed in series with the pump and heater. By this system the brine content of the coil only is displaced which foregoes the heating of an entire pipe line. Should the volume of the whole circuit be returned to the circulating system, it would, for an interval, affect the equilibrium of the entire plant.

Thermometers. The principal indicator of the functioning of a refrigerator plant is the thermometer. Those instruments associated with the central machinery plant reflect thermal efficiencies of the plant, and their purposes and location are well defined. They need no further description here.

The end results of the applied refrigeration, namely space temperature levels and control, are indicated by the room thermometers. The definition of room temperature is fixed to the location of the instrument's sensitive bulb within that space. Refrigeration is affected only by the temperature rise of the refrigerating air stream and it must follow that all parts of the room enclosure are not the same temperature reading.

In rooms operating with considerable margin below or above the freezing temperature of the product, the bulb can be located with considerable tolerance, but in rooms operating in a close range above the commodity's freezing temperature, care must be exercised that damage may not be done in cold zones while the thermometer is indicating a safe reading. In most ships the spaces are convertible to any temperature and the positioning of the bulb is critical. There will be cases when the operator should know this and apply refrigeration accordingly. The bulb should be so installed that there will no false readings due to being in direct contact with warmside surfaces or refrigerating equipment. Rooms fitted with cold air units should have the bulbs located in the supply air stream, that being the point of critical temperatures for chill cargo. When 32 to 33 F supply air is distributed the heat of the load is being removed as rapidly as possible with safety. Return air temperatures must volunteer.

Indicating thermometers inserted in walls through the insulation are not satisfactorily accurate or representative. Indicating dial thermometers should serve each room with the dial installed externally and near the access doors. All bulbs used for comparative readings should be installed adjacent each to the other. Switch-operated, electric resistance indicating thermometers should be installed with the dial located at the log desk.

Recording thermometers are essential to proper operation and management of cargo refrigerators. Mercury actuated instruments will, due to system limitations, have the instrument near the refrigerator. Electric resistance recording instruments are best located in the machinery room where they are under constant observation.

LOAD DETERMINATION

Specifications

The specifications should set forth the extreme operating conditions of loading, ambient and sea temperatures, and rates of pull-down.

In the all-purpose installation each compartment should be designed for the refrigeration of warm fresh products from the field or orchard, and for the over-all condition, a percentage division of chill and freezer cargo with simultaneous and total loading should be stated.

Typical conditions include the following:

1.	Arrangement and net cubic capacities of the refrigerated compartments.	
2.	Thicknesses and kinds of insulation.	
3.	Ambient temperatures	
	Weather Surfaces	100 F
	Adjacent Machinery Spaces	100 F
	Other Adjacent Spaces	85 F
	Sea Temperatures	85 F
4.	Overall stowage factor cu ft per short ton	70
5.	Percentage total loading as chill	75%
	Percentage total loading as freezer	25%
6.	Receiving temperature, chill cargo	80 F
	Receiving temperature, frozen cargo	25 F
7.	Carrying temperature, chill cargo	35 F
	Carrying temperature, frozen cargo	-10 F
8.	Initial period of cargo heat removal	72 hr
9.	Replacement air at 85 db, 75 wb	3%

The owner should describe the kind of refrigeration system to be installed and specify the number of compressors and other auxiliary parts or apparatus, together with sources of emergency pumping and water facilities.

All equipment and installations must be specified as complying with the rules and regulations of the Classification Societies (*American Bureau of Shipping, Lloyd's Register*, etc.), the U. S. Coast Guard, the U.S. Public Health Service and the ASHRAE Standard 26-56 (also ASA B59.1-1958), *Recommended Practice for Mechanical Refrigeration Installations on Shipboard.*

Unless the specification writer wishes to assume full responsibility for the functioning of the plant and all its parts, he must avoid specifying machinery characteristics other than limits of types, speeds, velocities, etc. He should, however, obtain from the vendors fullest details, description and capacities of the equipment they propose to furnish, in order to permit comparative analysis of the several proposals.

Completion tests should be required to determine workmanship and functional performance. Guarantees of performance should be extended to cover operations under loaded service conditions.

Calculations

The following method of calculation of refrigeration loads for a general service plant carrying heterogeneous chill cargo is basic and may appear simplified, but is justified by the great range of conditions common to marine installations. The many associated variable factors and arbitrary bases do not justify minutia in formulae for this type of plant. Refrigeration loads for freezer cargo may be calculated in similar manner using the same stowage factor, a specific heat of 0.40 and an equivalent pulldown period of 72 hr. The loads for respiration heat, replacement air, or latent heat of fusion will not be present.

Specialized service in known ambients will yield to meticulous calculations, but to the results one should still add arbitrary margins of safety.

When general calculations are made, the following operating variables and arbitrary bases must be first established:

1. *Ambient Air Temperature*—ranges from 32 to 100 F.
2. *Ambient Sea Temperature*—ranges from 32 to 85 F.
3. *Conductivity of Insulation*—for materials subject to moisture gain their conductivity may increase as much as 3 percent for each 1 percent moisture gain. Age is thus an indirect factor. (See Chapters 22 and 23 of the 1961 GUIDE AND DATA BOOK.)
4. *Resistivity of Outer Boundaries, Inner Linings and Surface Films*—these factors should be ignored as boundaries and linings are usually dense and have high conductivity coefficients.
5. *Infiltration and Open Door Leakage*—for cargo refrigeration installations such losses at sea are negligible. Port exposures during loading or discharge re-establish pulldown conditions.
6. *Ventilation or Replacement Air*—this factor is often missing when carrying heterogeneous cargo or for short-to-medium length voyage periods. For specialized service it may be as much as 5 percent of the gross room volume per minute.
7. *Electric Energy Conversion*—the energy load from variable output fans and brine pumps will be on demand load rather than connected load. (An arbitrary value of 3000 Btu per hp may be used.)
8. *Product Load*—this is a factor of widest range for heterogeneous cargo service. Its density will vary from 40–120 cu ft per short ton and its specific heat will vary from 0.22–0.95. Container loads cannot practically be distinguished from product load and it is recommended that the gross weight of the package and the specific heat of the product be used.
9. *Receiving Temperature of Chill Cargo*—ranges from ambient to carrying temperature. *Receiving Temperature of Frozen Cargo*—ranges from 0 to 28 F (when not conforming to code requirements).
10. *Carrying Temperature of Chill Cargo*—ranges from 33 to 55 F. *Carrying Temperature of Frozen Cargo*—ranges from -10 to 0 F. Product temperatures should be assumed to be 5 deg above environment temperatures.
11. *Respiratory Heat of Chill Cargo*—at 60 F ranges from 4000 to 46,000 Btu per day, per short ton; at 32 F, ranges from 450 to 82000 Btu per day per short ton. (An arbitrary value of 1000 Btu per ton per 24 hr may be used.)

CONTAINER VANS

The overall width and length of container vans are limited by highway regulations. The height and length are limited by the structural arrangement of the carrying vessel. The loaded weight is a factor of limitation by highway regulation and the lifting capacity of the cargo handling gear. Peculiarities of a specific trade will influence all of these factors. Despite the desirability of universal standardization of dimension, weight, and fittings, each company has developed its own proprietary standards. There has been little coordination between the railroads and the shipping industry.

The generally accepted width is 8 ft and the usual height of commercial containers has been between 8 and 8½ ft. The logistic container widely used by MSTS has dimensions of 6 ft-3 in., 6 ft-10½ in., 8 ft-6 in., for width, height, and length respectively, and is transported on land by flat-bed trucks and railway flat cars, in a transverse loading position. The various standards of length for commercial vans have been 17, 20, 24, 32, and 35 ft. The gross weights range from 5 tons for the logistic supply container to as much as 30 tons for the commercial vans. The refrigerated and insulated containers have the same range of dimensions and gross weights as that of the dry cargo containers.

The scantlings of the containers have been generally accepted as those which will permit loaded stacking 6-high in the cellular constructed container ship (Fig. 11). The corner posts and bottom longitudinals are generally of high tensile steel and the floor carlings, panel stiffeners and roof bows are commonly of extruded aluminum shapes. The boundary panels are of steel, stainless steel or special alloy aluminum sheet. Some designs use corrugated wall panels in lieu of shape stiffeners.

To attain highest allowable pay-loads on the highway, the structural elements have been cut to minimums. The insulation of the vans has likewise been reduced to minimums to gain maximum internal volumes at the expense of the useful capacity and power input of the refrigerating machinery.

The method of handling containers varies with each company. The logistic container may be handled by standard burtoning cargo gear of the ship and by single fork-lift trucks at the terminal or within the ship. The larger containers require floating or resident heavy-lift gear at the terminal, or cranes mounted on the ship. The ship-mounted crane is preferable, since the ship's movements are then unlimited by port facilities. The use of shore-mounted cranes restricts the ship to specific ports, terminals, and berths.

The earlier concepts of design of marine refrigerated cargo containers have borrowed heavily from the highway truck builder's specifications, using ultra-light fibrous insulating batting and an extensive use of wood furring to support the