

staple food items, including bread and milk, available at off-hours of the day or night and Sundays and holidays.

Military Refrigerators

The Armed Services make extensive use of both the commercial type and specially designed refrigerators. Adaptation of the conventional reach-in refrigerator and walk-in cooler are widely used on shipboard and at bases throughout the world. The all steel readily transportable food carrier and the military mess refrigerator have supplanted the ice refrigerator for military use.

Refrigerated display cases of more or less conventional design, including self-service open type models for both normal and low temperatures, are also being widely used at American bases and in occupation areas throughout the world where they may be called upon to meet most severe climatic conditions. Similarly, ice cream cabinets and cases, beverage coolers, backbars and soda fountains, along with such specialized equipment as hospital refrigerators of the various types mentioned in this chapter, and, of course, the full range of refrigerated food service equipment, are liberally employed.

ENVIRONMENTAL TEST EQUIPMENT

Cooling Systems: Primary, Expendable, and Secondary Refrigerants; Heating Systems; Humidification, Air Movement, Dehumidification; Altitude and Space Simulators: Altitude Simulators, Mechanical Vacuum Pumps, Steam Jet Ejectors, Space Simulation, Diffusion, Ion, and Cryogenic Pumps, Radiant Conditions of Space; System Control and Instrumentation; Design Calculations: Cooling and Heating Loads, Relative Humidity; Chamber Construction: Altitude Chambers, Gaskets, Insulation, Doors, Windows, Accessories; Mechanical Refrigeration Systems: Evaporators, Refrigerant Flow Control, System Accessories, Piping, Capacity Modulation and Load Limits

ENVIRONMENTAL test equipment is used to simulate an environment or combination of environments under laboratory controlled conditions in a manner which duplicates or exaggerates the effects found in actual service. It is used to assist the engineer and scientist in exploration of the effects and in the development of equipment for resistance to the many environmental forces.

Environmental test equipment was originally considered a research tool but is finding extensive application in reliability and proof testing of many consumer items. The acceptance and demand for environmental simulation facilities are due to the following features: (1) parallel and reproducible tests can be made, (2) equipment under test may usually be observed and analyzed during testing, and (3) the supporting equipment requirements are reduced to a minimum. Field testing and product development costs are reduced, lead time required for completion of development of products is shortened, and most desirable features of reliability can be incorporated in the original manufacture of the product.

Environmental equipment is used to determine performance not only of mechanical and electrical equipment but for certain tests on personnel as well. Personnel testing includes: (1) checking of protective equipment and clothing for personnel; (2) altitude and space procedures indoctrination; and (3) studying physiological and psychological effects on the human body and mind.

Environmental testing is usually divided into two general classifications: climatic and dynamic. The climatic tests of primary interest include the following:

1. *Temperature Testing.* This includes (a) temperature soaks at high and low extremes, (b) temperature shock testing in which the part is subjected to rapid high and low temperature cycling and (c) programmed cycling in which the parts are subjected to repetitive expansion and contraction stresses and breathing.
2. *Humidity Testing.* This may involve simply exposing the equipment to a constant humidity level or to cycling wherein the temperature and relative humidity are varied. This type of testing induces breathing and condensation within the parts tested. Subcooling may also be used to produce icing conditions.
3. *Salt Spray Chambers.* These are used for the study of the corrosive action of salt vapor on components. This is usually a constant high humidity test.
4. *Fungus Chambers.* These are used to stimulate the growth of fungus on electrical equipment in a study to assure good protection against tropical climates.
5. *Miscellaneous Climatic Chambers.* These include chambers for the simulation of desert sand and dust with high velocity air

movement, sunshine, and rain as well as chambers for proof testing of explosion resistant wiring devices.

6. *Altitude and Space Chambers.* Altitude chambers have been used for some time in proving aircraft equipment. In recent years space chambers have been developed for missiles, rockets, and space vehicle development work.

7. *Combined Environment Testing.* This type of equipment combines two or more of the above environments in one system with all the complexity implied. The thinking in recent years is that this type of testing is the only satisfactory means of proving that a piece of equipment will stand up in actual service.

Dynamic or non-climatic tests include vibration, physical shock, acceleration, mechanical stresses, nuclear radiation, cosmic radiation, micro meteorite bombardment, and many other types of stresses.

The air conditioning and refrigerating engineer may be directly concerned with the design of equipment for the application of most of the climatic environments listed in preceding paragraphs. The dynamic tests are beyond the scope of this text. Some suggested approaches to design of equipment for the production and control of various environments will be given. Due to the wide variety of tests that must be produced, detailed descriptions are not possible within the limited scope of this chapter.

Many of these test apparatus design techniques are used also in the related fields of basic research and low and high temperature processing. Some related industrial processes and equipment are: low temperature chambers for shrink fitting mechanical parts, the frozen mercury precision casting process, storage of biological and food products, vacuum and freeze drying, and stabilization and heat treating of ferrous, aluminum, and other metallic alloys. Many existing Federal Specifications outline basic environmental test specifications and the design approach for some of the chambers to be used in this work.^{1,2} The referenced documents are representative samples of the many available established specifications. The rapid pace of missile and space vehicle development has led to a series of informal special test criteria developed by the project contractors. The environmental equipment designer is required to extend the state of his art to develop equipment to meet these needs.

COOLING SYSTEMS

Temperature reduction in test chambers is accomplished both by mechanical refrigeration systems and by the use of