Aircraft Environmental Systems

Bill Neese

Associate Professor
Embry-Riddle Aeronautical University

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Chapter One

Air Conditioning And Pressurization Systems

The cabin air conditioning and pressurization system supplies conditioned air for heating and cooling the cockpit and cabin spaces. This air also provides pressurization to maintain a safe, comfortable cabin environment. In addition to cabin air conditioning, some aircraft equipment and equipment compartments require air conditioning to prevent heat buildup and consequent damage to the equipment.

Some of the air conditioning systems installed in modern aircraft utilize air turbine refrigerating units to supply cooled air. These are called air cycle systems. Other modern aircraft utilize a compressed gas cooling system. The refrigerating unit is a freon type, quite similar in operation to a common household refrigerator. Systems utilizing this refrigeration principle are called vapor cycle systems.

A. Terms and Definitions

The system which maintains cabin air temperatures is the air conditioning system. The sources of heat which make cabin air conditioning necessary are: (1) Ram-air temperature, (2) engine heat, (3) solar heat, (4) electrical heat, and (5) body heat.

It is necessary to become familiar with some terms and definitions to understand the operating principles of pressurization and air conditioning systems. These are:

(1) *Absolute pressure*. Pressure measured along a scale which has zero value at a complete vacuum.

(2) *Absolute temperature*. Temperature measured along a scale which has zero value at that point where there is no molecular motion (–273.1°C. or –459.6°F.).

(3) *Adiabatic*. A word meaning no transfer of heat. The adiabatic process is one in which no heat is transferred between the working substance and any outside source.

(4) *Air Conditioning*. The artificial treatment of air to make living conditions more comfortable.

(5) *Aircraft altitude*. The actual height above sea level at which an aircraft is flying.

(6) *Ambient temperature*. The temperature in the area immediately surrounding the object under discussion.

(7) *Ambient pressure*. The pressure in the area immediately surrounding the object under discussion.

(8) *Boiling Point*. The temperature at which a liquid changes to a vapor.

(9) *British Thermal Unit (BTU)*. the amount of heat required to raise one pound of water one degree Fahrenheit.

(10) *Cabin altitude*. Used to express cabin pressure in terms of equivalent altitude above sea level.

(11) *Calorie*. The amount of heat required to raise one gram of water one degree Celsius (Centigrade).

(12) *Capillary Tube*. A small tube with a definite inside diameter and length used to meter a fluid.

(13) *Cold*. Absence of heat.

(14) *Condensation*. The changing of a vapor to a liquid.

(15) *Desiccant*. A material used to absorb moisture.

(16) *Differential pressure*. The difference in pressure between the pressure acting on one side of a wall and the pressure acting on the other side of the wall. In aircraft air conditioning and pressurizing systems, it is the difference between cabin pressure and atmospheric pressure.

(17) *Evaporate*. The changing of a liquid into a vapor.

(18) *Gage pressure*. A measure of the pressure in a vessel, container, or line, as compared to ambient pressure.

(19) *Heat*. A form of energy whose effect is produced by accelerated molecular motion.

(20) *Heat Load*. The amount of heat the air conditioner is required to remove.

(21) *Latent Heat*. The quantity of heat absorbed or released by a substance undergoing a change of state without a change in temperature.

(22) *Latent Heat of Evaporation*. The quantity of heat absorbed by a substance changing from a liquid to a vapor.

(23) *Latent Heat of Condensation.* The quantity of heat given off when a substance changes from a vapor to a liquid.

(24) *Latent Heat of Fusion*. The quantity of heat removed from a substance to change it from a liquid to a solid without changing its temperature.

(25) *Liquid*. A fluid which will assume the shape of the container in which it is held but will not expand to completely fill the container.

(26) *Phosgene*. A colorless gas with an unpleasant odor which is produced when Refrigerant 12 is passed through an open flame. It causes severe respiratory irritation.

(27) *Ram-air temperature rise*. The increase in temperature created by the ram compression on the surface of an aircraft traveling at a high rate of speed through the atmosphere. The rate of increase is proportional to the square of the speed of the object.

(28) *Reed Valve*. Thin leaf type valves located in the valve plate of a reciprocating compressor to control the inlet and outlet of the refrigerant.

(29) *Refrigerant*. A fluid which is used in an air conditioning system to absorb heat from the cabin and carry it outside the airplane where it can be transferred to the outside air.

(30) *Refrigerant 12*. Dichlorodifluoromethane, a chemical compound used in most aircraft air conditioning systems. Refrigerant 134a is the latest type developed.

(31) *Relative Humidity*. The ratio of the amount of water vapor in the air to the amount of water vapor required to saturate the air at the existing temperature.

(32) *Saturated Vapor*. The condition of the vapor above a liquid in which no further vaporization can take place without an increase in its temperature.

(33) *Sensible Heat*. Heat added to a substance which causes a change in the temperature of the substance.

(34) *Specific Heat*. The amount of heat required to raise the temperature of a pound of substance one degree Fahrenheit.

(35) *Standard barometric pressure*. The weight of gases in the atmosphere sufficient to hold up a column of mercury 760 millimeters high (approximately 30 in.) at sea level (14.7 p.s.i.). This pressure decreases with altitude.

(36) *Super Heat*. Heat energy added to a gas after evaporation has been completed.

(37) *Superheated Vapor*. Vapor which has been heated above its boiling point for a given pressure.

(38) *Temperature scales.*

(a) *Centigrade*. A scale on which 0°C. represents the freezing point of water, and 100°C. is equivalent to the boiling point of water at sea level.

(b) *Fahrenheit*. A scale on which 32°F. represents the freezing point of water, and 212°F. is equivalent to the boiling point of water at sea level.

(39) *Thermostat*. An air conditioning control which senses the temperature of the evaporator coil and causes the system to cycle to maintain the proper temperature of the cooling air.

(40) *Ton of Refrigeration*. A measure of the cooling capacity of an air conditioning system. It has the same cooling effect as would be had by melting one ton of ice in 24 hours. It is equal to 12,000 BTU of heat energy absorbed in one hour.

(41) *Vapor Pressure*. The pressure exerted by the vapor above a liquid which prevents the release of additional vapor at any specific temperature.

B. Basic Requirements

Five basic requirements for the successful functioning of a cabin pressurization and air conditioning system are:

(1) A source of compressed air for pressurization and ventilation. Cabin pressurization sources can be either engine-driven compressors, independent cabin superchargers, or air bled directly from the compressor section of a gas turbine engine.

(2) A means of controlling cabin pressure by regulating the outflow of air from the cabin. This is accomplished by a cabin pressure regulator and an outflow valve.

(3) A method of limiting the maximum pressure differential to which the cabin pressurized area will be subjected. Pressure relief valves, negative (vacuum) relief valves, and dump vales are used to accomplish this.

(4) A means of regulating (in most cases cooling) the temperature of the air being distributed to the pressurized section of the airplane. This is accomplished by the refrigeration system, heat exchangers, control valves, electrical heating elements, and a cabin temperature control system.

(5) The sections of the aircraft which are to be pressurized must be sealed to reduce inadvertent leakage of air to a minimum. This area must also be capable of safely withstanding the maximum pressure differential between cabin and atmosphere to which it will be subjected.

Designing the cabin to withstand the pressure differential and hold leakage of air within the limits of the pressurization system is primarily an airframe engineering and manufacturing problem.

In addition to the components just discussed, various valves, controls, and allied units are necessary to complete a cabin pressurizing and air conditioning system. When auxiliary systems such as windshield rain-clearing devices, pressurized fuel tanks, and pressurized hydraulic tanks are required, additional shutoff valves and control units are necessary. Figure 1-1 shows a schematic diagram of a pressurization and air conditioning system. The exact details of this system are peculiar to only one model of aircraft, but the general concept is similar to that found in the majority of aircraft.

C. Aircraft Air Conditioning Systems

We have become accustomed to thinking of air conditioning as the cooling of air, but actually it means much more than just this. A complete air-conditioning system for an aircraft should control both the temperature and humidity of the air, heating or cooling it as is necessary. It should provide adequate movement of the air for ventilation, and there should be provision for the removal of cabin odors.

1. Vapor-cycle Air Conditioning

a. Theory of Refrigeration

The vapor-cycle air-conditioning system operates on the same refrigeration cycle as the mechanical refrigeration we use to cool our food and water. A refrigerant changes its state from a liquid into a vapor, and in doing so, it absorbs heat from the cabin. This heat is taken outside of the aircraft and is given off to the outside air as the refrigerant returns to its liquid state.

(1) Transfer of Heat

Heat, we must remember, is a form of energy, and we have neither the prerogative to create nor destroy energy. We can, however, transform it, or move it from one place or material to another. This energy continues to exist regardless of its form or location.

Heat will flow from an object having a certain level of energy into an object having a lower level. And any material that allows this transfer easily is said to be a conductor of heat, while any material that blocks or impedes the transfer is called an insulator.

The refrigerant used in an aircraft air-conditioning system is a liquid under certain conditions, but when it is surrounded by air having a higher level of heat energy, heat will flow from the air into the liquid. As the liquid absorbs the heat it will change its state and become a gas. The air that give up its heat to the refrigerant is cooled.

(2) Basic Vapor Cycle of Refrigeration

Heat is a form of energy that manifests itself in the molecular movement within a material. If there were no heat, there would be no molecular motion. When heat is added to a material, its molecular movement increases, and the material even increases in physical size. This is called thermal expansion.