zone. Many of the available zone controllers are arranged in such a way as to be affected also by the temperature of the heating system and the indoor temperature in the zone. Whatever the mechanical features of the regulator, its function is to dictate the flow impulse, or rate of flow, in such a way as to maintain the desired indoor temperature in the zone, regardless of the fluctuations in the outdoor temperature. Provisions also may be made to maintain a predetermined low economy temperature in each zone during periods of non-occupancy; to facilitate quick warming-up following such periods; and to follow those portions of the daily cycle of control with normal heating effect during the occupancy period.

A control panel, at a central location, may be arranged so that manual switches for each zone may raise or lower the operating temperature. Time switches, if desired, may be provided for obtaining, automatically, any day-night or other predetermined control program which the operators of the building may desire. The characteristics of the regulators which are operated by the zone controllers depend upon which of the basic systems of zone control is employed in a given installation. Shut-off, mixing or throttling valves, and various forms of devices to reset or pilot the action of reducing valves and to control firing means, are some of the more common regulators which are used to control the flow of steam or hot water, under the command of zone controllers. The characteristics of these regulators usually are determined by the manufacturer of the type of controller which is selected.

AUTOMATIC CONTROL APPLICATION

Some of the considerations affecting the selection of automatic controls for applications are given in the following paragraphs which describe controls and operation for various types of units.

Unit Heater Control

Two-position (on-off) control by means of a room thermostat is the standard method of control for unit heaters. A limit control should be incorporated to prevent operation of the unit heater fan motor when steam or hot water is not available. The limit control can be a surface thermostat or pressure control. Where there is no possibility of drafts, and continuous air circulation is required, the unit heater fan motor may operate continuously. In this case, a room thermostat controls a valve (two-position or proportioning) in the steam or hot water supply line.

Unit Ventilator Control

Various makes of unit ventilators are designed for different control cycles. Selection of automatic temperature control for unit ventilators is largely determined by the design of the particular unit. The choice of control cycle may also be determined by local and state ventilating codes, particularly where units are installed in school rooms. It is desirable to coordinate the selection of control cycle with the unit ventilator manufacturer since, in many cases, modifications of the unit are required for the installation of the control equipment; and, in some cases, it is desirable to have the equipment factory-mounted. Two typical control cycles are: (1) *Variable Outdoor Air with Fixed Minimum,* and (2) *Variable Outdoor Air without Fixed Minimum.*

Control Cycle No. 1. In full heating position, the outdoor air damper is closed, the recirculating air damper is open, and the supply valve is open.

In full cooling position the outdoor air damper is open, the recirculating air damper is closed, and the supply valve is closed or at a minimum position to maintain a minimum discharge air temperature. The sequence of control operations is: On call for cooling, under control of a room thermostat, outdoor air damper opens to minimum setting. The supply valve then closes gradually, after which the outdoor air damper gradually opens to the maximum position and, simultaneously, the recirculating air damper closes. A low limit thermostat mounted above the coil prevents the discharge temperature from dropping below a predetermined minimum.

Control Cycle No. 2. In full heating position the outdoor air damper is closed, the recirculating air damper is open and the supply valve is open.

In full cooling position the supply valve is closed, the outdoor air damper is open, and recirculating air damper is closed or at any position required to maintain a minimum discharge air temperature. The sequence of control operations is: On call for cooling, under control of a room thermostat, the valve gradually closes. As the valve leaves full-open position, control of the recirculated air and outdoor air dampers is transferred to a thermostat installed ahead of the heating coil to maintain a minimum air temperature. On continued call for cooling, the valve gradually closes.

If direct radiation is used, it is desirable that it be controlled in sequence with whatever control cycle is adapted for the unit ventilators.

Unit Coolers

Although most unit coolers can be adapted to any control cycle, continuous fan operation is recommended to avoid stratification and wide fluctuations in space temperature. Should the unit be completely self-contained, control of the direct expansion refrigeration unit may be obtained from the temperature of the recirculated air and from suction pressure. In the case of multiple unit systems supplied with refrigerant or chilled water from a central source, a valve in the supply to each cooling coil may be controlled thermostatically from space temperature.

Refrigeration and Dehumidification Equipment

Typical control equipment and its functions are described in the following paragraphs.

Well Water. Where well water is used directly in air washers or cooling coils, control of temperature or humidity is usually obtained by thermostat- or humidistat-operated valves (two-position or proportioning). The two-position valve will provide better dehumidification since a lower coil temperature will be maintained, but the temperature of the discharge air will fluctuate. With proportioning control, better control of discharge air temperatures will be maintained. In both cases the sensible-latent heat ratio is basically a matter of coil design rather than automatic control. Proportioning three-way valves may be used as mixing or diverting valves for better pump performance, and may also be applied to an air washer used with a recirculating pump to control water temperature rather than volume.

Ice Bunkers. Where water is sprayed over the ice in bunkers and circulated to air washers or cooling coils, control is obtained by a thermostat in the water line from the bunker. The thermostat proportions a three-way valve to by-pass enough return water around the ice bunker to maintain a constant discharge temperature.

Compressors. Compressors may supply refrigerant to direct expansion cooling coils in air conditioning units, or to direct expansion coils in water-chilling units. In either case, the compressor motor may be started and stopped directly by a room or duct thermostat, or a pressure controller may be used to regulate the suction pressure of the compressor. In the latter case, a room or duct thermostat may be used to control a solenoid valve in the refrigerant supply line to the cooling coil. A high and low pressure cut-out is standard safety equipment on most compressor installations. Reduced capacity of the refrigerating unit may be obtained by means of temperature or pressure controlled unloading devices which vary the capacity of the compressor in some proportion to variations of cooling load. Program or step controllers, actuated by temperature or pressure, are commonly used in multiple compressor installations. It is desirable in such installations to return the program or step controller to the *off* position when the system is shut down to prevent the full electrical load of multiple compressors from being thrown across the line at the same time. Thermostatic control of water supply to water-cooled condensers may be achieved by means of self-contained controllers or valve and thermostat application.