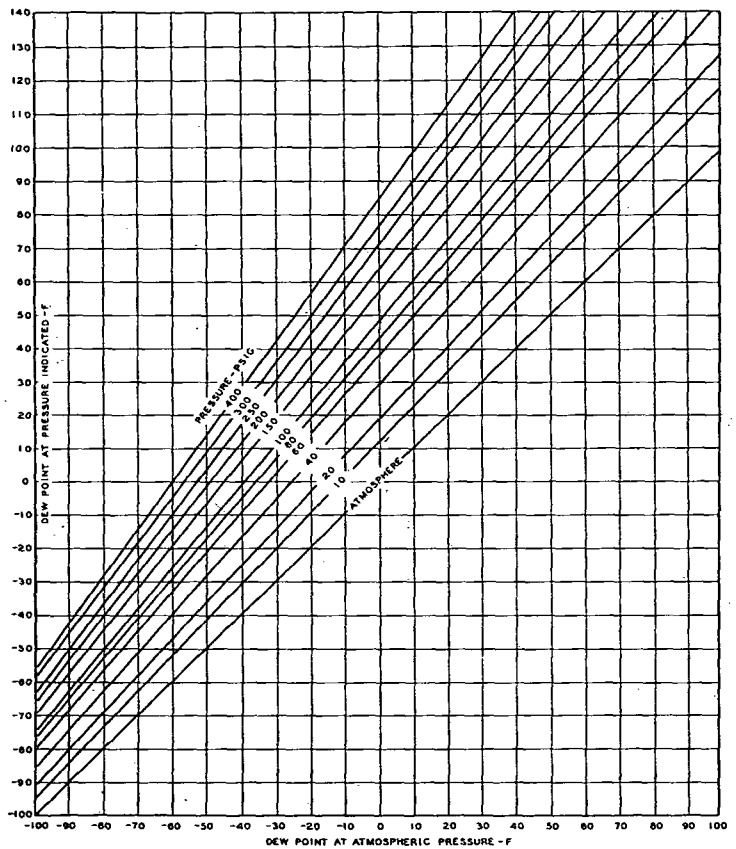

Fig. 11 .... Dew Point Conversion Chart

transfer is controlled. For these reasons a vapor barrier should be located within the wall construction as near to the high vapor-pressure side as feasible. To be effective, a barrier must be continuous and should be so located within the structure that it will be protected from rupture. (See Chapter 10 Moisture In Building Construction.)

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CHAPTER 43

AUTOMATIC CONTROL

Fundamentals: Types of Control Systems and Action, System Components, Controllers and Controlled Devices, Auxiliary Control Equipment; Design Coordination: Equipment Selection and Layout; Location of Controllers; Control of Steam, Water, or Air Flow; Zone Control; Control Applications: Central Fan, Temperature Control in Hot Water Systems, Zoned Steam and Water Systems, Terminal Equipment, Residential Heating and Air Conditioning

PRESENT-DAY standards of comfort combined with capacity and rapid response of modern heating and cooling equipment make automatic controls an essential part of heating, ventilating, and air-conditioning systems. These automatic controls respond to variables such as temperature, relative humidity, and pressure. They operate individually or in sequence to maintain the desired conditions throughout the system and in the occupied space. A factor that has made the subject of automatic control somewhat confusing has been the matter of terminology. Many different expressions or words have sometimes been used to convey a single idea or concept. This chapter, therefore, attempts to use and define the terms that are most common and suitable so that they will be readily understood. The terms and definitions used are also selected so as to conform, as nearly as possible, to automatic control terminology used by engineers in other fields of control.

PART I—FUNDAMENTALS OF AUTOMATIC CONTROL

A *control system*, Fig. 1, consists essentially of (1) a controller, (2) a controlled device, and (3) a source of energy.

A *controller* is a device which measures a variable condition such as temperature, humidity, pressure, and liquid level, and produces a suitable action or impulse for transmission to the controlled devices. Thermostats, humidistats, and pressure controllers are examples.

A *controlled device* reacts to the impulse received from a controller and varies the flow of the control agent. It may be a valve, damper, electric relay, or a motor driving a pump, fan, etc.

The *control agent* is the medium manipulated by the controlled device. It may be air or gas flowing through a damper; gas, steam, water, etc., flowing through a valve; or an electric current.

The *controlled variable* is the condition such as temperature, humidity, or pressure, being controlled.

Most control systems, of which Fig. 1 is typical, form a closed loop. That is, the controller measures and responds to changes in the controlled variable and actuates the controlled device to bring about an opposite change which is again measured by the controller. This system of transmitting information about the results of an action or operation back to its origin is known as *feedback*, and makes true automatic control possible.

An open-loop system is sometimes employed in control circuits, but it does not provide complete control. An outdoor thermostat arranged to control the flow of heat to a building in proportion to the load caused by changes in outdoor temperature is an example. This system has no feedback. It depends for its operation on a prearranged relationship between outdoor temperature and heat input to the building, and room temperature has no effect on the controller.

TYPES OF CONTROL SYSTEMS

Control systems are divided into five main groups according to the primary source of energy:

1. A *self-contained system* combines the controller and controlled device in one unit and employs the power of the measuring system to effect the necessary corrective action. The measuring system derives its energy from the process under control without amplification by any auxiliary source of energy, and may be of the sealed-bellows or remote-bulb type as described under Types of Measuring Elements. Temperature changes at the bellows or the remote bulb result in pressure or volume changes of the enclosed media, which are transmitted directly to the operating device of the valve or damper.

2. A *pneumatic system* utilizes compressed air, usually at a pressure of 15 to 25 psig, as a source of energy. This is supplied to the controller which in turn regulates the pressure supplied to the controlled device.

3. A *hydraulic system* utilizes a suitable liquid under pressure as the source of energy. The pressure often is considerably higher than in a pneumatic system, but in other respects the systems are similar. Hydraulic systems find their chief use in applications where large forces are required for operation of the controlled devices.

4. An *electric system* utilizes electric energy, either low or line voltage as the energy source. The electric energy supplied to the controlled device is regulated by the controller either directly or through relays.

5. An *electronic system* also utilizes electric energy, but employs an electronic amplifier to increase the minute voltage variations of the measuring element to values required for operation of standard electrically controlled devices. Measuring elements usually are of the resistance type, but thermocouples also are employed. Combination electronic-pneumatic systems utilize compressed air for operation of the controlled device by converting the output of the electronic amplifier into

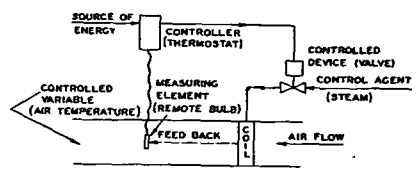

Fig. 1 .... Essentials of a Control System