CHAPTER 24

MECHANICAL DEHUMIDIFIERS AND RELATED COMPONENTS

THE correct moisture level in the air is important for health and comfort. Controlling humidity and condensation is important to prevent moisture damage and mold or mildew development, thus protecting buildings and occupants, and preserving building contents. This chapter covers mechanical dehumidification using a cooling process only, including basic dehumidifier models (with moisture removal capacity of less than 3 lb/h) used for home basements and small storage areas, as well as larger sizes required for commercial applications. Other methods of dehumidification are covered in Chapter 23.

Commercial applications for mechanical dehumidifiers include the following:

- Indoor swimming pools
- Makeup air treatment
- Ice rinks
- Dry storage
- Schools
- Hospitals
- Office buildings
- Museums, libraries, and archives
- Restaurants
- Hotels and motels
- Assisted living facilities
- Supermarkets
- Manufacturing plants and processes

In addition, an air-to-air heat exchanger (such as a heat pipe, coil runaround loop, fixed-plate heat exchanger, or rotary heat exchanger) may be used to enhance moisture removal by a mechanical dehumidifier or air conditioner. The section on Wraparound Heat Exchangers discusses how dehumidification processes can be improved by using such a device. Other uses of air-to-air heat exchangers are covered in Chapter 25.

MECHANICAL DEHUMIDIFIERS

Mechanical dehumidifiers remove moisture by passing air over a surface that has been cooled below the air's dew point. This cold surface may be the exterior of a chilled-water coil or a direct-expansion refrigerant coil. To prevent overcooling the space (and avoid the need to add heat energy from another source), a mechanical dehumidifier also usually has means to reheat the air, normally using recovered and recycled energy (e.g., recovering heat from hot refrigerant vapor in the refrigeration circuit). Using external energy input for reheat is wasteful and is prohibited or limited in many countries (see ASHRAE *Standard* 90.1).

A mechanical dehumidifier differs from a typical off-the-shelf air conditioner in that the dehumidifier usually has a much lower sensible heat ratio (SHR). The dehumidifier starts the compressor on a call for dehumidification, whereas an air conditioner starts the compressor on a call for sensible cooling. Typically, a room dehumidifier has an SHR of 0.6 or less, compared to a standard air-conditioning system of 0.8 SHR. Dehumidifiers must also allow condensation from the cooling coil to drain easily from the coils. They may need air velocities over the cooling coil lower than those for a typical air conditioner, to improve moisture runoff and minimize carryover of condensed moisture.

In addition, the need to introduce code-mandated ventilation air may require that outside air be treated to avoid introducing excessive moisture. Basic strategies include precooling outside air entering the air-conditioning evaporator coil, or providing a separate system to provide properly conditioned outside air. For some low-dew-point (below 45°F) applications, mechanical dehumidification may be used as the first stage, with desiccant dehumidification for the final stage to maximize efficiency and minimize installed cost.

Although the main purpose of a mechanical dehumidifier is to remove moisture from the air, many features can be incorporated for various applications, such as

- Dehumidifying and cooling (no reheat)
- Dehumidifying with partial reheat (leaving dry-bulb temperature is cooler than with a dehumidifier with full reheat)
- Dehumidifying with full reheat
- Dehumidifying with heat recovery to various heat sinks
- Dehumidification capacity modulation
- Reheat capacity modulation
- Ventilation air introduction
- Auxiliary space or water heating

Often, mechanical dehumidifiers can be incorporated in a system to use waste heat from mechanical cooling (e.g., heat rejection to a swimming pool, whirlpool, domestic hot water, heat pump loop, chilled-water loop, or remote air-cooled condenser).

Outdoor dehumidifiers should be protected against internal moisture condensation when winter conditions are severe, because of the higher dew-point temperature of air circulating in the unit.

Psychrometrics of Dehumidification

Air enters the dehumidifying coil at point A (Figures 1 and 2). The dehumidifying coil removes sensible heat (SH) and latent heat (LH) from the airstream. The dehumidified, cooled air leaves the coil at its saturation temperature at point B. The total heat removed (TH) is the net cooling capacity of the system.

In reheating, the hot gas rejects heat from three sources. First, sensible heat absorbed in the air-cooling process is rejected to air leaving the cooling coil. This air is at point C, which is the same dry-bulb temperature as the entering air minus the moisture content. Second, the latent heat removal that causes the moisture to condense also adds heat to the hot refrigerant gas. This heat is also rejected into the airstream, raising the air temperature to point D. Third, nearly all electric power required to drive the refrigeration cycle is converted to heat. This portion of heat rejection raises the air leaving temperature to point E.

The preparation of this chapter is assigned to TC 8.10, Mechanical Dehumidification Equipment and Heat Pipes.

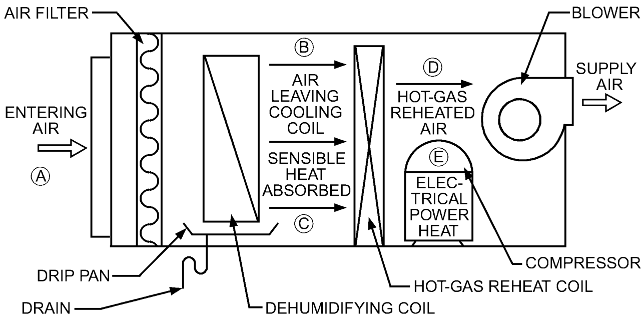

Fig. 1 Dehumidification Process Points

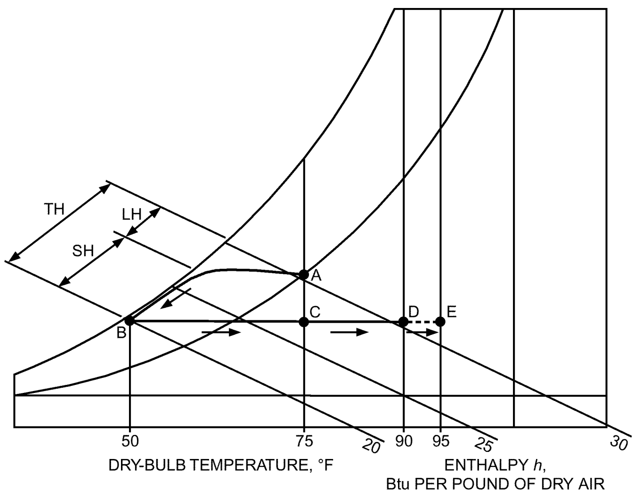

Fig. 2 Psychrometric Diagram of Typical Dehumidification Process

This process assumes that all heat is rejected by the reheat coil. Depending on the refrigerant system complexity, any part of the total heat rejection can be diverted to other heat exchangers (condensers/desuperheaters).

Dehumidifier supply air temperatures can be controlled between 50 and 95°F. However, system design should not rely on a mechanical dehumidifier as a dependable heat source for space heating, because heat is only available when the unit is operating.

Domestic Dehumidifiers

Domestic dehumidifiers are smaller (usually less than 1 ton), simpler versions of commercial dehumidifiers. They are self-contained and easily movable.

As shown in Figure 3, a single fan draws humid room air through the cold coil, removing moisture that either drains into the water receptacle or passes through the cabinet into some other means of disposal. The cooled air passes through the condenser, reheating the air.

Domestic dehumidifiers ordinarily maintain satisfactory humidity levels in an enclosed space when the airflow rate and unit placement move the entire air volume of the space through the dehumidifier once an hour.

Design and Construction. Domestic dehumidifiers use hermetic motor-compressors; the refrigerant condenser is usually conventional finned tube. Refrigerant flow is usually controlled by a capillary tube, although some high-capacity dehumidifiers use an expansion valve. A propeller fan moves air through the unit at typical airflows of 125 to 250 cfm.

The refrigerated surface (evaporator) is usually a bare-tube coil, although finned-tube coils can be used if they are spaced to allow rapid runoff of water droplets. Vertically disposed bare-tube coils tend to collect smaller drops of water, promote quicker runoff, and cause less water reevaporation than finned-tube or horizontally arranged bare-tube coils. Continuous bare-tube coils, wound in a flat circular spiral (sometimes with two coil layers) and mounted with the flat dimension of the coil in the vertical plane, are a good design compromise because they have most of the advantages of the vertical bare-tube coil.

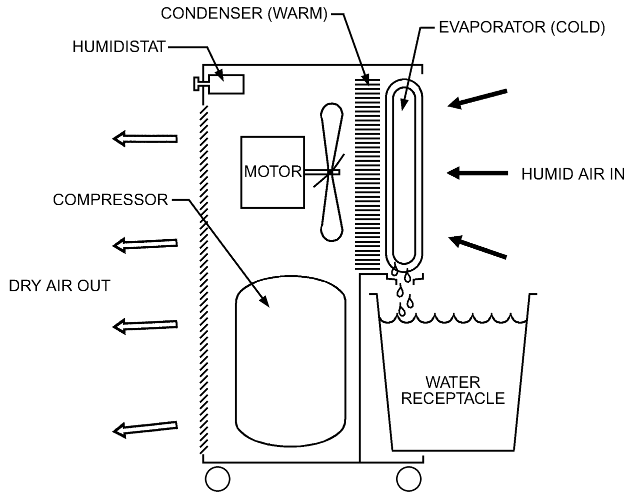

Fig. 3 Typical Domestic Dehumidifier

Evaporators are protected against corrosion by finishes such as waxing, painting, or anodizing (on aluminum). Waxing reduces the wetting effect that promotes condensate formation; however, tests on waxed versus nonwaxed evaporator surfaces show negligible loss of capacity. Thin paint films do not have an appreciable effect on capacity.

Removable water receptacles, provided with most dehumidifiers, hold 16 to 24 pints and are usually made of plastic to withstand corrosion. Easy removal and handling without spillage are important. Most dehumidifiers also provide either a means of attaching a flexible hose to the water receptacle or a fitting provided specially for that purpose, allowing direct gravity drainage to another means of disposal external to the cabinet.

More expensive dehumidifiers usually have higher output capacities, are more attractively styled, and have various auxiliary features. An adjustable humidistat (30 to 80%) automatically cycles the unit to maintain a preselected relative humidity. The humidistat may also provide a detent setting for continuous operation. Some models also include a sensing and switching device that automatically turns the unit off when the water receptacle is full.

Dehumidifiers are designed to provide optimum performance at standard rating conditions of 80°F db room temperature and 60% rh. When the room is less than 65°F db and 60% rh, the evaporator may freeze. This effect is especially noticeable on units with a capillary tube.

Some dehumidifiers are equipped with defrost controls that cycle the compressor off under frosting conditions. This control is generally a bimetal thermostat attached to the evaporator tubing, allowing dehumidification to continue at a reduced rate when frosting conditions exist. The humidistat can sometimes be adjusted to a higher relative humidity setting, which reduces the number and duration of running cycles and allows satisfactory operation at low-load conditions. Often, especially in the late fall and early spring, supplemental heat must be provided from other sources to maintain above-frosting temperatures in the space.

Capacity and Performance Rating. Domestic dehumidifiers are available with moisture removal capacities of 11 to 60 pints per 24 h, and are operable from ordinary household electrical outlets

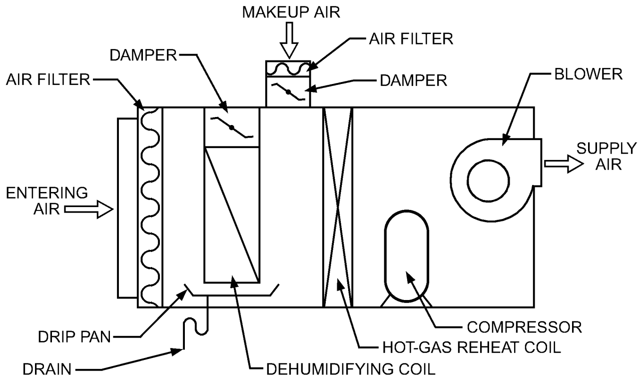

Fig. 4 Typical General-Purpose Dehumidifier

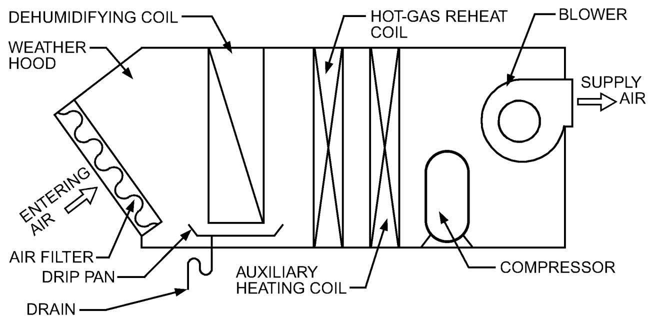

Fig. 5 Typical Makeup Air Dehumidifier

(115 or 230 V, single-phase, 60 Hz). Input varies from 200 to 800 W, depending on the output capacity rating.

AHAM *Standard* DH-1 establishes a uniform procedure for determining the rated capacity of dehumidifiers under specified test conditions and also establishes other recommended performance characteristics. An industry certification program sponsored by AHAM covers the great majority of domestic dehumidifiers and certifies dehumidification capacity.

The U.S. Environmental Protection Agency (EPA) qualifies dehumidifiers to carry its ENERGY STAR® label if they remove the same amount of moisture as similarly sized standard units, but use at least 10% less energy. The EPA's ENERGY STAR web site provides additional information on qualifying products (EPA 2008).

Codes. Domestic dehumidifiers are designed to meet the safety requirements of UL *Standard* 474, *Canadian Electrical Code*, and ASHRAE *Standard* 15. UL-listed and CSA-approved equipment have a label or data plate indicating approval. UL also publishes the *Electrical Appliance and Utilization Equipment Directory*, which covers this type of appliance.

General-Purpose Dehumidifiers

Basic components of general-purpose dehumidifiers are shown in Figure 4. An air filter is required to protect the evaporator. Dehumidifying coils, because of their depth and thoroughly wetted surfaces, are excellent dust collectors and not as easily cleanable as much thinner air-conditioning evaporator coils. However, the large amount of condensate has a self-cleaning effect. The bypass damper above the evaporator coil allows airflow adjustments for the evaporator without decreasing airflow for the reheat coil. Dehumidifying and reheat coils perform best at different airflows.

The compressor may be isolated from the airstream or located in it. Locating the compressor in the airstream may make service more difficult, but this arrangement allows heat lost through the compressor casing to be provided to the conditioned space while reducing the size of the enclosure. During the cooling season, this compressor location reduces the unit's sensible cooling capacity.

Code-required ventilation air may be introduced between the evaporator and reheat coil. The amount of makeup air should be controlled to not adversely affect the refrigeration system's operation. Preheating ventilation air may be required in colder climates.

Computerized controls can sense return air temperature and relative humidity. Remote wall-mounted sensors are also available. More sophisticated controls are desirable to regulate dew-point temperature and maintain the desired relative humidity in the space.

General Considerations. Before considering installation of any type of dehumidification equipment, all latent loads should be identified and quantified. In many cases, this might lead to decisions that reduce the latent load. For example, a storage facility that does not have an adequate vapor retarder in the building envelope should be retrofitted first before attempting to calculate the amount of moisture migration through the structure. The same approach should be taken to reduce the amount of uncontrolled air infiltration.

Consider covering large water surfaces, such as vats, and/or providing a local exhaust hood to evacuate concentrated water vapor from where it is generated. Although these corrections seem to add cost to a project, the resulting reduced size of the dehumidifier and its lower operating cost often result in an attractive financial payback.

Other special considerations include the following:

- **High volumes of makeup air.** A project may start out to be suitable for a general-purpose dehumidifier. However, once makeup air requirements are quantified to compensate for exhaust and to pressurize the facility, a general-purpose dehumidifier may no longer be applicable. The maximum acceptable portion of outdoor air for general-purpose dehumidifiers is limited, and depends on climatic conditions and the desired indoor conditions to be maintained. As a general rule, when outdoor air requirements exceed 20% of the dehumidifier's total airflow, the manufacturer should be consulted to determine whether the equipment is suitable for the application. In many cases, a makeup air dehumidifier should be considered instead.
- **Low-temperature applications.** Many storage facilities require humidity control, but do not have specific temperature control requirements. When the space temperature is allowed to drop below 65°F, consult the manufacturer of the dehumidifier to determine whether the equipment is suitable for the application. Some dehumidifiers, such as those used for indoor ice rinks, can operate at ambient conditions as low as 50°F. Lower air temperatures are likely to require a desiccant dehumidifier.

Makeup Air Dehumidifiers

A makeup air dehumidifier [or **dedicated outdoor air system (DOAS)**] is used to separately condition all outdoor air brought into the building for ventilation or to replace air that is being exhausted. (As such, a makeup air dehumidifier should be selected based on its latent dehumidification capacity, not necessarily on its total air-conditioning capacity.) This conditioned outdoor air is then delivered either directly to each occupied space, to small HVAC units located in or near each space, or to central air handlers serving those spaces. Meanwhile, the local or central HVAC equipment is used to maintain space temperature. Treating the outdoor air separately from recirculated return air makes it easy to verify sufficient ventilation airflow and enables enforcement of a maximum humidity limit in the occupied spaces.

Makeup air dehumidifiers may require simultaneous heat rejection to the reheat coil and/or another condenser (air- or water-cooled), because it may not always be possible to reject the total heat of rejection from the dehumidifying coil to the makeup air. A rainproof air intake and cooling capacity modulation (or staging) are important. With constantly changing weather conditions, even throughout the day, compressor capacity must be adjusted to prevent coil freeze-ups. Basic components are shown in Figure 5.

Auxiliary heating may be required for year-round operation in some climates. Water- and steam-heating coils should have freeze protection features. When using indirect-fired gas heaters, the combustion chamber should be resistant to condensation.

Makeup air dehumidifiers may be interfaced with a building automation system (BAS) to control the unit's on/off status and operating mode, because most spaces do not require continuous makeup air. Air exhaust systems must also be synchronized with the makeup air equipment to maintain proper building pressurization.

Combining exhaust air with makeup air systems provides the opportunity to transfer energy between the two airstreams. A typical arrangement is shown in Figure 6.

Types and functions of air-to-air energy recovery devices are covered in Chapter 25. During summer, entering outdoor air is precooled and possibly partially dehumidified to lower the enthalpy of air entering the cooling coil. Conversely, during winter operation, entering outdoor air is preheated and possibly partially humidified. When using air-to-air energy recovery, the required compressor capacity of the makeup air dehumidifier may be significantly reduced. Using a proper damper system, a makeup air dehumidifier may also be able to treat recirculated air, which can allow for humidity control during unoccupied periods.

Efficient use of makeup air dehumidifiers may improve the overall efficiency of a building air-conditioning system.

General Considerations. The sophistication of a makeup air dehumidifier varies greatly with its application. Typically, it requires some type of capacity modulation for dehumidification as well as the heating mode (if so equipped). On/off cycles are normally not acceptable when supplying outdoor air to a conditioned space. Other considerations include the following:

- **Deliver conditioned outdoor air dry.** Regardless of where conditioned outdoor air is delivered, the makeup air dehumidifier should dehumidify the outdoor air so that it is drier than the required space dew point. If the dew-point temperature of the conditioned outdoor air is lower than the dew point in the space, it can also offset some or all of the space latent loads (Morris 2003). This adequately limits indoor humidity at both full and part load without the need for additional dehumidification enhancements in the local HVAC units. The local units only need to offset the space sensible cooling loads. To prevent warm discomfort, Nevins et al. (1975) recommended that, on the warm side of the comfort zone, relative humidity should not exceed 60%. At 77°F, this results in a dew-point temperature of 62°F. Therefore, this type of dehumidifier typically requires only a basic step control to prevent evaporator coil freezing at low loads.

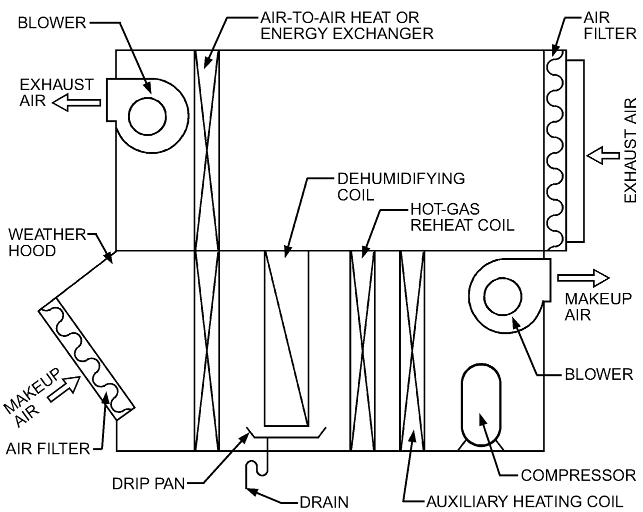

Fig. 6 Typical Makeup Air Dehumidifier with Exhaust Air Heat/Energy Recovery

- **Neutral versus cold leaving air temperature.** Many dedicated outdoor-air systems are designed to dehumidify outdoor air so it is drier than the space, and then reheat it to approximately space temperature (neutral). (Various methods of heat recovery can be used to increase the efficiency of this process by recovering heat for reheat.) This can simplify control of the local HVAC units, eliminate the concern about overcooling the space, and avoid condensation-related problems when conditioned air is delivered to an open ceiling plenum.

  However, when a cooling coil is used to dehumidify outdoor air, the dry-bulb temperature of air leaving the coil is colder than the space. In some applications and under some operating conditions, this air can be delivered at a dry-bulb temperature cooler than the space (not reheated to neutral), thus offsetting part of the sensible cooling load in the space. This means less cooling capacity is required from the local HVAC equipment than if the air is delivered at a neutral temperature. A control sequence can be used to reset the leaving air dry-bulb temperature, and activate reheat when necessary, to avoid overcooling the space (Murphy 2006) while still dehumidifying the outdoor air to the required dew point.
- **Exhaust air heat recovery.** Because all outdoor air is brought in at a central location, consider including an air-to-air heat exchanger to precondition the outdoor air (Figure 6). During summer operation, outdoor air is cooled and possibly dehumidified. During winter, outdoor air is heated and possible humidified. This reduces operating costs and may allow downsizing of the mechanical cooling, dehumidification, heating, and humidification equipment. Types and functions of air-to-air energy recovery devices are covered in Chapter 25.
- **Makeup air for processes.** Commercial processes may require a large amount of makeup air (because a large amount of air is exhausted) and precise dew-point temperature control. As an additional challenge, airflow may be variable. This type of application may require a near-proportional capacity reduction control using several stages of compressor capacity and modulating refrigeration controls.

Indoor Swimming Pool Dehumidifiers

Indoor pools (natatoriums) are an efficient application for mechanical dehumidifiers. Humidity control is required 24 h a day, year-round. Dehumidifiers are available as single- and double-blower units (see Figures 7 to 10).

The latent heat (LH) from dehumidification (see Figure 2) comes nearly exclusively from pool water (excluding humidity from makeup air and latent heat from large spectator areas). Loss of evaporation heat cools the pool water. By returning evaporation heat losses to the pool water, the sensible heat between points C and D of Figure 2 is not rejected into the supply air, which can reduce supply air temperature by approximately 15°F.

Methods for classifying and rating performance of single-blower pool dehumidifiers are published in ARI *Standard* 910. The ARI rating configuration is for a dehumidifier operating in recirculated air mode, with no ventilation air being introduced to the system. Caution is suggested when reviewing the performance of a dehumidifier and at what mode of operation it is being rated. Introducing ventilation air to a dehumidifier and adding exhaust fans for energy recovery between the two airstreams can affect the dehumidifier's performance and ratings. The sensible and latent capacity of the dehumidifier may change from the actual listed performance. All unit performance ratings must be reviewed during each mode of operation against the building load. Where ventilation air is introduced to the system, as well as the location of the exhaust air, may affect dehumidifier performance differently, depending on whether the space is being cooled or heated. The dehumidifier and associated equipment must be selected based on space heating and cooling loads, including ventilation loads, so that both sensible and latent loads are satisfied to the extent possible.

Single-blower pool dehumidifiers (Figure 7) are similar to general-purpose dehumidifiers (see Figure 4), with the following exceptions:

- One or several water heaters may be installed to add recovered heat from the refrigeration circuit into the pool water. Heaters can provide full pool-water heating for several pools maintained at different temperatures.
- All components must be corrosion-resistant to chloramine-laden air.
- The pool water heater must be resistant to chlorinated water.
- Cross-contamination prevention features are not required but should be considered. Pool water must be kept sanitary at all times. Accidental contamination with refrigerant oil should be prevented.

Figure 8 shows a double-blower pool dehumidifier with economizer dampers and a full-sized return fan located upstream of the evaporator coil. This configuration can provide up to 100% makeup air to maintain humidity levels, which can be attractive when the outdoor dew point is below the required indoor dew point during mild weather, or in climates when enough hours of dry- and wet-bulb conditions are below the level to be maintained. Preheating outdoor air may be required to prevent condensation inside the mixing box. Also, this configuration does not recover energy from the warm, moist exhaust air. During dehumidifying coil operation, the amount of makeup and exhaust air is limited by outdoor condition, especially during the heating season. Cold makeup air may lower the mixed-air temperature to the point where the dehumidifying coil cannot extract any moisture.

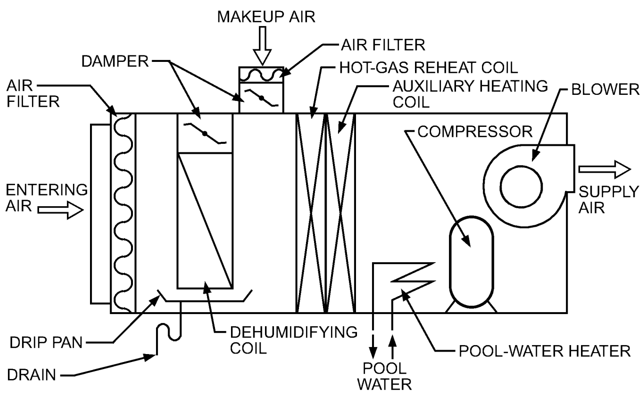

Fig. 7 Typical Single-Blower Pool Dehumidifier

In some regions, it is economically attractive to remove moisture from the exhaust air to recover its latent heat. In this case, the dehumidifying coil is installed in the return air section. Figure 9 shows a double-blower pool dehumidifier with economizer dampers and return fan located downstream of the evaporator coil. A damper system can also be incorporated to exhaust before the evaporator coil during colder conditions and after the evaporator during warmer conditions. This configuration recovers energy from the warm, moist exhaust air; however, exhausting air from downstream of the evaporator coil also reduces the unit's sensible capacity by the amount of the exhaust air. The ratio of return air to exhaust air must be considered to determine the unit's capacity to remove moisture from the conditioned space.

Figure 10 shows a different unit configuration that addresses concerns related to blower energy use during the various operating modes. This unit can operate with the supply blower only, or with the addition of one or two exhaust blowers.

Some manufacturers also offer air-to-air heat recovery between the exhaust and makeup airstreams (see Chapter 25). During cold weather, this arrangement preheats entering makeup air with heat recovered from the exhaust airstream. Latent heat recovery may not be practical, however, because it transfers moisture to the entering air, thus possibly increasing dehumidification requirements.

Control systems should be compatible with building automation systems; however, the BAS must not disable dehumidifier operation because indoor pools always need some dehumidification, regardless of occupancy, and require specialized control sequences.

General Considerations. The primary function of an indoor swimming pool dehumidifier is to lower the space dew-point temperature to an acceptable level and to provide adequate air circulation to comply with minimum air change rates.

For more information on indoor swimming pool (natatorium) applications, see Chapter 4 of the 2007 *ASHRAE Handbook—HVAC Applications*.

Types of Equipment. Indoor swimming pool dehumidifiers are available in single- and double-blower configurations (see Figures 7 to 10). Heat from the refrigeration circuit can be (1) used to reheat supply air, (2) used to heat pool water, or (3) rejected to the outdoors by an optional air- or water-cooled condenser. Equipment configurations are available to use the heat for any combination of these three purposes.

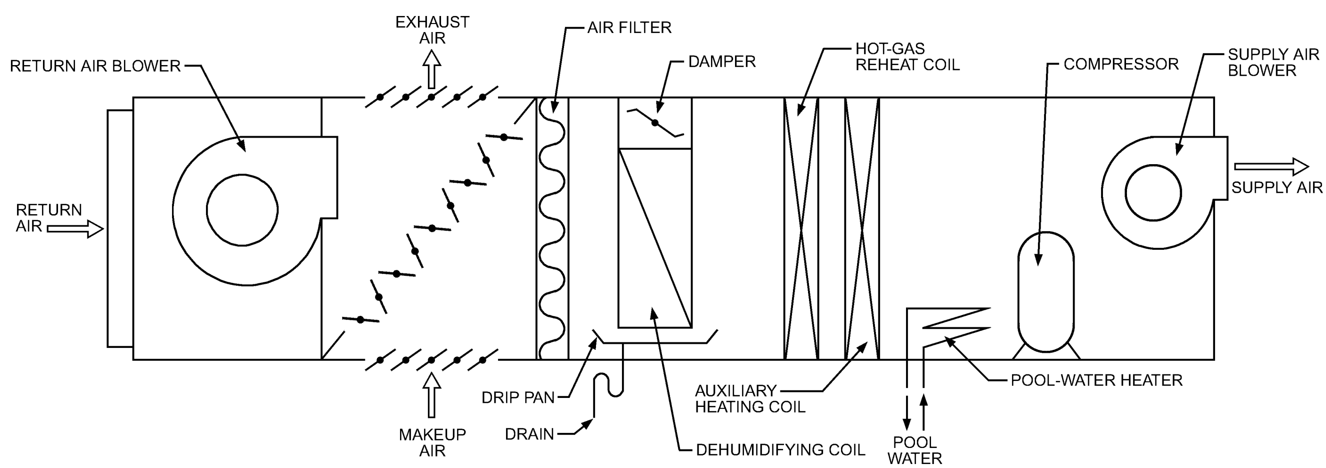

Fig. 8 Typical Double-Blower Pool Dehumidifier with DX Coil in Supply Air Section

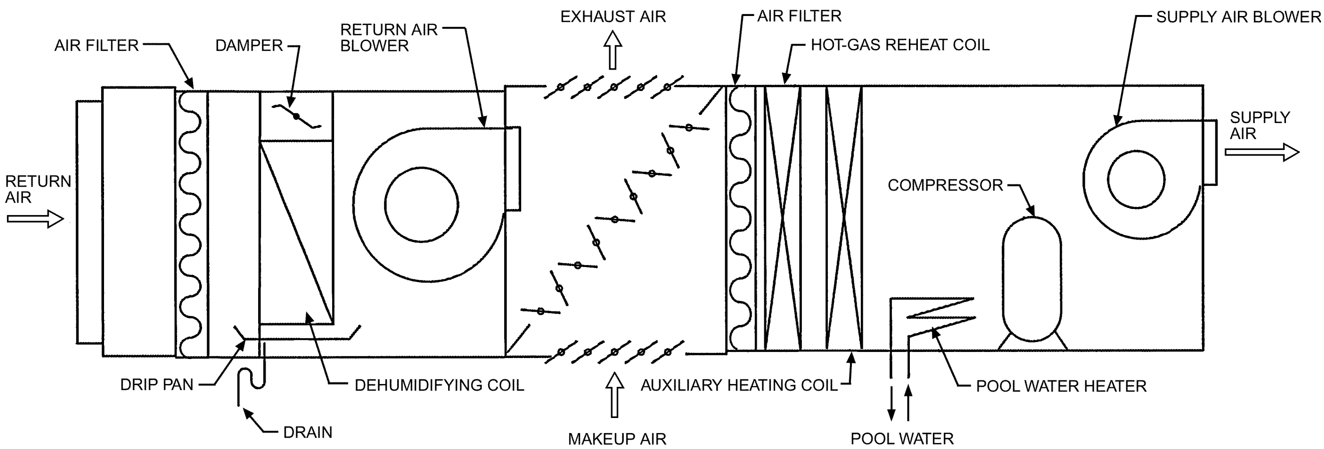

Fig. 9 Typical Double-Blower Pool Dehumidifier with DX Coil in Return Air Section

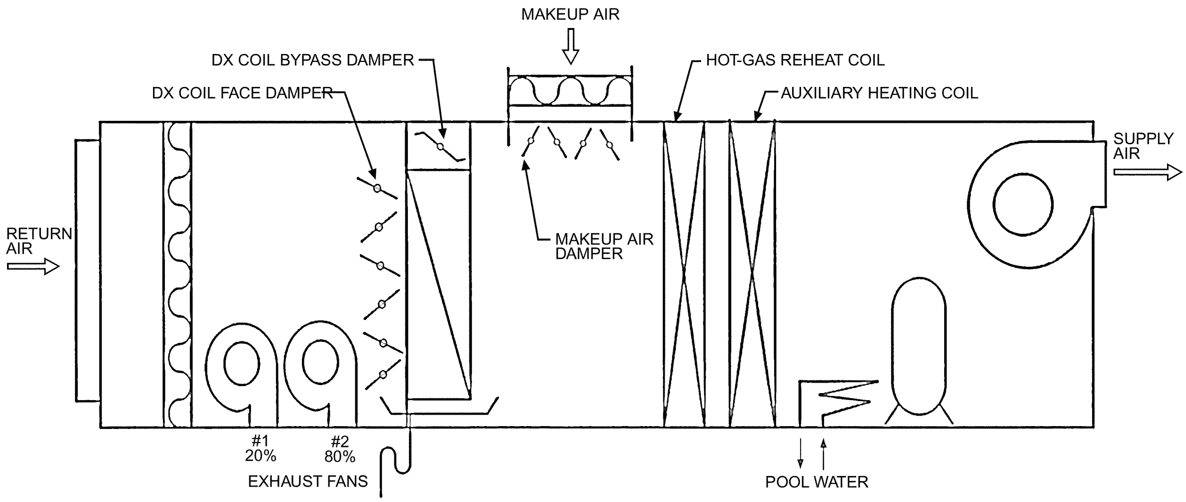

Fig. 10 Supply Blower and Double Exhaust Blower Pool Dehumidifier

The equipment can be located indoors or outdoors, and may be manufactured as a single package or as a split system with a remote condenser. Indoor, air-cooled condensers are typically equipped with a blower-type fan suitable for duct connections. An optional economizer allows for the introduction of up to 100% of outdoor air (turning off the compressors) when conditions are appropriate.

When selecting a dehumidifier for an indoor swimming pool application, several questions need to be addressed:

- In what mode of operation is the dehumidifier rated?
- Does the rating include ventilation air, and what effect, if any, does it have on dehumidifier performance?
- Does the unit include exhaust air, and what effect, if any, does it have on dehumidifier performance?
- Does the cost of running a second fan offset the energy saved by the economizer?
- Will the dehumidifier maintain the desired space conditions during all modes of operation?

Ice Rink Dehumidifiers

Design for ice rink dehumidifiers is similar to that of general-purpose dehumidifiers (see Figure 4). However, because of the lower temperatures, airflow and dehumidifying and reheat coils are selected in accordance with the following conditions:

- The dehumidifying coil may or may not have an air bypass, depending on the location of makeup air intake and/or coil selection.
- The dehumidifying coil may have means to defrost or to prevent frost formation.
- Makeup air treatment is limited.

For large spectator areas, special makeup air dehumidifiers may be required.

General Considerations. For community ice rinks with small spectator areas (or none), it is customary to install two small dehumidifiers over the dasher boards in a diagonal arrangement, 12 to 15 ft above the ice surface (Figure 11). Take care that discharge air from dehumidifiers is not directed toward the ice surface. Forced airflow at any temperature may damage the ice surface. Ice rinks with large spectator areas have different requirements.

The spectator area is typically maintained at 70°F. To limit moisture migration to the ice sheet, space conditions must be maintained at 50% rh or less. The resulting dew-point temperature is then 50°F or less. The air temperature over the ice sheet in the dasher boards, however, is approximately 5°F lower than the air in the spectator area. With an air temperature of 65°F and a dew-point temperature of 50°F or less, fog over the ice sheet cannot develop. As a general rule, mechanical ice rink dehumidifiers are most effective for condensation and fog control when dry-bulb space temperature is at least 15°F above the dew point. For additional fog and condensation prevention methods, see Chapter 35 of the 2006 *ASHRAE Handbook—Refrigeration*.

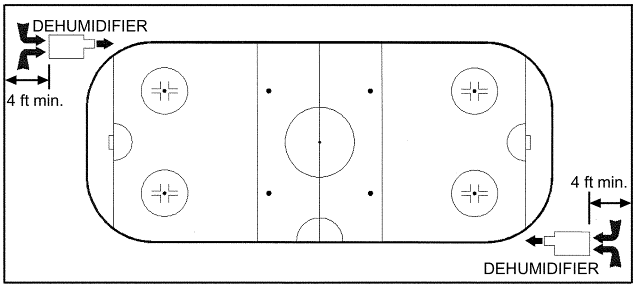

Fig. 11 Typical Installation of Ice Rink Dehumidifiers

INSTALLATION AND SERVICE CONSIDERATIONS

Equipment must be installed properly so that it functions in accordance with the manufacturer's specifications. Interconnecting diagrams for the low-voltage control system should be documented for proper future servicing. Planning is important for installing large, roof-mounted equipment because special rigging is frequently required.

The refrigerant circuit must be clean, dry, and leak-free. An advantage of packaged equipment is that proper installation minimizes the risk of field contamination of the circuit. Take care to properly install split-system interconnecting tubing (e.g., proper cleanliness, brazing, evacuation to remove moisture). Split systems should be charged according to the manufacturer's instructions.

Equipment must be located to avoid noise and vibration problems. Single-package equipment of over 20 tons in capacity should be mounted on concrete pads if vibration control is a concern. Large-capacity equipment should be roof-mounted only after the roof's structural adequacy has been evaluated. Additional installation guidelines include the following:

- In general, install products containing compressors on solid, level surfaces.
- Avoid mounting products containing compressors (e.g., remote units) on or touching the foundation of a building. A separate pad that does not touch the foundation is recommended to reduce noise and vibration transmission through the slab.
- Do not box in outdoor air-cooled units with fences, walls, overhangs, or bushes. Doing so reduces the unit's air-moving ability, reducing efficiency.
- For a split-system remote unit, choose an installation site that is close to the indoor part of the system to minimize refrigerant charge and pressure drop in the connecting refrigerant tubing.
- Contact the equipment manufacturer or consult the installation instructions for further information on installation procedures.

Equipment should be listed or certified by nationally recognized testing laboratories to ensure safe operation and compliance with government and utility regulations. Equipment should also be installed to comply with agency standards' rating and application requirements to ensure that it performs according to industry criteria. Larger and more specialized equipment often does not carry agency labeling. However, power and control wiring practices should comply with the *National Electrical Code*® (NFPA *Standard* 70). Consult local codes before design, and consult local inspectors before installation.

A clear, accurate wiring diagram and well-written service manual are essential to the installer and service personnel. Easy, safe service access must be provided for cleaning, lubrication, and periodic maintenance of filters and belts. In addition, access for replacement of major components must be provided and preserved.

Service personnel must be qualified to repair or replace mechanical and electrical components and to recover and properly recycle or dispose of any refrigerant removed from a system. They must also understand the importance of controlling moisture and other contaminants in the refrigerant circuit; they should know how to clean a hermetic system if it has been opened for service (see Chapter 6 of the 2006 *ASHRAE Handbook—Refrigeration*). Proper service procedures help ensure that the equipment continues operating efficiently for its expected life.

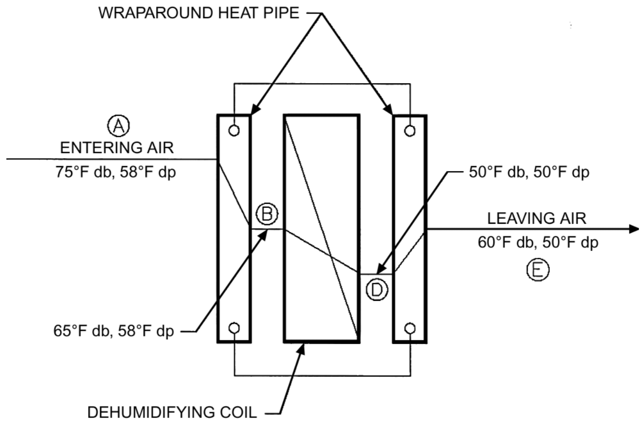

Fig. 12 Dehumidification Enhancement with Wraparound Heat Pipe

WRAPAROUND HEAT EXCHANGERS

An air-to-air heat exchanger (heat pipe, coil runaround loop, fixed-plate heat exchanger, or rotary heat exchanger) in a series (or wraparound) configuration can be used to enhance moisture removal by a mechanical dehumidifier, improving efficiency, and possibly allowing reduced refrigeration capacity in new systems. Other uses of air-to-air heat exchangers are covered in Chapter 25.

Air-to-air heat exchangers are used with a mechanical dehumidification system to passively move heat from one place to another. The most common configuration used for dehumidification is the **runaround** (or **wraparound**) configuration (Figure 12), which removes sensible heat from the entering airstream and transfers it to the leaving airstream. (Points A to E correspond to points labeled in Figure 13.) This improves the cooling coil's latent dehumidification capacity. This method can be applied if design calculations have taken into account the condition of air entering the evaporator coil.

In the runaround or wraparound configuration (Figure 12), one section of the air-to-air heat exchanger is placed upstream of the cooling coil and the other section is placed downstream of the cooling coil. The air is precooled before entering the cooling coil. Heat absorbed by the upstream section of the air-to-air heat exchanger is then transferred to air leaving the cooling coil (or supply airstream) by the downstream section.

Sensible precooling by the air-to-air heat exchanger reduces the sensible load on the cooling coil, allowing an increase in its latent capacity (Figure 13). The combination of these two effects lowers the system SHR, much like the process described in the Mechanical Dehumidifiers section. The addition of the air-to-air heat exchanger brings the condition of air entering the evaporator coil closer to the saturation line on the psychrometric chart (A to B). In new installations, this requires careful evaporator coil design that accounts for the actual range of air conditions after the air-to-air heat exchanger, which may differ significantly from the return air conditions.

In retrofits, the **duct-to-duct** (or **slide-in**) configuration (Figure 14) is sometimes used. One section of the air-to-air heat exchanger is placed in the return airstream, and the other section is placed in the supply airstream. This configuration, however, does not provide

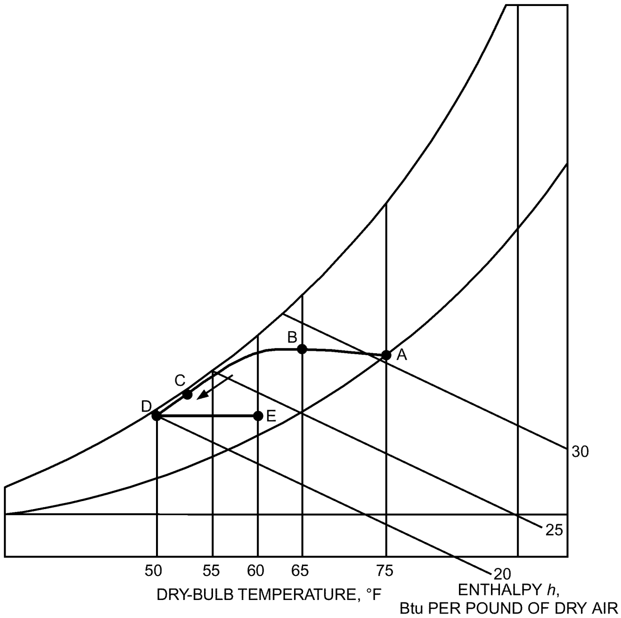

Fig. 13 Enhanced Dehumidification with a Wraparound Heat Pipe

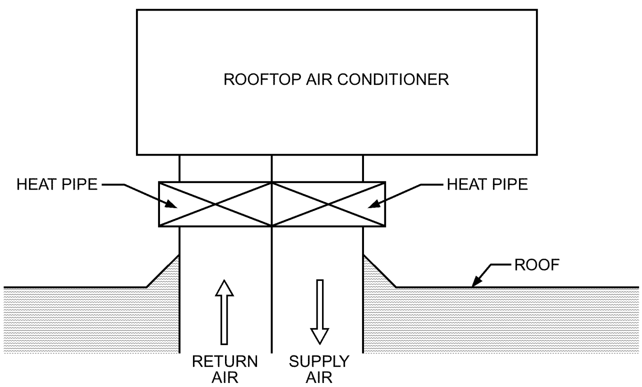

Fig. 14 Slide-in Heat Pipe for Rooftop Air Conditioner Refit
(Kittler 1996)

as much benefit as the wraparound configuration because (1) the upstream side of the heat exchanger is located upstream of where outdoor air enters the system, (2) the higher velocity reduces the effectiveness and increases the air-side pressure drop of the heat exchanger, and (3) it requires an additional filter upstream of the air-to-air heat exchanger.

In retrofits, the lower entering-air temperature at the evaporator coil lowers the temperature of the air leaving the evaporator coil. Evaporator coil capacity is reduced because of the lower entering wet-bulb temperature, changing the operating point of the system. This must be analyzed to ensure that the mechanical refrigeration system still operates correctly. If evaporator coil freeze-up is possible, the system must include some means of deactivating the air-to-air heat exchanger or increasing airflow to prevent evaporator freezing. Some way to modulate the air-to-air heat exchanger's capacity may be incorporated to better meet the load requirement of the mechanical dehumidifier.

Adding an air-to-air heat exchanger typically improves the moisture removal capacity of an existing mechanical dehumidification system by allowing a lower supply air dew point, while providing some reheat without additional energy use. Proper design practices must be followed to ensure that the unit's mechanical refrigeration system will still operate efficiently with the new entering air conditions and additional air-side pressure drop. Also, the added pressure drop of the air-to-air heat exchanger is likely to reduce the airflow delivered, unless fan speed in increased. If increasing fan speed is necessary, verify that the fan motor can handle the added load.

Figure 13 shows the dehumidification process when an air-to-air heat exchanger is added to an existing evaporator coil. Point A to C shows the cooling and dehumidification process of an existing direct-expansion (DX) evaporator coil, without the air-to-air heat exchanger. Point A to B shows precooling by the upstream section of heat exchanger. The process line from B to D (versus B to C, without the heat exchanger) shows how the evaporator coil's dehumidification performance improves (lowering leaving air dew point, from C to D) if an air-to-air heat exchanger is added to the existing system, because the enthalpy of the air entering the evaporator is lowered. Point D to E illustrates that the heat removed from air upstream of the evaporator (A to B) is added back into air leaving the evaporator. The total amount of heat energy (enthalpy) removed in section A-B is equal to the amount of heat added in section D-E.

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