Coils: Direct Expansion, Chilled Water, and Heating
Technical Development Programs (TDP) are modules of technical training on HVAC theory, system design, equipment selection and application topics. They are targeted at engineers and designers who wish to develop their knowledge in this field to effectively design, specify, sell or apply HVAC equipment in commercial applications.

Although TDP topics have been developed as stand-alone modules, there are logical groupings of topics. The modules within each group begin at an introductory level and progress to advanced levels. The breadth of this offering allows for customization into a complete HVAC curriculum – from a complete HVAC design course at an introductory-level or to an advanced-level design course. Advanced-level modules assume prerequisite knowledge and do not review basic concepts.

There are many different coil applications used in HVAC design. They range from small residential sizes to large built-up coil banks in custom air-handling units. Regardless of their size, all coils serve the important function of changing the temperature of the air to satisfy comfort or process requirements. There are two main categories of coils, heating or cooling. Heating coils use electricity, hot water, or refrigerant hot gas as a heating medium. Cooling coils use direct expansion (cold refrigerant) or chilled water. In this TDP, a design engineer will learn about the components, features, and applications for direct expansion and chilled water cooling, and hot water, steam, and electric heating coils. With an understanding of these items, the design engineer can proceed with confidence to perform a proper coil selection and prepare a specification.
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Introduction

This TDP module reviews the terms, construction features, heat transfer characteristics, performance, and applications of the various types of heating and cooling coils. Heating coils use electricity, hot water, steam, hot gas reheat, or the reverse cycle of a heat pump unit to raise the temperature of the air flowing through the coil. Cooling coils use direct expansion (refrigerant) or chilled water to lower the temperature of the air flowing through the coil.

The term “coil” refers to a fluid-to-air heat exchanger. The fluid used in the coil may be water, steam, antifreeze solution, or refrigerant. The exception is electric heat coils, which do not use fluids. Coils are used for heating and cooling in air-handling units, packaged air conditioning units, and VAV terminals and can also be mounted in a duct or on a furnace. Figure 1 shows an example of a water coil.

The primary emphasis in this TDP will be placed on coils used in air-handling units operating in comfort air-conditioning applications because the design engineer for those products has the widest variety of coil types to choose from. In packaged equipment, the coil is already included as part of the unit design; however, some coil options may be available. The technical principles are the same for coils in packaged equipment and air-handling units.

“Cooling coil” is a generic term for coils that use chilled fluid or refrigerant as the cooling medium. The term “evaporator coil” has been used in the past for cooling coils that use refrigerant since refrigerant evaporates at a low temperature and pressure to extract heat from the airstream. “Direct expansion” or DX coil is the term that will be used in this TDP for coils that use refrigerant for cooling. If the heating or cooling coil application requires a fluid other than fresh water for purposes of freeze protection, that fluid will be referred to as antifreeze.

Outdoor refrigerant condenser coils that are part of packaged equipment designs, such as condensing units and rooftop units, are not covered in this module because their design is normally determined by the manufacturer. For information on condenser coils in packaged equipment refer to TDP-634, Split Systems.

Before starting this module, the reader should have knowledge of the following topics: cooling load estimation, psychrometric theory, refrigeration principles, and air-handling equipment. The Carrier Technical Development Program for each of these topics is listed in the Prerequisite List on the inside back cover of this book.
Typical Coil Applications in HVAC Systems

In comfort cooling applications, there are five general application categories that use coils: residential systems, commercial packaged systems, duct mounted systems, air terminals, and air-handling units. We will discuss each and examine the coil designs that each of them use. Later in the TDP we will examine the construction and materials used in each coil type discussed below.

Residential Systems

Residential systems usually have less than five tons of cooling capacity. Residential cooling coils are usually a direct expansion (DX) design. Residential heating coils are available for heat pump units or electric heat. Hot water, steam, and chilled water coils are uncommon for residential applications so will not be discussed here.

A residential split system is comprised of a separate indoor coil (fan required) or coil and fan combination unit, coupled to an outdoor cooling-only or heat pump condensing unit.

The indoor DX cooling coil is often mounted on top of a residential furnace or fan unit. Residential cooling coils are similar to the larger commercial packaged unit cooling coils, but are available in smaller tonnage ranges. The coils are traditionally installed on the discharge side of the fan. Cooling coils are available in a number of configurations, “A,” (shown here) “N,” and slab. The coil can be a cased (factory enclosed) or uncased design. When an uncased coil is used, the field fabricated ductwork forms the casing around it when it is installed. See Figure 2 for an example of cased and uncased coils.

Figure 2
Residential Coils
Commercial Packaged Units

Packaged commercial units are typically available in capacities from 7½ tons to over 100 tons. Packaged units are available in a limited number of pre-defined sizes. The advantage of the packaged air handler DX cooling coil is that the components, such as thermostatic expansion valves (TXVs) and nozzles, are normally factory selected and may be mounted at the factory. Nozzles and TXVs are discussed on pages 22 and 23 of the TDP.

Direct expansion cooling coils are used in small commercial applications. These coils depend on the airflow provided by a furnace or small commercial fan unit to circulate the air through the coil. Two types of coils can be used: an “A” coil design, which is used when two furnaces are twinned (used together as one), or a cased evaporator coil that is installed in the ductwork. See Figure 3 for an example. These coils are available in a variety of capacities. The most common capacities are 7½ and 10 tons.

Larger commercial packaged units include indoor vertical packaged products and outdoor rooftop units. These types of units will also utilize a direct expansion cooling coil. See Figure 4 for an example. However, chilled water coils are also available for use in many indoor packaged fan coils. Chilled-water cooling coils tend to be used in larger central station air-handling units which are discussed on page 26.

Indoor commercial packaged air handlers often utilize hot water or electricity as the source for heating coils. Typically the air handler is available standard with a DX cooling coil, and a heating coil is a field-installed accessory.
Duct-Mounted Coils

Duct-mounted coils are usually heating type. Cooling coils are not typically used because a duct-mounted cooling coil would require an insulated condensate pan.

There are several types of duct-mounted heating coils: hot water, steam, or electric. There are also several methods to attach the ductwork. The drive slip and flanged casings are shown with connection details in Figures 5 and 6. Duct-mounted heating coils are often called reheat coils. Multizone systems that use a reheat coil in each zone supply duct are limited in their application by ASHRAE Standard 90.1 because of potential excessive energy usage.

Air Terminals

Air terminals are used in variable air volume systems and dual-duct systems and often incorporate small hot water or electric heating coils. These coils are available factory mounted or ready to install as an integral part of the air terminal as an accessory. See Figure 7. The industry also classifies unit ventilators and fan coils as air terminals.