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.

Self-contained units are a unique segment of the packaged air-conditioning industry. They are available in a variety of configurations for both air-cooled and water-cooled applications. For comfort air conditioning applications, they are popular for use as spot coolers in stores, restaurants, and industrial buildings. Self-contained units are often used in multiples, usually with a cooling tower, to form a floor-by-floor system in hi-rise buildings. All sizes of self-contained units are available for constant volume (CV) applications. Smaller tonnage self-contained units can be used with zoning systems such as variable volume and temperature (VVT®) systems where multiple control zones are required. Units above 20 tons in capacity are available factory-modified for variable air volume (VAV) applications where multiple zones of control are necessary and fan energy savings is desired.
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Introduction

Packaged HVAC units are a large segment of the air-conditioning industry. They are easy to select and apply because they are a pre-engineered (packaged) type of product and have low installed cost. This makes them attractive to owners, contractors, and engineers.

While packaged equipment covers a wide range of products, including rooftop units, this Technical Development Program module covers a specific type of packaged unit: indoor self-contained units. Indoor self-contained units are a subset of “unitary” packaged products that are installed in or near the occupied space. See Figure 1.

The Air Conditioning and Refrigeration Institute (ARI) defines a unitary air conditioner as one or more factory-made assemblies that normally include: an evaporator or cooling coil, an air-moving device or fan, and a compressor and condenser combination. The air conditioner may include a heating function as well. This is also a description of a self-contained unit.

In this TDP we will examine both air-cooled and water-cooled self-contained units. For water-cooled units, their condensers are typically piped to a condenser water loop containing a cooling tower for heat rejection. For air-cooled units, the condenser is either integral to the unit cabinet or at a remote location.

Versatility

Indoor self-contained units offer a versatile approach to providing comfort on small single-zone or large multiple-zone systems.

The function of a packaged unit is to provide complete air conditioning, including control of temperature, humidity, air circulation, and filtering of air. Although indoor self-contained units do not directly control relative humidity, in most cases they dehumidify the air, which may result in acceptable humidity levels for most applications. Steam, hot water, or electric resistance heating coils can be added as an accessory to provide year-round control of temperature. Self-contained units are intended for installation indoors, near the occupied zones.

The self-contained units discussed in this TDP are fully assembled products with factory-matched components. Little exterior piping or wiring is required for these units and they are usually five tons and larger in capacity. However, we will also discuss a spot cooling self-contained unit that is less than 5 tons.

As we will learn in this TDP module, there are many design considerations involved when using self-contained units such as the use of an airside or a waterside economizer, sound dampening choices, and constant volume (CV) versus variable air volume (VAV) unit types. Variable air volume units comprise a large segment of self-contained unit configurations as they are used in the larger building systems.
Indoor self-contained units are usually selected with software provided by the manufacturer. The selection is based on the customer’s air or water-cooled requirements. An example selection of a water-cooled unit is included at the end of this TDP module.

Self-Contained Unit Configurations

Self-contained units are available in three different configurations. The first configuration that we will cover is an air-cooled unit with an integral, ductable condenser. Secondly, we will discuss a configuration that uses a remote air-cooled condenser. The condenser may either be an indoor type with centrifugal fans or an outdoor type with propeller fans. Lastly, we will discuss water-cooled, self-contained units.

Air-cooled units usually offer lower installation and maintenance costs than water-cooled units, but air-cooled units have a higher operating cost. This is because air-cooled condensing temperatures are higher than water-cooled condensing temperatures. The higher the condensing temperature, the harder the compressor must work. This results in an increase in energy per ton of cooling produced.

Figures 2 and 3 show the self-contained unit market breakdown. Notice that below 20 tons, the self-contained unit market is almost entirely constant volume units. The market is also predominantly air-cooled units using either a remote or integral air-cooled condenser.

Above 20 tons, water-cooled units are 75 percent of the self-contained industry. In this category, the majority of self-contained units are variable air volume.
Air-Cooled Units with Integral Condenser

We will look at the smallest self-contained units first. Some manufacturers offer horizontal indoor self-contained systems as small as 2 tons, however, the vast majority of self-contained units are vertical designs. These small horizontal designs can be conveniently located in the ceiling above the conditioned space. This saves floor space and potentially eliminates the need for return ductwork, as shown in Figure 4. Small self-contained units are often referred to as “spot coolers,” because they can be located to condition a specific spot in a building, such as a conference room. These units range from 2 to 5 tons and feature a centrifugal fan condenser capable of overcoming the resistance from the intake and discharge ductwork and louvers. These units are available for constant volume use and have a single refrigeration circuit.

The small self-contained units also feature a design that permits splitting the centrifugal fan condenser section from the compressor and evaporator fan section. This allows the condenser fan to be located closer to the outside wall, minimizing airside pressure drop and ductwork length, resulting in lower condenser fan brake horsepower (bhp).

As self-contained units with integral condensers increase in capacity over 5 tons, they typically use a vertical configuration. See Figure 5. The evaporator fans can be ducted or use a free blow plenum. A one-piece design incorporates a centrifugal air-cooled condenser inside the unit chassis. Vertical units with an integral air-cooled condenser are typically available between 5 and 20 tons. Above 20 tons, the air-cooled condenser coil becomes large and may be difficult to design and install in a one-piece design. At 10 tons and above, self-contained units usually have multiple refrigeration circuits.

Water source heat pump (WSHP) units are applied in the same manner as small capacity self-contained units. Vertical WSHP units one ton and above can be used with larger water-cooled self-contained units. Often, the WSHP is applied in the cooling-only mode. For further information on WSHP Systems, see TDP-706, Water Source Heat Pumps.
Self-contained units in this capacity range are available with constant volume control. However, they can be used with a variable air volume and temperature (VVT®) system. The VVT system utilizes a constant volume unit of 20 tons and under.

Air-cooled, vertical, self-contained units are used in industrial applications such as factories for larger scale spot cooling. Other applications include nightclubs, retail outlets, and restaurants. In most of these applications, the unit is located in the same space as the occupants. Figure 6 shows a typical integral condenser fan unit.

Self-contained units are designed for comfort cooling applications. Another type of self-contained unit is called “close-control” unit. Close-control units are designed to maintain a precise specified temperature and humidity. This type of unit comes equipped with special features and is not covered in this TDP module. An example of a close-control unit would be a dedicated computer room unit equipped with extra steps of capacity control, humidification controls, and other special features built into the design.

**Easy Installation**

Vertical air-cooled units are often used in retail stores with a “free blow” discharge plenum mounted on top of the unit. No ductwork is used. If there is access to an outside wall or window, condenser air intake and discharge is easily accomplished.

**Remote Air-Cooled (Split System) Units**

This type of air-cooled self-contained unit can use one or more remote condensers to form a split system. This configuration is available in larger sizes, up to 60 tons. Above 60 tons, the number and size of the remote condensers required becomes less practical and multiple air-cooled self-contained units or a single large water-cooled unit are used instead. Split systems require field-installed refrigerant piping and separate power supplies for the self-contained unit and the condenser section. Split systems are limited to about 100 to 200 feet in their total separation distance depending on the tonnage and manufacturer. This limits the application of these units on larger buildings.