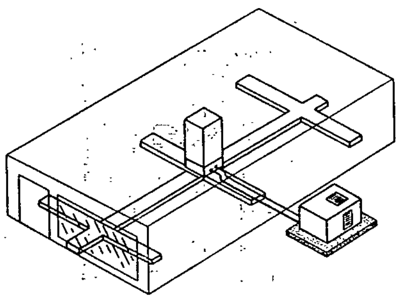
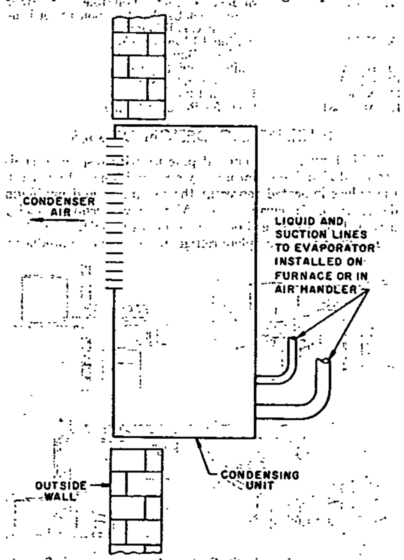


Fig. 6 .... Split System with Cooling Coil and Downflow Furnace[5]

given capacity at a stated operating condition can usually be accomplished by a wide variety of component combinations. Thus, a high capacity compressor used with a small evaporator and condenser may balance out at the same capacity performance point as an oversize coil and condenser, linked to a low capacity compressor. This balancing out of the evaporator, condenser, and compressor is largely an economic choice to yield the lowest overall system cost compatible with other system performance requirements. Although capacities will



[a]All service performed from inside for multistory buildings.

Fig. 7 .... Through-the-Wall Installation of Air-Cooled Condensing Unit[5]

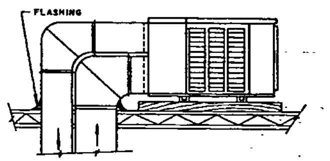


Fig. 8 .... Roof-Top Installation of Air-cooled Single-Package Unit[5]

be equal at the balance point, other performance items such as Btu per watt and sensible heat factor will be affected by the choice. For this reason, it is impossible to state the capacity rating of a compressor or coil without relating it to the operating condition limits imposed upon it by the other components of the system.

The following paragraphs are intended to serve as a general index of details which must be considered in the design of unitary air conditioners. Comments are limited to general industry practice, with no attempt to explain in detail each of these design considerations. Wherever possible, reference is made to other chapters in this book dealing with the various components of unitary air-conditioning equipment.

Refrigeration System

The refrigeration system in a unitary air conditioner includes the following:

1. *Compressor*. Compressors are usually of the reciprocating type, and most unitary equipment is now designed for use with compressors of either welded shell or semi-hermetic construction. The use of open compressors with belt or direct drive is generally restricted to the largest units. For detailed discussion of compressor design, see Chapter 38.

2. *Cooling Coil*. Cooling coils are either direct-expansion type evaporators or chilled-water coils for use with a water chiller. For details on evaporator coil design, see Chapter 34.

3. *Condenser*. Condensers are of three types: water-cooled; air-cooled, and evaporative-cooled. Design of condensers is discussed in Chapter 42.

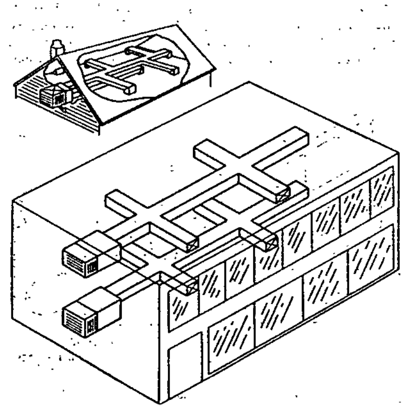


Fig. 9 .... Through-the-Wall Installation of Horizontal Air-Cooled Single-Package Unit[5]

Water-cooled condensers, although least expensive from a first cost standpoint, have rapidly given way to air-cooled condensers due to water shortages. Other advantages of air-cooled condensing include ability to operate at all seasons of the year without danger of freeze-up, and freedom from water treatment problems.

Overall unit cost for evaporative-cooled condensers is about equal to air-cooled condensers.

If a cooling tower and circulating pump are used in conjunction with water-cooled unitary equipment, the relative first cost of all three condenser types is approximately equal.

Operating costs for water-cooled condensing equipment are generally lower than for air-cooled condensing. (See Btu per watt ratios in Table 1.) However, when a cooling tower is used with water-cooled equipment, the relative operating costs are about equal. In some cases, depending upon geographic location, air-cooled equipment may actually be less expensive to operate.[6]

Operating costs of evaporative condensing equipment are equal to, and can be less than, the cost of water-cooled units.

4. *Expansion Device*. Current design uses capillary tubes, constant pressure valves and thermostatic expansion valves (adjustable or non-adjustable superheat). No specific expansion device is particularly favored, each being used as design situation warrants (See Chapter 45 for details of flow control devices).

5. *Refrigerants*. Unitary equipment is currently designed for use of Refrigerants 12, 22, 500, and 502.

6. *Water Chillers*. Unitary air conditioners designed for use with a remote chilled-water cooling coil must include a water chiller. For design details, see Chapters 43 and 61.

7. *Refrigerant Piping*. Equipment in the category of factory-assembled refrigeration cycles includes complete factory-assembled refrigerant piping. This permits the unit to be evacuated, dehydrated and shipped from the factory with the correct refrigerant charge. The unit requires no further work on its refrigeration system at installation. This is also true of unitary air conditioners for use with remote water chillers, in which the refrigerant cycle is also completely factory-assembled and charged. The two remaining categories of unitary air conditioners are designed for use with either remote condensers or remote condensing units. They require inter-connecting refrigerant piping installed at the job site. In split systems of this type, it is industry practice to ship the low side evacuated and dehydrated and with a gas holding charge sealed by means of caps or quick-coupling type connectors.

The high side is likewise evacuated and dehydrated and usually shipped with the correct refrigerant charge. The inter-connecting refrigerant piping (liquid line and hot-gas line or suction line) must be installed, purged and leak-tested on the job by the installing contractor.

Some of the smaller split systems are now available with sealed flexible inter-connecting piping. Quick-coupling type connectors are used with this system in order to eliminate the need for field-fabricated joints, purging, and leak-testing.

Air-Handling System

The air-handling system includes the following:

1. *Propeller Fans*. Because of their performance characteristics, propeller fans are used for low-static pressure application. Hence, most air-cooled condensers (not designed for use with duct work) are equipped with propeller fans. (Refer to Chapter 32 for design details on both propeller fans and centrifugal fans.)

2. *Centrifugal Fans*. Evaporator air systems, in general, and some condenser air systems, are designed for use with extensive duct work. Therefore, evaporator air fans are almost always of the centrifugal type. Air-cooled condensers for use with duct work should generally be used with centrifugal fans. Again, this choice is based on performance characteristics of housed fans. (See Chapter 32.)

3. *Fan Motors*. Fan motors used for unitary air conditioners must be quiet, efficient, and dependable. Quiet operation is essential because the evaporator fan motor is generally located in the circulating air stream and contributes directly to the sound level of the unit. This same location also makes efficiency important because all power to the fan motor reappears in the form of heat which must, in turn, be removed by the refrigeration system. Motors must frequently be life-time lubricated because of difficult or impossible service access after installation. (Refer to Chapter 57 for a discussion of the types of motors used for fan duty purposes.)

4. *Direct vs. Belt Drive*. Propeller fans are generally direct-driven up to speeds of 1500 rpm, depending upon size and sound

Table 1 .... Engineering Design Details

Item	Detail	Range of Current Values	Comments
1	Evaporator Cfm/Ton	300–500 Cfm	ARI certified capacity rating at 450 Cfm/Ton maximum.
2	Air-Cooled Condenser Cfm/Ton	600–1200	Median 900
3	Evap. Cooled Condenser Cfm/Ton	200–500	
4	Btu/Watt—Air-Cooled Condenser	6–11	An efficiency rating expressed as the ratio of net cooling effect to total power input.
5	Btu/Watt—Water-Cooled and Evap. Cooled	9–15	An efficiency rating expressed as the ratio of net cooling effect to total power input.
6	Sensible Heat Factor	0.65–0.85	Ratio of sensible to total cooling effect at 80 F DB —67 F WB entering air
7	Maximum Operating Conditions	As Specified By ARI	See ARI 210–64 Section 5, Sub-Section 5.20
8	Low-Temp. Operating Conditions	As Specified By ARI	See ARI 210–64 Section 5, Sub-Section 5.30
9	External Static Press. Evaporator	As Specified By ARI	See ARI 210–64 Section 4, Para. 4.18
10	Sound Level	No Standard	Receiving increasing industry attention. Restricted by local codes.

level requirements. In the larger sizes (30-in. diameter and up) some propeller fans are belt driven to reduce the speed below that of the driving motor and meet sound-level requirements.

Centrifugal fans in the smaller sizes (up to 10 in.), are either direct-driven or belt-driven in accordance with sound-level and other application requirements. Centrifugal fans in the larger sizes are almost exclusively belt driven.

Adjustable pitch pulleys are usually provided with belt-driven centrifugal fans to permit balancing air delivery against system resistance.

5. *Filters*. Low-velocity filters (300 fpm) are still used in many unitary air conditioners. However, the trend to reduced physical size has led to the more general use of high-velocity filters (400 fpm and up) for more compact design. These are satisfactory where the filter is specifically designed for the higher velocity service. Both disposable and cleanable types of filters are in use. See Chapter 36.

The filter is always located on the inlet side of the evaporator coil to prevent dirt accumulation on the wetted coil surface.

Controls System

The controls system includes safety devices, protective controls and capacity control devices.

1. *Safety Devices*. Since the unitary air conditioner is a pressure system, protection from excessive pressures must be provided. The several codes pertaining to this item differ, depending upon the exact type of unit, its location in the building, and the size of the refrigerant charge.

[6] See *American Standard Safety Code for Mechanical Refrigeration* (ASA B9.1-1964) and Underwriters' Laboratories. *Air Conditioners, Central Cooling* (UL No. 465).