SECTION 7

AIR CONDITIONING (COOLING)

UNIT 36

REFRIGERATION APPLIED TO AIR CONDITIONING

UNIT OBJECTIVES

After studying this unit, the reader should be able to

- Explain three ways that heat transfers into a structure
- Explain refrigeration as applied to air conditioning
- Describe the evaporators, compressors, condensers and metering
- devices that are used on air conditioning systems
- List the various types of evaporators found on air conditioning systems
- Explain the difference between standard and high efficiency systems
- Describe package and split-type air conditioning systems

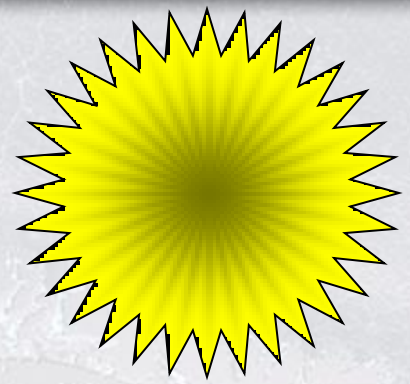
REFRIGERATION

- Air conditioning is refrigeration applied to keeping the temperature of an occupied space at the desired temperature in the warmer months
- Air conditioning equipment removes heat that leaks into the structure from the outside and deposits that heat outside where it originally came from

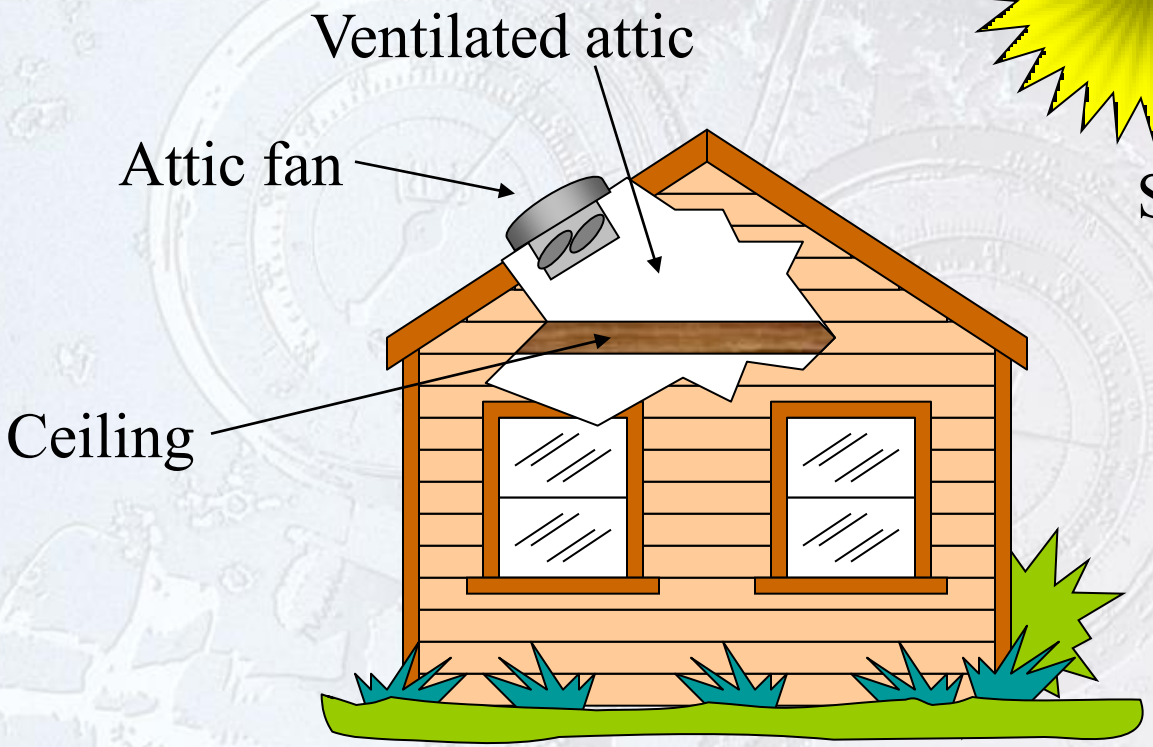
STRUCTUREAL HEAT GAIN

- Heat leaks into a structure by conduction, infiltration and radiation
- Solar load on a structure is greater on the east and west sides
- Heat enters the structure through the walls, windows and doors by conduction
- Air contains a certain amount of humidity for each cubic foot that leaks in

Outside temperature 95° F

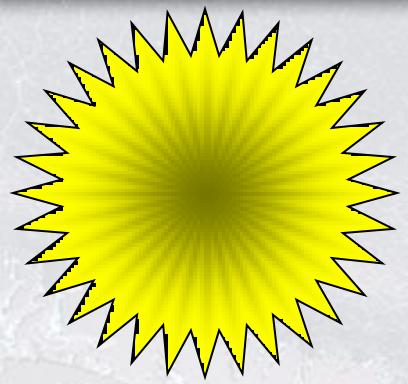


Summer sun heats the attic



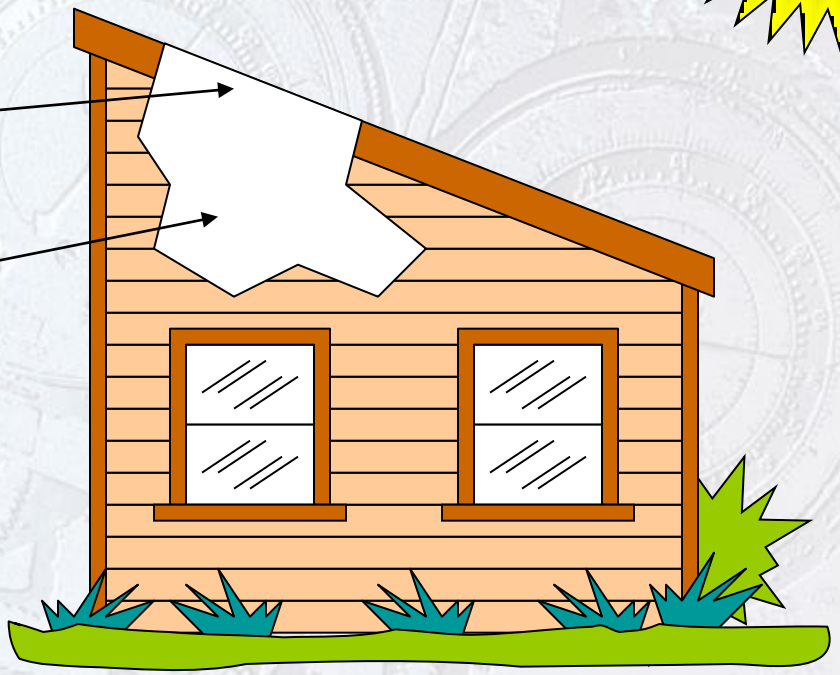
Living space is shielded from the solar heat

Outside temperature 95° F



Ceiling of living space

No attic



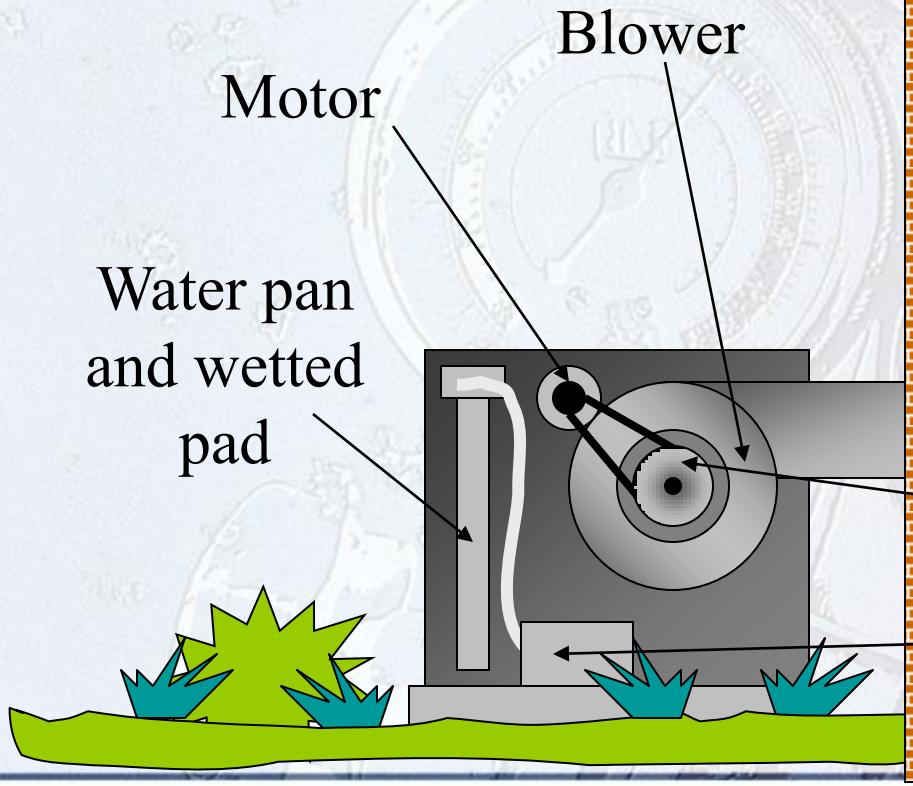
Sun shines directly on the ceiling of the living space

EVAPORATIVE COOLING

- Used primarily in geographic regions where the humidity is low
- Uses fiber mounted in a frame that uses running water over the fiber as the cooling medium
- Fresh air is drawn through the fiber and cooled by evaporation to a temperature close to the wet-bulb temperature of the ambient air

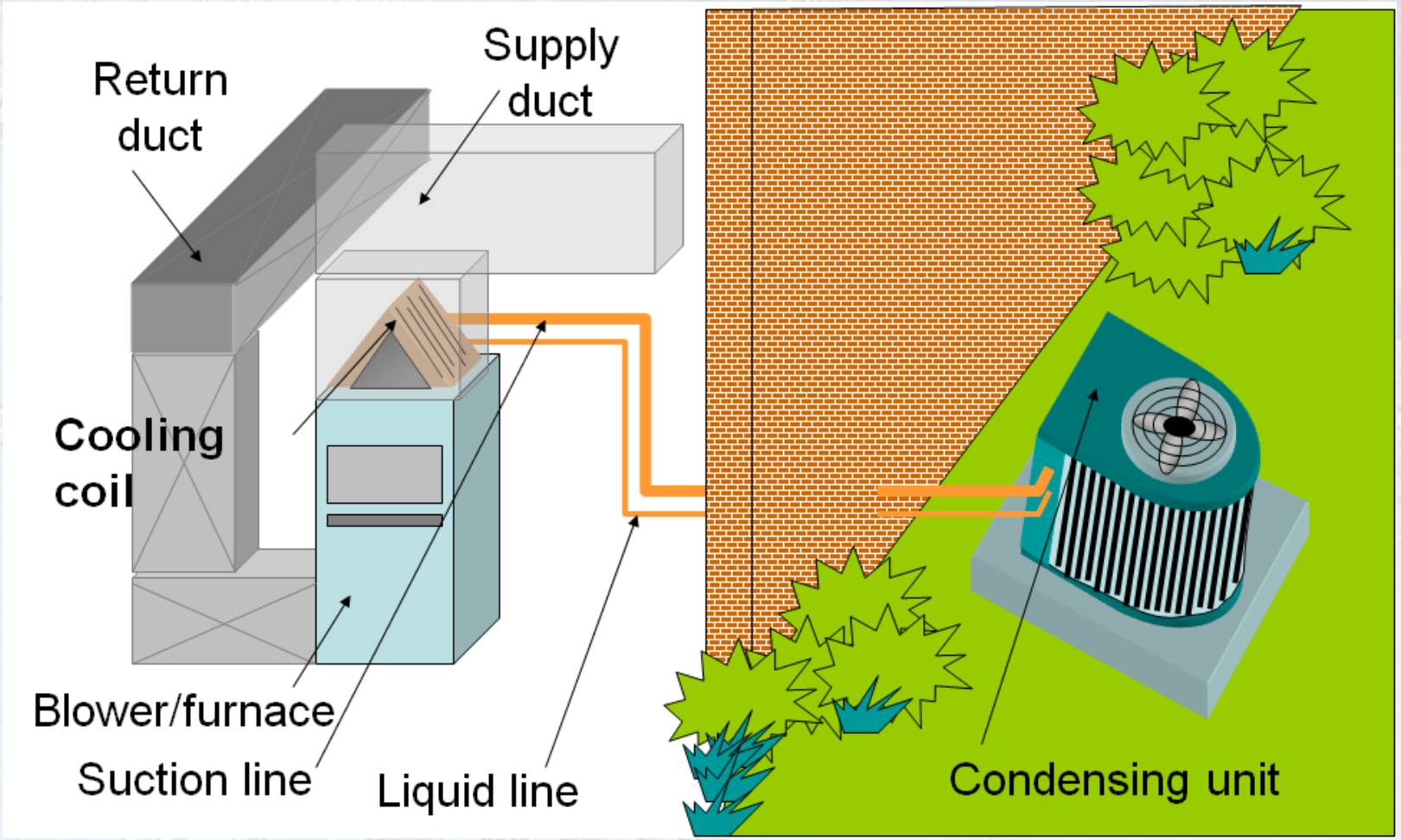
Evaporative Cooler

Interior of structure



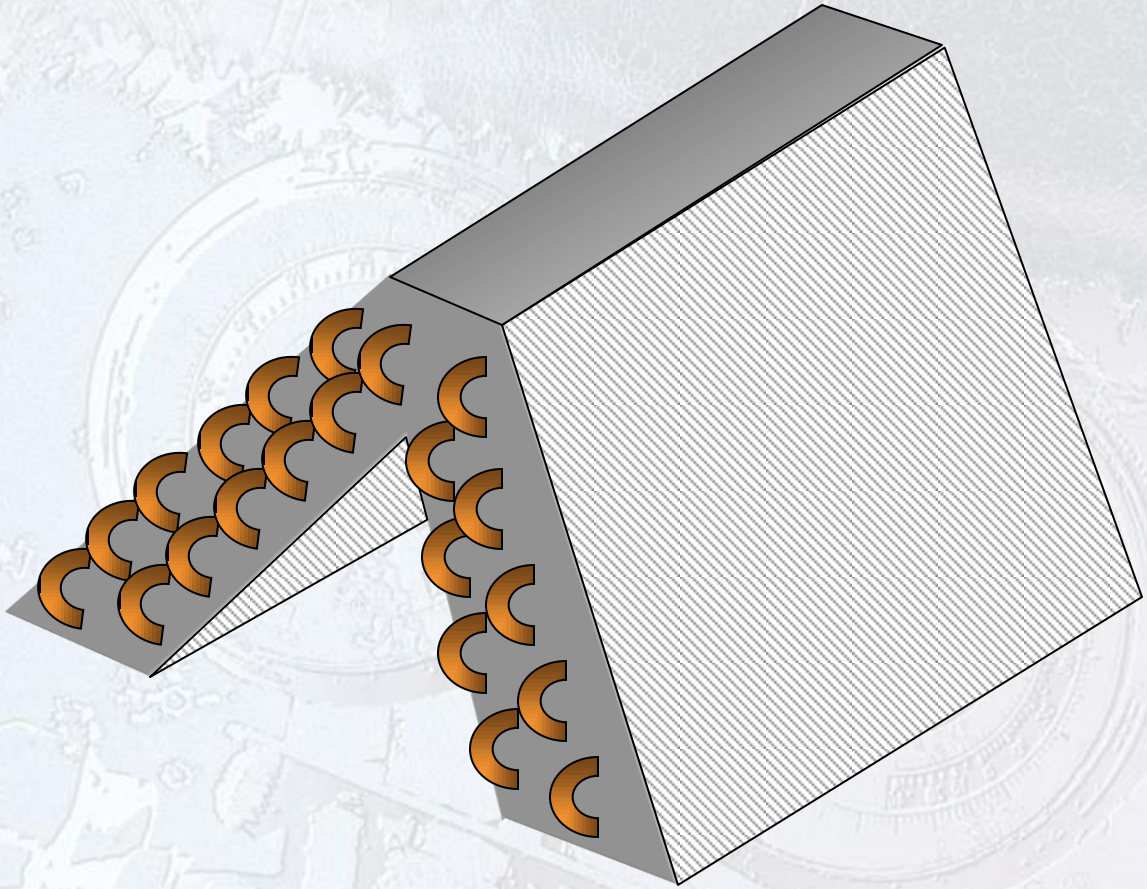
REFRIGERATED COOLING or AIR CONDITIONING

- Air conditioning similar to commercial refrigeration
- Package air conditioning
  - All system components located in one cabinet
  - Factory charged, air is ducted to and from the unit
- Split-system air conditioning
  - Condensing unit outside (Compressor and condenser)
  - Air handler inside (evaporator and expansion device)
  - Liquid line and suction line connect the two sections

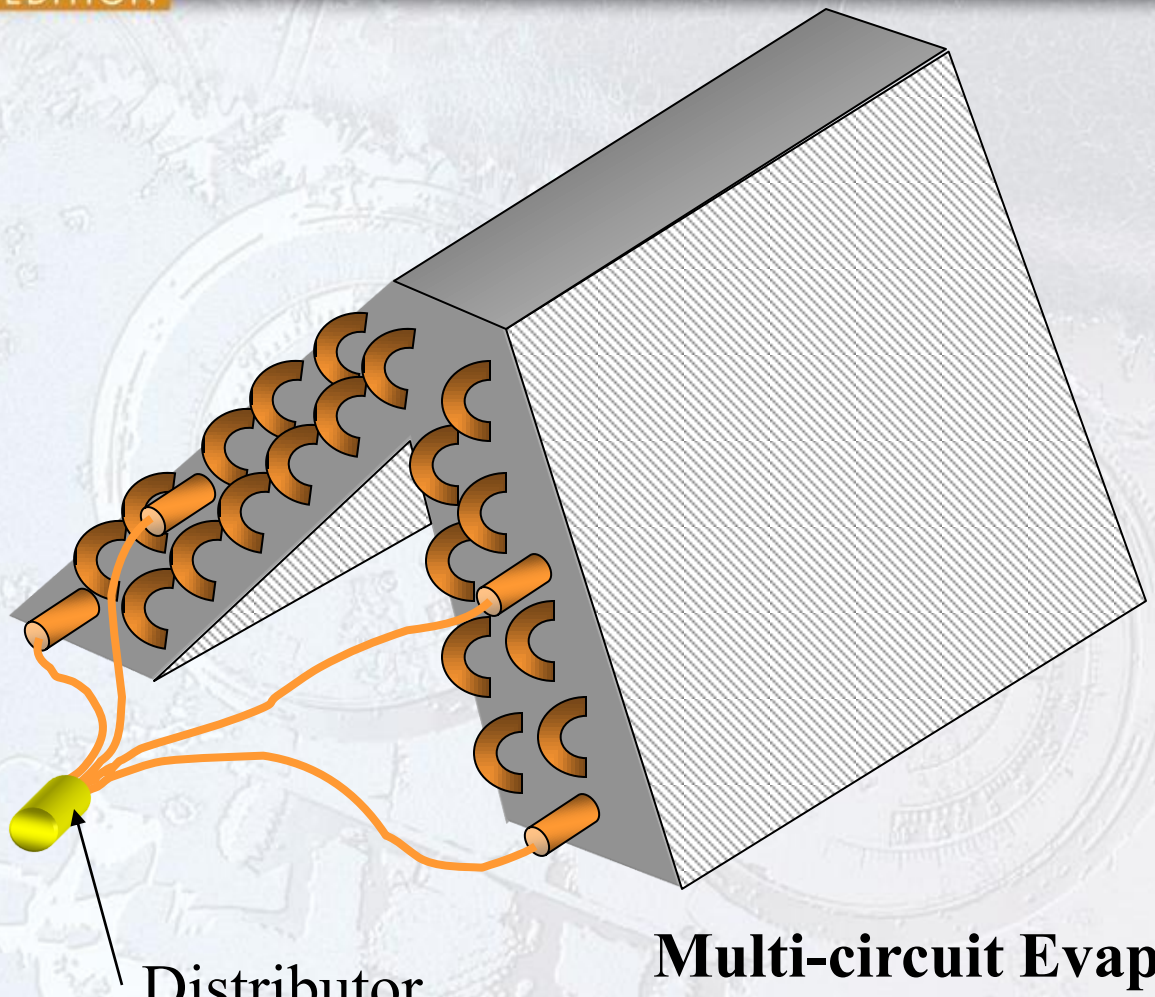


THE EVAPORATOR

- Absorbs heat into the system
- Coil is made of copper or aluminum with aluminum fins to increase the heat exchange surface
- Common evaporator coil types
  - Slant coil, “A” coil, and “H” coil
- Coil circuits
  - A coil may have multiple circuits in parallel
  - Multiple circuit coils use distributors
  - Reduces large pressure drops in the coil



“A” Coil Evaporator



Multi-circuit Evaporator

EVAPORATOR FUNCTION

- Absorbs latent heat: removing moisture
- Absorbs sensible heat: lowering air temperature
- Condensate collects on the evaporator and runs down to the drain where it is removed
- Typical room conditions
  - 75˚ F dry bulb temperature
  - 50% relative humidity
  - 62.5˚ F wet bulb temperature

EVAPORATOR FUNCTION (cont'd)

- The evaporator coil operates at about 40° F
- Air leaves the coil at about 55° F
- Humidity of the air leaving the coil is about 95%
- Humidity is higher because of the air being cooled
- When humidity is higher, the coil temperature may be lower to remove more humidity
- Coil temperature is controlled by amount of airflow
  - More airflow results in higher coil temperatures
  - Less airflow results in lower coil temperatures

EVAPORATOR APPLICATION

- Methods of installing evaporator in the air stream
  - The coil may be enclosed in a separate case, such as when air conditioning is added to a heating system
  - The coil may be located in the ductwork of the system
  - The coil may have been factory installed in an air handler
- Coil will normally operate below the dew point temperature

THE COMPRESSOR

- Compressors are vapor pumps
- Compressors pump heat-laden vapor from the low side of the system to the high side
- Compressors increases the temperature and pressure of the suction gas to the temperature and pressure of the discharge gas
- Common compressor types include the rotary, reciprocating, scroll, centrifugal and the screw

THE RECIPROCATING COMPRESSOR

- May be welded hermetic or semi-hermetic
- Often suction gas cooled
- Positive displacement compressors
- Typically use R-22, R-410a or R-407c
- Hermetic compressors can be either suction gas or air cooled
- Suction gas should return to the compressor at a temperature below 70˚ F

COMPRESSOR SPEEDS

- Small and medium-size ranges turn at 1,750 or 3,450 rotations per minute (rpm)
- Most older compressors operated at 1,750 rpm
- Newer compressors operate with faster motor speeds and pump more efficient refrigerants, making the systems more efficient

COOLING THE COMPRESSOR & MOTOR

- Lack of cooling results in winding damage and can also cause the compressor oil to break down
- Large compressors are cooled by suction gas
- Some serviceable hermetic compressors are air cooled and have “ribs” that dissipate the heat
- Air-cooled compressors must have ample airflow
- Some compressors are water-cooled and are surrounded with a water-jacket

COMPRESSOR MOUNTINGS

- Most use rubber mounting feet and a spring-mounted motor
- Welded hermetic compressors have rubber mounting feet on the outside
- Motors on welded hermetic compressors are mounted on springs inside the shell
- Many newer compressors have a vapor space between the motor and the shell of the compressor

THE ROTARY COMPRESSOR

- Typically small and light, small footprint
- Often cooled with compressor discharge gas
- More efficient than reciprocating compressors
- Used in small to medium-size systems
- Can be stationary or rotary vane design
- All of the refrigerant that enters the compressor is discharged from the compressor, making them highly efficient

THE SCROLL COMPRESSOR

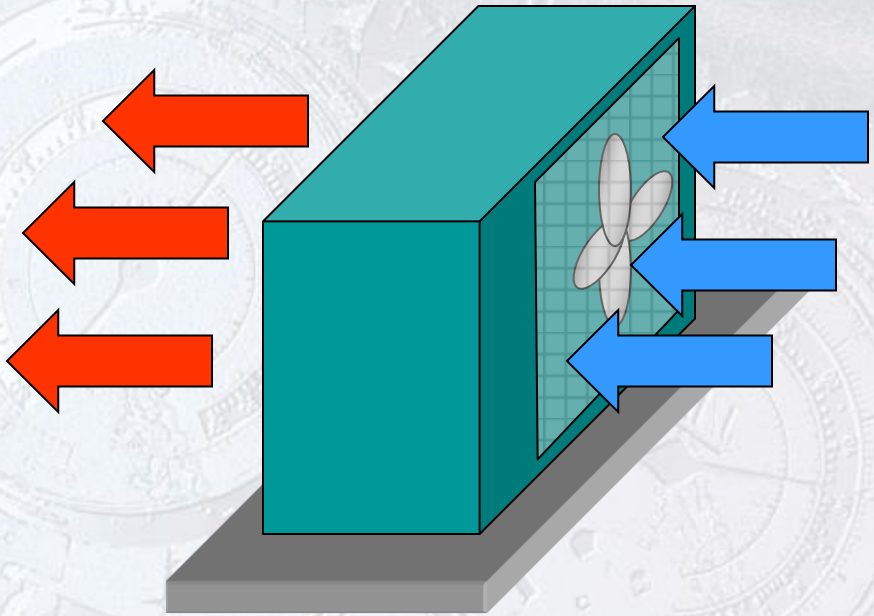
- Uses two perfectly machined nesting scrolls
- One scroll is stationary, while the other orbits
- The two scrolls form a number of individual “pockets” where refrigerant is trapped
- The “pockets” get smaller and smaller as the refrigerant makes its way through the compressor, increasing the pressure and temperature of the gas
- Many compression stages occurring simultaneously

THE CONDENSER

- Designed to reject heat from the system
- Most are air-cooled and reject system heat to the surrounding air
- The coils are made of copper or aluminum tubing with aluminum fins to increase the heat transfer rate
- Increased heat transfer rate lowers operating temperatures and pressures and increases system efficiency

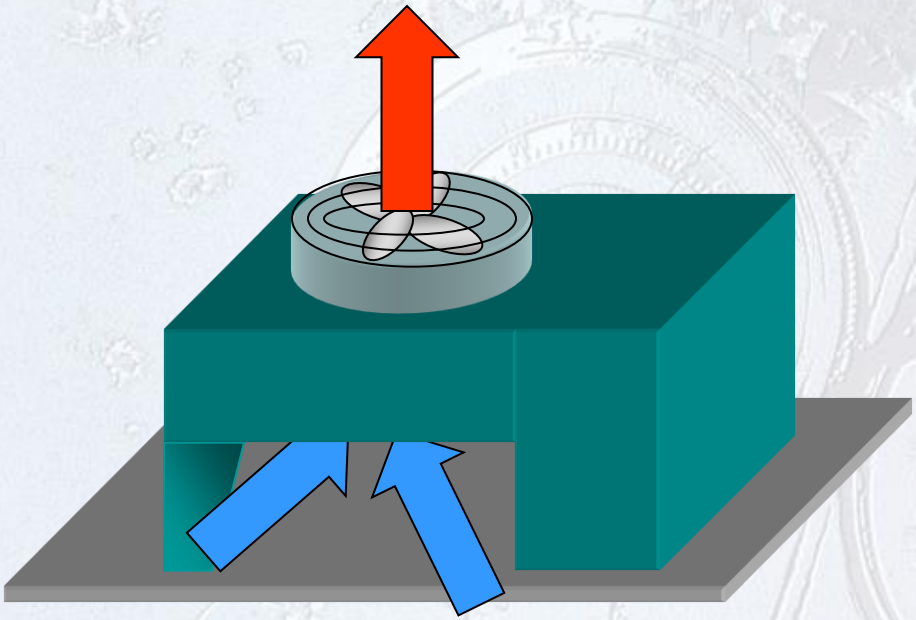
SIDE-AIR-DISCHARGE CONDENSING UNITS

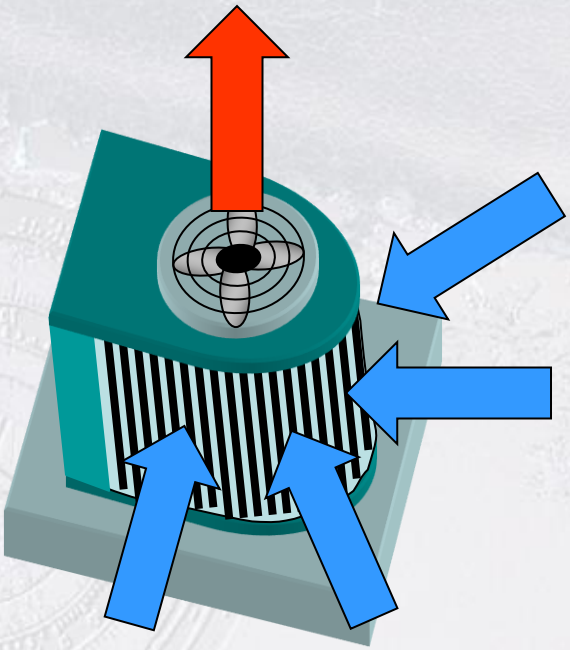
- Discharge air out the side of the unit
- Fan and motor are located under the top panel
- Typically a noisier-type unit
  - Internal unit noise
  - Noise is transmitted from the unit
- Heat from the condenser coil can often be hot enough to kill plants



TOP-AIR-DISCHARGE CONDENSING UNITS

- Most commonly used condensing unit type
- Hot air and noise are discharged from the top
- Fan and motor are on the top of the unit
- Fan motor protected with a rain shield
- More stress put on the end of the motor, which is mounted with the shaft point upwards
- A thrust surface is needed for this application





CONDENSER COIL DESIGN

- Vertical condenser coils are susceptible to becoming clogged with grass and dirt
- Coils must be cleaned periodically
- Bottom rows of the coil are used for subcooling
- It is common for the refrigerant to leave the condenser coil at a temperature that is about 15˚ F cooler than the condenser saturation temperature
- Low subcooling affects the system's ability to effectively cool a structure

HIGH-EFFICIENCY CONDENSERS

- Federal government demanding higher efficiency
- Physically larger coils → Greater surface area
- Greater surface area → Lower head pressures
- Lower head pressures → Higher efficiency
- Higher efficiency means that compressor amperages are lower and less power consumed
- Some units use two-speed condenser fan motors

EXPANSION DEVICES

- Meter the flow of refrigerant into the evaporator
- Most common types include the fixed-bore and the thermostatic expansion valve
- TXVs are more efficient than capillary tubes and allow more refrigerant flow during a hot pull down
- The pressures in systems with TXVs typically do not equalize in the off cycle, so compressors with high starting torque are desired

AIR SIDE COMPONENTS

- Consist of the supply air and return air systems
- On the average, 400 cfm of air/ton are required
- In very humid areas, 350 cfm is the norm
- In very dry areas, 450 cfm is common
- Supply and return ducts should be insulated
- Supply registers for cooling should be located high in the room for better distribution

INSTALLING PROCEDURES – PACKAGE SYSTEMS

- Equipment is located outside the structure
- Completely factory assembled and charged
- No field refrigerant piping work is needed
- Unit located on a firm foundation
- Supply and return ducts connected to the unit
- Ducts properly sealed to withstand the elements
- Only one electrical power supply required

INSTALLING PROCEDURES – SPLIT SYTEMS

- Condensing unit and air handler are in different locations (typically indoors and outdoors)
- Interconnecting refrigerant lines must be installed by the field technician (suction and liquid lines)
- Condensing unit and air handler should be as close together as possible and practical
- Suction line should be insulated

UNIT SUMMARY - 1

- Heat leaks into a structure by conduction, convection and radiation
- Air conditioning involves the cooling of an occupied space for comfort purposes
- Evaporative cooling is used primarily in areas where the humidity is low
- Air conditioning systems are typically package units or split-type systems

UNIT SUMMARY - 2

- Air conditioning systems typically use the same four major components as commercial refrigeration systems
- Common evaporator types include the slant coil, “A” coil and the “H” coil
- The most common condensing unit type is a top-air discharge unit
- Higher efficiency condensers have larger surface areas than standard efficiency coils

UNIT SUMMARY - 3

- Expansion devices commonly found on air conditioning systems are the thermostatic expansion valve and the fixed-bore metering device
- TXVs are more efficient than capillary tubes
- Typically, 400 cfm of air are needed for each ton of refrigeration
- Supply registers for cooling systems should be located high in the room for better distribution