SECTION 7

AIR CONDITIONING (COOLING)

UNIT 40

TYPICAL OPERATING CONDITIONS

UNIT OBJECTIVES

After studying this unit, the reader should be able to

- Explain what conditions will cause the evaporator pressure and
- temperature to change
- Explain how ambient and evaporator conditions affect condenser
- operation and, in turn, overall system performance
- Compare high efficiency and standard efficiency equipment
- Describe how humidity affects system operating pressures
- Explain how air conditioning systems are made more efficient

MECHANICAL OPERATING CONDITIONS

- Design conditions for air conditioning
  - 95° outside air temperature
  - 80° inside air temperature
  - 50% humidity
- Systems are rated at the above conditions
- Standard efficiency systems condense refrigerant at about 125° at design conditions

RELATIVE HUMIDITY AND THE LOAD

- Relative humidity increases the load on the system
- Equipment capacity varies with changes in humidity

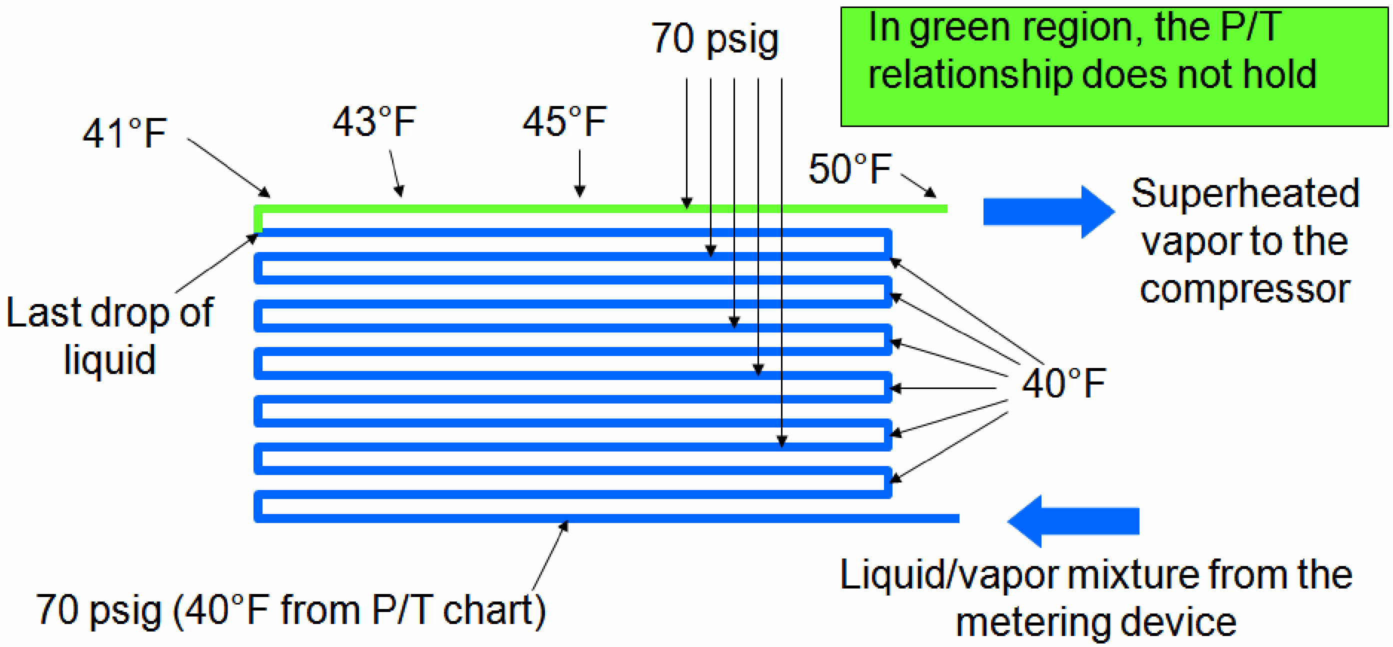
SYSTEM COMPONENT RELATIONSHIPS UNDER LOAD CHANGES

- Increases in outside temperature
  - Higher head pressure
  - Higher suction pressure (except AEV systems)
  - Reduced system capacity
- Space temperature and humidity affects system capacity
- Refrigerant holds different amounts of heat at different temperatures and pressures

EVAPORATOR OPERATING CONDITIONS

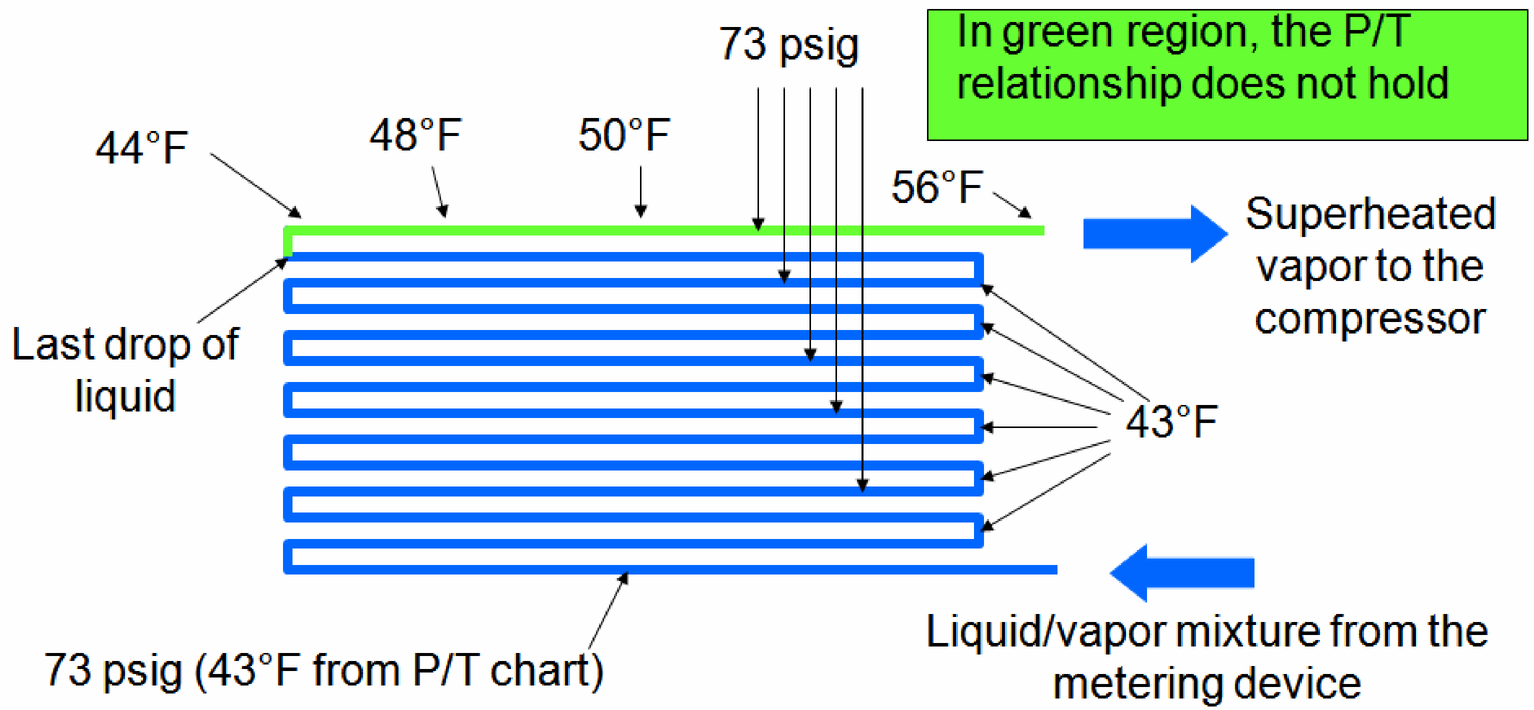
- Normal operating temperature 40°F
  - 75°F inside air temperature
  - 50% humidity
  - Approximate evaporator superheat is 10°
- Actual field conditions are rarely ideal
- Common conditions are used for troubleshooting purposes

A/C APPLICATION: R-22 EVAPORATOR (Fixed Bore)



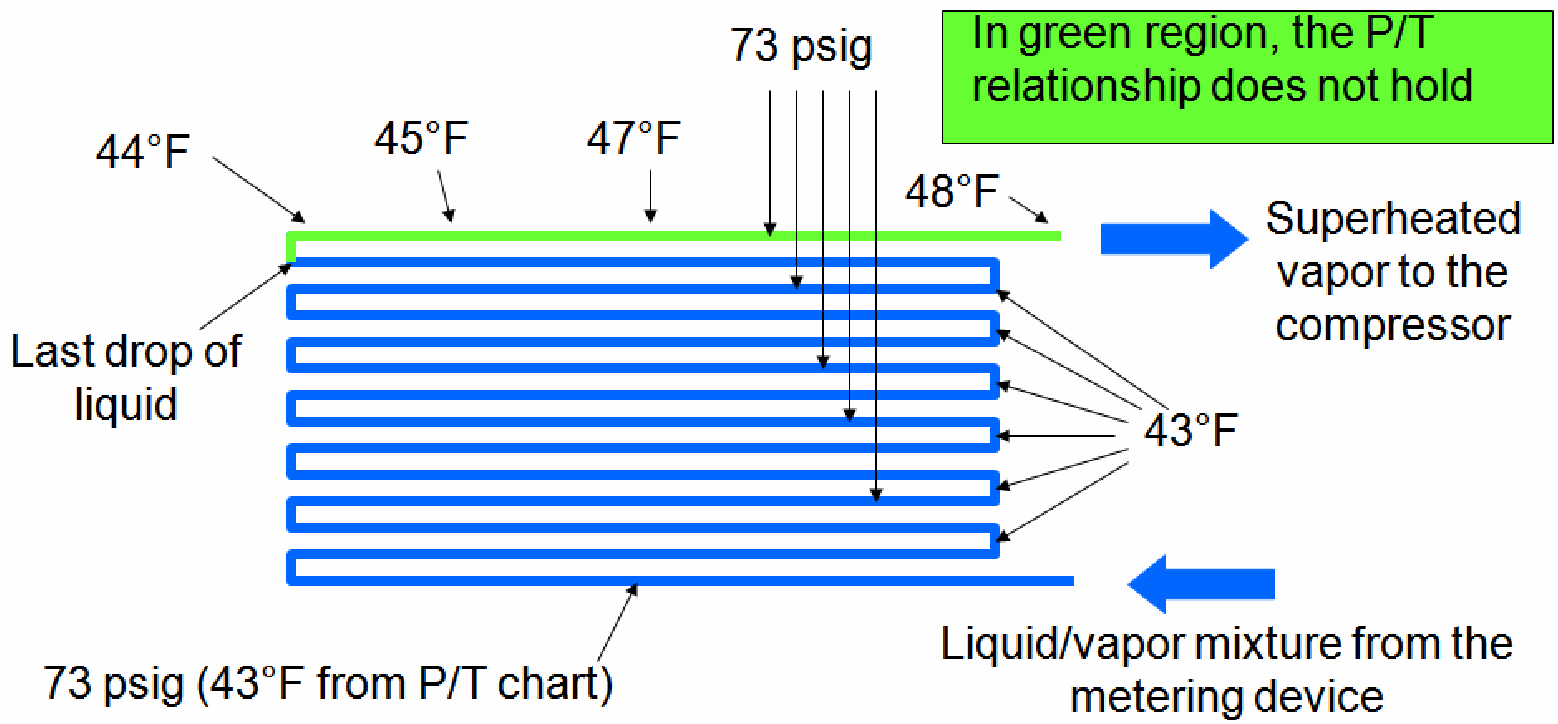
(IDEAL CONDITIONS, SUPERHEAT = 10°)

A/C APPLICATION: R-22 EVAPORATOR (Fixed Bore)



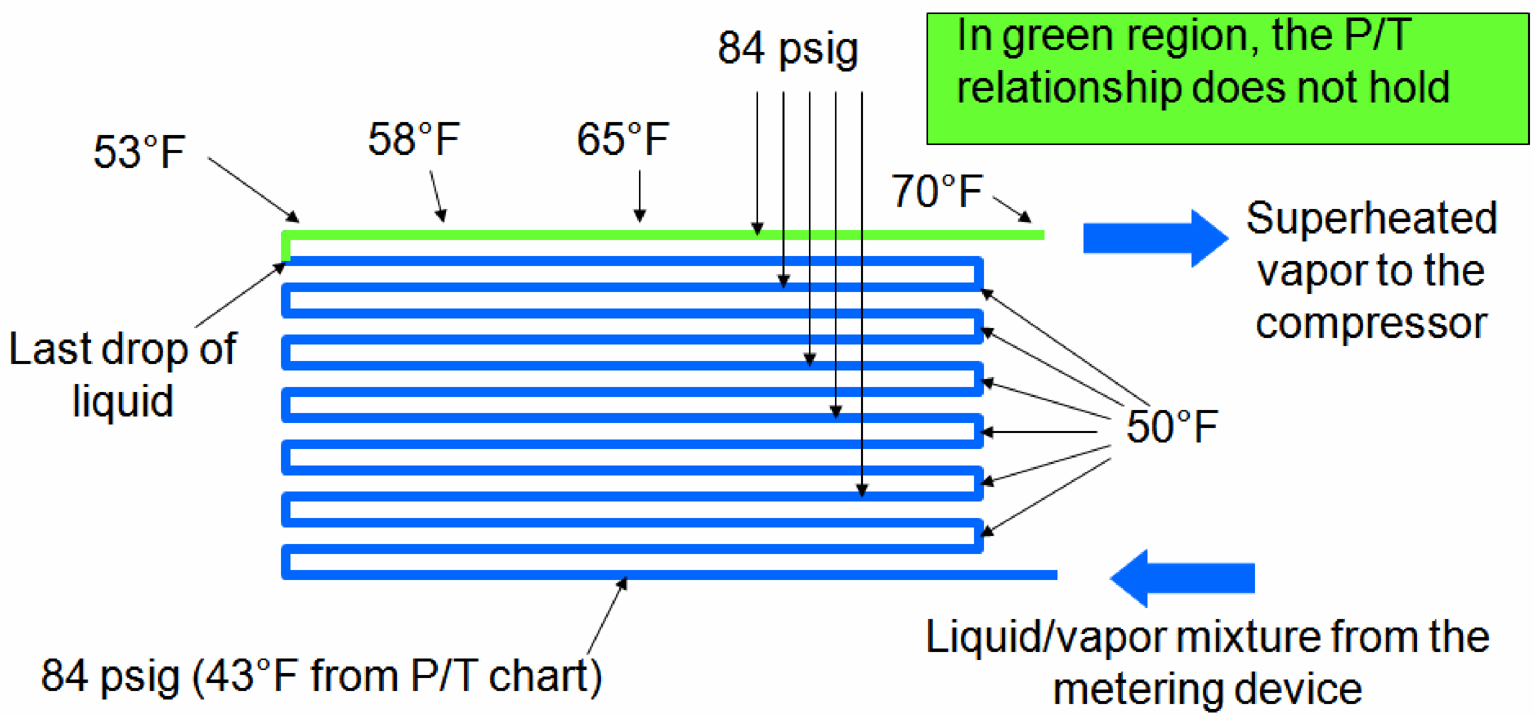
(INCREASED LOAD CONDITIONS, SUPERHEAT = 13°)

A/C APPLICATION: R-22 EVAPORATOR (Fixed Bore)



(HIGH HEAD PRESSURE, SUPERHEAT = 5°)

A/C APPLICATION: R-22 EVAPORATOR (Fixed Bore)

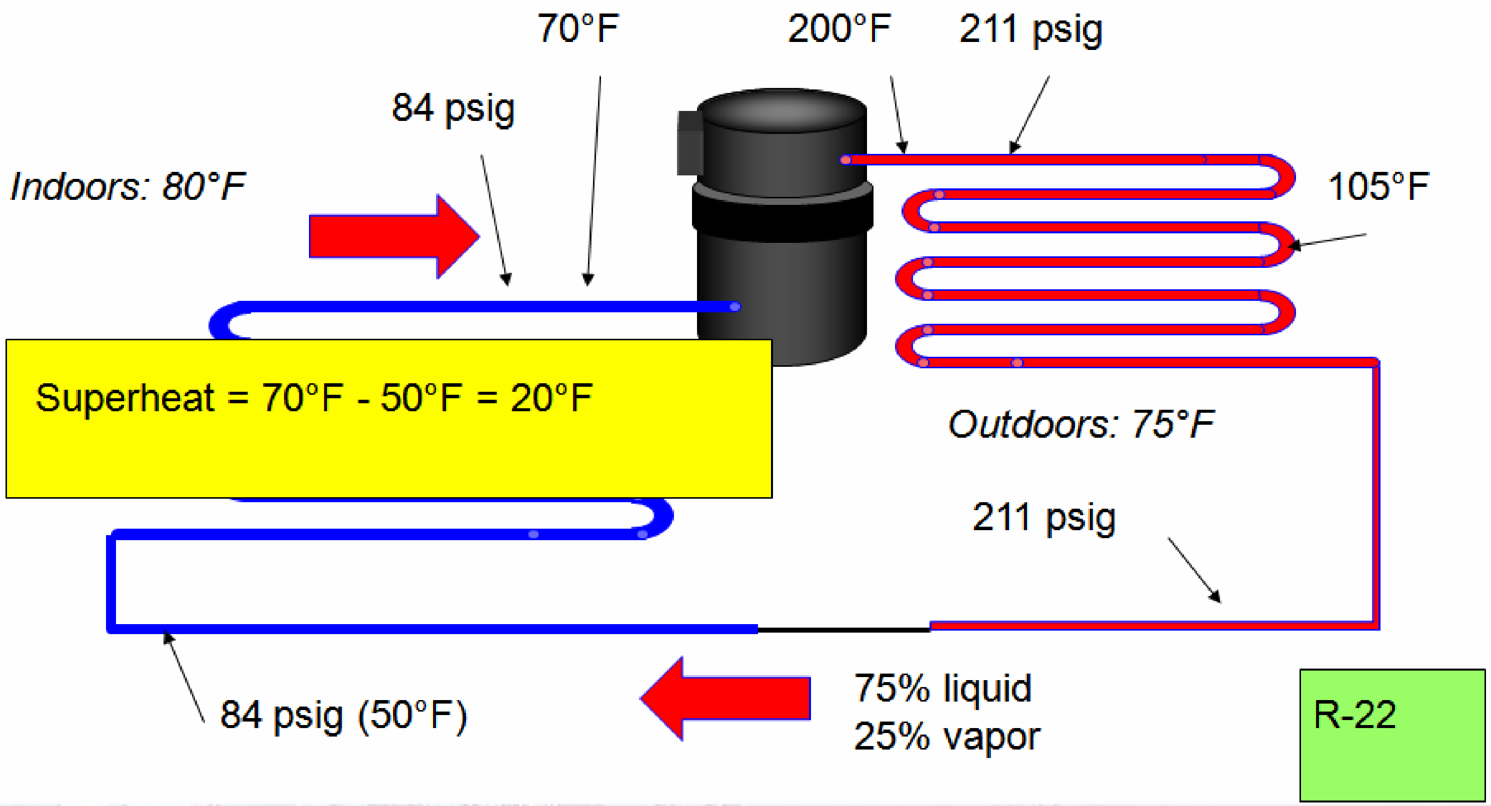


(HIGH INSIDE TEMPERURE/HUMIDITY, SUPERHEAT = 20°)

HIGH EVAPORATOR LOAD AND A COOL CONDENSER

- The space temperature becomes warmer than the outside ambient
- The condenser will become too efficient
- Liquid refrigerant will accumulate in the condenser
- The evaporator will starve and lose system capacity
- The evaporator coil may freeze

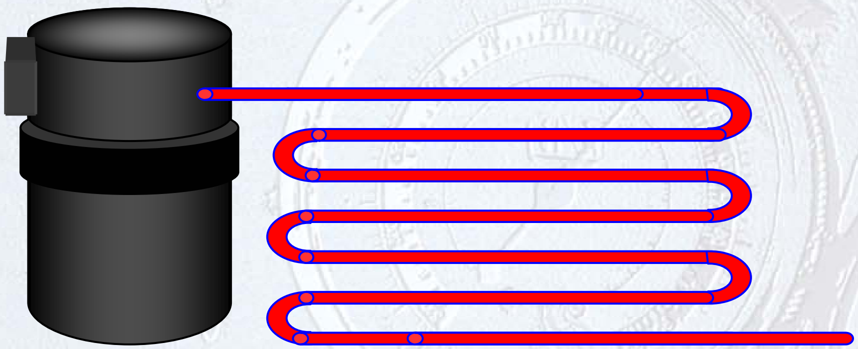
OUTSIDE AMBIENT TEMPERATURE IS LOWER THAN THE INSIDE AIR TEMPERATURE



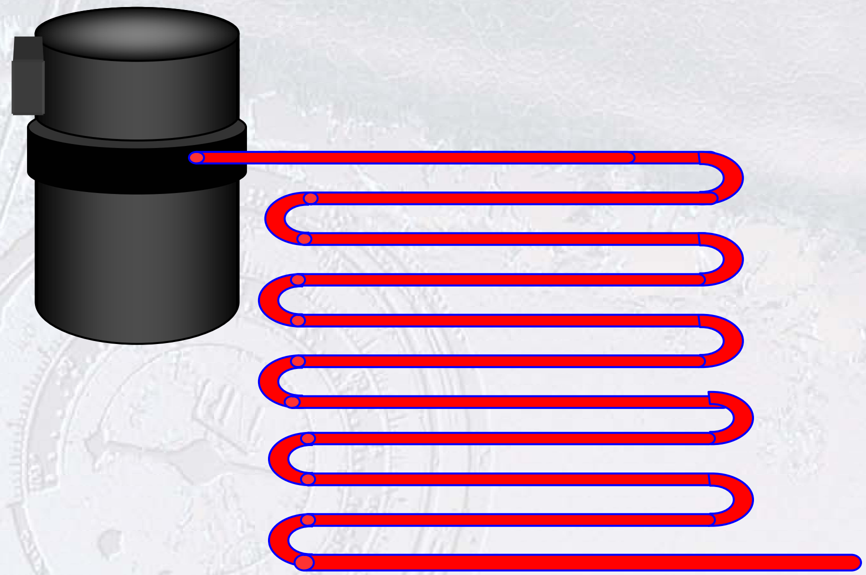
GRADES OF EQUIPMENT

- Economy and standard efficiency
  - Economy and standard efficiencies are similar
  - Refrigerant condenses at a temperature about 30° to 35° higher than ambient
- High-efficiency systems
  - Operate with lower head pressures
  - Have larger condenser coils
  - Refrigerant condenses at a temperature as low as 20° higher than ambient

STANDARD EFFICIENCY vs. HIGH EFFICIENCY CONDENSERS



Standard efficiency condenser

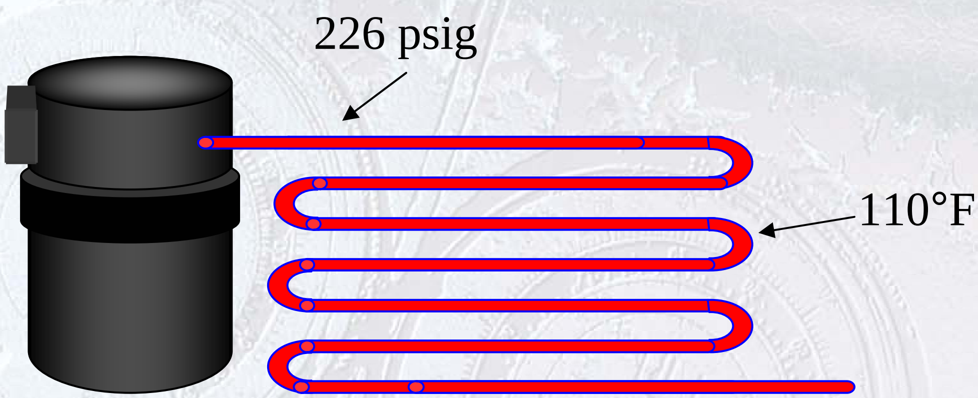


High efficiency condenser

High efficiency condenser coils are physically larger

STANDARD EFFICIENCY vs. HIGH EFFICIENCY CONDENSERS

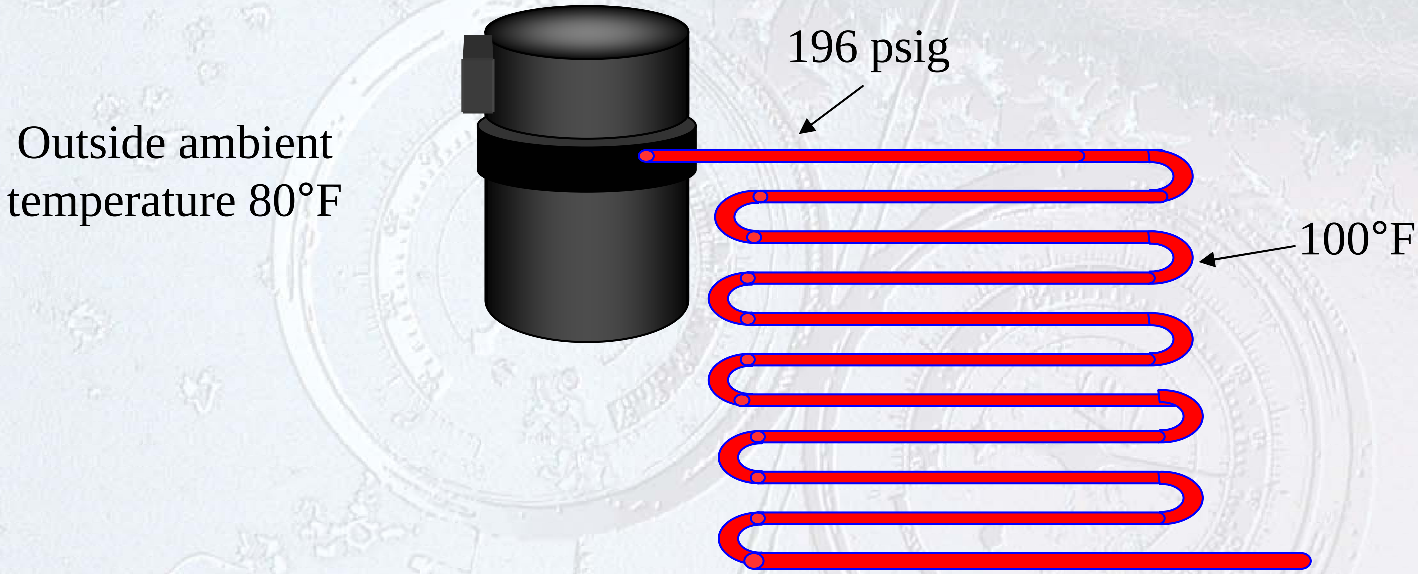
Outside ambient temperature 80°F



Standard efficiency condenser

Refrigerant condenses at a temperature about 30 degrees higher than the outside ambient temperature

STANDARD EFFICIENCY vs. HIGH EFFICIENCY CONDENSERS



High efficiency condenser

Refrigerant condenses at a temperature about 20 degrees higher than the outside ambient temperature

DOCUMENTATION WITH THE UNIT

- Provides suction and discharge pressure charts
- Furnished with the unit in the start-up manual
- Existing conditions are plotted on the charts
- Conditions must be considered
  - Load on condenser coil
  - Sensible and latent heat loads on the evaporator coil

ESTABLISHING A REFERENCE POINT ON UNKNOWN EQUIPMENT

- High-efficiency equipment is usually larger
- High-efficiency systems operate with lower head pressures
- High-efficiency systems have lower amperage ratings than standard efficiency systems

Approximate full load amperages for alternating current motors

Motor	Single Phase		3-Phase Squirrel Cage Induction		
HP	115V	230V	230V	460V	575V
1/6	4.4	2.2			
1/4	5.8	2.9			
1/3	7.2	3.6			
1/2	9.8	4.9	2	1	0.8
3/4	13.8	6.9	2.8	1.4	1.1
1	16	8	3.6	1.8	1.4
1 1/2	20	10	5.2	2.6	2.1
2	24	12	6.8	3.4	2.7
3	34	17	9.6	4.8	3.9
5	56	28	15.2	7.6	6.1

METERING DEVICES FOR HIGH-EFFICIENCY EQUIPMENT

- High-efficiency systems usually use a thermostatic expansion valve
- High-efficiency systems may have oversized evaporator coils
- Boiling temperature is higher due to the oversized evaporator coil
- Normal saturation temperature is about 45°
- High-efficiency systems become too efficient when the ambient temperature is low

EQUIPMENT EFFICIENCY RATING

- EER = Btu/hr (output) / wattage (input)
- The higher the EER, the higher the efficiency
- Does not account for the time to reach peak efficiency
- Seasonal Energy Efficiency Ratio (SEER) includes start-up and shut down cycles
- 13.0 SEER ratings may be mandated in the future
- More expensive from the first cost standpoint

EER EXAMPLE 1

- System Output = 36,000 btu/hour
- Power Input = 4,000 Watts
- EER = System Output ÷ Power Input
- EER = 36,000 btu/hr ÷ 4,000 Watts
- EER = 9.0

EER EXAMPLE 2

- System Output = 36,000 btu/hour
- Power Input = 3,600 Watts
- EER = System Output ÷ Power Input
- EER = 36,000 btu/hr ÷ 3,600 Watts
- EER = 10.0

The higher the EER, the more efficient the equipment

MATCHING THE UNIT TO THE CORRECT POWER SUPPLY

- Operating voltages should be within 10% of nameplate ratings
- 208-V nameplate has a range from 187 V to 229 V
- 230-V nameplate has a range from 207 V to 253 V
- If the supply voltage is out of range, the equipment should not be started

208-VOLT MOTOR

10% OF RATED VOLTAGE = 20.8 VOLTS

LOW END OF VOLTAGE RANGE =

208 VOLTS – 20.8 VOLTS = **187.2 VOLTS**

HIGH END OF VOLTAGE RANGE =

208 VOLTS + 20.8 VOLTS = **228.8 VOLTS**

230-VOLT MOTOR

10% OF RATED VOLTAGE = 23 VOLTS

LOW END OF VOLTAGE RANGE =

230 VOLTS – 23 VOLTS = **207 VOLTS**

HIGH END OF VOLTAGE RANGE =

230 VOLTS + 23 VOLTS = **253 VOLTS**

FINDING A POINT OF REFERENCE FOR AN UNKNOWN MOTOR RATING

- Electrical ratings can be improvised or estimated by estimating system capacity
- Compare the system in question to a known unit
- Nameplate data may not be correct if the motor was replaced

DETERMINING THE COMPRESSOR RUNNING AMPERAGE

- Running load amperage is usually not provided on the data tag
- If the running load amperage is supplied, it should not be exceeded
- Compressor rarely operates at full-load amperage
- Suring high-load conditions, the compressor may operate near full-load amperage

HIGH VOLTAGE, THE COMPRESSOR AND CURRENT DRAW

- Higher supply voltages result in lower compressor currents
- Overloaded compressors may still draw low current if the voltage is high
- Nameplate currents are usually the high end of the operating range

CURRENT DRAW AND THE TWO-SPEED COMPRESSOR

- Used to achieve high seasonal efficiencies
- Can operate as two- of four-pole motors
- Can operate at 1,800 rpm or 3,600 rpm
- Lower speed is used for mild weather and low load conditions
- Usually controlled by electronic circuits

SUMMARY - 1

- Systems are typically rated at 95 degree outside temperature and 80 degree inside temperature at 80% humidity
- Relative humidity increases the load on the system
- Increased outdoor temperature results in increased head pressure and reduced system capacity
- Normal evaporator temperature is 40 degrees
- Normal evaporator superheat is about 10 degrees
- Actual field conditions are rarely ideal

SUMMARY - 2

- When the indoor temperature is warmer than the outdoor temperature, the evaporator can starve and lose capacity
- High efficiency systems typically operate at lower pressures and have larger condenser coils
- High-efficiency systems have lower amperage ratings than standard efficiency systems
- High-efficiency systems usually use a thermostatic expansion valve metering device

SUMMARY - 3

- High-efficiency systems become too efficient when the ambient temperature is low
- Normal saturation temperature is about 45° for high efficiency systems
- EER = Btu/hr (output) / wattage (input)
- The higher the EER, the higher the efficiency
- Operating voltages should be within 10% of nameplate ratings

SUMMARY - 4

- Electrical ratings can be improvised or estimated by estimating system capacity
- If the compressor's running load amperage is supplied on the data tag, it should not be exceeded
- Overloaded compressors may still draw low current if the voltage is high
- Two-speed compressors can operate at 1,800 rpm or 3,600 rpm
- Lower speed is used for mild weather and low load conditions