

Refrigeration & Air Conditioning Technology
SIXTH EDITION

SECTION 7

AIR CONDITIONING (COOLING)

UNIT 40

TYPICAL OPERATING CONDITIONS

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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

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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

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RELATIVE HUMIDITY AND THE LOAD

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

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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

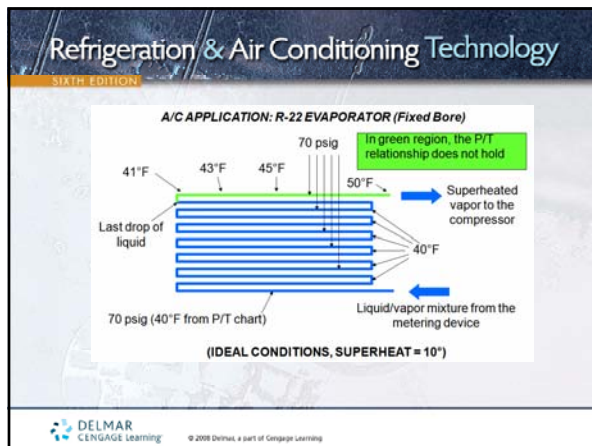
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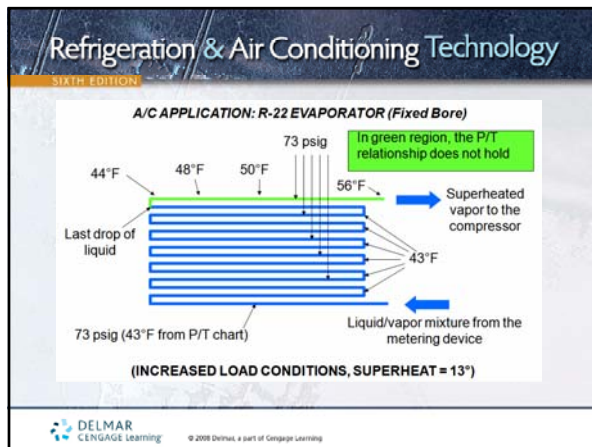
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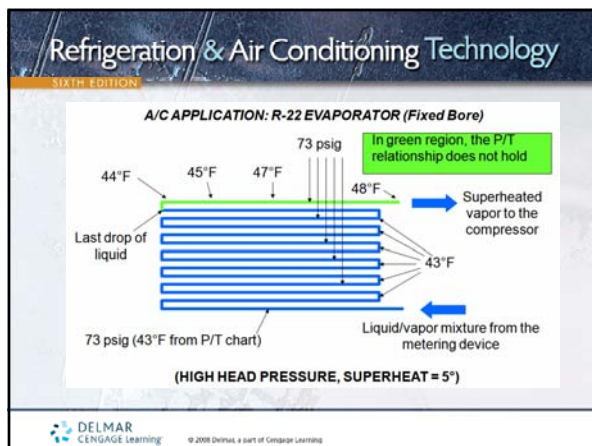
EVAPORATOR OPERATING CONDITIONS

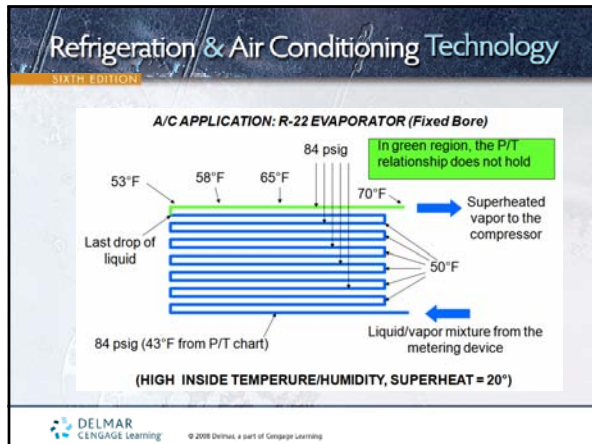
- Normal operating temperature 40°F
 - 75°F inside air temperature
 - 50% humidity
 - Approximate evaporator superheat is 10°
- Actual field conditions are rarely ideal
- Common conditions are used for troubleshooting purposes

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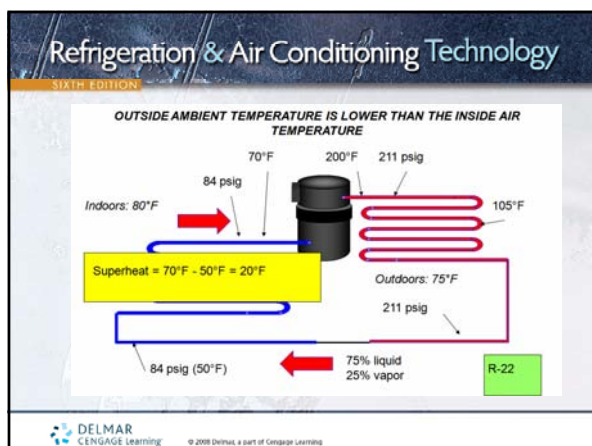
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HIGH EVAPORATOR LOAD AND A COOL CONDENSER

- 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

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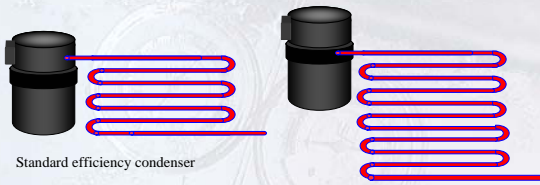
GRADES OF EQUIPMENT

- 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

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STANDARD EFFICIENCY vs. HIGH EFFICIENCY CONDENSERS



Standard efficiency condenser

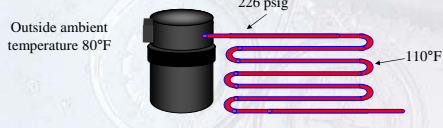
High efficiency condenser

High efficiency condenser coils are physically larger

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STANDARD EFFICIENCY vs. HIGH EFFICIENCY CONDENSERS



Outside ambient temperature 80°F

226 psig

110°F

Standard efficiency condenser

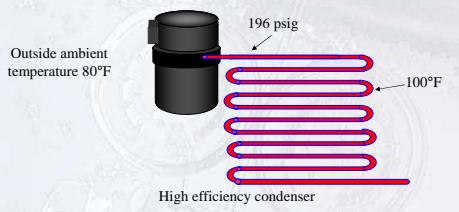
Refrigerant condenses at a temperature about 30 degrees higher than the outside ambient temperature

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STANDARD EFFICIENCY vs. HIGH EFFICIENCY CONDENSERS



Outside ambient temperature 80°F

196 psig

100°F

High efficiency condenser

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

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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

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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

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Motor	Single Phase	3-Phase Squirrel Cage Induction
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- 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

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- High-efficiency systems become too efficient when the ambient temperature is low



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- $EER = \text{Btu/hr (output)} / \text{wattage (input)}$
- 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

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EER EXAMPLE 1

- System Output = 36,000 btu/hour
- Power Input = 4,000 Watts
- $EER = \text{System Output} \div \text{Power Input}$
- $EER = 36,000 \text{ btu/hr} \div 4,000 \text{ Watts}$
- $EER = 9.0$

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EER EXAMPLE 2

- System Output = 36,000 btu/hour
- Power Input = 3,600 Watts
- $EER = \text{System Output} \div \text{Power Input}$
- $EER = 36,000 \text{ btu/hr} \div 3,600 \text{ Watts}$
- $EER = 10.0$

The higher the EER, the more efficient the equipment

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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

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208-VOLT MOTOR

10% OF RATED VOLTAGE = 20.8 VOLTS

LOW END OF VOLTAGE RANGE =
 $208 \text{ VOLTS} - 20.8 \text{ VOLTS} = \mathbf{187.2 \text{ VOLTS}}$

HIGH END OF VOLTAGE RANGE =
 $208 \text{ VOLTS} + 20.8 \text{ VOLTS} = \mathbf{228.8 \text{ VOLTS}}$

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230-VOLT MOTOR

10% OF RATED VOLTAGE = 23 VOLTS

LOW END OF VOLTAGE RANGE =
 $230 \text{ VOLTS} - 23 \text{ VOLTS} = \mathbf{207 \text{ VOLTS}}$

HIGH END OF VOLTAGE RANGE =
 $230 \text{ VOLTS} + 23 \text{ VOLTS} = \mathbf{253 \text{ VOLTS}}$

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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

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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
- During high-load conditions, the compressor may operate near full-load amperage

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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

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CURRENT DRAW AND THE TWO-SPEED COMPRESSOR

- Used to achieve high seasonal efficiencies
- Can operate as two- or 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

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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

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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

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SUMMARY - 3

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

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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
