

AIR FORCE
QUALIFICATION TRAINING PACKAGE (AFQTP)



FOR
HEATING, VENTILATION, AIR
CONDITIONING/REFRIGERATION (HVAC/R)
(3E1X1)

MODULE 16
ELECTRICAL

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CORRECTIONS/IMPROVEMENT LETTER..... APPENDIX A

Career Field Education and Training Plan (CFETP) references from 1 July 2002 version.

OPR: HQ AFCESA/CEOF
(SMSgt Dan Sacks)
Supersedes AFQTP 3E1X1-16, 30 Jul 00

Certified by: HQ AFCESA/CEOF
(CMSgt Myrl F. Kibbe)
Pages: 19/Distribution F

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

**AIR FORCE QUALIFICATION TRAINING PACKAGES
FOR
HEATING, VENTILATION, AIR CONDITIONING/REFRIGERATION
(HVAC/R)
(3E1X1)**

INTRODUCTION

Before starting this AFQTP, refer to and read the “[AFQTP TRAINER/TRAINEE GUIDE](#).”

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. **It is important for the trainer and trainee to understand** that an AFQTP **does not** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:

AFQTP completion
Hands-on certification

Diamond task:

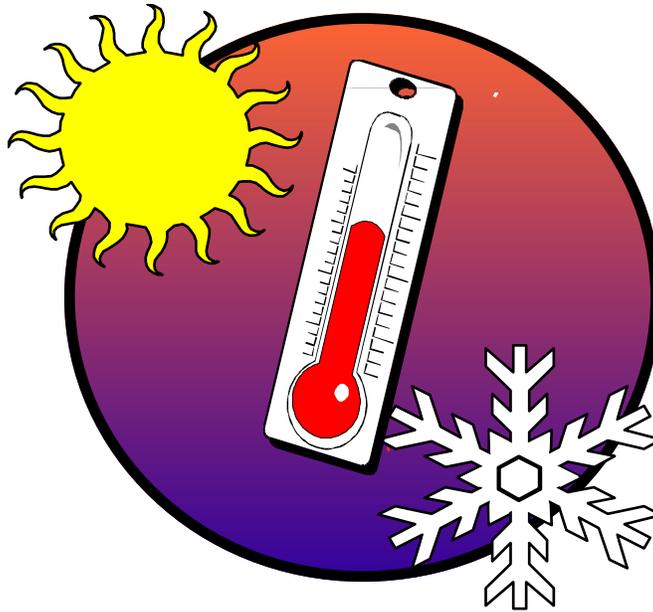
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.*

Put this package to use. Subject matter experts, under the direction and guidance of HQ AFCESA/CEOF, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

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ELECTRICAL

MOTORS

MODULE 16

AFQTP UNIT 9

ELECTRICALLY CONNECT (SINGLE-PHASE AND THREE-PHASE) (16.9.5.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

ELECTRICALLY CONNECT (SINGLE-PHASE AND THREE-PHASE) MOTORS
Task Training Guide

STS Reference Number/Title:	16.9.5. - Electrically connect (single-phase and three-phase) motors.
Training References:	<ol style="list-style-type: none"> 1. CD-ROM Air Force Qualification Training Package (AFQTP) 3E1X1 HVAC/R, Version 1.0, Mar 00: <i>HVAC Electrical Troubleshooting and Repair</i>. 2. Career Development Course (CDC) HVAC/R Journeyman 3E151D Volume 3, Unit 3, Section 3-3, Lesson 427: <i>Connecting 3-phase motors</i> and Lesson 429: <i>Connecting 1-phase AC motors</i>. 3. Applicable manufacturers' manuals. 4. Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, Hazardous Energy Control and Mishap Prevention Signs and Tags.
Prerequisites:	<ol style="list-style-type: none"> 1. Possess a minimum of a 3E131 AFSC. 2. Review the following references: <ol style="list-style-type: none"> 2.1. CDC 3E151D Volume 3., Section 3-3, Lessons 427 and 429. 2.2. Applicable manufacturers' manuals or motor data plates. 2.3. AFOSHSTD 91-45 for lockout/ tag out procedures. 3. Complete CD-ROM AFQTP 3E1X1 HVAC/R, Version 1.0, Mar 00: <i>HVAC Electrical Troubleshooting and Repair</i>.
Equipment/Tools Required:	<ol style="list-style-type: none"> 1. Personnel Protective equipment. 2. HVAC/R tool bag. 3. Single-phase and three-phase motor. 4. Lock-out/Tag-out kit.
Learning Objective:	Trainee will electrically connect single-phase and three-phase motors with out assistance.
Samples of Behavior:	Trainee will electrically connect single-phase and three-phase motors.
Notes:	Any safety violation is an automatic failure.

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ELECTRICALLY CONNECT (SINGLE-PHASE AND THREE-PHASE) MOTORS

1. Background. Working with electricity is a big part of the HVAC/R career field. Whether working on burners, air conditioners, or system control circuits, HVAC/R technicians must be familiar with electricity. Without this much-needed knowledge the Air Force mission could be jeopardized. It is important to remember that whenever working on electrical equipment --safety must *always* come first!

2. Connecting Electrical Motors. For this objective, we will explore the steps to electrically connect a motor. The many types of electric motors highlight the necessity of technicians following manufacturers' installation instructions. As trained HVAC/R technicians, it is our job to protect Air Force resources. Through education and training, we can limit connection mishaps and motor failures. The steps in this section are a basic guideline for the trainee, trainer, and certifier to follow.

2.1. Single-phase motors are available in many different voltage and connection schemes. It would be nearly impossible to cover every connection procedure for each type of single-phase motor. These steps listed below are just a general guideline to ensure task completion.

2.2. Unlike single-phase motors, three-phase motors are fairly standardized. The differences depend on internal winding type and voltage rating. Though less critical when compared to connecting a single-phase motor, we still suggest following the manufacturer's instructions.

3. Complete the CD-ROM AFQTP 3E1X1 HVAC/R, Version 1.0, Mar 00: HVAC Electrical Troubleshooting and Repair. Upon completion of the above-mentioned CD-ROM, properly connect single-phase and three-phase motor using the step-by-step procedures listed below.

NOTE:

The review questions for this material are contained in the above-mentioned CD-ROM.

4. Procedures. Follow these steps to perform the following tasks:

4.1. Electrically Connect a Single-phase Motor.

Step 1: Gather data:

1.1. Locate manufacture's installation procedures.

1.2. Refer to the manufacturer's procedures corresponding to available voltage. If a dual voltage motor is used, the manufacturer's procedures (cut sheet) will be broken down, step-by-step, for both voltages. Also, most motors will have a wiring or connection diagram physically located on the motor. Usually this diagram is stamped into the data plate, or inside of the wiring connection box.

1.3. Familiarize yourself with all the steps given on the cut sheet.

1.4. If this is a new motor, ensure the wire and conduit are long enough to reach the motor's connection box.

Step 2: Physically identify line voltage with a meter, disconnect power at the main switch and apply Lock-out/Tag-out procedures in accordance with (IAW) AFOSHSTD 91-45.

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Step 3: Connect motor:

- 3.1. With a voltage meter (check each phase to ground), ensure power is still disconnected to the motor and Lock-out/Tag-out procedures are being used IAW AFOSHSTD 91-45. If applicable, discharge all motor capacitors to prevent electrical shock. With an Ohmmeter, check all circuits to ground. If you should find a grounded circuit, repair the ground before proceeding.
- 3.2. Electrically connect the single-phase motor by following the steps given in the cut sheet or by following a wiring diagram. Ensure the diagram you are using corresponds to the correct supply voltage being used.
- 3.3. After completing the connection, inspect the wiring to ensure all connections are electrically and mechanically secure and proper grounding techniques were used.
- 3.4. Clean area and secure all previously removed covers.

SAFETY:

EXERCISE EXTREME CAUTION AVOIDING ELECTRICAL HAZARDS WHILE WORKING WITH AN ENERGIZED MOTOR.

Step 4: Operational test:

- 4.1. If the motor is connected to a load (e.g., fan, pump, compressor), ensure the device is free from binding or any other unnecessary resistance by manually turning it. Compression type load devices cannot be manually turned, so you must assume these types of devices are in good working order. Open all system (e.g., hydronic, refrigeration) valves prior to starting the motor.
- 4.2. Apply power to the motor.
- 4.3. Check amperage to ensure it matches the rating identified on the manufacturers' data plate.

4.2. Electrically Connect Three-phase Motor.

Step 1: Gather data:

- 1.1. Locate manufacture's installation procedures.
- 1.2. Refer to the manufacturer's procedures corresponding to available voltage. If a dual voltage motor is used, the manufacture's procedures (cut sheet) will be broken down, step-by-step, for both voltages. Also, most motors will have a wiring or connection diagram on the motor. Usually this diagram is stamped on the data plate, or inside the wiring connection box.
- 1.3. Familiarize yourself with all the steps given in the cut sheet.
- 1.4. If this is a new motor, ensure the wire and conduit are long enough to reach the motor's connection box.

Step 2: Physically identify line voltage with a meter, disconnect power at the main switch and apply Lock-out/Tag-out procedures IAW AFOSHSTD 91-45.

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Step 3: Connect motor:

- 3.1. With a voltage meter (check each phase to ground), ensure power is still disconnected to the motor and Lock-out/Tag-out procedures are being used IAW AFOSHSTD 91-45. With an Ohmmeter, check all circuits to ground. If you should find a grounded circuit, repair the ground before proceeding.
- 3.2. Electrically connect the three-phase motor by following the steps given in the manufacturer's cut sheet or following a wiring diagram. Ensure the diagram you are using corresponds to the correct supply voltage being used.
- 3.3. After completing the connection, inspect the wiring to ensure connections are electrically and mechanically secure and proper grounding techniques were used.
- 3.4. Clean area and secure all previously removed covers.

SAFETY:

EXERCISE EXTREME CAUTION AVOIDING ELECTRICAL HAZARDS WHILE WORKING WITH AN ENERGIZED MOTOR.

Step 4: Operational test:

- 4.1. If the motor is connected to a load (e.g., fan, pump, compressor), ensure the device is free from binding or any other unnecessary resistance by manually turning it. Compression type load devices cannot be manually turned, so you must assume these types of devices are in good working order. Open all system (e.g., hydronic, refrigeration) valves prior to starting the motor.
- 4.2. Apply power to the motor.
- 4.3. Check amperage to ensure it matches the rating identified on the manufacturers' data plate.

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ELECTRICALLY CONNECT (SINGLE-PHASE AND THREE-PHASE) MOTORS

PERFORMANCE CHECKLIST

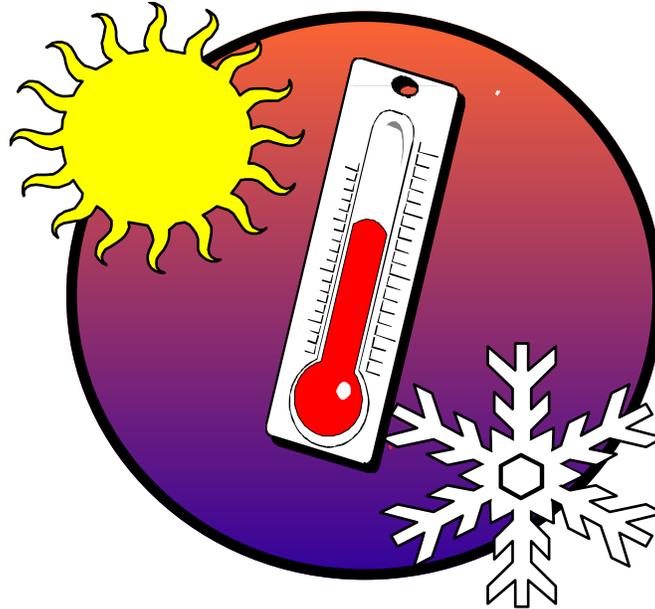
INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE....	YES	NO
1. locate manufacture's installation procedures?		
2. arrive at the job site with all tools and equipment required?		
3. disconnect power and apply Lock-out/Tag-out procedures?		
4. use voltage meter correctly?		
5. without assistance, connect single-phase motor correctly?		
6. properly connected ground circuit for a single-phase motor?		
7. properly check a single-phase motor for shorts?		
8. without assistance, connect three-phase motor correctly?		
9. properly connected ground circuit for a three-phase motor?		
10. properly check a three-phase motor for shorts?		
11. comply with all safety requirements while performing entire task?		

FEEDBACK: Trainer/Certifier should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer/certifier.

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ELECTRICAL
MOTORS

MODULE 16

AFQTP UNIT 9

REVERSE ROTATION OF (SINGLE-PHASE AND THREE-PHASE) ELECTRIC MOTORS (16.9.6.)

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REVERSE ROTATION OF (SINGLE-PHASE AND THREE-PHASE) ELECTRIC MOTORS

Task Training Guide

STS Reference Number/Title:	16.9.6. - Reverse rotation of (single-phase and three-phase) electric motors.
Training References:	<ol style="list-style-type: none"> 1. CD-ROM Air Force Qualification Training Package (AFQTP) 3E1X1 HVAC/R, Version 1.0, Mar 00: <i>HVAC Electrical Troubleshooting and Repair</i>. 2. Career Development Course (CDC) HVAC/R Journeyman 3E151D, Volume 3, Unit 3, Section 3-3, <i>Motors</i>. 3. Applicable manufacturers' Manuals or data plates. 4. Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, Hazardous Energy Control and Mishap Prevention Signs and Tags.
Prerequisites:	<ol style="list-style-type: none"> 1. Possess a minimum of a 3E131 AFSC. 2. Review the following references: <ol style="list-style-type: none"> 2.1. CDC 3E151D, Volume 3, Section 3-3. 2.2. Applicable manufacturers' Specifications. 2.3. AFOSHSTD 91-45 for lockout/ tag out procedures. 3. Complete CD-ROM AFQTP 3E1X1 HVAC/R, Version 1.0, Mar 00: <i>HVAC Electrical Troubleshooting and Repair</i>.
Equipment/Tools Required:	<ol style="list-style-type: none"> 1. Personnel Protective equipment. 2. HVAC/R tool bag. 3. Single-phase (Reversible) and three-phase motor. 4. Lock-out/Tag-out kit.
Learning Objective:	Trainee will reverse rotation of single-phase and three-phase electric motors with out assistance.
Samples of Behavior:	<ol style="list-style-type: none"> 1. Trainee will reverse rotation of single-phase and three-phase electric motors. 2. Trainee will observe all safety requirements including lock-out tag-out procedures.
Notes:	<ol style="list-style-type: none"> 1. Trainer will have to develop a scenario where the trainee can reverse the rotation of a single-phase and three-phase electrical motor. 2. Any safety violation is an automatic failure.

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REVERSE ROTATION OF (SINGLE-PHASE AND THREE-PHASE) ELECTRICAL MOTORS

1. Background. As a HVAC/R technician, you must be able to safely reverse the rotation of electrical motors. A motor rotating in the wrong direction can cause major damage to HVAC systems or air and water flow to reduce or flow in reverse.

2. Reverse Rotation of Electrical Motors.

2.1. Single-phase motors require a two wire service and a ground. One from line voltage the other from neutral or in the case of higher voltage single-phase, each from a different line connection. These motors are usually bought with the required rotation in mind. Single-phase motors that were built to reverse have jumper pins or multi colored wires to correspond to the diagram printed on the motor data plate. The correct placement of the jumpers or wiring will determine the rotation of these motors. It is critically important to follow the manufacturer's data plate when reversing these motors.

2.2. All three-phase motors are reversible. Three lines feeding the three-phase motor and a ground. Each of the wires is connected to a different phase. The rotation of these motors is determined by which lead is placed on which line. To reverse rotation of these motors, disconnect power to the motor then reverse any two of the wires from the bottom of the motor starter, or to the line leads at the motor (first wire you pulled is placed where the second wire was, and second placed where the first was). Reconnect power and the motor will run in the opposite direction.

3. Complete the CD-ROM AFQTP 3E1X1 HVAC/R, Version 1.0, Mar 00: HVAC Electrical Troubleshooting and Repair. Upon completion of the above-mentioned CD-ROM, properly reverse rotation (single-phase and three-phase) motor using the step-by-step procedures listed below.

NOTE:

The review questions for this material are contained in the above-mentioned CD-ROM.

4. Procedures. Follow these steps to perform the following tasks:

4.1. Reverse Rotation of a Single-phase Motor.

Step 1. Obtain manufacturer's technical data sheet/plate and read procedures for changing rotation.

Step 2: Observe rotation of motor.

Step 3: Disconnect power. With a voltage meter (check each phase to ground), ensure power is disconnected to the motor and Lock-out/Tag-out procedures are being used in accordance with (IAW) AFOSHSTD 91-45.

Step 4: Disconnect wires to existing motor.

Step 5: Rewire motor as the manufacturer indicated and replace all electrical covers.

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SAFETY:

EXERCISE EXTREME CAUTION AVOIDING ELECTRICAL HAZARDS WHILE WORKING WITH AN ENERGIZED MOTOR.

Step 6: Reconnect power.

Step 7: Test run motor to verify rotation.

4.2. Reverse Rotation of a Three-phase Motor.

Step 1. Obtain manufacturer's technical data sheet/plate and read procedures for changing rotation.

Step 2: Observe operation of motor.

Step 3: Disconnect power. With a voltage meter (check each phase to ground), ensure power is disconnected to the motor and Lock-out/Tag-out procedures are being used IAW AFOSHSTD 91-45.

Step 4: Disconnect any two wires at the motor or the motor contactor.

Step 5: Move each of the wires to the wire nut or terminal that the other had occupied and replace electrical covers.

SAFETY:

EXERCISE EXTREME CAUTION AVOIDING ELECTRICAL HAZARDS WHILE WORKING WITH AN ENERGIZED MOTOR.

Step 6: Reapply power. With a voltage meter, ensure that the motor has all three phases available.

Step 7: Observe motor rotation.

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REVERSE ROTATION OF (SINGLE-PHASE AND THREE-PHASE) ELECTRICAL MOTORS

PERFORMANCE CHECKLIST

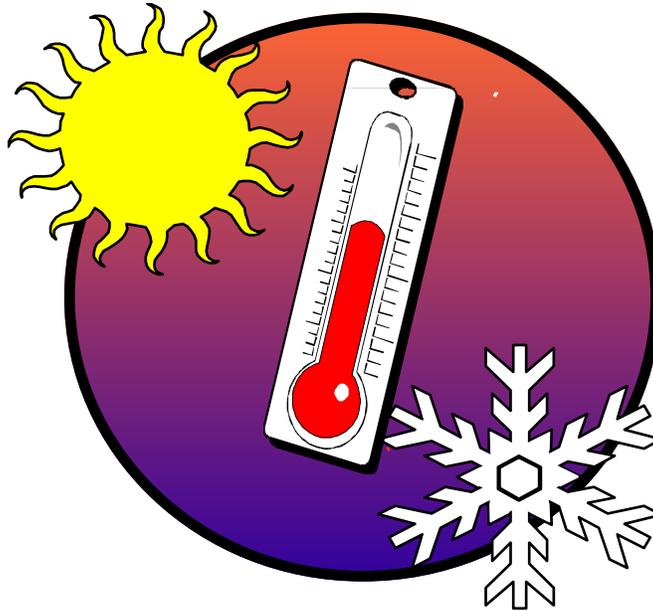
INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE....	YES	NO
Single-phase Motor Reversal		
1. comply with all safety requirements and lock-out tag-out procedures?		
2. arrived at the job site with all necessary tools and equipment?		
3. disconnected power at the main disconnect?		
4. correctly identified the connections for reversing the single-phase motor?		
5. used meter to insure that power had been disconnected?		
6. Insured that all connections were tight and sound?		
7. clamped on amp probe and took readings to compare against data plate on restart?		
8. ensure motor functioned correctly after restart?		
9. correctly reversed the single phase motor?		
10. cleaned job site when complete?		
Three phase Motor Reversal		
1. comply with all safety requirements and lock-out tag-out procedures?		
2. arrived at the job site with all necessary tools and equipment?		
3. disconnected power at the main disconnect?		
4. used meter to insure that power had been disconnected?		
5. swapped two wires?		
6. insured that all connections were tight and sound?		
7. clamped on amp probe and took readings to compare against data plate on restart?		
8. ensure motor functioned correctly after restart?		
9. cleaned up work site when complete?		

FEEDBACK: Trainer/Certifier should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer/certifier.

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ELECTRICAL MOTORS

MODULE 16

AFQTP UNIT 9

MEASURE MOTOR CURRENT DRAW (16.9.7.)

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MEASURE MOTOR CURRENT DRAW
Task Training Guide

STS Reference Number/Title:	16.9.7. - Measure motor current draw.
Training References:	<ol style="list-style-type: none"> 1. CD-ROM Air Force Qualification Training Package (AFQTP) 3E1X1 HVAC/R, Version 1.0, Mar 00: <i>HVAC Electrical Troubleshooting and Repair</i>. 2. Career Development Course (CDC) HVAC/R Journeyman 3E151D, Volume 3, Section 2-2, <i>Meters</i>. 3. Manufacturers' Specifications. 4. <u>Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, Hazardous Energy Control and Mishap Prevention Signs and Tags.</u>
Prerequisites:	<ol style="list-style-type: none"> 1. Possess a minimum of a 3E131 AFSC. 2. Review the following references: <ol style="list-style-type: none"> 2.1. CDC 3E151D Volume 3, Section 2-2. 2.2. Applicable Manufacturers' Specifications. 2.3. AFOSHSTD 91-45 for lockout/ tag out procedures. 3. Complete CD-ROM AFQTP 3E1X1 HVAC/R, Version 1.0, Mar 00: <i>HVAC Electrical Troubleshooting and Repair</i>.
Equipment/Tools Required:	<ol style="list-style-type: none"> 1. Personnel Protective equipment. 2. HVAC/R tool bag. 3. Amp Meter. 4. Access to operational single-phase and three-phase motors.
Learning Objective:	Given equipment, trainee will measure motor current draw with no assistance.
Samples of Behavior:	<ol style="list-style-type: none"> 1. Trainee will measure motor current draw. 2. Observe safety precautions.
Notes:	
Any safety violation is an automatic failure.	

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MEASURE MOTOR CURRENT DRAW

1. Background. Throughout your career as a HVAC/R technician, you will frequently have to measure current draw in order to troubleshoot electrical motors. Continued experience in the field will add to the ability to troubleshoot these problems and recognize those that may be causing other problems. This AFQTP will describe the proper method to use an Amp Meter.

2. Measuring Motor Current Draw. Amperage is a unit of measurement used to measure the amount of work performed by an energized circuit under resistive load. Amperage is measured with an amp meter. This meter is used to show how hard a unit or load device is working. There is a direct correlation between the load on a refrigeration circuit and the amount of current draw (measured in amperage) required by the compressor motor. The greater the load, the harder the compressor must work to move the refrigerant through the system against the corresponding increase in high side pressure.

2.1. If a unit has a dirty condenser not only will there be an increase in system high side pressures, but in compressor amperage draw. If a system has no load on it, or too little refrigerant, the compressor will have a decreased amount of work and the amp probe will indicate this condition. In addition, every unit or equipment item carries a data plate. We can find the unit full load amperage (FLA) number on this data plate. FLA is the amount of amperage the unit will pull when it is fully loaded. Also on the data plate is the term locked rotor amperage (LRA). This is the amount of current, again measured in amperage, which the motor will pull if the rotor lock-up and won't turn. These are the two terms used most often to describe the amperage of a motor. Contact your motor manufacturer if your data plate uses different terms you are unsure of.

2.2. Another example of higher than normal amperage draw occurs when a motor is dragging, due to worn bearings or improper lubrication. This motor will have to work harder to overcome this resistance. That increased amount of work will again show up as an increase in current draw, warning the technician that the motor may need repairs.

3. Complete the CD-ROM AFQTP 3E1X1 HVAC/R, Version 1.0, Mar 00: HVAC Electrical Troubleshooting and Repair. Upon completion of the above-mentioned CD-ROM, properly measure motor current draw using the step-by-step procedures listed below.

NOTE:

The review questions for this material are contained in the above-mentioned CD-ROM.

SAFETY:

EXERCISE EXTREME CAUTION AVOIDING ELECTRICAL HAZARDS WHILE WORKING WITH AN ENERGIZED MOTOR.

4. Procedures. Follow these steps to measure motor current draw for a single-phase motor and three-phase motor:

Step 1: Clamp the amp meter around one of the power leads to the motor.

Step 2: Repeat this process for all power leads going to the motor.

Step 3: Compare readings against unit data plate for over or under current condition.

Step 4: Remove Amp meter.

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MEASURE MOTOR CURRENT DRAW

PERFORMANCE CHECKLIST

INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE....	YES	NO
1. arrive at the job site with all tools and equipment required?		
2. properly measure current draw for single-phase and three-phase motors?		
3. compare findings against the equipment data plate?		
4. require NO assistance from the trainer/certifier?		
5. clean up the area when complete?		
6. comply with all safety requirements?		

FEEDBACK: Trainer/Certifier should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer/certifier.

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MEMORANDUM FOR HQ AFCESA/CEOF
139 Barnes Drive Suite 1
Tyndall AFB, FL 32403-5319

FROM:

SUBJECT: Air Force Qualification Training Package Improvement

1. Identify module.

Module # and title _____

2. Identify improvement/correction section(s)

<input type="checkbox"/> STS Task Reference	<input type="checkbox"/> Performance Checklist
<input type="checkbox"/> Training Reference	<input type="checkbox"/> Feedback
<input type="checkbox"/> Evaluation Instructions	<input type="checkbox"/> Format
<input type="checkbox"/> Performance Resources	<input type="checkbox"/> Other
<input type="checkbox"/> Steps in Task Performance	

3. Recommended changes--use a continuation sheet if necessary.

4. You may choose to call in your recommendations to DSN 523-6445 or FAX DSN/Commercial 523-6488 or (850) 283-6488 or email ceof.helpdesk@tyndall.af.mil.
5. Thank you for your time and interest.

YOUR NAME, RANK, USAF
Title/Position