**Occupational Endorsement Certificate**

**REFRIGERATION AND HEATING TECHNOLOGY**

**Educational Effectiveness**

**Assessment Plan**

**Adopted by**

**The R&H faculty: September 18, 2020**

Reviewed by MSC Academic Assessment Committee: 10/7/20

Reviewed with curriculum proposal by the Academic Assessment Committee: 11/6/20

Reviewed by the Faculty Senate as an information item: 11/6/20

**Contents**

[***Assessment Plan 1***](#_Toc469049759)

[***Summary 3***](#_Toc469049761)

[***Mission Statement 4***](#_Toc469049762)

[***Program Introduction 4***](#_Toc469049763)

[***Program Requirements 5***](#_Toc469049764)

[***Program Objectives/Outcomes 5***](#_Toc469049765)

[***Assessment Tools 6***](#_Toc469049766)

[***Table 1 6***](#_Toc469049767)

[***Table 2 7***](#_Toc469049768)

[***Assessment Implementation & Analysis for Program Improvement 8***](#_Toc469049769)

[***Appendix A: Laboratory project 9***](#_Toc469049770)

[***Appendix B: Pre and Post tests 10***](#_Toc469049771)

[***Appendix C: EPA Certification 11***](#_Toc469049772)

[***Appendix D: ESCO Employment Ready (ER) Exams 12***](#_Toc469049773)

[***Appendix E: Sample Pre/Post Tests 13***](#_Toc469049774)

Summary

The purpose of this document is to outline a series of steps for determining the academic effectiveness of the Matanuska Susitna College Refrigeration and Heating (R&H) Program.

Skill standards establish a clear set of performance expectations that help both educators and trainers. They assist in the design, development, and delivery of student recruiting strategies, appropriate curriculum, and training consistent with industry standards. This plan has been developed to meet the guidelines of the Heating, Air-Conditioning, and Refrigeration Technician National Skill Standards. The plan was developed to provide some means for demonstrating the effectiveness of the program.

This document identifies measures that are used to evaluate the effectiveness of the R&H Program.

**Mission Statement**

The mission of the Refrigeration and Heating Technology program is to deliver high quality instruction to Alaskans through a sequence of hands-on coursework, applying current technologies and integrating academics to prepare students for employment in residential and commercial heating, ventilating, air conditioning, and refrigeration (HVACR) industries.

**Program Introduction**

Matanuska-Susitna College (MSC) is an extended college of the University of Alaska Anchorage (UAA). MSC is accredited through the University of Alaska Anchorage and the Northwest Commission on Colleges and Universities (NWCCU).

One Occupational Endorsement Certificate in Refrigeration and Heating is available. Satisfactory completion of 24 credits of technical courses will qualify a student for the Certificate in Refrigeration and Heating. A student satisfactorily completing the requirements for the certificate will possess a background in heating, air conditioning, applied physics, and electricity. The student will also possess the technical skills required to diagnose and repair modern commercial and residential heating, refrigeration, air-conditioning, and ventilation systems. The faculty place heavy emphasis on student preparation for job entry-level skills. Professional tests related to the industry are administered as part of this program. If possible, additional training may take place on the job to provide a student with work-related experience. The Refrigeration and Heating Technology program is offered only through MSC.

**Program Requirements**

**OCCUPATIONAL ENDORSEMENT CERTIFICATE in REFRIGERATION AND HEATING**

**CERTIFICATE REQUIREMENTS** (24 credits)

**First Semester (Fall)**

RH A101 Refrigeration & Air Conditioning I (4)

RH A105 Electrical Circuits for Refrigeration & Heating (3)

RH A107 Fundamentals of Heating (4)

RH A109 HVAC/R Codes (1)

**Second Semester (Spring)**

RH A122 Refrigeration & Air Conditioning II (4)

RH A124 HVAC/R Distribution Systems (4)

RH A126 HVAC/R Control Systems (3)

RH A132 HVAC/R Troubleshooting Essentials (1)

**Program Objectives/Outcomes**

Students graduating with an Occupational Endorsement Certificate in Refrigeration and Heating will be able to:

1. Apply the fundamental laws of physics related to the Heating, Ventilation, Air Conditioning, and Refrigeration (HVAC/R) industry.
2. Understand and describe the function of individual components that make up HVAC/R systems.
3. Work safely with tools, torches, electricity, refrigerants, heating fuels, and other equipment and material associated with HVAC/R work.
4. Follow work practices that are environmentally responsible.
5. Systematically troubleshoot HVAC/R systems.
6. Apply municipal, state, and national mechanical codes to decisions involving the design, installation, operation, and maintenance of HVAC/R systems.

**Assessment Tools**

A summary description of the tools used in the assessment of the program objectives and outcomes and their implementation can be found in Table 1. The tools and their relationships to the program objectives are listed in Table 2.

There is a separate appendix for each tool describing the factors that affect the results and giving examples of the tools and how they are implemented.

**Table 1**

**Program Objectives/Outcomes Assessment Tools and Administration**

| **Tool** | **Description** | **Frequency/ Start Date** | **Collection Method** | **Administered by** |
| --- | --- | --- | --- | --- |
| Laboratory Project | Hands-on project completed by the student | Annual upon inception or alternately with pre/post tests | Project Artifact | Faculty |
| Course Level Exams | Pre and Post Test | Annual upon inception or alternately with laboratory projects | Class Examinations | Faculty |
| EPA Certification | Environmental Protection Agency Refrigerant Handling Certification required for Employment in the trade | Annual upon inception | EPA exam results | Environmental Protection Agency |
| ESCO ER Certification | The ESCO Institute Employment Ready Certification | Annual upon inception | ESCO ER exam results | Industry trade association |

**Table 2**

**Association of Assessment Tools to Program Objectives/Outcomes**

|  | Laboratory project | Pre/Post tests | EPA Certification | EXSCO ER  exam |
| --- | --- | --- | --- | --- |
| Apply the fundamental laws of physics related to the Heating, Ventilation, Air Conditioning, and Refrigeration (HVAC/R) industry. | 0 | 1 | 0 | 1 |
| Understand and describe the function of individual components that make up HVAC/R systems. | 0 | 1 | 1 | 1 |
| Work safely with tools, torches, electricity, refrigerants, heating fuels, and other equipment and material associated with HVAC/R work. | 1 | 1 | 1 | 1 |
| Follow work practices that are environmentally responsible. | 1 | 1 | 1 | 0 |
| Systematically troubleshoot HVAC/R systems. | 0 | 1 | 1 | 1 |
| Apply municipal, state, and national mechanical codes to decisions involving the design, installation, operation and maintenance of HVAC/R systems. | 1 | 1 | 1 | 1 |

0 = Tool is not used to measure the associated objective.

1 = Tool is used to measure the associated objective.

**Assessment Implementation & Analysis for Program Improvement**

***General Implementation Strategy***

Annually, as soon as the results of the assessment tools are available, the faculty of the R&H program will meet to analyze the data and determine if programmatic changes are in order. After determining what changes, if any, are required, R&H faculty will initiate the process to implement those changes.

***Method of Data Analysis and Formulation of Recommendations for Program Improvement***

Program Faculty will meet at least once a year to review the data collected by the assessment tools. If the data indicates changes are needed in an area, faculty will make recommendations for program changes that are designed to enhance performance relative to the program’s objectives and outcomes. The results of the data collection, an interpretation of the results, and the recommended programmatic changes are to be collected and analyzed by the end of May each year. A plan for implementing the recommended changes is also to be completed at this meeting.

The proposed programmatic changes may be any action or change in policy that the faculty deems necessary to improve performance relative to the program’s objectives and outcomes. Recommended changes should also consider workload (faculty, staff, and students), budgetary, facilities, and other relevant constraints.

***Goals for Student Success Rates***

It is the goal of MSC R&H Faculty that an average of 80% of students will meet or exceed the student learning outcomes.

***Modification of the Assessment Plan***

The faculty, after reviewing the collected data and the processes used to collect it, may decide to alter the assessment plan. If assessment tools are ineffective, they may be discarded, and if deemed beneficial, additional assessment tools may be implemented. Changes may be made to any component of the plan, including the objectives, outcomes, assessment tools, or any other aspect of the plan. The changes are to be approved by the faculty of the program and follow the required institutional procedures to make such changes. The modified assessment plan is to be forwarded to the MSC Director’s Office and the Office of Academic Affairs.

**APPENDIX A: Laboratory project**

***Tool Description:***

Classes containing a lab component will be assessed annually. The faculty member may choose either a pre/post test or a graded laboratory project as the assessment tool. To use a laboratory project, the project will be photographed and compiled with the student’s name and the instructor’s evaluation. The evaluation should include a statement indicating if the student’s work:

* Exceeds expectations for the project
* Meets expectations for the project
* Fails to meet expectations for the project

To meet the expectation for the project, the student will receive a B or C grade for the project (a score in the range of 69.5% to 89.5%). To exceed the expectation the student must achieve an A grade (a score above 89.5%). Any grade below 69.5% indicates a failure to meet the expectations for the project.

It is recommended that different tools be used in classes that combine academic and lab components on different assessment cycles. For instance, a pre/post test may be used on alternate years with a lab project evaluation to provide better diversity in the evaluation process.

The lab evaluation will be reviewed by Refrigeration and Heating Faculty to determine if it is relevant to the outcomes and objectives for the course and trends in the HVACR industry.

Any changes deemed necessary to the assessment tool will be discussed by the full-time faculty.

***Factors that could affect the collected data:***

Several factors may have some bearing on the results of the data collected by this tool:

* Previous experience with similar technology
* A student’s physical limitations
* The amount of time and effort expended preparing for and completing the project
* Attendance
* Student’s enthusiasm for the project

***How to interpret the data:***

Care should be taken in evaluating results of the tool and extrapolating the data for program performance. At the program level, results should be compared with other data sources in order to gain the proper perspective needed for a meaningful evaluation. The results of both of the nationally administered certification tests should be considered in conjunction with the laboratory project results for an appropriate assessment.

**APPENDIX B: Pre and Post tests**

***Tool Description:***

A test consisting of 10 to 20 questions, representative of material covered in each course, will be issued at the beginning of the semester. The same test will be administered at the end of the semester. A comparative analysis will be made of each student’s results to determine the effectiveness of the teaching. The assessment tool will be written by faculty teaching the course. The test will be reviewed by Refrigeration and Heating Faculty periodically to determine relevance to the course content and trends in the HVACR industry. Any changes deemed necessary to the assessment tool will be discussed by the full-time faculty.

***Factors that could affect the collected data:***

Several factors may have some bearing on synthesizing the collected data for use in program assessment:

* The student’s level of preparedness for college level academic coursework at the time of entry to the course
* Other time commitments, e.g. employment, family, commuting, etc.
* Was there a strong student leader in this cohort? If so, how did this affect overall grades during his or her academic tenure?
* Overall commitment or energy level of this cohort of students (Was the attendance record good? Did students show enthusiasm for accomplishments in the lab projects?) A student cohort with an overall positive attitude and strong work ethic will generally have a higher average grade than a less motivated class, even if the presentation of the program is identical in all respects.

***How to interpret the data:***

Care should be taken in evaluating results of the tool and extrapolating the data for program performance. At the program level, results should be compared with other data sources in order to gain the proper perspective needed for a meaningful evaluation. The results of both of the nationally administered certification test should be considered in conjunction with the pre/post test results for an appropriate assessment.

**Appendix C: EPA Certification**

***Tool Description:***

The Environmental Protection Agency (EPA) requires that anyone buying refrigerants or servicing refrigerant systems be certified in proper refrigerant handling and containment. The exam is closed book, and consists of 100 questions, which are divided into four categories. Near the end of their refrigeration training, students are required to take the EPA certification exam. The percentage of R&H students obtaining certification is a good indicator of the effectiveness of the refrigeration training program.

***Factors that affect the collected data:***

After each testing session, the testing agency provides a summary sheet of the results on a student-by-student basis. This assures that we are able to collect 100% of the data. If, however, a student has previously passed an EPA certification exam, they are not required to test again, so those students would not be contributors to the data source.

***How to interpret the data:***

The EPA certification is nationally required, and the tests are nationally standardized. Therefore, our students’ success rate on the exam is a clear indicator of their comprehension of the required skills. National success rate data is available for the EPA certification exam, and the results of MSC students will be compared to the national average. Furthermore, the testing session result summary gives each student’s score for each of the four areas of the exam. This further refines the data so specific areas that may need improvement can be identified.

The testing sessions at the college are open to the public, so occasionally, a person who is not a student in the R&H program will join one of the testing sessions. As these certification candidates are not a reflection on the effectiveness of the R&H program, their results will not be compiled in the data bank.

**APPENDIX D: ESCO Employment Ready (ER) Certification**

***Tool Description:***

The ESCO Employment Ready Exams measure industry agreed standards of basic competency. ER Exams are nationally recognized as being developed by a panel of industry experts, and are updated regularly. Students in this program will be required to take either the Gas Heat or Oil Heat ER exam. Each exam is proctored and has 100 multiple-choice questions, and candidates have 2 hours in which to complete the exam. Exams are scored by an independent testing agency, and the results are reported to the R&H Faculty. These exams serve as a broad-based measuring tool for secondary and post-secondary HVAC/R programs.

***Factors that affect the collected data:***

Several factors may have some bearing on the collected data.

* A number of students obtain employment with HVAC/R firms before completing their studies. As a benefit of this exposure outside of the curriculum, these students can often be expected to perform better on the exams than do their peers without field experience.
* These are rigorous exams and are administered in a rigid, formal, format. This can result in a certain amount of intimidation and test anxiety for some candidates. Because of this, scores obtained on the national exam may differ overall from scores developed from the traditional rubric sources. ESCO ER data is best evaluated in a broad-based context against nationally normalized standards.

***How to interpret the data:***

The ESCO ER exams are nationally standardized and industry validated. The reports provide statistical information on how we measure up to the nationally expected norms. For this reason, they are used at numerous educational institutions for assessment purposes. Individual and program rankings on a national basis provide our program with a clear insight into the strengths and weaknesses of our efforts. It also provides focus for adjustments to the program as we work to achieve academic excellence. Care must be taken when evaluating this data as each class of students has its own dynamic and some groups will perform at a much higher level than other groups.

**Appendix E: Sample Pre/Post Tests**

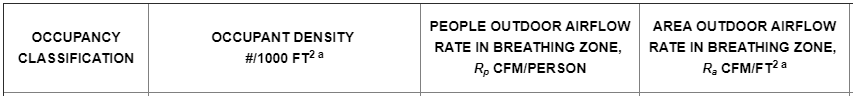
**RH A109 HVAC/R Codes**

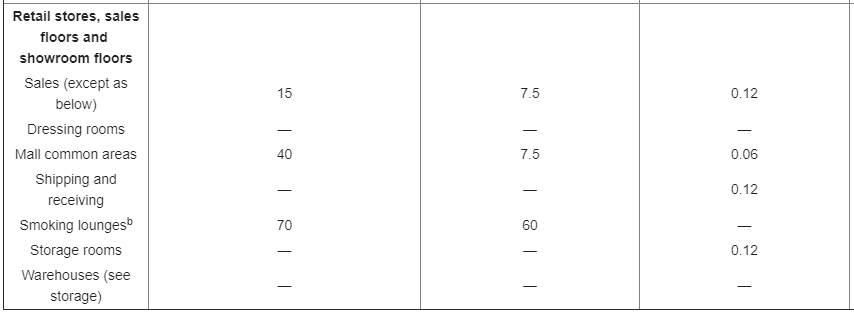
**Pre-Assessment**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*(53 possible points)*

1. If there is a conflict in code provisions regarding the specification of different materials or methods of construction, the ‘\_\_\_\_\_’ requirement shall apply. (3 pt)
   1. general
   2. specific
   3. least restrictive
   4. most restrictive
2. In order for an alternative material, design or method of construction to be considered acceptable, it must be equivalent to the code based on all except which of the following criteria? (3 pt)
   1. durability
   2. economics
   3. strength
   4. fire resistance
3. Fuel-fired appliances shall not be located in or obtain their combustion air from, ‘\_\_\_\_\_’, with exceptions made for certain appliance types. (Choose all that apply) (3 pt)
   1. Sleeping rooms
   2. Living areas
   3. Bathrooms
   4. Garages
4. When located within a garage, appliances with an ignition source shall be elevated such that the ignition source is a minimum of ‘\_\_\_\_\_’ inches above the garage floor. (3 pt)
   1. 12
   2. 14
   3. 16
   4. 18
5. Bored holes cannot be located any closer than ‘\_\_\_\_\_’ to the edge of the stud. (3 pt)
   1. 3/8”
   2. ½”
   3. 5/8”
   4. ¾”
6. Areas in which stationary motor vehicles are operated shall be equipped with a(n) ‘\_\_\_\_\_’. (3 pt)
   1. Make-up Air system
   2. Source capture system
   3. NO2 sensor and alarm
   4. Natural ventilation system
7. When using two ducts or openings to supply combustion air to an appliance, one needs to commence within ‘\_\_\_\_\_’ of the ceiling while the other needs to commence within ‘\_\_\_\_\_’ of the floor. (3 pt)
   1. 6”
   2. 12”
   3. 18”
   4. 24”
8. When operating an exhaust system in a kitchen (or many other locations), you will need to also supply the area with ‘\_\_\_\_\_’. (3 pt)
   1. Fire suppression
   2. Make-up air
   3. Humidification
   4. CO sensors
9. Smoke detectors need to be installed in any return air distribution system or any shared supply air distribution system if that system has a maximum capacity of ‘\_\_\_\_\_’ CFM or greater. (3 pt)
   1. 1000
   2. 2000
   3. 2500
   4. 3000
10. When you install a wall furnace or room heater, you should not place the unit where any door can swing into a position within ‘\_\_\_\_\_’ of the unit’s circulation inlets or outlets. (3 pt)
    1. 6 inches
    2. 8 inches
    3. 12 inches
    4. 18 inches
11. Horizontal exhaust terminations that are next to a walkway must be at least ‘\_\_\_\_\_’ above the walkway. (3 pt)
    1. 6 feet
    2. 7 feet
    3. 8 feet
    4. 10 feet
12. When you install a mechanical exhaust system for use with a manually fired appliance, the mechanical exhaust system must provide a(n) ‘\_\_\_\_\_’ alarm, with a battery backup, to indicate exhaust system failure due to either mechanical failure or loss of power. (3 pt)
    1. Audible or Visual
    2. Oxygen depletion
    3. Audible and Visual
    4. Carbon monoxide
13. Every boiler must have a ‘\_\_\_\_\_’ valve on both the supply and return piping. (3 pt)
    1. Mixing
    2. Shutoff
    3. Temperature/Pressure Relief
    4. One way
14. Temperature/pressure relief valve discharge pipes must terminate within ‘\_\_\_\_\_’ of the floor or into a drain. (3 pt)
    1. 8 inches
    2. 12 inches
    3. 18 inches
    4. 24 inches
15. Machinery rooms that have devices containing refrigerant installed within the room must not have any open flames or surfaces above ‘\_\_\_\_\_’ within the room. (3 pt)
    1. 600℉
    2. 700℉
    3. 800℉
    4. 900℉
16. Refrigeration system components located inside an air duct and for use with air conditioning to an occupied space must be able to withstand pressures of ‘\_\_\_\_\_’ of the design pressure or any associated system pressure relief valve. (3 pt)
    1. 100%
    2. 150%
    3. 200%
    4. 250%
17. Using the below table and formulae, calculate the minimum outside air required for a general retail store of 1500 ft2 that does not use occupancy sensors. (5 pt) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_





The outdoor airflow rate required in the breathing zone (Vbz) of the occupiable space or spaces in a zone shall be determined in accordance with Equation 4-1. 

Diagram provides an equation and assumptions.

**RH A107 Fundamentals of Heating**

**Pre-Assessment**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*(51 possible points)*

1. What is sealed combustion? (3 pt)
   1. The process used to create perfect combustion.
   2. When a heating unit pulls its combustion air from the room in which it sets.
   3. When a heating unit pulls its combustion air from outside of the structure it heats.
   4. The process of burning natural animal oils to produce heat and light.
2. If a heating appliance has an input BTU rating of greater than 350,000 BTU/H, then it should use a “\_\_\_\_\_” for the gas supply. (3 pt)
   1. Automatic Combination Gas Valve
   2. Heat-Motor controlled valve
   3. Gas Train
   4. Three Solenoid valves
3. Why do heating appliances require de-rating for higher altitudes? (3 pt)
   1. Atmospheric pressure is greater, providing more oxygen per cubic foot of air.
   2. Fuel gas burns hotter at higher altitudes.
   3. Atmospheric pressure is less, providing less oxygen per cubic foot of air.
   4. Atmospheric pressure is less, providing more oxygen per cubic foot of air.
4. After being exposed to an operational pilot for 60 seconds or more, what voltage should a thermocouple produce? (3 pt)
   1. 5-10 mV
   2. 24-30 mV
   3. 40-50 mV
   4. 72-90 mV
5. The ‘\_\_\_\_\_’ carries gas from the gas valve to the ‘\_\_\_\_\_’, or the precisely drilled hole in the spud. (3 pt)
   1. Orifice; Burner
   2. Orifice; Manifold
   3. Manifold; Orifice
   4. Manifold; Burner
6. Furnaces obtain the heat that they transfer to the supply air when they are operating at above 84% efficiency from the ‘\_\_\_\_\_’. (3 pt)
   1. Flame
   2. Sensible heat in the flue gasses
   3. Latent heat in the flue gasses
   4. Condensate
7. If a furnace tries and fails to start several times, then flashes an error code prior to attempting to fire again after one to three hours, it is referred to as having a ‘\_\_\_\_\_’ lockout classification. (3 pt)
   1. 100% Shutoff
   2. Non-100% Shutoff
   3. Soft
   4. Continuous Retry with 100% Shutoff
8. What is the maximum allowable PPM of CO in flue gasses of heating units according to the EPA? (3 pt)
   1. 50
   2. 200
   3. 400
   4. 800
9. Which type of centrifugal fan is most typical for residential furnaces? (3 pt)
   1. Airfoil
   2. Forward curved
   3. Backward inclined
   4. Multi-position
10. Calculate the BTU/H output of a furnace using the sensible heat formula, below, given that you have air movement of 200 CFM, a return air temperature of 70℉, and a supply air temperature of 115℉.. (3 pt) 

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. You should not ‘\_\_\_\_\_’ the primary control more than a few times due to the possibility of unburned oil accumulating in the burner chamber. (3 pt)
   1. use
   2. activate
   3. reset
   4. shut off
2. What is the volume of air needed for the practical combustion of 1 gallon of #2 heating oil? (3 pt)
   1. 1050 ft3
   2. 2060 ft3
   3. 3070 ft3
   4. 4080 ft3
3. What is the typical flash point for #1 Heating Oil as produced in this area? (3 pt)
   1. 100 ℉
   2. 150 ℉
   3. 200 ℉
   4. 400 ℉
4. What fuel pressure is typical at the nozzle for residential service high-pressure oil-atomizing burners? (3 pt)
   1. 50 psi
   2. 100 psi
   3. 150 psi
   4. 200 psi
5. A gun-type oil burner ignition transformer produces ‘\_\_\_\_\_’ volts. (3 pt)
   1. 24
   2. 1,000-1,500
   3. 10,000 -15,000
   4. 100,000-150,000
6. When you expose a cadmium sulfide cell to bright light, its electrical resistance ‘\_\_\_\_\_’. (3 pt)
   1. Increases
   2. Decreases
   3. Stays the same
   4. Varies wildly
7. What is the acceptable range for the breach draft pressure on most gun-type oil burning units? (3 pt)
   1. 0.02-0.04” WC
   2. 0.04-0.06” WC
   3. 0.06-0.08” WC
   4. 0.08-0.10” WC

**RH A105 Electrical Circuits for Refrigeration & Heating**

**Pre-Assessment**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*(49 possible points)*

1. If you need to use a hard-start kit, it would be with a ‘\_\_\_\_\_’ motor. (3 pt)
   1. Resistance start, induction run
   2. Capacitor start, induction run
   3. Permanent Split-Capacitor
   4. Capacitor start, capacitor run
2. A flow switch that uses the movement of a physical device by the monitored fluid to indicate flow will typically be either a ‘\_\_\_\_\_’ switch or a rotating paddle switch. (3 pt)
   1. Transducer
   2. Sail
   3. Balloon
   4. Thermistor
3. Why would you not want a fuse that is too large for the expected amp draw on the circuit? (3 pt)
   1. Nuisance trips
   2. Lack of protection
   3. Cost
   4. Increased CEMF
4. Which two temperature-sensing methods do thermostats primarily utilize? (3 pt)
   1. Bimetal strip
   2. Solid-state / Silicon diode
   3. Thermocouple
   4. RTD
   5. Thermistor
   6. Pressure bulb
5. A step-down transformer would have ‘\_\_\_\_\_’. (3 pt)
   1. Fewer turns on the secondary coil than the primary, providing a higher voltage output.
   2. Fewer turns on the secondary coil than the primary, providing a lower voltage output.
   3. More turns on the secondary coil than the primary, providing a higher voltage output.
   4. More turns on the secondary coil than the primary, providing a lower voltage output.
6. Provide the formulae to calculate the electrical resistance of a load if you have measured both the amperage and voltage of that portion of the circuit. (3 pt)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Match the thermostat color-coding and functions below. (2 pt each)
   1. 24v Power \_\_\_\_\_\_\_ 1. Blue
   2. Cool \_\_\_\_\_\_\_ 2. White
   3. Common \_\_\_\_\_\_\_ 3. Red
   4. Heat \_\_\_\_\_\_\_ 4. Green
   5. Fan \_\_\_\_\_\_\_ 5. Yellow
2. If a high-limit switch on a furnace opens due to the monitored temperature reaching the set point of the limit switch, this typically indicates that ‘\_\_\_\_\_’. (Circle all that apply) (3 pt)
   1. The conditioned area has reached the desired temperature
   2. The filter is clogged
   3. The circulation fan is not working
   4. The combustion inducer fan is not working
3. When using Ohm’s Law, Inductive Reactance can replace ‘\_\_\_\_\_’, if you do not have or are not considering any other impedance in the circuit. (3 pt)
   1. Voltage
   2. Amperage
   3. Resistance
   4. Power
4. You can correct the power factor of a motor by installing a ‘\_\_\_\_\_’ in parallel with the motor. (3 pt)
   1. Inductor
   2. Resistor
   3. Capacitor
   4. Reactance
5. Multi-speed motors use different levels of ‘\_\_\_\_\_’ in series with the run winding to effectively produce changes in speed. (3 pt)
   1. Resistance
   2. Inductance
   3. Capacitance
   4. Reactance
6. Variable Frequency Drives can adjust the RPM of ‘\_\_\_\_\_’ motors, by effectively changing the frequency of the supplied power. (3 pt)
   1. 1-phase
   2. 3-phase
   3. PSC
   4. Synchronous