A Comparison Study Defining the Competencies of the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Program Versus the Needs of Industry

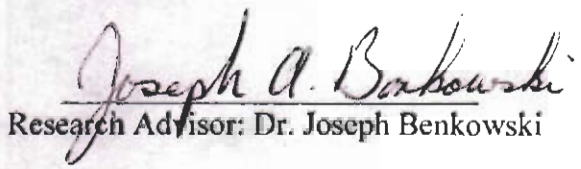
by

Kenneth F. Delcore

A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
in

Training and Development

Approved: 4 Semester Credits



Research Advisor: Dr. Joseph Benkowski

The Graduate School

University of Wisconsin-Stout

March, 2005

The Graduate School

University of Wisconsin Stout

Menomonie, WI 54751

ABSTRACT

Delcore Kenneth F.

(Writer) (Last Name) (First Name) (Middle Initial)

A Comparison Study Defining the Competencies of the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Program Versus the Needs of Industry

(Title)

Training and Development Dr. Joseph Benkowski 04/23/2005 52

(Graduate Program) (Research Advisor) (Month/Year) (# of Pages)

American Psychological Association, 5th edition

(Name of Style Manual Used in this Study)

The purpose of this study is to validate the curriculum of the Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) Program at Northeast Wisconsin Technical College (NWTC). This is achieved by comparing the Northeast Wisconsin Technical College HVACR Program competencies with the competencies listed in the Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA) Technical Program Requirements.

The Northeast Wisconsin Technical College HVACR program seeks accreditation by industry authorities by ensuring the competencies taught by the NWTC HVACR program are in alignment with the nationally recognized standards.

The competencies in the PAHRA technical document and the NWTC HVACR program competency list closely matched the competencies outlined as the standard in the PAHRA Technical Program Requirement document. Congruency was found in 79.6% of the outlined competencies, which included PAHRA competencies that are considered outside of the content focus of the NWTC program. Removing the competencies that are not essential to the NWTC HVACR Technology program focus, 90.5% of the competencies were congruent. Therefore, the competencies established by the NWTC instructional staff exceeded the minimum requirements in several areas, mainly electrical motor control systems, troubleshooting HVACR systems, hydronics, and building automation systems.

ACKNOWLEDGMENTS

Special thanks to my family for supporting me through this process of completing my graduate studies. This could not have been done without my lovely wife, Jane, for allowing me to spend countless hours studying and researching. Jane managed to keep the rest of the kids stimulated while I worked on work and school. Thank you for all you have done.

Dr. Joseph Benkowski, my research advisor, provided essential guidance to narrow the focus of my research and provided timely assistance during the completion of the research project. Thank you for your willingness to respond to questions in a timely manner and provide suggestions. I really appreciate your instructional methods and style.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I: INTRODUCTION

Background of Research

The demand for qualified entry level Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) technicians is better than ever. According to the Air Conditioning & Refrigeration Institute (ARI, 2004), a nationally recognized HVACR industry organization, approximately 20,000 new technicians will be needed each year to meet the needs of the employers. Employers demand qualified technicians to be productive employees with in their organizations. A career as a HVACR technician provides excellent opportunity for growth within the organizations that employ them.

The Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program offers individuals an opportunity to obtain an Associate Degree in a two year timeframe. The program is intended to provide entry level skills allowing graduates to be employed in the HVACR field. The NWTC HVACR Technology program started in 1992 through an initiative by regional contractors within the Northeast Wisconsin Technical College district. Regional contractors desired to have a local HVACR program to provide entry level skills to individuals seeking employment as an HVACR technician. The program had its first graduates beginning in May 1994.

The curriculum provided by the College to the program instructors for instruction in the HVACR Technology program was deemed as inadequate by the program instructors. The original curriculum was not sufficient to train entry level technicians for a successful career as an HVACR technician. Both of the original and current HVACR Technology program instructors felt strongly about the curriculum's inadequacies as both

the instructors had come directly from industry as an HVACR service technician and both instructors were products of two year technical college HVACR programs.

The curriculum used to instruct the HVACR students was developed by the HVACR instructors during the semester. Changes to the curriculum evolved throughout the past 12 years of the program as changes to competencies were deemed necessary. Input to make changes to the instructional curriculum has been primarily based on instructors' experience, input from the program's advisory board, current and past student feedback, and information obtained during the program's two program evaluations. The curriculum was not developed or improved through the use of the DACUM process.

The NWTC HVACR Technology program instructors care deeply for the development of individuals seeking training and hope that all students set completion of the two year program as a personal goal. Students are encouraged to take the core program courses as well as the general education support courses during the two year time period. Some students elect to take the core courses during the program, but do not always take the general education courses outlined in the program track. Students not fulfilling the program requirements do not graduate, but are allowed to complete the general education courses at a later time period. Upon completion of all the program requirements, students may then graduate. Students not completing all of the courses outlined as requirements in the NWTC HVACR program do not receive any certificate or degree.

Graduates of the HVACR Technology program will have the potential for employment as a mechanical contractor HVACR technician, facilities Maintenance HVACR technician, HVACR equipment manufacturer technician, or HVACR wholesaler

servicing a combination of commercial, industrial, and residential HVACR systems. Based on post graduate data from NWTC, a majority of the graduates either work as a service technician or installation technician for a mechanical contractor. Most graduates employed by such mechanical contractors work performing service on residential, light commercial and commercial HVACR systems (NWTC, 2004).

Required Credentialing

Currently in the State of Wisconsin Commerce Department (2004), the HVACR industry does not have a licensing requirement for a technician to work on HVACR equipment. The only licensing requirement is actually an HVACR credential which is provided upon successfully completing the Environmental Protection Agency (EPA), section 608 refrigeration handling exam. The EPA section 608 refrigerant certification exam is merely an exam to ensure technicians know the laws when handling refrigerants. The EPA section 608 refrigerant certification exam does not ensure the competency of a technician and an understanding of the operation of the equipment.

Accreditation Initiative

Without a State of Wisconsin standard statewide curriculum alignment initiative, each educational institution offering instruction to HVACR students is allowed to develop the competencies for the HVACR programs. It is up to each institution to provide the best curriculum that will be in alignment with the goals and objectives of their respective HVACR program.

The NWTC HVACR Technology program is interested in the benefits of accreditation by a nationally recognized industry organization. Accreditation affords many benefits. Accreditation is to enhance a school's curriculum, image, funding, and

faculty. Accreditation provides a mechanism for continuous quality improvement and provides students, industry personnel, and other stakeholders an objective third party assurance of a sound curriculum (Hazeldine & Munilla, 2004).

One such nationally recognized industry organization offering accreditation is the Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA). PAHRA is the only program recognized by all the major HVACR associations and approximately 200 equipment manufacturers (PAHRA, n.d.). PAHRA's affiliation with Air Conditioning & Refrigeration Institute (ARI), North American Technician Excellence (NATE), as well as a numerous other leading industry organizations, makes accreditation with PAHRA essential to maintaining the high quality standards in the NWTC HVACR Technology program.

Statement of the Problem

The Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program does not have an industry affiliated accreditation. The HVACR Technology program would like to determine if the competencies taught are in alignment with the national standards set by the industry. Does the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program successfully prepare students for employment in the region?

Purpose of the Study

The purpose of the study is to validate the curriculum in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program and to see if it satisfies the needs of the HVACR industry. The researcher, for the method of comparison, will use the list of competencies outlined in the PAHRA Technical Program Requirements and compare them to the competencies that make up the HVACR Technology curriculum at Northeast Wisconsin Technical College.

Impact of the Study

1. The Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program will benefit from the evaluation process of this study.
2. NWTC HVACR Technology program students will be better prepared for successful employment in the HVACR industry.
3. Program competencies will be validated through this program
4. Employers of HVACR graduates will be assured that students have met minimum competency levels required for graduation and certification, as determined by the HVACR industry associations.
5. National recognition by an industry association will lead to a greater number of enrolled students entering the NWTC HVACR Technology program.
6. Improvement, using the process of the accreditation evaluation, will lead to future program curriculum improvements that will benefit the college, the program, and the students.

Research Objectives

1. Identify the competencies currently taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program that prepare entry-level HVACR Technicians for employment.
2. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find congruency.
3. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find where they are not congruent.

Assumptions of the Study

1. It is assumed that the competencies developed by PAHRA and HVACR industry experts are valid and reasonable expectations for entry level HVACR technicians.
2. It is assumed that all the competencies developed by PAHRA and HVACR industry experts is the industry standard for entry-level HVACR programs.
3. It is assumed that all the competencies developed by PAHRA and HVACR industry experts are available in the HVACR Technician Training Program Accreditation self-study document.
4. It is assumed that the competencies taught at the Northeast Wisconsin Technical College HVACR Technology program are listed in the curriculum.
5. It is assumed that the Northeast Wisconsin Technical College HVACR Technology program graduate follow-up information is accurate and valid.

6. It is assumed that the researcher has the support of Northeast Wisconsin Technical College during this research project.

Definition of Terms

1. Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) Technology program – an educational program that prepares students to develop the knowledge, skills, and understanding required for employment in this field as entry level technician.
2. Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA) – an industry organization supporting an HVACR Technician Training Program accreditation process. The program is developed, supported and implemented by all segments of the HVACR industry as well as many HVACR educators, administrators and vocational technical education state supervisors to improve the quality of training offered at all levels of education by meeting or exceeding established industry standards in the heating, ventilation, air conditioning and refrigeration industry. (PAHRA, 2002)
3. Accreditation – a process to ensure a level of educational quality by establishing and maintaining high educational standards (PAHRA, 2002).
4. Air Conditioning & Refrigeration Institute (ARI) – a national trade association representing manufacturers of more than 90 percent of North American produced central air-conditioning and commercial refrigeration equipment. (ARI, 2004)
5. Entry-level residential air-conditioning and heating technician – one who performs start-up and preventive maintenance, service and repair, and/or installation of residential heating and air-conditioning equipment. (ARI, 2004)

6. Residential equipment - considered to have the capacity of five ton systems or smaller. (ARI, 2004)
7. Entry-level light commercial air-conditioning and heating technician – one who performs start-up preventive maintenance, service and repair, and/or installation of light commercial heating and air-conditioning systems. (ARI, 2004)
8. Light commercial equipment - considered to have the capacity of six to twenty ton systems. (ARI, 2004)
9. Entry-level commercial refrigeration technician – one who performs installation and start-up, preventive maintenance, and/or service and repair. The technician understands system design principles. He/she can do installation, start-up and preventive maintenance with relatively minor supervision, if any. Entry-level technician is supervised when servicing equipment. (ARI, 2004)
10. Competencies – major skills, knowledge, attitudes or abilities needed to perform a task effectively and efficiently. (WIDS)

Limitations of the Study

1. This study is limited to HVACR technicians at an entry-level.
2. These results are limited to the curriculum of Northeast Wisconsin Technical College HVACR Technology program and the PAHRA Technical Program Requirements.
3. This study is limited to the documented HVACR Technology curriculum at Northeast Wisconsin Technical College.

CHAPTER II: LITERATURE REVIEW

Introduction

The literature related to competencies for Heating, Ventilation, Air Conditioning and Refrigeration (HVACR) training programs varies significantly between programs. Without an industry governing body to advise training programs on the technical competencies, the depth and intensity of instruction between training programs can significantly compromise the training of new technicians. One way to have documented validation of an HVACR training program is to seek accreditation by an independent industry sponsored accrediting body. One such industry sponsored accrediting body is The Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA). The literature review identifies why industry sponsored accreditation is important, steps to achieve accreditation, education requirements for instructors, institutional requirements, curriculum development, and responsibilities of HVACR Technicians.

Accreditation

Educational institutions look for ways to enhance their educational programs to attract more students. In order to insure the qualities of a sound educational program, educational institutions seek validation by accreditation. "Accreditation is a method of certifying that a school, college, or program meets or exceeds all established standards and requirements of academic excellence in curriculum, student facilities, placement services, financial aid, training facilities, equipment, safety and faculty credential" (HVAC Excellence).

Two types of accreditation are institutional accreditation and programmatic accreditation. Currently Northeast Wisconsin Technical College has institutional

accreditation through the North Central Association (NCA). As part of the accreditation process, NWTC must adhere to a model of continuous improvement. The institution, NWTC, benefits from the accreditation by focusing on quality improvement that ultimately leads to increased student performance (North Central Association, 2004). The other type of accreditation is programmatic accreditation, which normally applies to specialized programs within an institution. Programmatic accreditation is usually available to accredited institutions.

The Importance of Accreditation

For individuals seeking credentials within an industry, a certification process may establish credibility to individuals within the industry. Training programs teaching specialized skills to individuals have programmatic accreditation to look to for credentialing.

The Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA) was formed to provide programmatic accreditation to educational institutions. PAHRA was developed to set standards for HVACR training programs. The purpose of the HVACR Technician Training Program Accreditation is to improve the quality of training offered at all levels by meeting or exceeding established industry standards in the Heating, Ventilation, Air Conditioning and Refrigeration (HVACR) Industry. Through this program, employers of HVACR graduates will be assured that students have met minimum competency levels required for graduation and certification, as determined by the HVACR industry associations (Siegel, 2000). As a component of the accreditation process, the researcher will provide a comparative analysis of the industry validated standards to the Northeast Wisconsin Technical College HVACR Technology program.

Steps to Achieve Accreditation

According to the accreditation guidelines set forth by PAHRA, the steps needed for accreditation are (Siegel, 2000):

1. Request a review copy of the PAHRA document which explains many of the processes involved in programmatic accreditation by which the HVACR training program evaluates their strengths and weaknesses as compared to industry standards.
2. Training program decides to proceed with the PAHRA process and requests an application. Note: Programs will have a maximum of 18 months to complete the accreditation process from the time their program's request for application is received by the PAHRA office. A program can seek PAHRA accreditation in 1, 2 or all 3 of the following categories:
3. Residential A/C and Heating;
4. Light Commercial A/C and Heating; and/or
5. Commercial Refrigeration
6. PAHRA documentation material is sent to the school so that the program can begin its self-evaluation.
7. Program submits its findings in a self-study report.
8. PAHRA office reviews the self-study for completeness and adherence to the standards. PAHRA Executive Director coordinates the scheduling of a Site Evaluation Team Leader (SETL) to evaluate the program during a two-day on-site visit.
9. PAHRA Accreditation Committee will review the report of the SETL and the documentation materials.

10. PAHRA Accreditation Committee will decide accreditation, accreditation with a report, or non-accreditation.

Instructor Requirements for Accreditation

Requirements of the HVACR Technology program instructors needed for PAHRA accreditation as listed in the HVACR Technician Training Program Accreditation document (2002) are as follows:

1. All staff must meet the state and local requirements for educational license and/or certification if necessary for the institution.
2. All HVACR instructional staff must have provable technical qualifications.
3. All staff must currently hold the EPA Refrigerant Handling Certification under Section 608 of the Clean Air Law
4. Basic Entry Level Competency as shown by passing the Industry Competency Exam (ICE) with a minimum grade of 80% in the area of program accreditation being taught as listed below:

   Residential Heating and Air Conditioning

   Light Commercial Heating and Air Conditioning

   Commercial Refrigeration

   Instructors holding a current ICE, NATE, or CM/CMS certification are exempt from this requirement.
5. Service Sector Technician Certification

   ACE Service Technician Certification Test administered by NATE
6. All Staff must have five (5) years of documented HVACR industry field experience.

7. Full time instructional staff shall maintain their technical competency in the HVACR industry
8. Continuing education should be available as required by the institution according to the law regulating educational standards applicable to the location. Not withstanding local law, a minimum total of one hundred (100) hours of continuing education will be completed within a five- (5) year period.

Institutional Requirements

Institutional requirements needed for PAHRA accreditation as listed in the HVACR Technician Training Program Accreditation document (2002) are as follows:

1. The administration provides proactive support by providing necessary capitol to maintain the facilities and educational resources.
2. The HVACR program is easily identified within the school organization
3. The administration issues degrees upon successful program completion.
4. The administration has written operational policies providing guidelines and guidance for decisions affecting the organization and the students.
5. An advisory committee of HVACR Industry representative is appointed that will meet a minimum of two times a year.
6. The administration provides a means to keep the local community informed of the HVACR program.
7. The administration has policies controlling projects other than lab requirements.

Curriculum Development

The Northeast Wisconsin Technical College HVACR Technology program curriculum development was not developed with the use of a DACUM. Curriculum

development for the HVACR Technology program has been primarily developed by the program instructors, in cooperation with the curriculum designers at Northeast Wisconsin Technical College (NWTC) using the Wisconsin Instructional Design System (WIDS). The program instructors have a significant amount of experience as field service technicians, which allow them the knowledge base to develop program competencies. The WIDS software is a software program that allows user to develop a curriculum, meeting all the requirements for the college. All curriculum at NWTC must meet the WIDS standards. Despite the lack of a DACUM process used for development of curriculum, the NWTC HVACR Technology program is recognized by industry peers during the NWTC evaluation process as teaching to the student and industry needs (Northeast Wisconsin Technical College Evaluation Team, 2003). The curriculum design standards are documented in the WIDS manual.

Skills required of HVACR Technicians

The areas of expertise and skill levels required to be an HVACR technician vary depending on the job level for the technician. If an HVACR technician works as an installer, that individual will need a different set of skills compared to a person working as a service technician. An individual working as a service technician for a contractor that primarily works on commercial and light commercial equipment will need different skills compared to an individual working on residential equipment despite both being a service technician. It is the goal of the HVACR Technology program to provide a basic set of skills for an entry level technician. Depending on the job placement of the student, additional training on the specific types of equipment and continuing education will be needed. "The goal of every HVAC technician is to install, service, and troubleshoot

stationary equipment according to manufacturer specifications the first time out is not just a dream – it can be a reality." To achieve this goal, organizations such as The Air Conditioning and Refrigeration Institute have made it a goal to work with education institutions, teaching HVACR, to implement curriculum and evaluation assistance towards continuous quality improvement (Sandler, 2002).

Documented in the Heating, Ventilation, Air Conditioning, and Refrigeration Technology Evaluation (2003), the evaluation team sited a trend in the industry towards more specific product training due to the specialization of equipment. The evaluation team also noted increasing changes in the industry towards electronic digital equipment. New technicians need to be prepared to learn the new technologies and be capable of keeping up with industry changes.

CHAPTER III: METHODOLOGY

Study Introduction

The Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program does not have an industry affiliated accreditation. The researcher will validate if the competencies of the HVACR Technology program at Northeast Wisconsin Technical College are in alignment with the national standards set by the industry. The study will determine if the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program successfully prepare students for employment in the region? The researcher will compare the competencies of the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program and the industry standard competencies developed by an industry development committee for The Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA).

Research Objectives

1. Identify the competencies currently taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program that prepare entry-level HVACR Technicians for employment.
2. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find congruency.
3. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with

the list of competencies outlined in the PAHRA Technical Program Requirements to find where they are not congruent.

Instrumentation

Industry training standards developed by industry professionals for The Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA) will be used in this comparative study along with the documented competencies of the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program. The document containing the competencies was developed by a development committee of ten industry professionals and was reviewed and validated by over five hundred individuals in a collaborative effort.

Data Collection

Historical research is used to identify the nominal data for this comparative study. The competency list from The Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA) and the competency list from the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program are compared to identify congruency. The competency differences identified are acknowledged and studied to determine the educational value of the competencies for the HVACR students at Northeast Wisconsin Technical College.

Data Analysis

The nominal data listing the competencies from PAHRA and the NWTC HVACR Technology program will be identified and analyzed using a table determining congruency and non congruency. The tabulation of the data determines the percentage of

the congruent competencies and the percentage of non congruency competencies. The industry standard established benchmark competency quantity is used as the baseline quantity for comparison.

Limitations

This study is limited to HVACR technicians at an entry-level. The results are limited to the curriculum of Northeast Wisconsin Technical College HVACR Technology program and the PAHRA Technical Program Requirements. This study is limited to the documented HVACR Technology curriculum at Northeast Wisconsin Technical College. Any non documented changes to the HVACR Technology curriculum at Northeast Wisconsin Technical College were not included in this study.

Summary

The comparative study will provide valuable information identifying the established competencies of the industry standard and the competencies of the HVACR Technology curriculum at Northeast Wisconsin Technical College. The comparative study will provide a benchmark evaluation of the HVACR Technology program at NWTC. The evaluation process will lead to continuous improvement processes for the NWTC HVACR Technology program through the evaluation phases during accreditation. This study identifies program strengths and weaknesses of the HVACR Technology program at Northeast Wisconsin Technical College.

CHAPTER IV: RESULTS

Purpose of the Study

The purpose of the study is to validate the curriculum in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program and to see if it satisfies the needs of the HVACR industry. The researcher, for the method of comparison, will use the list of competencies outlined in the PAHRA Technical Program Requirements and compare them to the competencies that make up the HVACR Technology curriculum at Northeast Wisconsin Technical College.

Statement of the Problem

The Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program does not have an industry affiliated accreditation. The HVACR Technology program would like to determine if the competencies taught are in alignment with the national standards set by the industry. Does the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program successfully prepare students for employment in the region?

Data Analysis

Each competency was compared on an individual basis. This chapter compares the competency list of the Heating, Ventilation, Air Conditioning, and Refrigeration Technology program at Northeast Wisconsin Technical College with the list of competencies outlined in the PAHRA Technical Program. The results are formulated in consideration of the three research objectives. The research objectives addressed are the following:

1. Identify the competencies currently taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program that prepare entry-level HVACR Technicians for employment.
2. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find congruency.
3. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find where they are not congruent.

Item Analysis: NWTC HVACR Competencies

The first research objective is to identify the competencies currently taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program that prepare entry-level HVACR Technicians for employment. The competencies are listed in Table 1 in Appendix A. Table 1 identifies the instructional content down to three general categories, major content topics, content subtopics, and NWTC HVACR program competencies. The list of competencies was developed by the program instructors. Changes to the curriculum evolved throughout the past 12 years of the program as changes to competencies were deemed necessary. Input to make changes to the instructional curriculum has been primarily based on instructors' experience, input from the program's advisory board, current and past student feedback,

and information obtained during the program's two program evaluations. The curriculum was not developed or improved through the use of the DACUM process.

Item Analysis: Congruent Competencies

The second research objective is to compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find congruency. Table 2 in Appendix B identifies all competencies outlined between the PAHRA and the NWTC curriculum. For easier comparison, the table identifies all standard congruent competencies in normal black text and non-congruent competencies in boldfaced, red colored text.

Table 2 identifies 15 major elements of instruction. From the 15 major content instructional areas, 62 content subtopics are split into specific instructional competency elements. Of the listed 315 competencies, 250 competencies were congruent. The 250 congruent competencies represent 79.4% of the total competencies listed in the PAHRA Technical Program Requirements.

Item Analysis: Non-congruent Competencies

The third and final research objective is to compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find where they are not congruent.

Table 3 lists 15 major content topics of instruction. From the 15 major content instructional areas, 62 content subtopics are split into specific instructional competency elements. A total of 315 competencies were listed in the PAHRA technical program

requirements. A total 280 competencies were listed as competencies currently taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program. The third and forth columns from the left list the competencies found not congruent.

The result of the comparison process left 92 competencies that were not congruent between the two competency lists. The total competencies found not congruent compared to the standards set forth by PAHRA, represents 20.6% of the 315 total listed competencies. A total of 65 competencies listed in 19 specific content areas within The Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA) document were found not congruent. Within the 19 specific content areas found non-congruent, only three content areas are not currently taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program. A total of 27 competencies listed in 16 specific content areas within the current curriculum being taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program were found not congruent. The competencies currently being taught in excess of the basic standards set forth by PAHRA, account for 8.6% of the 315 total listed competencies.

The three content areas not currently taught are specifically heating and cooling loads, absorption refrigeration, and multiplexed evaporator systems. Heating and cooling loads were being taught, but were not seen as a value to entry level students within the first few years upon entering the workforce and subsequently were removed from the program competency list. Absorption refrigeration and multiplexed evaporator systems are not currently taught and by many local industry professionals would be considered

beyond the requirements of entry level personnel. Since a majority of the students have a difficult time developing a thorough understanding of single evaporator systems, it is unlikely that multiplexed evaporator systems will be incorporated into the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program.

In addition to the three content areas not being currently taught, areas that need additional consideration for adoption into the current NWTC curriculum are in the instructional areas of safety, piping and piping practices, electricity, solid state electronics, air conditioning systems, heat pump systems, and indoor air quality. In the instructional area of safety, a noticeable area of improvement is in OSHA training and the use of MSDS sheets. In the instructional area of piping and piping practices, a noticeable area of improvement is in the content area of refrigerant line sizing. In the instructional area of electricity, a noticeable deficiency is in using the National Electric Code (NEC) book for determining wire sizes. Due to local codes, this is handled by licensed electricians and is not something that Heating, Ventilation, Air Conditioning, and Refrigeration Technology program graduates are required to perform. Other areas within the electricity content areas are electronically controlled motors, and heat pump control systems. Heat pump systems have not been an area of significance in the past due to climate considerations within the local region. Heat pump systems are not a widely accepted method of providing heating or cooling in the local region due to there inefficiencies in the cool northern climate. In the instructional area of solid state electronics, it is rare that a heating and air conditioning technician would ever need to service or install the listed non-congruent items as technicians do not perform repair to

integrated circuit boards. In the instructional area of air conditioning systems, desiccant cooling and dehumidification systems were found not congruent. Desiccant cooling and dehumidification systems are not currently being used in this region due to climate issues. In the content area of indoor air quality, few deficiencies were found, with exception to the use of the ASHRAE standard 62. The use of the ASHRAE standard 62 is an area that will need to be addressed in future curriculum modifications. Table 3 items not congruent are bold faced and colored in **RED**. Congruent items are not listed.

Table 3: PAHRA competencies found not congruent with NWTC

Items not congruent are bold faced and colored in **RED**. Congruent items are not listed.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**Current NWTC Competencies**
Principles of Thermo-dynamics	Measurement Systems	**Converting Tons cooling to KW**	
Safety	Personal safety and workplace practices	**OSHA standards** **Effects of substance abuse** **Safe driving practices** **Proper use of scaffolding, and hearing protection**	
	Handling hazardous materials	**Use of MSDS sheets** **Hazardous material manifest**	
Tools and equipment	Electrical testing equipment		**Watt meters**
	Air conditioning and Refrigeration: servicing and testing equipment		**Sling Psychrometers**
	Airflow: Measurement and testing equipment		**Flow hoods** **Multipoint sensors** **Variable air volume systems**
Piping and piping practices	Piping material and fabrication	**Soldering aluminum tubing**	

Items not congruent are bold faced and colored in RED. Congruent items are not listed.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**Current NWTC Competencies**
	Pipe sizing and troubleshooting	**Refrigerant line capacities and sizing** **Equivalent lengths of fittings for refrigerant lines** **Use of refrigerant traps** **Using manufacturer's refrigerant pipe sizing charts**	**Equivalent lengths of fittings for gas piping and hydronic systems** **Calculating pipe sizes for hydronic systems**
Electricity	Basic Electricity		**Development of ladder diagrams from pictorials**
	Electrical generation and distribution	**Delta and wye distribution systems** **Use NEC code to determine wire and conduit sizes** **Determine voltage drops for electrical circuits** **Determine load center power capacities**	**Diagramming of load centers and typical distribution panels**
	Electric motors	**Electronically controlled-motors (ECM)**	**Hard-start kits** **Manual motor starters**
	Electrical circuits and controls	**Size electric motor circuits, and *over-current protection* using the NEC code book**	**Size electric motor circuit *over-current protection* using manufacturer tables**
Controls	Heat pump controls	**Defrost controls** **Geothermal system controls** **Emergency heat controls** **Auxiliary heat controls** **Heat pump thermostats**	
	Direct digital controls (DDC)		**Programming DDC controllers**
	Energy management computer control systems		**Creating database backups** **Graphic monitoring**
Solid state electronics	Solid state components	**Amplifiers** **Bilateral switches** **Diodes** **Photoelectric cells** **Semiconductors** **Transistors**	

Items not congruent are bold faced and colored in RED. Congruent items are not listed.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**Current NWTC Competencies**
Load calculations	Heating and cooling loads	**Interpret structure design data** **Interpret building prints** **Total resistance to flow** **Conduction loads** **Infiltration** **Ventilation load** **Duct loads** **Equipment load** **Lighting load** **Calculate total load**	
Refrigerant system components	Metering devices	**low side float** **high side float** **Electronic expansion valves,** **Solid state expansion valves** **Sizing of metering devices**	**Installation of thermal expansion metering devices**
	Condensers	**Cooling tower range and approach calculations** **Size cooling towers**	
Air conditioning systems	Absorption refrigeration	**Explain operation of absorption systems** **Verify operation of all external absorption components**	
	Desiccant cooling and dehumidification	**Methods of desiccant dehumidification** **Desiccant wheels** **Troubleshooting desiccant systems** **Maintenance of desiccant dehumidification systems**	
Heat pump systems	Basic principles of operation, components, and applications	**Water source systems** **Geothermal systems** **Electrical and mechanical system components** **Efficiency rating factors** **Balance points** **Defrost methods** **Perform startup procedures** **Heat pump thermostats** **Dual fuel system integration**	

Items not congruent are bold faced and colored in RED. Congruent items are not listed.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**Current NWTC Competencies**
Heating systems	Forced air systems		**Troubleshoot gas heat systems** **Check heat exchangers** **Troubleshoot ignition systems**
	Hydronic systems		**Design a hydronic system** **Install a hydronic system**
	Oil furnaces		**Combustion chambers** **Refractory servicing** **Troubleshooting oil systems**
Commercial Refrigeration systems	Single compressor systems		**Troubleshooting single compressor systems**
	Multiplexed evaporator systems	**Operation and application of multiplexed evaporator systems** **Service multiple evaporator systems**	
Air handling systems	Mechanical and electronic filtration	**Testing power packs**	
Indoor air quality (IAQ)	Requirement and maintenance of air quality	**ASHRAE standard 62** **Sick building syndrome** **Building related illness**	
	Heat recovery systems		**Energy recovery ventilators** **Heat recovery systems**

CHAPTER V: CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of the study was to validate the curriculum in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program to see if it satisfies the needs of the HVACR industry. For the method of comparison, the researcher used the list of competencies outlined in the PAHRA Technical Program Requirements and compared them to the competencies that make up the HVACR Technology curriculum at Northeast Wisconsin Technical College. This study is intended to provide the initial comparison data that will eventually lead to program accreditation by an industry organization. The researcher identified three specific objectives throughout the research that are as follows:

1. Identify the competencies currently taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program that prepare entry-level HVACR Technicians for employment.
2. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find congruency.
3. Compare the competencies taught in the Northeast Wisconsin Technical College Heating, Ventilation, Air Conditioning, and Refrigeration Technology program with the list of competencies outlined in the PAHRA Technical Program Requirements to find where they are not congruent.

The objectives were met by documenting standard competencies from the PAHRA Technical Program Requirement document and comparing the competencies to a list from the Northeast Wisconsin Technical College HVACR Technology curriculum. The comparison process involved matching the tasks and learning objectives from both curriculums that were identical in meaning. Through a process of elimination, the items that were congruent and not congruent were identified. Additional competencies currently being taught at NWTC that exceed minimum expectations were also identified. The results of the comparison were evaluated and recommendations for possible curriculum and equipment modifications and/or additions were made for the benefit to the Northeast Wisconsin Technical College HVACR Technology program. The results will be shared with the HVACR Technology program advisory board at a future date.

Limitations

This study is limited to HVACR technicians at an entry-level. The results are limited to the curriculum of Northeast Wisconsin Technical College HVACR Technology program and the PAHRA Technical Program Requirements. This study is limited to the documented HVACR Technology curriculum at Northeast Wisconsin Technical College. Any non documented changes to the HVACR Technology curriculum at Northeast Wisconsin Technical College were not included in this study.

Conclusions

The study, along with the literature review, identified the importance of industry accreditation and validation of curriculum. Industry accreditation is an essential component in the improvement process of a quality training technical program. Through the accreditation process, employers of HVACR graduates will be assured that students

have met minimum competency levels required for graduation and certification, as determined by the HVACR industry associations.

The list of competencies currently being taught at NWTC, as defined by research objective number one, closely matches the competencies outlined as the standard in the PAHRA Technical Program Requirement document. Analysis of the products as a result of research objective two, congruency was found in 79.6% of the outlined competencies, which included PAHRA competencies that are considered outside of the content focus of the program. Removing the competencies that are not essential to the Northeast Wisconsin Technical College HVACR Technology program focus, the total of non congruent competencies is only 30 out of the 315 listed competencies. With the removed non-essential competencies, 90.5% of the competencies were congruent. The competencies established by the NWTC instructional staff exceeds the minimum requirements in several areas, mainly electrical motor control systems, troubleshooting HVACR systems, hydronics, and building automation systems.

The results of the research yields reasonable belief that improvements can be made in the HVACR program to benefit the students, instructional staff, and the Northeast Wisconsin Technical College. With the results of the deficient instructional curriculum areas, additional funding for equipment to meet the needs of industry will be possible. The support of the advisory board and college administration will be required for program modifications.

The researcher believes the competencies currently being taught in the Northeast Wisconsin Technical College HVACR Technology program are valid and useful on a national level. With the improvements in equipment and curriculum as a result of this

process, students will be assured that the highest level of training is being delivered based on the current instructional content.

Recommendations

It is recommended that the Northeast Wisconsin Technical College use the results of this study to provide a standard for curriculum improvement. The researcher recommends the college use the PAHRA standard as a guide in ensuring the needs of the industry are being met and that graduates are assured of a curriculum that does meet national standards.

Recommendations for future research

1. The researcher recommends further research to identify the competencies that the NWTC students are taking to the workplace.
2. The researcher recommends a study to determine if a statewide curriculum for HVACR technicians would be accepted by the Wisconsin Technical College System.
3. The researcher recommends research on the viability of a tiered training level system for HVACR technicians. Thus yielding a degree for residential, light commercial, and commercial technicians within a single technician training program.
4. The researcher recommends research on the viability of creating a technician licensing system in the State of Wisconsin making it mandatory for all technicians to maintain a license on a term basis.
5. The researcher recommends research to identify advanced placement classes for continued improvement of current HVACR technicians.

References

Air Conditioning & Refrigeration Institute (ARI). (2004). Retrieved November 19, 2004, from http://www.ari.org

Air Conditioning & Refrigeration Institute. (1995). *ARI Curriculum Guide*, (2nd ed.) Arlington, VA: ARI

Hazeldine, M. F., & Munilla, L. (2004). The 2003 AACSB accreditation standards and implications for business faculty: A short note. *Journal of Education for Business, 80*(1), 29-34.

HVAC Excellence. (n.d.). Retrieved November 23, 2004, from http://www.hvacexcellence.org/Accreditation.htm

Northeast Wisconsin Technical College Evaluation Team. (2003). *Heating, Ventilation, Air Conditioning, and Refrigeration Technology Evaluation.*

Northeast Wisconsin Technical College. (2004). *Graduate report* (Graduate statistical report No. NWSR178). Green Bay, WI: Northeast Wisconsin Technical College. (Graduate Report - HVACR) November 23, 2004, from the GAD-RP database.

North Central Association. (2004). Retrieved November 23, 2004, from http://www.ncacasi.org

Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA). (2002). *HVACR technician training program accreditation.* Arlington, VA: PAHRA.

Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA). (n.d.). Retrieved November 18, 2004, from http://www.pahrahvacr.org

Sandler, L. (2002). Hand in hand: Competency and recruitment. *Techniques: Connecting Education & Careers, 77*(3), 18.

Siegel, J. J. (2000). The Importance of Accreditation. *Air Conditioning Heating & Refrigeration News, 211*(10), 10-12. Retrieved November 23, 2004, from Ebsco Host database.

Wisconsin Instructional Design System (WIDS) (Version 7.0) [Computer software]. (November 19, 2004). Wisconsin Technical System Foundation, Inc.

Wisconsin Department of Commerce. (2004). *Licenses and Permits*. Retrieved November 18th, 2004, from http://www.commerce.state.wi.us

Appendix A: Table 1: Northeast Wisconsin Technical College Competency List

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
Principles of Thermodynamics	Matter and heat behavior	Heat flow and transfer properties Measurement of heat and temperature Enthalpy British thermal unit calculations
	Fluids and pressure	Effects of pressure on boiling points Gauge pressures Absolute pressures Pressure measurement
	Refrigeration Cycle/Diagrams	Components of vapor compression systems Refrigerant conditions Temperature/pressure diagram
	Measurement Systems	Converting from IP to metric Heat, Power, Velocity, Mass Energy conversions
Safety	Personal safety and workplace practices	Clothing and equipment safety Proper use of ladders, hardhat, safety glasses, goggles, and footwear Proper housekeeping Fire extinguisher use Site evaluation
	Handling of pressurized fluids	Safety requirements Relief devices Storage and handling of refrigerant cylinders Effect of temperature on hydraulic expansion Storage of acetylene, oxygen, and nitrogen cylinders Mixing oil and oxygen MSDS sheets Cylinder capability and retesting requirements
	Handling hazardous materials	Hazardous materials, substances, and wastes
	Electrical safety	Ground fault circuit interrupters Environmental safety practices Proper testing procedures for live equipment
Tools and equipment	Hand tools and accessories	Basic hand tools Power tools Fasteners Pipe and tubing tools Lubrication methods
	Electrical testing	Digital meters

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
	equipment	Analog meters Clamp-on ammeters Megohmmeters Capacitance meters Continuity testers Watt meters
	Air conditioning and Refrigeration: servicing and testing equipment	Gauge manifolds Vacuum pumps Micron gauges Temperature meters Charging cylinders Electronic charging scales Electronic leak detection Halide torch Sling Psychrometers
	Heating: servicing and testing equipment	Draft measurement Efficiency test equipment Smoke tests Pressure and vacuum gauges Sling Psychrometers Gas pressure measurement Vent sizing Check thermostat operation Tachometer usage
	Airflow: Measurement and testing equipment	Pitot tube usage Flow hoods Multipoint sensors Variable air volume systems Calculate air velocity Calculate air volume Measure pressure drop using magnehelic gauge Duct calculators
Piping and piping practices	Piping material and fabrication	Types of pipe used for refrigeration work Fitting types Insulating pipe and tubing Soldering and brazing alloys Heat sink methods Vibration eliminators Torch usage Flaring Swaging Bending copper tubing Threading and cutting steel pipe

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
	Pipe sizing and troubleshooting	Effects of improper refrigerant velocities Equivalent lengths of fittings for gas piping and hydronic systems Calculating gas pipe sizes Calculating pipe sizes for hydronic systems
	Sheet metal	Bending tools Cutting tools Types of ductwork and fittings
Electricity	Basic Electricity	Watts, ohms, volts, amps Single and 3 phase power Electrical loads: capacitive, inductive, and resistive Magnetism Conductors and insulators Ohms law calculations Electrical measurement Series, parallel, and series/parallel circuits Circuit analysis of loads Development of ladder diagrams from pictorials
	Electrical generation and distribution	Generators Distribution Diagramming of load centers and typical distribution panels
	Electrical components	Aquastats, capacitors, contactors, relays, timers, damper actuators, oil pressure safety controls, thermostats, water valves, zone valves, crankcase heaters, positive temperature coefficient(PTC) thermistors
	Electric motors	Motor theory CSIR, CSCR, Modulating, Multi-speed, PSC, shaded pole, split phase, and 3-phase motors Hard-start kits Manual motor starters
	Electrical circuits and controls	Circuit diagramming Circuit wiring Meter usage in testing of circuits Diagram symbols Size electric motor circuit over-current protection using manufacturer tables
	Gas controls	Gas valve types

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
Controls		Gas regulators Pilot burners Ignition controls Fan control methods for heating systems Gas furnace sequence of operation Gas furnace component identification Adjustments to gas controls
	Fuel oil controls	Test ignition controls Oil delay valves
	Residential control systems: heating and cooling	Residential heating and cooling thermostats Heating and cooling controls Anticipator circuits Accessory wiring
	Commercial control systems	Electromechanical, pneumatic, electronic, programmable, and building management control systems Identify sequence of operation for control systems
	Heat pump controls	Reversing valves
	Direct digital controls (DDC)	Wiring methods Input and output devices Peripheral devices Central processing units Remote communication Alarming systems System sequence of operation Programming DDC controllers
	Energy management computer control systems	Applications Utility rebate programs Wiring methods Peripheral devices Remote communications Monitoring and alarming Energy accounting Programming host systems and downloading programs Creating database backups Graphic monitoring
Solid state electronics	Solid state components	Shielded wiring Triacs Thermistors
Load calculations	Refrigeration loads	U, K, C, and R factors Heat transfer tables Heat load sources Vapor barriers

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
		Interpret specific heat, latent heat, and heat of respiration values
	Psychrometrics	Identify elements of the psychrometric chart Apply the elements of the psychrometric chart Calculate sensible heat ratios, sensible and latent capacities, enthalpy, mixed air properties
Refrigerant system components	Metering devices	Cap tubes, thermal expansion valves, automatic expansion valves, hand expansion valve, and restrictor orifices Installation of thermal expansion metering devices Installation of cap tubes Adjust thermal metering devices
	Evaporators	Types of evaporators Evaporator temperature difference Determine evaporator performance under various loads and refrigerant charges Size and select evaporators
	Compressors	Types of compressors: hermetic, semi-hermetic, and open drive Methods of compression Compressor capacity control Select replacement compressors based on selected components
	Condensers	Types of condensers: air cooled, water cooled, evaporative cooled Determine proper air and water flow Maintenance of condensers Heat reclaim Select and size air cooled condensers
	Accessories	Identify proper location of refrigerant accessories Select appropriate accessories for refrigerant applications Determine proper operation of accessories
	Access valves	Identify the proper operation and use of front and back seat valves, and Schrader type valves Use quick connect service valves Install solder type access valves
Air conditioning systems	Unitary cooling systems	Detail the sequence of operation for unitary systems

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
		Basic refrigeration cycle Determine and verify actual operating performance data
	Commercial Central station systems	Function of: air distribution systems, expansion tanks, heat recovery, water chiller, water cooling tower Determine the control requirements for commercial electronic controls, pneumatic, and computer control systems
	Service and problem analysis	Determine causes of: electrical, mechanical, and hydronic problems
	Absorption refrigeration	
	Desiccant cooling and dehumidification	Dehumidification applications
Heat pump systems	Basic principles of operation, components, and applications	Operation of: Air to air systems Refrigeration cycle operation Charging methods during heating and cooling
Heating systems	Forced air systems	Ignition system operation Burner adjustments Derating burners Safety controls Adjust temperature rise Service fan system Adjust thermostat anticipator Use orifice sizing charts Test induced draft systems Check operation Perform startup procedures Troubleshoot gas heat systems Check heat exchangers Troubleshoot ignition systems
	Hydronic systems	Identify types of systems Identify types of boilers Remove air from systems Circulator alignment Set aquastat Water control valves Expansion tanks Check water temperature rise Wire multizone systems Perform startup procedures Design a hydronic system

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
		Install a hydronic system
	Testing and balancing	Verify airflow Make required adjustments to fuel supply system Perform efficiency tests and make required adjustments Make adjustments to air and water systems
	Humidification	Humidification systems Factors affecting humidity Maintenance of humidification systems Psychrometer usage
	Unitary combination heating and cooling equipment	Operation of heat system Control system operation
	Oil furnaces	Stack switches Primary controls Oil nozzles Electrodes Filter servicing Oil pumps Combustion chambers Refractory servicing Troubleshooting oil systems
	Electric furnaces	Electric furnace sequencers Temperature rise adjustments Check operation
Commercial Refrigeration systems	Single compressor systems	Compressor/evaporator balance point Compression ratios Compressor capacity at various temperatures Pump down/out cycles Select compressors Starting systems Supermarket display cases EPR valves Adjust pressure controls Wiring diagrams Perform startup procedures Troubleshooting single compressor systems
	Multiplexed evaporator systems	
	Refrigerated storage systems	Open cased systems Service and self-service storage systems Defrost methods
	Ice makers	Cubed and flake ice systems

Major Content Topic	Content Subtopic	NWTC HVACR Program Competencies
		Detail sequence of operation Perform service to ice machines Check production Install ice making systems
	Dispensing freezers	Dispensing freezer applications, operation, and maintenance
	Packaged liquid chillers	Application and operation Maintenance of chillers Determine capacity
Air handling systems	Airflow principles and duct design	Duct system layout Effective static pressure Size registers Duct system design Fabricate sheet metal fittings
	Mechanical and electronic filtration	Mechanical filters Electronic filters
	Fans	Fan types Interpret fan curves Select fans from curves Check operation
Indoor air quality (IAQ)	Requirement and maintenance of air quality	Ventilation factors IAQ factors Occupant comfort Air distribution effectiveness Pollutant levels
	Heat recovery systems	Energy recovery ventilators Heat recovery systems

Appendix B: Table 2: Complete Competency Listing of PAHRA vs. NWTC

Items not congruent are bold faced and colored in **RED**. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
Principles of Thermo-dynamics	Matter and heat behavior	Heat flow and transfer properties Measurement of heat and temperature Enthalpy British thermal unit calculations	Heat flow and transfer properties Measurement of heat and temperature Enthalpy British thermal unit calculations
	Fluids and pressure	Effects of pressure on boiling points Gauge pressures Absolute pressures Pressure measurement	Effects of pressure on boiling points Gauge pressures Absolute pressures Pressure measurement
	Refrigeration Cycle/Diagrams	Components of vapor compression systems Refrigerant conditions Temperature/pressure diagram	Components of vapor compression systems Refrigerant conditions Temperature/pressure diagram
	Measurement Systems	Converting from IP to metric Heat, Power, Velocity, Mass Energy conversions **Converting Tons cooling to KW**	Converting from IP to metric Heat, Power, Velocity, Mass Energy conversions
Safety	Personal safety and workplace practices	Clothing and equipment safety **OSHA standards** **Effects of substance abuse** **Safe driving practices** **Proper use of scaffolding,** ladders, hardhat, safety glasses, goggles, **hearing protection,** and footwear Proper housekeeping Fire extinguisher use Site evaluation	Clothing and equipment safety Proper use of ladders, hardhat, safety glasses, goggles, and footwear Proper housekeeping Fire extinguisher use Site evaluation
	Handling of pressurized fluids	Safety requirements Relief devices Storage and handling of refrigerant cylinders Effect of temperature on hydraulic expansion	Safety requirements Relief devices Storage and handling of refrigerant cylinders Effect of temperature on hydraulic expansion

Items not congruent are bold faced and colored in **RED**. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
		Storage of acetylene, oxygen, and nitrogen cylinders Mixing oil and oxygen MSDS sheets Cylinder capability and retesting requirements	Storage of acetylene, oxygen, and nitrogen cylinders Mixing oil and oxygen MSDS sheets Cylinder capability and retesting requirements
	Handling hazardous materials	**Use of MSDS sheets** Hazardous materials, substances, and wastes **Hazardous material manifest**	Hazardous materials, substances, and wastes
	Electrical safety	Ground fault circuit interrupters Environmental safety practices Proper testing procedures for live equipment	Ground fault circuit interrupters Environmental safety practices Proper testing procedures for live equipment
Tools and equipment	Hand tools and accessories	Basic hand tools Power tools Fasteners Pipe and tubing tools Lubrication methods	Basic hand tools Power tools Fasteners Pipe and tubing tools Lubrication methods
	Electrical testing equipment	Digital meters Analog meters Clamp-on ammeters Megohmmeters Capacitance meters Continuity testers	Digital meters Analog meters Clamp-on ammeters Megohmmeters Capacitance meters Continuity testers **Watt meters**
	Air conditioning and Refrigeration: servicing and testing equipment	Gauge manifolds Vacuum pumps Micron gauges Temperature meters Charging cylinders Electronic charging scales Electronic leak detection Halide torch	Gauge manifolds Vacuum pumps Micron gauges Temperature meters Charging cylinders Electronic charging scales Electronic leak detection Halide torch **Sling Psychrometers**
	Heating: servicing and testing equipment	Draft measurement Efficiency test equipment Smoke tests Pressure and vacuum gauges Sling Psychrometers	Draft measurement Efficiency test equipment Smoke tests Pressure and vacuum gauges Sling Psychrometers

Items not congruent are bold faced and colored in RED. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
		Gas pressure measurement Vent sizing Check thermostat operation Tachometer usage	Gas pressure measurement Vent sizing Check thermostat operation Tachometer usage
	Airflow: Measurement and testing equipment	Pitot tube usage Calculate air velocity Calculate air volume Measure pressure drop using magnehelic gauge Duct calculators	Pitot tube usage **Flow hoods** **Multipoint sensors** **Variable air volume systems** Calculate air velocity Calculate air volume Measure pressure drop using magnehelic gauge Duct calculators
Piping and piping practices	Piping material and fabrication	Types of pipe used for refrigeration work Fitting types Insulating pipe and tubing Soldering and brazing alloys Heat sink methods Vibration eliminators Torch usage Flaring Swaging Bending copper tubing **Soldering aluminum tubing** Threading and cutting steel pipe	Types of pipe used for refrigeration work Fitting types Insulating pipe and tubing Soldering and brazing alloys Heat sink methods Vibration eliminators Torch usage Flaring Swaging Bending copper tubing Threading and cutting steel pipe
	Pipe sizing and troubleshooting	**Refrigerant line capacities and sizing** Refrigerant velocities effects **Equivalent lengths of fittings for refrigerant lines** **Use of refrigerant traps** **Using manufacturer's refrigerant pipe sizing charts** Calculating gas pipe sizes	Effects of improper refrigerant velocities **Equivalent lengths of fittings for gas piping and hydronic systems** Calculating gas pipe sizes **Calculating pipe sizes for hydronic systems**
	Sheet metal	Bending tools Cutting tools Types of ductwork and fittings	Bending tools Cutting tools Types of ductwork and fittings
Electricity	Basic Electricity	Watts, ohms, volts, amps Single and 3 phase power	Watts, ohms, volts, amps Single and 3 phase power

Items not congruent are bold faced and colored in RED. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
		Electrical loads: capacitive, inductive, and resistive Magnetism Conductors and insulators Ohms law calculations Electrical measurement Series, parallel, and series/parallel circuits Circuit analysis of loads	Electrical loads: capacitive, inductive, and resistive Magnetism Conductors and insulators Ohms law calculations Electrical measurement Series, parallel, and series/parallel circuits Circuit analysis of loads **Development of ladder diagrams from pictorials**
	Electrical generation and distribution	Generators Distribution **Delta and wye distribution systems** **Use NEC code to determine wire and conduit sizes** **Determine voltage drops for electrical circuits** **Determine load center power capacities**	Generators Distribution **Diagramming of load centers and typical distribution panels**
	Electrical components	Aquastats, capacitors, contactors, relays, timers, damper actuators, oil pressure safety controls, thermostats, water valves, zone valves, crankcase heaters, positive temperature coefficient (PTC)thermistors	Aquastats, capacitors, contactors, relays, timers, damper actuators, oil pressure safety controls, thermostats, water valves, zone valves, crankcase heaters, positive temperature coefficient(PTC) thermistors
	Electric motors	Motor theory CSIR, CSCR, Modulating, Multi-speed, PSC, shaded pole, split phase, and 3-phase motors **Electronically controlled-motors (ECM)**	Motor theory CSIR, CSCR, Modulating, Multi-speed, PSC, shaded pole, split phase, and 3-phase motors **Hard-start kits** **Manual motor starters**
	Electrical circuits and controls	Circuit diagramming Circuit wiring Meter usage in testing of circuits Diagram symbols **Size electric motor circuits, and over-current protection**	Circuit diagramming Circuit wiring Meter usage in testing of circuits Diagram symbols **Size electric motor circuit over-current protection**

Items not congruent are bold faced and colored in **RED**. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
		using the NEC code book	**using manufacturer tables**
Controls	Gas controls	Gas valve types Gas regulators Pilot burners Ignition controls Fan control methods for heating systems Gas furnace sequence of operation Gas furnace component identification Adjustments to gas controls	Gas valve types Gas regulators Pilot burners Ignition controls Fan control methods for heating systems Gas furnace sequence of operation Gas furnace component identification Adjustments to gas controls
	Fuel oil controls	Test ignition controls Oil delay valves	Test ignition controls Oil delay valves
	Residential control systems: heating and cooling	Residential heating and cooling thermostats Heating and cooling controls Anticipator circuits Accessory wiring	Residential heating and cooling thermostats Heating and cooling controls Anticipator circuits Accessory wiring
	Commercial control systems	Electromechanical, pneumatic, electronic, programmable, and building management control systems Identify sequence of operation for control systems	Electromechanical, pneumatic, electronic, programmable, and building management control systems Identify sequence of operation for control systems
	Heat pump controls	Reversing valves **Defrost controls** **Geothermal system controls** **Emergency heat controls** **Auxiliary heat controls** **Heat pump thermostats**	Reversing valves
	Direct digital controls (DDC)	Wiring methods Input and output devices Peripheral devices Central processing units Remote communication Alarming systems System sequence of operation	Wiring methods Input and output devices Peripheral devices Central processing units Remote communication Alarming systems System sequence of operation **Programming DDC controllers**
	Energy management computer control	Applications Utility rebate programs Wiring methods	Applications Utility rebate programs Wiring methods

Items not congruent are bold faced and colored in RED. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
	systems	Peripheral devices Remote communications Monitoring and alarming Energy accounting Programming host systems and downloading programs	Peripheral devices Remote communications Monitoring and alarming Energy accounting Programming host systems and downloading programs **Creating database backups** **Graphic monitoring**
Solid state electronics	Solid state components	**Amplifiers** **Bilateral switches** **Diodes** **Photoelectric cells** **Semiconductors** Shielded wiring **Transistors** Triacs Thermistors	Shielded wiring Triacs Thermistors
Load calculations	Refrigeration loads	U, K, C, and R factors Heat transfer tables Heat load sources Vapor barriers Interpret specific heat, latent heat, and heat of respiration values	U, K, C, and R factors Heat transfer tables Heat load sources Vapor barriers Interpret specific heat, latent heat, and heat of respiration values
	Psychrometrics	Identify elements of the psychrometric chart Apply the elements of the psychrometric chart Calculate sensible heat ratios, sensible and latent capacities, enthalpy, mixed air properties	Identify elements of the psychrometric chart Apply the elements of the psychrometric chart Calculate sensible heat ratios, sensible and latent capacities, enthalpy, mixed air properties
	Heating and cooling loads	**Interpret structure design data** **Interpret building prints** **Total resistance to flow** **Conduction loads** **Infiltration** **Ventilation load** **Duct loads** **Equipment load** **Lighting load** **Calculate total load**	
Refrigerant	Metering devices	Cap tubes, thermal expansion	Cap tubes, thermal expansion

Items not congruent are bold faced and colored in RED. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
system components		valves, automatic expansion valves, **low side float, high side float**, hand expansion valve, and restrictor orifices **Electronic expansion valves, Solid state expansion valves** **Sizing of metering devices** Installation of cap tubes Adjust thermal metering devices	valves, automatic expansion valves, hand expansion valve, and restrictor orifices **Installation of thermal expansion metering devices** Installation of cap tubes Adjust thermal metering devices
	Evaporators	Types of evaporators Evaporator temperature difference Determine evaporator performance under various loads and refrigerant charges Size and select evaporators	Types of evaporators Evaporator temperature difference Determine evaporator performance under various loads and refrigerant charges Size and select evaporators
	Compressors	Types of compressors: hermetic, semi-hermetic, and open drive Methods of compression Compressor capacity control Select replacement compressors based on selected components	Types of compressors: hermetic, semi-hermetic, and open drive Methods of compression Compressor capacity control Select replacement compressors based on selected components
	Condensers	Types of condensers: air cooled, water cooled, evaporative cooled Determine proper air and water flow Maintenance of condensers **Cooling tower range and approach calculations** **Size cooling towers** Heat reclaim Select and size air cooled condensers	Types of condensers: air cooled, water cooled, evaporative cooled Determine proper air and water flow Maintenance of condensers Heat reclaim Select and size air cooled condensers
	Accessories	Identify proper location of refrigerant accessories Select appropriate accessories for refrigerant applications Determine proper operation of accessories	Identify proper location of refrigerant accessories Select appropriate accessories for refrigerant applications Determine proper operation of accessories

Items not congruent are bold faced and colored in RED. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
	Access valves	Identify the proper operation and use of front and back seat valves, and Schrader type valves Use quick connect service valves Install solder type access valves	Identify the proper operation and use of front and back seat valves, and Schrader type valves Use quick connect service valves Install solder type access valves
Air conditioning systems	Unitary cooling systems	Detail the sequence of operation for unitary systems Basic refrigeration cycle Determine and verify actual operating performance data	Detail the sequence of operation for unitary systems Basic refrigeration cycle Determine and verify actual operating performance data
	Commercial Central station systems	Function of: air distribution systems, expansion tanks, heat recovery, water chiller, water cooling tower Determine the control requirements for commercial electronic controls, pneumatic, and computer control systems	Function of: air distribution systems, expansion tanks, heat recovery, water chiller, water cooling tower Determine the control requirements for commercial electronic controls, pneumatic, and computer control systems
	Service and problem analysis	Determine causes of: electrical, mechanical, and hydronic problems	Determine causes of: electrical, mechanical, and hydronic problems
	Absorption refrigeration	**Explain operation of absorption systems** **Verify operation of all external absorption components**	
	Desiccant cooling and dehumidification	Dehumidification applications **Methods of desiccant dehumidification** **Desiccant wheels** **Troubleshooting desiccant systems** **Maintenance of desiccant dehumidification systems**	Dehumidification applications
Heat pump systems	Basic principles of operation, components, and applications	Operation of: Air to air systems **Water source systems** **Geothermal systems**	Operation of: Air to air systems Refrigeration cycle operation Charging methods during

Items not congruent are bold faced and colored in RED. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
		Electrical and mechanical system components **Efficiency rating factors** **Balance points** Refrigeration cycle operation **Defrost methods** Charging methods during heating and cooling **Perform startup procedures** **Heat pump thermostats** **Dual fuel system integration**	heating and cooling
Heating systems	Forced air systems	Ignition system operation Burner adjustments Derating burners Safety controls Adjust temperature rise Service fan system Adjust thermostat anticipator Use orifice sizing charts Test induced draft systems Check operation Perform startup procedures	Ignition system operation Burner adjustments Derating burners Safety controls Adjust temperature rise Service fan system Adjust thermostat anticipator Use orifice sizing charts Test induced draft systems Check operation Perform startup procedures **Troubleshoot gas heat systems** **Check heat exchangers** **Troubleshoot ignition systems**
	Hydronic systems	Identify types of systems Identify types of boilers Remove air from systems Circulator alignment Set aquastat Water control valves Expansion tanks Check water temperature rise Wire multizone systems Perform startup procedures	Identify types of systems Identify types of boilers Remove air from systems Circulator alignment Set aquastat Water control valves Expansion tanks Check water temperature rise Wire multizone systems Perform startup procedures **Design a hydronic system** **Install a hydronic system**
	Testing and balancing	Verify airflow Make required adjustments to fuel supply system Perform efficiency tests and	Verify airflow Make required adjustments to fuel supply system Perform efficiency tests and

Items not congruent are bold faced and colored in **RED**. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
		make required adjustments Make adjustments to air and water systems	make required adjustments Make adjustments to air and water systems
	Humidification	Humidification systems Factors affecting humidity Maintenance of humidification systems Psychrometer usage	Humidification systems Factors affecting humidity Maintenance of humidification systems Psychrometer usage
	Unitary combination heating and cooling equipment	Operation of heat system Control system operation	Operation of heat system Control system operation
	Oil furnaces	Stack switches Primary controls Oil nozzles Electrodes Filter servicing Oil pumps	Stack switches Primary controls Oil nozzles Electrodes Filter servicing Oil pumps **Combustion chambers** **Refractory servicing** **Troubleshooting oil systems**
	Electric furnaces	Electric furnace sequencers Temperature rise adjustments Check operation	Electric furnace sequencers Temperature rise adjustments Check operation
Commercial Refrigeration systems	Single compressor systems	Compressor/evaporator balance point Compression ratios Compressor capacity at various temperatures Pump down/out cycles Select compressors Starting systems Supermarket display cases EPR valves Adjust pressure controls Wiring diagrams Perform startup procedures	Compressor/evaporator balance point Compression ratios Compressor capacity at various temperatures Pump down/out cycles Select compressors Starting systems Supermarket display cases EPR valves Adjust pressure controls Wiring diagrams Perform startup procedures **Troubleshooting single compressor systems**
	Multiplexed evaporator systems	**Operation and application of multiplexed evaporator systems**	

Items not congruent are bold faced and colored in **RED**. Congruent items colored in black.			
Major Content Topic	**Content Subtopic**	**PAHRA Competencies**	**NWTC HVACR Program Competencies**
		Service multiple evaporator systems	
	Refrigerated storage systems	Open cased systems Service and self-service storage systems Defrost methods	Open cased systems Service and self-service storage systems Defrost methods
	Ice makers	Cubed and flake ice systems Detail sequence of operation Perform service to ice machines Check production Install ice making systems	Cubed and flake ice systems Detail sequence of operation Perform service to ice machines Check production Install ice making systems
	Dispensing freezers	Dispensing freezer applications, operation, and maintenance	Dispensing freezer applications, operation, and maintenance
	Packaged liquid chillers	Application and operation Maintenance of chillers Determine capacity	Application and operation Maintenance of chillers Determine capacity
Air handling systems	Airflow principles and duct design	Duct system layout Effective static pressure Size registers Duct system design Fabricate sheet metal fittings	Duct system layout Effective static pressure Size registers Duct system design Fabricate sheet metal fittings
	Mechanical and electronic filtration	Mechanical filters Electronic filters **Testing power packs**	Mechanical filters Electronic filters
	Fans	Fan types Interpret fan curves Select fans from curves Check operation	Fan types Interpret fan curves Select fans from curves Check operation
Indoor air quality (IAQ)	Requirement and maintenance of air quality	**ASHRAE standard 62** **Sick building syndrome** **Building related illness** Ventilation factors IAQ factors Occupant comfort Air distribution effectiveness Pollutant levels	Ventilation factors IAQ factors Occupant comfort Air distribution effectiveness Pollutant levels
	Heat recovery systems		**Energy recovery ventilators** **Heat recovery systems**