ASSESSMENT OF ROADSIDE TECHNICIANS' TECHNICAL KNOWLEDGE AND TROUBLESHOOTING EXPERTISE IN REFRIGERATORS AND AIR CONDITIONERS IN MINNA METROPOLIS

BY

UPELLE ADIYA MARY

2007/1/27252BT

A RESEARCH PROJECT SUBMITTED TO

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION,

SCHOOL OF SCIENCE AND SCIENCE EDUCATION,

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE AWARD OF BACHELOR OF TECHNOLOGY (B.TECH) IN INDUSTRIAL AND TECHNOLOGY EDUCATION, ELECTRICAL AND ELECTRONICS TECHNOLOGY OPTION

OCTOBER, 2012.

CERTIFICATION

I, Upelle Adiya Mary with matric number 2007/1/27252BT an undergraduate student of the department of Industrial and Technology Education certify that the work embodied in this project is original and has been submitted in part or in full for any diploma or degree of this or other university.

______________________________ ______________________________

Name Sign/Date

APPROVAL PAGE

This project has been read and approved as meeting the requirement for the award of B.Tech Degree in Electrical and Electronics Technology in the Department of Industrial and Technology Education, School of Science and Science Education, Federal University of Technology, Minna.

______________________	______________________
Supervisor	Sign/Date
______________________	______________________
Head of Department	Sign/Date
______________________	______________________
External supervisor	Sign/Date

DEDICATION

I dedicate this project to Almighty God who has brought me save thus far, and to my outstanding parents Mr. and Mrs. Emmanuel Upelle.

ACKNOWLEDEGEMENTS

With deep gratitude and love, I will like to appreciate God for His infinite love, guidance, provision and protection all through my stay in school. I want to say a big thank you to my supervisor Mr. Raymond E. for putting me through this project work and my academics as a whole, you are more than a supervisor, and you are a mentor, the project coordinator Mr. Moses Saba the H.O.D Dr. Ohize Emmanuel Jose and all the departmental staff for making this project a success.

To my wonderful parents Mr. and Mrs. Emmanuel Upelle who made my stay in school comfortable through their prayers, financial and moral supports, I say I owe you a lot, may God grant you long life to enjoy the fruit of your labor. To my lovely siblings for their encouragements, financial support and prayers and to my adorable nephews and nice Shedrack, Joseph, Damian and Emmanuella I love you all.

My sincere appreciation goes to my friends: Mr. Njoku, Mr. Emmanuel Odoh Upelle, Rev. Fr Nuhu Joseph, Rev. Fr. Philip Gaya, Rev Fr. Philemon, Folashade Olude, Sunday Adejo, Rufai, Mr. P.D. Mr. and Mrs. Ojiako and to all my course mates ITE 2012 you all have done so marvelous in my life and I truly appreciate.

TABLE OF CONTENTS

CHAPTER 2

REVIEW OF RELATED LITERATURE

CHAPTER 3

METHODOLOGY

CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

LIST OF TABLES

Abstract.

The study was designed to assess roadside technicians in Minna metropolis in order to determine the impact of technical knowledge on troubleshooting skills of roadside technicians. To carry out the study, three research questions and three hypotheses were formulated for the study; the questionnaire was used to collect relevant data from a sample of 25 master craft men and 25 senior apprentices of the refrigerators and air conditioners roadside technicians. Mean and standard deviation were used to analyze the answer to the research questions, while t-test statistic was employed to test the null hypotheses at the 0.05 level of significance. To determine the acceptance, mean score of 2.50 was fixed as deciding point between agree and disagree. Responses with mean score of 2.50 and above are considered accepted, while responses below 2.50 are rejected. The study revealed among others that roadside technicians in refrigerators and air conditioners have high level of technical knowledge that makes troubleshooting easier for them. Finally, recommendations were made in regards to the findings among which are; roadside technicians should acquaint themselves with the use of the leak detector and also acquaint themselves with the use of an infrared thermometer to scan the temperature of refrigerators and air conditioners.

CHAPTER 1

INTRODUCTION

Background of the study

Refrigerators and air conditioners are electrical appliances basically used at homes, offices, hotels, business centers and so on. The uses of these appliances have made life more comfortable for its users. A refrigerator is a common household appliance that consists of a thermally insulated compartment and a heat pump (mechanical, electronic, or chemical) that transfers heat from the inside of the fridge to its external environment so that the inside of the fridge is cooled to a temperature below the ambient temperature of the room. Air Conditioning and Refrigeration Institute (1995). Cooling is a popular food storage technique in developed countries and works by decreasing or even arresting the reproduction rate of bacteria. The device is thus used to reduce the rate of spoilage of foodstuffs.

A refrigerator maintains a temperature a few degrees above the freezing point of water. Optimum temperature range for perishable food storage is 3 to 5 °C (37 to 41 °F). A similar device which maintains a temperature below the freezing point of water is called a freezer. The refrigerator is a relatively modern invention among kitchen appliances. It replaced the icebox, which had been a common household appliance for almost a century and a half ago. For this reason, a refrigerator is sometimes referred to as an icebox.

On the other hand an air conditioner (AC) is a home appliance, system, or mechanism designed to dehumidify and extract heat from an area. The cooling is done using a simple refrigeration cycle. In construction, a complete system of Heating,Ventilation and Air Conditioning is referred to as "HVAC". Air-conditioning systems control the temperature, humidity, and the total air quality in residential, commercial, industrial, and other buildings. Bureau of Labor Statistics. (2003b). by providing a climate controlled environment, refrigeration systems make it possible to store and transport food, medicine, and other perishable items. Air-conditioning, and refrigeration technicians—install, maintain, and repair such systems, because ventilation, air-conditioning, and refrigeration systems often are referred to as HVACR (heating, ventilation, air conditioning and refrigeration) systems, these workers also may be called HVACR technicians Beard & Wilson (2002). Refrigerators and air conditioners have the same principle of operations. The most common refrigeration cycle uses an electric motor to drive a compressor. In an automobile, the compressor is driven by a belt over a pulley, the belt being driven by the engine's crankshaft (similar to the driving of the pulleys for the alternator, power steering, etc.). Whether in a car or building, both use electric fan motors for air circulation. Since evaporation occurs when heat is absorbed, and condensation occurs when heat is released, air conditioners use a compressor to cause pressure changes between two compartments, and actively condense and pump a refrigerant around. A refrigerant is pumped into the evaporator coil, located in the compartment to be cooled, where the low pressure causes the refrigerant to evaporate into a vapor, taking heat with it. At the opposite side of the cycle is the condenser, which is located outside of the cooled compartment, where the refrigerant vapor is compressed and forced through another heat exchange coil, condensing the refrigerant into a liquid, thus rejecting the heat previously absorbed from the cooled space.

By placing the condenser (where the heat is rejected) inside a compartment, and the evaporator (which absorbs heat) in the ambient environment (such as outside), or merely running a normal air conditioners refrigerant in the opposite direction, the overall effect is the opposite, and the compartment is heated. This is usually called a heat, and is capable of heating a home to comfortable temperatures (25 °C; 70 °F), even when the outside air is below the freezing point of These principles of operations need to be properly understood before adequate troubleshooting can take place that is the technicians need to have the technical knowledge of these machines. Technical knowledge includes knowledge of and proficiency in certain specialized field, such as engineering, computers, accounting, or manufacturing. Those with technical skills are often referred to as "technicians" in their chosen field, i.e. auto technicians, electronics technicians, engineering technicians, etc Doolittle & Camp (1999).

Sometimes these machines develop faults just like any other machines. If these faults are not attended to, the machine will not function as expected. In view of these, there are personnel who attend to these faults who are called the technicians. A technician is a worker in a field of technology who is proficient in the relevant skills and techniques, with a relatively practical understanding of the theoretical principles, experienced technicians in a specific tool domain typically have intermediate understanding of theory and expert proficiency in technique. Flesher (1993). As such, technicians are generally much better versed in technique compared to average layman and even general professionals in that field of technology. Technicians may be classified as either skilled workers or semi-skilled workers, and may be part of a larger (production) process.

This study is concerned with the semi-skilled who are called road side technicians. They basically do not undergo any form of formal education; they mostly troubleshoot through try and error method. Troubleshooting is a form of problem solving, often applied to repair failed products or processes. It is a logical, systematic search for the source of a problem so that it can be solved, and so the product or process can be made operational again. Lavoie (1991). Troubleshooting is needed to develop and maintain complex systems where the symptoms of a problem can have many possible causes. Troubleshooting is used in many fields such as engineering, system administration, electronics, automotive repair, and diagnostic medicine. Troubleshooting requires identification of the malfunction(s) or symptoms within a system. Then, experience is commonly used to generate possible causes of the symptoms. Finally, troubleshooting requires confirmation that the solution restores the product or process to its working state. In general, troubleshooting is the identification of or diagnosis of "trouble" in a system caused by a failure of some kind. The problem is initially described as symptoms of malfunction, and troubleshooting is the process of determining and remedying to the causes of these symptoms.

This technician's level of technical knowledge needs to be assessed. Therefore assessment is the ongoing process of gathering, analyzing and reflecting on evidence to make informed and consistent judgments to improve the competency and reliability of roadside technicians in troubleshooting refrigerators and air-conditioners. The opportunities to work and simultaneously acquire essential knowledge, skills and qualification with assessment based on worker's achievement and on capability to perform task according to industrial and labor demands.

Therefore assessment is criterion referenced, because performance (skills) is judged on the basis of desirable performance characteristics (criterion) and degree of quality of performance (standards). This provides a rational basis for valid and reliable assessment and certification.

Statement of the problem

It is generally believed that roadside technicians troubleshoot refrigerators and air conditioners without knowing the basic principle behind the appliance they are troubleshooting; they basically carry out repairs through the try and error method. Nichols, (1994) further added that the roadside technicians do not pass through any formal training on these appliances to have the adequate knowledge on how they operate.

Refrigerator and air Conditioner technicians need a good balance of manual skills and theory. Without a good grounding in theory it would be almost impossible to diagnose problems associated with refrigerators and air conditioners systems. Because of the increasing sophistication of air-conditioning, and refrigeration systems, employers prefer to hire those who have completed technical school training or a formal apprenticeship. Some mechanics and technicians, however, still learn the trade informally on the job. However these technicians who learn the trade informally usually called roadside technicians do not have adequate technical knowledge and basic principle of operation but still troubleshoot these machines.

Therefore, the focus of this study is to find out the relationship between technical knowledge and troubleshooting skills, that is, to find out the impact of technical knowledge on the troubleshooting skills of roadside technician.

Purpose of the study

The purpose of the study is to assess roadside technician’s technical knowledge and troubleshooting expertise in refrigerators and air conditioners in Minna metropolis. In specific term, the study will determine:

1. The technical knowledge possessed by roadside technicians in refrigerators and air conditioners.
2. Troubleshooting skills possessed by technicians in refrigerator and air conditioners.
3. The impact of technical knowledge on troubleshooting skills of roadside technicians.

Significance of the study

This study will be of benefit to the following:

- The Niger start government; It will be of relevance to the Niger state government in other to have a clear picture of the roadside technicians and derive ways of helping them to undergo a formal training so as to have the basis of troubleshooting these machines. Some of the ways the government can be of help to the roadside technicians is by mobilizing qualified technicians to go round the state to sensitize these technicians on the importance of acquiring the technical knowledge, giving of free technical training, organizing of seminars, workshops and so on.
- The roadside technicians; It will benefit the roadside technicians, because if they undergo the formal training of technical knowledge in troubleshooting expertise on these machines, where they will know the principle of operation of these appliances and the principle of troubleshooting them, in addition they will know the correct tools and instruments used in troubleshooting, thereby widening their skills of carrying out maintenance and repairs on refrigerators and air conditioners.
- The users of these appliances; With the understanding and changes made by the state government and the roadside technicians, the study will be of great benefits to all users of refrigerators and air conditioners as they will be assured of a better outcome of the

services of the roadside technicians, also the users will be able to carry out some daily cleaning and maintenance of them to pro long their life span.

Scope of the study

The study is delimited to technicians of refrigerators and air conditioners in Minna metropolis. This study will not cover other electronic technicians.

Assumption of the study

The following assumptions are made in the pursuit of this study:

1. Responses formed the bases on the assessment of roadside technician’s technical knowledge.
2. The utilization of questionnaire was adequate and suitable for the collection of necessary data for the study.

Research questions

The following research questions where formulated to guide the study:

1. What are the extent of technical knowledge possessed by roadside technicians in refrigerators and air conditioners?
2. What are the troubleshooting skills possessed by technicians in refrigerators and air condoners?
3. What are the impact of technical knowledge on troubleshooting skills of roadside technicians?

Hypothesis

The following null hypothesis were formulated and tested at $p<0.05$ level of significance.

Ho1: There is no significant difference in the mean responses of the master craft and senior apprentice on the technical knowledge possessed by them.

Ho2: There is no significance difference in the mean responses of the master craft and senior apprentice on the troubleshooting skills possessed by technicians in refrigerators and air conditioners.

Ho3: There is no significance difference in the mean responses of the master craft and senior apprentice on the impact of technical knowledge on troubleshooting skills.

CHAPTER 2

REVIEW OF RELATED LITERATURE

In this chapter, literature related to this study was reviewed under the following sub headings.

- General principles of troubleshooting refrigerators and air conditioners.
- Technical knowledge necessary for troubleshooting in refrigerators and air conditioners.
- Troubleshooting skills needed by technicians in refrigerators and air conditioners.
- Relationship between technical knowledge and troubleshooting skills.
- Summary of the reviewed literature.

GENERAL PRINCIPLES OF TROUBLESHOOTING REFRIGERATORS AND AIR CONDITIONERS

The core of a refrigeration system is the compressor, which is designed to pump cool refrigerant gas from the evaporator into the condenser. To accomplish this task the compressor raises the temperature and pressure of the low superheated gas, forcing it into the condenser. The compressor should never pump liquid. This will not only damage the compressor, but can create a potential safety hazard.

Similar to the human heart, the refrigeration compressor needs to be properly maintained and requires periodic inspection and testing. Unfortunately, the compressor is often ignored until it malfunctions or stops running altogether, at which time it gets replaced and the system is back up and running - temporarily. Waetjen (1989), said oftentimes the culprit is not the compressor, but a system failure or design problem with accessory equipment which killed the compressor prematurely.

This sub heading describes how to troubleshoot a compressor and the associated problems that can cause a system to fail prematurely. It also describes the proper methods of diagnosing and repairing system problems, rather than just their symptoms.

MEASURING THE COMPRESSOR SUCTION AND DISCHARGE PRESSURE

Both the suction and discharge pressures at the compressor are normally measured with a standard set of refrigeration gauges. However, this article will explain how to measure both pressures on the suction and high side of the system with your digital multimeter (DMM) and a pressure/vacuum module, with or without your standard gauges. If the gauges are left on the system and used in conjunction with this test, the module will verify the accuracy of the standard manifold gauges.

To measure the pressures on your DMM in conjunction with your standard manifold gauges, the following steps should be followed:

- Attach the pressure/vacuum module hose fitting to the refrigerant service hose on your manifold gauge set, usually the yellow hose.
- Attach the pressure/vacuum module to a DMM and set the module function to cm/in. Hg.
- Install your blue and red hoses to the suction side and high side of the system as during any normal service process.

To read the suction pressure on your DMM, open the blue handle on the manifold gauges. This puts the system suction pressure into the pressure/vacuum module. Read the pressure on the digital readout and compare it to the gauge pressures. Don't be alarmed if the pressures don't match exactly. Modules like the Fluke PV350 are typically much more accurate than a standard set of refrigeration gauges. To read the discharge pressure on your DMM, close the blue valve on your gauges and open the red handle on the manifold gauges. This puts the system discharge pressure into the module.

To remove the module, simply reverse the process you followed when installing the unit.

Caution: Be sure to close the high side port of your gauges first, and remember to remove the refrigerant from the high side gauge by allowing the compressor to run and pull excess refrigerant into the low side of the system.

To measure the pressures on your DMM and pressure/vacuum module without installing your manifold gauges, take the following steps:

- Attach the module hose fitting to any standard refrigerant service hose.
- Connect the refrigeration hose to the service port on the compressor.
- Open up the service port and read the refrigerant pressure directly on the pressure/vacuum module.

You can read one pressure at a time using a single pressure vacuum module, so you will need to record the suction or discharge pressure one at a time. Or if you are using a DMM meter such as a Fluke 179 with a min/max feature, you can record the suction pressure as the min value and then record the discharge pressure as the max value.

To remove the pressure/vacuum module, simply reverse the process you followed when installing the unit.

Caution: Be careful when removing the high side port of your gauges as it can be under very high pressure. To minimize refrigerant loss, learn to practice safe refrigerant handling habits when removing the module from the high side of the system. This includes shutting off the compressor prior to gauge removal and allowing the pressure to equalize. When removing the gauge from the low side of the system it is not necessary to first shut down the compressor.

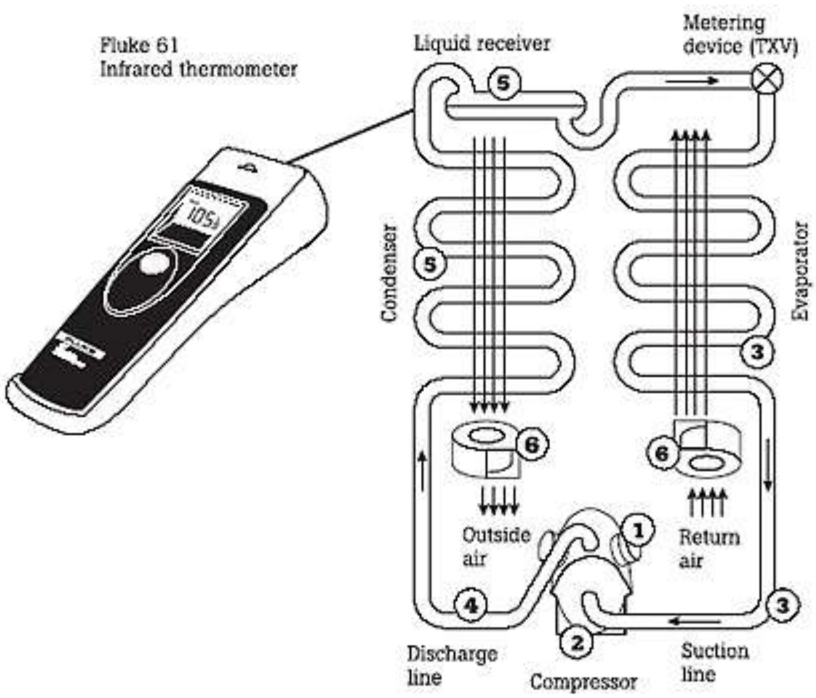


Fig 1

Using an infrared thermometer to scan the temperatures of different components

TROUBLESHOOTING THE COMPRESSOR DISCHARGE LINE TEMPERATURES

Pressure and temperature are fundamental tests that you can perform to determine what is happening inside the compressor.

To measure the temperature of the compressor, the following steps should be followed:

- Use a pipe clamp accessory with a DMM to measure the discharge line temperature at the discharge of the compressor. High temperatures above 275-300Â°F (135-148Â°C) will slowly destroy lubricant qualities and performance of the compressor. These high temperature conditions can be caused by high condensing temperatures/pressures, insufficient refrigerant charge, non-condensable within the system, high superheat from the evaporator, restricted suction line filters, or low suction pressure. These conditions cause the compressor to have a higher than normal compression ratio, work harder, generate hotter internal hermetic motor windings, and as a result, cause compressor wear, fatigue, and failure.

A temperature survey is a critical part of the service technician's job. A quick check of a system's components not only helps to diagnose troubles but also allows you to anticipate failures by regular monitoring of critical temperatures. Use an infrared thermometer to do a quick survey of:

- Compressor oil sump temperatures
- Evaporator coil and suction line temperatures
- Discharge line temperatures
- Condenser coil and liquid line temperatures
- Fan motor temperatures.

With an infrared thermometer, you can quickly survey a refrigeration system by scanning the temperatures of various components, Flesher (1993). While touching each of the components often does this, a noncontact infrared tool is faster. By keeping careful records, it is possible to detect trends that indicate impending failure. This allows you to keep the system in top condition and avoid costly failures.

RECORDING A TEMPERATURE OVERNIGHT

To check refrigeration system performance, it is often useful to record temperatures in the refrigerated space. This allows you to detect problems that may go unnoticed with a single system check.

For instance, in a refrigerated space it is important to ensure that temperature variations are minimized. Temperature variations may result from changes in load or ambient conditions that occur over periods of time, so constant monitoring is called for. By recording minimum and maximum temperatures in key locations over a period of time you can be sure that air circulation and refrigeration capacity meets the application requirements.

Digital recording thermometers allow you to record minimum and maximum temperatures over extended periods of time. Temperature values can be viewed at any time by pressing the view button (recording still continues). If the HOLD button is pushed, the recorded MIN/MAX values are saved and recording stops. The data is saved until the user selects a different input or turns off the instrument. Some DMMs can also measure MIN/MAX of a single temperature, plus they offer the benefit of a 100-hour relative time stamp to record when the MIN/MAX occurred.

When selecting a digital recording thermometer, look for a model that can record hundreds of temperature samples so you get precise measurement. Additional features that are helpful include a time stamp feature, operator interval settings, and dual channels to record two temperatures at the same time. With this type of device you can record temperature difference across a coil for extended periods of time. This feature is especially handy for troubleshooting erratic problem areas of the HVAC equipment where time limitations do not allow the technician to wait until the problem occurs. Flesher (1993), and Whitman, Johnson, & Tomczyck (2005).

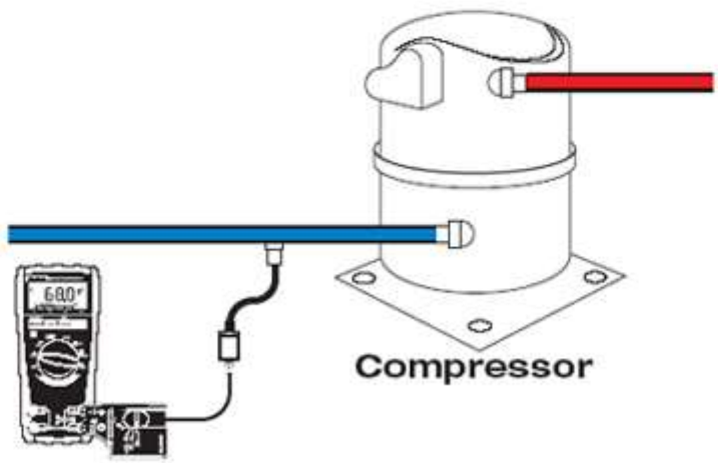


Fig 2

Suction pressure. Use a multimeter and a pressure module to quickly and accurately determine suction pressure.

COMPRESSOR VALVE PERFORMANCE TEST

To test small hermetic and semi-hermetic compressors used for medium and low temperature applications, the following method can be used to test for internal valve leakage.

- Attach a pressure/vacuum module to a DMM and set the module to cm/in. Hg.
- Connect the module at the suction line service port.

- Close the compressor off from the low side of the system by front seating the suction service valve.
- Run the compressor for two minutes.
- Turn off the compressor and observe the reading.

The compressor should have pulled down to at least 16 inches (410 mm) of Hg. If the vacuum reading starts weakening toward 10 inches (254 mm) of Hg vacuum, the discharge valves of the compressor may be leaking and will probably need to be replaced. If the compressor doesn't pull a vacuum below 16 inches Hg, the suction valves are weakening and may need to be replaced. If the compressor is welded or hermetically sealed and these conditions exist, a new compressor is the only possible remedy, Flesher (1993), and Whitman, et al (2005).

Caution: Whenever replacing a compressor with faulty valves, be sure to diagnose the complete refrigeration system before and after a new compressor is installed to avoid repeated compressor failures.

TROUBLESHOOTING COMPRESSOR ELECTRICAL MOTOR FAULTS

A clamp meter is a great tool for troubleshooting electrical motor faults, especially meters designed to accurately measure both AC voltage and AC current. These meters allow current to be measured without breaking into the electrical circuit. A compressor failure is often caused by an electrical fault. To check the compressor for electrical problems, remove the electrical terminal cover and check the following external connections.

- Check line voltage at the load center with the compressor off. Low line voltage causes the motor to draw more current than normal and may result in overheating and premature failure. Line voltage that is too high will cause excessive inrush current at motor start, again leading to premature failure.

- Check line voltage at the motor terminals with the compressor running. The voltage should be within 10 percent of the motor rating.
- Check running current. The readings should not exceed manufacturer's full load rated amps during heavy load periods. Low amps are normal during low load conditions. Excessive high current may be due to shorted or grounded windings, a bad capacitor, a faulty start relay, or an indication of excessive bearing fatigue.

Caution: When performing electrical measurements on compressors with internal thermal motor protection devices that have been running extremely hot, be sure to give the compressor time to cool down prior to the electrical test. This will allow the device to reset to its normal position.

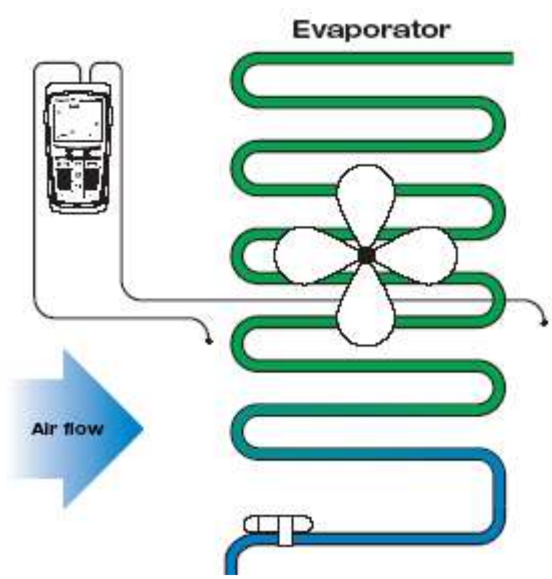


Fig 3

ΔT across coils. Record evaporator temperature differences as well as minimum/maximum temperatures with a digital thermometer.

TROUBLESHOOTING COMPRESSOR ELECTRICAL MOTOR FAILURES CAUSED BY REFRIGERATION SYSTEM PROBLEMS

Occasionally defective compressors with electrical winding failures are diagnosed by a service technician as caused by an electrical system problem. However, mechanical system failure or inferior installation and service practices often cause compressor electrical problems. Mostia (2000), said these problems include:

1. Poor piping practices resulting in oil not adequately returning to the compressor during the run cycle.

2. High discharge temperatures creating acids in the oil.

3. Insufficient airflows across the evaporator and condenser coils.

4. Extremely low suction pressures.

5. Liquid refrigerant flooding back into the compressor.

Diagnosing these refrigeration system problems and avoiding compressor failure can be done effectively using DMMs, clamp meters, digital thermometers, pipe clamps, infrared thermometer, and pressure/vacuum modules.

Here are some simple procedures to diagnose these problems.

1. Compressor bearings can fail or lock up due to poor piping practices, which causes oil clogging in the system and results in insufficient oil return to the compressor. If the bearings don't lock-up and continue to wear during these conditions, the rotor will lower into the stator housing, shorting out the windings. To diagnose this problem, measure the compressor amps. They should not exceed the manufacturer's full load ratings. Worn bearings will cause higher than normal amps. Inspect the oil level via the compressor sight glass. If there is no sight glass, use your infrared thermometer to measure the sump of the compressor housing. The oil level can be detected with the temperature probe. The sump temperature will be different on the compressor housing at the oil level.

Caution: Whenever an oil problem exists due to poor piping practices, the correct remedy is to fix the piping, not to continue to add more oil to the system.

2. High discharge temperatures are caused by high head pressures or high superheat. The compressor discharge line can be measured quickly using the infrared thermometer on a dull section of pipe. Measure the discharge pressure using a pressure/vacuum module. Convert the refrigerant pressure to temperature and compare it to the ambient air temperature. If there is a temperature difference greater than 20-30Â°F (11-17Â°C), there is either no condensable gases in the system or restricted airflow across the condenser.

Note: Temperature differences will vary due to original manufacturer's design and efficiencies.

3. Check for insufficient airflows across the evaporator using a digital thermometer. Place a bead thermocouple on the discharge side of the coil and on the return side of the coil. Record the temperature difference on the air conditioning unit. Expect about 18-22Â°F (10-12Â°C) temperature difference. On refrigeration units, expect about 10-15Â°F (5-8.5Â°C) temperature difference.

Note: Temperature differences may vary depending upon initial design and humidity requirements.

4. Extremely low suction pressures can be checked using the pressure/vacuum module and your DMM. Install it at the compressor and record your suction pressure. Convert the refrigerant pressure to temperature using a pressure-temperature (PT) chart. Measure the return air temperature before the evaporator. Compare the refrigerant temperature to the desired evaporator return air temperature. On air conditioning units, expect about 35-40Â°F (19-22Â°C) temperature difference and, on refrigeration units, expect about 10-20Â°F (5-11Â°C) temperature difference.

5. Check for liquid refrigerant flooding back to the compressor by determining the superheat using your pressure/vacuum module and pipe clamp, along with your DMM. Check suction pressure and convert the refrigerant pressure to temperature, using your PT chart. Measure the suction line pipe temperature. Compare the difference of the two temperatures. If there is no temperature difference, then you are bringing back liquid to the compressor. If there is a temperature difference between 10-20Â°F (5-11Â°C), then you have normal superheat and you are not slugging the compressor with unwanted liquid. Lavoie (1991).

SUMMARY: Troubleshooting and servicing refrigeration, air conditioning, and heat pump systems is a challenge for any technician, entry level or experienced. Regardless of the size or location of the system, it is imperative that the service technician understands the principles and the tools needed to perform proper troubleshooting efficiently

TECHNICAL KNOWLEDGE NECESSARY FOR TROUBLESHOOTING IN REFRIGERATORS AND AIR CONDITIONERS

Prerequisites to troubleshooting

The key to troubleshooting industrial equipment lies beyond the process itself. A prerequisite to troubleshooting is the knowledge and understanding of the equipment. Knowing how the equipment functions, what each component installed on the equipment is, what the component does, how the component does what it should, and how the components interact are essential in applying any troubleshooting methodology or process. D'Zurilla & Maydeu-Olivares (1995).

Knowledge is power, especially when it comes to supporting your end users. Your detailed understanding of anything that can be applied or reasoned with in any shape or form for any issues or applications is technical knowledge. That is why technicians in refrigerators and air conditioners need to have technical knowledge of these appliances to troubleshoot well. Heating, air conditioning, and refrigeration mechanics and installers—often referred to as HVACR technicians—work on heating, ventilation, cooling, and refrigeration systems that control the air quality in many types of buildings. The technical knowledge necessary for troubleshooting in refrigerators and air conditions includes the knowledge of the tools used in troubleshooting these appliances. The refrigeration and air-conditioning technician must work with electricity. Equipment that has been wired may have to be replaced or rewired. In any case, it is necessary to identify and use safely the various tools and pieces of equipment. Special tools are needed to install and maintain electrical service to air-conditioning units. Wires and wiring should be installed according to the National Electrical Code (NEC) (2011) to safeguard people and property and avoid violations. However, it is possible that this will not have been done. In such a case, the electrician will have to be called to update the wiring to carry the extra load of the installation of new air-conditioning or refrigeration equipment. Following is a brief discussion of the more important tools used by the electrician in the installation of air-conditioning and refrigeration equipment. Althouse, Turnquest, & Bracciano (2003).

Pliers and Clippers

Pliers come in a number of sizes and shapes designed for special applications. Pliers are available with either insulated or uninsulated handles. Although pliers with insulated handles are always used when working on or near "hot" wires, they must not be considered sufficient protection alone. Other precautions must be taken. Long-nose pliers are used for close work in panels or boxes. Slip-joint, or gas, pliers are used to tighten locknuts or small nuts. Wire cutters are used to cut wire to size.

Fig 4

Pillars.

Fuse Puller

The fuse puller is designed to eliminate the danger of pulling and replacing cartridge fuses by hand, it is also used for bending fuse clips, adjusting loose cutout clips, and handling live electrical parts. It is made of a phenol material, which is an insulator. Both ends of the puller are used. Keep in mind that one end is for large-diameter fuses; the other is for small diameter fuses.

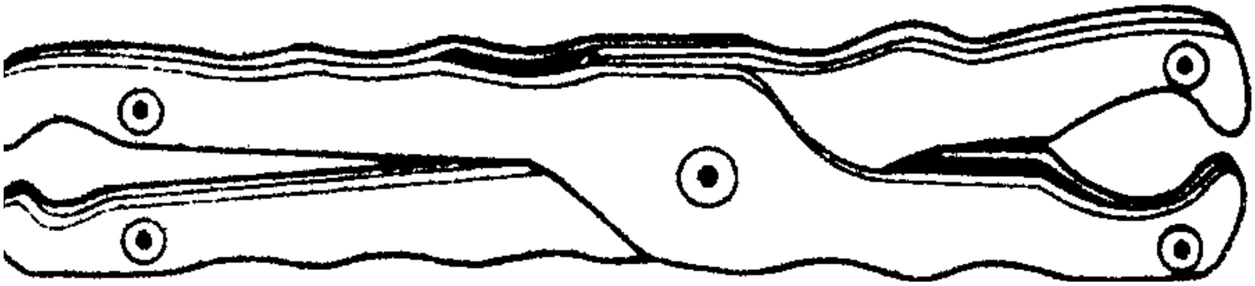
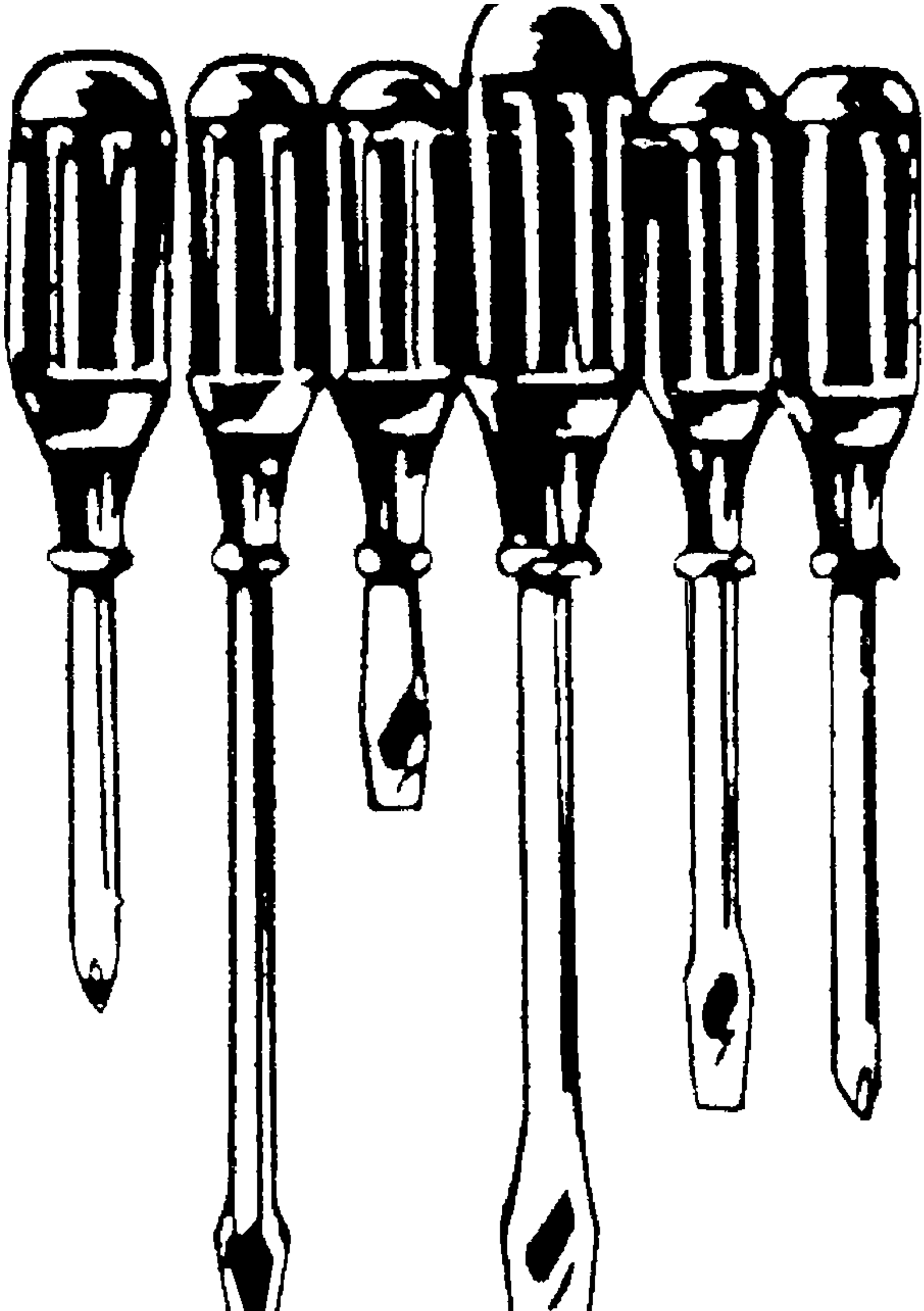


Fig 5

Fuse puller

Screwdrivers

Screwdrivers come in many sizes and tip shapes. Those used by electricians and refrigeration technicians should have insulated handles. One variation of the screwdriver is the screwdriver bit. It is held in a brace and used for heavy-duty work. For safe and efficient use, screwdriver tips should be kept square and sharp. They should be selected to match the screw slot. The Phillips-head screwdriver has a tip pointed like a star and is used with a Phillips screw. These screws are commonly found in production equipment. The presence of four slots, rather than two, assures that the screwdriver will not slip in the head of the screw. There are a number of sizes of Phillips-head screwdrivers. They are designated as No. 1, No. 2, and so on. The proper point size must be used to prevent damage to the slot in the head of the screw. Fig 6



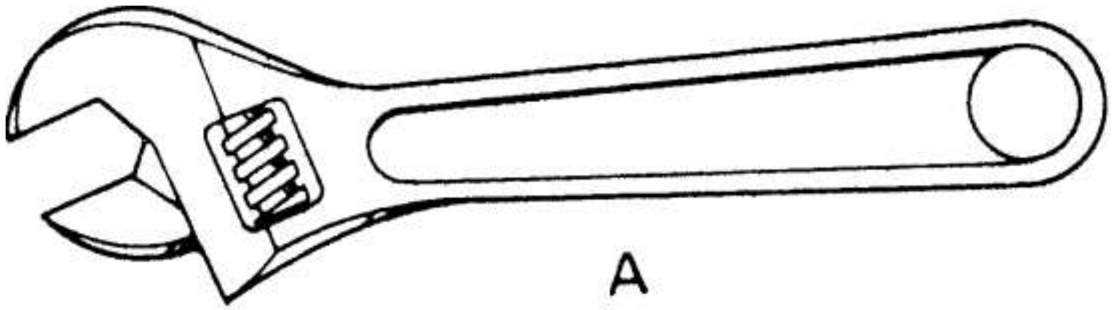
Wrenches

Kliefgen & Frens-Belken (1996) mentioned three types of wrenches used by the air-conditioning and refrigeration trade are shown below.

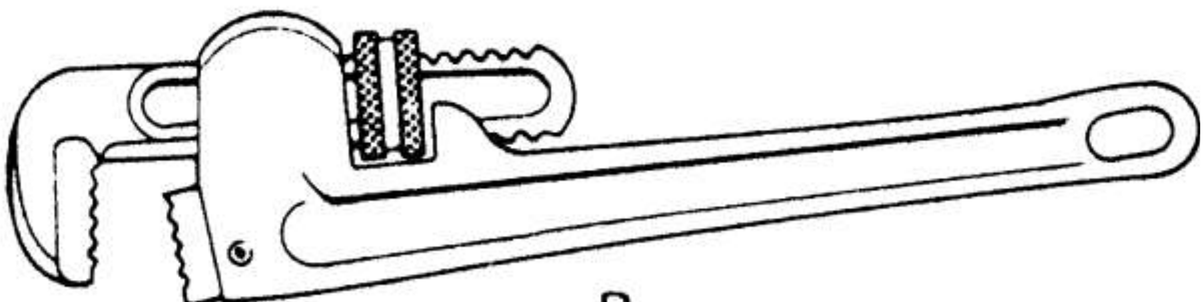
• The adjustable open-end wrenches are commonly called crescent wrenches.

• Monkey wrenches are used on hexagonal and square fittings such as machine bolts, hexagonal nuts, or conduit unions.

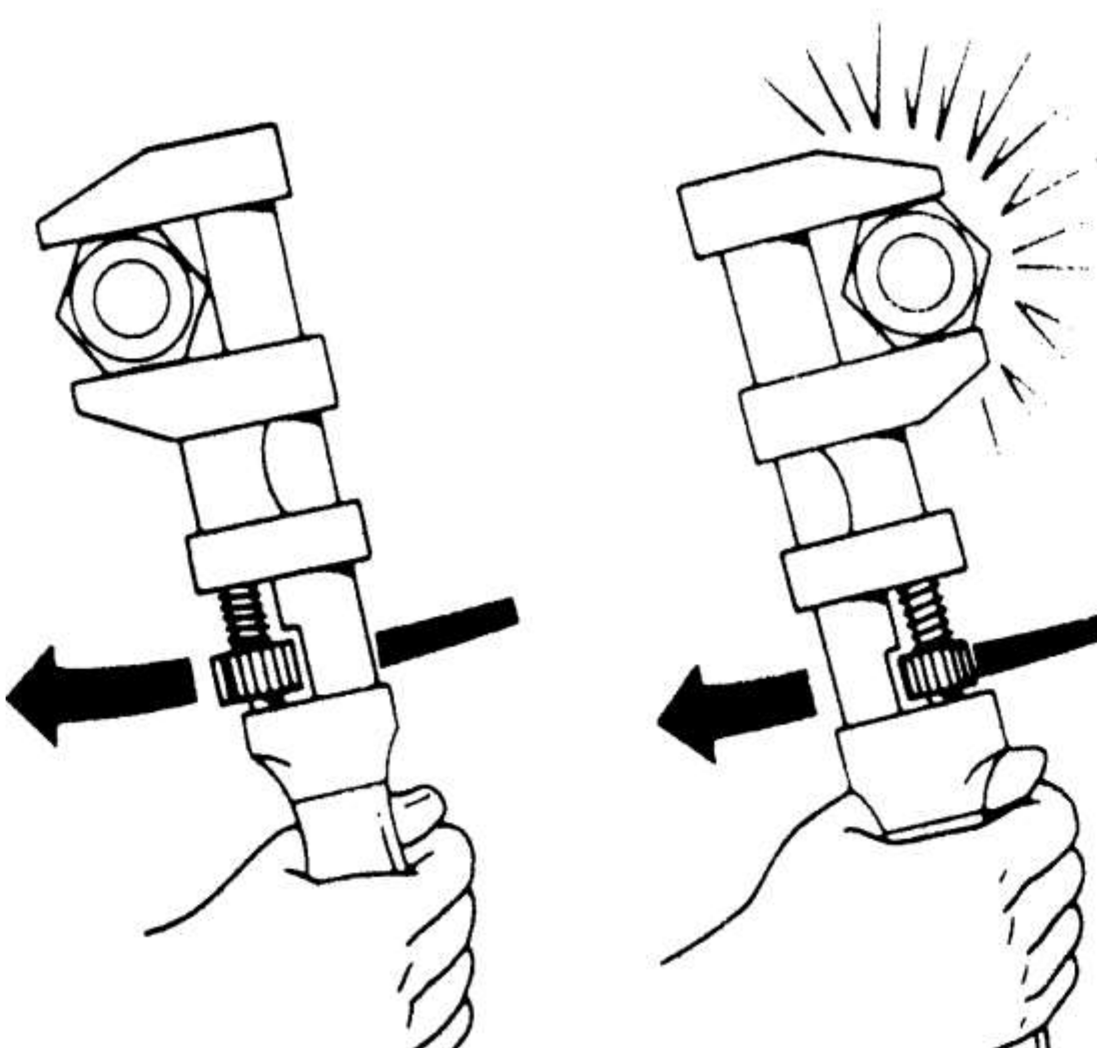
• Pipe wrenches are used for pipe and conduit work. They should not be used where crescent or monkey wrenches can be used. Their construction will not permit the application of heavy pressure on square or hexagonal material. Continued misuse of the tool in this manner will deform the teeth on the jaw face and mark the surfaces of the material being worked. The figure below shows example of wrench and how it is held while in use. (Fig 7).



A



B



Soldering Equipment

The standard soldering kit used by electricians consists of the same equipment that the refrigeration mechanics use. It consists of a nonelectric soldering device in the form of a torch with propane fuel cylinder or an electric soldering iron, or both. The torch can be used for heating the solid-copper soldering iron or for making solder joints in copper tubing. A spool of solid tin-lead wire solder or flux-core solder is used. Flux-core solder with a rosin core is used for electrical soldering. Solid-core solder is used for soldering metals. It is strongly recommended that acid-core solder should not be used with electrical equipment. Soldering paste is used with the solid wire solder for soldering joints on copper pipe or solid material. It is usually applied with a small stiff-haired brush.

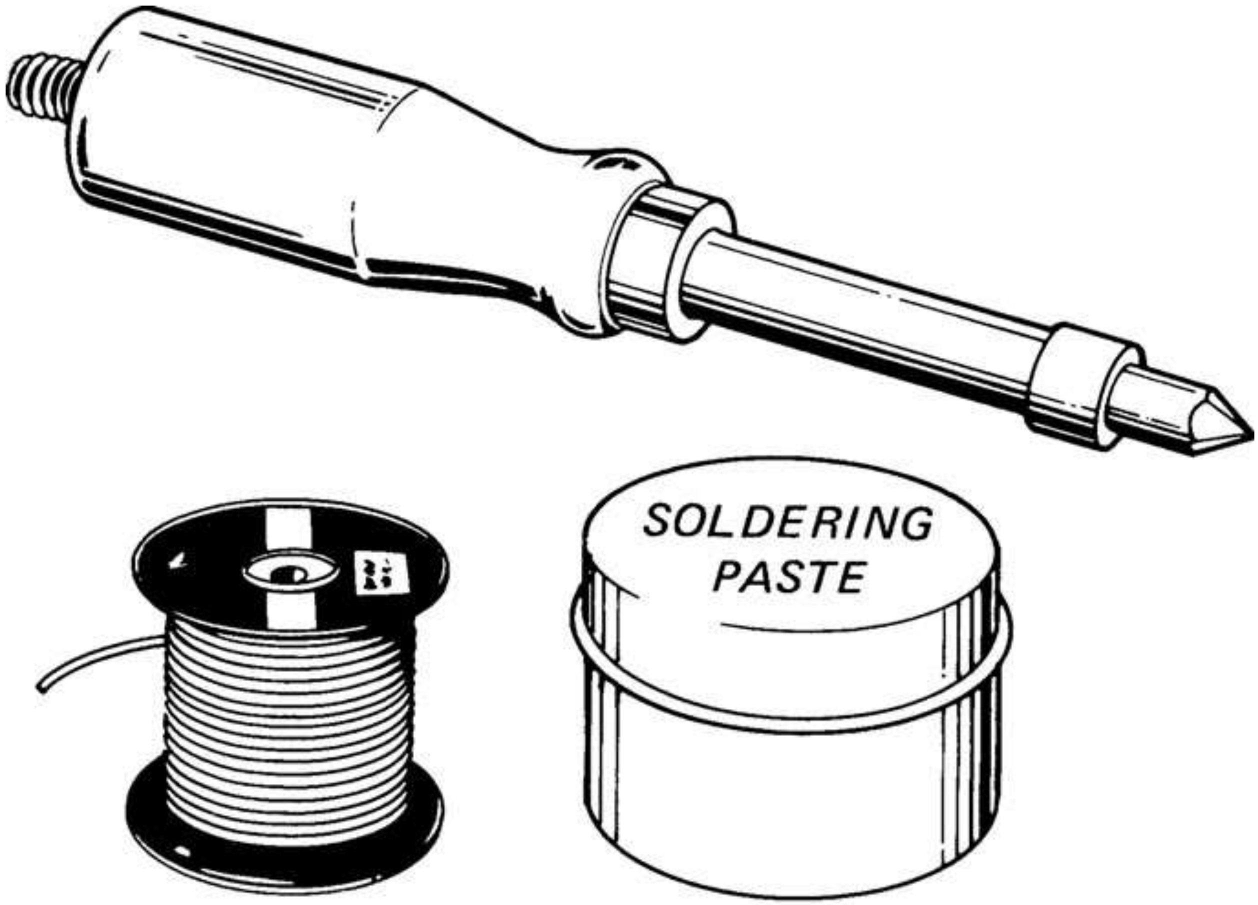


Fig 8

Soldering equipment

Woodworking Tools

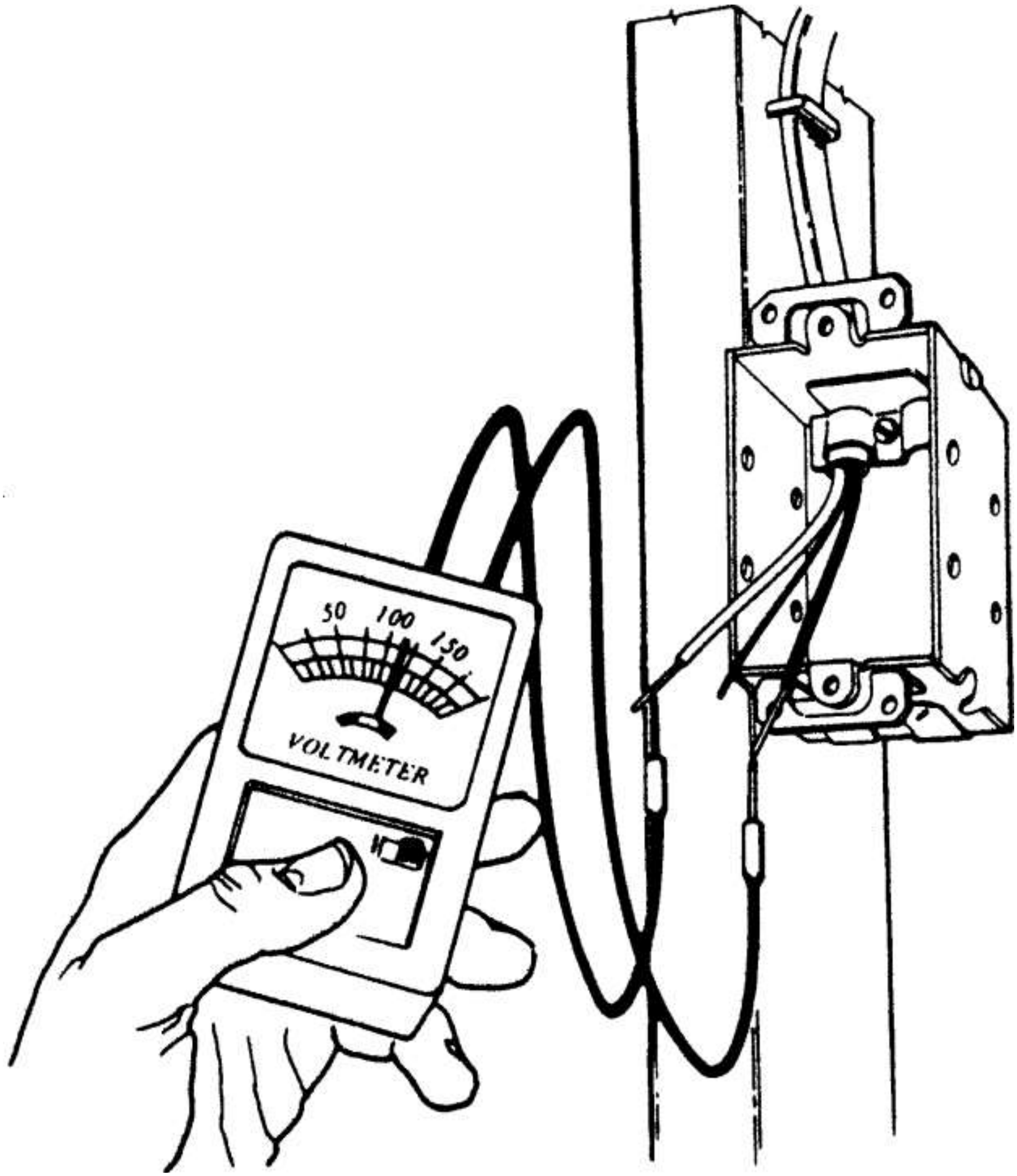
Crosscut saws, keyhole saws, and wood chisels are used by electricians and refrigeration and air-conditioning technicians. They are used to remove wooden structural members, obstructing a wire or conduit run, and to notch studs and joists to take conduit, cable, box-mounting brackets, or tubing.

Fig 9

Wood working tools.

Meters and Test Prods

An indicating voltmeter or test lamp is used when determining the system voltage. It is also used in locating the ground lead and for testing circuit continuity through the power source. They both have a light that glows in the presence of voltage.


50 100 150
VOLTMETER

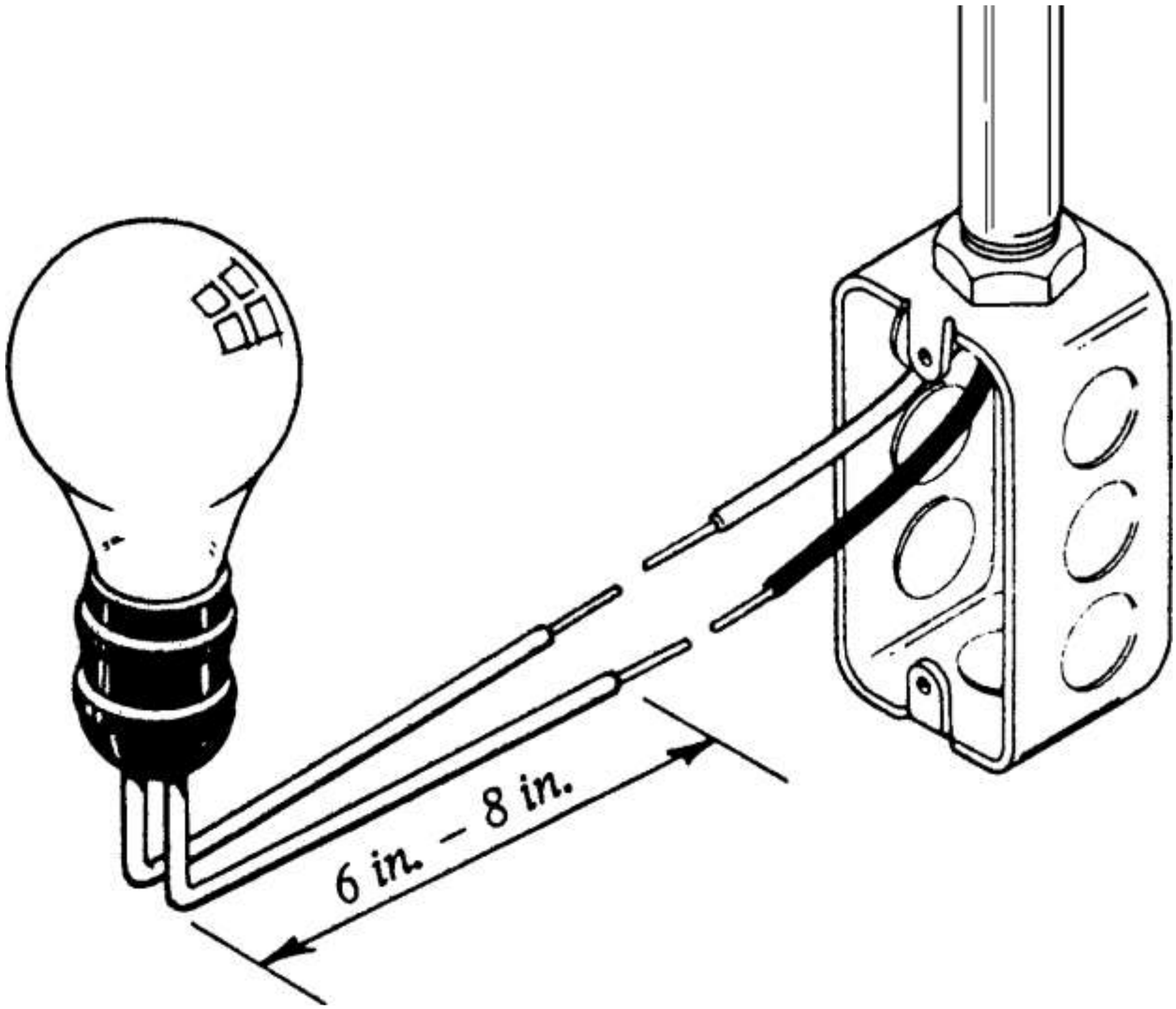


Fig 10

Test devices.

Tool kit

Technicians need to keep their working tools save and in good working condition. Some tool manufacturers make up tool kits for the refrigeration and appliance trade. In the Snap-on tool kit, the leak detector is part of the kit. The gages are also included. An adjustable wrench, tubing cutter, hacksaw, flaring tool, and ball-peen hammer can be hung on the wall and replaced when not in use. One of the problems for any repairperson is keeping track of tools. Markings on aboard will help locate at a glance when one is missing.

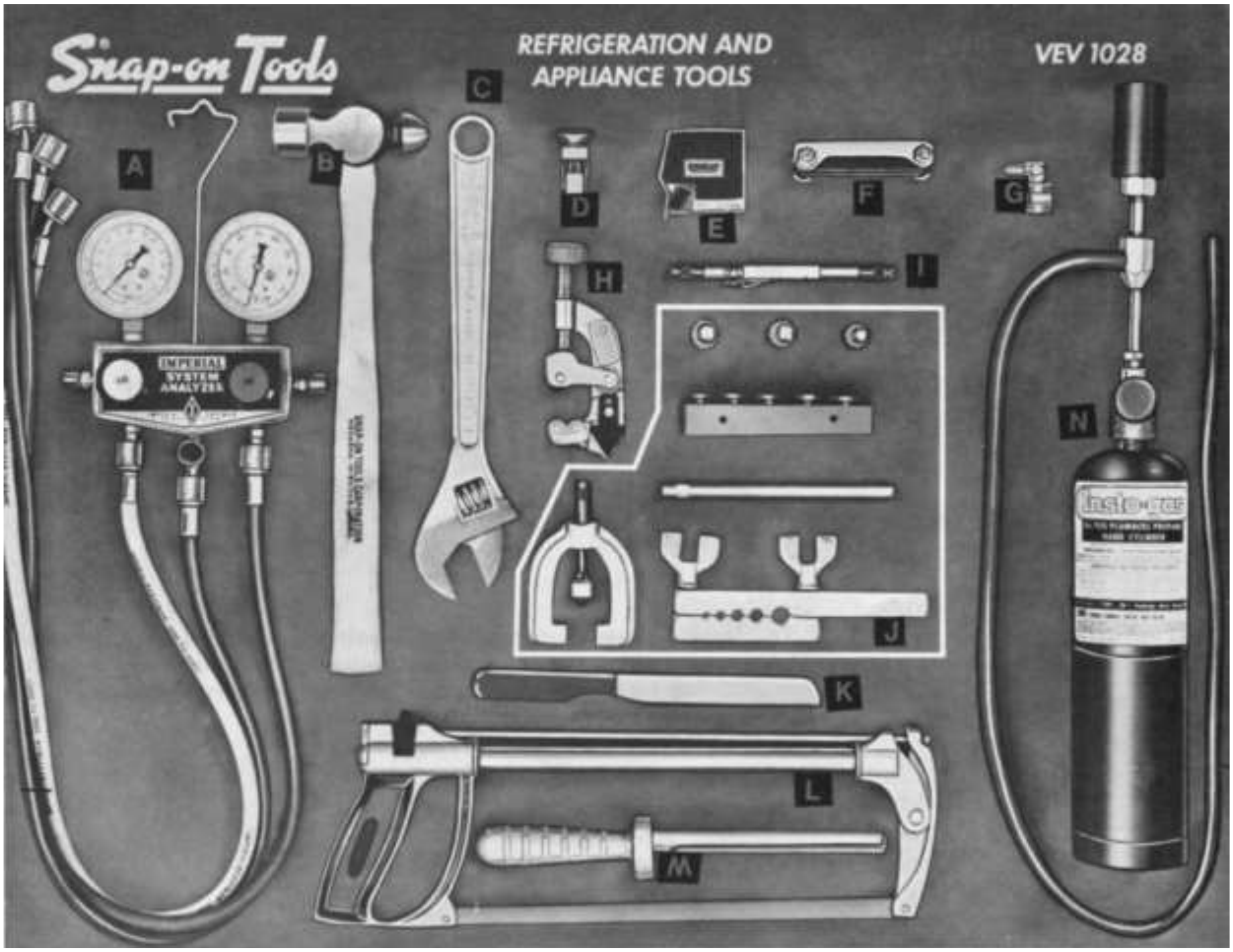


Fig 11

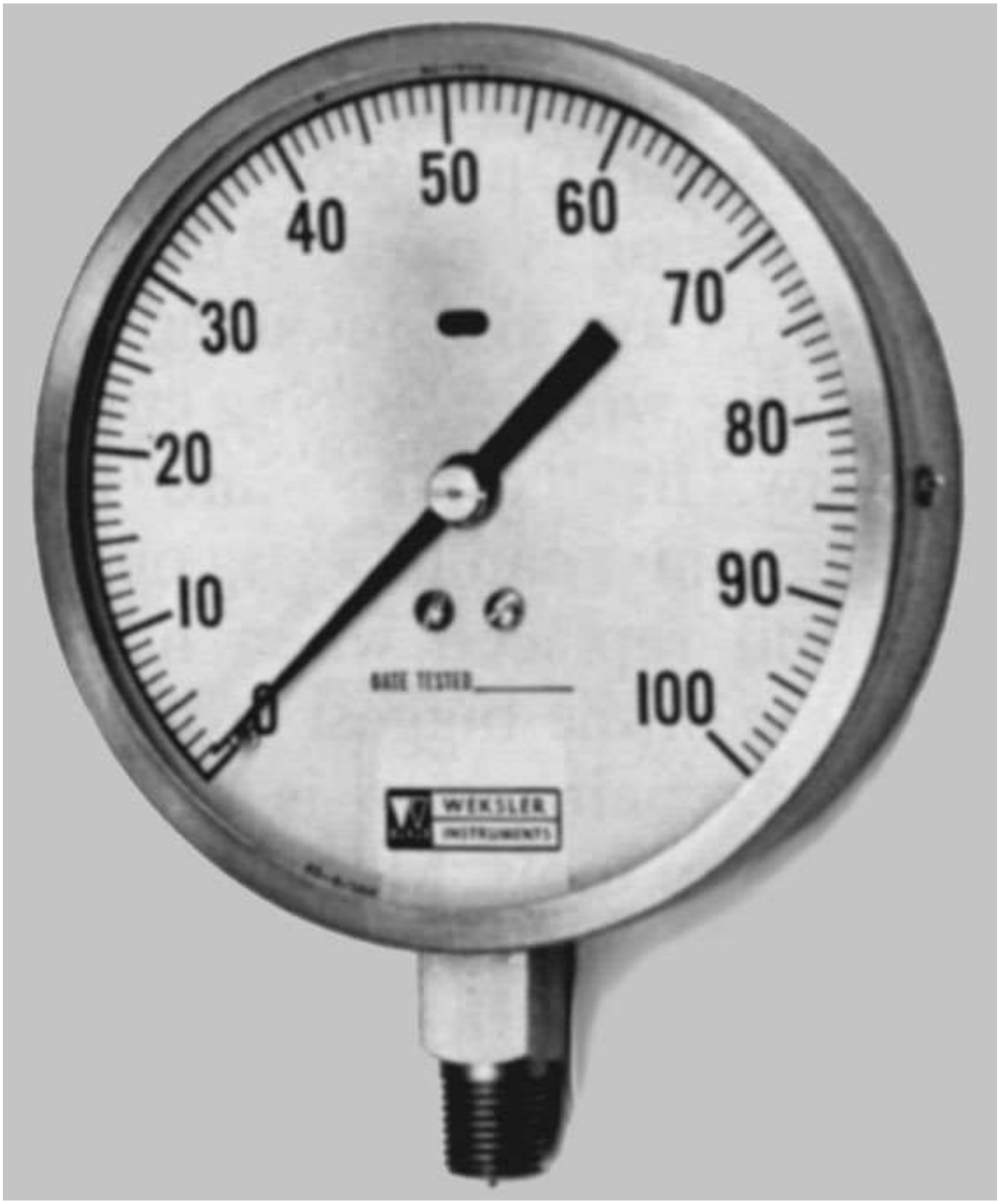
Example of a tool kit (A) Servicing manifold. (B) Ball-peen hammer. (C) Adjustable wrench. (D) Tubing tapper. (E) Tape measure. (F) Allen wrench set. (G) 90° adapter service part (H) Tubing cutter. (I) Thermometer (J) Flaring tool kit. (K) Knife. (L) Hacksaw. (M) Jab saw. (N) Halide leak detector.

Gauges and instruments

It is impossible to install or service air-conditioning and refrigeration units and systems without using gauges and instruments. A number of values must be measured accurately if air-conditioning and refrigeration equipment is to be operated properly. Refrigeration and air-conditioning units must be properly serviced and monitored if they are to give the maximum efficiency for the energy expended. Here, the use of gauges and instruments becomes important. It is not possible to analyze a system's operation without the proper equipment and procedures. In some cases, it takes thousands of naira worth of equipment to troubleshoot or maintain modern refrigeration and air-conditioning system. Instruments are used to measure and record such values as temperature, humidity, pressure, airflow, electrical quantities, and weight. Instruments and monitoring tools can be used to detect incorrectly operating equipment. They can also be used to check efficiency. Instruments can be used on a job, in the shop, or in the laboratory. If properly cared for and correctly used, modern instruments are highly accurate. Althouse, et al (2003).

Pressure Gauges

Pressure gages are relatively simple in function.



A pressure gauge

Refrigeration Analyzer

A refrigeration system analyzer checks the coolant lines to determine measurements of the temperature and pressure of the equipment. This handheld refrigeration tool has a digital screen with female connections located on the bottom. The connection can be spliced into the refrigeration line to measure whether the correct temperature and amount of pressure is flowing into the refrigeration unit (Brockman, 2004).

Leak Detector

A leak detector is a tool used by a technician to determine where a possible coolant leak is coming from in the coolant line of a refrigeration unit. This tool is a handheld device that connects to coolant line by a flexible probe that slides into the line. The leak detector pumps air into the line and can determine where the coolant leak is coming from. The leak detector comes with replacement sensors and filters to prevent a false reading on other refrigeration lines (Brockman, 2004).

Anemometer

An anemometer is used by a technician to check the air flow of the ventilation system installed for air-conditioning. The anemometer also measures the air velocity and ambient temperature of the air-conditioning flow. The tool has a digital readout that attaches to a hose leading to the measuring sensor, which looks similar to a small fan. The anemometer can read the air flow, air velocity and ambient temperature at the same time to determine if the air circulation is enough to cool all the rooms in the building (Brockman, 2004).

TROUBLESHOOTING SKILLS NEEDED BY TECHNICIANS IN REFRIGERATORS AND AIR CONDITIONERS

Troubleshooting skills is the ability to troubleshoot well, this is usually gained through training or experience. This also include the proper use of the tools and equipment used in troubleshooting, a good technician must have been well trained and during this period of training the technician should be open minded so as to learn whatever is been taught. Flesher (1993). Experience they say is the best teacher, the technician should also carry out repairs in the course of training to have a good experience of how to troubleshoot properly. Understanding the general principle of operation of a refrigerator and air conditioner and also the general principle of troubleshooting these appliances will go a long way in improving the troubleshooting skills of the technician this is because the problem of an appliance differs from another. According to Johnson (1989), there are important skills a technician needs to possess these are;

- Customer-service skills. Technicians often work in customers' homes or business offices, so it is crucial that they be friendly, polite, and punctual. HVACR repair technicians must sometimes deal with unhappy customers whose heating or air condition is not working.
- Detail oriented. Technicians must be able to find problems and make precise repairs or adjustments. They must pay attention to details when installing or repairing equipment to make sure it works properly.
- Dexterity. Technicians use many hand tools and must have good hand-eye coordination to avoid injury.
- Mechanical skills**.** HVACR technicians install and work on complicated climate-control systems. Workers must understand the components and be able to properly assemble and disassemble them.

- Physical strength**.** Workers may have to lift and support heavy equipment and components, often without help.
- Time-management skills. HVACR technicians often have a set number of daily maintenance calls. They should be able to keep a schedule and complete all necessary repairs or tasks.
- Troubleshooting skills. Heating, air conditioning, and refrigeration systems involve many intricate parts. To repair malfunctioning systems, technicians must be able to identify problems, often with sophisticated diagnostic equipment.

Duties of refrigerators and air conditioners technicians

Green (1990), said Heating, Air conditioning, and Refrigeration mechanics and installers typically do the following:

- Travel to worksites
- Follow blueprints or other design specifications to install or repair refrigerators and air conditioners systems
- Connect systems to fuel and water supply lines, air ducts, and other components
- Install electrical wiring and controls and test for proper operation
- Inspect and maintain customers' refrigerators and air conditioners systems
- Test individual components to determine necessary repairs
- Repair or replace worn or defective parts

Heating and air conditioning systems control the temperature, humidity, and overall air quality in homes, businesses, and other buildings. By providing a climate controlled environment, refrigeration systems make it possible to store and transport food, medicine, and other perishable items.

Although trained to do all three, HVACR technicians sometimes work strictly with heating, air conditioning, or refrigeration systems. They also may specialize in certain types of HVACR equipment, such as water-based heating systems, solar panels, or commercial refrigeration. Mostia (2000). Depending on the task, HVACR technicians use many different tools. For example, they often use screwdrivers, wrenches, pipe cutters and other basic hand tools when installing systems. To test or install complex system components, technicians may use more sophisticated tools, such as carbon monoxide testers, voltmeters, combustion analyzers, and acetylene torches.

When working on air conditioning and refrigeration systems, technicians must follow government regulations regarding the conservation, recovery, and recycling of refrigerants. This often entails proper handling and disposal of fluids. Green (1990) said some HVACR technicians sell service contracts to their clients, providing regular maintenance of heating and cooling systems. Other technicians sometimes help install or repair cooling and heating systems. For example, on a large air conditioning installation job, especially one in which workers are covered by union contracts, ductwork might be done by sheet metal workers and duct installers, or electrical work by electricians.

RELATIONSHIP BETWEEN TECHNICAL KNOWLEDGE AND TROUBLESHOOTING SKILLS

With a high technical knowledge and troubleshooting skills of technicians they troubleshoot better since they know the basic principle of operation and principles of troubleshooting refrigerators and air conditioners, and even the tools and equipment to use for troubleshooting, repair and maintenance of the refrigerators and air conditioners. It also improves their confidence in attending to issues and satisfying their customers. Nichols (1994) also added that consistent technical knowledge on troubleshooting skills is integral to providing world class customer service in support centers. Customers want timely, professional, and consistent issue resolution – every time.

Impacts of Consistent Troubleshooting Skills

Ultimately, companies desire to keep customers happy. Providing sound resolutions, delivered as fast as possible, is the number one way to maintain customer loyalty. Green (1990) highlighted four reasons why roadside technicians must possess efficient technical knowledge on troubleshooting skills**:**

1. Increased Customer Satisfaction: Resolving customer issues quickly decreases the inconvenience for the customer and increases satisfaction. There is a direct relationship between resolution time and customer satisfaction.
2. Reduced Operational Costs: Reducing time to resolution increases efficiency reduces the labor requirement, and the total cost per call.
3. Improved Internal Communication: Having a common language and process for solving problems improves communication between departments and different levels of support.

Improved communication not only expedites issue resolution, but also reduces employee stress.

4. Improved Employee Satisfaction: Technicians who are better skilled are more adept at resolving customer issues. This increases their confidence and motivation to perform well on the job.

When customers have issues, soft skills training teaches technicians to open the call in a way that quickly builds rapport, diffuses customer anxiety, and focuses the customer on the process of finding a solution. But can training improve diagnostic troubleshooting skills for IT professionals? Yes! It is important to set customers' at ease, but it's equally important to consistently identify and solve issues correctly – the first time. Diagnostic troubleshooting training will streamline processes and ensure all technicians are approaching common issues the same way.

Steps for Consistent Troubleshooting

Technical support professionals must possess good decision making skills and the ability to quickly anticipate and devise solutions to a seemingly unending list of potential product or service issues.

Good decision making requires clear, logical, and systematic thinking habits as well as the aptitude for conceptualizing, analyzing, and evaluating information rapidly. Deductive reasoning – determining a conclusion based on previously known facts–will come readily for more seasoned agents. According to Bureau of Labor Statistics, United Sttates Department of Labor(2012), having a standardized process for known issues collected in a knowledge base or process guide book will assist new technicians and shorten their the time to resolution.

To provide consistent technical support, Mostia (2000) said, agents must have the diagnostic troubleshooting skills necessary to:

1. Verify the problem
2. Define the problem
3. Isolate the problem
4. Identify the problem
5. Justify the solution
6. Resolve the problem

Summary of reviewed related literature

The literature review on the technical knowledge of roadside technicians in troubleshooting expertise in refrigerators and air conditioners was done under various sub-topics. The review revealed that roadside technicians troubleshoot using the try and error method because of their lack of technical knowledge on the skill.

The review also indicates that roadside technicians need to acquire technical knowledge on the skill so as to know the basic and general principle of troubleshooting in refrigerators and air conditioners. In achieving this they will troubleshoot better. It is imperative that the service technician understands the principles and the tools needed to perform proper troubleshooting efficiently.

CHAPTER 3

METHODOLOGY

This chapter describes the procedures used in carrying this study under the following; research design, area of study, population, sample, instrument for data collection, validation of instruments, method of data analysis and decision rule.

Research design

This study employs a survey research design since the study was to assess the roadside technician's technical knowledge and troubleshooting expertise in refrigerators and air conditioners in Minna metropolis. A survey research is one in which a group of people or items is studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group (Nworgu, 2006).

Area of study

Minna metropolis comprises of two local government areas which are Bosso and chanchaga. This research will cover roadside technicians in Bosso and chanchaga local government area in Minna metropolis only.

Population

The targeted population used for this research comprises of 10 master craft men and 15 senior apprentices in Bosso Local Government Area, 15 master craft and 10 senior apprentices in Chanchaga Local Government Area of the refrigerators and air conditioners roadside technicians. Since the population was small there was no need for sampling.

Instruments for data collection

The instrument for data collection was a structured questionnaire developed by the researcher. The questionnaire contains items organized into two parts:

Part 1- contains personal data of the respondents.

Part 2-contains the item of the questionnaire structured into three sections, sections A, B & C. Section A contains 20 items on the extent of technical knowledge possessed by roadside technicians in refrigerators and air conditioners. Section B contains 16 items on the troubleshooting skills possessed by technicians in refrigerators and air condoners. Section C contains 20 items on the impact of technical knowledge on troubleshooting skills of roadside technicians in Minna metropolis.

A 4-point rating scale was used; for section A, Very High (VH), High (H), Low (L) and Very Low were used while for sections B and C, Strongly Agreed (SA), Agreed (A), Disagreed (D) and Strongly Disagreed (SA) were used. The weight values assigned to the various measurements are 4, 3, 2 and 1 respectively.

Validation of the instrument

For the purpose of validating the instrument, copies of the draft questionnaire was given to three lecturers in the Department of Industrial and Technology Education to make necessary modification on the structuring and organization of the item, their suggestions and modification was considered when preparing the final draft of the instrument.

Administration of instrument

The researcher and research assistant administered the questionnaire, that is the distribution and collection of the questionnaire was carried out by the researcher and research assistant.

Method of analysis

Frequency count, mean, standard deviation and t-test were used for data analysis.

Mean: summing up the product of the frequency and nominal value of each response option for each item and dividing by the number of respondents to each item.

Mean $=\overline{X} = \frac{\Sigma fX}{N}$

Where,

$\overline{X}$= mean of each item

X = nominal value of option

Σ=summation

N =number of items

F =frequency of response to each item.

The standard deviation of each item was computed using the formula

$$S.D \sqrt{\frac{\Sigma f(X-\bar{X})^2}{N}}$$

Where,

S.D = standard deviation

X = mean of each item

$\bar{X}$ = grand mean of all items

F = frequency of scores

N = total number of items

Σ = summation.

T-test was used to compare the mean of each item of roadside technicians of refrigerators and air conditioners and the users of these appliances and to determine between their responses.

The formula for calculating t-value is:

$$t = \sqrt{\frac{(N_1 - 1)S^2 + (N_1 - 1)S^2}{N_1 + N_2 - 2}\left[\frac{1}{N_1} + \frac{1}{N_2}\right]}$$

Where,

t = test of significance

$\bar{X}_1$ = grand mean of group 1

$\bar{X}_2$ = grand mean of group 2

N_1 = number of respondent in group 1

N_2 = number of respondent in group 2

$s^2{}_1$= variance of group 1 (squared of S.D for group 1)

$s^2{}_1$= variance of group 1 (squared of S.D for group 1)

$N_1 + N_2 - 2$= degree of freedom.

Decision rule

The mean of 2.50 was used as decision point for every questionnaire item. Consequently, any item with mean responses of 2.50 and above was considered to be agreed. Any item with a mean response of 2.49 and below was equally considered disagreed in Section A, B and C respectively. Also t- test statistics was used to test the hypothesis at 0.05 level of significance to compare the mean response of the groups. A t- critical value of ± 2.00 was selected based on the degree of freedom at 0.05 level of significant. Therefore, any item with t- calculated value less than the critical was regarded as not significant. While any item with t- calculated value equal or greater than the critical was regarded as significant.

CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

This chapter deals with the presentation and analysis of the data collected in respect to the study. The data was presented according to research question and the hypotheses formulated for the study.

Research Question 1

What is the extent of technical knowledge possessed by roadside technicians in refrigerators and air conditioners in Minna metropolis?

Table 1:

Mean response of the master craft men and senior apprentice on the extent of technical knowledge possessed by roadside technicians in refrigerators and air conditioners in Minna metropolis

$N_1 = 25$, $N_2 = 25$

S/NO	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_t$	Remarks
1	Knowledge of the general principle of troubleshooting.	3.40	3.09	3.24	High.
2	Principle of operation of the refrigerators and air conditioners.	3.48	3.44	3.46	High.
3	Ability to read and interpret instructions, blueprint, work orders and even assembling.	3.64	3.48	3.56	High.
4	The principle of measuring the compressor suction and discharge pressure.	3.60	3.56	3.58	High.
5	Understanding the components of the appliances to properly assemble or disassemble its parts.	3.72	3.40	3.56	High.
6	Comprehend the importance of a safe working environment.	3.88	3.84	3.86	High.
7	The proper use of special safety equipment while working on heating, ventilation, air conditioning and refrigeration system.	3.96	3.88	3.92	High.
8	The use of safe operating procedures with tools and equipment such as hand and power tools, ladder and lifting equipment.	3.88	3.84	3.86	High.

9	Ability to identify specific regulations and requirements for the heating, ventilation, air conditioning and refrigeration industry as defined by the Environment Protection Agency. (EPA)	2.28	1.96	2.12	Low.
10	Ability to interprets and apply manufactures' correspondence for safety procedures.	3.72	3.64	3.68	High.
11	The use of metering devices in refrigerators and air conditioners	3.40	3.36	3.38	High.
12	Understanding how the compressor works.	3.84	3.76	3.80	High.
13	Examine the physical and chemical properties of refrigerants.	3.56	3.44	3.50	High.
14	Identify the different refrigerant oils and their uses.	3.64	3.44	3.54	High.
15	Construct and interpret refrigerators and air conditioners schematics and wiring diagrams.	3.88	2.68	3.28	High.
16	Knowledge of characteristics and identification of refrigerant.	3.60	3.48	3.54	High.
17	Install/ service/ troubleshoot/ replace refrigeration system.	3.36	2.92	3.14	High.
18	Troubleshoot and replace power element.	3.44	3.32	3.38	High.
19	Install/ check/ refill refrigeration compressor.	3.84	3.76	3.80	High.
20	Knowledge of flushing, purging and pressure testing for leaks.	3.84	3.52	3.68	High.

Key

N_1 = number of master craft men.

N_2 = number of senior apprentice.

$\bar{X}_1$ = mean of master craft men.

$\bar{X}_2$ = mean of senior apprentice.

$\bar{X}_t$ = average mean of master craft men and senior apprentice

Results emanating from table 1 reveals that the respondents scored high on 19 of the items with average mean score of 2.50 and above, meaning that the respondent's technical knowledge in these areas of refrigerators and air conditioners is high. Respondents however scored low on item 9. Meaning that respondents have low knowledge in identifying specific refrigerants

these areas of refrigerators and air conditioners is high. Respondents however scored low on item 9. Meaning that respondents have low knowledge in identifying specific refrigerants

Research question 2

What are the troubleshooting skills possessed by technicians in refrigerators and air conditioner.

Table 2:

Mean responses of the master craft men and senior apprentices on the troubleshooting skills possessed by technicians in refrigerators and air conditioners.

$N_1 = 25$ $N_2 = 25$

S/NO	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_t$	Remarks.
1	The ability to do the work of a refrigeration and air conditioning equipment with less supervision is high.	3.92	3.84	3.88	Agree.
2	Analyzing a system operation using gauges and instruments.	3.88	3.76	3.82	Agree.
3	Detect problems and make precise repairs or adjustments.	3.36	3.28	3.32	Agree.
4	Using refrigeration system analyzer to check coolant lines to determine measurements of the temperature and pressure of the equipment.	3.00	2.32	2.66	Agree.
5	Using an anemometer to check the air flow of the ventilation system installed for air-conditioning.	2.64	2.60	2.62	Agree.
6	Using a leak detector to determine possible coolant leak in the coolant line of a refrigeration unit.	2.08	1.36	1.72	Disagree.
7	Using the correct tool for the correct work.	3.76	3.64	3.70	Agree.
8	Using gauges to measure valve measured accurately.	3.96	3.92	3.94	Agree.
9	Using voltmeter to determine the system's voltage.	3.88	3.84	3.86	Agree.
10	Using fuse puller designed to eliminate the danger of pulling and replacing cartridge fuses by hand.	3.56	3.44	3.50	Agree.
11	Using pliers to tighten locknuts or small nuts.	3.96	3.92	3.94	Agree.
12	Using wire cutters to cut wire to size.	3.92	3.80	3.86	Agree.
13	Using a multimeter and a pressure module to quickly and accurately determine suction pressure.	2.68	2.08	2.38	Disagree.
14	Using an infrared thermometer to scan the temperatures of different components.	2.24	1.80	2.02	Disagree.
15	Operate and maintain tools in accordance with manufacturer's instruction and as required by regulations or instructors.	3.84	3.04	3.44	Agree.
16	Using screw driver to tighten or loosen nuts.	3.92	3.80	3.86	Agree.

Results emanating from table 2 reveals that respondents agree with 13 of the items, with average mean score of 2.50 and above, meaning that troubleshooting skills possessed by technicians in refrigerators and air conditioners is agreed. Respondent's however disagree with items 6, 13 and 14 meaning respondents do not know how to use a leak detector, multimeter and pressure module and an infrared thermometer respectively.

Research question 3:

What is the impact of technical knowledge on troubleshooting skills of roadside technicians?

Table 3:

Mean responses of the master craft and senior apprentices on the impact of technical knowledge on troubleshooting skills of roadside technicians in Minna metropolis.

$N_1 = 25$, $N_2 = 25$

S/NO	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_t$	Remarks.
1	Understanding the principle of operation of refrigerators and air conditioners boost troubleshooting skills	3.44	3.40	3.42	Agree.
2	Reading and interpreting instructions, blueprint, and work orders have positive impact on my troubleshooting skills	3.52	3.44	3.48	Agree.
3	Interpreting refrigerators and air conditioners schematics and wiring diagrams helps in troubleshooting faults	3.96	3.84	3.90	Agree.
4	Knowledge of safety rules while working on refrigerators and air conditioners improves troubleshooting skills.	3.80	3.72	3.76	Agree.
5	Knowledge on anemometer guides a technician to check the air flow of the ventilation system installed for air conditioners.	3.28	3.00	3.14	Agree.
6.	Having technical knowledge increases satisfaction of the customer and decreases inconveniences.	3.68	3.64	3.68	Agree.
7	Knowledge of the principle of operation of voltmeter helps a technician to use voltmeter to determine the voltage of refrigerators and air conditioners.	3.96	3.92	3.94	Agree.
8.	Technical knowledge improves the speed of troubleshooting.	3.80	3.76	3.78	Agree.
9.	Technical knowledge reduces time of resolution, increases efficiency, reduces the labor requirements and reduces the total cost per call.	3.28	3.20	3.24	Agree.
10.	Technical knowledge increases the confidence and motivation to perform well on the job.	3.44	3.40	3.42	Agree.
11.	Technical knowledge helps to constantly identify and solve issues correctly.	3.52	3.48	3.50	Agree.
12.	Technical knowledge helps to streamline processes and ensure that technicians are approaching common issues the same way.	2.72	2.04	2.38	Disagree.
13.	Technical knowledge reduces the risk of try and error.	2.88	2.60	2.74	Agree.
14.	Having the knowledge of the principle of operation of these	3.32	3.28	3.30	Agree.

	appliances has helped in troubleshooting better and faster.				
15.	Skills of troubleshooting is better understood with technical knowledge	3.24	3.04	3.14	Agree.
16.	Technical knowledge helps in keeping tools safe and clean after use.	3.92	3.88	3.90	Agree.
17.	Technical knowledge helps in troubleshooting the refrigerators and air conditioners by using gauges.	3.76	3.66	3.71	Agree.
18.	Safety is achieved during work because of the knowledge of the usage of tools and equipment.	3.84	3.80	3.82	Agree.
19.	Technical knowledge helps to Maintain a courteous and responsive attitude towards all customers.	3.80	3.32	3.56	Agree.
20.	Measuring the compressor suction and discharge pressure can be achieved with the possession of technical knowledge.	3.28	3.20	3.24	Agree.

Respondents agreed with items 1-11, and 13-20 on table 3 with average mean score of 2.50 and above, which reveals that if the roadside technicians have the technical knowledge of the refrigerators and air conditioners it will do them a lot good to troubleshoot better and faster, but these roadside technicians disagreed with item 12 because no matter the impact of technical knowledge on them they all have their different method of approaching issues as regards troubleshooting refrigerators and air conditioners.

Hypotheses 1

There is no significant differences in the mean responses of the master craft men and senior apprentices with respect to the technical knowledge possessed by roadside technicians in refrigerators and air conditioners in Minna metropolis at [$p<0.05$] level of significance.

Table 4

t- test analysis of the respondents regarding the extent of technical knowledge possessed by roadside technicians in refrigerators and air conditioners in Minna metropolis.

Status of respondents	Number of respondents	Mean	Standard deviation	Degree of freedom	Calculated t-value	Table t-value	Decision
Master craft men	25	2.875	0.189	48	1.089	2.00	Accepted
senior apprentice	25	2.696	0.132				

Key

Number of respondents	50
Calculated t value	1.089
Degree of freedom	48
Table t-value	2.00
Decision	Accepted

The calculated t-value (1.089) in table 4 is not equal or exceeds the critical value of (2.00) necessary for rejection of null hypothesis at 0.05 level of significance. Therefore the null hypothesis is upheld. Hence there is no significant difference in the mean responses of the master craft men and senior apprentice on the technical knowledge possessed by them in refrigerators and air conditioners in Minna metropolis.

Hypotheses 2

There is no significance difference in the mean response of master craft and senior apprentice in relation to the troubleshooting skills possessed by technicians in refrigerators and air conditioner.

Table 5:

t-test of the Respondents on the troubleshooting skills possessed by technicians in refrigerators and air conditioner.

Status of respondents	Number of respondents	Mean	Standard deviation	Degree of freedom	Calculated t-value	Table t-value	Decision
Master craft men	25	2.184	0.169	48	1.041	2.00	Accepted
senior apprentice	25	2.017	0.169				

Key

Number of respondents	50
Calculated t value	1.041
Degree of freedom	48
Table t-value	2.00
Decision	Accepted

The calculated t-value (1.041) in table 5 is not equal or exceeds the critical value of (2.00) necessary for rejection of null hypothesis at 0.05 level of significance. Therefore the null hypothesis is upheld. Hence there is no significance difference in the mean response of master craft men and senior apprentice on the troubleshooting skills possessed by them in refrigerators and air conditioner.

Hypotheses 3

There is no significance difference in the mean responses of the master craft and senior apprentice as regards the impact of technical knowledge on troubleshooting skills of roadside technicians in Minna metropolis.

Table 6

t-test analysis of the Respondents as regards the impact of technical knowledge on troubleshooting skills of roadside technicians in Minna metropolis.

Status of respondents	Number of respondents	Mean	Standard deviation	Degree of freedom	Calculated t-value	Table t-value	Decision
Master craft men	25	2.817	0.206	48	1.752	2.00	Accepted
senior apprentice	25	2.702	0.226				

Key

Number of respondents 50

Calculated t value 1.752

Degree of freedom 48

Table t-value 2.00

Decision Accepted

The calculated t-value (1.752) in table 6 is not equal or exceeds the critical value of (2.00) necessary for rejection of null hypothesis at 0.05 level of significance. Therefore the null hypothesis is upheld. Hence there is no significance difference in the mean response of master craft men and senior apprentice on the impact of technical knowledge on troubleshooting skills on them.

Summary of findings

The following the findings of the study:

A. Findings related to the extent of technical knowledge possessed by roadside technicians in refrigerators and air conditioners shows that technicians have high knowledge in the following areas;

1. There is a high technicial knowledge of the principle of operation of the refrigerators and air conditioners by the roadside technicians.
2. There is a high knowledge of the principle of measuring the compressor suction and discharge pressure by the roadside technicians.
3. The roadside technicians make proper use of special safety equipment while working on heating, ventilation, air conditioning and refrigeration system.
4. The roadside technicians make use of safe operating procedures with tools and equipment such as hand and power tools, ladder and lifting equipment.
5. The roadside technicians have the ability to interprets and apply manufactures' correspondence for safety procedures.

6. The use of metering devices in refrigerators and air conditioners by the roadside technicians.
7. The roadside technicians can examine the physical and chemical properties of refrigerants.
8. The roadside technicians have the knowledge of characteristics and identification of refrigerant.
9. The roadside technicians can troubleshoot and replace power element.
10. The roadside technicians can install/ check and refill refrigeration compressor.

B. Findings related to the troubleshooting skills possessed by technicians in refrigerators and air conditioners.

1. The roadside technicians have the ability to do the work of refrigeration and air conditioning equipment with less supervision.
2. The roadside technicians can detect problems and make precise repairs or adjustments.
3. The roadside technicians can use an anemometer to check the air flow of the ventilation system installed for air-conditioning.
4. Using the correct tool for the correct work by the roadside technicians.
5. Using voltmeter to determine the system’s voltage by the roadside technicians.
6. Using pliers to tighten locknuts or small nuts by the roadside technicians.
7. The roadside technicians can use wire cutters to cut wire to size.
8. The roadside technicians can use screw driver to tighten or loosen nuts.
9. The ability of roadside technicians to make proper use of a leak detector is poor.

10. Roadside technicians do not know how to use a multimeter and a pressure module to quickly and accurately determine suction pressure

C. Findings related to the impact of technical knowledge on troubleshooting skills of roadside technicians in Minna metropolis.

1. The roadside technicians have understood the principle of operation of refrigerators and air conditioners.
2. The roadside technicians can read and interpret instructions, blueprint, and work orders.
3. The roadside technicians have understood the importance of using special safety equipment while working on refrigerators and air conditioners.
4. They can use voltmeter to determine the voltage of refrigerators and air conditioners.
5. It has improved the speed of troubleshooting skills of the roadside technicians.
6. The roadside technicians can constantly identify and solve issues correctly.
7. The principle of troubleshooting is better understood by the roadside technicians.
8. The roadside technicians have known the importance of keeping tools safe and clean after use.
9. Safety is achieved during work because of the knowledge of the usage of tools and equipment by the roadside technicians.
10. The roadside technicians can troubleshoot the refrigerators and air conditioners by using gauges.

Discussion of findings

The discussion of findings of this study were organized and presented according to the research questions and hypothesis.

As regards to the technical knowledge possessed by roadside technicians in Minna metropolis, the findings reveal that, even with the inadequate or no formal training of these roadside technicians they still understand the principle of operation and the principle of troubleshooting the refrigerators and air conditioners this is in disagreement with Nichols (1994) that said the roadside technicians do not pass through any formal training on these appliances to have the adequate knowledge on how they operate, so they will not be able to troubleshoot adequately. It also showed that roadside technicians can measure the compressor suction and troubleshoot it. Roadside technicians also use the right tool for the right job keeping in mind safety precautions while working with them which afterwards they keep the tools clean and save for easy location. Roadside technicians also make sure they use wires and wiring according to National Electrical Code (NEC) (2011) to safeguard people and property.

Furthermore, as regards to the findings of troubleshooting skills possessed by technicians in refrigerators and air conditioners shows that the road side technicians can troubleshoot these equipment without been supervised by anyone because of the skills they possessed, they can also detect problems and make precise repairs, they are also familiar with using the voltmeter to check the voltage of these equipments. As regards using a leak detector to determine possible coolant leak in the coolant line of a refrigeration unit, it was found out that most of the respondent do not make use of a leak detector, there reason been that the leak detector is not affordable, so after troubleshooting either a refrigerator or an air conditioner that has leaking fault, in other for them to be sure it is not leaking anymore they make use of the fume from detergents especially (omo) to do so, and this take a longer time to show the result. Also roadside technicians disagree with the effective use of the multimeter and pressure module to quickly and accurately determine suction pressure and also the use of an infrared thermometer to scan the temperature of refrigerators and air conditioners, the respondents complained that these instruments are expensive are such they cannot afford them. It was found that roadside technicians make use of soldering equipments to soldering joints on copper pipe or solid material. It is no doubt that these roadside technicians need adequate tools and instruments to troubleshoot easier and faster. Kliefgen & Frens-Belken (1996).

Finally, the findings as regards to the impact of technical knowledge on troubleshooting skills of roadside technicians in Minna metropolis, shows that the roadside technicians do not agree to the item of streamlining processes and ensuring that technicians are approaching common issues the same way, there reason been that every technician has his own way of approaching issues depending on the way the complaint presents the problem, so they disagree that technicians cannot have the same way of troubleshooting the refrigerators and air conditioners. It also shows that understanding the principle of operation of the refrigerator and air conditioner has boost troubleshooting skills, and this has lead to troubleshooting easier, better and faster. Technical knowledge has helped reduce the risk of try and error which has made technicians to approach issues directly thereby increasing their confidence in troubleshooting.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary of the study

The main purpose of this study is to assess the roadside technicians' technical knowledge and troubleshooting expertise in refrigerators and air conditioners in Minna metropolis. Three (3) research questions and three (3) hypotheses were formulated and used for the study.

Related literature were reviewed under the following headings: General principles of troubleshooting refrigerators and air conditioners, technical knowledge necessary for troubleshooting in refrigerators and air conditioners, troubleshooting skills needed by technicians in refrigerators and air conditioners, relationship between technical knowledge and troubleshooting skills and summary of the reviewed literature. A fifty six (56) questionnaire was used to assess the roadside technicians' technical knowledge and troubleshooting expertise in refrigerators and air conditioners in Minna metropolis. The statistical tools used for the analysis of the result were mean, standard deviation and t-test. The methodology described the research design, area of study which is Bosso and chanchaga local government area in Minna metropolis, the total population of 50 roadside technicians was used, since the population is few there was no need for sampling so the whole population was used which comprises of 10 master craft men and 15 senior apprentices in Bosso local government area, 15 master craft and 10 senior apprentices in chanchaga local government area. For the purpose of validating the instrument, copies of the draft questionnaire was given to three lecturers in the Department of Industrial and Technology Education to make necessary modification on the structuring and organization of the item, after which the administration of the instrument was carried out by the researcher and research

assistance and the return percentage was 100%. Mean and standard deviation was used to analyze the formulated questionnaire, while t-test was used to analyze the hypotheses in method of data analysis. A survey research design was used for the study because it is the one which a group of people or items is studied by collecting and analyzing data from only a few people or items considered being representative of the entire group. Recommendations were made in relation to the findings such as subsidizing the price of the leak detector so as to enable the technicians to afford it, use an anemometer to check the air flow of the ventilation system installed for air conditioners among others for effective troubleshooting.

Implication of the study

The study found out that the roadside technicians have a high knowledge of the principle of operations of the refrigerators and air conditioners, this implies that they can detect problems and make precise repairs, having the knowledge of the proper use of safety equipment while working on refrigerators and air conditioners has helped reduce hazards on either the refrigerators and air conditioners or the technicians. The roadside technicians also know the right tools to use for the right job and keeping the tools clean and save in the tool box after each use for easy identification when the need arise; this has made troubleshooting a whole lot easier and faster. Roadside technicians should be aware of using the leak detector to check for coolant leak instead of using the local method; this saves time and gives precise results, also they should acquaint themselves with the use of modern instruments like the multimeter and pressure module to quickly and accurately determine suction pressure and also the use of an infrared thermometer to scan the temperature of refrigerators and air conditioners.

Conclusion

The findings show that roadside technicians possess to a high extent technical knowledge and troubleshooting expertise in refrigerators and air conditioners, but they still need the formal training to compliment their practical skills. In conclusion, roadside technicians can troubleshoot refrigerators and air conditioners even though most of them did not pass through formal training; this is according to the findings which is 78% true.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Roadside technicians should acquaint themselves with the use of the leak detector.
2. Roadside technicians should try and afford multimeter and pressure module to quickly and accurately determine suction pressure.
3. Roadside technicians should also acquaint themselves with the use of an infrared thermometer to scan the temperature of refrigerators and air conditioners.

Suggestion for further research

The following was made for further research:

1. Strategies for improving the roadside technicians' technical knowledge and troubleshooting expertise in refrigerators and air conditioners in Niger state.

2. Replica study should be carried out on this topic in other states of the Federation.

REFERENCES

Air Conditioning and Refrigeration Institute (1995). *ARI curriculum guide* (2nd ed.). Arlington, VA: Author.

Althouse, A., Turnquest, C., & Bracciano, A. (2003). *Modern refrigeration and air conditioning* (5th ed.). Tinley Park, IL: Goodheart-Wilcox.

Beard, C., & Wilson, J.P. (2002). *The power of experiential learning: A handbook for trainers and educators*. Sterling, VA: Stylus.

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. Chicago, IL: Open Court Press.

Bureau of Labor Statistics (2003b). Summary *report for: 49-9021.01 – heating and air conditioning mechanics*. U.S. Department of Labor. Retrieved September 13, 2004, from http://online.onetcenter. org/report?r=1&id=746

Bureau of Labor Statistics. (2003a). *Details report for: 49-9021.01 – heating and air conditioning mechanics*. U.S. Department of Labor. Retrieved October 8, 2004, from http://online.onetcenter. org/report?r=1&id=745

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2012-*

13 Edition, Heating, Air Conditioning, and Refrigeration Mechanics and Installers, on the Internet at http://www.bls.gov/ooh/installation-maintenance-and-repair/heating-air-conditioning-and-refrigeration-mechanics-and-installers.htm (visited *May 01, 2012*).

Brockman, J. L. (2004). Problem solving of machine operators within the context of everyday work: Learning through relationships and community. (Doctoral dissertation, Michigan State University 2004). *Dissertation Abstracts International*, *65*, 1282.

Doolittle, P.E., & Camp, W. G. (1999). Constructivism: The career and technical education perspective. *Journal of Vocational and Technical Education 16(1*). Retrieved February 19, 2000, from http://scholar.lib.vt.edu/ejournals/JVTE/v16n1/dolittle.html 167

D'Zurilla, T., & Maydeu-Olivares, A. (1995). Conceptual and methodological issues in social problem-solving assessment. *Behavior Therapy,* 26(3), 409-432.

D'Zurilla, T. J., & Nezu, A. M. (1990). Development and preliminary evaluation of the Social Problem-solving Inventory. Psychological Assessment: *A Journal of Consulting and Clinical Psychology, 2, 156-163.*

Flesher, J. W. (1993). An exploration of technical troubleshooting expertise in design, Manufacturing, and repair concepts (Doctoral dissertation, University of Illinois). *Dissertation Abstracts International, 54,* 0156.

Gobet, F., & Simon, H. A. (1996). The roles of recognition processes and look-ahead search in time-consuming expert problem-solving: Evidence from grand master-level chess. *Psychological Science*, 7(1), 52-55

Green, D. (1990). These logical steps lead the way to consistent troubleshooting success. *School Shop/Tech Directions*, *50*(2), 31.

Hill, B., & Wichklein, R. (1999). A factor analysis of primary mental processes for technological problem solving. *Journal of Industrial Teacher Education, 36*(2), 83-100.

Johnson, S. (1989). A description of expert and novice performance differences on technical troubleshooting tasks. *Journal of Industrial Teacher Education*, 26(3), 19-37.

Johnson, S. D., & Thomas, R. G. (1994). Implications of cognitive science for instructional design in technology education. *Journal of Technological Studies*, 20(1), 33-44.

Kliefgen, J., & Frens-Belken, P. (1996). *Problem solving at a circuit-board assembly machine: A microanalysis*. National Center for Research in Vocational Education, MDS-1043, Berkeley, CA.

Lavoie, D. R. (1991). 1991 The construction and application of a cognitive-network model of prediction problem solving. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. Lake Geneva, WI.

Mostia, W. L. (2000). *Troubleshooting: A technician's guide*. Research Triangle Park, NC: Instrumentation Society of America. 171

Needham, J. (1991). Science and Civilisation in China, Volume 4: Physics and Physical Technology, Part 2, Mechanical Engineering. Cambridge University Press. pp. 99, 151, 233. ISBN 978-0-521-05803-2.

Nichols, F. W. (1994). Reengineering the problem-solving process (finding better solutions faster). *Performance Improvement Quarterly,* 7(40). 3-19.

Nworgu, B. G. (2006). *Educational Research: Basic Issue and Methodology.*

Simon, H. A. (1996). The roles of recognition processes and look-ahead search in time-consuming expert problem solving: Evidence from grand master-level chess. *Science*, 7(1), 52-55.

Whitman, B., Johnson, B., & Tomczyck, J. (2005). Refrigeration and air conditioning technology (5th ed.). Clifton Park, NY: Thomson Delmar Learning.

Waetjen, W. B. (1989). *Technological problem-solving: A proposal*. International Technology Education Association. Reston, VA.

APPENDIX A

APPENDIX B

QUESTIONNAIRE

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

SCHOOL OF SCIENCE AND SCIENCE EDUCATION

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION

QUESTIONNAIRE ON THE ASSESSMENT OF ROADSIDE TECHNICIANS' TECHNICAL KNOWLEDEGE AND TROUBLESHOOTING EXPERTISE IN REFRIGERATORS AND AIR CONDITIONERS IN MINNA METROPOLIS.

PART 1

INTRODUCTION

Dear respondent:

This research work is to assess the roadside technician's technical knowledge and troubleshooting expertise in refrigerators and air conditioners in minna metropolis.

Please kindly complete this questionnaire as faithfully as possible and sincerely by ticking (√) the column that best represents your opinion about the topic. All information provided will be highly confidential and strictly used for the purpose of this research work. Your response will be highly appreciated.

SECTION A

Name of local government…………………………………………………………..

Designation

Mastercraft man ☐

Senior apprentice ☐

A four (4) point rating scale is used to indicate your opinion as stated below:-

Section A	Section B	Section C
Very high (V.H)	strongly agreed (S.A)	Strongly Agreed (S.A)
High (H)	Agreed (A)	Agreed (A)
Low (L)	Disagree (D)	Disagreed (D)
Very low (V.L)	strongly disagree (S.D)	Strongly Disagreed (S.D)

PART 2

SECTION A

What is the extent of technical knowledge possessed by roadside technicians in refrigerators and air conditioners?

S/NO	ITEMS	V.H	H	L	V.L
1.	Knowledge of the general principle of troubleshooting.				
2.	Principle of operation of the refrigerators and air conditioners.				
3.	Ability to read and interpret instructions, blueprint, work orders and even assembling.				
4.	The principle of measuring the compressor suction and discharge pressure.				
5.	Understanding the components of the appliances to properly assemble or disassemble its parts.				
6.	Comprehend the importance of a safe working environment.				
7.	The proper use of special safety equipment while working on heating, ventilation, air conditioning and refrigeration system.				
8.	The use of safe operating procedures with tools and equipment such as hand and power tools, ladder and lifting equipment.				
9.	Ability to identify specific regulations and requirements for the heating, ventilation, air conditioning and refrigeration industry as defined by the Environment Protection Agency. (EPA)				
10.	Ability to interprets and apply manufactures' correspondence for safety procedures.				
11.	The use of metering devices in refrigerators and air conditioners.				
12.	Understanding how the compressor works.				
13.	Examine the physical and chemical properties of refrigerants.				
14.	Identify the different refrigerant oils and their uses.				
15.	Construct and interpret refrigerators and air conditioners schematics and wiring diagrams.				
16.	Knowledge of characteristics and identification of refrigerant.				

17.	Install/ service/ troubleshoot/ replace refrigeration system.				
18.	Troubleshoot and replace power element.				
19.	Install/ check/ refill refrigeration compressor.				
20.	Knowledge of flushing, purging and pressure testing for leaks.				

SECTION B

What are the troubleshooting skills possessed by technicians in refrigerators and air conditioner.

S/NO	ITEMS	S.A	A	D	S.D
1.	The ability to do the work of a refrigeration and air conditioning equipment with less supervision is high.				
2.	Analyzing a system operation using gauges and instruments.				
3.	Detect problems and make precise repairs or adjustments.				
4.	Using refrigeration system analyzer to check coolant lines to determine measurements of the temperature and pressure of the equipment.				
5.	Using an anemometer to check the air flow of the ventilation system installed for air-conditioning.				
6.	Using a leak detector to determine possible coolant leak in the coolant line of a refrigeration unit.				
7.	Using the correct tool for the correct work.				
8.	Using gauges to measure valve measured accurately.				
9.	Using voltmeter to determine the system's voltage.				
10.	Using fuse puller designed to eliminate the danger of pulling and replacing cartridge fuses by hand.				
11.	Using pliers to tighten locknuts or small nuts.				
12.	Using wire cutters to cut wire to size.				
13.	Using a multimeter and a pressure module to quickly and accurately determine suction pressure.				
14.	Using an infrared thermometer to scan the temperatures of different components.				
15.	Operate and maintain tools in accordance with manufacturer's instruction and as required by regulations or instructors.				
16.	Using screw driver to tighten or loosen nuts.				

SECTION C

What is the impact of technical knowledge on troubleshooting skills of roadside technicians?

S/NO	ITEMS	S.A	A	D	S.D
1	Understanding the principle of operation of refrigerators and air				

	conditioners boost troubleshooting skills				
2	Reading and interpreting instructions, blueprint, and work orders have positive impact on my troubleshooting skills				
3	Interpreting refrigerators and air conditioners schematics and wiring diagrams helps in troubleshooting faults/				
4	Knowledge of safety rules while working on refrigerators and air conditioners improves troubleshooting skills.				
5	Knowledge on anemometer guides a technician to check the air flow of the ventilation system installed for air conditioners.				
6.	Having technical knowledge increases satisfaction of the customer and decreases inconveniences.				
7	Knowledge of the principle of operation of voltmeter helps a technician to use voltmeter to determine the voltage of refrigerators and air conditioners.				
8.	Technical knowledge improves the speed of troubleshooting.				
9.	Technical knowledge reduces time of resolution, increases efficiency, reduces the labor requirements and reduces the total cost per call.				
10.	Technical knowledge increases the confidence and motivation to perform well on the job.				
11.	Technical knowledge helps to constantly identify and solve issues correctly.				
12.	Technical knowledge helps to streamline processes and ensure that technicians are approaching common issues the same way.				
13.	Technical knowledge reduces the risk of try and error.				
14.	Having the knowledge of the principle of operation of these appliances has helped in troubleshooting better and faster.				
15.	Skills of troubleshooting is better understood with technical knowledge				
16.	Technical knowledge helps in keeping tools safe and clean after use.				
17.	Technical knowledge helps in troubleshooting the refrigerators and air conditioners by using gauges.				
18.	Safety is achieved during work because of the knowledge of the usage of tools and equipment.				
19.	Technical knowledge helps to Maintain a courteous and responsive attitude towards all customers.				
20.	Measuring the compressor suction and discharge pressure can be achieved with the possession of technical knowledge.				

APPENDIX C

COMPUTATION OF MEAN AND STANDARD DEVIATION FOR THE MASTER CRAFT MEN AND SENIOR APPRENTICE ROADSIDE TECHNICIANS

Table 1: the mean response of Master craft men roadside technicians

Responses	F	f	fX
Very high	4	12	48
High	3	11	33
Low	2	2	4
Very low	1	0	0
		∑f = 25	**∑fX = 85**

MEAN ($\bar{X}$) = $\frac{\sum fX}{\sum f}$ = $\frac{85}{25}$ = 3.40

Table 2: the mean response of senior Apprentice of roadside technicians

Responses	X	f	fX
Very high	4	0	0

High	3	18	54
Low	2	6	12
Very low	1	1	1
		∑f = 25	**∑fX = 67**

MEAN ($\bar{X}$) = $\frac{\sum fX}{\sum f}$ = $\frac{67}{25}$ = 2.68

Table 3: Standard Deviation for Master craft men **$\bar{X}$=3.40**

Responses	**X**	**F**	$(X - \bar{X})$	$(X - \bar{X})^2$	$f(X - \bar{X})^2$
Very high	4	12	(4 – 3.40) = 0.60	0.36	4.32
High	3	11	(3 – 3.40) = -0.40	0.16	1.76
Low	2	2	(2 – 3.40) = -1.40	1.96	3.92
Very low	1	0	(2 – 3.0) = -1.40	1.96	0
		∑f = 25			**$\sum f(X - \bar{X})^2$ = 10.00**

Variance (S^2) given as $\frac{\sum f(X-\bar{X})2}{N-1}$

(S^2) = $\frac{10.00}{25-1}$

(S^2) = $\frac{10.00}{24}$

(S^2) = 0.4166

Standard deviation = ($S.D_1$) = $\sqrt{s_1}$

($S.D_1$) = $\sqrt{0.4166}$

$= 0.6454$

Table 4: Standard Deviation for senior Apprentice of roadside technicians

$\bar{X}$=2.68

Responses	**X**	**F**	$(X - \bar{X})$	$(X - \bar{X})^2$	$f(X - \bar{X})^2$
Very high	4	0	(4 – 2.68) = 1.32	1.7424	0
High	3	18	(3 – 2.68) = 0.32	0.1024	1.84
Low	2	6	(2 – 2.68) = -0.68	0.4624	2.77
Very low	1	1	(1– 2.68) = -1.68	2.8224	2.82
		$\sum f = 25$			$\sum f(X - \bar{X})^2 = 7.43$

Variance (S^2) given as $\frac{\sum f(X-\bar{X})2}{N-1}$

(S^2) $= \frac{7.43}{25-1}$

(S^2) $= \frac{7.43}{24}$

(S^2) = 0.3095

Standard deviation = ($S.D_2$) = $\sqrt{s_2}$

($S.D_2$) = $\sqrt{0.3095}$

= 0.5563

t – test

$$t - test = \frac{\overline{X1} - \overline{X2}}{\sqrt{\frac{S.D_1^2}{N_1} + \frac{S.D_2^2}{N_2}}}$$

$$t - test = \frac{3.40 - 2.68}{\sqrt{\frac{(0.64)2}{25} + \frac{(0.55)2}{25}}}$$

$$t - test = \frac{3.40 - 2.68}{\sqrt{0.0163 + 0.0121}}$$

$$t - test = \frac{0.72}{\sqrt{0.0284}}$$

$$t - test = \frac{0.72}{0.16}$$

t-test = 4.5