The two courses of study described and outlined here are offered at Burr D. Coe Vocational and Technical High School in East Brunswick, New Jersey, for students wishing to prepare for a career in air conditioning and refrigeration. Section 1 deals with a 4-year high school course, Section 2 with a 1-year course for those who have completed high school or its equivalent. Each section includes a job description for the air conditioning and refrigeration mechanic, a course description and notes on length of course, entrance requirements, diploma, and equipment and facilities, with most of the section being devoted to a course outline which lists objectives, course content, and text and reference books for each unit. The shop practice outlines are set up in parallel columns to clarify the dual role of the teacher responsible for teaching both the tools of the trade and related trade information. Left columns list operations to be performed by the student while parallel right columns list related information required. The courses stress the basic jobs, operations, and skills needed in the servicing, repairing and installation, of air conditioning and refrigeration units. Related subject matter, consisting of mathematics, science, and drawing related to the air conditioning and refrigeration trade is an integral part of the course for high school students; for post high school students related subject matter requirements will depend upon the student's educational background. (HD)
MIDDLESEX COUNTY VOCATIONAL AND TECHNICAL HIGH SCHOOLS

and

MIDDLESEX COUNTY ADULT TECHNICAL SCHOOLS

*****

AIR CONDITIONING AND REFRIGERATION

*****

Volume XXVI

1975 Edition of

COURSE OF STUDY OUTLINES

*****

Prepared by

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Burr D. Coe Vocational and Technical High School

East Brunswick, N. J.

*****

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ACKNOWLEDGEMENTS

The Air Conditioning and Refrigeration Advisory Committee, appointed by the Board of Education, reviewed a tentative draft of the Auto Body Repair and Refinishing Course of Study Outline. There were several valuable suggestions made for its improvement. These suggestions were incorporated into the outline and became part of the final draft.

The Board of Education is very grateful to the following members of this committee for their assistance and interest in our program.

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Board of Education of the Vocational Schools in the County of Middlesex
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Acknowledgements</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH SCHOOL COURSES</td>
<td>1</td>
</tr>
<tr>
<td>Job Description</td>
<td>1</td>
</tr>
<tr>
<td>Course Description</td>
<td>2</td>
</tr>
<tr>
<td>Length of Course</td>
<td>2</td>
</tr>
<tr>
<td>Entrance Requirements</td>
<td>2</td>
</tr>
<tr>
<td>Diploma</td>
<td>3</td>
</tr>
<tr>
<td>Where Offered</td>
<td>3</td>
</tr>
<tr>
<td>Equipment and Facilities Available</td>
<td>3</td>
</tr>
<tr>
<td>Program of Studies</td>
<td>4</td>
</tr>
<tr>
<td>Course of Study Outline</td>
<td>5</td>
</tr>
<tr>
<td>Shop Safety</td>
<td>7</td>
</tr>
<tr>
<td>Shop Practice - Exploratory Class</td>
<td>16</td>
</tr>
<tr>
<td>Shop Practice - Grade 9</td>
<td>27</td>
</tr>
<tr>
<td>Shop Practice - Grade 10</td>
<td>38</td>
</tr>
<tr>
<td>Shop Practice - Grade 11</td>
<td>46</td>
</tr>
<tr>
<td>Shop Practice - Grade 12</td>
<td>60</td>
</tr>
<tr>
<td>Applied Physics - Grade 10</td>
<td>80</td>
</tr>
<tr>
<td>Applied Chemistry - Grade 11</td>
<td>85</td>
</tr>
<tr>
<td>Related Algebra - Grade 10</td>
<td>91</td>
</tr>
<tr>
<td>Related Geometry - Grade 11</td>
<td>95</td>
</tr>
<tr>
<td>Applied Mathematics - Grade 12</td>
<td>98</td>
</tr>
<tr>
<td>Related Drawing - Grade 10</td>
<td>103</td>
</tr>
<tr>
<td>Related Drawing - Grade 12</td>
<td>107</td>
</tr>
<tr>
<td>ADULT TECHNICAL SCHOOL COURSES</td>
<td>Page</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Job Description</td>
<td>110</td>
</tr>
<tr>
<td>Course Description</td>
<td>111</td>
</tr>
<tr>
<td>Academic Subjects</td>
<td>111</td>
</tr>
<tr>
<td>Related Subjects</td>
<td>112</td>
</tr>
<tr>
<td>Length of Course</td>
<td>112</td>
</tr>
<tr>
<td>Entrance Requirements</td>
<td>112</td>
</tr>
<tr>
<td>Adult Technical School Diploma</td>
<td>112</td>
</tr>
<tr>
<td>Where Offered</td>
<td>112</td>
</tr>
<tr>
<td>Equipment and Facilities Available</td>
<td>112</td>
</tr>
<tr>
<td>Program of Studies</td>
<td>113</td>
</tr>
<tr>
<td>Shop Practice: One Year Course for Adults</td>
<td>114</td>
</tr>
<tr>
<td>SHOP VOCABULARY</td>
<td>150</td>
</tr>
<tr>
<td>SUGGESTED TEACHING AIDS</td>
<td>153</td>
</tr>
<tr>
<td>FINAL EXAMINATION SAMPLE</td>
<td>156</td>
</tr>
</tbody>
</table>
MIDDLESEX COUNTY VOCATIONAL AND TECHNICAL HIGH SCHOOLS

Air Conditioning and Refrigeration

D.O.T. 637-281: 0101-014

Job Description

The work of the air-conditioning and refrigeration mechanic is varied since he installs, maintains, and repairs different types of equipment in many places and situations.

The equipment to be installed, repaired and maintained by this mechanic ranges from small wall units, either water or air cooled, to large central plant type systems.

He may work on commercial refrigeration fixtures used in super markets, hotels and restaurants, i.e., display cases, walk-in coolers and frozen food plants. Evaporators, compressors and motors installed in locker plants are also covered in this line of work.

His job may take the air-conditioning and refrigeration mechanic to private homes, stores, hotels, factories and restaurants. At times he may have to go to new construction sites to install the various motors, condensers and fans. Some of these mechanics, however, concentrate on the heating and cooling accessory units used in automobiles and buses.

In the installation of new air-conditioning or refrigeration equipment, the mechanic must be a good welder, solderer and pipe-fitter. He must be able to connect ducts, water and electric work. After completing his installation, the mechanic must check his work: often he uses a halide leak detector to check the lines for leaks; he may also use test bulbs and probes to check for continuity of an electric circuit and location of grounds.

The mechanic inspects and examines the various parts of the system to detect leaks and other faults. He must adjust compressors and motors as well as thermostatic controls to keep temperatures at a specified level.

The repair work of the air-conditioning and refrigeration mechanic commences with the diagnosis of the cause of the breakdown. In doing so he often disassembles brushes, valves, springs and connections to inspect their condition. After the trouble is located, the reassembly may include the installation of such things as new piping, packing, valves or the complete overhauling of a pump or a compressor, which will put the equipment into working order.
Many different tools are used by the air-conditioning and refrigeration mechanic ranging from simple hand tools like wrenches, pliers, hammers and screw drivers to such expensive equipment as electric drills, soldering torches, leak detectors and pressure gauges.

Course Description

The course stresses the basic jobs, operations, and skills needed in the servicing, repair and installation of air-conditioning and refrigeration units. The student will gain a thorough knowledge of the materials and equipment used by the air-conditioning and refrigeration mechanic. He will learn to use meters, measuring instruments, tools and equipment; learn to interpret sketches, schematics and diagrams and use shop manuals and other source materials.

Each student will have an opportunity to use hand tools of the air-conditioning and refrigeration trade and learn how to perform the operations of the trade, including the evaluation of the completed work.

The student will have shop experiences not only in the mastery of manipulative skills but also related information or technology. Under the direction of the shop instructor, the student will learn related information in order that he may have a complete understanding of why he performs the operations of the trade in certain ways.

The course will include related subjects consisting of mathematics, science and drawing related to the air-conditioning and refrigeration trade. Here emphasis will be placed on the mastery of fundamental concepts and principles as well as the ability to solve practical problems. Those related subjects will help to provide the foundation which makes the shop work meaningful and functional.

It is expected that the student will have sufficient knowledge of the trade to enable him to enter into satisfactory employment upon completion of the course.

Length of Course

The complete course provides for four (4) years of instruction. The first half-year is for orientation; 3-1/2 years are for specific trade training. A minimum of 180 days per school year is required, with three clock hours per day of shop instruction and three clock hours per day of academic and related instruction.

Entrance Requirements

Pupils who enter this course must have completed the eighth grade, have the ability to profit from the instruction and have an interest in the air-conditioning and refrigeration trade in terms of vocational goal upon completing high school.
Diploma

The student may earn a high school diploma provided he has been in the shop program for a minimum of two years and satisfactorily meets all of the other requirements for a high school diploma. Transfer credit will be allowed for appropriate work satisfactorily completed in other high schools.

Where Offered

Burr D. Coe Vocational & Technical High School
112 Rues Lane
East Brunswick, New Jersey 08816

Equipment and Facilities Available

The schools in the Middlesex County Vocational system are well equipped with text and laboratory books that cover every phase of the trade.

As each lesson and skill is taught, it is practiced in a shop that contains all the necessary materials and equipment that are required to learn the trade thoroughly.

There is a continuous effort to secure the latest equipment available to keep up with the ever increasing progress in the air-conditioning and refrigeration field.
### Program of Studies

**AIR CONDITIONING AND REFRIGERATION**

Time Allotments in 45 Minute Periods Per Week

<table>
<thead>
<tr>
<th>Subject</th>
<th>Grade Level</th>
<th>Total Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Shop Practice</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Academic Subjects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>American History</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health and Physical Education</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Occupations</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Related Subjects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Chemistry of Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Mathematics</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Algebra</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Geometry</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Applied Mathematics</td>
<td></td>
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<td>Related Drawing</td>
<td>3</td>
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**Totals**

40 40 40 40 160
Course of Study Outline

The following outlines include the shop practice outlines for the high school courses in grades 9 through 12 and for the one year adult technical school course. The outlines for mathematics, science and drawing related to the air-conditioning and refrigeration trade are included in this volume. They cover the grades of the high school program and the adult technical school courses.

The shop practice outlines are set up in parallel columns in order to clarify the dual role of the shop teacher. He is responsible for teaching the skills of the trade and also the related trade information. "Operations" stress HOW things are done and "Related Trade Information" stresses WHY operations are performed as they are.

The teacher of related subjects is primarily concerned with the principles, fundamentals and basic skills of mathematics, science and drawing. He uses applications from the shop to motivate, stimulate and facilitate transfer of mathematics, science or drawing skills to the shop situation. There is a shift of emphasis as pupil progresses from ninth through twelfth grade. At tenth grade there is heavy emphasis on mastery of fundamentals; by the end of the twelfth grade there is heavy emphasis on applications.

Example: Using the compressor and condenser as a typical and commonly used application, the science teacher teaches the principles of change of state.

The shop teacher applies to real situations in his trade the principles of mathematics, science or drawing and teaches the student how and why of the application.

Example: The air-conditioning and refrigeration teacher not only teaches the boys how to repair the compressor but how the compressor operates.

There always will be a certain amount of overlapping and reinforcement between what the related subjects teacher covers and what the shop teacher covers.

The overall curriculum pattern; philosophy, teaching and evaluation methods, curriculum development procedures, requirements for the diploma, and supervisory policies are described in detail in Volume 1 of the complete set of course of study outlines.
The course of study outline is only the beginning of a complete course of study. The outline merely shows the content covered at the various grade levels. The complete course of study includes all of the various instructional manuals and materials which spell out what is to happen in the classroom or shop during the process of teaching and learning. They describe the learning experiences which are planned to give the outlines substance and meaning. These materials are available or are in preparation as supplements to the outlines. Many of them are referred to in the bibliographies given at the end of each outline.
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Shop Safety

Objectives:

1. To learn how to work safely and how to prevent accidents.

2. To learn how to care for machinery and equipment so as to reduce the possibility of accidents.

3. To develop habits of good housekeeping, proper storage and handling of materials, and sanitation.

4. To become familiar with personal protective devices and the proper clothing to be worn for safety purposes.

5. To develop skills in the safe use of hand and portable tools.

6. To learn how to cooperate with others in the promotion and operation of a safety program in a school shop.

UNIT I  ACCIDENTS AND ACCIDENT PREVENTION

A. Causes of Accidents
B. Prevention of Accidents
C. Accident Prevention and Safety Programs in Industry
D. Accident Prevention as a Responsibility of All
E. Importance of Proper Conduct and Attitude
F. Dangers in Horseplay and Carelessness

Unit II  MAKING THE SHOP A SAFE PLACE TO WORK

A. Shop Layout
B. Painting
C. Lighting
D. Ventilation
E. Floors
F. Fire Prevention and Drills
G. Sanitation and Personal Hygiene
UNIT III MACHINE GUARDING

A. Purpose of Guards
B. Types of Guards
C. Use of Guards
D. Care and Maintenance of Guards

UNIT IV MAINTAINING A SAFE PLACE TO WORK

A. Housekeeping
   1. Floors
   2. Stairs
   3. Loose objects
   4. Materials
   5. Rags and Waste
   6. Lockers and cabinets

B. Storage of Tools
C. Storage of Materials and Supplies
D. Shop Cleanliness
E. Dust, Fumes and Gases
F. Electrical Hazards
G. Soldering and Welding Hazards

UNIT V PERSONAL PROTECTIVE DEVICES

A. Eye Protection
B. Protective Clothing
C. Foot Protection
D. Respirators
E. Dollies

UNIT VI HAND AND PORTABLE TOOL SAFETY

A. Use of Correct Tools
B. Correct Use of Tools
C. Defective Tools
D. Hazards in Use of Specific Tools
E. Portable Electric Hand Tools
UNIT VII

SHOP SAFETY PROGRAM

A. Shop Safety Organizations
B. Shop Rules and Regulations
C. Analysis of Shop Jobs for Safety Content
D. Job Safety Instruction
   1. Group
   2. Individual
E. Safety Meetings and Assemblies
F. Posters and Bulletin Boards
G. Films and Other Visual Aids
H. Safety Tests
I. Safety Contests
J. Shop Safety Surveys
K. Safety Pledge

UNIT VIII

ACCIDENT INVESTIGATION AND REPORTING

A. First Aid
B. Accident Reports
C. Student Insurance
D. Protection of Teacher by "Safe Harmless Law"

UNIT IX

SAFE PRACTICES IN REFRIGERATION SHOP

"Horseplay is Prohibited"

A. Do not operate any equipment until you are instructed in its use.
B. Do not use any tool until you have been instructed in its use.
C. Shop coveralls shall be worn in the shop.
D. Use good housekeeping methods.
E. Use waste rags to wipe oil from tools and hands.
F. Use proper tools for a specific job.
G. File burrs left on pipe from wrenches or vises.
H. Use goggles for all jobs that create eye hazards.
I. Do not ascend a ladder without someone holding the bottom.
J. Do not leave tools on the top of a ladder.
K. Be careful when working with open flames.
UNIT IX

SAFE PRACTICES IN REFRIGERATION SHOP - (Cont'd)

L. Know the location of the fire extinguishers and learn how to use them.
M. When an alert or fire drill signal is given follow prescribed procedures.
N. Report defective tools and equipment to the instructor.
O. Observe all personal safety rules when lifting anything heavy.
P. Leather top shoes must be worn in the shop.
Q. Do not use the top rung of a ladder.
R. Inspect all ladders before using them.
S. Use proper size ladder for each job.
T. Keep floors, benches and machines free from scrap to prevent injury.
U. Do not clean or repair moving equipment.

UNIT X

EYE PROTECTIVE DEVICES

A. Clear goggles are to be worn at all times when observing, aiding, or performing operations dealing with refrigerants.
B. Wear safety glasses when soldering or welding.
C. Safety goggles must be worn when grinding or chipping.
D. Wear goggles when striking a punch or chisel with a hammer. Steel chips can cause eye injury.

UNIT XI

SAFE PRACTICES IN THE HANDLING OF REFRIGERANTS

A. Always wear goggles when observing, aiding or performing operations dealing with refrigerants.
B. Liquid refrigerant, if allowed to strike the eye, can cause blindness. If allowed to strike the body, can cause frostbite.
C. Always use gauges and scales to indicate weight and pressures within a cylinder.
D. If refrigerant is allowed to come in contact with an open flame or heated metal, a poisonous gas will be created. Inhalation of this gas can cause you to become violently ill.
E. Never fill a cylinder beyond its capacity. When the surrounding temperature rises, bursting can result.
F. Never use a torch to speed up emptying of cylinders. Fusible caps let go and dangerous conditions are created.
UNIT XI  SAFE PRACTICES IN THE HANDLING OF REFRIGERANTS (Cont'd)

G. High pressure tanks should be securely fastened because if they fall, the valves break and they will be propelled like a rocket.
H. Refrigerant cylinders should never be heated to temperatures above 125°F.
I. Other rules recommended for the safe handling of refrigerant cylinders include

1. Open valves slowly
2. Replace outlet caps when finished
3. Never force connections
4. Do not tamper with safety devices
5. Do not alter cylinders
6. Do not drop, dent or abuse

J. Remember - Refrigerants can be dangerous. They should only be used and handled by a trained refrigeration serviceman.

UNIT XII  SAFETY IN WORKING WITH ELECTRICAL CIRCUITS

A. Keep hands off all equipment unless assigned to work with it.
B. De-energize all circuits before making repairs.
C. Use lockout switches and danger signs when working on circuits.
D. Test a circuit before working on it.
E. Use fuse pullers for removing and replacing cartridge fuses.
F. Repair all circuit defects before replacing fuses.
G. Never leave untaped wires in junction boxes.
H. Ground all portable electrical equipment.
I. Make sure all equipment, tools and machinery have good wiring connections and a ground wire at all times.
J. Always use a three-pronged male plug on a 112/220 volt circuit. The U-prong is the ground.
K. Any frayed wire or strands should be replaced or repaired immediately.
L. Avoid entering areas that have wiring or power if you are perspiring or if any water is present.
M. Stay away from wet surfaces when using an electrical tool or appliance.
UNIT XIII
SOLDERING SAFETY

A. Always set tank securely on the floor near a supporting wall.
B. Never set a tank in an aisle or work area. Someone may walk into it and cause tank to fall over.
C. Never pick up or attempt to touch a piece of tubing you have just finished soldering without using pliers.
D. Always be sure that both ends of the tubing being soldered are open. Any residue of gases can cause explosions.
E. Always use a flint lighter when lighting torch tips. Lighted matches have been thrown into combustible areas.
F. Always solder where protection against fire is evident by the use of asbestos or tin.
G. Keep a fire extinguisher handy on all soldering jobs.
H. Any burns received while soldering should be taken care of immediately by applying a crushed ice pack to the burnt area.

UNIT IVX
SAFETY PRECAUTIONS FOR OXYACETYLENE WELDING

A. Setting up Precautions

1. Open slightly (crack) cylinder valves to free accumulated dust and dirt.
2. Connect regulators to cylinders, making sure the connecting nuts are secured tightly to prevent leaks.
3. Turn out the pressure adjusting screw of the regulators until it is loose to avoid pressures rupturing the diaphragms.
4. Always stand to one side of and away from the gauge face of the regulators when opening cylinder valves.
5. Never open the cylinder valves suddenly, as the rush of high pressure may injure the regulator mechanism.
6. When oxygen cylinders are in use, the cylinder should be opened all the way to prevent leaks.
7. When acetylene cylinders are in use, the cylinder valve must not be opened over one-half turn so it can be secured quickly.
8. Always leave the "T" wrench in place while the acetylene cylinder is in use so the cylinder can be secured quickly in an emergency.
9. Never interchange oxygen and acetylene hoses as it may create fires and explosion.
10. When damaged nuts or connections are found, they shall be removed from service.
11. When testing equipment for leaks, use soapy water ("Ivory" soap is recommended).

B. General Operating Precautions

1. Never allow oil or grease to come in contact with oxygen under pressure.
2. Never use oxygen as a substitute for compressed air.
3. Before starting to weld or braze make certain there is no material that flame or spark might ignite.
4. Always use the proper size tip and the proper gas pressure.
5. Always wear goggles when working with a lighted torch.
6. Be sure to keep a clear space between cylinders and work.
7. Never use matches for lighting torches.
8. Never use acetylene at pressures above 15 PSI.
9. Do not hang the torch and hose on regulators or cylinder valves.
10. Never release acetylene where it may cause a fire or explosion.
11. Do not experiment with regulators or torches and do not alter them in any way.
12. Never connect an oxygen regulator to a cylinder containing combustible gas.
13. Store extra cylinders away from congested areas and excessive heat.
14. When welding near materials that will burn be ready to put out any fire promptly with fire extinguishers, water or sand.
15. When welding close to wooden construction protect it from direct heat.
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American Technical Society, 1966
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Shop Practice

Exploratory Class

Objectives:

1. To enable the student to explore the job opportunities, working conditions, financial gains and security in the air-conditioning and refrigeration trades.

2. To provide the student with a background of knowledge and experience which will enable him to understand and appreciate some of the complexities of industrial life.

3. To assist the student to discover his capacities and desire for learning a skilled craft.

4. To provide the student with an opportunity to learn what is required to become an air-conditioning and refrigeration mechanic.

5. To teach certain basic skills that are of value regardless of the trade ultimately studied.

6. To develop a knowledge of related information.

7. To develop an appreciation and pride in craftsmanship.

8. To develop through shop experience and technical instruction, the operations, skills and knowledge necessary for successful employment in the field of air-conditioning and refrigeration.

9. To learn and carry out safe trade practices.

10. To acquaint the student with the history of refrigeration.

11. To familiarize students with the basic refrigeration cycle, terminology, components and tubing in a refrigeration system.

12. To teach the proper use and care of tools, parts and equipment used on refrigeration systems.

13. To develop proper attitudes in the safe use of tools and equipment used on refrigeration systems.
UNIT I  OVERVIEW OF THE AIR-CONDITIONING AND REFRIGERATION TRADE

A. History of the Refrigeration Trade

B. Jobs in the Refrigeration Trades

1. Refrigeration Mechanic - Domestic (637.281)
2. Refrigeration Mechanic - Commercial (637.281)
3. Air-Conditioning Mechanic - Domestic (637.281)
4. Air-Conditioning Mechanic - Commercial (637.281)
5. Refrigeration-Machine Operator (919.782)
6. Refrigeration-Equipment Erector (637.281)
7. Refrigeration System Installer (827.381)
8. Refrigeration Unit Repairman (637.381)
9. Refrigerator Inspector (723.387)
10. Refrigerator Tester (827.387)
11. Refrigeration Foreman (950.132)
12. Refrigeration Engineer (007.081)
13. Refrigeration Mechanic Helper (637.887)
14. Automobile-Refrigeration Mechanic (620.281)
15. Air-Conditioning Mechanic Industrial (637.281)
16. Air-Conditioning Installer (827.884)
17. Air-Conditioning Unit Tester (827.381)
18. Air-Conditioning Assembler (706.884)
19. Aircraft Air-Conditioning-Truck Operator (912.782)
20. Air-Conditioning Engineer (007.081)

C. Guidance Implications

UNIT II  SHORT ORIENTATION

A. Shop Rules and Procedures

B. Shop Vocabulary and Terminology

1. Hand tools
2. Materials
3. Equipment
4. Machines

C. Shop Clothing

D. Shop Safety

E. Shop Hygiene
UNIT III  HOUSEKEEPING
A. Care of Hand Tools
B. Care of Power Tools
C. Care of Equipment
D. Care of Work Space
E. Care and Storage of Materials
F. Care of Tool Crib
G. Clean-up Duties

UNIT IV  MATERIALS

Operations
A. How to Select Proper Tools for the Job
1. Selecting proper hand tools.
2. Selecting proper electrical tools.
3. Selecting proper bench tools.
4. Location of all tools and equipment.
5. Use, purpose and description of hand tools.
6. Care and cleaning of hand tools.

Related Information
1. What are the various types of hand tools.
   1. Screw drivers, flat blade, assorted sizes.
   2. Screw drivers, Phillips #1,#2.
   3. Screw drivers, Offset.
   5. Wrenches, crescent.
   6. Wrenches, box end.
   7. Wrenches, pipe.
   8. Wrenches, Allen.
  11. Hammer, claw.
  14. Pliers, diagonal cutting.
  15. Pliers, long nose.
  17. Square, combination set.
  19. Chisels.
  20. Files: Coarse, smooth, bastard.
  22. Tap and Die (small set)
UNIT IV  MATERIALS (Cont'd)

Operations

B. How to Select the Proper Material for a Job

1. Selecting proper type of tubing for a Freon system
2. Selecting material for an ammonia system
3. Selecting material for a water cooled system
4. Selecting material for an air cooled system

Related Information (Cont'd)

23. Calipers
24. Rulers (Scales)
25. Tubing cutters
26. Bending springs
27. Pinch off block
28. Tube benders
29. Flaring tools
30. Gauge, screw pitch

2. Safety Precautions

1. Types of Copper Tubing
   a. ACR - "K" - "L" - "M"
   b. Hard drawn tubing
   c. Soft drawn tubing (annealed)

2. Sizes of Copper Tubing

3. Types of Pipe
   a. Black pipe
   b. Galvanized pipe
   c. Cast iron pipe

4. Sizes of Pipe

5. Aluminum Tubing

6. Safety Precautions

UNIT V  MEASUREMENTS

Operations

A. How to Take Measurements

1. Taking end-to-end measurements
2. Taking end-to-center measurements
3. Taking end-to-back measurements
4. Taking center-to-center measurements
5. Taking back-to-back measurements

Related Information

1. What is meant by a fitting
2. Fitting Allowances
3. Types of Fittings

   a. Flared fittings
   b. Copper-sweat fittings
   c. Compression joint fittings
   d. Flare to sweat fittings
UNIT VI  CUTTING COPPER TUBING

A. How to Prepare Copper Tubing
1. Unrolling tubing from master roll.
2. Handling tubing with precaution.
3. Selecting proper size and type of tubing before cutting.

B. How to Use Cutting Tools
1. Using tubing cutter
2. Using hacksaw
3. Using tube reamer
4. Using a pinch-off block
5. Using tube cleaning brushes
6. Using a refacing tool
7. Using a file

C. How to Cut Copper Tubing
1. Using a vise
2. Using a flare block
3. Using a reamer
4. Using a pinch-off tool

UNIT VII  FLARING COPPER TUBING

A. How to Flare Copper Tubing
1. Preparing copper tubing
   a. Square tubing
   b. Remove burrs
   c. Install proper flare fitting
2. Insert tubing into proper hole or flare block

-20-
UNIT VII  FLARING COPPER TUBING (Cont'd)

Operations (cont'd)

3. Applying oil to spinner
4. Tighten spinner
5. Removing tubing
6. Checking angle of flare

Related Information (Cont'd)

8. Causes of Flares Being Too Large or Too Small
9. Safety Precautions

UNIT VIII  SWAGING COPPER TUBING

Operations

A. How to Swage Copper Tubing

1. Preparing copper tubing
   a. Square ends of tubing
   b. Remove burrs
2. Insert tubing into proper hole on flare block
3. Using proper size swaging tool
4. Applying oil to swaging tool
5. Proper method of striking swaging tool
6. Checking tubing for proper fit

Related Information

1. Definition of Swaging
2. Purpose of a Swage Fitting
3. Importance of Positioning Tubing in Flare Block
4. Purpose of Using Oil
5. Causes of Improper Swage Fittings
6. Safety Precautions

UNIT IX  BENDING COPPER TUBING

Operations

A. How to Bend Copper Tubing

1. Bending hard copper tubing
2. Bending soft copper tubing
3. Preparing and marking copper tubing
4. How to hold hands on bending springs
5. How to position tubing in tube bender
6. How to operate tube bender properly
7. Removing tubing from tube bender

Related Information

1. Types of Tube Benders
   a. Bending springs
   b. Mechanical benders
2. Measurements Involved
3. Meaning of Minimum and Maximum Radius
4. Reasons for Using Different Bending Tools
5. Principle of Stress
6. Definition of Buckle
7. Reasons for Heating Hard Tubing
8. Meaning of Normal Bends, Reverse Bends and 45° Bends
9. Bending Allowances
10. Safety Precautions
UNIT X
TOOLS USED IN MAKING COPPER SWEAT JOINTS

Operations
A. How to Use The Tools in Making Copper Sweat Joints
1. Using tubing cutters
2. Using hacksaws
3. Using reamers
4. Using cleaning tools
5. Using heat-generating tools
6. Using torches

Related Information
1. Types of Tubing Cutters
2. Types of Hacksaws
3. Types of Cleaning Tools
4. Types of Reamers
5. Types of Heat-generating Tools
6. Types of Torches
7. Importance of Proper Tool Maintenance
8. Principle of heat-generating Tools
9. Principle of Tubing Cutter
10. Safety Precautions

UNIT XI
COPPER SWEAT JOINTS

Operations
A. How to Make A Copper Sweat Joint
1. Preparing copper tubing
   a. Cleaning tubing
   b. Reaming tubing
   c. Applying flux
2. Preparing copper fittings
   a. Cleaning fitting
   b. Applying flux
3. Applying heat
4. Applying solder
5. Wiping finished joint (removing excess solder)

Related Information
1. Kinds of Tools Used
2. Types of Fittings Used
3. Types of Cleaning Tools Used
   a. Sandpaper
   b. Emery paper
   c. Steel wool
4. Types of Flux
5. Purpose of Flux
6. Types of Solders
7. Composition of Solders
8. Types of Heat
9. Meaning of Wiping
   Reason for removing excess solder
10. Safety Precautions
    a. Burns
    b. Hot solder
    c. Cooling tubing

B. How to Make a Sweat Joint Using the Brazing Method
1. Setting up brazing outfit
2. Selecting proper tip
3. Heating metals
4. Completing job

Related Information
1. What is meant by brazing
2. Principle of Brazing
3. Composition of Silver Solder
4. Types of Flux
5. Safety Precautions

-22-
UNIT XI COPPER SWEAT JOINTS (cont'd)

Operations

C. How to Set-up a Brazing Outfit
1. Setting-up tanks
2. Installing regulator on tank
3. Connecting hoses
4. Connecting torch
5. Selecting tips

D. How to Prepare a Soldering Iron
1. Heating soldering iron
2. Cleaning soldering iron
3. Shaping soldering iron
4. Tinning soldering iron

E. How to Solder with a Soldering Iron
1. Preparing metal to be soldered
2. Soldering brass
3. Soldering copper
4. Soldering galvanized iron

Related Information

1. Construction of Acetylene Tank
2. What is meant by Single-stage Pressure
3. Principle of Heat
4. Safety Precautions

UNIT XII PRINCIPLES OF REFRIGERATION THEORY

Operations

A. How the Application of Refrigeration Has Aided Mankind
1. History of Refrigeration
2. Progress of Refrigeration
3. Refrigeration in Industry

Related Information

1. Use of snow and Ice in Early Civilization
2. Manufacture of Ice by Natural Refrigeration
3. Shipping of Ice by Clipper Ship
4. Modern-day Usage of Refrigeration
UNIT XII PRINCIPLES OF REFRIGERATION THEORY (cont'd)

Operations (cont'd)

4. Refrigeration in manufacturing
5. Refrigeration in construction
6. Refrigeration in medicine
7. Refrigeration for comfort
8. Refrigeration in food preserving and processing

B. How to Become Familiar with the Basic Refrigeration Cycle

C. How to Become Familiar with Basic Refrigeration Terms

D. How to Identify the Refrigeration Components

E. How Refrigeration Systems Vary

1. Domestic Refrigeration and Air-conditioning
2. Commercial Refrigeration and Air-Conditioning
3. Industrial Refrigeration and Air-Conditioning
4. Automotive Air-Conditioning
5. Refrigeration
   a. Absorption
   b. Evaporative

Related Information (cont'd)

5. Using it for Preservation of Drugs and Medicine
6. Using it to Obtain Clean Air and Constant Temperatures

B. How to Become Familiar with the Basic Refrigeration Cycle

C. How to Become Familiar with Basic Refrigeration Terms

D. How to Identify the Refrigeration Components

E. How Refrigeration Systems Vary

1. Definitions
   a. Heat
   b. Cold
   c. Refrigeration
   d. Mechanical refrigeration

1. Evaporation
2. Condensation
3. Compression
4. Heat transmission

1. Evaporator
2. Condenser
3. Compressor
4. Metering device

1. Types of domestic refrigerators and air-conditioners
2. Types of commercial refrigerators and air-conditioners
3. Types of industrial refrigeration and air-conditioners
4. Types of automobile air-conditioners
5. Uses of various types of refrigeration systems
COURSE OF STUDY OUTLINE
Air-Conditioning and Refrigeration Shop
9th Grade Exploratory Class

Typical Shop Jobs

A. Determine tubing sizes

B. Recognition of types of tubing

C. Measuring tubing lengths

D. Measuring tubing diameters

E. Cutting tubing, using different types of tube cutters

F. Cutting tubing using hacksaw

G. Flaring tubing of different sizes using compression type flare block

H. Flaring tubing of different sizes using a double flare type flare block

I. Swaging copper tubing of different sizes

J. Bending tubing of different sizes with a bending spring

K. Bending tubing of different sizes with a mechanical bending tool

L. Bending tubing of different sizes with a gear type tube bender

M. Using inner and outer types of reamers

N. Cleaning tubing

O. Assemble all of the pieces of cut, flared, swaged and bent tubing

P. Solder together all of the assembled pieces of tubing

Q. Pressure test the finished project

R. Disassemble a compressor or refrigerating unit, using the proper hand tools

S. Reassemble a compressor using proper hand tools

T. Work with an electric powered tool
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air-Conditioning and Refrigeration
9th Grade Exploratory Class


General Motors Corporation, Public Relations Department A to Zero of Refrigeration


Objectives:

1. To review the principles and practices taught in the exploratory class.

2. To review and put to use the safety rules taught in the exploratory class.

3. To develop an understanding of heat quantity measurements.

4. To learn the use of heat intensity measuring devices.

5. To develop skills in measuring heat intensity and calculating heating quantity.

6. To develop an understanding of the pressures within a refrigeration system.

7. To acquire a knowledge of the instruments which are used in the measurements of pressures in a refrigeration system.

8. To teach the use and care of the gauges and instruments involved in reading pressures.

9. To train students in the use of equipment used in leak detection.

10. To teach students the basic refrigeration fittings and assembly devices used in a refrigeration system.

11. To instruct students on proper use of test manifold, gauges and compressor service valves.

12. To teach the functions of the component parts of a refrigeration system.

13. To increase the manipulative skills in the use of hand tools and equipment.

14. To develop greater skills in soldering procedures.
UNIT I  REFRIGERATION FITTINGS

Operations

A. How to Install Copper Tubing in a Refrigeration System
1. Planning job
2. Selecting size of tubing
3. Selecting type of fitting
4. Selecting size of fitting
5. Installing a flare type fitting
6. Installing a sweat type fitting
7. Installing a compressor type fitting

Related Information
1. Type of tubing to be used
   a. Hard drawn
   b. Soft (annealed) drawn
2. Types of fitting
   a. Flare fitting
   b. Sweat fitting
   c. Compression fitting
3. Purpose of each type of fitting
4. Types of threads used on flare fittings
   a. National Fine (N.F.)
   b. Society of Automotive Engineers (S.A.E.)
   c. Briggs taper pipe thread (N.P.)
5. Protection of fittings
6. Thread lubricants and sealers used with fittings
7. Sizes of flare wrenches to be used
8. Types of material from which fittings are made
   a. Copper
   b. Brass
   c. Steel
   d. Aluminum
   e. Plastic
9. Safety Precautions

UNIT II  ASSEMBLY DEVICES

Operations

A. How to Install an Evaporator Supporting Bracket
1. Planning job
2. Selecting type of metal to be assembled
3. Selecting type of fastening device to be used
   a. frequency of dismantling
4. Using gauges to measure threads

Related Information
1. Methods of fastening
   a. Soldering
   b. Brazing
   c. Welding
   d. Crimping
   e. Riveting
   f. Bolting
2. Devices for fastening metal
   a. Nuts
   b. Bolts
   c. Plugs
   d. Set screws
   e. Cap screws
   f. Machine screws
3. Types of thread gauges
4. Purposes of thread gauges
5. Safety Precautions
UNIT II  ASSEMBLY DEVICES  (cont'd)

Operations

B. How to Make External and Internal Threads
   1. Securing die in die stock
   2. Chamfering end of work
   3. Setting adjusting screws
   4. Holding die stock square with work
   5. Using proper pressure
   6. Reversing stock and die
   7. Protecting finished surface
   8. Repairing damaged internal and external threads

Related Information

1. Sizes of drills
2. Sizes and types of taps
   a. Tapered tap
   b. Plug tap
   c. Bottoming tap
3. Techniques in cutting threads with a tap
4. Sizes and types of dies
5. Techniques in cutting threads with a die
6. Thread systems
7. Safety precautions

UNIT III  REFRIGERATION SERVICE GAUGES AND TEST MANIFOLD

Operations

A. How to Install a Test Manifold to an Open Type Refrigeration Unit to Observe Readings
   1. Remove valve caps from service valves
   2. Check service valves to determine whether the valve stems are backseated
   3. Remove the 1/8" MP plugs from the gauge-ports
   4. Install the half unions fittings (1/4 MF x 1/8 MP) into gauge-ports
   5. Connect flexible charging hose from compound gauge on manifold to Suction Service Valve (SSV)
   6. Connect flexible charging hose from pressure gauge on manifold to Discharge Service Valves (DSV)
   7. Plug the center charging line on manifold with 1/4 plug
   8. Crack open the DSV and use pressure to purge air from the hose lines
   9. Crack hose connection at SSV to purge air from hose

Related Information

1. Types of gauges
   a. Pressure - High side
   b. Compound - Low side
2. Parts of a gauge
   a. Bourden tube
   b. Linkage
   c. Gear
   d. Gauge connection - 1/8 Male pipe thread
   e. Calibration spring
3. Operation of a gauge
   a. Internal pressure
   b. Atmospheric pressure
4. Dial markings and limitations
   a. Pressure - 0 - 500
   b. Compound - 30"-0-200
5. Pressure and vacuum scales
6. Temperature and pressure relationship
7. Types of test manifolds
8. Parts of test manifold
   a. Compound gauge
   b. Pressure gauge
   c. Manifold
   d. Three charging lines or hoses
   e. Three flare plugs
   f. Two 1/4 MF x 1/8 MP half-unions

-29-
UNIT III REFRIGERATION SERVICE GAUGES AND TEST MANIFOLD (cont'd)

**Operations**

10. Frontseat the valves on manifold
11. Crack open the SSV
12. Run unit and observe operating pressures on gauges

**Related Information**

9. Compressor service valves
   a. Frontseat - to close
   b. Backseat - to open
   c. Crack to open slightly
   d. Types of service valves used
      1. Two-way service valve
      2. One-way service valve
      3. Liquid line service valve
   e. Line service valves
      1. Compression type
      2. Solder type
      3. Piercing copper tubing
      4. Hermetic charging kits

10. Safety Precautions
   a. Always wear goggles
   b. Use 2 wrenches when working
   c. Keep lines sealed and clean

**B. How to Remove Gauges from an Open Type Refrigeration System**

1. Backseat DSV at compressor
2. Open valves (backseat) on manifold
3. Operate unit until both gauges are a slightly above zero - 0
4. Close suction service valve (SSV)
5. Shut service valves on test manifold
6. Remove charging lines from compressor
7. Remove fittings from compressor
8. Replace 1/8" plugs
9. Replace valve caps

**C. How to evacuate an open type refrigeration unit**

1. Install test manifold to unit
2. Connect the high vacuum pump to the center gauge manifold opening
3. Open Suction Service Valve (SSV) at compressor
4. Open compound gauge service valve on manifold
5. Discharge to atmosphere any refrigerant left in system through center gauge port

**Related Information**

1. Types of Vacuum pumps
2. Principles of vacuums
3. Why is it necessary to evacuate a system?
4. When is it required to evacuate a system?
5. Proper maintenance of vacuum pump
6. Operation of vacuum pump
7. Methods of evacuating a refrigeration system
   a. Triple evacuation method
   b. Low micron-range evacuation
   c. Vacuum required for moisture removal (dehydration)
8. Safety Precautions
UNIT III  REFRIGERATION SERVICE GAUGES AND TEST MANIFOLD  
(cont'd)  

Operations

6. Open Discharge Service Valve (DSV) at compressor  
7. Open pressure gauge service valve on manifold  
8. Open valve at vacuum pump  
9. Operate vacuum pump and draw highest vacuum possible
10. Close Discharge Service Valve (DSV)
11. Close Suction Service Valve (SSV)  
12. Close valve at vacuum pump  
13. Shut off operating switch at vacuum pump  
14. Disconnect vacuum pump  
15. Leave test manifold connected to unit for next operation

Related Information

D. How to Add Refrigerant to an Open Type Unit
1. Install test manifold to unit  
2. Connect the refrigerant cylinder to the center gauge manifold opening
3. Open valve on cylinder to purge air from charging line  
4. Open Suction Service Valve  
5. Test for leaks  
6. Turn unit on  
7. Add refrigerant to system until desired suction pressure is obtained  
8. Shut off valve at cylinder  
9. Close manifold valves  
10. Close SSV
11. Remove test manifold

1. Types of refrigerants  
   a. R-12  
   b. R-22  
   c. R-502
2. Types and sizes of refrigerant cylinders
3. Purging of lines  
4. Methods of leak detection  
5. Safety precautions  
   a. Always wear goggles  
   b. Avoid getting liquid refrigerant on skin  
   c. Avoid inhalation of vapor or gas

E. How to Check for Leaks in an Open Type Unit
1. Install test manifold to unit  
2. Leak test unit using all methods of leak detection

1. Types of leak detectors  
   a. Halide leak detector  
   b. Electronic leak detector  
   c. Soap bubbles  
   d. Vacuum pumps
UNIT III
REFRIGERATION SERVICE GAUGES AND TEST MANIFOLD
(cont'd)

Operations
3. Repair leak
4. Remove test manifold

Related Information
e. Use of senses
   1. Sight
   2. Touch
   3. Sound

2. Using pressures to locate leaks
3. Safety Precautions
   a. Never use oxygen, air or any inflammable gas for testing a system

UNIT IV
COMPRESSOR SERVICE VALVES

Operations
A. How to take apart and identify parts of a compressor service valve
   1. Remove a discharge service valve from compressor
   2. Take valve apart
   3. Clean all parts
   4. Identify and indicate the function of each part
   5. Reassemble the parts in proper order

B. Same procedure with all types of service valves

Related Information
1. Names and types of compressor service valves
   a. Discharge Service Valve
   b. Suction Service Valve
   c. Liquid Line Valve

2. Other types of valves
   a. Two-way Service Valve
   b. One-way Service Valve

3. Operation of service valves
   a. Front-seat
   b. Back-seat
   c. Crack

4. Service valves attached to refrigerant tubing
   a. Piercing type valve
   b. Compression type
   c. Solder type

5. When to use this type of service valve

6. When to use a hermetic service valve kit

7. Parts and functions of each part of service valve

8. Safety precautions

UNIT V
REFRIGERATION SYSTEM COMPONENTS

Operations
A. How to work with the refrigeration system components and to know their functions

Related Information
1. Compressors
   a. Types
      1. Open type
      2. Sealed or hermetic
UNIT V
REFRIGERATION SYSTEM COMPONENTS (cont'd)

Operations

1. Compressor
2. Condensers
3. Evaporators
4. Refrigerant controllers
5. Receivers

Related Information

b. Classification
1. Reciprocating
2. Rotary
3. Centrifugal

2. Condensers
a. Types
1. Air cooled
2. Water cooled
3. Evaporative

3. Evaporators
a. Types
1. Dry or direct-expansion
2. Flooded type

4. Refrigerant Controllers
a. Types
1. Low-pressure float
2. High-pressure float
3. Automatic expansion valve
4. Thermostatic expansion valve
5. Capillary tubing

5. Safety precautions

UNIT VI
MATTER AND MOLECULES

Operations

A. How to relate matter to Refrigeration
1. The states of matter
2. The changes of state of matter

Related Information

1. Mass and weight
2. States of matter
   a. Solid
   b. Liquid
   c. Gas
3. Size and shape
4. Change of state
   1. Vaporization
   2. Condensation
   3. Liquification
   4. Solidification
   5. Sublimation
5. Molecular Movement

-33-

38
UNIT VII
HEAT MEASUREMENT

Operations
A. How to use the basic principles of temperature measurements in refrigeration

1. Heat intensity
2. Heat quantity
3. Heat energy

Related Information
1. Measurement of heat intensity
   a. Unit of intensity
      1. Fahrenheit scale
      2. Centigrade scale
      3. Rankine scale
      4. Kelvin scale
   b. Measuring devices
      1. Thermometers
      2. Thermocouples
   c. Fixed references
      1. Boiling point
      2. Freezing point
      3. Absolute zero
   d. Temperature conversion
2. Measurement of heat quantity
   a. British thermal unit (BTU)
   b. Heat equation used in calculations
3. Energy Conversion Units
   a. Heat energy
   b. Mechanical energy
   c. Electrical energy

UNIT VIII
HEAT AND PRESSURE IN REFRIGERATION

Operations
A. How to use the knowledge of heat and pressures in the refrigeration trade

1. Temperature-pressure relationship
2. Heat in refrigeration
3. Heat in air-conditioning

Related Information
1. Types of heat
   a. Specific heat
      1. Various metals
      2. Variance due to change of state
      3. Temperature of mixtures
   b. Total heat
      1. Sensible heat
         a. Sensible heat equation
      2. Latent heat
         a. Latent heat of fusion
         b. Latent heat of vaporization
      3. Super heat
2. Types of pressures
   a. Meaning of pressure
   b. Pressures as applied to refrigeration
   c. Atmospheric pressure
UNIT VIII HEAT AND PRESSURE IN REFRIGERATION (cont'd)

Operations

3. Measurement of pressures
   a. Absolute scale
   b. Standard (gauge) scale
   c. Compound scale
   d. Mercury scale
   e. Small pressures

Related Information
Typical Shop Jobs

A. Identify various types of flare fittings.
B. Identify various types of sweat and pressure fittings.
C. Identify various types of assembly devices.
D. Drill holes in metal plate with different size drills.
E. Make threads in holes with a tap.
F. Measure different lengths of rods.
G. Make threads on rods using a die set.
H. Measure, cut, flare, bend new pieces of copper tubing.
I. Solder together all of the assembled pieces of tubing using different types of solder.
J. Pressure test the finished project, using refrigerant.
K. Install a test gauge manifold on a refrigeration system.
L. Evacuate system using a vacuum pump.
M. Recharge system with refrigerant and adjust charge.
N. Use various types of thermometers and record data.
O. Study the various types of gauges and the construction of service valves installed in an open type system.
P. Use various types of leak detecting devices.
Q. Repair a leak using epoxy compounds.
R. Repair a hole leak in copper tubing using solder.
S. Install a service valve on a hermetic system.
T. Overhaul and identify parts on an open type compressor.
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9th Grade Class

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Kilmer Campus, New Brunswick, New Jersey

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Refrigeration Service Engineer's Society Shop Manual, Des Plaines,
Illinois 1965
Objectives:

1. To continue to use all of the previous safety rules taught.
2. To develop an understanding of the basic concepts of the compression cycle used in refrigeration systems.
3. To teach the principles of subcooling and super heat.
4. To train with the methods of heat transfer which apply to the refrigerant lines.
5. To teach the students on becoming familiar with the heat transfer capacities of some common metals.
6. To train in the tear-down and identification of compressor parts and their purpose.
7. To teach with the different types of components necessary to build a model refrigeration unit.
8. To teach the students the correct methods in the construction, evacuation, charging and testing their lab unit.
9. To train students how to disassemble an open type reciprocating compressor and become acquainted with the construction of it.
10. To teach the construction and function of various types of metering devices.
11. To develop skills in testing efficiency of compressors and correct operation of expansion valves.
12. To develop skill in attaching adapter valves to those hermetic and semi-hermetic units not equipped with service valves.
13. To develop an understanding that some common refrigeration circuit problems might indicate one or more of several causes of trouble and to become proficient in some procedures through repetition.
14. To develop an appreciation of safety precautions in the complete evacuation of a refrigeration system, once it has been exposed to the atmosphere.
15. To develop an appreciation for safety requirements when they are working with refrigeration equipment.
UNIT I COMPRESSORS

Operations

A. How to overhaul an open type compressor
1. Select proper tools
2. Remove compressor from unit
3. Remove fly wheel and key, record data
4. Remove cylinder head and record data. Mark head.
5. Remove valve plate and record data. Mark plate.
6. Remove the crank case, base and seal plate. Record data.
7. Remove one connecting rod, mark rod, and record data.
8. Make new gasket
9. Assemble the compressor
10. Tighten and torque all assembly devices
11. Put oil into compressor and remount into unit
12. Test the compressor for vacuum and pressure.

B. How to overhaul a rotary type compressor
1. Select proper tools
2. Dismantle the compressor
3. Mark all parts
4. Record all data from parts
5. Reassemble the compressor
6. Add oil
7. Test compressor

C. How to service a hermetic compressor without any service valves
1. Select proper tools
2. Select proper material
3. Install the service valve kit if unit has a valve adapter
4. Install clamp piercing valve, if unit has no adapter valve
5. Install gauge manifold
6. Test the compressor for vacuum and pressures

Related Information

1. Types of compressors
A. Reciprocating
1. Accessible or open type
   a. Cylinder construction
   b. Cylinder arrangement
   c. Piston construction
   d. Connecting rod construction
   e. Crankshaft construction
   f. Valve construction
   g. Crankshaft seals
   h. Gaskets
   i. Compressor drives
2. Hermetic or sealed type
   a. Construction differences
   b. Compressor cooling
   c. Mufflers
B. Rotating
1. Accessible or open type
   a. Stationary blade
   b. Rotary blade
   c. Cylinder construction
   d. Rotor construction
   e. Blade construction
   f. Crankshaft construction
   g. Crankshaft seals
   h. Valve construction
2. Hermetic or sealed type
   a. Construction differences
   b. Operation
C. Centrifugal
1. Single stage
2. Multi-stage
3. Rotor (impeller)
4. Stators
   a. Marking of compressor parts
   b. Using a torque wrench
   c. Making a gasket
   d. Using a wheel puller
   e. Hermetic valve kit
   f. Uses of piercing valves
   g. Fan belts types and sizes
   h. Types of flywheels
   i. Alignment of fly wheels and pulleys
   j. Safety precautions
UNIT I  COMPRESSORS (cont'd)

Operations

7. Remove gauges
8. Remove valve kit or piercing valve adapter

Related Information

UNIT II  SOLDERING WITH OXYACETYLENE TORCH

A. How to Silver Solder or Braze Refrigerant Lines
1. Select proper material
2. Select proper tools
3. Preparing tubing
   a. Cleaning tubing
   b. Reaming tubing
   c. Applying flux
4. Preparing fitting
   a. Cleaning fitting
   b. Applying flux
5. Applying heat
6. Applying solder
7. Wiping finished joint
8. Testing finished joint

UNIT III  CALIBRATION OF GAUGES

A. How to Calibrate Pressure Gauges by Means of the Dead Weight Tester
1. Fill weight tester with mineral oil (SAE 20)
2. Connect gauge to be tested
3. Make adjustments on dead weight tester
4. Record all data
5. Adjust gauge scales if required
6. Remove calibrated gauge

Related Information

1. Kinds of tools used
2. Types of tubing or material used
3. Types of solder used
4. Composition of solder
5. Flow temperature of solder
6. Types of flux used
7. Purpose of flux
8. Purpose and use of basic equipment
   a. Gas supply-oxygen and acetylene
   b. Gas regulators
   c. Color code of hoses
   d. Sizes of tanks
9. Torch construction
10. Types of tips
11. The oxyacetylene flame
   a. Parts
   b. Temperature
   c. Colors
12. Techniques of good brazing
   a. Selection of tip
   b. Adjustment of torch
   c. Angle of torch
   d. Movement of the filler rod and torch
13. Safety precautions
UNIT IV  COMPONENT PARTS OF REFRIGERATION SYSTEM

A. How to Install or Replace an Evaporator Coil
1. Determine size and type of evaporator coil
2. Select proper tools
3. Select proper type and size of evaporator coil
4. Install gauge manifold, check for leaks
5. Purge refrigerant from system
6. Cut refrigerant lines at the evaporator coil
   a. Cut lines at a place that will permit brazing or soldering of the lines to new unit
   b. Allow enough tubing to permit flaring, if brazing or soldering cannot be done
7. Remove the evaporator by unbolting it from the cabinet
8. Install new evaporator
9. Clean the tubing. Braze or solder the connections, using the correct procedure
10. Install a new drier-filter
11. Evacuate, using vacuum pump
12. Charge to a 60 pound gas pressure
13. Test for leaks

B. How to Install or Replace a Condenser
1. Select proper tools for job
2. Determine size and type of condenser coil
3. Install gauge manifold, check for leaks
4. Purge refrigerant from system
5. Cut refrigerant lines at the condenser coil
6. Remove the condenser coil from cabinet, by unbolting or removing screws
7. Install new condenser coil in proper location
8. Clean the tubing. Braze or solder all refrigerant lines together, using proper procedure

Related Information

1. Types of evaporators
   A. Bare tube
   B. Plate type
   C. Finned
   D. Air cooling coils
     1. Dry coil
        a. Natural convection
        b. Forced circulation
        c. Frosting
        d. Non-frosting
     2. Flooded
   E. Liquid cooling coils
     1. Submerged
     2. Shell and tube
     3. Tube within a tube

2. Types of condensers
   A. Air cooled
      1. Bare pipe
      2. Finned
      3. Natural convection
      4. Forced circulation
   B. Water cooled
      1. Double pipe
      2. Double tube
      3. Shell and coil
      4. Shell and tube
   C. Evaporative condensers
   D. Water towers
   E. Complete condensing units
      1. Compressor
      2. Condenser
      3. Receiver
UNIT IV  COMPONENT PARTS OF REFRIGERATION SYSTEM  
(cont'd)

Operations

9. Install a new filter-drier
10. Evacuate system using vacuum pump
11. Charge to a 60 pound gas pressure
12. Test for leaks at all connections

Related Information

F. Knowledge of non-condensable gases
G. Safety precautions

C. How to Install, Replace or Repair Capillary Tube
1. Select proper tools for job
2. Remove the capillary tube
   a. Remove the refrigerant by safely purging (use good ventilation)
   b. Balance unit pressures, clean the capillary tube connections
   c. Remove the capillary tube and plug the openings if possible
3. Repair the capillary tube by using a capillary tube cleaner. If necessary replace with new one
4. Install the capillary tube filter-drier into unit
   a. Clean and dry all connections
   b. Evacuate system, using vacuum pump
   c. Charge with refrigerant
5. Test for leaks
6. Charge system with correct amount of refrigerant

D. How to Remove, Test, Install and Adjust a Thermostatic Expansion Valve
1. Select proper tools for job
2. Select proper thermostatic expansion valve
3. Install the gauge manifold

1. Types of capillary tubes
2. Purpose of capillary tube
3. Length and inside diameter of capillary tube
4. Capillary tube used as a heat exchanger
5. Capillary tube systems have very critical charge of refrigerant
6. Measuring charge put into a system
7. Drier and filter requirements
8. Other types of metering devices
   a. High side float
   b. Low side float
   c. Manual control valves
   d. Automatic expansion valves
   e. Thermostatic expansion valves
9. Trouble shooting system
10. Safety precaution

1. Types of thermostatic expansion valves
    a. Diaphragm type-adjustable
    b. Diaphragm type non-adjustable
    c. Internal equalizer
    d. External equalizer
    e. Bellows type-adjustable
UNIT IV COMPONENT PARTS OF REFRIGERATION SYSTEM (cont'd)

Operations

4. Adjust the service valves—remove refrigerant
5. Remove the thermostatic expansion valve
6. Clean the thermostatic expansion valve, including the screen
7. Test the valve
8. Adjust to a 10°F superheat
9. Reinstall thermostatic expansion valve into system
10. Purge and evacuate system using vacuum pump
11. Build up pressure in system
12. Test for leaks.

E. How to Install a Filter-drier
1. Select proper tools for job
2. Select proper filter-drier
3. Install the gauge manifold
4. Adjust the service valve
5. Remove refrigerant from system—ventilate wheel-wear goggles
6. Remove old drier and record the size of the fittings
7. Install the new drier carefully
8. Test for leaks, using a refrigerant cylinder, create a 70 to 90 psig head pressure
9. Charge the system

Related Information

2. Automatic valves
   a. Application
   b. Selection
3. Thermostatic valves
   a. Application
   b. Charge in sensing bulk
      1. Gas charged
      2. Liquid charged
      3. Cross charged
   c. Selection
4. Trouble shooting system
5. Safety precautions

1. Types of filter-driers
   a. Liquid line filters
   b. Suction line filters
2. Desiccants
   a. Silica gel
   b. Activated alumina
   c. "Drierite"
3. Properties of desiccants
4. Function of filter-driers
5. Drier size
6. Drier location
7. Drier cores
   a. Replaceable
   b. Non-replaceable
8. Moisture indicators
9. Safety precautions

-43-

48
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration Shop

10th Grade Class

Typical Shop Jobs

A. Construct a refrigeration trainer unit.
B. Install a condensing unit, consisting of compressor, condenser and receiver onto training unit.
C. Install an evaporator on training unit.
D. Install a metering device on training unit.
E. Overhaul an open type compressor.
F. Overhaul a rotary type compressor.
G. Service a hermetic type compressor without any service valves.
H. Soldering with an oxy-acetylene torch.
I. Calibrate gauges with a dead-weight tester.
J. Install a filter-drier on training unit.
K. Use a charging cylinder to measure refrigerant going into training unit.
L. Use a 1 pound can of refrigerant to charge a unit.
M. Replace a capillary tube.
N. Remove, test, and adjust a thermostatic expansion valve.
O. Locate trouble in an ice maker.
P. Dismantle, test, assemble and operate an evaporator fan motor.
Q. Remove and install door hardware and gasket.
R. Add oil to a hermetic system.
S. Locate trouble in a hermetic system.
T. Remove and install a hermetic system.
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-45-

50
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Shop Practice

Grade 11

Objectives:

1. To develop personal characteristics and work habits necessary for success in the refrigeration trade.

2. To develop the various skills required to install electrical materials.

3. To learn the fundamentals of basic wiring circuits.

4. To learn the application of theory in analyzing circuit problems.

5. To learn to use meters and testing equipment.

6. To learn the various types of wiring methods.

7. To teach the operation and function of the electrical components normally present in a refrigeration system.

8. To install the electrical components normally found in a refrigeration system.

9. To learn how to trouble shoot the electrical components in a refrigeration system.

10. To teach the fundamentals of motors and their characteristics.

11. To develop knowledge and skill in the measurement and in the connection of wires in electricity.

12. To acquire skills in the soldering of wire.

13. To learn the skills and knowledge necessary for a refrigeration service man to be proficient in the installation of all types of motors, controls and refrigerating and air conditioning systems.

14. To develop an appreciation for safety around electrical equipment.

15. To develop proper attitudes of safety precautions in the handling and usage of any electrical wiring, tools, electric meters and motors.
UNIT I  MATERIALS

Operations

A. How to identify and prepare wire for use
1. Removing insulation
2. Cleaning wire
3. Handling wire with precaution
   a. knicking
   b. cutting strands

B. How to splice solid wire
1. Pig tail splicing
2. Tap splicing
3. Western Union splicing
4. Mechanical splicing

C. How to splice stranded wire
1. Tap splicing
2. Western Union splicing
3. Extension cord splicing

D. How to solder splices
1. Preparing soldering iron
   a. Cleaning iron
   b. Heating iron
   c. Tinning iron
2. Heating splice
3. Applying flux
4. Applying solder
5. Removing excess solder
6. Test all wiring for continuity with test light
7. Test all terminals, connections and wiring with ohm meter.

Related Information

1. Types of wire
   a. Solid
   b. Stranded
   c. Copper
   d. Aluminum

2. Types of insulation
   a. Thermoplastic
   b. Rubber
   c. Asbestos
   d. Varnish cambric

1. Purpose of splicing
   a. Reason for branching wire
   b. Reason for tapping wire
   c. Reason for line extensions

2. Importance of using proper tools
   a. Work knife
   b. Side cutters
   c. Diagonals
   d. Wire strippers

3. Safety precautions
   a. Work knife
   b. Diagonals
   c. Side cutters
   d. Wire strippers

1. Types of soldering irons
   a. Copper iron
   b. Electric iron
   c. Soldering gun
   d. Propane torch

2. Purpose of cleaning iron

3. Heat effects on soldering
   a. Warm iron
   b. Hot iron

4. Purpose of flux

5. Types of solders to use
   a. Acid core
   b. Rosin core

6. Reason for removing excess solder

7. Safety precautions
   a. Overheated iron
   b. Burns
   c. Hot solder
   d. Cooling iron
UNIT I MATERIALS (cont'd)

Operations

E. How to insulate splices
   1. Using rubber tape
   2. Using friction tape
   3. Using plastic tape
   4. Using wire connectors

F. How to install armored cable
   1. Handling cable
   2. Cutting cable
   3. Connecting cable to outlet
   4. Stapling cable

G. How to install non-metallic cable (Romex)
   1. Handling cable
   2. Cutting cable
   3. Connecting cable to outlet
   4. Stapling cable
   5. Grounding cable

Related Information

1. Purpose of insulation
2. Effects of poor insulation
   a. Grounds
   b. Shorts
3. Types of wire connectors

1. Code requirements
2. Sizes of wire
3. Kinds of cable
   a. Two-wire
   b. Three-wire
   c. Four-wire
   d. Solid wire
   e. Stranded wire
4. Types of connectors
   a. Set screws
   b. Split
   c. Duplex
   d. Angle
5. Types of outlets
   a. Octagon
   b. Square box
   c. Wall case
   d. Utility box
6. Safety precautions

1. Sizes of cable
2. Code requirements
3. Kinds of cable
   a. Two-wire
   b. Three-wire
   c. Four-wire
   d. Solid
   e. Stranded
4. Purpose of a ground wire
5. Types of connectors
   a. Set screw
   b. Split
   c. Duplex
   d. Angle
UNIT I          MATERIALS (cont'd)

Operations

H. How to install receptacles, fixtures and controls in a refrigeration system
1. Installing a single pole switch
   a. Selecting switch
   b. Wiring switch
   c. Testing switch
2. Installing double-pole switch
3. Installing three-way switch
4. Installing outlet receptacle
5. Installing fixtures
6. Installing controls
   a. Selecting control
   b. Wiring control
   c. Testing control

Related Information

6. Types of outlets
   a. Octagon
   b. Square box
   c. Wall case
   d. Utility box

7. Safety precautions

UNIT II          CONDUCTORS AND INSULATORS

Operations

A. How to use wire gauges and measure sizes of wires, and see how lengths effect conductance
1. Cut several pieces of wire and measure with wire gauge
2. Splice wire
3. Solder wire
4. Connect wire with tape
5. Connect wire with wire-nut
6. Cut wire to several different lengths and measure resistances

Related Information

1. Conductors have low resistance to current flow
   a. Copper
   b. Iron
   c. Aluminum
   d. Silver
   e. Brass
   f. Zinc

2. Sizes of conductors
   a. Effect of type
   b. Resistance
   c. Load
UNIT II  CONDUCTORS AND INSULATORS  (cont'd)

Operations  Related Information
3. Semi-conductors have low resistance to current flow in one direction. High resistance to current flow in other direction.
   a. Germanium
   b. Silicon
   c. Copper oxide
   d. Copper sulphide
   e. Lead sulphide
4. Insulators have high resistance to current flow
   a. Dry air
   b. Glass
   c. Rubber
   d. Asbestos
   e. Bakelite
   f. Mica

UNIT III  CIRCUIT APPLICATION AND TESTING INSTRUMENTS

Operations  Related Information
A. How to test and analyze effects of voltage, current and resistance changes in electrical circuits
   1. Using ohmmeters
   2. Using voltmeters
   3. Using ammeters
   4. Using multi-testers
   5. Using watt meters
   6. Using voltage testers
   7. Using an amprobe
1. Types of current
   a. Alternating current
   b. Direct current
   c. Pulsating
2. Ways of generating voltage
   a. Mechanical
   b. Chemical
   c. Thermal
   d. Light
3. Ohm's Law and Kirchhoff's Laws
4. Precautions in connecting meters
5. Applying formulas to prove meter readings
6. Determine power factors.
B. How to detect circuit troubles
   1. Testing
   2. Wiring
1. Principle involved in the short circuit
2. Principle involved in the open circuit
3. Principle involved in grounding
UNIT III  CIRCUIT APPLICATION AND TESTING INSTRUMENTS  
(cont'd)

<table>
<thead>
<tr>
<th>Operations</th>
<th>Related Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C. How to work with series circuits</strong></td>
<td>1. Definition of circuits</td>
</tr>
<tr>
<td>1. Source</td>
<td>a. Series</td>
</tr>
<tr>
<td>2. Load</td>
<td>b. Parallel</td>
</tr>
<tr>
<td>3. Testing</td>
<td>c. Combination</td>
</tr>
<tr>
<td>4. Wiring</td>
<td>2. Effects of voltage</td>
</tr>
<tr>
<td></td>
<td>3. Effects of current</td>
</tr>
<tr>
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<td>4. Effects of resistance</td>
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</table>

| D. How to work with parallel circuits | 1. Definition of circuits |
| 1. Source | a. Series |
| 2. Load | b. Parallel |
| 3. Testing | c. Combination |
| 4. Wiring | 2. Effects of voltage |
| | 3. Effects of current |
| | 4. Effects of resistance |

| E. How to work with series and parallel circuits | 1. Definition of circuits |
| 1. Source | a. Series |
| 2. Load | b. Parallel |
| 3. Testing | c. Combination |
| 4. Wiring | 2. Effects of voltage |
| | 3. Effects of current |
| | 4. Effects of resistance |

| F. How to measure electrical power and energy | 1. Principle of transforming energy |
| 1. Using voltmeter and ammeters | a. Generator |
| 2. Using watt meters | b. Motor |
| 3. Using watt-hour meters | 2. Power formulas |
| | 3. Relationship between mechanical and electrical energy |
| | 4. Power ratings of equipment |
| | 5. Efficiency of operation |

| G. How to select circuit conductors | 1. Kinds of A.W.G. number markings |
| 1. Measuring sizes | 2. Code requirements |
| 2. Measuring line power losses | 3. Differences in current carrying capacities |
| 3. Measuring line voltage drops | 4. Effects of overloading |
| 4. Fusing | 5. Effects of heat |
| | 7. Safety precautions |
UNIT III  CIRCUIT APPLICATION AND TESTING INSTRUMENTS (cont'd)

Operations

H. How to produce magnetism with electricity and produce electricity with magnetism
1. Electron theory
   a. Displacement of electrons
   b. Flow of electrons
2. Use of electricity to create magnetism
   a. Show polarity using a bar magnet
   b. Create magnetic lines of force using various magnets and iron filings
   c. Make permanent magnets
   d. Make temporary magnets

Related Information

1. Sources of energy
   a. Friction
   b. Magnetism
   c. Chemical action
   d. Pressure
   e. Heat action
   f. Light action
   g. Nuclear action
2. Charges
   a. Positive - Plus - North
   b. Negative - Minus - South
   c. Attraction of unlike charges
   d. Repulsion of like charges
3. Static electricity - electrons at rest
4. Current electricity - electrons in motion

UNIT IV  SINGLE PHASE MOTORS

Operations

A. How to install single-phase motors
   1. Connecting motors
   2. Testing motors
   3. Trouble shooting

B. How to install a split-phase motor
   1. Connecting motor
      a. Voltage and amperage ratings
   2. Testing motors

Related Information

1. Theory of operation
   a. Phasing or start winding
   b. Starting torque
2. Construction and uses
   a. Hermetically sealed
   b. Open type
3. Types of single-phase motors
   a. Split phase
   b. Permanent split capacitors
   c. Capacitor start-induction run
   d. Capacitor start-capacitor run
4. Ratings of single phase motors
5. Code rules and regulations

1. Theory of operation
   a. Rotor winding
   b. Stator winding
2. Parts and function of each part
   a. Rotor
   b. Stator
UNIT IV
SINGLE PHASE MOTORS (cont'd)

Operations

Related Information

a. Excessive wear on shaft, bearings, other
c. End plates
b. Freedom of rotation: shaft bearing
d. Centrifugal switch
c. Electrical test
1. Ground
2. Open winding
3. Short
4. Centrifugal switch
3. Trouble shooting motor
4. Reverse rotation of motor

3. Types of motor
a. Two running windings with one starting winding
b. Two running windings with two starting windings

4. Ratings of motor
a. Single-speed
b. Multiple speed

5. Reversing a split-phase motor
a. Interchange of running winding leads
b. Interchange of starting winding leads

6. Safety precautions

1. Theory of operation
a. High-starting torque using low starting current

2. Parts and function of each part
a. Brush holders and brushes
b. Bearings
c. Short circuiting necklace and frame
d. Governor spring
e. Commutator
f. Push rods
g. Rotor

3. Types of repulsion-induction motors
a. 110 volt
b. 220 volt
c. Reverse rotation

4. Ratings of motors

5. Code rules and regulations

6. Safety precautions

1. Theory of operation—designed for high starting torque, used on water pumps and compressors on commercial units
a. Uses a capacitor in circuit
b. Rotor winding
c. Stator winding
1. Main
2. Starting

D. How to install a capacitor-start motor
1. Connecting motor
   a. Voltage and amperage rating

2. Testing motors
   a. Mechanical tests
      1. Excessive wear on shaft, bearings

C. How to install a repulsion-induction start motor
1. Connecting motor
   a. Voltage and amperage rating

2. Testing motors
   a. Brushes
   b. Bearings
   c. End play
   d. Position of reversing switch
   e. Centrifugal throwout switch
   f. Armature

3. Trouble shooting motor
   a. Use of VOM in checking for starts, open circuits
   b. Use of tachometer in checking RPM's
   c. Use of growler in checking armature
UNIT IV  SINGLE PHASE MOTORS (cont'd)

Operations

2. Freedom of rotation of shaft, bearing
3. Centrifugal switch
4. Lack of sufficient lubrication
5. Misalignment of parts
6. Excessive end play
b. Electrical tests
   1. Ground
   2. Open winding
   3. Short
   4. Defective capacitor
3. Trouble shooting motor
   a. Test capacitor for capacitance valve
   b. Test stator windings and identify leads
   c. Check for overload, over voltage, under voltage

E. How to install a PSC motor.
   "P.S.C. means Permanent Split Capacitor"
   1. Connecting motor
   2. Testing motor
   3. Trouble shooting

UNIT V  POLYPHASE MOTOR

Operations

A. How to identify and tag dual voltage motor leads
   1. Locating leads with an ohmmeter
   2. Using voltmeter
   3. Using voltage tester
   4. Connecting leads

B. How to connect stator-windings
   1. Counting the number of coils
   2. Calculating coils per pole
   3. Calculating coils per phase
   4. Soldering leads
   5. Applying test voltages
   6. Checking speed

Related Information

2. Parts and function of each part
   a. Capacitor
   b. Centrifugal switch
   c. Rotor
   d. Windings
   e. End plates
3. Types of motors
   a. Capacitor-start, induction-run
   b. Capacitor-start, capacitor-run
4. Rating of Motor
   a. Volts
   b. Amps
   c. Watts
   d. Speed
   e. Horse power or size
5. Safety precautions
   a. Always discharge a capacitor before testing

UNIT V  POLYPHASE MOTOR

Operations

A. How to identify and tag dual voltage motor leads
   1. Locating leads with an ohmmeter
   2. Using voltmeter
   3. Using voltage tester
   4. Connecting leads

B. How to connect stator-windings
   1. Counting the number of coils
   2. Calculating coils per pole
   3. Calculating coils per phase
   4. Soldering leads
   5. Applying test voltages
   6. Checking speed

Related Information

1. Theory of operation
2. Parts and function of each part
3. Types of motors
4. Rating of motor
5. Safety precautions

1. Kinds of standard lead markings
2. Reason for tagging
3. Safety when making tests
4. Types of polyphase motors
   a. Three-phase
   b. Two-phase
5. Parts and function of each part

1. Types of windings
2. What the winding accomplishes
3. Effects of voltage
4. Why the number of phases affects the winding
5. Why the frequency affects the winding
UNIT V  POLYPHASE MOTOR

Operations

C. How to locate faults
   1. Checking for overload
   2. Measuring starting conditions
   3. Testing for performance
   4. Testing for grounds
   5. Testing for short-circuits
   6. Checking bearings
   7. Reversed phase
   8. Defective controller
   9. Checking for worn or tight bearings

Related Information

6. Less common connections
7. Formulas for new windings
8. How to use schematic and master diagrams
9. Reasons for reconnecting

UNIT VI  TROUBLE SHOOTING MOTORS

Operations

A. How to trouble shoot split-phase and capacitor start motors
   1. Analyze problem
   2. Locate cause of problem
   3. Repair problem
   4. Test motor

B. How to use meters

Related Information

1. Types of problems
   a. Mechanical
   b. Electrical
2. Parts of motors defective
3. Tools required
4. Meters required

C. How to start a compressor
D. How to check a capacitor
E. How to trouble shoot a relay starter circuit
F. How to make a complete electrical check on an air conditioner

Related Information

1. Types of meters
2. Operation of meters
3. Uses of meters
4. Handling meters
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COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Typical Shop Jobs

11th Grade Class

1. Identify various types and sizes of wire.
2. Measure, cut, prepare, then make various types of spliced connections.
3. Soldering and taping together the spliced connections.
4. Measure, cut and prepare for installation armored cable.
5. Measure, cut and prepare for installation non-metallic cable.
6. Install a receptacle, a junction box, a single pole switch and motor controlling device on training unit.
7. Learn how to connect a series circuit on electrical training board.
8. Learn how to connect a parallel circuit on electrical training board.
9. Learn how to connect equipment in combination circuits, using the electrical training board.
10. Learn how to connect, read and use a voltmeter, an ammeter and a multi-meter.
11. Learn the construction and uses of an ohmmeter and a wattmeter.
12. Remove old wire and replace with new wire on a domestic type refrigerator.
13. Check out, repair and install a thermal type, current type and a potential type relay in a domestic refrigeration system.
14. Study methods of making and testing electrical connections.
15. Learn how to trace out electrical circuits in a refrigeration system.
16. Learn the various types of fan motors, and study the construction and operation of the open type refrigeration motor.
Typical Shop Jobs (cont'd)

11th Grade Class

17. Dismantle, test, reassemble and operate the various types of motors, using all types of meters to obtain readings.

18. Remove, repair and replace a relay and a motor overload.

19. Learn how to trouble shoot a hermetic (sealed) system.

20. Remove, inspect, reinstall and readjust a temperature and pressure motor control.

21. Learn about, inspect, test and install various types of fuses.

22. Learn about, inspect, test and install various types of capacitors.

23. Learn how to free a stuck motor compressor.

24. Learn about, then install into a refrigeration system, a defrost timer clock.

25. Learn about, then install into a refrigeration system, a selenoid valve, a magnetic starter and a safety switch.

26. Learn about several electrical testing and measuring instruments and safe steps in trouble-shooting, repairing and maintaining different types of equipment used in air-conditioning and refrigeration.
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Air-Conditioning and Refrigeration

11th Grade Shop


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Basic Electricity, Bradner, James E., Litton Instructional Materials, Inc., 1695 West Crescent Avenue, Anaheim, California 92801 1966

Turnowski, Anthony F., Experiments in Electricity - Volume II, Curriculum Laboratory, Department of Vocational-Technical Education, Rutgers - the State University 1962

Lefkus, Thomas F., Experiments in Electricity - Volume I, Curriculum Laboratory, Department of Vocational-Technical Education, Rutgers - The State University 1964
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Basic Comfort Heating Principles, Chalmer T. Dempster, Curriculum Laboratory, Vocational-Technical Education Department, Rutgers - The State University 1968
Objectives:

1. To continue to develop personal characteristics and work habits necessary for success in the air conditioning and refrigeration field.

2. To learn the basic fundamentals of all types of air conditioning.

3. To develop a knowledge and understanding of proper methods in the selection of cooling coils and condensing units.

4. To learn the cooling cycle of heat pumps and room air conditioners.

5. To teach what calculations are necessary for a thorough check of total heat gain.

6. To teach the methods of formulating air and humidity calculations and to acquire a knowledge of the various properties of air with the aid of a psychrometric chart.

7. To teach what is heat loss and heat gain, and how they can be controlled.

8. To learn how to install a room air conditioner unit.

9. To learn how to install a central air conditioning unit.

10. To learn how to check, calibrate and replace air conditioning operating components.

11. To learn how to use Air Velocity measuring equipment.

12. To learn the construction and operation of the sling psychrometer.

13. To learn how to locate troubles in an air conditioner.

14. To develop an appreciation for safety around air conditioning equipment and material.

15. To develop proper attitudes of safety precautions in the handling and usage of any tools, equipment, meter and other materials used in air conditioning.
16. To learn the principles, fundamentals and operation of automobile air conditioning.

17. To repair and install automobile air conditioners, and any of their components.

18. To learn all of the safety habits required when working with automotive air conditioning.
COURSE OF STUDY OUTLINE
Air Conditioning and Refrigeration

Typical Shop Jobs
12 Grade Class

UNIT I
INTRODUCTION

Operations

A. How to understand what air-conditioning is
1. Introduction to air-conditioning
   a. Introduction
   b. Body comfort
      1. Temperature
      2. Humidity
      3. Air Movement
   c. Air cycle
      1. Cooling and heating coil
         a. Winter operation
            (Heating Coil)
         b. Summer operation
            (Cooling coil)
         c. Cooling and removing moisture
      d. Refrigeration cycle
         1. Cooling coil (Evaporator)
         2. Compressor
         3. Condenser
         4. Expansion valve
   e. Heat pumps

B. To understand how psychrometrics is involved with air-conditioning
1. How to use a sling psychrometer
   a. Construction and operation of the sling psychrometer
   b. Construction and operation of a wall type humidity indicator
2. How to determine the wet and dry bulb temperature of a room using a sling psychrometer

Related Information

1. Types of air-conditioning systems
   a. Heating-Cooling systems
      1. Gas burning units
      2. Oil burning units
   b. Cooling systems
      1. Air cooled units
      2. Water cooled units
      3. Forced-circulation air units
   c. Humidifiers
      1. Cold water humidifiers
      2. Chemical humidifiers
   d. Cooling towers
   e. Self-contained units
   f. Portable units

1. Types of psychrometrics charts
   a. Dry bulb lines
   b. Wet bulb lines
   c. Dew-point lines
   d. Relative humidity lines
2. Properties of air
3. Air and humidity calculations
   a. Heating
   b. Cooling
   c. Heating and humidification
   d. Cooling and humidification
   e. Cooling and dehumidification
4. Safety precautions
   a. Care in handling sling psychrometers
   b. Wetting wick on wet bulb thermometer with room temperature water
UNIT II  AIR CONDITIONING UNITS

Operations

A. How to install a window type comfort cooler

1. Installation of base
   a. Install unit base on window sill
   b. Locate center of window, place the base in place
   c. Level the base and mark screw holes
   d. Drill the screw marks
   e. Install the rubber gasket on the window sill
   f. Fasten the mounting base to window sill
   g. Adjust the leveling bolts and lock

2. Installation of unit
   a. Prepare comfort cooler for operation
   b. Loosen the hold down bolts
   c. Inspect the unit for condition
   d. Mount the unit on the base
   e. Fasten the unit to the base
   f. Install the spacers between each side of the unit and the window frame
   g. Install the rubber gasket along the top of the unit
   h. Install the gasket between the inner double hung window and the outer one
   i. Operate the unit
   j. Check damper adjustments for unit noise

B. How to locate trouble in a window type comfort cooler

1. Test the external circuit first
   a. Power in
   b. Thermostat
   c. Motor compressor relay and overload protector
   d. Filters
   e. Air flow

Related Information

1. Selection of proper size unit for the application
   a. Heat transfer
      1. Heat loss
      2. Infiltration
      3. Heat gain
      4. Ventilation air
   b. Air and Humidity calculations
   c. Sensible heat calculations
   d. Latent heat calculations
   e. Solar heat calculations
   f. Moisture calculations

2. Types of window air conditioners
   a. Casement windows
   b. Double hung windows
   c. Wall units
   d. Console or portable units
   e. Heat pump conversions
   f. Voltage characteristics
   g. Current characteristics

3. Selection of proper tools for installation
   a. Screw drivers
   b. Socket set
   c. Twist drill
   d. Electric drill
   e. Spirit level
   f. 10" straight tin snips
   g. Sealing compound

4. Safety in installation

1. Mechanical troubles
   a. Test for air in system
   b. Test for dirt and moisture in system
   c. Purging a system with air, moisture or dirt in it
   d. Checking and repairing a hermetic unit
   e. Checking and repairing an open type unit
UNIT II
AIR CONDITIONING UNITS

Operations

2. Install gauges
   a. Operate unit
   b. Test for leaks
3. If the unit has no or little charge in it
4. If unit is frosting or sweating down the suction line, unit may be overcharged
5. If the screen or drier is clogged with dirt or moisture
6. Repair what is necessary
7. Remove refrigerant where necessary
8. Replace any worn part
9. Reassemble the unit
10. Evacuate system with vacuum pump, recharge system with proper charge
11. Test for leaks

C. How to locate trouble in a self-contained comfort cooler
1. Test the external circuit first
   a. Power in
   b. Thermostat
   c. Motor compressor, relay and overload protectors
   d. Filters and air flow
   e. Water connections and water valves if water cooled
   f. Air supply if air cooled
   g. Condensate drain
2. Install gauges
   a. Operate unit
   b. Check pressures
   c. Test for leaks
3. Replace Thermostatic Expansion Valve, if one is used
4. If unit is frosting on coil
   a. TEV valve is leaking
   b. Thermostat is not shutting off
   c. TEV bulb is loose

Related Information

f. Detecting and correcting a unit with leak
f. Detecting and correcting a unit with noise problems
h. Loose blower or fans
i. Repairing and replacing a capillary tube
j. Installing a filter-drier in system
k. Remove, test, install and adjust a thermostat expansion valve
l. Remove, test, install and adjust a water valve
m. Checking fan motor CFM
n. Checking fan motor for proper rotation
o. Safety requirements

2. Electrical and wiring defects
   a. Check motor wiring for sufficient voltage capacity
   b. Detect and correct improper control wiring in a self-contained unit
   c. Knowing how to use electrical testing equipment
   d. Knowing about many types of motors used in air conditioning units
   e. Reading schematic drawings
   f. Repairing and adjusting fan controls
   g. Repair and adjust a heating and cooling thermostat
   h. Measuring volts and resistance using a voltmeter and ammeter
   i. Using a wattmeter to calculate unit power factor
   j. Checking relay circuits operation for component part failure
   k. Checking the operation of a thermostat
UNIT II  AIR CONDITIONING UNITS

Operations

5. If system is undercharged
   a. TE valve screen is partially clogged with moisture
   b. Dirt is in screen
6. Repair what is necessary
7. Remove refrigerant where necessary
8. Replace any worn parts
9. Reassemble the unit
10. Evacuate system with vacuum pump.

UNIT III  SERVICE PROBLEM

Related Information

(cont'd)

Related Information

1. Checking an electronic thermostat against a conventional thermostat
   m. Knowing how to calibrate a thermostat
   n. Safety requirements

UNIT III  SERVICE PROBLEM

Operations

A. Installations
   1. How to understand the codes applicable to air-conditioning
   2. How to acquire an understanding of good installing practices
   3. How to develop an attitude for good workmanship in the installation of air conditioning and the copper tubing going to the units

Related Information

1. State and local codes
   a. Safety codes for commercial and industrial air conditioning
      b. Purpose of codes
      c. Applications
2. Self-contained units
   a. Conventional or open type units
   b. Hermetic units
   c. Compressor ventilation requirements
      1. Air-cooled
      2. Water-cooled
      3. Manufacturer's recommendations
3. Remote condensing units
   a. Accessible location
   b. Noise factors
   c. Protection for unit
4. Cooling coils
   a. Air circulation and distribution
   b. Careful mounting
   c. Supports and hangers
5. Tubing
   a. Type used
   b. Support for tubing
   c. Accessories-Valve, drier sight glass
UNIT III  SERVICE PROBLEM (cont'd)

Operations

B. Initial Start-up
1. How to take proper steps that are required for the initial start up of a commercial air conditioning unit
2. How to develop the attitude of the occurrence of possible future troubles in an air conditioning system if a satisfactory operational check is not completed on initial start-up

Related Information

d. Vibration absorbers and loops
e. Condensate drains
f. Slope of vapor lines

1. Evacuation
a. On all new systems, except those that are precharged
b. On all systems that have been open
c. The use and operation of a vacuum pump
d. Extent and importance of vacuum

2. Charging
a. Critical charge systems-self contained
   1. Manufacturers recommendations
   2. Portable charging equipment
b. Non-critical charge systems
   1. Liquid charging
   2. Vapor charging-sight glass

3. Operational check
a. Remove shipping bolts and/or blocks
b. Oil all motor bearings
c. Check operation pressures
   1. Suction
   2. Discharge
   3. Compressor oil
d. Pressure controls
e. Electrical check out
   1. Volts
   2. Amperage
   3. Correct fuse size
f. Adjust super heat
g. Adjust motor control
h. Adjust evaporator and condenser fans

C. Diagnosing Service Problems
1. How to diagnose the numerous problems that may arise when servicing an air conditioning system

1. Entire unit will not run
a. No power at compressor
   1. Check disconnect switch
   2. Check fuse or circuit breaker
   3. Check source of main power
   4. Broken wire or loose connection
Operations

2. How to look for any signs that something is wrong in an air-conditioning system

3. Diagnosing must be made to find the source of the trouble

4. How to develop an attitude that even in trouble-shooting service problems, safety precautions should be taken for the protection of equipment and personnel

Related Information

b. Power at compressor
   1. Compressor motor
   2. Overload
   3. Control wiring and control

2. Unit runs - no cooling
   a. Loss of refrigerant
   b. Inefficient compressor
   c. Restriction in tubing or accessories

3. Unit runs - insufficient cooling
   a. Shortage of refrigerant
   b. Inefficient compressor
   c. Obstruction in lines
      1. Refrigerant control
      2. Drier
   d. Control setting

4. Unit noisy
   a. Vibration in lines
   b. Surplus of oil
   c. Defective compressor valves
   d. Refrigerant overcharge
   e. High head pressure
   f. Loose components or compressor mounts

5. Unit short cycles
   a. Partial obstruction in lines
   b. Leaky power element
   c. Improper adjustment of refrigerant control device

Load Calculations

Operations

Heat gain calculations
1. How to understand the many miscellaneous heat gains that must be taken into consideration when selecting a proper air-conditioning unit.

2. How to develop a knowledge and understanding of room heat

Related Information

1. Sources of heat
   a. Transmission-sensible heat
      1. Conduction
         a. Walls, ceiling and floors
         b. Time of year and day
         c. Types of insulation
         d. Thickness of insulation
         e. External area
         f. Temperature difference
   b. Radiation
      a. Type of glass
      b. Other transparent materials
UNIT IV LOAD CALCULATIONS (cont'd)

Operations

3. How to make a complete survey of the area to be conditioned
   a. Obtain all the room dimensions
   b. Note the windows, walls, ceiling and floor construction

4. How to make a floor plan of area to be conditioned

5. How to become familiar with the different types of construction in residences and commercial buildings and the importance of this information for calculation and installation purposes
   a. Heat Loss Calculation
      1. How to become familiar with the various methods of heat movement or transfer through building materials
      2. How to know the difference between heat gain and heat loss in a building
      3. How to control the heat gain and heat loss in a building
      4. How, with the use of calculations, it will help in the selection of cooling coils and condensing units
      5. How to know and understand the various instruments and their use in taking measurements for correct air distribution
         a. Pitot tube
         b. U-tube Manometer
         c. Inclined manometer or draft gauge
         d. Velocities
            1. Velometer
            2. Anemometer
            3. Anemotherm air meter

Related Information

3. Solar
   a. Time of year and day
   b. Exposure
   c. Latitude
   d. Shading

4. Product
   a. Sensible heat
   b. Latent heat
   c. Respiration

5. Appliances, gas or electric

6. Lights
   a. Fluorescent
   b. Incandescent

7. Machines

8. Motors

9. People-Degree of activity

10. Air Changes
    a. Inside volume
    b. Type of usage

11. Duct work
    a. Supply-air heat gain
    b. Return-air duct gain

12. Ventilation air
    a. CFM per person
    b. CFM per square of floor space

    b. Transmission-Latent heat
       1. Internal
          a. Appliances
          b. People-degree of activity
       2. External-ventilation air
          a. Desired resulting conditions
          b. Air mixture proportions
          c. Sensible heat ratio

2. Insulation
   a. Purpose or need
      1. Prevention against heat transfer
      2. Humidity control
      b. Thermal insulation
      c. Water vapor barriers
      d. Economic considerations
      e. Building insulation

3. Building construction
   a. Exterior walls
   b. Interior walls
   c. Floors and ceilings
   d. Insulation
UNIT V AUTOMOTIVE AIR CONDITIONING

Operations

A. How to install belts, align adjust the tension and operate an automobile air conditioning unit
1. Engine off, check belt tension, loosen adjustment bolts, remove belt
2. Inspect and measure belt
3. Replace or install new belt
4. Carefully check the alignment of the pulleys and their shafts, realign if necessary
5. Apply lever pressure on the compressor or idler pulley until the correct belt tension is obtained
6. Tighten the adjustment bolts
7. Recheck the belt tension
8. Install the fan guard and run engine. Recycle several times
9. Recheck the belt tension
10. Shut down the system

3. How to install a compressor on an automobile air conditioning system
1. Check the compressor oil level
2. Check the magnetic clutch operation
3. Install the compressor
   a. Install belt
   b. Check belt for correct alignment and tension
4. Install the refrigerant lines
5. Install gauge manifold
6. Check for leaks at 25 psig then at 70 psig
7. Evacuate the system
8. Operate the system
   a. Charge system
   b. Check sight glass
   c. Test for leaks

Related Information

1. Introduction to automotive air conditioning
   A. Automotive air-conditioning principles
   B. Development of auto. air-conditioning
   C. Operating conditions
      1. Idling engine
      2. Fresh air ducts closed
      3. Operating engine
      4. Heat load
   D. Performance of system
   E. Types of systems
      1. Pressure operated low side pressure regulators
      2. Pressure operated bypass
      3. Solenoid operated bypass
      4. Electro-magnetic clutch
         a. Revolving magnetic coil
         b. Stationary magnetic coil
   F. Types of compressors
   G. Compressor seals
   H. Belts
      1. Belt tensions—new and used belts
   I. Condenser (air-cooled)
   J. Receiver-Drier
   K. Refrigerant lines
      1. Flared fittings
      2. O ring fittings
      3. Hose clamp fittings
   L. Evaporators
   M. Expansion Valves
   N. Suction pressure control valves
      1. Suction throttling valves (STV)
      2. Evaporator pressure regulator (EPR)
      3. Pressure operated altitude Valve (POA)
   O. Service valves
UNIT V  AUTOMOTIVE AIR CONDITIONING  (cont'd)

Operations

9. Check operating pressures and the evaporator outlet temperature
10. Remove the gauge manifold and shut down system

C. How to install an evaporator on an automotive air conditioning system
1. Select proper cooling coil
2. Mount the thermostatic expansion valve on the evaporator and install the suction and liquid lines
3. Mount the evaporator, level and connect the refrigerant lines and drain hose
4. Complete the electrical wiring and connect the gauge manifold
5. Test for leaks
6. Evacuate the system, using the deep vacuum procedure
7. Operate the system, charge it, check its operation
8. Seal the tubing opening in the firewall, install the evaporator housing

D. Locate and repair trouble in an automobile air-conditioning system
1. Install the gauge manifold
2. Check the compressor belt tightness
3. Check for leaks
4. Check oil charge
5. Operate the system
6. Check the operating pressures, temperatures and quantity of refrigerant
7. Replace, repair or adjust the system until normal operation is obtained

E. How to install, test and adjust the clutch

F. How to install, test and adjust the thermostatic expansion valve (TEV)
1. Install gauge manifold

Related Information

2. Air distribution
A. Duct system
   1. Fresh air inlet
   2. Return air inlet
   3. Evaporator housing
   4. Drain pan and drain connections
   5. Plenum chamber
   6. Conditioned air outlets
   7. Dampers

B. Fans
   1. Radial flow
   2. Squirrel cage
   3. Centrifugal

C. Fan motors
   1. 6 volts
   2. 12 volts

D. Insulation
   1. Types
   2. Areas

3. Special tools and equipment for working on automotive air-conditioning
A. Gauge manifold test unit
B. Two-way valve
C. Three way tee
D. 90° gauge line adapter
E. Puller and puller pilot
F. Multi-opener (4 cans)
G. Non-magnetic clutch shims
H. #21 Snap Ring pliers
I. #26 Snap Ring pliers
J. Compressor holding fixture
K. Compressing fixture
L. Clutch hub holding tool
M. Hub and drive plate assembly remover and installer
N. Seal and seal seat removers - pulley bearing remover
O. Shaft seal protector
P. Pressure test connector

4. Sections of component parts
A. The drive belt
   1. Used to drive the compressor
   2. Belt adjustment
   3. Belt tension gauge
UNIT V  AUTOMOTIVE AIR CONDITIONING  (cont'd)

Operations

2. Discharge the system
3. Remove the thermostatic expansion valve from the liquid line and evaporator.
   Remove the thermal bulb.
   Disconnect the equalizer tube.
4. Test the thermostatic expansion valve
5. Reinstall the TEV. Tighten all fittings. Connect the equalizer tube and mount the thermal bulb securely
6. Replace all insulation
7. Install the gauge manifold, pressurize to 25 psig, test for leaks, pressurize to 70 psig and test for leaks
8. Charge to clear sight glass - test for leaks
9. Operate the system
10. Check operating pressures, refrigerant quantity and evaporator outlet air temperatures
11. Check the sweat back on the suction line
12. Remove the gauge manifold

Related Information

B. The electro-magnetic clutch
   1. Operates the compressor
   2. Operates by the principle of magnetic attraction
C. The compressor
   1. Purpose of compressor is to pump refrigerant into the condenser
D. The condenser
   1. Purpose of condenser is to dissipate heat
E. The receiver-drier
   1. The receiver-drier has four functions
      a. Storage
      b. Moisture absorption
      c. Filtration
      d. Trouble diagnosis
F. The thermostatic expansion valve (TEV)
   1. The TEV meters liquid refrigerant as needed to the evaporator
G. The evaporator
   1. The purpose of the evaporator core is to cool and remove moisture from the air flowing through it
5. The electrical control system
   A. The thermostatic switch
   B. Blower motor
   C. Control switch
   D. Rheostat
   E. Clutch field
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COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Safety Precautions

Grade 12

1. Do not operate water-cooled unit without water running.
2. Check fans for proper rotation.
3. Exercise care in handling psychrometers.
4. Do not put air filters in backwards.
5. Exercise care when climbing ladders.
6. Check all voltages before making any connections.
7. Shut off power when working on high voltage lines.
8. Wear goggles when handling refrigerant or breaking any tubing connections.
9. Check voltages when working with low voltage controls.
10. Avoid using improper tools.
11. Handle high voltage and sensitive equipment with care.
12. When removing a valve from a system, one should always use two wrenches to avoid twisting the valve or the tubing.
13. Use a fan guard whenever possible.
14. Carefully avoid touching the pulleys, fans, or belts with one's hand, tools or clothing.
15. Use gauge and service manifold when servicing automobile air conditioning systems.
16. Be sure that the gauge manifold lines do not come in contact with the fan or pulleys.
17. When it is necessary to make air conditioning adjustments with the engine running, be sure the transmission control lever is in "Park" position.
18. Protect the hands with a wiping cloth when removing the radiator pressure cap or refrigerant service caps to prevent burning or freezing one's hand.
19. Never apply heat from a torch to a sealed refrigeration system. Refrigerant will expand rapidly and could cause an explosion.

20. Refrigerant 12 in the presence of an open flame produces phosgene gas. It is very toxic. Never breathe it.

*NOTE: FOR YOUR OWN PROTECTION, WEAR GOGGLES WHEN OPENING ANY REFRIGERANT SYSTEM.
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Typical Shop Jobs

Grade 12

1. Residential Air Conditioning
   
   A. Window Units
      
      1. Install a window unit
      2. Install a service valve attachment
      3. Check the refrigerant charge on a hermetic unit
      4. Troubleshoot a capillary tube system on a hermetic unit
      5. Test and/or replace a capacitor and relay on a hermetic unit
      6. Make electrical checks of motors on air-conditioning units
         containing different types of electric motors
      7. Check CFM and clean condenser and evaporator
      8. Check, calibrate, or replace thermostatic control
      9. Replace a hermetic compressor
     10. Make a complete electrical check on a complete window unit

   B. Central Systems
      
      1. Measure relative humidity, dew point and air velocity
      2. Install a self contained comfort cooler
      3. Install a residential central cooling system
      4. Install a heat pump
      5. Calculate the comfort cooling heat load for an assigned area
      6. Locate trouble in a self contained comfort cooler system
      7. Locate trouble in a residential central comfort cooling system
      8. Locate trouble in a water chiller
      9. Troubleshoot the electrical circuits of a central system
     10. Install, test and operate a 24 volt and a 120 volt heating
         control system

2. Automotive Air Conditioning
   
   A. Basic Service Procedures
      
      1. Evacuating an automobile air-conditioning system
      2. Install refrigerant lines and test system for leaks
      3. Charging the system
      4. Putting a partial charge into system
      5. Remove and reinstall the compressor and return it to service
      6. Checking and adding oil to the compressor
2. Automotive Air Conditioning (cont'd)

A. Basic Service Procedures (cont'd)

7. Checking and isolating the compressor
8. Replace a compressor seal
9. Install belts, align, adjust the tension on a system
10. Connect a one pound can of R-12 to the gauge manifold, system off and system running

B. Advanced Service Procedures

1. Install an evaporator on an automobile air conditioning system
2. Remove, service and reinstall a condenser
3. Install an "Add On" Automobile air cooling system
4. Locate and remove trouble from an "Add-On" system
5. Remove, test, reinstall and adjust a thermostatic expansion valve
6. Dismantle, replace worn parts, assemble and test compressor
7. Locate and repair trouble in an automobile air conditioning system
8. Test system pressures with engine off, and engine running
9. Check out an automobile air conditioning system's electrical circuit
10. Test the operation of an evaporator pressure regulator valve
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Typical Jobs

Grade 12

Air Conditioning - Cooling
Air Conditioning - Heating
Air Conditioning - Automotive

A. Theory - Air Conditioning - Cooling and Heating

1. Review of general safety rules
2. Introduction to air conditioning
3. Humidity
4. Psychrometric chart
5. Comfort cooling systems
6. Window comfort coolers
7. Self-contained comfort coolers
8. Residential central systems
9. Heat loads
10. Load calculations
11. Air distribution
12. Air cleaning, dehumidifiers
13. Heat pump systems
14. Electrical circuits
15. Electrical controls

B. Shop Jobs

1. Installing window systems
2. Installing self-contained systems
3. Installing residential control systems
4. Installing heat pumps
5. Replacing fans and motors
6. Trouble-shooting above units
7. Calculating heat loads
8. Checking duct systems
9. Measuring relative humidity
10. Measure air velocities using an Anemometer Pitot Tube and Velocimeter
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Typical Jobs (cont'd)

Grad 12

A. Theory - Automotive Air Conditioning

1. Safety around automotive equipment
2. Introduction to automotive air conditioning systems
3. Compressors, compressor drives
4. Condensers, receivers, sight glasses
5. Thermostatic expansion valves
6. Evaporators, blowers and motors
7. Thermostats
8. Electrical circuits
9. All of the different manufacturer's motor systems
10. Independent systems
11. Air distribution

B. Shop Jobs

1. Install belts, align, adjust the tension and operate an automobile air conditioning system
2. Install a two cylinder compressor
3. Install an evaporator
4. Remove and reinstall a condenser
5. Remove, test, reinstall and adjust a thermostatic expansion valve
6. Install refrigerant lines and test for leaks
7. Locate and remove trouble from an "Add-On" system
8. Evacuate, then recharge system with two cylinder compressor
9. Replace compressor seal
10. Dismantle, replace worn parts, assemble and test a compressor
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air Conditioning and Refrigeration


Faris, Kamil J., Refrigeration I and II, Vocational-Technical Curriculum Laboratory, Rutgers - The State University, Bldg. 4103, Kilmer Campus, New Brunswick, New Jersey 1971


Faris, Kamil J., Electricity in Refrigeration and Air Conditioning, Vocational-Technical Curriculum Laboratory, Rutgers, The State University, Bldg. 4103, Kilmer Campus, New Brunswick, New Jersey 1968

Automotive Air-Conditioning Service Manual, Refrigeration and Air-Conditioning Division, Parker-Hannifin, 17325 Euclid Avenue, Cleveland, Ohio 44112 1967


Czinkota, Michael, Sands, Leo G., How to Select, Install and Service Air Conditioners, Chilton Book Company, Philadelphia, Penna. 1969


Air Conditioning and Heating Technology II, Gattone, Felix, Dept. of Vocational-Technical Education, Rutgers-The State University, New Brunswick, New Jersey 1965

Carmody, John J., Basic Automotive Air Conditioning, Vocational-Technical Curriculum Laboratory, Rutgers - The State University, Bldg. 410, Kilmer Campus, New Brunswick, New Jersey 1971

Kaberlein, John J., Air Conditioning Metal Layout, The Bruce Publishing Company, Milwaukee, Wisconsin
OBJECTIVES:

1. To learn some fundamental concepts of the physical laws of nature.

2. To learn how some of these physical laws apply to the air conditioning and refrigeration trade.

3. To learn how these laws may aid in solving problems found in this trade.

UNIT I. MATTER

A. Structure of Matter
   1. Molecules
   2. Atoms

B. Measurement of Matter
   1. Density
   2. Specific gravity

C. Physical States of Matter
   1. Solid
      a. Density of copper
      b. Density of aluminium
      c. Density of steel
   2. Liquid
      a. Special properties
         1. Under pressure
         2. Under different temperatures
         3. Effect of pressure on boiling point
      b. Specific gravity
         1. Of water
         2. Of certain common acids
         3. Of oils
   3. Gas
      a. Special properties
         1. Under pressure
         2. Under different temperatures
         3. Charles' Law
         4. Boyles' Law
         5. Dalton's Law
      b. Density of gases
         1. Oxygen
         2. Helium
         3. Carbon dioxide
         4. Freon
UNIT II. MEASUREMENT

A. English System
   1. Linear
      a. Inches, feet, yards
   2. Area
      a. Square inches, square feet, square yards
   3. Volume
      a. Cubic inches, cubic feet, cubic yards

B. Metric System
   1. Linear
      a. Centimeter, meter
   2. Area
      a. Square centimeters, square meters
   3. Volume
      a. Cubic centimeters, cubic meters, liters
   4. Weight
      a. Gram, kilogram

UNIT III. FORCES

A. Kinds of Forces
B. Effects of Forces
C. Mechanical Advantage
D. Work, Power, and Efficiency
E. Balance and Equilibrium
F. Vectors
G. Pressure
   1. Atmospheric pressure
   2. Measuring devices
      a. Bourdon gauge
      b. Manometer
      c. Barometer
   3. Absolute pressure

UNIT IV. SIMPLE MACHINES

A. Levers
   1. Hand tools
   2. Mechanical advantage
B. Inclined planes
   1. Wedges
   2. Mechanical advantage
C. Pulleys
   1. Fixed, moveable
   2. Pulley systems
D. Wheels and Axles
E. Screw Threads
F. Power Transmission
   1. Belts, V-belt drives
   2. Coupling
   3. Measurement using horsepower
G. Friction
   1. Causes and reduction
   2. Coefficients of friction
UNIT IV.  (continued)

H. Lubrication
  1. Types of lubrication
     a. Gravity
     b. Pressure
     c. Splash
  2. Types of lubricants

UNIT V.  HEAT

A. Sources of Heat
  1. Solar (sun's rays)
  2. Electrical
  3. Atomic
  4. Frictional
  5. Chemical and other
B. Measurement of Heat
  1. Specific heat
  2. Latent heat
     a. Fusion
     b. Evaporation
  3. Calorie and B.T.U.
C. Transfer of Heat
  1. Radiation
  2. Conduction
  3. Convection
  4. Evaporation
D. Boiling Points of Liquids and Gases
  1. Refrigerant 12
  2. Refrigerant 22
  3. Alcohol
  4. Water
E. Change of State of Heat as in Refrigerators
F. Temperature
  1. Measurement of
  2. Kinds of thermometers
     a. Fahrenheit
     b. Centigrade
  3. Kelvin scale
G. Humidity
  1. What is humidity?
  2. Measurement of
  3. Effect on human body
H. Expansion and Contraction of Matter
  1. Peculiar action of water at 4°C.
I. Methods of Heating Homes and Other Buildings
  1. Steam Heat
  2. Hot Water
     a. Forced and Convection Methods
  3. Hot Air
     a. Gravity
     b. Forced air
     c. Hot and cold air ducts
UNIT V. (Continued)

J. Insulation
   1. Common kinds used in refrigerators, freezers, air conditioners
   2. Common insulating materials used in buildings

UNIT VI. MAGNETISM

A. Nature and Theory of Magnetism
B. Laws of Magnetism
C. Kinds of Magnets
   1. Natural
   2. Permanent
   3. Electro-magnet
D. Magnetic Effects of an Electric Current
E. Electro-magnetic Induction

UNIT VII. ELECTRICITY

A. Static Electricity
B. "Moving" Electricity
C. Simple circuits
   1. Series
   2. Parallel
   3. Combination
D. Direct Current
   1. Generation
      a. Parts of generators
   2. D.C. motors
      a. Parts
E. Alternating Current
   1. Generation
      a. Parts of generators
   2. A.C. Motors
      a. Parts
F. Transformers
   1. Primary coil
   2. Secondary coil
   3. Function
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air Conditioning and Refrigeration
Related Physics
Grade 10

TEXT:


WORKBOOKS:

Turner, Carpenter *Discovery Problems in Physics*
College Entrance Book Co. 1970
Objectives:

1. To understand the importance of chemistry in our modern world.

2. To learn some fundamental principles of chemistry and how to apply these principles in solving problems of the air conditioning and refrigeration trade.

3. To learn certain important special applications of chemistry in the operation and construction of refrigeration units and refrigerants.

UNIT I   INTRODUCTION

A. Role of chemistry in our daily lives

B. Chemical symbols

C. Definition of terms

D. Laboratory apparatus

UNIT II   SAFETY IN THE LABORATORY AND CLASSROOM

A. Horseplay

B. Housekeeping

C. Glassware

D. Chemicals

E. Water

F. Fire

G. Organic solvents

H. Electrical equipment
UNIT III  STRUCTURE OF MATTER

A. Matter
   1. Composition
      a. Molecule
      b. Atom

B. Elements

C. Compounds and mixtures

D. Solids, liquids, gases

UNIT IV  LIQUIDS

A. Solutions and suspensions

B. Distillation of liquids

C. Liquids used in air conditioning and refrigeration trade

UNIT V  MATTER

A. Physical change

B. Chemical change
   1. Examples of each

UNIT VI  OXYGEN

A. Properties
   1. Physical
   2. Chemical

B. Preparation
   1. In laboratory
   2. Commercially

C. Oxidation
   1. Of iron
   2. Of copper and aluminum
   3. Other metals

D. Ozone

UNIT VII  HYDROGEN

A. Properties
   1. Physical
   2. Chemical
UNIT VII  HYDROGEN  (cont'd)

B. Preparation
   1. In laboratory
   2. Commercially

C. Safety precautions to follow when using

D. Reduction

E. Commercial uses

UNIT VIII  NITROGEN

A. Properties
   1. Physical
   2. Chemical

B. Preparation
   1. Commercially

C. Common compounds
   1. Nitrous oxide
   2. Nitric acid
   3. Ammonia

D. Commercial uses

UNIT IX  ACIDS, BASES AND SALTS

A. Properties of each
   1. Physical
   2. Chemical

B. Action on litmus paper.

C. Common acids
   1. Hydrochloric
   2. Sulfuric
   3. Nitric
   4. Acetic
   5. Others

D. Common bases
   1. Sodium hydroxide
   2. Calcium hydroxide
   3. Aluminum hydroxide
UNIT IX  ACIDS, BASES AND SALTS (cont'd)

E. Common salts
   1. Sodium chloride
   2. Potassium chloride
   3. Sodium sulfate
   4. Zinc chloride
   5. Sodium nitrate

F. Neutralization of an acid and a base
   1. Resulting products

G. Commercial uses of acids, bases and salts

UNIT X  COMMON METALS

A. Ferrous metals
   1. Iron and steel
      a. Kinds
      b. Manufacture
      c. Use in air conditioning and refrigeration

B. Non-ferrous metals
   1. Aluminum
      a. Occurrence in the earth
      b. Manufacture
      c. Properties
      d. Uses in air conditioning and refrigeration
   2. Copper
      a. Manufacture
      b. Properties
      c. Common alloys
      d. Uses in air conditioning and refrigeration
   3. Zinc
      a. Manufacture
      b. Properties
      c. Uses in air conditioning and refrigeration
   4. Chromium, nickel, tin, silver
      a. Manufacture
      b. Properties
      c. Uses in air conditioning and refrigeration
UNIT XI  CARBON AND CARBON COMPOUNDS

A. Carbon

1. Occurrence
2. Common compounds
   a. Carbon monoxide
   b. Carbon dioxide
   c. Graphite
   d. With calcium and sodium to form carbonates
   e. Coal, coke, petroleum
   f. Carbonic acid and "dry ice"
   g. Hydrocarbons

UNIT XII  ADSORPTION AND ABSORPTION

A. Definition and meaning

B. Absorption

1. Air in water
2. Ammon absorption system in a refrigerator
3. Lithium chloride in water
4. Water by calcium chloride and calcium sulfate

C. Adsorption

1. In solids
2. Silica gel
3. Activated alumina
4. Importance of temperature and pressure in adsorption

UNIT XIII  REFRIGERANTS

A. Physical and chemical properties of

1. Ethane
2. Carbon dioxide
3. Propane
4. Refrigerant 11
5. Refrigerant 12
6. Refrigerant 500
7. Refrigerant 22
8. Refrigerant 113 and 114
9. Refrigerant 502
10. Ammonia
11. Methyl chloride
12. Sulfur dioxide
13. Butane
14. Ethyl chloride
15. Methyl formate
16. Methylene chloride
BIBLIOGRAPHY OF TEXTS AND REFERENCE BOOKS

Air Conditioning and Refrigeration
Applied Chemistry
Grade 11


References:


Refrigeration Compressors and Their Lubrication. Mobil Oil Corp.

Refrigerants and Service Pointers Manual. E. I. DuPont de Nemours
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Related Algebra

Grade 10

Objectives:

1. To review the basic concepts of arithmetic.
2. To learn the basic concepts of algebra.
3. To learn how to use algebra to solve problems related to air conditioning and refrigeration.

UNIT I  REVIEW OF ARITHMETIC

A. Whole numbers, fractions, decimals
   1. Addition
   2. Subtraction
   3. Multiplication
   4. Division

B. Measurement - English and Metric
   1. Linear
   2. Square
   3. Cubic
   4. Temperature and heat
   5. Measuring instruments used in trade

C. Percentage
   1. Trade applications

D. Graphs and charts
   1. Development and interpretation

E. Ratio and proportion
   1. Trade application

UNIT II  ALGEBRAIC SYMBOLS

A. Using symbols
UNIT III ALGEBRAIC EVALUATION

A. Simple expressions
B. Expressions involving parentheses
C. Expressions involving exponents
D. The meaning of formulas

1. Evaluation of formulas
   a. Algebraically
   b. Algebraically with units of measure, mass and energy as related to Air-Conditioning and Refrigeration

UNIT IV EQUATIONS

A. Solution by subtraction axiom
B. Solution by addition axiom
C. Solution by division axiom
D. Solution by multiplication axiom
E. Mixed equations
F. Evaluation of equations

   a. Algebraically
   b. Algebraically with units of measure, mass and energy as related to Air-Conditioning and Refrigeration

G. Problems solved by formulas

1. Geometric (covering squares, rectangles, rectangular solids, circles and cylinders)
2. Gears, pulleys, and sprockets
3. Electricity
4. Levers
5. Temperature

UNIT V POSITIVE AND NEGATIVE NUMBERS

A. Meaning of signed numbers
B. Comparison of signed numbers
C. Addition of signed numbers
D. Subtraction of signed numbers
E. Multiplication of signed numbers
F. Division of signed numbers
G. Evaluation of simple expressions
H. Evaluation of expressions involving parentheses
I. Evaluation of expressions involving exponents

UNIT VI FUNDAMENTAL OPERATIONS

A. Addition of monomials
B. Addition of polynomials
C. Subtraction of monomials
UNIT VI  FUNDAMENTAL OPERATIONS (cont'd)

D. Subtraction of polynomials
E. Removing parentheses by addition or subtraction
F. Inclosing terms within parentheses
G. Multiplication of monomials
H. Division of monomials

UNIT VII  FRACTIONS

A. Reduction of fractions
B. Multiplication of fractions
C. Division of fractions
D. Addition and subtraction of monomial denominators
E. Addition and subtraction of like denominators

UNIT VIII  REARRANGING AND EVALUATION OF FORMULAS

A. Rearranging formulas
B. Evaluation of formulas

UNIT IX  POWERS AND ROOTS

A. Powers of monomials
B. Roots of monomials
C. Square roots

-93-
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air Conditioning and Refrigeration

Related Algebra

Grade 10

King, Guy R. Modern Refrigeration Practice N. Y. McGraw Hill, 1971

Marsh, W., Olivo, T. Principles of Refrigeration Albany, N.Y. Delmar Publishers 1966

OBJECTIVES:

1. To learn the basic principles of geometry.
2. To learn how to construct basic geometric shapes.
3. To learn how to solve problems in air conditioning and refrigeration dealing with geometry.

UNIT I POINTS, LINES, PLANES AND SPACE

A. Naming points, lines and planes
B. Kinds of lines
C. Intersecting, parallel and perpendicular lines
D. Scales (and drawing by scale)

UNIT II ANGLES

A. Naming angles
B. Kinds of angles
C. Measuring angles
D. Drawing angles

UNIT III GEOMETRIC FIGURES

A. Simple closed plane figures
   1. Triangles
   2. Quadrilaterals
   3. Circles
   4. Solid or space figures

UNIT IV CONSTRUCTIONS

A. Triangles
B. Regular polygons
C. Bisecting line segments
D. Bisecting an angle
E. Constructing a perpendicular to a line at a point on the line
F. Constructing a perpendicular to a line from a point outside the line
G. Constructing an angle equal to a given angle
H. Constructing a line parallel to a given line through a point outside the given line
UNIT IV CONSTRUCTIONS (cont'd)

I. Pairs of angles  
J. Parallel lines and angle relationships  
K. Congruent triangles  
L. Similar triangles

UNIT V INDIRECT MEASUREMENT

A. By rule of Pythagoras  
B. By similar triangles

UNIT VI PERIMETER AND CIRCUMFERENCE

A. Perimeter of a rectangle  
B. Perimeter of a square  
C. Perimeter of a triangle  
D. Circumference of a circle

UNIT VII AREA

A. Area of a rectangle  
B. Area of a square  
C. Area of a parallelogram  
D. Area of a triangle  
E. Area of a trapezoid  
F. Area of a circle  
G. Total area of a rectangular solid and a cube  
H. Lateral area and total area of a right circular cylinder

UNIT VIII VOLUME - MEASURE OF SPACE

A. Volume of a rectangular solid  
B. Volume of a cube  
C. Volume of a right circular cylinder  
D. Volume of a sphere, right circular cone, and a pyramid.

N.B. Trade applications for individual lessons are numerable. Rather than specify individual applications, the instructor is encouraged to employ those applications that are of immediate interest.
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air Conditioning and Refrigeration

Related Geometry

Grade 11


COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Applied Mathematics

Grade 12

Objectives:

1. To learn how to use the psychrometric chart as applied to the air conditioning and refrigeration field.

2. To learn the principles of load estimating and to be able to apply these principles in estimating heating and cooling loads.

3. To learn the principles involved in designing a direct expansion cooling system for residences.

UNIT I

PROBLEMS INVOLVING PSYCHROMETRICS AND THE PSYCHROMETRIC CHART

A. Psychrometrics

1. Its meaning
2. Relation to air conditioning and refrigeration as a useful tool

B. The psychrometric chart

1. Psychrometric terms and the location of scales and lines for these terms on the chart
   a. Dry bulb temperature
   b. Wet bulb temperature
   c. Relative humidity
   d. Grains of moisture per pound of dry air
   e. Dew point
   f. Specific volume

2. Relationship of terms as determined by the intersecting of lines on the chart
   a. Wet bulb and dry bulb for relative humidity
   b. Dry bulb and relative humidity for wet bulb
   c. Wet bulb and dry bulb for dewpoint
   d. Wet bulb and relative humidity for dewpoint
   e. Dry bulb and relative humidity for dewpoint
   f. Dry bulb and wet bulb for grains of moisture
UNIT I PROBLEMS INVOLVING PSYCHROMETRICS AND THE PSYCHROMETRIC
CHART (cont'd)

C. Application of psychrometric terms

1. Practical application of the term humidity in -
   a. Winter air conditioning
   b. Summer air conditioning

2. Practical application of the term dewpoint
   a. Condensation in winter
   b. Condensation in unconditioned spaces

3. Practical application of the term wet bulb
   a. The use of wet bulb to determine moisture content
      of air and its dew point

D. Psychrometric processes

1. Latent heating and cooling
2. Sensible heating and cooling
3. Latent and sensible heating and cooling
   a. Heating and humidifying
   b. Cooling and dehumidifying

4. Sensible heat factor and its applications
5. Air mixtures
6. Bypass air for a coil and the bypass factor

E. Advanced psychrometrics

1. Specific volume
2. Enthalpy
3. Spray coil operations
   a. Cooling and humidifying
   b. Cooling and dehumidifying
   c. Heating and humidifying

UNIT II PRINCIPLES AND PROBLEMS OF LOAD ESTIMATING

A. Cooling load heat sources

1. Outdoor heat sources
2. Indoor heat sources
3. Heating load heat losses

B. Cooling and heating load estimating guides

1. The heat transfer factor ("u") for glass, walls,
   roofs, etc.

-99-

108
UNIT II

PRINCIPLES AND PROBLEMS OF LOAD ESTIMATING (cont'd)

2. The effects on cooling and heating loads

   a. Ventilation
   b. Materials
   c. Light
   d. People
   e. Equipment

C. Estimating the air conditioning load

1. The survey pattern of a structure to be conditioned

   a. Building orientation

      1. Size
      2. Shape
      3. Materials of construction
      4. Glass areas
      5. Infiltration
      6. People occupancy
      7. Appliances
      8. Lights
      9. Ventilation
     10. Utility services
     11. Local and State codes

2. Load estimate forms

   a. Residential cooling load estimates
   b. Residential heating load estimates
   c. Commercial cooling load estimates
   d. Commercial heating load estimates

UNIT III

PROBLEMS INVOLVING AIR DISTRIBUTION

A. Air distribution - ducts

   1. Circular, rectangular or square shaped ducts and materials used.
   2. Duct systems

      a. Loop perimeter
      b. Radial perimeter
      c. Extended plenum

B. Air distribution - outlets

   1. Types of outlets

      a. Supply
      b. Return
      c. Ceiling diffusers
      d. Grilles and Registers
C. Direct expansion cooling system design for residences

1. Determining cooling load and temperature swing
2. Determining type of cooling unit and its location
3. Determining CFM per BTUh, CFM for each room and entire house
4. Layout of duct system
5. Calculation of CFM load for extended plenums (and respective static pressures)
6. Size of plenum and branches
7. Size of return ducts
8. Selecting diffusers, grilles, etc.
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air Conditioning and Refrigeration

Applied Mathematics

Grade 12


COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Related Drawing

Grade 10

Objectives:

1. To learn the basic fundamentals of blueprint reading and drawing as applied to the air conditioning and refrigeration trade.

2. To learn how to make sketches and drawings of air conditioning ducts and simple equipment layouts.

3. To learn how to read and interpret trade diagrams.

UNIT I USE OF DRAWING INSTRUMENTS

A. Drawing board and T-square
B. Scales
C. Triangles
D. Compass and dividers
E. Protractors

UNIT II BASIC DRAWING

A. Standards and principles
B. Lettering
C. Orthographic projection
   1. Object
   2. Point of sight
   3. Projection lines
   4. Projection plane
   5. Angles of projection
UNIT III   WORKING DRAWINGS

A. Pictorial drawings
   1. Isometric drawings
   2. Oblique drawings

B. Slanting surfaces

C. Invisible edges

D. Half-size scale

E. Cylindrical objects

F. Two-view drawings

G. Dimensioning holes

UNIT IV   SYMBOLS AND CONVENTIONS

A. Materials in section
   1. Wood
   2. Stone
   3. Brick
   4. Concrete

B. Symbols
   1. Doors
   2. Windows
      a. Double hung
      b. Single sash
      c. Casement

C. Built-in fixtures

UNIT V   STRUCTURAL MEMBERS OF A FRAME STRUCTURE

A. Foundations

B. Sills and gutters

C. Vertical framing

D. Openings
   1. Doors
   2. Windows
   3. Stair-well
   4. Dormers
   5. Porches and breezeways
UNIT V  STRUCTURAL MEMBERS OF A FRAME STRUCTURE  (cont'd)

E. Studding

F. Sheathing

UNIT VI  INTERPRETING RESIDENTIAL BLUEPRINTS

A. Sewage system and house drain system

B. Stack and vent piping

C. Hot and cold water piping

D. Fuel storage and supply lines

UNIT VII  INTERPRETING COMMERCIAL BLUEPRINTS

A. Plot plans and the engineers scale

B. Elevations and plumbing installations

C. Soil stack, waste and vent piping

D. Hot and cold water piping

Sundberg, Elmer W. Building Trades Blueprint Reading. Chicago, American Technical Society, 1967

Polena, Bruce. Drafting - 1. New Brunswick; Curriculum Laboratory, Rutgers University 1970
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration
Related Drawing
Grade 12

Objectives:

1. The students will be able to apply the principles of orthographic projection by developing two and three-view drawings.
2. To demonstrate the ability to visualize one or more views.
3. To develop skill in drawing plan and elevation views.
4. To practice reading architectural drawings related to air-conditioning and refrigeration systems.

UNIT I REVIEW OF BASIC DRAWING TECHNIQUES

UNIT II ARCHITECTURAL DRAFTING SYMBOLS

A. Plumbing symbols
B. Electrical symbols for architectural plans
C. Welding symbols
D. Sheet metal ductwork symbols

UNIT III WARM-AIR HEATING SYSTEMS

A. Loop perimeter system
B. Radial perimeter system
C. Crawl space plenum
D. Extended plenum
E. Overhead radial
F. Graduated plenum
UNIT IV  LAYOUT OF A RADIAL HEATING PLAN

UNIT V  SINGLE LINE AND CONVENTIONAL METHODS OF HEATING PLAN LAYOUT

UNIT VI  VENTILATION SYSTEMS
  A. Ducts, dampers and casings
  B. Fans
  C. Air-cleaning devices - filters and washers
  D. Intake and discharge ventilators
  E. Registers, grilles
  F. Unit heaters
  G. Humidifiers
  H. Temperature and humidity controls

UNIT VII  MULTIZONE VENTILATION SYSTEMS

UNIT VIII  AIR-CONDITIONING SYSTEMS
  A. Involving several duct systems

UNIT IX  EXHAUST SYSTEMS
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air Conditioning and Refrigeration

Related Drawing

Grade 12


References:


Faris, Kamil J. Electricity in Refrigeration and Air Conditioning Part II. Curriculum Laboratory - Rutgers, 1968

Trade Catalogs:

Job Description

The work of the air-conditioning and refrigeration mechanic is varied since he installs, maintains, and repairs different types of equipment in many places and situations.

The equipment to be installed, repaired and maintained by this mechanic ranges from small wall units, either water or air cooled, to large central plant type systems.

He may work on commercial refrigeration fixtures used in supermarkets, hotels and restaurants, i.e., display cases, walk-in coolers and frozen food plants. Evaporators, compressors and motors installed in locker plants are also covered in this line of work.

His job may take the air-conditioning and refrigeration mechanic to private homes, stores, hotels, factories and restaurants. At times he may have to go to new construction sites to install the various motors, condensers and fans. Some of these mechanics, however, concentrate on the heating and cooling accessory units used in automobiles and buses.

In the installation of new air-conditioning or refrigeration equipment, the mechanic must be a good welder, solderer and pipe-fitter. He must be able to connect ducts, water and electric work. After completing his installation, the mechanic must check his work: often he uses a halide leak detector to check the lines for leaks; he may also use test bulbs and probes to check for continuity of an electric circuit and location of grounds.

The mechanic inspects and examines the various parts of the system to detect leaks and other faults. He must adjust compressors and motors as well as thermostatic controls to keep temperatures at a specified level.

The repair work of the air-conditioning and refrigeration mechanic commences with the diagnosis of the cause of the breakdown. In doing so he often disassembles brushes, valves, springs and connections to inspect their condition. After the trouble is located the reassembly may include the installation of such things as new piping, packing, valves or the complete overhauling of a pump or a compressor, which will put the equipment into working order.
Many different tools are used by the air-conditioning and refrigeration mechanic ranging from simple hand tools like wrenches, pliers, hammers and screwdrivers to such expensive equipment as electric drills, soldering torches, leak detectors and pressure gauges.

Course Description

The course stressed the basic jobs, operations, and skills needed in the servicing, repair and installation of air-conditioning and refrigeration units. The student will gain a thorough knowledge of the materials and equipment used by the air-conditioning and refrigeration mechanic. He will learn to use meters, measuring instruments, tools and equipment; learn to interpret sketches, schematics and diagrams; and use shop manuals and other source materials.

Each student will have an opportunity to use hand tools of the air-conditioning and refrigeration trade and learn how to perform the operations of the trade, including the evaluation of the completed work.

The student will have shop experiences not only in the mastery of manipulative skills but also related information or technology. Under the direction of the shop instructor the student will learn related information in order that he may have a complete understanding of why he performs the operations of the trade in certain ways.

The course will include related subjects consisting of mathematics, science and drawing related to the air-conditioning and refrigeration trade. Here emphasis will be placed on the mastery of fundamental concepts and principles as well as the ability to solve practical problems. Those related subjects will help to provide the foundation which makes the shop work meaningful and functional.

It is expected that the student will have sufficient knowledge of the trade to enable him to enter into satisfactory employment under completion of the course.

Academic Subjects

Since it is expected that entrants will be high school graduates or the equivalent, it is assumed that they will have a sufficient background of general education and mastery of fundamentals to enable them to concentrate on shop practice and related theory. If deficiencies do exist or needs become apparent, students will be scheduled to appropriate high school classes or special classes will be organized.
Related Subjects

The amount of time the student will spend on the study of the related science, math and drawing will depend somewhat on the educational background and experiences of the student. Special classes and schedules may be set up according to an analysis of individual needs. In some cases the shop instructor may be able to teach the related subject matter; in other cases the student may be assigned to a regularly scheduled high school class. Regardless of how this is set up, the subject matter content is the same as that shown in the course of study outlines for the high school courses in related mathematics, related science or related drawing.

Length of Course

The course provides for one (1) year of instruction. A minimum of 180 days per school year is required. New pupils normally begin with the opening of school in September but entrants may be accepted at other times if openings are available.

Entrance Requirements

Pupils who enter this course normally are high school graduates or the equivalent. They should have the ability to profit from the instruction and have an interest in the air-conditioning and refrigeration trade in terms of a vocational goal upon completing the program. Applicants must be 17 years of age, or older upon entrance.

Diploma

The student may earn a Middlesex County Adult Technical School Diploma provided he satisfactorily meets all of the requirements. If the adult is not a high school graduate upon entering the course, he may earn a high school diploma, provided he is in the shop program for a minimum of two years and meets all the requirements for a high school diploma. Transfer credit will be allowed for appropriate work satisfactorily completed in other high schools.

Where Offered

Burr D. Coe Vocational & Technical High School
112 Rues Lane
East Brunswick, New Jersey 08816

Equipment and Facilities Available

The schools in the Middlesex County Vocational system are well equipped with text and laboratory books that cover every phase of the trade.
As each lesson and skill is taught, it is practiced in a shop that contains all the necessary materials and equipment that are required to learn the trade thoroughly.

There is a continuous effort to secure the latest equipment available to keep up with the ever increasing progress in the air-conditioning and refrigeration field.

Program of Studies

Air Conditioning and Refrigeration

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shop Practice</td>
<td>540 or more*</td>
</tr>
<tr>
<td>Related Science-Physics, Chemistry</td>
<td>324 or less*</td>
</tr>
<tr>
<td>Related Math-Algebra, Geometry</td>
<td>108 or less*</td>
</tr>
<tr>
<td>Related Drawing</td>
<td>108 or less*</td>
</tr>
</tbody>
</table>

*If less time is needed in the related subject areas, the extra hours may be devoted to shop.
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Shop Practice

One Year Course for Adults

Objectives:

1. To assist the student to discover his capacities and desire for learning a skilled craft.

2. To provide the student with an opportunity to learn what is required to become an air-conditioning and refrigeration mechanic.

3. To learn how to work safely and how to prevent accidents.

4. To enable the student to explore the job opportunities, working conditions, financial gains and security in the air-conditioning and refrigeration trades.

5. To develop personal characteristics and work habits necessary for success in the refrigeration trade.

UNIT I

Review Course of Study on Shop Safety

UNIT II SHORT ORIENTATION

A. Shop Rules and Procedures

B. Shop Vocabulary and Terminology

1. Hand tools
2. Materials
3. Equipment
4. Machines

C. Shop Clothing

D. Shop Safety

E. Shop Hygiene
UNIT III  MATERIALS

Operations

A. How to Select Proper Tools for the Job

1. Selecting proper hand tools
2. Selecting proper electrical tools
3. Selecting proper bench tools
4. Location of all tools and equipment
5. Use, purpose and description of hand tools
6. Care and cleaning of hand tools

B. How to Select the Proper Material for a Job

1. Selecting proper type of tubing for a Freon system
2. Selecting material for an ammonia system

Related Trade Information

1. What are the various types of hand tools

1. Screw drivers, flat blade, assorted sizes
2. Screw drivers, Phillips #1, #2
3. Screw drivers, offset
4. Wrenches, socket: with attachments
5. Wrenches, crescent
6. Wrenches, box end
7. Wrenches, pipe
8. Wrenches, Allen
9. Wrenches, torque
10. Hammer, ball peen
11. Hammer, claw
12. Hammer, plastic
13. Mallet, rawhide, rubber
14. Pliers, diagonal cutting
15. Pliers, long nose
16. Shears, tinner
17. Square, combination set
18. Scribes, awls, drift pins
19. Chisels
20. Files: coarse, smooth, bastard
21. Hack saws, blades and teeth
22. Tap and die (small set)
23. Calipers
24. Rules (scales)
25. Tubing cutters
26. Bending springs
27. Pinch off block
28. Tube benders
29. Flaring tools
30. Gauge, screw pitch

2. Safety Precautions

1. Types of copper tubing

a. ACR - "K" - "L" - "M"
b. Hard drawn tubing
c. Soft drawn tubing (annealed)
UNIT III  MATERIALS (cont'd)

Operations
3. Selecting material for a water cooled system
4. Selecting material for an air cooled system

UNIT IV  MEASUREMENTS

Operations
A. How to Take Measurements
1. Taking end-to-end measurements
2. Taking end-to-center measurements
3. Taking end-to-back measurements
4. Taking center-to-center measurements
5. Taking back-to-back measurements

UNIT V  CUTTING COPPER TUBING

Operations
A. How to Prepare Copper Tubing
1. Unrolling tubing from master roll
2. Handling tubing with precaution
3. Selecting proper size and type of tubing before cutting

B. How to Use Cutting Tools
1. Using tubing cutter
2. Using hacksaw
3. Using tube reamer
4. Using a pinch-off block
5. Using tube cleaning brushes
6. Using a refacing tool
7. Using a file

Related Trade Information
2. Sizes of copper tubing
3. Types of pipe
   a. Black pipe
   b. Galvanized pipe
   c. Cast iron pipe
4. Sizes of pipe
5. Aluminum tubing
6. Safety precautions

UNIT V  CUTTING COPPER TUBING

Operations
A. How to Prepare Copper Tubing
1. Unrolling tubing from master roll
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B. How to Use Cutting Tools
1. Using tubing cutter
2. Using hacksaw
3. Using tube reamer
4. Using a pinch-off block
5. Using tube cleaning brushes
6. Using a refacing tool
7. Using a file

Related Trade Information
1. What is meant by a fitting
2. Fitting allowances
3. Types of fittings
   a. Flared fittings
   b. Copper-sweat fittings
   c. Compression joint fittings
   d. Flare to sweat fittings
4. Sizes of pipe
5. Aluminum tubing
6. Safety precautions

UNIT V  CUTTING COPPER TUBING

Operations
A. How to Prepare Copper Tubing
1. Unrolling tubing from master roll
2. Handling tubing with precaution
3. Selecting proper size and type of tubing before cutting

B. How to Use Cutting Tools
1. Using tubing cutter
2. Using hacksaw
3. Using tube reamer
4. Using a pinch-off block
5. Using tube cleaning brushes
6. Using a refacing tool
7. Using a file

Related Trade Information
1. Removing and replacing seals
2. Proper method of uncoiling tubing from roll
3. Effects on tubing of improper unrolling
4. Effects of selecting improper size and type
5. Safety precautions

UNIT V  CUTTING COPPER TUBING

Operations
A. How to Prepare Copper Tubing
1. Unrolling tubing from master roll
2. Handling tubing with precaution
3. Selecting proper size and type of tubing before cutting

B. How to Use Cutting Tools
1. Using tubing cutter
2. Using hacksaw
3. Using tube reamer
4. Using a pinch-off block
5. Using tube cleaning brushes
6. Using a refacing tool
7. Using a file

Related Trade Information
1. Importance of using proper tools
2. Types of tube cutters
3. Types of hacksaws
4. Types of hacksaw blades
5. Types of tube reamers
6. Types of cleaning brushes
7. Types of refacing tools
8. Types of files
UNIT V  CUTTING COPPER TUBING

Operations

C. How to Cut Copper Tubing
1. Using a vise
2. Using a flare block
3. Using a reamer
4. Using a pinch-off tool

UNIT VI  FLARING COPPER TUBING

Operations

A. How to Flare Copper Tubing
1. Preparing copper tubing
   a. Square tubing
   b. Remove burrs
   c. Install proper flare fitting
2. Insert tubing into proper hole or flare block
3. Applying oil to spinner
4. Tighten spinner
5. Removing tubing
6. Checking angle of flare

UNIT VII  COPPER TUBING

A. How to Swage Copper Tubing
1. Preparing copper tubing
   a. Square ends of tubing
   b. Remove burrs
2. Insert tubing into proper hole on flare block
3. Using proper size swaging tool
4. Applying oil to swaging tool

Related Trade Information

9. Purpose of tube cutter
10. Purpose of tube reamer
11. Purpose of cleaning brushes
12. Purpose of refacing tools
13. Purpose of filing
14. Safety precautions

-117-
UNIT VII  COPPER TUBING  (cont'd)

Operations

5. Proper method of striking swaging tool
6. Checking tubing for proper fit

B. How to Bend Copper Tubing

1. Bending hard copper tubing
2. Bending soft copper tubing
3. Preparing and marking copper tubing
4. How to hold hands on bending springs
5. How to position tubing in tube bender
6. How to operate tube bender properly
7. Removing tubing from tube bender

UNIT VIII  COPPER SWEAT JOINTS

Operations

A. How to Use the Tools in Making Copper Sweat Joints

1. Using tubing cutters
2. Using hacksaws
3. Using reamers
4. Using cleaning tools
5. Using heat-generating tools
6. Using torches

B. How to Make a Copper Sweat Joint

1. Preparing copper tubing
   a. Cleaning tubing
   b. Reaming tubing
   c. Applying flux

Related Trade Information

1. Types of tube benders
   a. Bending springs
   b. Mechanical benders
2. Measurements involved
3. Meaning of minimum and maximum radius
4. Reasons for using different bending tools
5. Principle of stress
6. Definition of buckle
7. Reasons for heating hard tubing
8. Meaning of normal bends, reverse bends and 45° bends
9. Bending allowances
10. Safety precautions

Related Trade Information

1. Types of tubing cutters
2. Types of hacksaws
3. Types of cleaning tools
4. Types of reamers
5. Types of heat-generating tools
6. Types of torches
7. Importance of proper tool maintenance
8. Principle of heat-generating tools
9. Principle of tubing cutter
10. Safety precautions

1. Kinds of tools used
2. Types of fittings used
3. Types of cleaning tools used
   a. Sandpaper
   b. Emery paper
   c. Steel wool
UNIT VIII COPPER SWEAT JOINTS (cont'd)

Operations

2. Preparing copper fittings
   a. Cleaning fitting
   b. Applying flux
3. Applying heat
4. Applying solder
5. Wiping finished joint
   (removing excess solder)

Related Trade Information

4. Types of flux
5. Purpose of flux
6. Types of solders
7. Composition of solders
8. Types of heat
9. Meaning of wiping
   Reason for removing excess solder
10. Safety precautions
    a. Burns
    b. Hot solder
    c. Cooling tubing

C. How to Make a Sweat Joint Using the Brazing Method

1. Setting up brazing outfit
2. Selecting proper tip
3. Heating metals
4. Completing job

D. How to Set-up a Brazing Outfit

1. Setting-up tanks
2. Installing regulator on tank
3. Connecting hoses
4. Connecting torch
5. Selecting tips

E. How to Prepare a Soldering Iron

1. Heating soldering iron
2. Cleaning soldering iron
3. Shaping soldering iron
4. Tinning soldering iron
UNIT VIII    COPPER SWEAT JOINTS (cont'd)

Operations

F. How to Solder with a Soldering Iron

1. Preparing metal to be soldered
2. Soldering brass
3. Soldering copper
4. Soldering galvanized iron

UNIT IX    ASSEMBLY DEVICES

Operations

A. How to Install an Evaporator Supporting Bracket

1. Planning job
2. Selecting type of metal to be assembled
3. Selecting type of fastening device to be used
   a. Frequency of dismantling
4. Using gauges to measure threads

B. How to Make External and Internal Threads

1. Securing die in die stock
2. Chamfering end of work
3. Setting adjusting screws
4. Holding die stock square with work
5. Using proper pressure
6. Reversing stock and die
7. Protecting finished surface
8. Repairing damaged internal and external threads

Related Trade Information

1. Types of flux to be used
2. Purpose of flux
3. Kinds of cleaning materials
4. Importance of proper heat
5. Types of solder to be used
6. Differences in methods of heating different metals
7. Principles involved in soldering
8. Safety precautions

Related Trade Information

1. Methods of fastening
   a. Soldering
   b. Brazing
   c. Welding
   d. Crimping
   e. Riveting
   f. Bolting
2. Devices for fastening metal
   a. Nuts
   b. Bolts
   c. Plugs
   d. Set screws
   e. Cap screws
   f. Machine screws
3. Types of thread gauges
4. Purposes of thread gauges
5. Safety precautions

1. Sizes of drills
2. Sizes and types of taps
   a. Tapered tap
   b. Plug tap
   c. Bottoming tap
3. Techniques in cutting threads with a tap
4. Sizes and types of dies
5. Techniques in cutting threads with a die
6. Thread systems
7. Safety precautions
UNIT X  REFRIGERATION SERVICE GAUGES AND TEST MANIFOLD

Operations

A. How to Install a Test Manifold to an Open Type Refrigeration Unit to Observe Readings

1. Remove valve caps from service valves
2. Check service valves to determine whether the valve stems are backseated
3. Remove the 1/8" MP plugs from the gauge-ports
4. Install the half unions fittings (1/4 MF x 1/8 MP) into gauge ports
5. Connect flexible charging hose from compound gauge on manifold to Suction Service Valve (SSV)
6. Connect flexible charging hose from pressure gauge on manifold to Discharge Service Valves (DSV)
7. Plug the center charging line on manifold with 1/4 plug
8. Crack open the DSV and use pressure to purge air from the hose lines
9. Crack hose connection at SSV to purge air from hose
10. Frontseat the valves on manifold
11. Crack open the SSV
12. Run unit and observe operating pressures on gauges

Related Trade Information

1. Types of gauges
   a. Pressure - high side
   b. Compound - low side
2. Parts of a gauge
   a. Bourden tube
   b. Linkage
   c. Gear
   d. Gauge connection - 1/8 male pipe thread
   e. Calibration spring
3. Operation of a gauge
   a. Internal pressure
   b. Atmospheric pressure
4. Dial markings and limitations
   a. Pressure - 0 - 500
   b. Compound - 30"-0-200
5. Pressure and vacuum scales
6. Temperature and pressure relationship
7. Types of test manifolds
8. Parts of test manifold
   a. Compound gauge
   b. Pressure gauge
   c. Manifold
   d. Three charging lines or hoses
   e. Three flare plugs
   f. Two 1/4 MF x 1/8 MP half-unions
9. Compressor service valves
   a. Frontseat - to close
   b. Backseat - to open
   c. Crack to open slightly
   d. Types of service valves used
      1. Two-way service valve
      2. One-way service valve
      3. Liquid line service valve
   e. Line service valves
      1. Compression type
      2. Solder type
      3. Piercing copper tubing
      4. Hermetic charging kits
10. Safety precautions
    a. Always wear goggles
    b. Use 2 wrenches when working
    c. Keep lines sealed and clean
Operations

B. How to Remove Gauges from an Open Type Refrigeration System

1. Backseat DSV at compressor
2. Open valves (backseat) on manifold
3. Operate unit until both gauges are at slightly above zero - 0
4. Close suction service valve (SSV)
5. Shut service valves on test manifold
6. Remove charging lines from compressor
7. Remove fittings from compressor
8. Replace 1/4" plugs
9. Replace valve caps

C. How to Evacuate an Open Type Refrigeration Unit

1. Install test manifold to unit
2. Connect the high vacuum pump to the center gauge manifold opening
3. Open Suction Service Valve (SSV) at compressor
4. Open compound gauge service valve on manifold
5. Discharge to atmosphere any refrigerant left in system through center gauge port
6. Open Discharge Service Valve (DSV) at compressor
7. Open pressure gauge service valve on manifold
8. Open valve at vacuum pump
9. Operate vacuum pump and draw highest vacuum possible
10. Close Discharge Service Valve (DSV)
11. Close Suction Service Valve (SSV)
12. Close valve at vacuum pump

Related Trade Information

1. Types of vacuum pumps
2. Principles of vacuums
3. Why is it necessary to evacuate a system?
4. When is it required to evacuate a system?
5. Proper maintenance of vacuum pump
6. Operation of vacuum pump
7. Methods of evacuating a refrigeration system
   a. Triple evacuation method
   b. Low micron-range evacuation
   c. Vacuum required for moisture removal (dehydration)
8. Safety precautions
UNIT X  REFRIGERATION SERVICE GAUGES AND TEST MANIFOLD  
(cont'd)

Operations

13. Shut off operating switch at vacuum pump
14. Disconnect vacuum pump
15. Leave test manifold connected to unit for next operation

D. How to Add Refrigerant to an Open Type Unit

1. Install test manifold to unit
2. Connect the refrigerant cylinder to the center gauge manifold opening
3. Open valve on cylinder to purge air from charging line
4. Open Suction Service Valve
5. Test for leaks
6. Turn unit on
7. Add refrigerant to system until desired suction pressure is obtained
8. Shut off valve at cylinder
9. Close manifold valves
10. Close SSV
11. Remove test manifold

E. How to Check for Leaks in an Open Type Unit

1. Install test manifold to unit
2. Leak test unit using all methods of leak detection
3. Repair leak
4. Remove test manifold

UNIT XI  COMPRESSORS

Operations

A. How to Overhaul an Open Type Compressor

Related Trade Information

1. Types of refrigerants
   a. R-12
   b. R-22
   c. R-502
2. Types and sizes of refrigerant cylinders
3. Purging of lines
4. Methods of leak detection
5. Safety precautions
   a. Always wear goggles
   b. Avoid getting liquid refrigerant on skin
   c. Avoid inhalation of vapor or gas

1. Types of leak detectors
   a. Halide leak detector
   b. Electronic leak detector
   c. Soap bubbles
   d. Vacuum pumps
   e. Use of senses
      1. Sight
      2. Touch
      3. Sound
2. Using pressures to locate leaks
3. Safety precautions
   a. Never use oxygen, air or any inflammable gas for testing a system

Related Trade Information

1. Types of compressors
UNIT XI

COMPRESSORS (cont'd)

Operations

1. Select proper tools
2. Remove compressor from unit
3. Remove fly wheel and key, record data
4. Remove cylinder head and record data. Mark head
5. Remove valve plate and record data. Mark plate
6. Remove the crank case, base and seal plate. Record data
7. Remove one connecting rod, mark rod, and record data
8. Make new gasket
9. Assemble the compressor
10. Tighten and torque all assembly devices
11. Put oil into compressor and remount into unit
12. Test the compressor for vacuum and pressure

B. How to Overhaul a Rotary Type Compressor

1. Select proper tools
2. Dismantle the compressor
3. Mark all parts
4. Record all data from parts
5. Reassemble the compressor
6. Add oil
7. Test compressor

C. How to Service a Hermetic Compressor Without Any Service Valves

1. Select proper tools
2. Select proper material
3. Install the service valve kit if unit has a valve adapter
4. Install clamp piercing valve, if unit has no adapter valve
5. Install gauge manifold
6. Test the compressor for vacuum and pressures

Related Trade Information

A. Reciprocating

1. Accessible or open type
   a. Cylinder construction
   b. Cylinder arrangement
   c. Piston construction
   d. Connecting rod construction
   e. Crankshaft construction
   f. Valve construction
   g. Crankshaft seals
   h. Gaskets
   i. Compressor drives
2. Hermetic or sealed type
   a. Construction differences
   b. Compressor cooling
   c. Mufflers

B. Rotating

1. Accessible or open types
   a. Stationary blade
   b. Rotary blade
   c. Cylinder construction
   d. Rotor construction
   e. Blade construction
   f. Crankshaft construction
   g. Crankshaft seals
   h. Valve construction
2. Hermetic or sealed type
   a. Construction differences
   b. Operation

C. Centrifugal

1. Single stage
2. Multi-stage
3. Rotor (impeller)
4. Stators
   a. Marking of compressor parts
   b. Using a torque wrench
   c. Making a gasket
   d. Using a wheel puller
   e. Hermetic valve kit
   f. Uses of piercing valves
   g. Fan belts types and sizes
UNIT XI  COMPRESSORS  (cont'd)

Operations

7. Remove gauges
8. Remove valve kit or piercing valve adapter

Related Trade Information

h. Types of flywheels
i. Alignment of fly wheels and pulleys
j. Safety precautions

UNIT XII  SOLDERING WITH OXYACETYLENE TORCH

A. How to Silver Solder or Braze Refrigerant Lines

1. Select proper material
2. Select proper tools
3. Preparing tubing
   a. Cleaning tubing
   b. Reaming tubing
   c. Applying flux
4. Preparing fitting
   a. Cleaning fitting
   b. Applying flux
5. Applying heat
6. Applying solder
7. Wiping finished joint
8. Testing finished joint

UNIT XIII  HEAT AND PRESSURE

Operations

A. How to use the basic principles of temperature measurements in refrigeration

1. Heat intensity
2. Heat quantity
3. Heat energy

Related Trade Information

1. Measurement of heat intensity
   a. Unit of intensity
      1. Fahrenheit scale
      2. Centigrade scale
      3. Rankine scale
      4. Kelvin scale
UNIT XIII  HEAT AND PRESSURE (cont'd)

Operations

B. How to Use the Knowledge of Heat and Pressures in the Refrigeration Trade

1. Temperature-pressure relationship
2. Heat in refrigeration
3. Heat in air-conditioning

Related Trade Information

b. Measuring devices
   1. Thermometers
   2. Thermocouples

c. Fixed references
   1. Boiling point
   2. Freezing point
   3. Absolute zero

d. Temperature conversion

2. Measurement of heat quantity
   a. British thermal unit (BTU)
   b. Heat equation used in calculations

3. Energy conversion units
   a. Heat energy
   b. Mechanical energy
   c. Electrical energy

UNIT XIV  CALIBRATION OF GAUGES

Operations

A. How to Calibrate Pressure Gauges by Means of the Dead Weight Tester

1. Types of gauge calibrators
UNIT XIV  CALIBRATION OF GAUGES

Operations
1. Fill weight tester with mineral oil (SAE 20)
2. Connect gauge to be tested
3. Make adjustments on dead weight tester
4. Record all data
5. Adjust gauge scales if required
6. Remove calibrated gauge

Related Trade Information
2. Construction of dead weight tester
3. Purpose of dead weight tester
4. Construction of gauges
5. Types of gauges
   a. Compound
   b. Pressure
6. Safety precautions

UNIT XV  COMPONENT PARTS OF REFRIGERATION SYSTEM

Operations
A. How to Install or Replace an Evaporator Coil
1. Determine size and type of evaporator coil
2. Select proper tools
3. Select proper type and size of evaporator coil
4. Install gauge manifold, check for leaks
5. Purge refrigerant from system
6. Cut refrigerant lines at the evaporator coil
   a. Cut lines at a place that will permit brazing or soldering of the lines to new unit
   b. Allow enough tubing to permit flaring, if brazing or soldering cannot be done
7. Remove the evaporator by unbolting it from the cabinet
8. Install new evaporator
9. Clean the tubing. Braze or solder the connections, using the correct procedure
10. Install a new drier-filter
11. Evacuate, using vacuum pump
12. Charge to a 60 pound gas pressure
13. Test for leaks

Related Trade Information
1. Types of evaporators
   a. Bare tube
   b. Plate type
   c. Finned
   d. Air cooling coils
      1. Dry coil
         a. Natural convection
         b. Forced circulation
         c. Frosting
         d. Non-frosting
      2. Flooded
   e. Liquid cooling coils
      1. Submerged
      2. Shell and tube
      3. Tube within a tube
Operations

How to Install or Replace a Condenser

1. Select proper tools for job
2. Determine size and type of condenser coil
3. Install gauge manifold, check for leaks
4. Purge refrigerant from system
5. Cut refrigerant lines at the condenser coil
6. Remove the condenser coil from cabinet, by unbolting or removing screws
7. Install new condenser coil in proper location
8. Clean the tubing. Braze or solder all refrigerant lines together, using proper procedure
9. Install a new filter-drier
10. Evacuate system using vacuum pump
11. Charge to a 60 pound gas pressure
12. Test for leaks at all connections

How to Install, Replace or Repair Capillary Tube

1. Select proper tools for job
2. Remove the capillary tube
   a. Remove the refrigerant by safely purging (use good ventilation)
   b. Balance unit pressures, clean the capillary tube connections
   c. Remove the capillary tube and plug the openings if possible
3. Repair the capillary tube by using a capillary tube cleaner. If necessary replace with new one
4. Install the capillary tube filter-drier into unit

Related Trade Information

1. Types of condensers
   a. Air cooled
      1. Bare pipe
      2. Finned
      3. Natural convection
      4. Forced circulation
   b. Water cooled
      1. Double pipe
      2. Double tube
      3. Shell and coil
      4. Shell and tube
   c. Evaporative condensers
   d. Water towers
   e. Complete condensing units
      1. Compressor
      2. Condenser
      3. Receiver
   f. Knowledge of non-condensible gases
   g. Safety precautions

1. Types of capillary tubes
2. Purpose of capillary tube
3. Length and inside diameter of capillary tube
4. Capillary tube used as a heat exchanger
5. Capillary tube systems have very critical charge of refrigerant
6. Measuring charge put into a system
7. Drier and filter requirements
8. Other types of metering devices
   a. High side float
   b. Low side float
   c. Manual control valves
   d. Automatic expansion valves
   e. Thermostatic expansion valves
UNIT XV COMPONENT PARTS OF REFRIGERATION SYSTEM
(cont'd)

Operations

a. Clean and dry all connections
b. Evacuate system, using vacuum pump
c. Charge with refrigerant
5. Test for leaks
6. Charge system with correct amount of refrigerant

Related Trade Information

9. Trouble shooting system
10. Safety precaution

D. How to Remove, Test, Install and Adjust a Thermostatic Expansion Valve

1. Select proper tools for job
2. Select proper thermostatic expansion valve
3. Install the gauge manifold
4. Adjust the service valves - remove refrigerant
5. Remove the thermostatic expansion valve
6. Clean the thermostatic expansion valve, including the screen
7. Test the valve
8. Adjust to a 10°F superheat
9. Reinstall thermostatic expansion valve into system
10. Purge and evacuate system using vacuum pump
11. Build up pressure in system
12. Test for leaks

E. How to Install a Filter-drier

1. Select proper tools for job
2. Select proper filter-drier
3. Install the gauge manifold
4. Adjust the service valve
5. Remove refrigerant from system - ventilate wheel-wear goggles
6. Remove old drier and record the size of the fittings
7. Install the new drier carefully
8. Test for leaks, using a refrigerant cylinder, create a 70 to 90 psig head pressure
9. Charge the system

1. Types of thermostatic expansion valves
   a. Diaphragm type-adjustable
   b. Diaphragm type non-adjustable
   c. Internal equalizer
d. External equalizer
e. Bellows type-adjustable
2. Automatic valves
   a. Application
   b. Selection
3. Thermostatic valves
   a. Application
   b. Charge in sensing bulk
      1. Gas charged
      2. Liquid charged
      3. Cross charged
c. Selection
4. Trouble shooting system
5. Safety precautions

1. Types of filter-driers
   a. Liquid line filters
   b. Suction line filters
2. Desiccants
   a. Silica gel
   b. Activated alumina
c. "Dri-elete"
3. Properties of desiccants
4. Function of filter-driers
5. Drier size
6. Drier location
7. Drier cores
   a. Replaceable
   b. Non-replaceable
8. Moisture indicators
9. Safety precautions
UNIT XVI  MATERIALS

Operations

A. How to Identify and Prepare Wire For Use

1. Removing insulation
2. Cleaning wire
3. Handling wire with precaution
   a. Knicking
   b. Cutting strands

B. How to Splice Solid Wire

1. Pig tail splicing
2. Tap splicing
3. Western Union splicing
4. Mechanical splicing

C. How to Splice Stranded Wire

1. Tap splicing
2. Western Union splicing
3. Fixture splicing
4. Extension cord splicing

D. How to Solder Splices

1. Preparing soldering iron
   a. Cleaning iron
   b. Heating iron
   c. Tinning iron
2. Heating splice
3. Applying flux
4. Applying solder
5. Removing excess solder
6. Test all wiring for continuity with test light
7. Test all terminals, connections and wiring with ohmmeter.

Related Trade Information

1. Types of wire
   a. Solid
   b. Stranded
   c. Copper
   d. Aluminum

2. Types of insulation
   a. Thermoplastic
   b. Rubber
   c. Asbestos
   d. Varnish cambric

1. Purpose of splicing
   a. Reason for branching wire
   b. Reason for tapping wire
   c. Reason for line extensions

2. Importance of using proper tools
   a. Work knife
   b. Side cutters
   c. Diagonals
   d. Wire strippers

3. Safety precautions

1. Importance of using proper tools
   a. Work knife
   b. Diagonals
   c. Side cutters
   d. Wire strippers

1. Types of soldering irons
   a. Copper iron
   b. Electric iron
   c. Soldering gun
   d. Propane torch

2. Purpose of cleaning iron

3. Heat effects on soldering
   a. Warm iron
   b. Hot iron

4. Purpose of flux

5. Types of solders to use
   a. Acid core
   b. Rosin core

6. Reason for removing excess solder

7. Safety precautions
   a. Overheated iron
   b. Burns
   c. Hot solder
   d. Cooling iron
UNIT XVI MATERIALS (cont'd)

Operations

E. How to Insulate Splices
   1. Using rubber tape
   2. Using friction tape
   3. Using plastic tape
   4. Using wire connectors

F. How to Install Armored Cable
   1. Handling cable
   2. Cutting cable
   3. Connecting cable to outlet
   4. Stapling cable

G. How to Install Non-metallic cable (Romex)
   1. Handling cable
   2. Cutting cable
   3. Connecting cable to outlet
   4. Stapling cable
   5. Grounding cable

Related Trade Information

1. Purpose of insulation
2. Effects of poor insulation
   a. Grounds
   b. Shorts
3. Types of wire connectors

   1. Code requirements
   2. Sizes of wire
   3. Kinds of cable
      a. Two-wire
      b. Three-wire
      c. Four-wire
      d. Solid wire
      e. Stranded wire
   4. Types of connectors
      a. Set screws
      b. Split
      c. Duplex
      d. Angle
   5. Types of outlets
      a. Octagon
      b. Square box
      c. Wall case
      d. Utility box
   6. Safety precautions

   1. Sizes of cable
   2. Code requirements
   3. Kinds of cable
      a. Two-wire
      b. Three-wire
      c. Four-wire
      d. Solid
      e. Stranded
   4. Purpose of a ground wire
   5. Types of connectors
      a. Set screw
      b. Split
      c. Duplex
      d. Angle
UNIT XVI    MATERIALS (cont'd)

Operations

I. How to Install Receptacles, Fixtures and Controls in a Refrigeration System

1. Installing a single pole switch
   a. Selecting switch
   b. Wiring switch
   c. Testing switch
2. Installing double-pole switch
3. Installing three-way switch
4. Installing outlet receptacle
5. Installing fixtures
6. Installing controls
   a. Selecting control
   b. Wiring control
   c. Testing control

UNIT XVII    CONDUCTORS AND INSULATORS

Operations

A. How to Use Wire Gauges and Measure Sizes of Wires, and See How Lengths Effect Conductance

1. Cut several pieces of wire and measure with wire gauge
2. Splice wire
3. Solder wire
4. Connect wire with tape
5. Connect wire with wire-nut
6. Cut wire to several different lengths and measure resistances

Related Trade Information

6. Types of outlets
   a. Octagon
   b. Square box
   c. Wall case
   d. Utility box

7. Safety precautions

1. Types of switches
   a. Rotary or selector
      1. Pushbutton
      2. Stem type
   b. Push button
   c. Toggle
2. Principle of the switch
3. Ratings of switches
4. Types of controls
5. Principle of controls
6. Types and sizes of wire required
7. Sizes and fuses required
8. Safety precautions in fusing
9. Safety precautions in wiring

Related Trade Information

1. Conductors have low resistance to current flow
   a. Copper
   b. Iron
   c. Aluminum
   d. Silver
   e. Brass
   f. Zinc
2. Sizes of conductors
   a. Effect of type
   b. Resistance
   c. Load
3. Semi-conductors have low resistance to current flow in one direction. High resistance to current flow in other direction
UNIT XVII  CONDUCTORS AND INSULATORS  (cont'd)

Operations

Related Trade Information

3. a. Germanium
   b. Silicon
   c. Copper oxide
   d. Copper sulphide
   e. Lead sulphide

4. Insulators have high resistance to current flow
   a. Dry air
   b. Glass
   c. Rubber
   d. Asbestos
   e. Bakelite
   f. Mica

UNIT XVIII  CIRCUIT APPLICATION AND TESTING INSTRUMENTS

Operations

A. How to Test and Analyze Effects of Voltage, Current and Resistance Changes in Electrical Circuits

1. Using ohmmeters
2. Using voltmeters
3. Using ammeters
4. Using multi-testers
5. Using watt meters
6. Using voltage testers
7. Using an amprobe

Related Trade Information

1. Types of current
   a. Alternating current
   b. Direct current
   c. Pulsating

2. Ways of generating voltage
   a. Mechanical
   b. Chemical
   c. Thermal
   d. Light

3. Ohm's Law and Kirchhoff's Laws

4. Precautions in connecting meters
5. Applying formulas to prove meter readings
6. Determine power factors

B. How to Detect Circuit Troubles

1. Testing
2. Wiring

1. Principle involved in the short circuit
2. Principle involved in the open circuit
3. Principle involved in grounding
UNIT XVIII  CIRCUIT APPLICATION AND TESTING INSTRUMENTS
(cont’d)

Operations

C. How to Work with Series Circuits

1. Source
2. Load
3. Testing
4. Wiring

D. How to Work with Parallel Circuits

1. Source
2. Load
3. Testing
4. Wiring

E. How to Work with Series and Parallel Circuits

1. Source
2. Load
3. Testing
4. Wiring

F. How to Measure Electrical Power and Energy

1. Using voltmeter and ammeters
2. Using watt meters
3. Using watt-hour meters

G. How to Select Circuit Conductors

1. Measuring sizes
2. Measuring line power losses
3. Measuring line voltage drops
4. Fusing
5. Determining fuse protection

Related Trade Information

1. Definition of circuits
   a. Series
   b. Parallel
   c. Combination
2. Effects of voltage
3. Effects of current
4. Effects of resistance

1. Definition of circuits
   a. Series
   b. Parallel
   c. Combination
2. Effects of voltage
3. Effects of current
4. Effects of resistance

1. Definition of circuits
   a. Series
   b. Parallel
   c. Combination
2. Effects of voltage
3. Effects of current
4. Effects of resistance

1. Principle of transforming energy
   a. Generator
   b. Motor
2. Power formulas
3. Relationship between mechanical and electrical energy
4. Power ratings of equipment
5. Efficiency of operation

1. Kinds of A.W.G. number markings
2. Code requirements
3. Differences in current carrying capacities
4. Effects of overloading
5. Effects of heat
6. Effects of magnetic induction
7. Safety precautions
UNIT XVIII  CIRCUIT APPLICATION AND TESTING INSTRUMENTS (cont'd)

Operations

H. How to Produce Magnetism With Electricity and Produce Electricity with Magnetism

1. Electron theory
   a. Displacement of electrons
   b. Flow of electrons
2. Use of electricity to create magnetism
   a. Show polarity using a bar magnet
   b. Create magnetic lines of force using various magnets and iron filings
   c. Make permanent magnets
   d. Make temporary magnets

UNIT XIX  SINGLE PHASE AND POLYPHASE MOTORS

Operations

A. How to Install Single-phase Motors

1. Connecting motors
2. Testing motors
3. Trouble shooting

B. How to Install a Split-phase Motor

1. Connecting motor
   a. Voltage and amperage ratings
2. Testing motors

Related Trade Information

1. Sources of energy
   a. Friction
   b. Magnetism
   c. Chemical action
   d. Pressure
   e. Heat action
   f. Light action
   g. Nuclear action
2. Charges
   a. Positive - Plus - North
   b. Negative - Minus - South
   c. Attraction of unlike charges
   d. Repulsion of like charges
3. Static electricity - electrons at rest
4. Current electricity - electrons in motion

Related Trade Information

1. Theory of operation
   a. Phasing or start winding
   b. Starting torque
2. Construction and uses
   a. Hermetically sealed
   b. Open type
3. Types of single-phase motors
   a. Split phase
   b. Permanent split capacitors
   c. Capacitor start-induction run
   d. Capacitor start-capacitor run
4. Ratings of single phase motors
5. Code rules and regulations

1. Theory of operation
   a. Rotor winding
   b. Stator winding
2. Parts and function of each part
   a. Rotor
   b. Stator
UNIT XIX  SINGLE PHASE AND POLYPHASE MOTORS (cont'd)

Operations
a. Excessive wear on shaft, bearings, other
b. Freedom of rotation: shaft bearing
c. Electrical test
   1. Ground
   2. Open winding
   3. Short
   4. Centrifugal switch
3. Trouble shooting motor
4. Reverse rotation of motor

C. How to Install a Repulsion-induction Start Motor
1. Connecting motor
   a. Voltage and amperage rating
2. Testing motors
   a. Brushes
   b. Bearings
   c. End play
   d. Position of reversing switch
   e. Centrifugal throwout switch
   f. Armature
3. Trouble shooting motor
   a. Use of VOM in checking for starts, open circuits
   b. Use of tachometer in checking RPM's
   c. Use of growler in checking armature

D. How to Install a Capacitor-start Motor
1. Connecting motor
   a. Voltage and amperage rating
2. Testing motors
   a. Mechanical tests
      1. Excessive wear on shaft, bearings

Related Trade Information

C. End plates
d. Centrifugal switch
3. Types of motor
   a. Two running windings with one starting winding
   b. Two running windings with two starting windings
4. Ratings of motor
   a. Single-speed
   b. Multiple speed
5. Reversing a split-phase motor
   a. Interchange of running winding leads
   b. Interchange of starting winding leads
6. Safety precautions

1. Theory of operation
   a. High-starting torque using low starting current
2. Parts and function of each part
   a. Brush holders and brushes
   b. Bearings
   c. Short circuiting necklace and frame
   d. Governor spring
   e. Commutator
   f. Push rods
   g. Rotor
3. Types of repulsion-induction motors
   a. 110 volt
   b. 220 volt
   c. Reverse rotation
4. Ratings of motors
5. Code rules and regulations
6. Safety precautions

1. Theory of operation—designed for high starting torque, used on water pumps and compressors on commercial units
   a. Uses a capacitor in circuit
   b. Rotor winding
   c. Stator winding
      1. Main
      2. Starting
Operations

2. Freedom of rotation of shaft, bearing
3. Centrifugal switch
4. Lack of sufficient lubrication
5. Misalignment of parts
6. Excessive end play

b. Electrical tests
1. Ground
2. Open winding
3. Short
4. Defective capacitor

3. Trouble shooting motor
a. Test capacitor for capacitance valve
b. Test stator windings and identify leads
c. Check for overload, over voltage, under voltage

E. How to Install a PSC Motor
"P.S.C. means Permanent Split Capacitor"
1. Connecting motor
2. Testing motor
3. Trouble shooting

F. How to Identify and Tag Dual Voltage Motor Leads
1. Locating leads with an ohmmeter
2. Using voltmeter
3. Using voltage tester
4. Connecting leads

G. How to Connect Stator-windings
1. Counting the number of coils
2. Calculating coils per pole
3. Calculating coils per phase
4. Soldering leads
5. Applying test voltages
6. Checking speed

Related Trade Information

2. Parts and function of each part
   a. Capacitor
   b. Centrifugal switch
   c. Rotor
   d. Windings
   e. End plates

3. Types of motors
   a. Capacitor-start, induction-run
   b. Capacitor-start, capacitor-run

4. Rating of Motor
   a. Volts
   b. Amps
   c. Watts
   d. Speed
   e. Horse power or size

5. Safety precautions
   a. Always discharge a capacitor before testing

1. Theory of operation
2. Parts and function of each part
3. Types of motors
4. Rating of motor
5. Safety precautions

1. Kinds of standard lead markings
2. Reason for tagging
3. Safety when making tests
4. Types of polyphase motors
   a. Three-phase
   b. Two-phase
5. Parts and function of each part

1. Types of windings
2. What the winding accomplishes
3. Effects of voltage
4. Why the number of phases affects the winding
5. Why the frequency affects the winding
UNIT XIX  SINGLE PHASE AND POLYPHASE MOTORS (cont'd)

Operations

C. How to Locate Faults

1. Checking for overload
2. Measuring starting conditions
3. Testing for performance
4. Testing for grounds
5. Testing for short-circuits
6. Checking bearings
7. Reversed phase
8. Defective controller
9. Checking for worn or tight bearings

UNIT XX  TROUBLE SHOOTING MOTORS

Operations

A. How to Trouble Shoot Split-phase and Capacitor Start Motors

1. Analyze problem
2. Locate cause of problem
3. Repair problem
4. Test motor

B. How to Use Meters

Related Trade Information

6. Less common connections
7. Formulas for new windings
8. How to use schematic and master diagrams
9. Reasons for reconnecting

1. Operation of three phase motor
2. Standard ratings
3. Code rules and regulations
4. Why periodic maintenance is necessary
5. N.E.M.A. standards
6. Safety when making tests

UNIT XX  TROUBLE SHOOTING MOTORS

Related Trade Information

1. Types of problems
   a. Mechanical
   b. Electrical
2. Parts of motors defective
3. Tools required
4. Meters required

1. Types of meters
2. Operation of meters
3. Uses of meters
4. Handling meters

C. How to start a compressor
D. How to check a capacitor
E. How to trouble shoot a relay starter circuit
F. How to make a complete electrical check on an air conditioner

-138-

147
UNIT XXI  AIR CONDITIONING UNITS

Operations

A. How to Install a Window Type Comfort Cooler

1. Installation of base
   a. Install unit base on window sill
   b. Locate center of window, place the base in place
   c. Level the base and mark screw holes
   d. Drill the screw marks
   e. Install the rubber gasket on the window sill
   f. Fasten the mounting base to window sill
   g. Adjust the leveling bolts and lock

2. Installation of unit
   a. Prepare comfort cooler for operation
   b. Loosen the hold down bolts
   c. Inspect the unit for condition
   d. Mount the unit on the base
   e. Fasten the unit to the base
   f. Install the spacers between each side of the unit and the A-frame
   g. Install the rubber gasket along the top of the unit
   h. Install the gasket between the inner double hung window and the outer one
   i. Operate the unit
   j. Check damper adjustments for unit noise

B. How to Locate Trouble in a Window Type Comfort Cooler

1. Test the external circuit first
   a. Power in
   b. Thermostat
   c. Motor compressor relay and overload protectors
   d. Filters
   e. Air flow

Related Trade Information

1. Selection of proper size unit for the application
   a. Heat transfer
      1. Heat loss
      2. Infiltration
      3. Heat gain
      4. Ventilation air
   b. Air and humidity calculations
   c. Sensible heat calculations
   d. Latent heat calculations
   e. Solar heat calculations
   f. Moisture calculations

2. Types of window air conditioners
   a. Casement windows
   b. Double hung windows
   c. Wall units
   d. Console or portable units
   e. Heat pump conversions
   f. Voltage characteristics
   g. Current characteristics

3. Selection of proper tools for installation
   a. Screw drivers
   b. Socket set
   c. Twist drill
   d. Electric drill
   e. Spirit level
   f. 10" straight tin snips
   g. Sealing compound

4. Safety in installation

1. Mechanical troubles
   a. Test for air in system
   b. Test for dirt and moisture in system
   c. Purging a system with air, moisture or dirt in it
   d. Checking and repairing a hermetic unit
   e. Checking and repairing an open type unit
UNIT XXI  AIR CONDITIONING UNITS

Operations

2. Install guages
   a. Operate unit
   b. Test for leaks
3. If the unit has no or little charge in it
4. If unit is frosting or sweating down the suction line - unit may be over charged
5. If the screen or drier is clogged with dirt or moisture
6. Repair what is necessary
7. Remove refrigerant where necessary
8. Replace any worn part
9. Reassemble the unit
10. Evacuate system with vacuum pump, recharge system with proper charge
11. Test for leaks

C. How to Locate Trouble in a Self-Contained Comfort Cooler

1. Test the external circuit first
   a. Power in
   b. Thermostat
   c. Motor compressor, relay and overload protectors
   d. Filters and air flow
   e. Water connections and water valves if water cooled
   f. Air supply if air cooled
   g. Condensate drain
2. Install gauges
   a. Operate unit
   b. Check pressures
   c. Test for leaks
3. Replace thermostatic expansion valve, if one is used
4. If unit is frosting on coil
   a. TE valve is leaking
   b. Thermostat is not shutting off
   c. TEV bulb is loose

Related Trade Information

f. Detecting and correcting a unit with leak
2. Electrical and wiring defects
   a. Check motor wiring for sufficient voltage capacity
   b. Detect and correct improper control wiring in a self-contained unit
   c. Knowing how to use electrical testing equipment
   d. Knowing about many types of motors used in air conditioning units
   e. Reading schematic drawings
   f. Repairing and adjusting fan controls
   g. Repair and adjust a heating and cooling thermostat
   h. Measuring volts and resistance using a voltmeter and ammeter
   i. Using a wattmeter to calculate unit power factor
   j. Checking relay circuits operation for component part failure
   k. Checking the operation of a thermostat

-140-

149
UNIT XXI  AIR CONDITIONING UNITS (cont'd)

Operations
5. If system is undercharged
   a. TE valve screen is partially
clogged with moisture
   b. Dirt is in screen
6. Repair what is necessary
7. Remove refrigerant where
   necessary
8. Replace any worn parts
9. Reassemble the unit
10. Evacuate system with vacuum
    pump

UNIT XXII  SERVICE PROBLEM

Operations
A. Installations
1. How to understand the codes
   applicable to air-conditioning
2. How to acquire an understand-
ing of good installing
   practices
3. How to develop an attitude
   for good workmanship in the
   installation of air-conditioning
   and the copper tubing going to
   the units

Related Trade Information
1. Checking an electronic thermo-
   stat against a conventional
   thermostat
m. Knowing how to calibrate a
   thermostat
n. Safety requirements

Related Trade Information
1. State and local codes
   a. Safety codes for commercial
      and industrial air condition-
ing
   b. Purpose of codes
   c. Applications
2. Self-contained units
   a. Conventional or open type
      units
   b. Hermetic units
   c. Compressor ventilation require-
      ments
      1. Air-cooled
      2. Water-cooled
      3. Manufacturer's recommenda-
         tions
3. Remote condensing units
   a. Accessible location
   b. Noise factors
   c. Protection for unit
4. Cooling coils
   a. Air circulation and distri-
      bution
   b. Careful mounting
   c. Supports and hangers
5. Tubing
   a. Type used
   b. Support for tubing
   c. Accessories-valve, drier
      sight glass
UNIT XXII  SERVICE PROBLEM (cont'd)

Operations

B. Initial Start-up

1. How to take proper steps that are required for the initial start up of a commercial air conditioning unit
2. How to develop the attitude of the occurrence of possible future troubles in an air conditioning system if a satisfactory operational check is not completed on initial start-up

C. Diagnosing Service Problems

1. How to diagnose the numerous problems that may arise when servicing an air conditioning system

Related Trade Information

d. Vibration absorbers and loops
  e. Condensate drains
  f. Slope of vapor lines

1. Evacuation
  a. On all new systems, except those that are precharged
  b. On all systems that have been open
  c. The use and operation of a vacuum pump
  d. Extent and importance of vacuum

2. Charging
  a. Critical charge systems - self contained
     1. Manufacturers recommendation
     2. Portable charging equipment
  b. Non-critical charge systems
     1. Liquid charging
     2. Vapor charging - sight glass

3. Operational check
  a. Remove shipping bolts and/or blocks
  b. Oil all motor bearings
  c. Check operation pressures
     1. Suction
     2. Discharge
     3. Compressor oil
  d. Pressure controls
  e. Electrical check out
     1. Volts
     2. Amperage
     3. Correct fuse size
  f. Adjust super heat
  g. Adjust motor control
  h. Adjust evaporator and condenser fans

1. Entire unit will not run
  a. No power at compressor
     1. Check disconnect switch
     2. Check fuse or circuit breaker
     3. Check source of main power
     4. Broken wire or loose connection
UNIT XXII  SERVICE PROBLEM (cont'd)

Operations

2. How to look for any signs that something is wrong in an air-conditioning system
3. Diagnosing must be made to find the source of the trouble
4. How to develop an attitude that even in trouble-shoot-ing service problems, safety precautions should be taken for the protection of equipment and personnel

Related Trade Information

b. Power at compressor
   1. Compressor motor
   2. Overload
   3. Control wiring and control

2. Unit runs - no cooling
   a. Loss of refrigerant
   b. Inefficient compressor
   c. Restriction in tubing or accessories

3. Unit runs - insufficient cooling
   a. Shortage of refrigerant
   b. Inefficient compressor
   c. Obstruction in lines
      1. Refrigerant control
      2. Drier
   d. Control setting

4. Unit noisy
   a. Vibration in lines
   b. Surplus of oil
   c. Defective compressor valves
   d. Refrigerant overcharge
   e. High head pressure
   f. Loose components or compressor mounts

5. Unit short cycles
   a. Partial obstruction in lines
   b. Leaky power element
   c. Improper adjustment of refrigerant control device

UNIT XXIII  LOAD CALCULATIONS

Operations

A. Heat Gain Calculations

1. How to understand the many miscellaneous heat gains that must be taken into consideration when selecting a proper air-conditioning unit.
2. How to develop a knowledge and understanding of room heat

Related Trade Information

1. Sources of heat
   a. Transmission-sensible heat
      1. Conduction
         a. Walls, ceiling and floors
         b. Time of year and day
         c. Types of insulation
         d. Thickness of insulation
         e. External area
         f. Temperature difference
   2. Radiation
      a. Type of glass
      b. Other transparent materials
UNIT XXIII  LOAD CALCULATIONS (cont'd)

Operations

3. How to make a complete survey of the area to be conditioned
   a. Obtain all the room dimensions
   b. Note the windows, walls, ceiling and floor construction
4. How to make a floor plan of area to be conditioned
5. How to become familiar with the different types of construction in residences and commercial buildings and the importance of this information for calculation and installation purposes
   a. Heat loss calculation
      1. How to become familiar with the various methods of heat movement or transfer through building materials
      2. How to know the difference between heat gain and heat loss in a building
      3. How to control the heat gain and heat loss in a building
      4. How, with the use of calculations, it will help in the selection of cooling coils and condensing units
   5. How to know and understand the various instruments and their use in taking measurements for correct air distribution
      a. Pitot tube
      b. U-tube Manometer
      c. Inclined manometer or draft gauge
      d. Velocities
         1. Velometer
         2. Anemometer
         3. Anemotherm air meter

Related Trade Information

3. Solar
   a. Time of year and day
   b. Exposure
   c. Latitude
   d. Shading
4. Product
   a. Sensible heat
   b. Latent heat
   c. Respiration
5. Appliances, gas or electric
6. Lights
   a. Fluorescent
   b. Incandescent
7. Machines
8. Motors
9. People - degree of activity
10. Air changes
    a. Inside volume
    b. Type of usage
11. Duct work
    a. Supply-air heat gain
    b. Return-air duct gain
12. Ventilation air
    a. CFM per person
    b. CFM per square of floor space
    b. Transmission-latent heat
       1. Internal
          a. Appliances
          b. People-degree of activity
       2. External-ventilation air
          a. Desired resulting conditions
          b. Air mixture proportions
          c. Sensible heat ratio
2. Insulation
   a. Purpose or need
      1. Prevention against heat transfer
      2. Humidity control
   b. Thermal insulation
   c. Water vapor barriers
   d. Economic considerations
   e. Building insulation
3. Building construction
   a. Exterior walls
   b. Interior walls
   c. Floors and ceilings
   d. Insulation
UNIT XXIV  AUTOMOTIVE AIR CONDITIONING

Operations

A. How to Install Belts, Align, Adjust the Tension and Operate an Automobile Air Conditioning Unit

1. Engine off, check belt tension, loosen adjustment bolts, remove belt
2. Inspect and measure belt
3. Replace or install new belt
4. Carefully check the alignment of the pulleys and their shafts, realign if necessary
5. Apply lever pressure on the compressor or idler pulley until the correct belt tension is obtained
6. Tighten the adjustment bolts
7. Recheck the belt tension
8. Install the fan guard and run engine. Recycle several times
9. Recheck the belt tension
10. Shut down the system

B. How to Install a Compressor on an Automobile Air Conditioning System

1. Check the compressor oil level
2. Check the magnetic clutch operation
3. Install the compressor
   a. Install belt
   b. Check belt for correct alignment and tension
4. Install the refrigerant lines
5. Install gauge manifold
6. Check for leaks at 25 psig then at 70 psig
7. Evacuate the system
8. Operate the system
   a. Charge system
   b. Check sight glasses
   c. Test for leaks

Related Information

1. Introduction to automotive air conditioning
   a. Automotive air-conditioning principles
   b. Development of automotive air-conditioning
   c. Operating conditions
      1. Idling engine
      2. Fresh air ducts closed
      3. Operating engine
      4. Heat load
   d. Performance of system
   e. Types of systems
      1. Pressure operated low side pressure regulators
      2. Pressure operated bypass
      3. Solenoid operated bypass
      4. Electro-magnetic clutch
         a. Revolving magnetic coil
         b. Stationary magnetic coil
   f. Types of compressors
   g. Compressor seals
   h. Belts
      1. Belt tensions—new and used belts
   i. Condenser (air-cooled)
   j. Receiver-drier
   k. Refrigerant lines
      1. Flared fittings
      2. O ring fittings
      3. Hose clamp fittings
   l. Evaporators
   m. Expansion valves
   n. Suction pressure control valves
      1. Suction throttling valves (STV)
      2. Evaporator pressure regulator (EPR)
      3. Pressure operated altitude valve (POA)
   o. Service valves
Operations

9. Check operating pressures and the evaporator outlet temperature
10. Remove the gauge manifold and shut down the system

C. How to Install an Evaporator on an Automotive Air Conditioning System

1. Select proper cooling coil
2. Mount the thermostatic expansion valve on the evaporator and install the suction and liquid lines
3. Mount the evaporator, level connect the refrigerant lines and drain nose
4. Complete the electrical wiring and connect the gauge manifold
5. Test for leaks
6. Evacuate the system, using the deep vacuum procedure
7. Operate the system, charge it, check its operation
8. Seal the tubing opening in the firewall, install the evaporator housing

D. Locate and Repair Trouble in an Automobile Air-Conditioning System

1. Install the gauge manifold
2. Check the compressor belt tightness
3. Check for leaks
4. Check oil charge
5. Operate the system
6. Check the operating pressures, temperatures and quantity of refrigerant
7. Replace, repair or adjust the system until normal operation is obtained

E. How to Install, Test and Adjust the Clutch

F. How to Install, Test and Adjust the Thermostatic Expansion Valve (TEV)

1. Install gauge manifold

Related Trade Information

2. Air distribution
   a. Duct system
      1. Fresh air inlet
      2. Return air inlet
      3. Evaporator housing
      4. Drain pan and drain connections
      5. Plenum chamber
      6. Conditioned air outlets
      7. Dampers
   b. Fans
      1. Radial flow
      2. Squirrel cage
      3. Centrifugal
   c. Fan motors
      1. 6 volts
      2. 12 volts
   d. Insulation
      1. Types
      2. Areas

3. Special tools and equipment for working on automotive air-conditioning
   a. Gauge manifold test unit
   b. Two-way valve
   c. Three-way tee
   d. 90° gauge line adapter
   e. Puller and puller pilot
   f. Multi-opener (4 cans)
   g. Non-magnetic clutch shims
   h. #21 snap ring pliers
   i. #26 snap ring pliers
   j. Compressor holding fixture
   k. Compressing fixture
   l. Clutch hub holding tool
   m. Hub and drive plate assembly remover and installer
   n. Seal and seal seat removers-pulley bearing remover
   o. Shaft seal protector
   p. Pressure test connector

4. Functions of component parts
   a. The drive belt
      1. Used to drive the compressor
      2. Belt adjustment
      3. Belt tension gauge
2. Discharge the system
3. Remove the thermostatic expansion valve from the liquid line and evaporator. Remove the thermal bulb.
4. Test the thermostatic expansion valve
5. Reinstall the TEV. Tighten all fittings. Connect the equalizer tube and mount the thermal bulb securely
6. Replace all insulation
7. Install the gauge manifold, pressure to 5 psig, test for leaks, pressurize to 70 psig and test for leaks
8. Charge to clear sight glass-test for leaks
9. Operate the system
10. Check operating pressures, refrigerant quantity and evaporator outlet air temperatures
11. Check the sweat back on the suction line
12. Remove the gauge manifold

b. The electro-magnetic clutch
1. Operates the compressor
2. Operates by the principle of magnetic attraction
c. The compressor
1. Purpose of compressor is to pump refrigerant into the condenser
d. The condenser
1. Purpose of condenser is to dissipate heat
e. The receiver-drier
1. The receiver-drier has four functions
a. Storage
b. Moisture absorption
c. Filtration
d. Trouble diagnosis
f. The thermostatic expansion valve (TEV)
1. The TEV meters liquid refrigerant as needed to the evaporator
g. The evaporator
1. The purpose of the evaporator core is to cool and remove moisture from the air flowing through it

5. The electrical control system
a. The thermostatic switch
b. Blower motor
c. Control switch
d. Rheostat
e. Clutch field
BIBLIOGRAPHY OF TEXT AND REFERENCE BOOKS

Air Conditioning and Refrigeration


Faris, Kamil J., Refrigeration I and II, Vocational-Technical Curriculum Laboratory, Rutgers - The State University, Bldg. 4103, Kilmer Campus, New Brunswick, New Jersey 1971


Faris, Kamil J., Electricity in Refrigeration and Air Conditioning, Vocational-Technical Curriculum Laboratory, Rutgers, The State University, Bldg. 4103, Kilmer Campus, New Brunswick, New Jersey 1968

Automotive Air-Conditioning Service Manual, Refrigeration and Air Conditioning Division, Parker-Hannifin, 17325 Euclid Avenue, Cleveland, Ohio 44112 1967

Tricomi, Ernest, ABC's of Air Conditioning, Howard W. Sams & Co., Inc., Indianapolis, Indiana 46206 1970

Czinkota, Michael, Sands, Leo G., How to Select, Install and Service Air Conditioners, Chilton Book Company, Philadelphia, Penna. 1969


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Air Conditioning and Heating Technology II, Gattone, Felix, Dept. of Vocational-Technical Education, Rutgers-The State University, New Brunswick, New Jersey 1965

Carmody, John F., Basic Automotive Air Conditioning, Vocational-Technical Curriculum Laboratory, Rutgers - The State University, Bldg. 4103, Kilmer Campus, New Brunswick, New Jersey 1971

Kaberlein, Joseph J., Air Conditioning Metal Layout, The Bruce Publishing Company, Milwaukee, Wisconsin
# Course of Study Outline

## Air Conditioning and Refrigeration

### Shop Vocabulary

<table>
<thead>
<tr>
<th>Term</th>
<th>Term</th>
<th>Term</th>
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<tbody>
<tr>
<td>absorption</td>
<td>capillary</td>
<td>diaphragm</td>
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<tr>
<td>acetylene</td>
<td>centrifugal</td>
<td>discharge</td>
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<td>Centigrade</td>
<td>dismantle</td>
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<td>circuit</td>
<td>drier</td>
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<td>comfort</td>
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<td>copper</td>
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<td>flux</td>
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<td>brazing</td>
<td>cycle</td>
<td>freezing</td>
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<td>British thermal unit</td>
<td>cylinder</td>
<td>frosting</td>
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<td>buckle</td>
<td>damper</td>
<td>fuse</td>
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<td>calculate</td>
<td>dehumidify</td>
<td>galvanized</td>
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<td>calibrate</td>
<td>desiccant</td>
<td>gasket</td>
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<td>caliper</td>
<td>detector</td>
<td>gauge</td>
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<tr>
<td>capacitor</td>
<td>dew point</td>
<td>generator</td>
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</table>

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-150-  
159
valve
vapor
ventilation
vibration
voltage
voltmeter
wattmeter
welding
wet-bulb
wrench
zinc
COURSE OF STUDY OUTLINE

Air Conditioning and Refrigeration

Suggested Teaching Aids

Catalogs

The Harry Alter Co. - "Dependabook" - Refrigeration and Air Conditioning Parts
General Headquarters - 2399 S. Archer Ave., Chicago, Ill. 60616
Local - 49-01 Maspeth Ave., Maspeth, Queens, N.Y. 11378

W. W. Grainger, Inc.
55 Jackson Drive, Cranford, N.J. 07016

Tesco Distributors, Inc.
300 Nye Ave., Irvington, N.J. 07111

Luce, Schwab and Kase, Inc.
9 Gloria Lane, Fairfield, N.J. 07006

Charts

Sporlan Valve Company, Education and Training Dept.
7525 Sussex Ave., St. Louis, Missouri 63143

Alco Controls Division - Emerson Electric Co., Marketing Services Dept.
Box 12700, St. Louis, Missouri 63141

E. I. DuPont de Nemours and Co., Inc. "Freon" Products Division
Wilmington, Delaware 19898

Field Trips

Emerson "Quiet Kool" Air Conditioning Mfg. Co.
St. George and Woodbine Ave., Woodbridge, N.J.

Fedders Air Conditioner Mfg. Co., Woodbridge Ave.,
Edison, N.J.

Singer Climate Control Products
1300 Federal Boulevard, Carteret, N.J.
Tri-Con Service Inc., Industrial Air Conditioning and Heating
2208 Hamilton Boulevard, South Plainfield, N.J.

Films

General Motors Corporation, Public Relations Film Library
General Motors Building, Detroit, Michigan 48202

Frigidaire Division, Public Relations Dept.
300 Taylor St., Dayton, Ohio 45401

United Delco Division
3044 West Grand Boulevard, Detroit, Michigan 48202

Association of Home Appliance Manufacturers
20 North Wacker Drive, Chicago, Illinois 60606

Filmstrips

Whirlpool Corporation, Service Training Center
Benton Harbor, Michigan 49022

Carrier Air Conditioning Co.
Carrier Parkway, Syracuse, N.Y. 13201

Lennox Industries, Inc., Educational Division
Dept. A-15, P.O. Box 250
Marshalltown, Iowa 50158

Periodicals

Air Conditioning and Refrigeration Business
614 Superior Avenue West, Cleveland, Ohio 44113

Heating, Piping, Air Conditioning
25 Sullivan St., Westwood, N.J. 07675

Appliance Manufacturer
270 St. Paul St., Denver, Col. 80206

Refrigeration Service and Contracting
2720 Des Plaines Ave., DesPlaines, Ill. 60018

A.S.H.R.A.E. Journal
345 E. 47th St., New York, N.Y. 10017
Transparencies

Curriculum Laboratory
Dept. of Vocational-Technical Education
Building 4103 - Kilmer Campus
New Brunswick, N.J. 08903

DCA Educational Products, Inc.
4865 Stenton Avenue
Philadelphia, Pa. 19144

NOTE: Additional material can be obtained from the following catalogs.

Bibliography of Training Aids, 3rd Edition
Compiled by: Air Conditioning and Refrigeration Institute
1815 North Fort Myer Drive
Arlington, Virginia 22209

AHAM - Educational Activities and Teaching Aids
Association of Home Appliance Manufacturers
20 North Wacker Drive, Chicago, Illinois 60606
MIDDLESEX COUNTY VOCATIONAL AND TECHNICAL HIGH SCHOOLS

____New Brunswick  ____Perth Amboy  ____Woodbridge  ____East Brunswick

FINAL EXAMINATION

REFRIGERATION AND AIR CONDITIONING

Grade 10

RELATED THEORY (SHOP)

<table>
<thead>
<tr>
<th>SECTION</th>
<th>POSSIBLE SCORE</th>
<th>SCORE</th>
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<tbody>
<tr>
<td>I True-False</td>
<td>20</td>
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</tr>
<tr>
<td>II Multiple Choice</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>III Completion</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>IV Matching</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>V Sequence</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>VI Problems</td>
<td>20/100</td>
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</table>

100 = ____

_SCORED BY_ __________________________

165
FINAL EXAMINATION - REFRIGERATION
RELATED THEORY (SHOP) 10

PART I

TRUE - FALSE
(Value: 1 Point Each; Total 20 Points)

DIRECTIONS: Examine each statement below and decide whether it is true or false. If true, put a T on the line to the left of the exercise. If false, put an F on the line to the left of the exercise.

SAMPLE PROBLEM:

F A. Refrigeration has little effect upon the standards of living or industrial processes.

1. The capacity of a compressor is affected by its speed.

2. Purging increases pressure in the line and helps to add air to the line.

3. The refrigerant absorbs heat in the condenser section of the system.

4. Selection of the proper evaporator depends primarily upon the application of the system.

5. Heat energy that causes change in temperature is sensible heat.

6. Reamers are used for removing metal from outside of a metal tube.

7. The evaporator is sometimes called the high side of the system.

8. Since earliest recorded history, ice was used by some men for preserving food.

9. A good refrigerant should be nonflammable and nonexplosive as a gas, as a liquid, and when mixed with oil.

10. The refrigerant is a liquid as it leaves the condenser.

11. Precooling or subcooling of the liquid refrigerant has the same meaning.

12. High electrical resistance is unnecessary in a refrigerant.

1970-71 (Continued)
13. Temperature rise is accompanied by a decrease in the speed of molecules.

14. A hermetic unit may be either a reciprocating or rotary type compressor.

15. The tracking of a refrigerant in the evaporator is desirable.

16. A liquid exerts force when heated.

17. Heating copper tubing until it is a dark purple color softens or anneals it.

18. An unfilled space must be left on the top of a cylinder of refrigerant as a safety precaution.

19. The evaporator is a device to reject heat from the refrigeration system.

20. Sensible heat is removed from the refrigerant by the condenser.
R & AC-Theory - 10

PART II
MULTIPLE CHOICE
(Value: 1 Point Each; Total 20 Points)

INSTRUCTIONS: Each of the following statements can be correctly completed by one and only one of the lettered expressions. You are to write the letter which stands for the correct expression on the line to the left of the exercise.

AMPLE PROBLEM:

A. Refrigeration is
   (a) the removing of heat
   (b) the adding of heat
   (c) the adding of heat and cold
   (d) the removing of heat and cold

1. The compressor located in the refrigeration cycle is
   (a) between the condenser and receiver
   (b) in the liquid line between the receiver and the metering device
   (c) between the evaporator and condenser
   (d) between the metering device and the evaporator

2. Liquid slugging in the compressor is a result of
   (a) excessive compressor speeds
   (b) liquid refrigerant or oil in the clearance space of the compressor
   (c) incorrect oil in system
   (d) wrong refrigerant

3. Hidden heat in refrigeration work is referred to as
   (a) intensity of heat
   (b) dynamic heat
   (c) latent heat
   (d) heat a thermometer can "sense"

4. The cooling component of a refrigeration system is called
   (a) a valve
   (b) a compressor
   (c) an evaporator
   (d) a condenser

5. For practical purposes, the high side of a refrigeration system includes
   (a) the metering device
   (b) the compressor
   (c) the evaporator
   (d) none of the above
6. A mechanical shaft seal is necessary in a
(a) semi-hermetic compressor
(b) hermetic reciprocating compressor
(c) hermetic rotary compressor
(d) open type compressor

7. The main purpose of a condenser is to
(a) store liquid refrigerant
(b) remove heat from the refrigerant
(c) remove impurities from the refrigerant system
(d) cool heat to the refrigerant

8. The evaporator is a device to
(a) store liquid refrigerant
(b) absorb heat into the refrigeration system
(c) remove heat from the refrigeration system
(d) none of the above

9. The metering device is designed to
(a) keep the evaporator as cold as possible
(b) to control evaporator superheat
(c) control the flow of refrigerant
(d) to keep a constant evaporator pressure

10. The Fahrenheit scale is based on boiling water having a sea level temperature of
(a) 459°
(b) 180°
(c) 212°
(d) 100°

11. A ton of refrigeration is equal to
(a) 2,880,000 BTU per day
(b) 12,000 BTU per hour
(c) 2,000 lbs. per hour
(d) 180 BTU per hour

12. Superheat is heat added
(a) in changing liquid to vapor
(b) in raising temperature of water
(c) after all liquid has been changed to vapor
(d) to decrease pressure
13. A receiver is used
   (a) to condense the refrigerant
   (b) to cool the hot gas
   (c) to separate the oil
   (d) to store refrigerant

14. A capillary is located
   (a) in the liquid line feeding the evaporator coil
   (b) at the leaving side of the evaporator coil
   (c) in the hot gas line
   (d) at the condenser inlet

15. The type of threads used on flare fittings are
   (a) National Fine
   (b) National Coarse
   (c) U.S.S.
   (d) Briggs Standard Pipe Thread

16. Tubing may be safely bent to the desired radius by use of
   (a) pliers
   (b) vise
   (c) bending springs
   (d) none of the above

17. Tubing, after being cut, must be sealed
   (a) reasonably soon
   (b) immediately
   (c) never
   (d) within twenty-four hours

18. The tool that is used to clean internal threads is
   (a) knife
   (b) file
   (c) tap
   (d) die

19. The purpose of flux, when soldering, is
   (a) as a binder
   (b) to reduce the melting temperature
   (c) used to prevent oxidation
   (d) to form a different alloy
(Cont'd)

29. "Wiping" a copper tube joint is

(a) building up a pipe joint
(b) removing excess solder
(c) apply the flux
(d) none of the above
PART III
COMPLETION

DIRECTIONS: The words listed below may be used to aid you in filling in the blanks of the "Completion" test on the following page. The words may be used more than once or you may use your own words. All the words needed to fill in the blanks may not be on the list.

WORD LIST
compressor
vacuum pump
electronic detector
condenser
BTU
dissolve
molecules
sensible heat
cooling coil
potential
pounds
remote
metering device
rise
ice and water bath
elements
latent heat
refrigerant
CFM
lower
SAMPLE PROBLEM

A. The energy which moves heat from a low to high temperature level is supplied by a compressor.

PROBLEMS

1. The restriction which is included in the line between the condenser and the evaporator is called a ________________.

2. Sensible heat, when added to a material causes the temperature to _______ ____________.

3. Periodically a thermometer should be checked for accuracy by using an ________________.

4. A compound is a combination of ____________________.

5. The standard unit of heat measurement in the English system is the ________________.

6. Heat which causes a change of state is called ____________________.

7. Another name that is sometimes used for an evaporator is ________________.

8. Hermetic motors are cooled by the ________________.

9. The best component to use for the evacuation of a new system, is a ________________.

10. The device which can be used safely for detecting a leak for any kind of refrigerant is called an ________________.
PART IV
MATCHING TEST
(Value: 1 Point Each; Total 10 Points)

DIRECTIONS: Column A lists some refrigeration terms. Column B contains comparative refrigeration terms. In each blank in Column A place the letter of the answer from Column B you consider correct.

SAMPLE PROBLEM:

<table>
<thead>
<tr>
<th>COLUMN A</th>
<th>COLUMN B</th>
</tr>
</thead>
<tbody>
<tr>
<td>b  1. The refrigerant is a liquid as it leaves the</td>
<td>(a) water</td>
</tr>
<tr>
<td>a  2. Requires heating of the drain pan</td>
<td>(b) condenser</td>
</tr>
<tr>
<td>b  1. Sensible heat</td>
<td>(a) reciprocating compressor</td>
</tr>
<tr>
<td>b  2. Evaporator</td>
<td>(b) metering device</td>
</tr>
<tr>
<td>b  3. Subtract 32° and multiply by 5/9</td>
<td>(c) removes heat from refrigeration system</td>
</tr>
<tr>
<td>a  4. Has pistons and cylinders</td>
<td>(d) causes a change in temperature</td>
</tr>
<tr>
<td>a  5. Condenser</td>
<td>(e) swaging tubing</td>
</tr>
<tr>
<td>a  6. Capillary tubing</td>
<td>(f) part of the system where the refrigerant absorbs heat</td>
</tr>
<tr>
<td>a  7. Heat required to raise one pound of water, one degree Fahrenheit.</td>
<td>(g) connected to suction service valve</td>
</tr>
<tr>
<td>a  8. Motor surrounded by refrigerant</td>
<td>(h) changing a temperature from F° to C°</td>
</tr>
<tr>
<td>a  9. Compound gauge</td>
<td>(i) Hermetic</td>
</tr>
<tr>
<td>a  10. Joining tubing without a fitting</td>
<td>(j) BTU</td>
</tr>
</tbody>
</table>
CYCLE OF REFRIGERATION
SCHEMATIC DIAGRAM

1. 
2. 
3. 

4. 
5. 
6. 

-166-

175
PART V
SEQUENCES

DIRECTION: The diagram on the opposite page is the basic refrigeration cycle. Six (6) components are identified by the numbers 1-2-3-4-5-6.

1. On the lines below the sketch write the names of the six components.

2. Indicate the condition or state of the refrigerant in the various components (high or low pressure gas or liquid).

   1. __________________________

   2. __________________________

   3. __________________________

   4. __________________________

   5. __________________________

   6. __________________________

3. Where does the change of state of the refrigerant take place?

   __________________________

   __________________________

4. Indicate the flow of the refrigerant by arrows beside the refrigerant lines.

5. On the blank sheets attached to the booklet describe the function and/or operation of each of the six components.
PART VI
PROBLEMS
(Value: 5 Points Each; Total 20 Points)

DIRECTIONS: There are 10 problems below. You are to answer only four (4) of these problems. Do your calculations on the reverse side of this sheet. Show all calculations in a neat orderly manner. Carry calculations to two decimal places. Write the answers in place or spaces indicated.

The formulas listed below may be used to help solve the following problems.

1. \[ H = (m)(c)(A+) \]
2. \[ F = c \times 9/5 + 32^\circ \]
3. \[ C = (F-32^\circ) \times 5/9 \]
4. \[ P = 460 + F^\circ \]
5. \[ K = 273 + F^\circ \]

1. A motor has a rated temperature rise of .50°C. If the ambient temperature is 86°F., what is the continuous running temperature.

Answer (1)__________________________

2. Change the following
   (a) 77°F to C
   (b) 35°C to F

Answer (2) a.__________________________
     b.__________________________

3. Calculate the compression ratio of the compressor using the data given.

   Data
   Type refrigerant: R-12
   Readings (p.s.i.g.)
   Discharge gauge: 150
   Suction gauge: 15

Answer (3)__________________________

4. Name six main parts of a reciprocating compressor.

   (a)__________________________
   (b)__________________________
   (c)__________________________
   (d)__________________________
   (e)__________________________
   (f)__________________________

Answer (4)__________________________

Answer (5)__________________________

Answer (6)__________________________

Answer (7)__________________________

Answer (8)__________________________

Answer (9)__________________________

Answer (10)__________________________

1970-71 CONTINUED -168-
(Con'td)

5. Give the definition of heat

   Answer (5)

6. What is a B.T.U.?

   Answer (6)

7. Name the three basic methods of heat transfer.

   Answer (7)

8. What is specific heat?

   Answer (8)

9. A refrigeration system which circulates five pounds of R-12 per minute must subcool the liquid 20°F (from 86°F to 66°F) before it enters the metering device. How many B.T.U.'s are required to secure the results.

   Answer (9)

10. Determine the gauge pressure (p.s.i.g.) corresponding to an absolute pressure of 24.7 p.s.i.a.

   Answer (10)