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ABSTRACT

This course guide is oriented toward developing skills in air conditioning and refrigeration installation and service. Although primarily designed as a 2-year program for high school students at the junior and senior levels, it is equally acceptable for the post high school student as an occupational training program, or as a refresher course for those who have been in the industry and have not had the opportunity to keep up with recent developments in new methods and equipment. Eight major sections are included: The first three (Refrigeration, Basic Electricity, Commercial Refrigeration) are to be used the first year of the program, and the remaining five (Year Round Air Conditioning, Air Distribution, Controls, Trouble Shooting, Customer Relations) are to be used the second year. Each section includes from 1 to 15 units, with each unit providing unit objectives, tools and materials needed, and a unit outline. Occupational information and a vocabulary listing are included in the introduction for instructor use. (SH)

State of New Jersey
Department of Education
Division of Vocational Education

CLIMATE CONTROL

SECONDARY SCHOOL COURSE GUIDE

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CLIMATE CONTROL – SECONDARY SCHOOL COURSE GUIDE

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Foreword

The newness of the field of air conditioning and refrigeration compared to other industries has caused an unstable industry. The rapidity of its growth has caused concern within the industry because of the lack of trained personnel to cope with the wide range of activities encompassed within the industry and its related fields.

The tremendous growth of the industry requires that manufacturers, suppliers, sales personnel, service companies, and government agencies recognize the need for the training of young students in the basics of the industry. In this manner problems that are multiplying might be solved. The industry would be on a more sound base for continued expansion.

This guide was developed as a basic training program to present to high school students, preferably during the last two years of their schooling. If the graduate has absorbed the course as is intended, employers will have to spend a minimum of time and money on the new employee prior to the employee's receiving his jouryneyman papers.

Ernest P. DuPlantis, Instructor

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Brown, Frank, A. M. Brown Fuel Company – Industrial Advisor

Connors, Joseph, Inco Supply Company – Industrial Advisor

Althouse, Turnquist, et al. *Modern Refrigeration and Air Conditioning*

Audel's *Fundamentals of Electricity*

Slade and Margolis, *Mathematics for Technical High Schools*

OCCUPATIONAL INFORMATION

Upon satisfactory completion of this course, as outlined in the guide, the student will be qualified to enter the industry with the prospect of a successful career in air conditioning and refrigeration installation and service. With further training and proper experience his ability should increase to that of the technician or that of an assistant engineer.

In the air conditioning, heating and refrigeration industry, manpower forecasts indicate approximately 50,000 to 10,000 men will be needed within the next five years. The growth and expansion taking place will have to be filled by competent personnel. It is urgent, therefore, that necessary steps be taken to produce these men through our system of education. With air conditioning no longer considered a luxury, the situation is acute.

Factories engaged in the manufacturing of perishables will be in need of men on an around-the-clock basis. Utility companies are in great need of service personnel to service the equipment they sell. The medical profession is in need of refrigeration men in the treatment of certain illnesses and in the study of medicine in their pathology and surgery departments.

With the space program's giant strides, the study of cryogenics as a speciality is in need of men who are willing to further their studies in this field. To continue these studies at a higher level it is necessary for the basics to be learned as outlined.

The prospective student for this program should be at least average in intelligence and educational achievement, and if he has mechanical aptitude it would indeed be a desirable characteristic. Good physical condition is also important. Skilled refrigeration craftsmen are very frequently called upon to exhibit physical ability.

This program is primarily designed for high school students at the junior and senior level. It is equally acceptable for the post high school student as an occupational training program, or it could also be used as a refresher course for men who have been in the industry and have not had the opportunity to keep up with recent developments in new methods and equipment.

ADVISORY TO MATHEMATICS INSTRUCTOR

The purpose of this advisory is to aid the mathematics instructor assigned to instruct the students of Climate Control. Following is a recommended inclusion in his program that would be of definite service to the students.

1. COMMON FRACTIONS
   Reduction – addition – subtraction – multiplication – division

2. DECIMAL FRACTIONS
   Conversion of decimals to common fractions and common fractions to decimals – table of decimal equivalents – conversion of dimensions – addition – subtraction – multiplication – division.

3. PERCENTAGE
   Definitions – applications to problems pertaining to shop

4. RATIO AND PROPORTION
   Definitions – direct and inverse ratios – proportion – averages

5. MENSURATION
   Rectangles – square root (optional) – triangles – regular plane figures – scale – circle – cylinder – volume and weight formulas

6. PRACTICAL COMPUTATION
   Accuracy – use of diagrams – mental approximation (very important) – checking results

7. GRAPHS
   Types – use of graphs (very important) – bar graph

8. MEASURING INSTRUMENTS
   Micrometer – caliper

9. PRACTICAL ALGEBRA
   Use of letters – substitution – simple equations

10. THE ESSENTIALS OF TRIGONOMETRY
    Angles – tables – right angles – area of triangles

11. WORK AND POWER
    Foot-pound – horsepower – kilowatt – electrical horsepower – efficiency of machines

12. SPEED RATIOS OF PULLEYS
    Ratios between pulleys and flywheels

13. METRIC CONVERSION
    Explanation of tables

ADVISORY TO ENGLISH INSTRUCTOR

This guide is to help the English instructor in the identification of words used in the process of learning the subject of Climate Control.

ABSOLUTE
ABSORBENT
ABSORPTION
ACCELERATE
ACCUMULATOR
ALUMINA
ADIABATIC
ALTERNATING
ALTITUDE
AMBIENT

AMMETER
AMPERAGE
AMPLIFIER
ANEMOMETER
ANHYDROUS
ANNEALING
ANODE
ARMATURE
ASPIRATING
ATMOSPHERIC

ATOMIZE
ATTENUATE
AZEOTROPIC
BAROMETER
BAUDELOT
BELLOWS
BERNOULLI
BIMETAL
BOURDON
BOWDEN

BOYLE
BRAZING
BRINE
BUNKER
BUTANE
BYPASS
CADMIUM
CALCIUM
CALIBRATE
CALORIE

CALORIMETER
CAPACITANCE
CAPACITOR
CAPILLARY
CARRENE
CASCADE
CASEHARDENED
CATHODE
CELSIUS
CENTIGRADE

CENTIMETER
CENTRIFUGAL
CHEMICAL
CIRCUIT

CLUTCH
COEFFICIENT
COLLOID
COMMUTATOR
COMPOUND
COMPRESSION
CONDENSATE
CONDENSER
CONDUCTIVITY
CONDUCTOR

CONSTRICTOR
CONTAMINANT
CONVECTION
CONVERSION
COULOMB
CRANKSHAFT
CRISPER
CRITICAL
CRYOGENICS
CYLINDER

CYLINDRICAL
DECIBEL
DEGREE-DAY
DEHUMIDIFIER
DEHYDRATOR
DEICE
DENSITY
DEODORIZER
DESICCANT
DETECTOR

DIELECTRIC
DIAPHRAGM
DICHLORODIFLUOROMETHANE
DIFFERENTIAL
DIODE
DRIER
DUCT
DYNAMOMETER
EBULATOR
ECCENTRIC

ELECTROLYTIC
ELECTROMOTIVE
ELECTRON
ELECTROSTATIC
ENTHALPY
ENTROPY
ENZYME
EPOXY
EQUALIZER
EVAPORATION

EXPANSION
FAHRENHEIT
FARAD
FLUE
FLUX

FUSIBLE
GALVANIC
GAUGE
GRILLE
GROMMET
HALIDE
HERMETIC
HONE
HUMIDIFIER
HUMIDISTAT

HYDROGEN
HYDROMETER
HYDRONIC
HYGROMETER
HYGROSCOPIC
IMPELLER
INDUCTION
INFRARED
INSULATION
INTERMITTENT

ISOTHERMAL
KILOMETER
KILOWATT
LATENT
LITHARGE
LITER
MAGNETIC
MANIFOLD
MEGOHM
MERCOID

METER
METHANOL
METRIC
MICRO
MICRON
MILLI
MODULATING
MOLECULE
MULLION
NEOPRENE

NEUTRON
NOMINAL
ORIFICE
OSCILLOSCOPE
OVERLOAD
OZONE
PITOT
PLENUM
POLYPHASE
POTENTIAL

PROTON
PSYCHROMETER
PYROMETER
RADIATION

RECIPROCATING
RECTIFIER
REFRIGERANT
REPULSION
ROTARY
ROTOR
SADDLE
SATURATION
SCAVENGER
SCHRADER

SEEBECK
SENSIBLE
SENSOR
SEQUENCE
SHROUD
SILICA
SILICON
SINTERED
SLUG
SOLDERING

SOLENOID
SPECIFIC
SQUIRREL
STATOR
STELLITE
STOKER
SUBLIMATION
SUPERHEAT
SURGE
SWAGING

SYLPHON
SYNTHETIC
TEFLON
TEMPERATURE
THERM
THERMAL
THERMISTOR
THERMODYNAMICS
THERMOELECTRIC
THERMOMETER

THERMOSTAT
THROTTLING
TORQUE
TRANSDUCER
TRANSFORMER
URETHANE
VACUUM
VAPOR
VOLTAGE
VOLUMETRIC

VORTEX
WATT
WOBBLE
WOODRUFF

LENGTH OF COURSE AND COURSE UNITS

This guide is designed as a two-year secondary school program. The schedule below is based on three-hour periods five days a week. This includes time for preliminary instructions, lab experiments and necessary shop time. The hours as indicated are only a guide and the individual instructor will have to utilize the allotted time based on the progress of the students in each individual section.

FIRST YEAR

SECTION	AREA	HOURS CLASS	LAB	SHOP	TOTAL
I.	Refrigeration	60	20	100	180
II.	Basic Electricity	30	20	40	90
III.	Commercial Refrigeration	90	20	160	270
	SECOND YEAR				
IV.	Year Round Air Conditioning	90	45	135	270
V.	Air Distribution	35	20	50	105
VI.	Controls	35	20	50	105
VII.	Trouble Shooting	18	0	33	51
VIII.	Customer Relations	5	0	4	9
	Totals	363	145	572	1080

This guide is short of the necessary 1140 hours for the course. However, this will allow some time for each instructor to readjust the time according to his own desires for the welfare of the students.

The text referred to in this outline is the 1968 edition of *Modern Refrigeration and Air Conditioning*, Goodheart-Willcox Co. Publishers.

SECTION I - REFRIGERATION

SECTION I

REFRIGERATION

Unit	Title	Class	Hours Laboratory	Shop
1	Basic Refrigeration	3	2	4
2	Matter and Molecules	2	2	2
3	Measurements	5	2	8
4	Heat	5	1	9
5	Refrigeration Effects	5	1	9
6	Heat Transfer	2	1	3
7	Gases	3	1	5
8	System Testing and Theory	2	1	3
9	Pressures	3	2	4
10	Basic Refrigeration Cycle	15	3	27
11	Absorption Refrigeration	5	1	9
12	Refrigerants	3	1	5
13	Lubrication Systems	2	1	3
14	Refrigeration Circuit Problems	5	1	9
	Total	60	20	100

UNIT OUTLINES

Section I – Refrigeration

Unit 1 – Basic Refrigeration
- A. Orientation
  - 1. Purpose of the course
  - 2. Need of trained craftsmen in the field
    - a. Installation
    - b. Service and repair
    - c. Technical supervision
- B. Definitions
  - 1. Heat
  - 2. Cold
  - 3. Refrigeration
  - 4. Mechanical refrigeration
- C. Progress of refrigeration
  - 1. Use of snow and ice in early civilization
  - 2. Shipping of ice by clipper ships
  - 3. Manufacture of artificial ice in 19th century
  - 4. Early automatic machines
  - 5. Modern day uses of refrigeration
- D. Identification
  - 1. Major components of the system
  - 2. Refrigerant lines
    - a. Soft tubing
    - b. Hard drawn tubing
    - c. Proper care of tubing
  - 3. Refrigeration fittings

Unit 2 – Matter and Molecules
- A. Mass and weight
- B. Phases of matter
  - 1. Solid
  - 2. Liquid
  - 3. Gas
- C. Size and shape
- D. Change of phase
  - 1. Vaporization
  - 2. Condensation
  - 3. Liquification
  - 4. Solidification
  - 5. Sublimation

E. Stable forms of any material
F. Molecular movement
G. Identification
   1. Basic student refrigeration tool kit
   2. Shop tools and equipment

Unit 3 – Measurements
   A. Heat intensity
      1. Unit of intensity
         a. Fahrenheit scale
         b. Centigrade scale
         c. Rankin scale
         d. Kelvin scale
      2. Measuring devices
         a. Thermometers
            (1) Stem-type
            (2) Dial
            (3) Remote
         b. Thermocouples
      3. Fixed references
         a. Boiling point
         b. Freezing point
         c. Absolute zero
      4. Temperature conversion
   B. Heat quantity
      1. British thermal unit—water as a standard
      2. Calculating by means of heat equation
   C. Energy conversion units
      1. Heat energy
      2. Mechanical energy
      3. Electrical energy
   D. Copper tubing preparation procedures

Unit 4 – Heat
   A. Specific heat
      1. Of various metals (materials in general)
      2. Variation in specific heat due to change of phase
      3. Temperatures of mixes
   B. Total heat
      1. Sensible heat
         a. Sensible heat equation
         b. Sensible heat of a solid
         c. Sensible heat of a liquid
         d. Sensible heat of a vapor
      2. Fusion temperatures

3. Saturation temperatures
4. Latent heat
    a. Latent heat of fusion
    b. Latent heat of vaporization
5. Soldering materials
    a. 50/50 solder
    b. 95/5 solder
    c. Low temperature silver solder
    d. High temperature silver solder
6. Soldering equipment and fuels
    a. Prestolite
    b. Oxygen-acetylene
7. Soldering procedures
    a. Sweating fittings
    b. Proper cleaning methods
    c. Actual sweating process

Unit 5 - Refrigeration Effects

A. Refrigerating effect
    1. System capacity
    2. Weight of refrigerant circulated per minute per ton
    3. Volume of vapor displaced per minute per ton
    4. Compressor capacity

B. Pressure-enthalpy diagrams for various refrigerants

C. Simple saturated refrigerant cycle
    1. Expansion process
    2. Vaporizing process
    3. Compression process
    4. Condensing process
    5. Coefficient of performance
    6. Effect of suction temperature on efficiency

D. Superheat and subcooling

E. Deviations from the simple saturated refrigerant cycle
    1. Effect of superheating the suction vapor
    2. Superheating without useful cooling
    3. Superheat producing useful cooling

F. Liquid-suction heat exchangers

G. Demonstration of tool usage
    1. Tubing benders, bending springs
    2. Pinch-off and refacing tools

Unit 6 – Heat Transfer

A. Direction and rate of heat flow

B. Basic methods of heat transfer
    1. Conduction
        a. Differences in conductivity
        b. Influences of thickness and area

2. Convection
   a. Natural
   b. Forced
3. Radiation
   a. Absorption
   b. Reflection

C. Coefficients of heat transfer
   1. Pipe and fittings
   2. Appropriate tools

Unit 7 – Gases

A. Specific volume of gases
   1. Effects of heat on the volume
   2. Effects of pressure on the volume
B. Density
C. Charles' law
   1. Constant pressure form
   2. Constant volume form
D. Boyle's law
E. General laws of gases
F. Connection of lab units
   1. Location of refrigerant lines
   2. Location of accessories

Unit 8 – System Testing and Theory

A. Pressure
   1. Force per unit area
   2. Head
   3. Pascal's principle
B. Density
   1. Specific gravity
   2. Convenient units of weight and volume
C. Testing and evacuating equipment
   1. Testing manifold
   2. Gauges and hoses
   3. Vacuum pump

Unit 9 – Pressures

A. Atmospheric pressure
   1. Barometers
   2. Pressure decrease with altitude increase
B Standard of ordinary pressure
   1. Manometer
      a. Open arm
      b. Closed arm
   2. Burdon tube gauges
      a. Pressure
      b. Compound

C. Absolute pressure
D. Operational procedures
   1. System evacuation
   2. Vapor-charging
   3. Leak detecting

Unit 10 – Basic Refrigeration Cycle
A. Compressors
   1. Reciprocating
      a. Accessible or open type
         (1) Cylinder construction
         (2) Cylinder arrangements
         (3) Piston construction
         (4) Connection rod construction
         (5) Crank shaft construction
         (6) Valve construction
         (7) Crankshaft seal construction
         (8) Gaskets
         (9) Compressor drives
   2. Rotating
      a. General construction
      b. General operation
   3. Centrifugal
      a. Single-stage
      b. Multi-stage
      c. Rotors (impellers)
      d. Stators
B. Evaporators
   1. Bare tube
   2. Plate
   3. Finned
   4. Air cooling coils
      a. Dry
         (1) Natural convection
         (2) Forced circulation
         (3) Frosting
         (4) Defrosting
         (5) Non-frosting
      b. Flooded
   5. Liquid cooling coils
      a. Submerged
      b. Shell-and tube
      c. Tube-within-tube
      d. Baudelot cooler

C. Condensers
   1. Air cooled
      a. Bare pipe
      b. Finned
      c. Natural convection
      d. Forced circulation
   2. Water cooled
      a. Double pipe
      b. Double tube
      c. Shell-and-coil
      d. Shell-and-tube
   3. Combination
   4. Evaporative
D. Receivers
   1. Construction
   2. Safety devices
   3. Auxiliary
E. Refrigeration flow controls
   1. Automatic expansion valves
      a. Bellows type
      b. Diaphragm type
   2. Capillary tube
   3. Thermostatic expansion valve
      a. Bellows type
      b. Diaphragm type
      c. Internal equalizer
      d. External equalizer
   4. Auxiliary valves
      a. Check
      b. Solenoid
      c. Suction pressure
F. Refrigerant lines
   1. Piping principles
   2. Liquid lines
   3. Suction lines
   4. Hot gas lines
   5. Liquid return lines
   6. Condenser drain lines

Unit 11 – Absorption Refrigeration
A. Basic absorption cycles
   1. Ammonia-water cycle
      a. Refrigerant is ammonia
      b. Absorbent is water
   2. Lithium bromide-water cycle
      a. Refrigerant is water
      b. Absorbent is lithium bromide

B. Major components
   1. Generator
   2. Absorber
   3. Chiller
   4. Condenser
C. Auxiliary components
   1. Heat exchanger
   2. Pumps
      a. Solution
      b. Refrigerant
   3. Analyzer
   4. Rectifier
   5. Separator
   6. Piping
   7. Insulation
D. Controls and protective devices
E. Heat source
   1. Direct firing
   2. Indirect firing
      a. Steam
      b. Hot water or other fluids
F. Operational procedure of lab units
   1. Pump down
   2. Removal of components
   3. Purging

Unit 12 – Refrigerants
A. Requirements
   1. Chemical properties
      a. Non-flammable
      b. Non-explosive
      c. Non-toxic
      d. Low operating pressure
   2. Physical properties
      a. Volume
      b. Density
      c. Oil miscibility
      d. Low compression ratio
      e. Leak detection
B. Classification
   1. National Refrigeration Safety Code
      a. Group 1 –safest of refrigerants
      b. Group 2–toxic and somewhat flammable
      c. Group 3–very flammable

2. National Board of Fire Underwriters
    a. Toxicity
    b. Color code of refrigerant drums
C. Operational procedures
    1. Transfer of refrigerant
    2. Check of expansion valves
        a. Automatic
        b. Thermostatic

Unit 13 – Lubrication Systems

A. Lubricants
    1. Necessary properties
        a. Free of wax, moisture and foam
        b. Correct viscosity for refrigerant used
        c. Free of impurities
    2. Results of moisture
    3. Proper charge
        a. Results of undercharge
        b. Results of overcharge
B. Types of systems
    1. Splash feed
    2. Force feed
C. Operational procedures
    1. Adding of oil
    2. Use of valve kit and adapters
    3. Use of electronic leak detector

Unit 14 – Refrigeration Circuit Problems

A. High head pressure
    1. Dirty or partially blocked condenser
    2. Air or non-condensable gases in system
    3. Overcharge of refrigerant
    4. Insufficient condensing medium
    5. High temperature condensing medium
    6. Restricted metering device
B. Low suction pressure
    1. Insufficient air on cooling coil
    2. Low ambient temperature on evaporator coil
    3. Restricted refrigerant flow
    4. Undercharge of refrigerant
    5. Faulty expansion valve
    6. Low head pressure
C. High suction pressure
    1. Heavy load conditions
    2. Low super heat adjustment
    3. Improper expansion valve adjustment
    4. Poor installation of feeler bulb
    5. Inefficient compressor

UNIT 1 – BASIC REFRIGERATION

Class Instruction – 3 hours
Laboratory – 2 hours
Shop – 4 hours

Unit Guide

Unit Objectives

To inform trainees of the competencies required, and the employment opportunities available in the refrigeration field.

To acquaint the student with the history of refrigeration.

To familiarize the student with basic refrigeration terms, major components, tubing, and fittings in a refrigeration system.

To develop in the student the ability to use and care for tools, parts, and equipment used on refrigeration systems.

Tools and Materials

Text – Chapter 1 – Fundamentals of Refrigeration
Major components of a refrigeration system
Demonstration unit (glass)
Refrigeration tubing and panel-mounted fittings

Unit Outline

A. Orientation
   1. Purpose of the course
   2. Need of trained craftsmen in the field
      a. Installation
      b. Service and repair
      c. Technical supervision
B. Definitions
   1. Heat
   2. Cold
   3. Refrigeration
   4. Mechanical refrigeration
C. Progress of refrigeration
   1. Use of snow and ice in early civilization
   2. Shipping of ice by clipper ships
   3. Manufacture of artificial ice in 19th century
   4. Early automatic machines
   5. Modern day uses of refrigeration

D. Identification
   1. Major components of the system
   2. Refrigerant lines
      a. Soft tubing
      b. Hard drawn tubing
      c. Proper care of tubing
   3. Refrigeration fittings

Laboratory Activity

1. Point out each component of the system and briefly explain its operation.
2. Identify tube and fitting sizes associated with refrigeration.

Shop Activity

1. Allow students to observe the commercially made refrigerator in operation, and ask questions for discussion.
2. Have the students feel and identify fittings and tubing sizes.
3. Question the students orally or in writing.
4. Grade each student on the basis of his remarks and answers.

Classroom Activity

Acquaint the student with the different areas in the industry where men are needed, such as: pipe fitting mechanics' helpers, mechanics, technicians, and engineers' helpers. Emphasize how important it is for each student to learn each lesson and activity to the utmost of his ability. Explain how each lesson will lead into something that is directly related to the lesson or activity just learned. Explain how each student will reach a leveling point in his learning rate and how, when this point is reached, it is necessary for him to polish what he has learned by research and activity on an individual basis.

Explain the main phases of the industry and how they affect each of them as individuals.

1. Installation of equipment -- pipe fitting, leak testing, starting newly installed equipment. Explain the need for men who have a minimum of technical knowledge. It would be necessary to explain to them what the minimum technical knowledge is in this particular phase.

2. Service and repair -- Explain to the student that much more knowledge is needed to make repairs of equipment than to install equipment.

3. Technicians -- Explain to the student that his services as a field technician are in great demand and that this is the highest goal students can set for themselves.

4. Define to the students the simple terms that they will be using throughout the course, i.e.. heat, cold, refrigeration, and mechanical refrigeration.

5. Outline the progress of refrigeration, from the early days when ice and snow were used, to the present, as electrical and mechanical equipment make efficient refrigeration possible.

Laboratory Activity

Using demonstration equipment, point out the major components to the students and very simply explain the purpose of each. Using the more common types and sizes of copper tubing and fittings, explain the importance of learning by sight the name, size, and type of each. Explain the different types of copper used and where each is most suited. Have each student examine the materials being demonstrated. Direct a brief discussion among students as they examine the materials.

Shop Activity

Allow the students to observe glass demonstrator in operation. Briefly explain what is taking place. Have each student feel the lines and notice the differences in temperatures at different locations. Answer, with limited detail, any questions they may ask.

Student Activity

Assign necessary paragraphs in the text as homework. Begin each day with student explanations of what was learned the day before. A short question and answer period would probably precipitate discussion about the previous day's work. This could begin the classroom activity for the following lesson.

UNIT 2 – MATTER AND MOLECULES

Class Instruction – 2 hours
Laboratory – 2 hours
Shop – 2 hours

Unit Guide

Unit Objectives

To acquaint the student with the relationship of matter to refrigeration.

To develop an understanding of the phases of matter

To develop a knowledge of a change of phase.

To inform the students of the tools used and their purpose.

To develop proper attitudes about the safe use of tools.

Tools and Materials

Text – Chapter 1 through Chapter 2 – Refrigeration Tools and Materials
Shop tools
Basic refrigeration tool kit
Refrigeration training unit

Unit Outline

A. Mass and weight
B. Phases of matter
   1. Solid
   2. Liquid
   3. Gas
C. Size and shape
D. Change of phase
   1. Vaporization
   2. Condensation
   3. Liquification
   4. Solidification
   5. Sublimation
E. Stable forms of any material
F. Molecular movement
G. Identification
   1. Basic student refrigeration tool kit
   2. Shop tools and equipment

Laboratory Activity

1. Show the students the tools they will be using in the shop and how to use them in the proper way.
2. Have the students study the refrigeration trainer and write their interpretation of what is taking place.

Shop Activity

1 Have students identify all tools presented by writing the names of each and explaining their purpose.

2. Have the students study the trainer and write the locations where the changes of phase are taking place.

3. Grade students on their perceptiveness.

Classroom Activity

Explain mass and weight to the students and how it affects them in reference to the course. (Use different forms of Freon as an example – their boiling points, etc.)

Explain what solids, liquids and gases are, and how they are involved in refrigeration. Explain the change of phase. Explain molecular movement. Give students definitions of the words vaporization, condensation, liquification and sublimation.

Laboratory Activity

Using available materials, demonstrate the different phases that will be encountered during the course. Demonstrate the changes of phase using water, ice and dry ice (CO_2). Demonstrate the reaction of molecules when heat is applied. This can be done by observing water as heat is applied. Safety should be emphasized at all times during laboratory demonstrations and shop activity.

Prepare a tool kit with typical refrigeration tools. Name and explain the use of each tool, then have the students do the same.

Shop Activity

Have the students perform some of the tasks that have been demonstrated. At this point the instructor should observe each student for his safety habits, interest, comprehension, and general attitude towards the subject and his fellow students. During the next few days, the instructor should formulate a plan of organization and pick students for responsible positions within the class. These would be temporary appointments. At a future date, elections should be held for these various positions. This will give the class an opportunity to better understand each other and develop a sense of responsibility.

Materials

A tool kit
A burner
Water in heatable containers
Ice
CO_2 (if available)
Trainer
Job sheets

Testing

At this point the student will have completed fifteen hours of course activity and should be tested. This can be done orally or by means of a more formal written test. Particular emphasis should be placed on his knowledge of safety rules and responsibility. This will give the instructor an idea as to whether or not the instructions are being absorbed. Proper adjustments should be made regarding the quality and quantity of instruction.

Assignments

Proper assignments should be made for home study and/or research. Job sheets should be filled out and turned in for filing in each of the student's folders.

UNIT 3 – MEASUREMENTS
Class Instruction – 5 hours
Laboratory – 2 hours
Shop – 8 hours

Unit Objectives

To develop an understanding of heat quantity measurements.

To acquaint the students with heat-measuring devices.

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

To help the students acquire skill in handling refrigeration tools.

To develop proper attitudes in the safe use of the tools.

Tools and Materials

Text – Chapters 1 through 2
Basic student refrigeration tool kit
Shop tools
Refrigeration tubing of various sizes

Unit Outline

A. Heat intensity
    1. Unit of intensity
        a. Fahrenheit scale
        b. Centigrade scale
        c. Rankin scale
        d. Kelvin scale
    2. Measuring devices
        a. Thermometers
            (1) Stem-type
            (2) Dial
            (3) Remote
        b. Thermocouples
    3. Fixed references
        a. Boiling point
        b. Freezing point
        c. Absolute Zero
    4. Temperature conversion

B. Heat quantity
   1. British thermal unit – water as a standard
   2. Calculating by means of heat equation
C. Energy conversion units
   1. Heat energy
   2. Mechanical energy
   3. Electrical energy
D. Copper tubing preparation procedures

Laboratory Activity

1. Show the proper methods of cutting, reaming, flaring and swaging copper tubing. Use the soft-drawn copper. Demonstrate the difficulties encountered in trying to flare or swage hard-drawn tubing.

2. Emphasize the importance of proper care and use of tools used, showing what happens when improper tools and methods are used to cut, ream, flare, and swage soft-drawn copper tubing.

Shop Activity

1. Have the students cut various sizes of scrap tubing to given lengths. Then have them ream and flare both ends of each piece of tubing.

2. Check the individual work.

3. Have the students cut the flared pieces in half and then proceed to construct a swage connection.

4. Have the students attempt to flare some hard-drawn tubing, comparing the results with the soft-drawn tubing.

5. Have the students make a first-hand comparison of the difference in swaging soft-drawn and hard-drawn tubing.

Testing

At this point it is necessary for the instructor to test the students and evaluate his teaching method.

Assignments

Job sheets should be made out and examined. When satisfactory they should be filed in the student's personal folder.

UNIT 4 – HEAT
Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To develop a knowledge of the different heat categories.

To familiarize students with the variations in latent heat due to changes in temperature and pressure.

To teach students to calculate the amount of heat needed to change the temperature of material or mass.

To familiarize students with soldering tools and procedures.

To develop proper attitudes in the safe use of tools.

Tools and Materials

Text – Chapters 1 through 2
Heat source, pan or container, ice, thermometers
Selected lengths and sizes of copper tubing, sweat fittings
Soldering torches, soft solder, flux, cleaning brushes, and sand cloth

Unit Outline

A. Specific heat
    1. Of various metals (materials in general)
    2. Variation in specific heat due to change of phase
    3. Temperatures of mixes
B. Total heat
    1. Sensible heat
        a. Sensible heat equation
        b. Sensible heat of a solid
        c. Sensible heat of a liquid
        d. Sensible heat of a vapor
    2. Fusion temperatures
    3. Saturation temperatures
    4. Latent heat
        a. Latent heat of fusion
        b. Latent heat of vaporization

5. Soldering materials
   a. 50/50 solder
   b. 95/5 solder
   c. Low temperature silver solder
   d. High temperature silver solder
6. Soldering equipment and fuels
   a. Prestolite
   b. Oxygen-acetylene
7. Soldering procedures
   a. Sweating fittings
   b. Proper cleaning methods
   c. Actual sweating process

Laboratory Activity

1. Show the various types of sweat fittings, and demonstrate proper methods of cleaning tubing and fittings.

2. Demonstrate the proper use of the soldering torch, including the precautions taken in lighting and application.

Shop Activity

1. Have the students clean and prepare copper tubing and fittings of selected sizes for soldering. After they have practiced lighting and handling the torches, students should solder their individual projects.

2. Inspect all joints, then have the students cut selected (unsatisfactory) solder joints almost completely through with a hack saw. Peel the outer layer of copper back, exposing the solder joint so that any flaws in cleaning or in the application of flux or solder will be seen.

3. Explain that the joint may be checked with air pressure for possible leaks in any of the remaining projects.

Testing

Students should be tested on this unit. Their knowledge of the theory should be tested by means of discussion, including student comments about the subject matter taught in the classroom.

Assignment

Regular job sheets should be filled out and checked for content. Proper text content should be assigned as home study.

UNIT 5 – REFRIGERATION EFFECTS

Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To have students gain an understanding of the vapor-compression cycle.

To develop an understanding of pressure-enthalpy diagrams.

To acquaint the students with the principles of subcooling and superheat.

To teach the use of bending, pinching-off, and refacing tools.

To develop proper attitudes for safety habits in bending procedures.

Tools and Materials

Text – Chapters 1, 2, and 16
Refrigeration cycle trainer of built-up cycle
Pressure-enthalpy charts of various refrigerants
Skeleton pH chart
Chart of actual cycle components
Copper tubing, tubing benders, bending springs
Pinch-off tool, refacing tool

Unit Outline

A. Refrigerating effect
   1. System capacity
   2. Weight of refrigerant circulated per minute per ton
   3. Volume of vapor displaced per minute per ton
   4. Compressor capacity
B. Pressure-enthalpy diagrams for various refrigerants
C. Simple saturated refrigerant cycle
   1. Expansion process
   2. Vaporizing process
   3. Compression process
   4. Condensing process
   5. Coefficient of performance
   6. Effect of suction temperature on efficiency
D. Superheat and subcooling

E. Deviations from the simple saturated refrigerant cycle
   1. Effect of superheating the suction vapor
   2. Superheating without useful cooling
   3. Superheat producing useful cooling
F. Liquid-suction heat exchangers
G. Demonstration of tool usage
   1. Tubing benders, bending springs
   2. Pinch-off and refacing tools

Laboratory Activity

1. Demonstrate the refrigeration cycle trainer or the built-up cycle, explaining what is taking place, as compared to what was shown on the charts.

2. With the use of temperature gauges on the trainer, or with thermometers in the wall of the built-up unit, record the actual temperatures on the pressure-enthalpy charts.

3. Demonstrate the proper use of:
   a. Tubing benders
   b. Bending springs
   c. Pinch-off tool
   d. Refacing tool

Shop Activity

1. Have the students practice the use of the tubing benders and bending springs to obtain desired angles. They should use scrap copper tubing and follow the proper procedures.

2. Students will work on the copper tubing previously assigned to them. Emphasize safety procedures.

Testing

Have each student diagram or write an explanation of what is taking place during the refrigeration cycle. Details are not critical at this point. Have the students bend tubing of various sizes and at various angles. Have students complete job sheets. After approval file all paper work in each student's personal file.

Assignment

Have the students study the portion of the text that presents this information for the next lesson.

UNIT 6 – HEAT TRANSFER

Class Instruction – 2 hours
Laboratory – 1 hour
Shop – 3 hours

Unit Guide

Unit Objectives

To acquaint the students with the methods of heat transfer which apply to the refrigeration system.

To develop an understanding of the difference between conductors and insulators.

To assist the students in becoming familiar with the heat-transfer capacities of some common metals.

Tools and Materials

Text – Chapters 1, 2, and 27
Pipe of various sizes, vise pipe cutter, pipe dies, cutting oil, pipe fittings, wiping cloths
Radiant and fan-forced electric heaters, container for boiling water, thermocouples or thermometers

Unit Outline

A. Direction and rate of heat flow
B. Basic methods of heat transfer
   1. Conduction
      a. Differences in conductivity
      b. Influences of thickness and area
   2. Convection
      a. Natural
      b. Forced
   3. Radiation
      a. Absorption
      b. Reflection
C. Coefficients of heat transfer
   1. Pipe and fittings
   2. Appropriate tools

Laboratory Activity

1. Demonstrate conduction by heating metal tubing and rod at one end. At the same time, temperature increase should be measured on the non-heated end.

2. Demonstrate radiation with an electric heater element. Measure temperatures at various distances from heat source.

3. Demonstrate convection with a fan-forced heater. Measure temperatures at various distances from heat source.

4. Demonstrate heat absorption by dipping various metals into boiling water for certain lengths of time. Record material, time, temperature increase, and graph the rate of heat absorption.

5 Emphasize the importance of the proper care of tools while cutting and threading the pipe. Emphasize the care in storage of the equipment when it is not being used on the job.

Shop Activity

1. Have the students cut and thread pipe to specific dimensions.

2. Grade the completed work, pointing out any errors or faults that may have occured.

If the refrigeration shop does not have the proper equipment to perform the shop activity, it is suggested that the instructor make arrangements with the plumbing instructor to carry out this phase. This work would include cutting pipe and threading to specifications. Perhaps a class exchange could be made at this time and the refrigeration instructor could show the plumbing students how their trade is necessary in air conditioning and refrigeration. Using the shop equipment, demonstrations of value could be made to the plumbing student.

UNIT 7 – GASES
Class Instruction – 3 hours
Laboratory – 1 hour
Shop – 5 hours

Unit Guide

Unit Objectives

To familiarize the student with the behavior of gases under varying temperature, pressure, and volume conditions.

To impart an understanding in the application of these fundamental gas laws.

Tools and materials

Text – Chapter 1
Lab training condensing units
Refrigeration tool kit
Refrigeration tubing and fittings
Refrigeration controls
Sight glasses and driers

Unit Outline

A. Specific volume of gases
   1. Effects of heat on the volume
   2. Effects of pressure on the volume
B. Density
C. Charles' law
   1. Constant pressure form
   2. Constant volume form
D. Boyle's law
E. General laws of gases
F. Connection of lab units
   1. Location of refrigerant lines
   2. Location of accessories

Laboratory Activity

1. Using one of the lab training units, point out the general guidelines for running the necessary lines to complete a circuit. Emphasize that the refrigerant must have a closed path to flow from one component to another in the proper manner.

2. Also point out the general location where the controls, sight glasses, and driers should go in the circuit. This information should relate function and location.

Shop Activity

1. With the students divided into teams, have them take the necessary measurements to obtain the lengths of copper tubing needed for proper connection between their lab unit and the evaporator coil assigned to them.

2. After taking measurements the students should request the measured amount of copper tubing from the shop supply. Each team will flare, bend or solder as instructed.

Testing

Testing on this unit should be conducted in the form of a discussion. It is very important to the student that he understand the relationships between pressures and temperatures. Each student should be allowed to explain the different laws of thermodynamics as stated by Charles and Boyle.

The Test in shop should be closely supervised because of the importance of flaring and soldering tubing. To prevent leaks from occurring, particular emphasis should be placed on proper soldering.

UNIT 8 – SYSTEM TESTING AND THEORY

Class Instruction – 2 hours
Laboratory – 1 hour
Shop – 3 hours

Unit Guide

Unit Objectives

To impart an understanding of the total force exerted by any fluid.

To develop an understanding of the relationship between the head of a fluid and the pressure inherent in it.

To acquaint the students with the relationship between density and specific gravity.

To develop an appreciation of the necessity of complete evacuation of a refrigeration system once it has been exposed to the atmosphere.

Tools and materials

Basic refrigeration tool kit
Vacuum pump
Testing manifold and hoses
Gauges

Unit Outline

A. Pressure
   1. Force per unit area
   2. Head
   3. Pascal's principle
B. Density
   1. Specific gravity
   2. Convenient units of weight and volume
C. Testing and evacuating equipment
   1. Testing manifold and hoses
   2. Gauges
   3. Vacuum pump

Laboratory Activity

1. Demonstrate the correct procedure to follow in the connection of the testing manifold to the lab training unit.

2. Explain the vacuum pump and demonstrate its use.

Shop Activity

1. Have the students install lines to units available.

2. Have students evacuate the system.

3. Check the procedure with the student or have another student evaluate the procedure for you.

Testing

The use of gauges and the ability to connect the manifold to the unit or the vacuum pumps are very important to the progress of the student. The instructor should make sure that each student is made aware of this and that each student performs the tasks individually. The instructor should emphasize mistakes and should have the student practice until he masters the procedures. Job sheets should be made out, checked and filed.

Assignment

Assign proper paragraphs of the text to students. Perhaps at this point, an introduction to written homework would be in order. Problems pertaining to force and weight could be a start. It is suggested that, from this point on, the student should be given problems whenever they present themselves in the course of study. It is further suggested that students should be encouraged to evaluate fellow students' work.

Student Participation

It is suggested that schedules be made for a weekly group discussion period. The day and length of time can be determined by the instructor. The last period of the week might prove to be a good time because of the decline in work interest. Discussions could be about any subject, or school problem. Discussion would give each student an opportunity to air any complaint he may have. It is suggested that this be very closely supervised by the instructor.

UNIT 9 – PRESSURES
Class Instruction – 3 hours
Laboratory – 2 hours
Shop – 4 hours

Unit Guide

Unit Objectives

To develop an understanding of the categories of pressure with which refrigeration personnel must be concerned.

To impart a knowledge of the instruments which are used in the measurements of pressures.

To familiarize the students in the use of equipment used in the process of leak detection.

To develop an appreciation of the use and care of the gauges and instruments involved in reading pressures.

Tools and Materials

Text – Chapter 1
Model gauges
Manometer
Vacuum pump
Halide torch
Soap
Pan and water

Unit Outline

A. Atmospheric pressure
    1. Barometers
    2. Pressure decrease with altitude increase
B. Standard of ordinary pressure
    1. Manometer
        a. Open arm
        b. Closed arm
    2. Bourdon tube gauges
        a. Pressure
        b. Compound
C. Absolute pressure
D. Operational procedures
    1. System evacuation
    2. Vapor-charging
    3. Leak detecting

Laboratory Activity

1. Demonstrate how leaks will prevent a vacuum pump from pulling a deep vacuum.

2. Demonstrate how to vapor-charge.

3. Demonstrate how to find leaks.

Shop Activity

1. Have each student demonstrate how to leak-test, evacuate, and charge a system.

2. Have the rest of the class observe and record mistakes made by the student making the tests.

3. Discuss the errors made and have each student explain why the mistake could be costly.

Work Sheets

Each student should perform the tasks as outlined in the work sheets.

Assignment

Have the students study the section on instruments as outlined. Have the students write a short paragraph describing the use of each instrument studied in class.

Special Note:

The student should be made aware of the cost involved when purchasing instruments. Relate this to the proper use and care of the instrument.

Special Note:

It is suggested that at this point in the course the material which has been covered should be reviewed. This should be done with emphasis placed on weak spots revealed during the review discussions. It might be beneficial to give an overall written test prior to review. This would also determine the weak points as stated above.

Special note:

Safety measures should be checked for their effectiveness. Necessary changes can be made at this time.

UNIT 10 – BASIC REFRIGERATION CYCLE

Class Instruction – 15 hours
Laboratory – 3 hours
Shop – 27 hours

Unit Guide

Unit Objectives

To develop an understanding of the compression cycle.

To acquaint the students with the different types of refrigeration components.

To familiarize the students with the tear-down of the compressor and with compressor parts.

To develop proper attitudes toward the safe usage of tools, gauges, and other refrigeration equipment.

Tools and Materials

Text – Chapters 2 through 5
Basic refrigeration tool kit
Representative compressors
Representative refrigerant flow controls
Auxiliary valves

Unit Outline

A. Compressors
   1. Reciprocating
      a. Accessible or open type
         (1) Cylinder construction
         (2) Cylinder arrangements
         (3) Piston construction
         (4) Connection rod construction
         (5) Crank shaft construction
         (6) Valve construction
         (7) Crankshaft seal construction
         (8) Gaskets
         (9) Compressor drives
   2. Rotating
      a. General construction
      b. General operation
   3. Centrifugal
      a. Single stage
      b. Multi-stage
      c. Rotors (impellers)
      d. Stators

B. Evaporators
   1. Bare tube
   2. Plate
   3. Finned
   4. Air cooling coils
      a. Dry
         (1) Natural convection
         (2) Forced circulation
         (3) Frosting
         (4) Defrosting
         (5) Non-frosting
      b. Flooded
   5. Liquid cooling coils
      a. Submerged
      b. Shell-and-tube
      c. Tube-within-tube
      d. Baudelot cooler

C. Condensers
   1. Air cooled
      a. Bare pipe
      b. Finned
      c. Natural convection
      d. Forced circulation
   2. Water cooled
      a. Double pipe
      b. Double tube
      c. Shell-and-coil
      d. Shell-and-tube
   3. Combination
   4. Evaporative

D. Receivers
   1. Construction
   2. Safety devices
   3. Auxiliary

E. Refrigeration flow controls
   1. Automatic expansion valves
      a. Bellows type
      b. Diaphragm type
      c. Internal equalizer
      d. External equalizer
   4. Auxiliary valves
      a. Check
      b. Solenoid
      c. Suction pressure

F. Refrigerant lines
   1. Piping principles
   2. Liquid lines
   3. Suction lines
   4. Hot gas lines
   5. Liquid return lines
   6. Condenser drain lines

Laboratory Activity

1. Demonstrate the correct procedure for marking with a punch to assure that the major components of the compressor will reassemble in their original places.

2. Demonstrate the correct procedure for removing all bolts by loosening all bolts on the head before removing any of them.

3. Emphasize the use of correct tools for each job.

4. Instruct the student to check each item for damage as it is removed.

5. Demonstrate the proper way of reassembling the compressor and to never force any component in place.

6. Demonstrate the replacement of parts on all the types of valves and instruct the students in the importance of condemning any and all worn parts.

7. Stress safety in the usage of all tools and equipment during these operations.

Shop Activity

1. Have the students disassemble a compressor and reassemble it properly.

2. Have the students do the same on all valves discussed.

3. Have the class check as each student performs his task.

Because of the variety in compressor construction, the common parts that are found in all compressors should be emphasized and the instructor should spend most of the unit time on those critical parts.

Discuss the three main types of compressors as a group. Explain the use of each compressor type in the industry. Because of the broad usage of the reciprocating type compressor, most of the time alloted should be spend on this type compressor. Allow time for the discussion of the compressors as a single unit then a period of time should be spent in the shop to give the students time to disassemble and reassemble compressors. Close supervision should be maintained at this time so the compressors will not be damaged, particularily the shaft seal and the compressor shaft seal.

When the students are aware of the general construction of the compressor, each vital part should be discussed, with special careful instruction on the shaft seal and the valve plates.

Because there is little probability of having a centrifugal compressor in the shop, the instructor should have visual aids at his disposal on this piece of equipment.

The importance of the different types of evaporators should be discussed in class until all students can determine what type is best suited for each use. The student should be made aware of the evaporator during shop periods. It would be beneficial at that time for the instructor to explain the different types of evaporators and the usage of each. The same procedure should be used for liquid cooling coils as suggested for evaporators in general. This will be determined by what is available to the instructor. He may have to depend upon visual aids.

Condensers should be shown to the students. Special emphasis should be placed on proper sizing of air-cooled condensers.

Water-cooled condensers, shell-and-tube, tube-within-a-tube, and evaporative should be explained very much in the same way as were the various types of evaporator coils. The time spent on this equipment will be determined by what is available to the instructor. It may be necessary for more time to be used in the class with visual aids and drawings, with emphasis on the selection of and the determination of the types of condensers to be used for particular jobs.

Minimum time should be used on receivers. A simple explanation at this time is sufficient. The main instruction should pertain to safety devices on this piece of equipment.

Refrigerant controls should be covered broadly at this point, but because of the importance of these controls, detailed explanation and means of selection should be explored during the second year of instruction.

Auxiliary valves, i.e. check, solenoid and suction pressure valves should be explained as to their location in the system and their purpose. Detailed explanation as to their proper selection and individual use on particular systems should be held over for second year instruction.

Refrigerant lines should be explained to the student to the extent that the student will know the location and names of the several lines used. Selection and sizing should be left for the second year program.

Work sheets should be filled out as this unit progresses from one section to the other. The instructor should make sure that each student has the work sheets in order and properly filled out. A general review should be undertaken and proper testing of the students should take place.

Special research assignments should be given to the students. Each student may be assigned one part or component to research. When the unit is complete, each student should discuss his research with the class on an informal basis in a discussion period.

Assignments should be made for home study while this unit is being developed. The instructor should emphasize to the student that the unit being covered must be grasped, for if it isn't, further progress will be difficult.

At this point every student should know the safety rules and should act and react automatically to any given situation. Perhaps a test by the instructor should be made to evaluate the reaction of the class. As an example, cause a fairly large leak to occur in one of the systems near the students. CAUTION SHOULD BE OF PRIME IMPORTANCE IF THIS IS ATTEMPTED. THE INSTRUCTOR SHOULD MAKE SURE THAT THE NEAREST STUDENT IS NOT IN DANGER.

UNIT 11 – ABSORPTION REFRIGERATION

Class Instruction – 5 hours
Laboratory -- 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To develop an understanding of the simple operating cycle of an absorption system.

To develop a knowledge and understanding of the two main combination cycles in common use in refrigeration.

To acquaint the student with the components of a basic absorption system.

To familiarize the student with the correct methods of evacuating, charging and testing his lab unit.

To develop an appreciation for the safety requirements when working with refrigeration equipment.

Tools and Materials

Text – Chapter 3 and 17
Flow diagrams of absorption cycles, heating and cooling
Lab condensing unit
Evacuation, charging, and testing equipment
Overhead transparencies and projector

Unit Outline

A. Basic absorption cycles
   1. Ammonia-water cycle
      a. Refrigerant is ammonia
      b. Absorbent is water
   2. Lithium bromide-water cycle
      a. Refrigerant is water
      b. Absorbent is lithium bromide
B. Major components
   1. Generator
   2. Absorber
   3. Chiller
   4. Condenser

C. Auxiliary components
   1. Heat exchanger
   2. Pumps
      a. Solution
      b. Refrigerant
   3. Analyzer
   4. Rectifier
   5. Separator
   6. Piping
   7. Insulation
D. Controls and protective devices
E. Heat source
   1. Direct firing
   2. Indirect firing
      a. Steam
      b. Hot water or other fluids
F. Operational procedure of lab units
   1. Pump down
   2. Removal of components
   3. Purging

Laboratory Activity

1. Demonstrate the pump-down of the system.

2. Demonstrate how most components can be replaced without losing refrigerant.

3. Demonstrate purging.

Shop Activity

1. Pump down system under close supervision.

2. Place unit in operation and follow the procedure for purging.

3. Have each student do the job.

Because of the hazards involved in the operation and repair of this type of system, it is probable that the shop will not have this equipment. If this is so, it will be necessary for the instructor to use visual aids in conjunction with the text and other materials that may be available. It is suggested therefore that the unit be taught in the classroom without the actual equipment. The shop time as indicated on the outline should be used as classroom time.

Because it is part of the industry and because some of the students may want to specialize in this field, the unit should be covered as outlined.

The instructor should make known to the students where special instructions may be received on this type of equipment. This can be determined by calling the manufacturer.

The testing and assignments should be made as with any other unit.

The students should fill out work sheets and develop an understanding of the principles of the system.

Animated transparencies for this and other units may be acquired through the Vocational-Technical Curriculum Laboratory, Bldg. 4103 – Kilmer Campus, Rutgers University, New Brunswick, New Jersey 08903.

UNIT 12 – REFRIGERANTS
Class Instruction – 3 hours
Laboratory – 1 hour
Shop – 5 hours

Unit Guide

Unit Objectives

To inform the students of the chemical and physical properties of various refrigerants.

To familiarize the students with the national groups that set the standards concerning refrigerants.

To see that the students acquire skills in testing the efficiency of compressors, and learn the operations of expansion valves.

To develop proper atitudes toward safety with refrigeration equipment, and in the transfer of refrigerants.

Tools and Materials

Text – Chapter 9
Small service drum
Large drum of refrigerant
Testing equipment for expansion valves
Specification sheets

Unit Outline

A. Requirements
   1. Chemical properties
      a. Non-flammable
      b. Non-explosive
      c. Non-toxic
      d. Low operating pressure
   2. Physical properties
      a. Volume
      b. Density
      c. Oil miscibility
      d. Low compression ratio
      e. Leak detection
B. Classification
   1. National Refrigeration Safety Code
      a. Group 1 – safest of refrigerants
      b. Group 2 – toxic and somewhat flammable
      c. Group 3 – very flammable

2. National Board of Fire Underwriters
   a. Toxicity
   b. Color code of refrigerant drums

C. Operational procedures
   1. Transfer of refrigerant
   2. Check of expansion valves
      a. Automatic
      b. Thermostatic

Laboratory Activity

1. Demonstrate transfer of refrigerant.

2. Demonstrate the proper way to determine the efficiency of a compressor.

3. Demonstrate methods of checking expansion valves.

4. Show color coding and teach students to memorize the code.

Shop Activity

1. Check valves

2. Test students on identification.

Before any instruction is given to the students about refrigerants, the potential dangers due to pressures should be made apparent to them.

Because of the great amount of material available on refrigerants, the instructor can use this material to teach the student about refrigerants in general the first year and then in specific detail the second year.

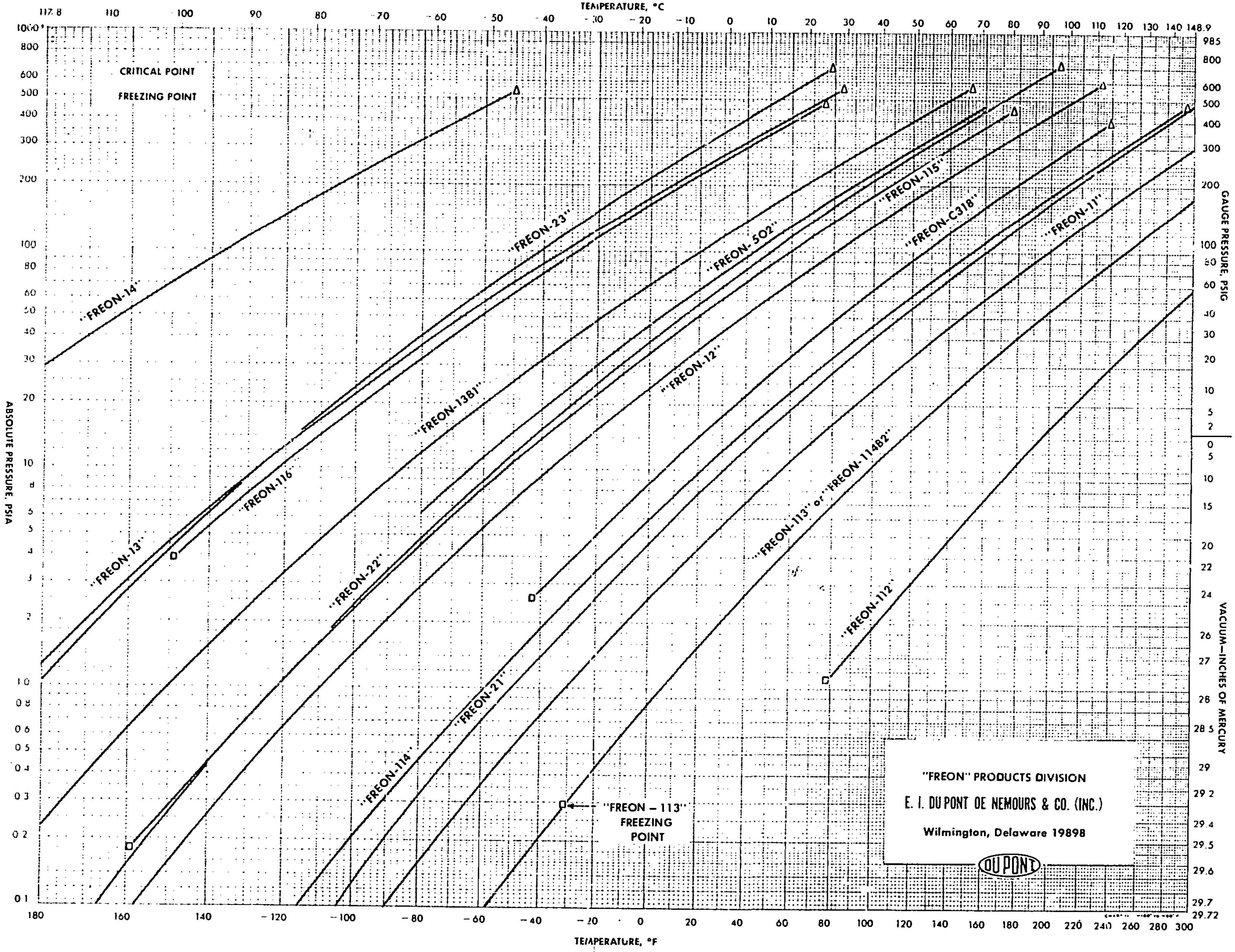
The DuPont Company will be happy to provide any instructor with all necessary visual aids to explain refrigerants.

Close supervision is necessary during the study of this unit. Safety precautions must be maintained at all times while the refrigerants are being used.

Testing should be done on each refrigerant, and work sheets should be completed and checked as soon as one refrigerant has been used or explained.

Pressure-temperature relationship charts should be given to each student at this time, and the importance of these charts should be explained. The use of charts should be explained thoroughly, and the students should be checked from time to time to make sure that they are in their possession.

PRESSURE-TEMPERATURE RELATIONSHIPS OF "FREON" COMPOUNDS



FREON COMPOUNDS

Product	Formula	Molecular Weight	Boiling Point °F	Boiling Point °C
Freon-14	CF_4	88.0	-198.4	-128.0
Freon-23	CHF_3	70.0	-115.7	-82.0
Freon-13	$CClF_3$	104.5	-114.6	-81.4
Freon-116	CF_3-CF_3	138.8	-108.8	-78.2
Freon-13B1	$CBrF_3$	148.9	-72.0	-57.8
Freon-502	$CHClF_2$/$CClF$-CF_3 (48.8/51.2% by weight)	111.6	-50.1	-45.6
Freon-22	$CHClF_2$	86.5	-41.4	-40.8
Freon-115	$CClF_2$-CF_3	154.5	-37.7	-38.7
Freon-12	CCl_2F_2	120.9	-21.6	-29.8
Freon-C318	C_4F_8 (cyclic)	200.0	21.5	-5.8
Freon-114	$CClF_2$-$CClF_2$	170.9	38.8	3.8
Freon-21	$CHCl_2F$	102.9	48.1	8.9
Freon-114B2	$CBrF_2$-$CBrF_2$	259.9	117.1	47.3
Freon-113	CCl_2F-$CClF_2$	187.4	117.6	47.6
Freon-112	CCl_2F-CCl_2F	203.9	199.0	92.8

Courtesy DuPont Co.

UNIT 13 – LUBRICATION SYSTEMS

Class Instruction – 2 hours
Laboratory – 1 hour
Shop – 3 hours

Unit Guide

Unit Objectives

To inform the students of the types of lubricants used in refrigeration systems, and how to add oil to a system.

To develop an appreciation for proper care of the oil to be used in their work.

To acquaint the students with the results when moisture mixes with oil and refrigerants in a system.

To have the students acquire skill in attaching adapter valves to those hermetic and semi-hermetic units not equipped with service valves.

Tools and Materials

Text – Chapters 4, 11 and pp. 445-446
Hermetic compressor unit
Valve kit and adapter
Lab condensing unit
Refrigerant oil
Clean, dry glass jar
Copper tubing
Electronic leak detector

Unit Outline

A. Lubricants
   1. Necessary properties
      a. Free of wax, moisture and foam
      b. Correct viscosity for refrigerant used
      c. Free of impurities
   2. Results of moisture
   3. Proper charge
      a. Results of undercharge
      b. Results of overcharge

B. Types of systems
   1. Splash feed
   2. Force feed

C. Operational procedures
   1. Adding of oil
   2. Use of valve kit and adapters
   3. Use of electronic leak detector

Laboratory Activity

1. Demonstrate how to add oil to all types of systems.

2. Demonstrate the use of the leak detector.

3. Demonstrate charging with a valve kit.

Shop Activity

1. Have each student add oil to a system.

2. Have each student use adapter and kit.

The instructor should inform the student of the importance of the proper care of the oil used in refrigeration systems. Different types of oils should be described to the student. Proper use of the different oils should be emphasized. Different viscosity should be explained as well as why different viscosities are used.

The students should be taught to add oil to a system. The student should be taught how to replace oil in a system. The student should be taught how to perform the above operations with different types of compressors, sealed, semi-sealed, and open type.

Testing of this unit will have to be by actual manipulation. Work sheets should be filled out and checked. Safety precautions should be observed at all times during the operations in this unit.

UNIT 14 – REFRIGERATION CIRCUIT PROBLEMS

Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To familiarize the students with the symptoms of come common refrigeration circuit problems.

To have them acquire knowledge and skills in identitying and solving some common refrigeration circuit problems.

To have them develop an understanding that some symptoms might indicate one or more of several causes of trouble.

To keep them proficient in some procedures through repetition.

Tools and Materials

Text – Chapters 12 and 15
Condensing unit
Refrigeration tool kit
Shop tools
Testing equipment

Unit Outline

A. High head pressure
   1. Dirty or partially blocked condenser
   2. Air or non-condensable gases in system
   3. Overcharge of refrigerant
   4. Insufficient condensing medium
   5. High temperature condensing medium
   6. Restricted metering device
B. Low suction pressure
   1. Insufficient air on cooling coil
   2. Low ambient temperature on evaporator coil
   3. Restricted refrigerant flow
   4. Undercharge of refrigerant
   5. Faulty expansion valve
   6. Low head pressure

C. High suction pressure
   1. Heavy load conditions
   2. Low super heat adjustment
   3. Improper expansion valve adjustment
   4. Poor installation of feeler bulb
   5. Inefficient compressor

Laboratory Activity

1. Demonstrate some of the above conditions with the equipment in the shop.

2. Have students identify some of the problems that are present.

Shop Activity

1. Devise shop activity for each unit as students learn programs as outlined.

The testing of this unit should be made a challenge to each student. It is suggested that each student be given theoretical symptoms that may appear in the field. From this he is to try to determine what the problem or possible problems are. This should be in written form. When each student has completed his task, he should present it to the class and discussion should take place as to the validity of his answers and/or presentation. Each student should eventually have written down the answer to each problem with a correct presentation.This unit is to be used as a thought-provoking situation.

Example:

Unit is short cycling.
Student is to write down all possible causes for this common occurrence. For each cause, he should indicate another symptom that would be apparent if that particular cause was the problem.

To wit:

Unit short cycling (problem)
Low on refrigerant (possible cause)
Second sympton (sight glass not full)

Or:

Unit short cycling (problem)
Dirty filters (possible cause, air conditioning)
Second symptom (not enough air over coil)
Third symptom (coil iced up)

It is suggested that from this point on whenever the student is tested in written form, problems should be part of the test, regardless of what unit is being worked on.

Perhaps special work sheets could be made up and mimeographed for use on this type of project.

SECTION II - BASIC ELECTRICITY

SECTION II

BASIC ELECTRICITY

		Hours		
Unit	Title	Class	Laboratory	Shop
1.	Basic Concepts	5	4	6
2.	Classes of Materials and Their Uses	5	4	6
3.	Circuits and Laws of Electricity	5	3	7
4.	Magnetic Circuits -- Electric Meters	5	3	7
5.	Transformers and Motors	5	3	7
6.	Relays, Contactors, Starters, Circuit Protection	5	3	7
	Total	30	20	40

Section II – Basic Electricity

Unit 1 – Basic Concepts

A. Sources of energy
   1. Friction
   2. Magnetism
   3. Chemical action
   4. Pressure
   5. Heat action
   6. Light action
   7. Nuclear
B. Electron theory
   1. Displacement of electrons
   2. Flow of electrons
C. Magnetism
   1. Polarity
   2. Magnetic lines of force
   3. Permanent magnets
   4. Temporary magnets
D. Charges
   1. Positive
   2. Negative
   3. Attraction of unlike charges
   4. Repulsion of like charges
E. Static electricity–electrons at rest
F. Current electricity–electrons in motion

Unit 2 – Classes of Materials and their Usage

A. Conductors
   1. Large numbers of free electrons
   2. Low resistance to current flow
      a. Copper
      b. Iron
      c. Aluminum
      d. Silver
      e. Brass
      f. Zinc
   3. Sizes of conductors
      a. Effect
      b. Resistance
      c. Load

B. Insulators
   1. Small numbers of free electrons
   2. High resistance to current flow
      a. Dry air
      b. Glass
      c. Rubber
      d. Asbestos
      e. Bakelite
      f. Mica

C. Semi-conductors
   1. Low resistance to current flow in one direction
   2. High resistance to current flow in other direction
      a. Germanium
      b. Silicon
      c. Copper oxide
      d. Copper sulfide
      e. Cadmium sulfide
      f. Lead sulfide

D. Capacitors
   1. Fixed
   2. Variable
   3. Dielectric
      a. Air
      b. Paper
      c. Mica
   4. Ceramic
   5. Vacuum

E. Wire gauges and measurements

F. Wire splices and soldering methods

Unit 3 – Circuits and Laws of Electricity

A. Basic components of a circuit
   1. Path for current
   2. Sources of voltage
      a. Batteries
         (1) Primary
         (2) Secondary
      b. Generators
      c. Alternators
   3. Power supply
      a. Single phase
      b. Three phase
      c. Frequency
   4. Load of resistence

B. Series circuits
   1. Source (batteries) in series
   2. Load (light bulbs) in series
C. Parallel circuits
   1. Source (batteries) in parallel
   2. Load (light bulbs) in parallel
D. Series-parallel
E. Parallel-series
F. Ohm's law
G. Kirchhoff's voltage law
H. Kirchhoff's current law
I. Voltage drop

Unit 4 – Magnetic Circuits–Electric Meters

A. Types of magnetic circuits
   1. Full iron
   2. Air gap
   3. Electromagnetic
B. Electromagnetic field
   1. Around a current-carrying conductor
   2. In coils
   3. In parallel conductors
      a. Current flow in same direction
      b. Current flow in opposite direction
   4. Strength of magnetic field
C. Electromagnets
   1. Solenoid and plunger types
   2. Armature types
D. Applications of electromagnets
   1. Electric bell
      a. Vibrator type
      b. Non-vibrator type
   2. Electric buzzer
   3. Circuit breaker
   4. Simple telegraph circuit
   5. Simple telephone circuit
   6. Relay
   7. Electric razor
   8. Electric hammer
E. Solenoid polarity test–lefthand rule
F. Meters
   1. Current
      a. Ammeter
      b. Milliammeter
   2. Voltage
      a. Voltmeter
      b. Millivoltmeter

3. Resistence and continuity
    a. Ohmmeter
    b. Wheatstone bridge
4. Power consumption

Unit 5 – Transformers and Motors

A. Transformer
    1. Construction
        a. Primary windings
        b. Secondary windings
        c. Step-down
        d. Step-up
        e. Winding ratio
        f. Core laminations
    2. Eddy currents
    3. VA ratings
    4. Phasing
B. Motors, single-phase
    1. Induction
        a. Shaded pole
        b. Split phase
        c. Capacitor
        d. Permanent-split capacitor
        e. Synchronous speed
        f. Actual motor speed
C. Motors, three-phase
    1. Induction
    2. Wound motor
    3. Synchronous
D. Shaded pole and multiple windings
E. Direct-drive multi-speed blower motors
F. Reversal of rotation
G. Speed changing
H. Proper maintenance
I. Hermetic motors

Unit 6 – Relays, Contactors, Starters, Circuit Protection

A. Relays and contactors
    1. Current coil
    2. Hot-wire
    3. Voltage
    4. Time delay
    5. Overlaod
B. Starters
    1. Manual
    2. Magnetic
        a. Across the line
        b. Reduced voltage
        c. Part winding

3. Fractional horsepower starting devices
    a. Thermostats
    b. Time delay

C. Circuit and unit protection
1. Fuses
    a. Plug and cartridge
    b. Time delay (fusetron)
2. Circuit breaker
3. Disconnect switches
4. Overload protectors

UNIT 1 – BASIC CONCEPTS
Class Instruction – 5 hours
Laboratory – 4 hours
Shop – 6 hours

Unit Guide

Unit Objectives

To inform the student of the sources of energy.

To familiarize the student with the basic concepts of the electron theory of electricity.

To acquaint the student with magnetism and its relationship to electricity.

To develop an appreciation for safety around electrical equipment.

Tools and Materials

Text – Chapter 7
Bar magnet
C-shaped magnet
Horse shoe magnet
Iron filings
Pith (paper pulp) balls
Nails
Glass rods
Hard rubber rods
Pieces of silk
Pieces of fur
Pieces of iron
Pieces of brass

Unit Outline

A. Sources of energy
   1. Friction
   2. Magnetism
   3. Chemical action
   4. Pressure
   5. Heat action
   6. Light action
   7. Nuclear
B. Electron theory
   1. Displacement of electrons
   2. Flow of electrons
C. Magnetism
   1. Polarity
   2. Magnetic lines of force
   3. Permanent magnets
   4. Temporary magnets
D. Charges
   1. Positive
   2. Negative
   3. Attraction of unlike charges
   4. Repulsion of like charges

E. Static electricity—electrons at rest

F. Current electricity—electrons in motion

Laboratory Activity

1. Demonstrate how a straight bar magnet, when suspended freely, will act as a compass needle.

2. Demonstrate the polarity of magnets and existence of magnetic lines of force, using the various magnets and the iron filings.

3. Demonstrate static electricity.

4. Demonstrate positive and negative charges.

Shop Activity

1. Have the students draw the magnetic field of a horseshoe magnet as they imagine it.

2. Have the students do this for the bar magnet and also the C-magnet.

3. With a piece of cardboard placed over the horseshoe magnet, have the students spread some iron filings over the ends of the magnet. Check the results with their sketches.

4. Have the students perform step three with the other magnets.

5. Have the students make a temporary magnet with nails.

6. Have the students experiment with the pith balls, glass and hard rubber rods. They should enter their findings on the experiment sheets.

It is suggested that the electric shop instructor and the air conditioning instructor make arrangements to exchange classes for a time. This could be done when some of the basics as outlined have been taught to the air conditioning students. The electric shop instructor could teach electrical component operation to the air conditioning students and the air conditioning instructor could teach and demonstrate to the electric shop students how his particular trade is of great importance to the air conditioning industry. Emphasis should be placed on how both trades must work together to accomplish a job for their respective employers.

When the students return from the electric shop they should be tested and their work sheets should be filled out and checked.

The experiments should be performed to the extent of materials available or perhaps performed in the electric shop if the shop has the facilities available.

The necessity for safety precautions should be demonstrated and enforced to the extreme during the time spent on this unit.

Necessary assignments should be given to encourage research and provoke interest in this area. The student should be made aware of how extensivly electricity is used in their field.

UNIT 2 – CLASSES OF MATERIALS AND THEIR USAGE

Class Instruction – 5 hours
Laboratory – 4 hours
Shop – 6 hours

Unit Guide

Unit Objectives

To acquaint the student with the materials used, their uses, and their limitations.

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

To have the student acquire skill in the soldering of wire.

To develop proper attitudes for safety in handling any electrical wiring and the tools used.

Tools and Materials

Text – Chapters 2, 8, 10, 11
Wire
Wire gauges
Soldering equipment
Electric tape
50/50 solder
Rosin core
Assorted necessary equipment

Unit Outline

A. Conductors
   1. Large numbers of free electrons
   2. Low resistance to current flow
      a. Copper
      b. Iron
      c. Aluminum
      d. Silver
      e. Brass
      f. Zinc
   3. Sizes of conductors
      a. Effect
      b. Resistance
      c. Load
B. Insulators
   1. Small numbers of free electrons
   2. High resistance to current flow
      a. Dry air
      b. Glass
      c. Rubber
      d. Asbestos
      e. Bakelite
      f. Mica

C. Semi-conductors
   1. Low resistance to current flow in one direction
   2. High resistance to current flow in other direction
      a. Germanium
      b. Silicon
      c. Copper oxide
      d. Copper sulfide
      e. Cadmium sulfide
      f. Lead sulfide

D. Capacitors
   1. Fixed
   2. Variable
   3. Dielectric
      a. Air
      b. Paper
      c. Mica
   4. Ceramic
   5. Vacuum

E. Wire gauges and measurements

F. Wire splices and soldering methods

Laboratory Activity

1. Demonstrate wire gauge.

2. Demonstrate good wire soldering practice.

3. Demonstrate good splicing.

Shop Activity

1. Have the students take the measurements of several pieces of wire using wire gauges, and label all the wires as to size, so that they may be examined by the instructor.

2. Have the students make the five different conductor splices, then have their work checked.

3. The students should attach solder and crimp-on lugs to the ends of two pieces of wire, and join the other ends of the wires with a wire nut. Tape all connections.

The outline should be used to instruct the student with the help of materials available. Because of possible limited materials, visual aids in the form of slides and literature may have to be used. Particular emphasis should be placed on the handling of the instruments that will be used. The usage of the instruments should be part of the testing of the student. If it is possible, the students could observe the electric shop instructor whenever the material is being taught. If the above is not possible it will be necessary for the air conditioning instructor to teach the complete outline, as presented. with the materials available.

UNIT 3 – CIRCUITS AND LAWS OF ELECTRICITY

Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To acquaint the student with the various sources of EMF.

To familiarize the student with the different types of electrical circuits.

To develop in the student knowledge and skills in the calculation of voltage, resistance, and current in the different types of electrical circuits.

To develop general understanding of the laws of electricity.

To promote continued awareness of the need for safety.

Tools and Materials

Text – Chapter 8
Dry cell batteries
Electrical sockets
Light bulbs
DC voltmeter and ammeter
AC voltmeter and ammeter
Boards
Other necessary tools as needed

Unit Outline

A. Basic components of a circuit
  1. Path for current
  2. Sources of voltage
    a. Batteries
      (1) Primary
      (2) Secondary
    b. Generators
    c. Alternators
  3. Power supply
    a. Single phase
    b. Three phase
    c. Frequency
  4. Load of resistance

B. Series circuits
   1. Source (batteries) in series
   2. Load (light bulbs) in series

C. Parallel circuits
   1. Source (batteries) in parallel
   2. Load (light bulbs) in parallel

D. Series-parallel

E. Parallel-series

F. Ohm's law

G. Kirchhoff's voltage law

H. Kirchhoff's current law

I. Voltage drop

Laboratory Activity

Demonstrate to the student how to connect batteries and light bulbs, both in series and in parallel.

Demonstrate with dry cell batteries how they can be connected in various circuits. Take the readings of voltage and current in each type of circuit.

Demonstrate the socket and board that they are to construct for their tests of series and parallel circuits, using 115-volt electrical service. Impress on the students the importance of caution in making proper connections between the sockets.

Shop Activity

1. Have the students take the voltage and current readings of a single dry-cell battery. They should then add batteries to the circuit until four of the dry cells are connected.

2. Have the students fill out the experiment sheets pertaining to this project as they progress.

3. Have the students construct the socket and light board, using four light bulb sockets mounted on the board with screws.

4. Students should fill out sheets explaining what they have accomplished. The instructor should check each individual project before it is plugged in.

This unit will be limited in scope depending on the material available and the instruments available. The instructor should strive to instill in the mind of the student all information possible on electricity and the important part it plays in the field of air conditioning. The instruments should be explained as to construction and operation. The importance of these instruments in the diagnosing of problems should be emphasized. The cost should also be noted to further emphasize the need for care in handling them.

Each student should know how to use each instrument in all possible ways. Particular emphasis should be placed on the care to be taken when working with electricity and the reason for such care. A demonstration such as the use of a Jacob's ladder could be used to show the power of this useful phenomenon.

Testing

Student demonstrations of instrument use should be utilized.

UNIT 4 – MAGNETIC CIRCUITS-ELECTRIC METERS

Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To have the students learn about magnetic circuits

To develop an understanding of some applications of electromagnetism.

To acquaint the students with the operation and care of electric meters.

To develop proper attitudes toward safety in the handling and use of electric meters.

Tools and Materials

Text
DC milliameter
AC ammeter
Combination meter
DC voltmeter
AC voltmeter
Ohmmeter
Wattmeter
Dry cell batteries
Light bulbs
Light bulb test board
Electric bells and buzzers

Unit Outline

A. Types of magnetic circuits
   1. Full iron
   2. Air gap
   3. Electromagnetic
B. Electromagnetic field
   1. Around a current-carrying conductor
   2. In coils
   3. In parallel conductors
      a. Current flow in same direction
      b. Current flow in opposite direction
   4. Strength of magnetic field
C. Electromagnets
   1. Solenoid and plunger types
   2. Armature types
D. Applications of electromagnets
   1. Electric bell
      a. Vibrator type
      b. Non-vibrator type
   2. Electric buzzer

3. Circuit breaker
4. Simple telegraph circuit
5. Simple telephone circuit
6. Relay
7. Electric razor
8. Electric hammer

E. Solenoid polarity test—left-hand rule

F. Meters
   1. Current
      a. Ammeter
      b. Milliammeter
   2. Voltage
      a. Voltmeter
      b. Millivoltmeter
   3. Resistence and continuity
      a. Ohmmeter
      b. Wheatstone bridge
   4. Power consumption
      a. Wattmeter
      b. Watt-hour meter
   5. Power factor
   6. Combination meters

Laboratory Activity

1. Demonstrate the electromagnetic field around any current-carrying conductor and demonstrate the left-hand rule.

2. Demonstrate and explain the operation both the AC and the DC meters, emphasizing their usage, and particularily that the DC meters should never be used on AC circuits.

3. Demonstrate applications of the electromagnetic principle in an electric bell and electric buzzer.

4. Show on the board the calculations necessary for finding the strength of flux density.

Shop Activity

1. Have the students calculate the current and resistance of various electric appliances (motors).

2. Have the students take actual meter readings and record their findings.

3. Compare the actual current flow in a circuit with the calculations of the students.

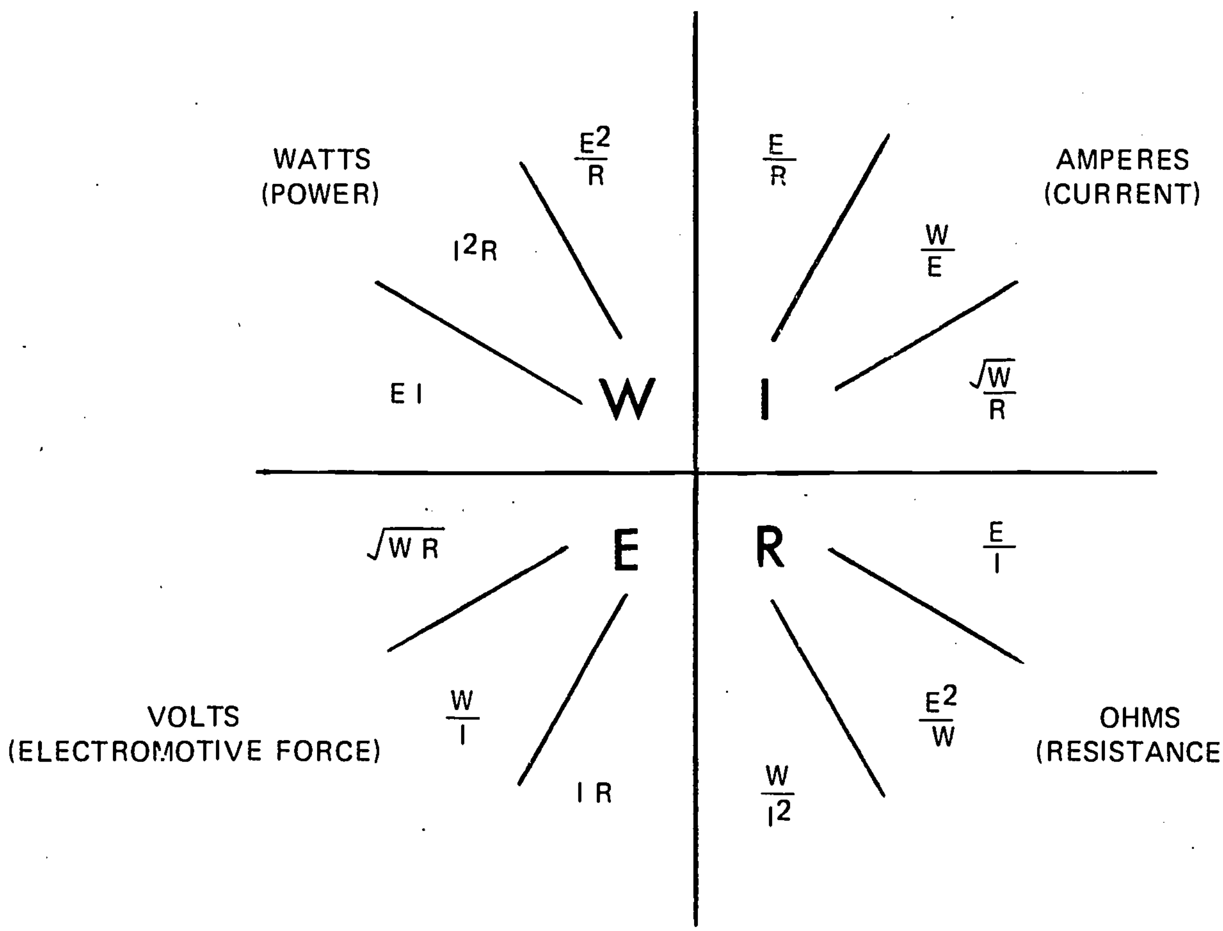
4. Have the students calculate and connect various circuits. Record current and voltage readings. Discuss any aspect of the findings where the actual readings do not correspond to the results of the calculations.

The student should have a fair knowledge of basics at this time. Each student should be allowed to make up some electrical demonstration unit. The instructor could suggest projects.

Example:

An instrument to test fuses.
What effect do lights connected in parallel have on voltage?

Explain the Ohm chart and have students use same.



OHM'S LAW

The basic law of electricity in this chart form will help you to determine whether you can safely add more load to an existing circuit or whether it is time to add another circuit.

I = Intensity–amperage–current
E = Volts–electromotive force
R = Ohms–resistence
W = Watts–power

Example:

Find amperage if the appliance is rated at 1100 watts at 115 volts. Using section on amps., W over E, divide 1100 by 115 and you get 9.5 amps.

UNIT 5 – TRANSFORMERS AND MOTORS

Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To acquaint the students with the construction of transformers and their uses.

To have the students learn about the voltage and current capabilities of transformers.

To familiarize the students with single-phase and 3-phase motors, and their characteristics.

To develop proper attitudes about the care of motors, and their safe usage in the field of refrigeration.

Tools and Materials

Step-down transformer
Step-up transformer
Boost-and-buck transformer
Cutaway or teardown motors
Voltmeters
Ammeters
Wattmeters

Unit Outline

A. Transformer
   1. Construction
      a. Primary windings
      b. Secondary windings
      c. Step-down
      d. Step-up
      e. Winding ratio
      f. Core laminations
   2. Eddy currents
   3. VA ratings
   4. Phasing
B. Motors, single-phase
   1. Induction
      a. Shaded pole
      b. Split phase
      c. Capacitor
      d. Permanent-split capacitor
      e. Synchronous speed
      f. Actual motor speed

C. Motors, three-phase
   1. Induction
   2. Wound motor
   3. Synchronous
D. Shaded pole and multiple windings
E. Direct-drive multi-speed blower motors
F. Reversal of rotation
G. Speed changing
H. Proper maintenance
I. Hermetic motors

Laboratory Activity

1. With the use of the step-up transformer, step-down transformer, and the meters demonstrate the variations in voltage and current with various loads.

2. Using either cutaway models or teardown units, point out the components of several motors.

3. Demonstrate the proper methods of changing the rotation in single-phase motors. Show the changing of rotation on three-phase motors as well. Students should be cautioned to follow specifications of the motor manufacturer as to rotation checked from the "front end" of the motor. (Generally the end opposite endshaft extension is the front end.) This rotation is very important with fan and centrifugal blowers.

4. Demonstrate the proper method of cleaning a commutator, and emphasize the importance of proper oiling and maintenance of motors for satisfactory operation.

Shop Activity

1. Have the students, with the use of the step-down and step-up transformers, meters, and proper loads, take the various readings of voltage, current flow and wattage consumption on on both the primary and secondary sides of the transformers.

2. Have the students tear down two or more motors, as instructed in operation sheets prepared by the instructor. They should label each component.

3. Their work should be checked by the instructor before explaining how the motor works. Reassemble motor.

4. Have the students check out their assigned lab condensing units, and record all pertinent electrical data on the motors in the system.

In addition to the outline, the instructor should teach the students the different types of motors used in the field, particularly the different phases of motors.

A group discussion on the part electricity plays in the air conditioning industry may be in order at this time. The discussion should center on the problems one may encounter in the field.

Perhaps each student could be assigned to find out what type of power is used in his home, what amounts are used for different appliances, and whether the load is too heavy for the facilities he has in his home.

Testing

Testing of students should be written and concentrated on factors encountered in the field that would be problem factors. Proper maintenance of motors should be included in the test.

Proper work sheets should be filled out and checked.

UNIT 6 – RELAYS, CONTACTORS, STARTERS, CIRCUIT PROTECTION

Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To acquaint the student with the different types of relays and their function in the refrigeration system.

To familiarize the student with the various means used for starting motors.

To have the student understand the need for circuit protection and learn the proper placement of the protective devices.

To develop an appreciation for the selection of proper controllers and safety devices.

Tools and Materials

Text – Chapter 8, 10, and 13
Ammeters
Voltmeters
Ohmmeters
Wattmeters
Test condensing unit
Disconnect switches
Relays
Contactors
Starters
Fuses

Unit Outline

A. Relays and contactors
    1. Current coil
    2. Hot-wire
    3. Voltage
    4. Time delay
    5. Overload
B. Starters
    1. Manual
    2. Magnetic
        a. Across the line
        b. Reduced voltage
        c. Part winding
    3. Fractional horsepower starting devices
        a. Thermostats
        b. Time delay
C. Circuit and unit protection
    1. Fuses
        a. Plug and cartridge
        b. Time delay (fusetron)

2. Circuit breaker
3. Disconnect switches
4. Overload protectors

Laboratory Activity

1. Show the students a torn down relay and contactor. Explain the components and their operation in the circuit.

2. Demonstrate methods of checking contact resistance and coil condition.

3. Show the student how a relay and contactor are connected to a circuit. Use blackboard.

4. Demonstrate a starter and show how it operates.

5. Explain how in a fractional horse power motor a small device can start and stop it.

6. Demonstrate correct methods of testing fuses.

7. Demonstrate the methods of testing overloads and disconnect contacts for resistances and condition of the components.

8. Explain appropriate parts of the National Electric Code, with emphasis concerning the location of any disconnect switch for a given unit.

Shop Activity

1. Have the students make a schematic drawing of the wiring on their laboratory condensing units. Then have them trace the service for their unit back to the electrical panel.

2. Have the students trouble-shoot. with the use of the meters, the various electrical components on their condensing unit. Simulated conditions on some components could be assigned.

The use of relays should be undertaken at this point. The checking of these small electrical parts should be done with the proper instruments and determinations made as to the status of each part tested. The use of the instruments should be closely supervised at all times so that the students are made aware of the importance of the proper use of these instruments.

The instructor should acquire as many relays and contactors as possible and have the student study them and learn their function and nomenclature. Emphasis should continually be placed on the absolute necessity for complete knowledge of these electrical components.

Safety practices should be closely supervised at all times during electrical demonstrations and/or study.

Testing

Testing should be on the ability of the student to handle and use the instrument.

Work sheets should be used and checked.

Assignments should be made according to item No. 1 of "Shop Activity."

SECTION III - COMMERCIAL REFRIGERATION

SECTION III

COMMERCIAL REFRIGERATION

Unit	Title	Hours Class	Hours Laboratory	Hours Shop
1.	History and Scope	5	2	8
2.	Refrigerated Storage	5	1	9
3.	Storage Conditions and Temperatures	5	1	9
4.	Evaporators	10	2	18
5.	Defrosting Methods	5	1	9
6.	Compressors	10	2	18
7.	Condensers	10	2	18
8.	Refrigerant Lines	10	2	18
9.	Pressure Reducing Devices	5	1	9
10.	Accessories	3	1	5
11.	Insulation	2	1	3
12.	Load Calculations	5	1	9
13.	Installations	5	1	9
14.	Initial Start Up	5	1	9
15.	Service Problems	5	1	9
	Total	90	20	160

UNIT OUTLINES

Section III – Commercial Refrigeration

Unit 1 – History and Scope

A. Early commercial refrigeration
   1. Ammonia units
      a. Semi-automatic
      b. Need for operating engineers
      c. High costs
   2. Units using other refrigerants
   3. Ice cream cabinets
   4. Water coolers
   5. Grocery store cabinets
B. Scope of applications
   1. Display and dispensing
      a. Grocery stores
      b. Restaurants
      c. Drug stores
         (1) Ice cream cabinets
         (2) Soda fountains
      d. Florist cabinets
      e. Beverage coolers
      f. Refrigerated vending machines
   2. Processing
      a. Candy manufacture
      b. Beverage process
      c. Bakery products
      e. Fish
      f. Fruits and vegetables
      g. Dairy products
   3. Transportation and distribution
      a. Land transport
         (1) Refrigerated trucks and trailers
         (2) Railway refrigerated cars
      b. Marine and air transport
   4. Ice machines
      a. Blocks
      b. Cubes
      c. Sized
C. Laboratory commercial units
   1. Identification
   2. Explanation of operation

Unit 2 -- Refrigerated Storage

- A. Temporary storage
  - 1. Storage life
    - a. Type of product
    - b. Condition of product
    - c. Respiration
    - d. Desiccation
  - 2. Supply and demand
  - 3. Shipment
- B. Long-term storage
  - 1. Wholesalers
  - 2. Storage warehouses
  - 3. Mixed storage
  - 4. Control of humidity
  - 5. Pre-cooling
  - 6. Storage by wholesaler
  - 7. Storage by retailer
  - 8. Storage by consumer
  - 9. Air circulation
- C. Water valves
  - 1. Components
  - 2. Adjustments

Unit 3 – Storage Conditions and Temperatures

- A. Freezing methods
  - 1. Sharp (slow) freezing
  - 2. Quick freezing
    - a. Immersion
      - (1) Canned products
      - (2) Unpackaged or lightly packaged products
    - b. Air blast freezing
      - (1) Tunnel freezing
      - (2) Continuous fast freezer
      - (3) Continuous shelf freezer
    - c. Indirect contact
      - (1) Contact plate
      - (2) Batch type contact
      - (3) Semi-automatic contact
      - (4) Automatic plate freeze
  - 3. Packaging materials and methods
    - a. Individual packages
    - b. Pre-cooked foods
    - c. Complete dinners
- B. Special purpose fixtures
  - 1. Freeze-drying
  - 2. Clinical uses
- C. Portable charging stations

Unit 4 – Evaporators

A. Heat transfer
   1. Evaporator design
   2. Air circulation
   3. Air velocity
   4. Air distribtuion
B. Refrigeration effect
   1. Work done by refrigerant
      a. Heat content of liquid entering
      b. Heat content of liquid leaving
   2. Pounds of refrigerant circulated
   3. Volume of refrigerant vapor removed
C. General types
   1. Dry–direct expansion
      a. Bare-tube
      b. Plate surface
      c. Finned
   2. Flooded–shell-and-tube
   3. Indirect expansion–secondary refrigerants
D. Circuiting and rating
   1. Correct velocities
   2. Desirable pressure drop
   3. Refrigerant migration
   4. Balancing with compressors
   5. Rated on BTU/degree T.D.
E. Superheat
F. Sub-cooling
   1. Advantages
   2. Effects on refrigeration effects
G. Air circulation and humidity
   1. Natural convection
      a. Overhead coils
      b. Side-wall evaporators
      c. Coil and baffle assemblies
   2. Forced convection
      a. Parallel flow
      b. Counter flow
      c. Cross flow
      d. Combination
   3. Dew point temperatures
H. Oil return and traps
   1. Oil separators
   2. Dual riser system
   3. Vapor line oil traps

I. Accumulators
   1. Location
   2. Advantage
J. Multiple coils
K. Test benches
   1. Explanation of facilities
   2. Demonstration

Unit 5 – Defrosting Methods
A. Manual
   1. Small freezers
   2. Plate type evaporators
B. Off-cycle
   1. Frequency of cycles
   2. Limitations
C. Hot gas
   1. Solenoid controlled by-pass
   2. Re-evaporator
   3. Multiple evaporator systems
D. Water
   1. Manual or automatic
   2. Limitations
E. Brine spray
   1. Concentrators
   2. Recirculation pumps
   3. Eliminator plates
F. Electric
   1. Resistance
   2. Double tube
   3. Immersion type
G. Ice machine maintenance

Unit 6 – Compressors
A. Displacement
   1. Constant factor
   2. Specification sheets
   3. Measured data
   4. Formulae used
   5. Theoretical capacity
B. Compressor ratio
   1. Determination
   2. Absolute pressures
   3. Variations with pressure changes
C. Volumetric efficiency
   1. Determining the actual capacity
   2. Compression ratio relationship

3. Affecting factors
    a. Clearance in cylinders
    b. Cylinder heating
    c. Leakage past pistons and valves

D. Brake horsepower requirements
1. Theoretical power
2. Overall efficiency
    a. Compressor efficiency
    b. Mechanical efficiency

E. Multiple units
1. Capacity control
2. Piping problems
3. Crankcase equalizer
4. Direct staging
5. Cascade staging

F. Measurements
1. Compressor speed
2. Sizing of motor pulley and belts

Unit 7 – Condensers

A. Heat transfer
1. Air-cooled
    a. Unit mounted
    b. Remote (optional)
    c. Air quantity
    d. Air velocity
2. Water cooled
    a. Waste water
        (1) Economically feasible
        (2) Well, lake, or river sources
    b. Recirculated water
        (1) Shell-and-coil
        (2) Shell-and-tube
        (3) Tube-in-tube
        (4) Water volume
        (5) Temperature rise

B. Piping and pump
1. Water velocity
2. Pressure drop through condenser
3. Make up water
4. Fouling factor

C. Water regulating valves
1. Operating pressures
2. Pressure drop
3. Water quantity
4. Ambient temperature

D. Evaporative condensers
   1. Air flow
   2. Control of water
   3. Purge valve
E. Cooling towers
   1. Natural draft
      a. Wind velocity
      b. Driftage
   2. Mechanical draft
      a. Forced draft
      b. Induced draft
      c. Parallel air flow
      d. Counter air flow
      e. Transverse air flow
      f. Spray eliminators
F. Condenser by-pass
   1. High wet-bulb condition
   2. Hand valve control or adjustment
G. Condenser and tower maintenance
   1. Algaecides
   2. Inhibited acid, acid pumps
H. Winter operation
   1. Air quantity control
   2. Low ambient temperature
      a. Cooling towers
      b. Evaporative condenser
      c. Air cooled condenser
I. Condenser service
   1. Air cooled condensers
   2. Water cooled condensers

Unit 8 – Refrigerant Lines
A. Allowable velocities
   1. Lubrication problems
   2. Noise
   3. Horizontal lines
   4. Vertical lines
   5. Double risers
   6. Oil traps

B. Pressure drop
  1. Friction
  2. Lift
  3. Liquid lines
    a. Flash gas
    b. Sub-cooling effect on system
  4. Suction lines
  5. Hot gas lines
C. Size calculations
  1. Liquid lines
  2. Suction lines
    a. Single-risers
    b. Double-risers
    c. Evaporator location
    d. Multiple evaporators
  3. Discharge lines
    a. Single risers
    b. Double risers
  4. Condenser drain lines
    a. Free drainage
    b. Receiver equalizer line
  5. Compressor equalizer lines
    a. Crankcase pressure equalizer
    b. Oil equalizer

Unit 9 – Pressure Reducing Devices

A. Expansion valves
  1. Hand valves
  2. Automatic valves
    a. Application
    b. Selection
  3. Thermostatic valves
    a. Application
    b. Charge in sensing bulb (element)
      (1) Gas charged
      (2) Liquid charged
      (3) Cross charged
    c. Selection
B. Pressure limiting valves
  1. Cartridge type
  2. Spring type
C. Refrigerant distributors
  1. Multi-pass
  2. External equalizer

D. Capillary tubes
   1. Length of tube
   2. Inside diameter
   3. Drier and filter requirements
E. System interlock

Unit 10 – Accessories

A. Solenoid valves
   1. Two-position control
   2. Liquid line stop valve
   3. Pump down systems
   4. Direct acting
   5. Pilot-operated
B. Check valves
   1. Condenser-hot gas line
   2. Suction line
      a. Multiple coils-different temperatures
      b. Lower temperature coil
   3. Noise
C. Two-temperature valves
   1. Pressure control
   2. Metering type
   3. Snap-action type
   4. Thermostatic type
D. Relief valves
   1. Pressure, spring-loaded type
   2. Temperature, fusible-plug type
E. Reversing valves, heat pump change-over
F. Sight glasses
   1. Double port
   2. Single port
   3. Moisture indicator
   4. Location
      a. Near receiver
      b. Near expansion valve
G. Strainers and driers
   1. Liquid line filters
   2. Suction strainers
   3. Desiccants
H. Heat exchangers
   1. Types
   2. Advantages
      a. Sub-cooling liquid refrigerant
      b. Super-heat suction vapor
   3. Detrimental effects on gas-cooled motors

I. Oil separators
   1. Recommended location
   2. Reduction of hot-gas pulsation
   3. Systems involved
      a. Flooded evaporator systems
      b. Low temperature applications
      c. Nonmiscible refrigerants
      d. Capacity-control systems
   4. Impingement type
   5. Chiller type
J. Vibration eliminators
   1. Condensing unit bases
      a. Isolate materials
      b. Factors involved in selection
   2. Refrigerant lines

Unit 11 – Insulation
A. Purpose or need
   1. Prevention against heat transfer
      a. Conduction
      b. Convection
      c. Radiation
   2. Humidity control
B. Thermal insulation
   1. Basic materials
   2. Physical composition
   3. Characteristic qualities
      a. Thermal properties
         (1) Conductivity
         (2) Specific heat
      b. Density
      c. Moisture resistance
      d. Resistance to chemical change
      e. Vermin proof
   4. Air space
C. Water vapor barriers
   1. Types
   2. Properties
   3. Effectiveness
   4. Location or placement
D. Economic considerations
   1. Thickness
   2. Cost of insulation and installation

E. Building insulation
    1. Blanket or batt
    2. Rigid board
    3. Loose-fill
    4. Vapor barrier
F. Air film
    1. Inside film
    2. Outside film
    3. Air velocity

Unit 12 – Load Calculations
A. Transmission of sensible heat
    1. Conduction
        a. Walls, ceiling, and floor
        b. Time
        c. Type of insulation
        d. Thickness of insulation
        e. External area
        f. Temperature difference
    2. Radiation
        a. Glass
        b. Other transparent materials
    3. Solar
B. Air change
    1. Inside volume
    2. Type of usage
C. Product
    1. Sensible
    2. Latent
    3. Respiration
    4. Cartons or containers
D. Miscellaneous
    1. People
    2. Lights
    3. Motors
    4. Appliances, gas and/or electric
E. Short form methods

Unit 13 – Installations
A. State and local codes
    1. Safety codes for mechanical refrigeration
    2. Purpose
    3. Applications

B. Self contained units
    1. Conventional units
    2. Hermetic units
    3. Compressor ventilation requirements
        a. Air cooled
        b. Water cooled
        c. Manufacturing recommendations
    4. Bases
    5. Vibration eliminators
    6. Noise factors

C. Remote condensing units
    1. Bases
    2. Hold-down bolts
    3. Level mounting
    4. Accessible location
    5. Noise factors
    6. Protection for unit

D. Cooling coils
    1. Air circulation
    2. Air distribution
    3. Careful mounting
    4. Supports or hangers

E. Single and multiple cabinets
    1. Same temperature
    2. Different temperatures
    3. Condensate drains

F. Tubing
    1. Type used
    2. Support, permanency
    3. Neatness, tubing cleanliness
    4. Accessories, valves, driers, sight glass
    5. Vibration absorbers
    6. Vibration loops
    7. Slope of vapor lines
    8. Tubing sealed

G. Condensate pump installation

Unit 14 – Initial start-up

A. Evacuation
    1. All new systems except those pre-charged
    2. All opened systems
    3. Extent and importance of vacuum

B. Charging
    1. Critical charge system
        a. Manufacturers' recommendations
        b. Portable charging equipment

2. Non-critical charge systems
    a. Liquid charging
        (1) Receiver valve
        (2) Discharge service valve
    b. Vapor charging
        (1) Suction service valve
        (2) Compound gage
        (3) Sight glass

C. Operational check
1. Remove shipping bolts and/or blocks
2. Oil all motor bearings
3. Check operating pressures
    a. Suction
    b. Discharge
    c. Compressor oil
4. Oil level
5. Amperage
6. Voltage
7. Superheat
8. Pressure controls
9. Evaporator fans
10. Condensing fans
11. Water pump
12. Adjust motor control
13. Correct fuse size

Unit 15 – Service Problems

A. Entire unit will not run
1. No power at the compressor
    a. Check disconnect switch
    b. Check fuse or circuit breaker
    c. Check source of main power
    d. Broken wire or loose connection
2. Power at compressor
    a. Compressor motor
    b. Overload
    c. Controls
    d. Control wiring

B. Unit runs, no cooling
1. Loss of refrigerant
2. Inefficient compressor
3. Restriction in lines or accessories
    a. Damaged tubing
    b. Moisture
    c. Scale or dirt

C. Unit runs, insufficient cooling
   1. Shortage of refrigerant
   2. Inefficient compressor
   3. Obstruction
      a. Lines
      b. Refrigerant control
      c. Drier
   4. Control setting

D. Unit noisy
   1. Vibration of lines
   2. Compressor mounts
   3. Surplus of oil
   4. Defective compressor valves
   5. Loose components
   6. Refrigerant overcharge
   7. High head pressure

E. Unit short cycles
   1. Partial obstruction
   2. Leaky power element
   3. Improper adjustments of refrigerant control device

F. Recommended periodic inspections
   1. Amount of refrigerant
   2. Amount of oil
   3. Belt alignment
   4. Belt tension
   5. Condition of belt
   6. Condition of air cooled condenser
   7. Electrical connections
   8. Tubing support
   9. Water flow

G. Other

   The above are a few of the possible trouble spots found on equipment in the field. It is not to be taken as a final list. The number of possible problems is so numerous that is not possible to list them all.

UNIT 1 – HISTORY AND SCOPE
Class Instruction – 5 hours
Laboratory – 2 hours
Shop – 8 hours

Unit Guide

Unit Objectives

To acquaint the students with the facts concerning early and present day commercial refrigeration, and its applications.

To develop an understanding of various types of units used in the process, display, and transportation of products.

To impart information on the components and various accessories used with the equipment.

Tools and Materials

Text
All available units in the shop
Utilize current equipment catalogs of various manufacturers

Unit Outline

A. Early commercial refrigeration
   1. Ammonia units
      a. Semi-automatic
      b. Need for operating engineers
      c. High costs
   2. Units using other refrigerants
   3. Ice cream cabinets
   4. Water coolers
   5. Grocery store cabinets

B. Scope of applications
   1. Display and dispensing
      a. Grocery stores
      b. Restaurants
      c. Drug stores
         (1) Ice cream cabinets
         (2) Soda fountains
      d. Florist cabinets
      e. Beverage coolers
      f. Refrigerated vending machines
   2. Processing
      a. Candy manufacture
      b. Beverage process
      c. Bakery products
      e. Fish
      f. Fruits and vegetables
      g. Dairy products

3. Transportation and distribution
    a. Land transport
        (1) Refrigerated trucks and trailers
        (2) Railway refrigerated cars
    b. Marine and air transport
4. Ice machines
    a. Blocks
    b. Cubes
    c. Sized

C. Laboratory commercial units
1. Identification
2. Explanation of operation

Laboratory Activity

1. When identifying the various available commercial units in the shop, explain that each of them will be used for several work projects and in the trouble-shooting of various problems.

2. Explain that the various work teams may be doing the same type of diagnosing of troubles but on different units; or different types of problems may be given to the teams, and they will rotate on the various units.

Shop Activity

1. Have the students list the commercial systems that are in the shop, particularly if a variety of equipment is available. They should also include the components used in each system, the various applications in which some of them could be used, and the approximate operating temperatures for each application.

2. The first project is to be assigned to all teams. This will facilitate a review of the correct procedure for installing the test manifold and the need for recording pertinent data after the systems have been operating at least 15 to 20 minutes.

Because of the hazards encountered in the use of ammonia, it should be made clear to the students that this is a specialty and a dangerous one.

If it is at all possible for the shop to acquire an ice machine, the theory and complete explanation of this piece of equipment should be a purpose of this particular unit. If the equipment is not available, then slides and/or diagrams should be utilized to a great extent. This is necessary because of the great number of machines in the field.

Testing

Testing should be made at this time on the unit. Discussion of answers given would benefit students after the oral response.

UNIT 2 – REFRIGERATED STORAGE

Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To acquaint the students with the difference between and the definite usages of temporary and long-term refrigerated storage.

To acquire a knowledge of the requirements for proper care of the products before and during the storage period.

To develop a knowledge and understanding of the various products that can be frozen, the means of processing, and the various packing methods used for food products.

Tools and Materials

Text – Chapter 14 and 15
Instructor-developed operating data or diagnostic sheets for student projects
Samples of hand-tight water-pressure operated water valves
Commercial unit with pressure-operated water valve
Basic refrigeration tool kit

Unit Outline

A. Temporary storage
  1. Storage life
    a. Type of product
    b. Condition of product
    c. Respiration
    d. Desiccation
  2. Supply and demand
  3. Shipment
B. Long-term storage
  1. Wholesalers
  2. Storage warehouses
  3. Mixed storage
  4. Control of humidity
  5. Pre-cooling
  6. Storage by wholesaler
  7. Storage by retailer
  8. Storage by consumer
  9. Air circulation

C. Water valves
   1. Components
   2. Adjustments

Laboratory Activity

1. Demonstrate on a water-cooled unit how to adjust the water valve to the proper pressure.

2. Measure the temperature and also the quantity of water flowing before and after adjustment has been made.

Shop-Activity

Have the students work on the projects assigned to them.

At this juncture the student should be fairly familiar with the system in general. This is the time to begin requiring that the students become more aware of the different components. Each student should be assigned a system at this time, and any instruction on components should be carried out on an individual basis as much as possible. Work sheets should now be completed and the students should insert all information that they notice is not called for on the sheet.

The instructor should now emphasize an air of professionalism in the shop for each student. Correct word usage and proper names for components should be insisted on. A test of that particular nature should be given at this time, either orally or written.

Now that each student or pair of students has been assigned a project, the instructor must see that all safety precautions are taken and that the students remain at their stations.

If the tool-crib attendants have as yet not been assigned, this is the time to do this. Each instructor should devise his own method of tool control.

Text assignments should be made to give students maximum benefit of all material available.

Special research projects can be assigned to each student or pair of students.

Testing

Testing of this unit is important and should be in written form.

UNIT 3 – STORAGE CONDITIONS AND TEMPERATURES

Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To acquaint the students with the different freezing methods used in commercial refrigeration.

To develop an understanding of what takes place during the freezing process, and why different methods are used.

To have the students become aware of new processes that may require special-purpose fixtures.

Tools and Materials

Instructor should refer to latest specifications from equipment manufacturers
Instructor-developed operating data or diagnosis sheets for student projects
Refrigerant charging station
Hermetic unit requiring specific charge of refrigerant
Basic refrigeration tool kit

Unit Outline

A. Freezing methods
  1. Sharp (slow) freezing
  2. Quick freezing
    a. Immersion
      (1) Canned products
      (2) Unpackaged or lightly packaged products
    b. Air blast freezing
      (1) Tunnel freezing
      (2) Continuous fast freezer
      (3) Continuous shelf freezer
    c. Indirect contact
      (1) Contact plate
      (2) Batch type contact
      (3) Semi-automatic contact
      (4) Automatic plate freeze
  3. Packaging materials and methods
    a. Individual packages
    b. Pre-cooked foods
    c. Complete dinners

B. Special purpose fixtures
   1. Freeze-drying
   2. Clinical uses
C. Portable charging stations

Laboratory Activity

Demonstrate the correct usage of a charging station. Use a hermetic unit in the shop.

Shop Activity

Have the students work on charging projects assigned to them.

When the theory of the various systems, as outlined, has been explained, the students should continue on their project. Accuracy and completeness should be emphasized.

UNIT 4 – EVAPORATORS
Class Instruction – 10 hours
Laboratory – 2 hours
Shop – 18 hours

Unit Guide

Unit Objectives

To acquaint the students with the different types of evaporators used in commercial refrigeration.

To teach an understanding of the purpose and the effect of the refrigerant in the evaporator.

To develop a knowledge and understanding of the problems involved in the correct installation of cooling coils.

Tools and Materials

Text – Chapter 15
Instructor-developed operating data or diagnosis sheets for student-practice projects on shop equipment
Pressure-actuated controls, fuses, motors, compressors
Basic refrigeration tool kit

Unit Outline

A. Heat transfer
   1. Evaporator design
   2. Air circulation
   3. Air velocity
   4. Air distribution
B. Refrigeration effect
   1. Work done by refrigerant
      a. Heat content of liquid entering
      b. Heat content of liquid leaving
   2. Pounds of refrigerant circulated
   3. Volume of refrigerant vapor removed
C. General types
   1. Dry–direct expansion
      a. Bare-tube
      b. Plate surface
      c. Finned
   2. Flooded–shell-and-tube
   3. Indirect expansion–secondary refrigerants

D. Circuiting and rating
   1. Correct velocities
   2. Desirable pressure drop
   3. Refrigerant migration
   4. Balancing with compressors
   5. Rated on BTU/degree T.D.
E. Superheat
F. Sub-cooling
   1. Advantages
   2. Effects on refrigeration effects
G. Air circulation and humidity
   1. Natural convection
      a. Overhead coils
      b. Side wall evaporators
      c. Coil and baffle assemblies
   2. Forced convection
      a. Parallel flow
      b. Counter flow
      c. Cross flow
      d. Combination
   3. Dew point temperatures
H. Oil return and traps
   1. Oil separators
   2. Dual riser system
   3. Vapor line oil traps
I. Accumulators
   1. Location
   2. Advantage
J. Multiple coils
K. Test benches
   1. Explanation of facilities
   2. Demonstration

Laboratory Activity

1. Demonstrate the use of facilities to test pressure-actuated accessories when they are connected to the air supply.

2. Demonstrate the use of the fuse tester, continuity-test leads, and point out the receptacles for different voltages and phases which are available for testing motors or motor-driven accessories.

3. Point out and demonstrate the facilities to test temperature-actuated accessories.

4. Demonstrate the connection of the vacuum pump to a repaired and/or reassembled compressor when placed in the drying oven (optional until such time as this facility is available).

Shop Activity

Have the students work on the projects assigned to them. Projects should reinforce prior demonstrations by practicing demonstrated concepts.

The student should have acquired enough knowledge by this time so that very beneficial discussions can take place. Students should be informed that their participation in these discussions will be noted and their grade will depend in part on this.

UNIT 5 – DEFROSTING METHODS

Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To acquaint the students with the need for defrosting commercial refrigeration equipment.

To develop in the student a knowledge and understanding of various methods and procedures of satisfactorily defrosting the equipment.

To develop in the student a knowledge and understanding of some of the problems involved with low-temperature equipment necessitating frequent defrost.

Tools and Materials

Instructor-developed operating data or diagnosis sheets for student practice on shop equipment
Ice machine, acid or vinegar, cleaning materials

Unit Outline

A. Manual
 1. Small freezers
 2. Plate type evaporators
B. Off-cycle
 1. Frequency of cycles
 2. Limitations
C. Hot gas
 1. Solenoid controlled by-pass
 2. Re-evaporator
 3. Multiple evaporator systems
D. Water
 1. Manual or automatic
 2. Limitations
E. Brine spray
 1. Concentrators
 2. Recirculation pumps
 3. Eliminator plates
F. Electric
 1. Resistence
 2. Double tube
 3. Immersion type
G. Ice machine maintenance

Laboratory Activity

Demonstrate the proper method of cleaning and caring for an ice machine, using acid or vinegar as recommended by the manufacturer so that peak efficiency of the ice production will be maintained.

Shop Activity

Have the students work on the assigned refrigeration system available in shop.

UNIT 6 – COMPRESSORS
Class Instruction – 10 hours
Laboratory – 2 hours
Shop – 18 hours

Unit Guide

Unit Objectives

To teach an understanding of the displacement of any given compressor, and how to calculate the displacement.

To acquaint the students with numerous variables in the use of the compressors.

To develop a knowledge and understanding of the brake horsepower needed for the operation of the compressor.

Tools and Materials

Instructor-developed operating data or diagnosis sheets for student practice on shop equipment
Belt-driven condensing unit, tachometer, measuring tape

Unit Outline

A. Displacement
   1. Constant factor
   2. Specification sheets
   3. Measured data
   4. Formulae used
   5. Theoretical capacity
B. Compressor ratio
   1. Determination
   2. Absolute pressures
   3. Variations with pressure changes
C. Volumetric efficiency
   1. Determining the actual capacity
   2. Compression ratio relationship
   3. Affecting factors
      a. Clearance in cylinders
      b. Cylinder heating
      c. Leakage past pistons and valves
D. Brake horsepower requirements
   1. Theoretical power
   2. Overall efficiency
      a. Compressor efficiency
      b. Mechanical efficiency

E. Multiple units
   1. Capacity control
   2. Piping problems
   3. Crankcase equalizer
   4. Direct staging
   5. Cascade staging

F. Measurements
   1. Compressor speed
   2. Sizing of motor pulley and belts

Laboratory Activity

1. Demonstrate the use of a tachometer. Also show how the compressor rpm can be found by actual measurements of compressor flywheel and motor pulley. Do the calculations on the blackboard.

2. In the same manner, show how to size a motor pulley when a given rpm of the compressor is needed for specific heat removal.

3. Show methods of determining the size of a replacement belt for a unit when the size of a broken belt or worn belt is not known.

4. If a shell-and-tube evaporator is available, show how cascade staging could be used (optional until equipment is available).

Shop Activity

Have students work on the projects assigned to them.
E. g., Remove pulley belts prior to class and have students measure and select replacements from identified selection.

Most of the work in this unit will be done on information obtained from the text and other literature available to the instructor. Emphasis should be placed on "B," "C-3abc," "D2a," "E," "F".

UNIT 7 – CONDENSERS
Class Instruction – 10 hours
Laboratory – 2 hours
Shop – 18 hours

Unit Guide

Unit Objectives

To acquaint the students with the different types of air- and water-cooled condensers used in commercial refrigeration.

To have them acquire an understanding of the problems involved in the correct selection and operation of piping, pumps, and water valves.

To develop in them a knowledge and understanding of cooling towers and their many applications, along with the problems involved.

Tools and Materials

Instructor-developed operating data or diagnostic sheets for student practice on shop equipment
Basic refrigeration tool kit
Accessible tube-in-tube condenser
Accessible shell-and-tube condenser
Acid pump, chemical scale remover (optional)

Unit Outline

A. Heat transfer
   1. Air-cooled
      a. Unit mounted
      b. Remote (optional)
      c. Air quantity
      d. Air velocity
   2. Water cooled
      a. Waste water
         (1) Economically feasible
         (2) Well, lake, or river sources
      b. Recirculated water
         (1) Shell-and-coil
         (2) Shell-and-tube
         (3) Tube-in-tube
         (4) Water volume
         (5) Temperature rise

B. Piping and pump
   1. Water velocity
   2. Pressure drop through condenser
   3. Make up water
   4. Fouling factor
C. Water regulating valves
   1. Operating pressures
   2. Pressure drop
   3. Water quantity
   4. Ambient temperature
D. Evaporative condensers
   1. Air flow
   2. Control of water
   3. Purge valve
E. Cooling towers
   1. Natural draft
      a. Wind velocity
      b. Driftage
   2. Mechanical draft
      a. Forced draft
      b. Induced draft
      c. Parallel air flow
      d. Counter air flow
      e. Transverse air flow
      f. Spray eliminators
F. Condenser by-pass
   1. High wet bulb condition
   2. Hand valve control or adjustment
G. Condenser and tower maintenance
   1. Algaecides
   2. Inhibited acid, acid pumps
H. Winter operation
   1. Air quantity control
   2. Low ambient temperature
      a. Cooling towers
      b. Evaporative condenser
      c. Air cooled condenser
I. Condenser service
   1. Air cooled condensers
   2. Water cooled condensers

Laboratory Activity

1. Demonstrate the method of taking a condenser apart. Show the method of cleaning any condensers available in the shop.

2. Demonstrate the use of chemicals in conjunction with a pump to clean condensers not constructed to be taken apart (optional).

Shop Activity

Have the students work on projects such as anticipated field problems.

Sections from the text should be assigned, and the students should be made aware of the necessity of knowing what is taking place internally on all the parts referred to in this unit. From now on, very serious discussions should take place whenever a new unit is introduced. Particular emphasis should be placed on the possible problems that will be encountered in the field.

Testing

Each student should have a very clear knowledge of the projects assigned to him.

UNIT 8 – REFRIGERANT LINES
Class Instruction – 10 hours
Laboratory – 2 hours
Shop – 18 hours

Unit Guide

Unit Objectives

To acquaint the students with the main refrigeration lines in a commercial refrigeration system.

To give them an understanding of the numerous problems that may arise from improper sizing, design and installation.

To develop proper attitudes about safe practices in the installation of copper lines.

Tools and Materials

Instructor-developed operating data or diagnostic sheets for students' work on in-shop equipment
Solder, torch, sand cloth, flux
Pipe insulation, insulation adhesive

Unit Outline

A. Allowable velocities
   1. Lubrication problems
   2. Noise
   3. Horizontal lines
   4. Vertical lines
   5. Double risers
   6. Oil traps
B. Pressure drop
   1. Friction
   2. Lift
   3. Liquid lines
      a. Flash gas
      b. Sub-cooling effect on system
   4. Suction lines
   5. Hot gas lines
C. Size calculations
   1. Liquid line
   2. Suction lines
      a. Single-risers
      b. Double-risers
      c. Evaporator location
      d. Multiple evaporators

3. Discharge lines
    a. Single risers
    b. Double risers
4. Condenser drain lines
    a. Free drainage
    b. Receiver equalizer line
5. Compressor equalizer lines
    a. Crankcase pressure equalizer
    b. Oil equalizer

Laboratory Activity

1. Demonstrate the technique of soldering the liquid and suction lines together to form a heat exchanger (not recommended with a gas cooled compressor-motor system).

2. Show the use of insulation for copper lines, the fitting of the insulation and also the necessary preparation when the insulation is used outside a building.

3. Demonstrate the installation of "P" traps or construct a trap out of ells.

Shop Activity

The shop activity should now change. The students should be paired off, if this has not been done, and the projects assigned to them should be taken apart. Care should be taken that all safety precautions are followed. Each part should be removed, cleaned, oiled, and wrapped in a material that will protect it as much as possible from air and moisture. Each part should be removed and the ends closed for protection. All procedures learned by the student from the start of the course should be followed. The student should be advised that his ability to follow instructions will be evaluated.

Appropriate text assignments should be continued throughout the course. Assignments should be made to correspond to the course outline. The unit objectives can be the instructor's guide in assigning student text study.

UNIT 9 – PRESSURE REDUCING DEVICES

Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To acquaint the students with the different types of throttling devices that separate the low and the high sides of the refrigeration system and control the evaporator pressure.

To develop an understanding of the various applications and the proper selection of pressure-reducing devices.

Tools and Materials

Text – Chapter 13
Instructor-developed operating data or diagnosis sheets for student projects
Manufacturers' specification sheets for condensing units
Commercial refrigeration units in the shop

Unit Outline

A. Expansion valves
  1. Hand valves
  2. Automatic valves
    a. Application
    b. Selection
  3. Thermostatic valves
    a. Application
    b. Charge in sensing bulb (element)
      (1) Gas charged
      (2) Liquid charged
      (3) Cross charged
    c. Selection
B. Pressure limiting valves
  1. Cartridge type
  2. Spring type
C. Refrigerant distributors
  1. Multi-pass
  2. External equalizer
D. Capillary tubes
  1. Length of tube
  2. Inside diameter
  3. Drier and filter requirements
E. System interlock

Laboratory Activity

Demonstrate how two refrigeration systems may be interlocked in case of a breakdown (other than burnout) if standby equipment is not available.

Shop Activity

Have the students work on the projects assigned, such as interlocking various systems.

UNIT 10 – ACCESSORIES
Class Instruction – 3 hours
Laboratory – 1 hour
Shop – 5 hours

Unit Guide

Unit Objectives

To acquaint the students with the valves other than those used for refrigerant flow control.

To have them acquire an understanding of other accessories that are used for better all-around operation of the systems.

To develop a knowledge and understanding of the purposes and advantages of heat exchangers and oil separators.

Tools and Materials

Instructor-developed operating data or diagnosis sheets for student projects
Fusible plug connected to air pressure, heating torch
Commercial refrigerating unit with pump-down control

Unit Outline

A. Solenoid valves
   1. Two-position control
   2. Liquid line stop valve
   3. Pump down systems
   4. Direct acting
   5. Pilot-operated
B. Check valves
   1. Condenser-hot gas line
   2. Suction line
      a. Multiple coils-different temperatures
      b. Lower temperature coil
   3. Noise
C. Two-temperature valves
   1. Pressure control
   2. Metering type
   3. Snap-action type
   4. Thermostatic type
D. Relief valves
   1. Pressure, spring-loaded type
   2. Temperature, fusible-plug type
E. Reversing valves, heat pump change-over

F. Sight glasses
   1. Double port
   2. Single port
   3. Moisture indicator
   4. Location
      a. Near receiver
      b. Near expansion valve

G. Strainers and driers
   1. Liquid line filters
   2. Suction strainers
   3. Desiccants

H. Heat exchangers
   1. Types
   2. Advantages
      a. Sub-cooling liquid refrigerant
      b. Super-heat suction vapor
   3. Detrimental effects on gas-cooled motors

I. Oil separators
   1. Recommended location
   2. Reduction of hot-gas pulsation
   3. Systems involved
      a. Flooded evaporator systems
      b. Low temperature applications
      c. Nonmiscible refrigerants
      d. Capacity-control systems
   4. Impingment type
   5. Chiller type

J. Vibration eliminators
   1. Condensing unit bases
      a. Isolate materials
      b. Factors involved in selection
   2. Refrigerant lines

Laboratory Activity

1. Demonstrate, on a commercial refrigeration system, the action of a solenoid valve and low-pressure controls in pump-down systems.

2. Demonstrate how a fusible-plug type of relief valve will open to release high pressure caused by extreme heat.

Shop Activity

Have students work on the projects assigned to them (See example below).

With four weeks left in the first year it is suggested that the instructor assign each student a final project that will be used in lieu of a final examination.

Example:

> Name the parts of the system that has been discussed and worked on. Explain the operation of the system. Give as many problems as possible that may occur with this particular system. Give the remedy for each problem. If the instructor feels that it would be beneficial to the student, he may give a list of parts he wants the student to do his work on. This should be done as a research assignment. The work should be done at home or during free time in school. Students should be allowed to use any reference available.

Shop activity should continue on the disassembly and the reassembly of the unit that has been assigned to the pair of students. Students should be made aware that the units must be in operating condition by the year's end.

UNIT 11 – INSULATION
Class Instruction – 2 hours
Laboratory – 1 hour
Shop – 3 hours

Unit Objectives

To inform the students of the need for insulation in refrigerated rooms and areas.

To acquaint the students with the different types of materials used with early-day refrigeration as well as with those used today.

To develop an appreciation for economic considerations in the selection of type and thickness of insulation.

Tools and Materials

Instructor-developed operating data or diagnosis sheets for student projects
Insulation material, samples

Unit Outline

A. Purpose or need
   1. Prevention against heat transfer
      a. Conduction
      b. Convection
      c. Radiation
   2. Humidity control
B. Thermal insulation
   1. Basic materials
   2. Physical composition
   3. Characteristic qualities
      a. Thermal properties
         (1) Conductivity
         (2) Specific heat
      b. Density
      c. Moisture resistance
      d. Resistance to chemical change
      e. Vermin proof
   4. Air space
C. Water vapor barriers
   1. Types
   2. Properties
   3. Effectiveness
   4. Location or placement

D. Economic considerations
   1. Thickness
   2. Cost of insulation and installation
E. Building insulation
   1. Blanket or batt
   2. Rigid board
   3. Loose-fill
   4. Vapor barrier
F. Air film
   1. Inside film
   2. Outside film
   3. Air velocity

Laboratory Activity

Using prevailing costs of insulation and labor, show by calculation whether it would be more costly to install another thickness of the insulation or to install the next size larger equipment.

Shop Activity

Have the students learn the different sizes of insulation materials. Have the students learn to insulate pipe (before soldering lengths together and after).

The shop activity should be carried out when the students reassemble their units.

UNIT 12 – LOAD CALCULATIONS

Class instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To acquaint the student with the many miscellaneous heat grains that must be taken into consideration.

To develop a knowledge and understanding of product heat, both above and below its freezing temperature.

Tools and Materials

Text – Chapters 15 and 16
Heat-gain calculation forms from various firms.

Unit Outline

A. Transmission of sensible heat
  1. Conduction
    a. Walls, ceiling, and floor
    b. Time
    c. Type of insulation
    d. Thickness of insulation
    e. External area
    f. Temperature difference
  2. Radiation
    a. Glass
    b. Other transparent materials
  3. Solar
B. Air change
  1. Inside volume
  2. Type of usage
C. Product
  1. Sensible
  2. Latent
  3. Respiration
  4. Cartons or containers
D. Miscellaneous
  1. People
  2. Lights
  3. Motors
  4. Appliances, gas and/or electric
E. Short form methods

Laboratory Activity

1. Utilizing the blackboard, demonstrate how to best set up an itemized sheet when calculating heat gains for a refrigeration problem.

2. Show the students forms prepared by several equipment manufacturers for calculating heat gains. Use both long and short forms as examples.

3. Review any pertinent data that may be needed by the students for their projects on load calculation.

Shop Activity

Work on projects or problems assigned to the students by the instructor.

Because of the extensive instruction to be given on load calculations during the second year, when air conditioning is covered, it is suggested that only the main topics be covered in this unit. Because of the fast-approaching end of the school year it is possible that the students may not absorb as much of the information in this unit as is needed because of its importance. It is suggested that the heat-load forms be explained and the main information inserted. The detailed information should be left out at this time.

UNIT 13 – INSTALLATIONS
Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To acquaint the student with the codes applicable to commercial refrigeration.

To teach an understanding of good installation practices.

To develop an attitude for good workmanship in the installation of copper tubing.

To develop an attitude of consideration for employer and customer alike.

Tools and Materials

Text – Chapters 14 and 15

Unit Outline

A. State and local codes
    1. Safety codes for mechanical refrigeration
    2. Purpose
    3. Applications
B. Self contained units
    1. Conventional units
    2. Hermetic units
    3. Compressor ventilation requirements
        a. Air cooled
        b. Water cooled
        c. Manufacturing recommendations
    4. Bases
    5. Vibration eliminators
    6. Noise factors
C. Remote condensing units
    1. Bases
    2. Hold-down bolts
    3. Level mounting
    4. Accessible location
    5. Noise factors
    6. Protection for unit

D. Cooling coils
   1. Air circulation
   2. Air distribution
   3. Careful mounting
   4. Supports or hangers
E. Single and multiple cabinets
   1. Same temperature
   2. Different temperatures
   3. Condensate drains
F. Tubing
   1. Type used
   2. Support, permanency
   3. Neatness, tubing cleanliness
   4. Accessories, valves, driers, sight glass
   5. Vibration absorbers
   6. Vibration loops
   7. Slope of vapor lines
   8. Tubing sealed
G. Condensate pump installation

Laboratory Activity

1. Demonstrate the possible damage to copper tubing when it is run through a floor or wall, when unprotected by a sleeve or insulation.

2. Demonstrate the use of a condensate pump when no floor drain is readily available.

Shop Activity

Have the students work on projects assigned to them, such as identifying each component and explaining its function.

Particular emphasis should be placed on the proper way of installing copper tubing. The reassembly of the units should be near completion at this time and the instructor should check each unit and have any necessary changes made in accordance with good practice.

Each student's job-sheet folder should be checked and those not completed or satisfactory should be completed. At this point the instructor should spend a lot of time in informal discussion about what has taken place during the year. Weak spots should be determined and the instructor should make notes so that during the following year the week points can be strengthened.

Testing

After each project is completed, a check list should be made and each project checked by the students and then by the instructor.

UNIT 14 – INITIAL START-UP

Class Instruction – 5 hours
Laboratory – 1 hour
Shop – 9 hours

Unite Guide

Unit Objectives

To acquaint the students with the steps required for the initial start-up of a commercial refrigeration system.

To develop an attitude about the occurence of possible future trouble in a system if a satisfactory operational check is not completed on initial start-up.

Tools and Materials

Text – Chapters 14, 15
Instructor-developed diagnosis sheets for student projects
Critical charge system
Portable charging equipment
Basic refrigeration tool kit
Test manifold and gauges
Drum of refrigerant

Unit Outline

A. Evacuation
   1. All new systems except those pre-charged
   2. All opened systems
   3. Extent and importance of vacuum
B. Charging
   1. Critical charge system
      a. Manufacturers' recommendations
      b. Portable charging equipment
   2. Non-critical charge systems
      a. Liquid charging
         (1) Receiver valve
         (2) Discharge service valve
      b. Vapor charging
         (1) Suction service valve
         (2) Compound gauge
         (3) Sight glass
C. Operational check
   1. Remove shipping bolts and/or blocks
   2. Oil all motor bearings

3. Check operating pressures
    a. Suction
    b. Discharge
    c. Compressor oil
4. Oil level
5. Amperage
6. Voltage
7. Superheat
8. Pressure controls
9. Evaporator fans
10. Condensing fans
11. Water pump
12. Adjust motor control
13. Correct fuse size

Laboratory Activity

1. Demonstrate the operation of portable charging equipment in order to obtain the proper amount of refrigerant in a critical charge system.

2. Show the students how, in a non-critical charge system, most of the refrigerant can be put into the system in a liquid state with the rest put in as vapor.

Shop Activity

Have the students work on the projects assigned to them.

Lab and shop activity should be carried out as outlined. Informal discussions should continue at this time and service problems should be the topic of discussion. The instructor should allow the students to ask each other questions on some of the problems that may be anticipated when they enter the industry. Question and answer periods should dominate the class at this point. They may be motivated by the instructor or the students themselves. Too much pressure at this time is not suggested. The year has been a hard one if the course outline has been followed and completed.

UNIT 15 – SERVICE PROBLEMS

Class Instruction – 5 hours
Laboratory - 1 hour
Shop – 9 hours

Unit Guide

Unit Objectives

To acquaint the students with the numerous problems that they may encounter in servicing commercial units.

To have the students acquire a sensitivity to the apparent signs when something is wrong in a system. To have them recognize that a diagnosis must be made to determine the source of the trouble.

To develop an attitude that even when trouble-shooting problems, safety precautions should be taken for the protection of the equipment and personnel.

Tools and Materials

Text – Chapters 14, 15 and 27 and Glossary of Terms
Basic refrigeration tool kit
Fuse tester or continuity tester
Other shop electrical test equipment
Instructor-developed diagnosis sheets for the student projects

Unit Outline

A. Entire unit will not run
    1. No power at the compressor
        a. Check disconnect switch
        b. Check fuse or circuit breaker
        c. Check source of main power
        d. Broken wire or loose connection
    2. Power at compressor
        a. Compressor motor
        b. Overload
        c. Controls
        d. Control wiring
B. Unit runs, no cooling
    1. Loss of refrigerant
    2. Inefficient compressor
    3. Restriction in lines or accessories
        a. Damaged tubing
        b. Moisture
        c. Scale or dirt

C. Unit runs, insufficient cooling
   1. Shortage of refrigerant
   2. Inefficient compressor
   3. Obstruction
      a. Lines
      b. Refrigerant control
      c. Drier
   4. Control setting
D. Unit noisy
   1. Vibration of lines
   2. Compressor mounts
   3. Surplus of oil
   4. Defective compressor valves
   5. Loose components
   6. Refrigerant overcharge
   7. High head pressure
E. Unit short cycles
   1. Partial obstruction
   2. Leaky power element
   3. Improper adjustments of refrigerant control device
F. Recommended periodic inspections
   1. Amount of refrigerant
   2. Amount of oil
   3. Belt alignment
   4. Belt tension
   5. Condition of belt
   6. Condition of air cooled condenser
   7. Electrical connections
   8. Tubing support
   9. Water flow
G. Other

   The above are a few of the possible trouble spots found on equipment in the field. It is not to be taken as a final list. The number of possible problems is so numerous that it is not possible to list them all.

Laboratory Activity

1. Demonstrate why a fuse should be checked when out of the fuse box or the circuit so that the meter reading will not be affected by feed-back from the other electrical lines.

2. Show how some electrical components may be by-passed for the checking of an operation.

Shop Activity

Have the students work on the projects assigned to them in combination with laboratory activities.

During the last week of the year, the instructor will have the opportunity to evaluate his instruction. By the end of the year the instructor has an idea of the weak points of most students and these should be worked on. Perhaps each student could be asked to prepare a short instruction period on any phase of the course and given an opportunity to give the lesson to the class. This will help to fortify his ability to speak to customers when he goes out into the field. It will also help the students to evaluate themselves.

SECTION IV - YEAR ROUND AIR CONDITIONING

SECTION IV

YEAR ROUND AIR CONDITIONING

Unit	Title	Hours Class	Hours Laboratory	Hours Shop
1	Comfort Standards	5	4	6
2	Blueprint Reading	5	3	7
3	Working Diagrams	5	3	7
4	Building Construction	5	3	7
5	Heat Transfer	5	3	7
6	Psychrometrics	5	3	7
7	Winter Air Conditioning-Heating	25	10	40
8	Summer Air Conditioning-Cooling	30	13	47
9	Equipment Maintenance	5	3	7
	Total	90	45	135

UNIT OUTLINES

Section IV – Year Round Air Conditioning

Unit 1 – Comfort Standards

- A. Design temperatures
  - 1. Outdoor design temperatures
    - a. Dry bulb
    - b. Wet bulb
    - c. Summer
    - d. Winter
  - 2. Indoor design temperatures
    - a. Dry bulb
    - b. Relative humidity
  - 3. Design temperature difference
  - 4. Effective temperature
  - 5. Comfort zone
- B. Body reaction
  - 1. Contraction and dilation of blood vessels
  - 2. Increase or decrease of blood pumped by the heart
- C. Discomfort
  - 1. Physical
    - a. Bacteria
    - b. Dirt
    - c. Dust
    - e. Odors
    - f. Smoke
    - g. Temperature of surrounding surfaces
  - 2. Mental
    - a. Excessive operating costs
    - b. Excessive care and maintenance
    - c. Space occupied by equipment
    - d. Effects of excessive humidity
    - e. Insufficient humidity
      - (1) Drying out of furniture
      - (2) Static discharges
- D. Air movement
  - 1. Grille and register location
  - 2. Stratification
  - 3. Throw
  - 4. Velocities
- E. Air impurities
  - 1. Carbon from incomplete combustion
  - 2. Bacteria
  - 3. Plant pollen

4. Dust from ground or manufacturing processes
5. Removal of air
    a. Contact with water
    b. Dry filtering
    c. Wet filtering
    d. Electrostatic and charged media units

Unit 2 – Blueprint Reading
- A. Elevation views
    1. Front
    2. Rear
    3. Left side
    4. Right side
- B. Pan views
    1. Top
    2. Separate floor levels
- C. Dimensioning and scaling
    1. Use of scales
    2. Reduction to scale
    3. Extension lines
    4. Dimension lines
    5. Structural members
    6. Invisible edge lines
    7. Object lines
    8. Use of graph paper
- D. Structural details
    1. Terms used
    2. Frame structure
    3. Masonry structure
    4. Combination structure
- E. Plot plan–building orientation
    1. Prevailing wind
    2. Solar effect

Unit 3 – Working Diagrams
- A. Floor plans
    1. How to trace from blueprints
    2. How to measure building outline
    3. How to make plans
    4. Locations of windows and doors
    5. Measurements of halls and stairways
    6. How plans are used
- B. Symbols and abbreviations
    1. Equipment
    2. Duct work
        a. Risers
        b. Supply
        c. Returns

3. Registers
4. Grilles
5. Dampers
6. Piping
   a. Electrical
   b. Refrigerant
   c. Water
   d. Steam
7. Accessories

C. Freehand sketching
1. Maintaining proportion
2. Orthographic projection
3. Pictorial drawings
   a. Isometric
   b. Perspective

D. Schematics

Unit 4 – Building Construction

A. Exterior walls
1. Frame construction
   a. Types of framing
   b. Sills
2. Masonry construction

B. Interior walls and partitions
1. Walls over double joists
2. Wall stacks in old buildings
   a. Draft stops
   b. Lath and plaster walls
3. Stacks in masonry construction
4. Wall finishes
   a. Dry wall
   b. Lath and plaster
   c. Wood paneling
   d. Masonite
   e. Masonry or tile

C. Floors and ceilings
1. Basement construction
2. Girders
3. Joist headers
4. Working space in unexcavated spaces
5. Slab floor
6. Vented attics
7. Unvented attics

D. Insulation
1. Side wall
2. Ceiling
3. Floor
   a. Crawl space
   b. Slab

E. Vapor barriers

Unit 5 – Heat Transfer

A. Heat loss
   1. Transmission
      a. Thermal conductivity
         (1) Windows and doors with storm sash
         (2) Windows and doors without storm sash
         (3) Wall surfaces
         (4) Cold interior partitions
         (5) Cold ceilings
         (6) Cold floors
         (7) Ducts to surrounding air
      b. Surface or film resistance
      c. Resistance of an air space
   2. Infiltration
      a. Uncontrolled
         (1) Quality of construction
         (2) Weather stripping
         (3) Wind velocity
         (4) Building orientation
      b. Crackage method
      c. Air-change method
   3. Ventilation-controlled
B. Heat gain
   1. Transmission
      a. Material conductance
         (1) Exterior walls
         (2) Glass
         (3) Warm interior partitions
         (4) Warm ceilings
         (5) Warm floors
         (6) Warm pipes
      b. Air film conductance
      c. Air space conductance
      d. Time lag
   2. Solar
      a. Absorption
      b. Reflection
      c. Latitude
      d. Direction
      e. Glass
      f. Roof
      g. Walls
   3. Infiltration
   4. Ventilation air

Unit 6 – Psychrometrics

A. Properties of air
   1. Change in volume with change of temperature
   2. Change in volume with change of pressure
   3. Change in volume with change of both temperature and pressure
      a. Dry bulb temperature
      b. Wet bulb temperature
   4. Dew point
   5. Relative humidity
   6. Humidity ratio
   7. Degree of saturation
      a. Sensible heat
      b. Total heat

B. Psychrometric charts
   1. Dry bulb lines
   2. Wet bulb lines
   3. Dew-point lines
   4. Relative humidity lines
   5. Grains of moisture lines
   6. Enthalpy scale

C. Air and humidity calculations
   1. Heating
   2. Cooling
   3. Heating and humidification
      a. Air washer process
      b. Heating coils and air washer
   4. Cooling and dehumidification
   5. Cooling and humidification
   6. Chemical dehumidification

D. Ventilation requirements
   1. Return air and outside air mixture
   2. Return air and chilled air mixture
   3. By-pass return air
   4. By-pass portion of air mixture

E. Evaporative cooling
   1. Wetted pad packaged air cooler
   2. Slinger-packaged air cooler
   3. Rotary-disc packaged air cooler
   4. Rotary-spray packaged air cooler
   5. Limitations

Unit 7 – Winter Air Conditioning – Heating

A. Hot water heating
   1. Gravity circulation-limitations

2. Forced circulation
    a. Low temperature water systems
    b. Medium temperature water systems
    c. High temperature water systems
    d. Water velocity
    e. System adaptability
    f. Circuit balancing

B. Steam heating
    1. Pressures and temperatures of steam
    2. Volume changes
    3. Enthalpy values
    4. Quantity of steam
    5. One-pipe vacuum systems
    6. Two-pipe vapor systems
        a. Return trap
        b. Condensate pump return
        c. Vacuum return lines
    7. Hartford loop
    8. Air venting
    9. Steam traps
    10. Safety valves

C. Fluid flow
    1. Piping
        a. Series loop
        b. One pipe with single circuit
        c. One-pipe reverse turn
        d. Two-pipe reverse turn
        e. Two-pipe direct turn
        f. Three-and four-pipe
        g. Head loss in a piping system
        h. Expansion tanks
            (1) Location
            (2) Sizing
        i. Air separators and venters
        j. Flow control valves
    2. Circulators
        a. Pressure imposed on pumps
        b. Relationship between circulator and piping
        c. Horsepower requirements
        d. Vacuum systems
    3. Zoning
        a. Individual temperature control
        b. Multiple units for zone control

D. Heat transfer elements
   1. Natural convection units
      a. Radiators
         (1) Floor
         (2) Ceiling mounted
         (3) Effects of finishes
         (4) Effect of enclosures
      b. Convectors
      c. Perimeter-type radiator
         (1) Baseboard
         (2) Along the wall
   2. Forced convection units
      a. Unit heaters
         (1) Horizontal
         (2) Down blow
         (3) Cabinet
         (4) Propeller-fan type
      b. Fan coil units
      c. Induction units
      d. Air-handling units
E. Boilers
   1. Types
      a. Cast iron
      b. Steel
      c. Copper
      d. Low temperature boilers
      e. High temperature water generators
   2. Selection
      a. Equivalent direct radiation (M.B.H.)
      b. I.B.R. ratings
      c. S.B.I. ratings
F. Fuels and consumption
   1. Coal
      a. Anthracite
      b. Bituminous
   2. Fuel oil
      a. Grades
      b. Caloric values
      c. Storage
         (1) Inside
         (2) Outside
   3. Gases
      a. Natural
      b. Liquefied
      c. Manufactured
      d. Mixed
      e. Availability
      f. Burning characteristics

4. Electricity
5. Fuel consumption estimation
    a. Degree days
    b. Interpretation tables
6. Combustion losses
7. Combustion efficiency

G. Space heaters
    1. Room heaters
        a. Vented
        b. Unvented
    2. Wall heaters
    3. Floor furnaces

H. Warm air furnaces
    1. Gravity
        a. Location
            (1) Basement
            (2) Within controlled area
        b. Limitations
        c. Location of warm air registers
        d. Location of return air grilles

I. Heat pumps
    1. Air-to-air
    2. Water-to-air
    3. System heat recovery and additional heat
    4. Heat supplement
        Electrical heaters

Unit 8 – Summer Air Conditioning–Cooling

A. Sensible heat calculations–conduction, convection, radiation
    1. Windows and doors
        a. With storm sash
        b. Without storm sash
    2. Wall surfaces
    3. Warm ceilings and/or roofs
    4. Warm floors
    5. Warm interior partitions
    6. Appliances
        a. Gas
        b. Electric
    7. Lights
        a. Fluorescent
        b. Incandescent
    8. Machines
    9. Motors
    10. People–degree of activity

11. Ductwork
    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. Latent heat calculations
1. Internal
    a. Appliance
        (1) Gas
        (2) Electric
    b. People – degree of activity
2. External-ventilation air

C. Solar heat calculations
1. Glass
    a. Types
        (1) Ordinary glass
        (2) Plate glass
        (3) Heat-absorbing sheet glass
        (4) Heat-absorbing plate glass
        (5) Glare-reducing glass
    b. Solar angle
        (1) Time of year
        (2) Time of day
        (3) Exposure
        (4) Latitude
    c. Shading
        (1) Exterior awnings, canopies
        (2) Indoor shades, venetian blinds
        (3) Overhang
2. Walls and roofs
    a. Equivalent temperature difference
    b. Color–reflection of rays

D. Moisture calculations
1. Room dew point requirements
2. Conditioned air supply
    a. Dew point temperature
    b. Moisture content–grains per pound
    c. Quantity of air required
    d. Humidity ratio
    e. Lower unit suction pressure
    f. Reheat
        (1) Steam
        (2) Hot water
        (3) Condenser water discharge
        (4) Run-around cycle
        (5) Outdoor air

3. Sources of moisture in building

E. Return and outside air
   1. Desired resulting condition
   2. Air mixture proportions
   3. By-pass return
      a. Mixture with chilled air
      b. No variation in D.B. temperature and humidity
   4. By-pass outside air – mixed with chilled air
   5. By-pass return air and outside air mixture
   6. Psychrometric chart plotting of mixtures
   7. Sensible heat ratio
   8. Standard air
   9. Formulae and table variations
   10. Mathematical calculations

F. Coil sizing and selection
   1. Factors to be considered
      a. Cooling required
      b. Dehumidification required
      c. Temperatures of entering air
      d. Operating temperatures
      e. Air quantity limitations
      f. Space and dimensional limitations
      g. Coil face velocity
      h. Allowable friction resistances
   2. Evaporator coil with blower
   3. Add-on coil with existing blower and duct work

G. Condensing unit selection
   1. Self-contained
      a. Air-cooled
      b. Water-cooled
   2. Remote unit
      a. Air-cooled
      b. Water-cooled
      c. Evaporative condenser
      d. Balance with cooling coil
   3. Pre-charged lines and components

H. Water chillers
   1. Unitary assembly water-cooled condensers
   2. Remote installations
      a. Air-cooled condenser
      b. Water-cooled condenser
      c. Evaporative condenser
   3. Direct expansion
   4. Flooded type
   5. Water coils
      a. Counter flow
      b. Parallel flow

I. Room air conditioners
    1. Window units
        a. Casement windows
        b. Double-hung windows
    2. Wall units
    3. Console or portable units
    4. Heat pump conversion
    5. Current characteristics
J. Heat pumps
    1. Method of rating cooling capacity
    2. Balance point
    3. Cooling cycle
        a. Power requirements
        b. Air volume requirements
K. Absorption equipment
    1. Application situations
        a. Low cost fuel available
        b. High electric rates
        c. Inadequate electric facilities
        d. Central station units
        e. Remote or add-on units
    2. Cycles in common use
        a. Lithium bromide-water
        b. Ammonia-water
    3. Components
        a. Chiller
        b. Absorbers
        c. Generator
        d. Condensers
        e. Heat exchangers
        f. Pumps
        g. System controls
            (1) Capacity control
            (2) Protective devices
    4. Size and selection

Unit 9 – Equipment Maintenance
A. Heating equipment
    1. Hot water systems
        a. Water treatment
            (1) Inhibitors
            (2) Acidity pH factor
        b. Inspection and cleaning
            (1) Flues
            (2) Traps, air vents
            (3) Safety devices
        c. Input fuels and combustion

2. Warm air furnaces
    a. Input fuels and combustion
        (1) Primary air
        (2) Flues
        (3) Motor lubrication
        (4) Pressure regulators
    b. Controls
        (1) Gas valves
        (2) Thermocouples
        (3) Fan and limit controls
        (4) Thermostats

B. Cooling equipment
1. Room and unit air conditioners
    a. Filters
    b. Lubrication
    c. Condenser air flow
    d. Condensate drains
2. Central units
    a. Electrical
        (1) Starters and contactors
        (2) Protective devices
        (3) Motors
    b. Air handlers
        (1) Filters
        (2) Blowers
        (3) Motors
    c. Refrigerant circuit
        (1) Operating pressures
        (2) Refrigerant charge
        (3) Oil level
        (4) Pressure-control settings
        (5) Current draw
        (6) Condenser coolant quantity
        (7) Expansion valve bulb location

C. Air handling unit
1. Air filters
    a. Clean
    b. Replace
2. Fans and blowers
    a. Lubrication of bearings
    b. Fan belts
        (1) Replacement
        (2) Tension

D. Air distribution equipment
1. Dampers
    a. Check setting
    b. Lubrication of bearings and linkage
2. Duct
3. Grilles and registers

UNIT 1 – COMFORT STANDARDS
Class Instruction – 5 hours
Laboratory – 4 hours
Shop – 6 hours

Unit Guide

Unit Objectives

To impart an understanding of body reactions to changes in climatic conditions.

To develop the knowledge and understanding of various air impurities that cause discomfort and how they may be removed from the air; also the standards necessary to assure comfort conditions.

Tools and Materials

Text – Chapters 16, 19, 21
Comfort zone charts (text)
Sling psychrometer
Desk or wall humidity indicators
Electrostatic air filter demonstrator (optional). Literature on filters
Filter material samples

Unit Outline

A. Design temperatures
   1. Outdoor design temperatures
      a. Dry bulb
      b. Wet bulb
      c. Summer
      d. Winter
   2. Indoor design temperatures
      a. Dry bulb
      b. Relative humidity
   3. Design temperature difference
   4. Effective temperature
   5. Comfort zone
B. Body reaction
   1. Contraction and dilation of blood vessels
   2. Increase or decrease of blood pumped by the heart
C. Discomfort
   1. Physical
      a. Bacteria
      b. Dirt
      c. Dust
      d. Noise
      e. Odors
      f. Smoke
      g. Temperature of sorrounding surfaces

2. Mental
   a. Excessive operating costs
   b. Excessive care and maintenance
   c. Space occupied by equipment
   d. Effects of excessive humidity
   e. Insufficient humidity
      (1) Drying out of furniture
      (2) Static discharges

D. Air movement
   1. Grille and register location
   2. Stratification
   3. Throw
   4. Velocities

E. Air impurities
   1. Carbon from incomplete combustion
   2. Bacteria
   3. Plant pollen
   4. Dust from ground or manufacturing processes
   5. Removal of air
      a. Contact with water
      b. Dry filtering
      c. Wet filtering
      d. Electrostatic and charged media units

Laboratory Activity

1. Demonstrate the use and application of the sling psychrometer.

2. Show how to find relative humidity and other properties of air in conjunction with the psychrometric chart.

3. Explain wet-bulb depression and illustrate how some tables or charts indicate relative humidity by difference between the dry bulb temperature and the wet bulb temperature.

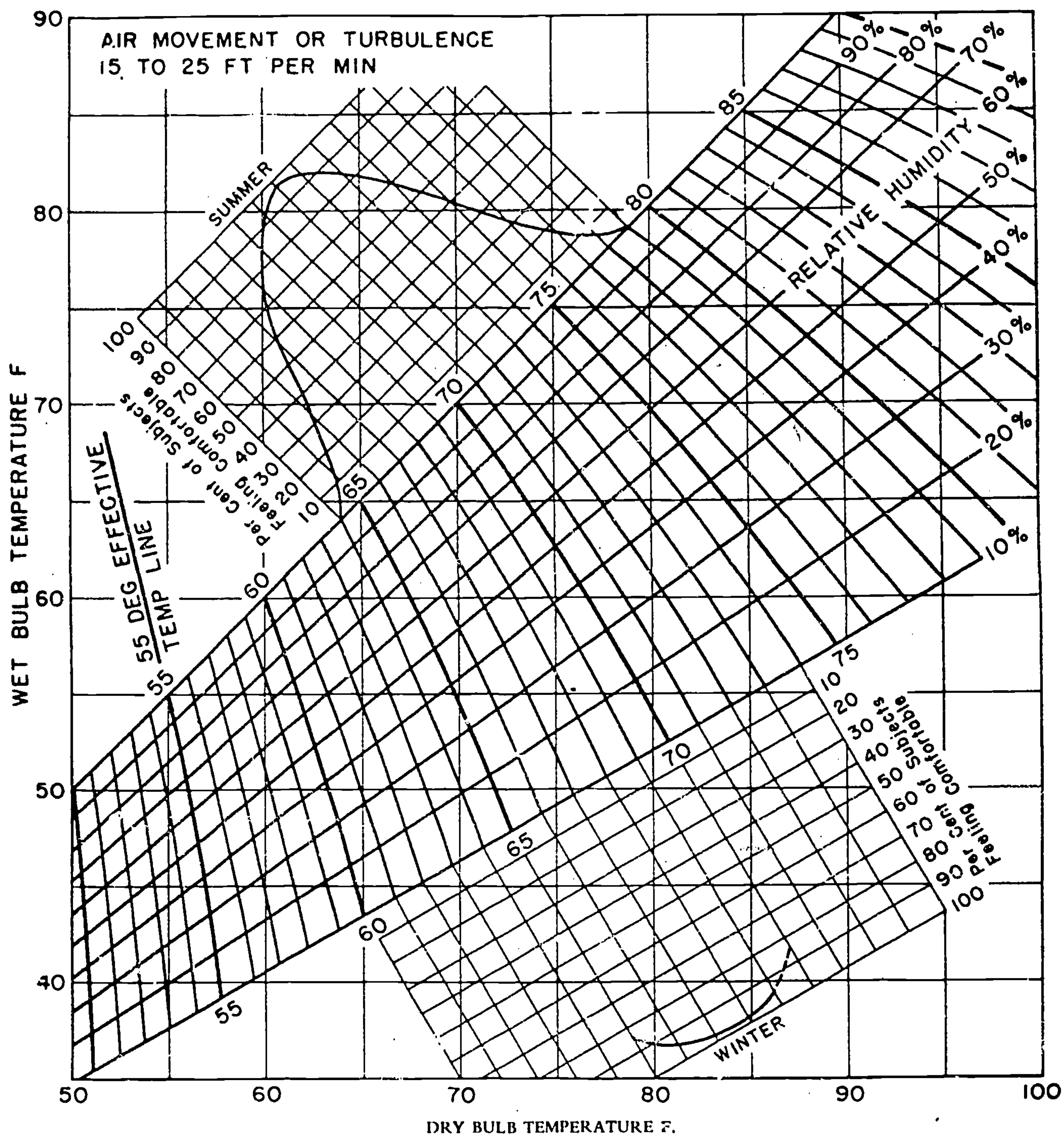
4. Show how cigarette smoke is removed with the electrostatic filter (optional).

5. Show the students various types of filters with pictures or filters if available.

6. Explain filter resistence to air flow.

Shop Activity

Have the students manipulate the instruments and record various readings and findings at several locations. Have the students supply as much information as possible using any two readings on the instruments. Have each student explain to the class his own interpretation of the use of the individual instruments.



A.S.H.V.E. Comfort Chart For Still Air

Note—Both summer and winter comfort zones apply to inhabitants of the United States only. Application of winter comfort line is further limited to rooms heated by central station systems of the convection type. The line does not apply to rooms heated by radiant methods. Application of summer comfort line is limited to homes, offices and the like, where the occupants become fully adapted to the artificial air conditions. The line does not apply to theaters, department stores, and the like where the exposure is less than 3 hours. The optimum summer comfort line shown pertains to Pittsburgh and to other cities in the northern portion of the United States and Southern Canada, and at elevations not in excess of 1000 ft. above sea level. An increase of one deg. ET should be made approximately per 5 deg. reduction in north latitude.

Dotted portion of winter comfort line was extrapolated beyond test data.

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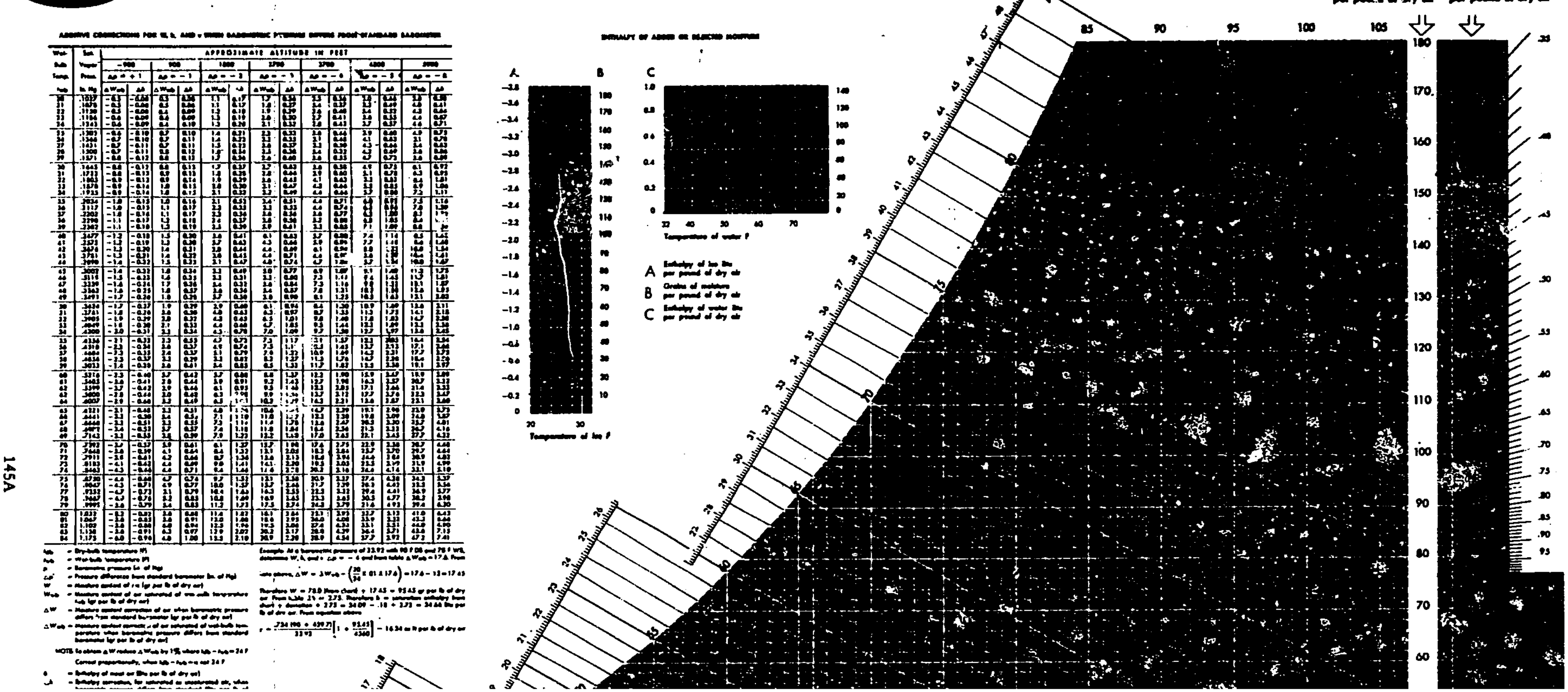
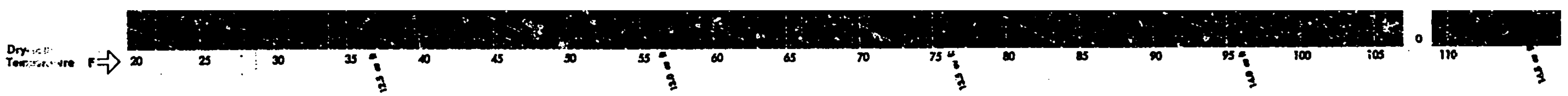
Carrier® PSYCHROMETRIC CHART Normal Temperatures





Below 32 F, properties and enthalpy deviation lines are for ice.

NOTE: Instructors should refer to the full-size psychrometric chart fold-out (available from the Carrier Corporation).

UNIT 2 – BLUEPRINT READING

Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To acquaint the student with the methods used in showing construction details and the need for different views and detail drawings.

To have the student acquire the capability of reading blueprints used in the refrigeration and air conditioning trade.

To have the student learn the names used for different portions of the structure.

Tools and Materials

Text – Chapters 18 and 21
Measuring tape
Graph paper
Architect's scales
Note paper and pencils
Drawing boards

Unit Outline

A. Elevation views
   1. Front
   2. Rear
   3. Left side
   4. Right side
B. Pan views
   1. Top
   2. Separate floor levels
C. Dimensioning and scaling
   1. Use of scales
   2. Reduction to scale
   3. Extension lines
   4. Dimension lines
   5. Structural members
   6. Invisible edge lines
   7. Object lines
   8. Use of graph paper

D. Structural details
   1. Terms used
   2. Frame structure
   3. Masonry structure
   4. Combination structure
E. Plot plan—building orientation
   1. Prevailing wind
   2. Solar effect

Laboratory Activity

1. Demonstrate on the board the differences in line presentation and weight for the showing of object lines, extension and dimension lines, and invisible lines that may be needed to clarify drawing.

2. Demonstrate the use of the architect's scales for the reduction of an actual object or wall-drawing on paper. Show how the different views of an object or building compliment one another for the complete comprehension of a project.

Shop Activity

1. With the students working in teams, have them take measurements of a room or small building, including pertinent data as to doors and windows.

2. Using graph paper, have them make reduced-scale drawings of the different views of the room or the building.

It would be beneficial at this time to have the instructor from the drafting department and the air conditioning instructor trade classes. The drafting instructor could teach the air conditioning students this unit while the air conditioning instructor shows the drafting students where their particular trade is an absolute necessity to the refrigeration industry. The air conditioning instructor could have the students make sketches of different electrical components and their relationship to the rest of the system.

UNIT 3 – WORKING DIAGRAMS
Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To have the student acquire a knowledge of working diagrams and the purpose of mechanical plans.

To acquaint the student with the need for correct measurements.

To develop an understanding and knowledge of sketching, and its importance to the craftsman.

Tools and Materials

Text Chapter 27
Tracing box
Drawing boards
Various plans
Simple regular and irregular objects

Unit Outline

A. Floor plans
    1. How to trace from blueprints
    2. How to measure building outline
    3. How to make plans
    4. Locations of windows and doors
    5. Measurements of halls and stairways
    6. How plans are used
B. Symbols and abbreviations
    1. Equipment
    2. Duct work
        a. Risers
        b. Supply
        c. Returns
    3. Registers
    4. Grilles
    5. Dampers
    6. Piping
        a. Electrical
        b. Refrigerant
        c. Water
        d. Steam
    7. Accessories

C. Freehand sketching
   1. Maintaining proportion
   2. Orthographic projection
   3. Pictorial drawings
      a. Isometric
      b. Perspective
D. Schematics

Laboratory Activity

1. Demonstrate on the blackboard and with the use of graph paper the sketching of straight and curved lines in non-uniform shapes. Show the difference between isometric and orthographic drawings.

2. Demonstrate the use of a tracing box.

3. Show on the blackboard various symbols commonly used in heating, refrigeration, ventilation, and comfort cooling. If possible prepare hand-out material of desired abbreviations and symbols from some appropriate piece of literature.

Shop Activity

1. Have the students trace simple house plans including windows and doors.

2. Have the student make some basic freehand sketches, including irregular shapes.

3. The instructor can prepare a test or completion sheet for students to fill out with the proper symbols and designated abbreviations that are predominantly in use in this area. The necessary symbols and abbreviations should be memorized by the students.

4. Students should make a layout of a typical installation of a small grocery store, including the refrigerant lines and the electrical lines. The duct work should be included in the air conditioning plans of the store.

5. If possible, students should use their neighborhood store as a model.

At this point the instructor should have prints of actual air conditioning jobs and have the students trace these and determine what each print tells them. Their findings should be written out for discussion.

UNIT 4 – BUILDING CONSTRUCTION
Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Objectives

To acquaint the students with the different types of construction in residences and commercial buildings, and the importance of this information for calculations and installation purposes.

To develop a knowledge and understanding of the different types of insulations encountered in various types of residential and commercial construction.

Tools and Materials

Text – Chapter 24
Samples of insulation and vapor barriers
Graph paper
Drawing boards
Architects' scales

Unit Outline

- A. Exterior walls
  - 1. Frame construction
    - a. Types of framing
    - b. Sills
  - 2. Masonry construction
- B. Interior walls and partitions
  - 1. Walls over double joists
  - 2. Wall stacks in old buildings
    - a. Draft stops
    - b. Lath and plaster walls
  - 3. Stacks in masonry construction
  - 4. Wall finishes
    - a. Dry wall
    - b. Lath and plaster
    - c. Wood paneling
    - d. Masonite
    - e. Masonry or tile
- C. Floors and ceilings
  - 1. Basement construction
  - 2. Girders
  - 3. Joist headers
  - 4. Working space in unexcavated spaces
  - 5. Slab floor
  - 6. Vented attics
  - 7. Unvented attics

D. Insulation
   1. Side wall
   2. Ceiling
   3. Floor
      a. Crawl space
      b. Slab
E. Vapor barriers

Laboratory Activity

1. Demonstrate with the use of cutaway sections if they are available, the problems of installing risers and stacks in interior walls with lath and plaster, or with draft stops in them.

2. Sketch on the blackboard different methods of installing insulation and vapor barriers in crawl spaces and slab floors.

3. Instruct students of the possibility of a change of plans if running of refrigeration piping is initially slated for these types of construction.

4. Teach the students to inform the company if there are apparent ways that would be less expensive to install piping and/or duct work. This would apply to any phase of the job as a whole.

Shop Activity

1. Have the students inspect the building or area (or another assigned building) and make notes of thickness of materials used. If it is feasible, the students should be taken on a field trip where new construction is going on. It would be advisable to take the students on a trip where a new food store or department store is being constructed.

2. Have the students make a sketch of a new construction and locate piping and/or duct work on the sketch as they believe it to be located.

UNIT 5 – HEAT TRANSFER
Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To acquaint the students with various methods of heat movement or transfer through building materials.

To have them learn about heat loss and heat gain, and how they may be controlled.

To teach the effects of direct solar rays on a structure.

Tools and Materials

Text – Chapter 16 and 19
Available short and long forms from various manufacturers
Slide rule type of calculator (available through equipment manufacturers)

Unit Outline

A. Heat loss
   1. Transmission
      a. Thermal conductivity
         (1) Windows and doors with storm sash
         (2) Windows and doors without storm sash
         (3) Wall surfaces
         (4) Cold interior partitions
         (5) Cold ceilings
         (6) Cold floors
         (7) Ducts to surrounding air
      b. Surface or film resistance
      c. Resistance of an air space
   2. Infiltration
      a. Uncontrolled
         (1) Quality of construction
         (2) Weather stripping
         (3) Wind velocity
         (4) Building orientation
      b. Crackage method
      c. Air-change method
   3. Ventilation-controlled

B. Heat gain
   1. Transmission
      a. Material conductance
         (1) Exterior walls
         (2) Glass
         (3) Warm interior partitions
         (4) Warm ceilings
         (5) Warm floors
         (6) Warm pipes
      b. Air film conductance
      c. Air space conductance
      d. Time lag
   2. Solar
      a. Absorption
      b. Reflection
      c. Latitude
      d. Direction
      e. Glass
      f. Roof
      g. Walls
   3. Infiltration
   4. Ventilation air

Laboratory Activity

1. Show the student samples of heat-load calculation forms such as those that are available from such places as National Warm Air Heating and Air Conditioning Association, and the Institute of Boiler and Radiator Manufacturers.

2. Demonstrate the use of the short form calculation sheets available and used by numerous manufacturers for unitary conditioner installation.

3. Demonstrate the use of heating and cooling slide-rule-type calculator.

Shop Activity

1. Have the students solve problems in heat transfer with various types of insulation and materials, with and without the added insulating characteristic of air film.

2. Have the students compare the heat-transfer values for a common wall with windows, depending on the latitude and also the time of day.

3. Have them make the same comparison for different types of shading on the same wall.

26.04 — (7 58)

COOLING AND HEATING LOAD ESTIMATE SHEET

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THE TRANE COMPANY
LA CROSSE, WISCONSIN

DATE ______ JOB NO. ______ EST. BY ______
NAME ______
ADDRESS ______
CITY & STATE ______
BRANCH OFFICE ______
ROOM ______ FLOOR ______ SH. NO. ______
L'GTH ______ W'DTH ______ HT. ______ VOL. ______ CU. FT

DESIGN DATA

OUTSIDE	SUMMER	INSIDE
F	DRY BULB	F
F	WET BULB	F
F	DEW POINT	F
%	PERCENTAGE HUMIDITY	%
	TOTAL HEAT BTU PER LB. OF AIR	
	GRAINS OF MOISTURE PER LB. OF DRY AIR	
F	WINTER	F

LATITUDE ______ TIME ______ AM. ______ PM.

WALL COLOR		ROOF COLOR		WINDOWS	
LIGHT	☐	LIGHT	☐	AWNINGS	☐
MEDIUM	☐	MEDIUM	☐	SHADES	☐
DARK	☐	DARK	☐	BARE	☐

SUMMARY OF HEAT GAINS

ITEM NO.	ITEM	SENSIBLE	LATENT
9	CONDUCTION		
17	EXCESS SOLAR		
18	DUCTS		
22	BODY		
29	EQUIPMENT		
32	INFILTRATION		
33	TOTAL SENSIBLE		X X X X X X X
34	TOTAL LATENT		←
35	TOTAL HEAT GAINS		

SENSIBLE HEAT PERCENTAGE

36 $\frac{\text{ITEM 33}}{\text{ITEM 35}}$ X 100 = ______ X 100 = %

37 DRY BULB TEMP. AIR SUPPLY = F.

38 WET BULB TEMP. AIR SUPPLY = F.

39 RISE IN DRY BULB TEMP. OF AIR SUPPLY ROOM D. B. — ITEM 37 = = F.

40 TOT. AIR SUPPLY = $\frac{\text{ITEM 33}}{1.1 \text{ X ITEM 39}}$ = CFM

______ / 1.1 X = CFM

HEAT LOAD OF VENTILATION AIR

41 NO. PEOPLE X CFM/PERSON = CFM

42 CFM O. A. X BTU/HR/CFM = BTU/HR

TOT. COOLING LOAD ON COILS & REFR. APPAR.

	ITEM 35	
	PLUS ITEM 42	
43	TOT. COOLING LOAD BTU/HR.	

TONNAGE EQUIVALENT OF COOLING LOAD

44 $\frac{\text{ITEM 43}}{12000}$ = $\frac{\quad}{12000}$ = TONS

CONDUCTION SENSIBLE HEAT GAINS AND LOSSES

ITEM NO.	ITEM	DIMENSIONS	AREA SQ. FT.	SUMMER U	SUMMER TD	SUMMER SEN. HT. BTU/HR.	WINTER U	WINTER TD	WINTER SEN. HT. BTU/HR
1	EXTERIOR WALL GROSS			X	X	X X X X X X	X	X	X X X X X
2	EXTERIOR GLASS								
3	EXTERIOR WALL NET								
4	PARTITIONS NET								
5	GLASS IN PARTITIONS								
6	FLOOR								
7	CEILING OR ROOF								
8	MISC.								
9	TOTAL CONDUCTION GAINS & LOSSES			•	•		•	•	

EXCESS SOLAR HEAT GAINS

ITEM NO.	ITEM					SENSIBLE	LATENT
10	WALLS FACING						
11	WALLS FACING						
12	GLASS FACING						
13	GLASS FACING						
14	ROOF						
15	SKYLIGHTS						
16	MISC.						
17	TOTAL EXCESS SOLAR HEAT GAINS						
18	DUCT GAINS						

BODY HEAT GAINS

ITEM NO.	ITEM			SENSIBLE	LATENT
19	SENSIBLE	NO. PEOPLE	X		
20	LATENT (QUIET)	NO. PEOPLE	X		
21	LATENT (ACTIVE)	NO. PEOPLE	X		
22	TOTAL BODY HEAT GAINS				

EQUIPMENT HEAT GAINS

ITEM NO.	ITEM			SENSIBLE	LATENT
23	ELECTRIC LIGHTS		WATTS X 3.4		
24	SMALL ELECTRIC MOTORS (2 H.P. & SMALLER)		H.P. X 3600		
25	LARGE ELECTRIC MOTORS (3 H.P. & LARGER)		H.P. X 3000		
26	ELECTRIC EQUIPMENT		WATTS X 3.4		
27	GAS EQUIPMENT	NO.	X		
28	MISC.	NO.	X		
29	TOTAL EQUIPMENT GAINS				

INFILTRATION GAINS

ITEM NO.	ITEM			SENSIBLE	LATENT
30	ROOM VOLUME	CU. FT. X	SEN. FACTOR		X X X X X X X X X
31	ROOM VOLUME	CU. FT. X	LAT. FACTOR		
32	TOTAL INFILTRATION HEAT GAINS				

CHRYSLER AIRTEMP

AIR CONDITIONING SURVEY AND CALCULATIONS

DEALER ____________ ADDRESS ____________ DATE ____________

CUSTOMER ____________ ADDRESS ____________

INST. ADDRESS ____________ BUSINESS OR USE ____________ ESTIMATOR ____________

ROOM VOLUME: Length ________ X Width ________ X Height ________ = Cu. Ft. ________

AIR CIRCULATIONS PER HOUR = CONDITIONER CFM ( ) / ROOM VOLUME ( ) X 60 = DRY TONS

CONDITIONED AIR, CFM ________

OUTSIDE AIR, CFM ________

HEAT LEAKAGE		Net Sq. Ft. of Surface	COOLING DUTY Multiply Sq. Ft. by		COOLING DUTY B. T. U. Per Hour	HEATING DUTY Multiply Sq. Ft. by	HEATING DUTY B. T. U. Per Hour
WALLS OR PORTIONS OF WALLS EXPOSED TO OUTSIDE	(North		4.5			21.6	
	(South—Shaded		4.5			21.6	
	(South—Unshaded		9.0			21.6	
	(East		4.5			21.6	
	(West—Shaded		4.5			21.6	
	(West—Unshaded		12.0			21.6	
WALLS OR PORTIONS OF WALLS DIRECTLY IN CONTACT WITH GROUND			0			9.6	
GLASS IN OUTSIDE WALLS			Glass Brick Walls	Glass Windows			
	(North		7.5	16.8		84	
South	Shaded by Buildings		7.5	16.8		84	
South	Shaded by Awnings or Koolshade Screens		12	30		84	
South	Shaded by Venetian Blinds or Shades		30	45		84	
	(East		7.5	16.8		84	
West	Shaded by Buildings		7.5	16.8		84	
West	Shaded by Awnings or Koolshade Screens		15	40		84	
West	Shaded by Venetian Blinds or Shades		38	67		84	
DOUBLE PLASTER PARTITIONS NEXT TO UNCONDITIONED AREAS (See table on Reverse side for other construction.)			4.2				
CEILINGS For other Factors see Table on Reverse Side.	(Under Fin. Rooms		3.6			0	
	(Under Attic					14.4	
	(Under Flat Roof					21.6	
SKYLIGHTS			100			120	
FLOOR OR PORTIONS OF FLOOR	(Over Fin. Rooms		3.6			0	
	(Over Basement		3.0			9.6	
	(Over Ground		0			0	

INTERNAL HEAT	Unit	No. of Units	Multiply No. of Units by	B. T. U. Per Hour	Heating Multiply	B. T. U. Per Hour
OUTSIDE AIR As Infiltration and/or Air Through Conditioner	C.F.M.		16		72	
PEOPLE (Normal No. of People)	Person		220			
LIGHTS (Watts on Sunny Day)	Watt		3.4			
OTHER SOURCES OF HEAT						
1. Coffee Urns	Urn		1800			
2. Steam Tables	Lineal Foot		340			
3. Motors	Horse Power		2546			
4. Motors,	Watts		3.4			
5. Electrical Apparatus	Watts		3.4			
6. Gas Apparatus	Per Burner		1500			
7.						

Total Dry Tons = ———— / 12000 = Total Dry B. T. U. per hour = Total Heating B.T.U. Per Hour =

MOISTURE TONS

INTERNAL HEAT	Unit	No. of Units	Multiply No. of Units by	B. T. U. per Hour
OUTSIDE AIR As Infiltration and/or Air Through Conditioner	c.f.m.		23.5 † 12	
PEOPLE	Person		*180	
OTHER SOURCES OF MOISTURE				
1. Coffee Urns	Urn		200	
2. Steam Tables	Lineal Foot		60	
3.				
4.				

Total Moisture Tons = ———— / 12000 = Total Moisture B.T.U. per hour =

† For factors corresponding to other wet bulbs, see reverse side.

*For Increased Activity Rates such as Shop Work, Use 280 BTU per Hour.

COOLING LOAD SUMMATION

Dry Tons.......... =
Moisture Tons....... =
Total Tons.......... =

Summer Conditions:
Inside 80° F.—50% R.H.
Outside 95° F.—75° F.W.B.

Winter Conditions:
70° Inside 0° Outside.

SKETCH ROOM ON REVERSE SIDE — Show adjacent rooms, doors, windows, outside walls, etc. Indicate North by arrow.

Form EF-108 (C) — 906 Printed in U.S.A.

ENGINEERING DATA

Sketch Areas To Be Conditioned Below

	ADDITIONAL PARTITION AND ROOF FACTORS	FACTORS: Without Insulation	FACTORS: With ½ Inch Insulation	Special
PARTITIONS	Single Plaster Partitions	7.5		
	Metal (or Wood) and Glass Partitions	10		
ROOFS No Attic Space	Corrugated Iron on Strips	50		
	Tar Paper on 1" Wood	26	17	
	Felt Roofing on 1" Wood	22	15	
	Composition Roofing on 3" Concrete	18	12	
	Composition Roofing on 6" Concrete	12	9	
WITH PLASTER (or Wood) CEILING under Attic Space	Tar Paper or Composition Roof on 1" Wood	18	12	
	Composition Roof on 3" Concrete	12	9	
	Composition Roof on 6" Concrete	10	7.5	
	Sprayed Roof—all wetted surface			3.0
	2" Blanket Insulation (or heavier)			6.0

Factors for Outside Air Moisture Load With Various Outside Wet Bulbs.	Outside Wet Bulb	Factors
	73	3.7
	74	7.6
	75	12
	76	13.7
	77	18.5
	78	23.5
	79	27.3
	80	31.4

CONVERSION FACTORS — HEATING

$$\text{E.D.R. (STEAM)} = \frac{\text{HEATING B.T.U.}}{240}$$

$$\text{E.D.R. (HOT WATER)} = \frac{\text{HEATING B.T.U.}}{150}$$

DATA FOR DESIGN:	
Maximum summer water temperature—degrees F.	
Average water pressure Lbs. per sq. in.	
Maximum summer temperature Degrees F. Compressor Room	
Electric Rate c. per K. W. H.	
Water Rate $ per	
If cold well—give water temp. and flow in gal-min.	

TYPE OF PRESENT HEATING SYSTEM

- ☐ Hot Air Furnace Gravity
- ☐ Hot Air Furnace with Blower
- ☐ One Pipe Steam
- ☐ Two Pipe Steam
- ☐ Two Pipe Vapor
- ☐ Two Pipe Vacuum
- ☐ Hot Water
- ☐ Forced Hot Water
- ☐ Central Fan and Heating Coil
- ☐ Unit Heaters

Steam Operating Pressure Lbs. Sq. In.

Hot Water Operating Temperature, Deg. F.

Direction of Prevailing Wind

Current Characteristics (Power Co.)------

------ Volts, ------ Cycle, ------ Phase

Water Supply and Drains by-----------

Length: Supply --------Drain---------

Steam Lines Furnished by-------------

Length: Supply-------- Return--------

Wiring Furnished by------------------

Foundation Furnished by--------------

UNIT 6 – **PSYCHROMETRICS**
Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To impart some knowledge of the various properties of air.

To acquaint the student with methods of formulating air and humidity calculations.

To develop a knowledge and understanding of ventilation requirements under specific load conditions.

Tools and Materials

Text – Chapter 16 and 20
Transparencies (optional)
Psychrometric charts
Pan of water
Glass jar and jar holder
Heat source

Unit Outline

A. Properties of air
   1. Change in volume with change of temperature
   2. Change in volume with change of pressure
   3. Change in volume with change of both temperature and pressure
      a. Dry bulb temperature
      b. Wet bulb temperature
   4. Dew point
   5. Relative humidity
   6. Humidity ratio
   7. Degree of saturation
      a. Sensible heat
      b. Total heat
B. Psychrometric charts
   1. Dry bulb lines
   2. Wet bulb lines
   3. Dew-point lines
   4. Relative humidity lines
   5. Grains of moisture lines
   6. Enthalpy scale

C. Air and humidity calculations
   1. Heating
   2. Cooling
   3. Heating and humidification
      a. Air washer process
      b. Heating coils and air washer
   4. Cooling and dehumidification
   5. Cooling and humidification
   6. Chemical dehumidification

D. Ventilation requirements
   1. Return air and outside air mixture
   2. Return air and chilled air mixture
   3. By-pass return air
   4. By-pass portion of . mixture

E. Evaporative cooling
   1. Wetted pad packaged air cooler
   2. Slinger-packaged air cooler
   3. Rotary-disc packaged air cooler
   4. Rotary-spray packaged air cooler
   5. Limitations

Laboratory Activity

1. Demonstrate a change in air volume with a change in temperature with the use of a pan of water, an inverted glass jar, a jar holder, and a source of heat. Hold the inverted glass jar so that the mouth of the jar is slightly under water. Carefully apply heat to the jar and the air will escape from the inverted jar. As the glass jar is permitted to cool, water will rise in the glass jar.

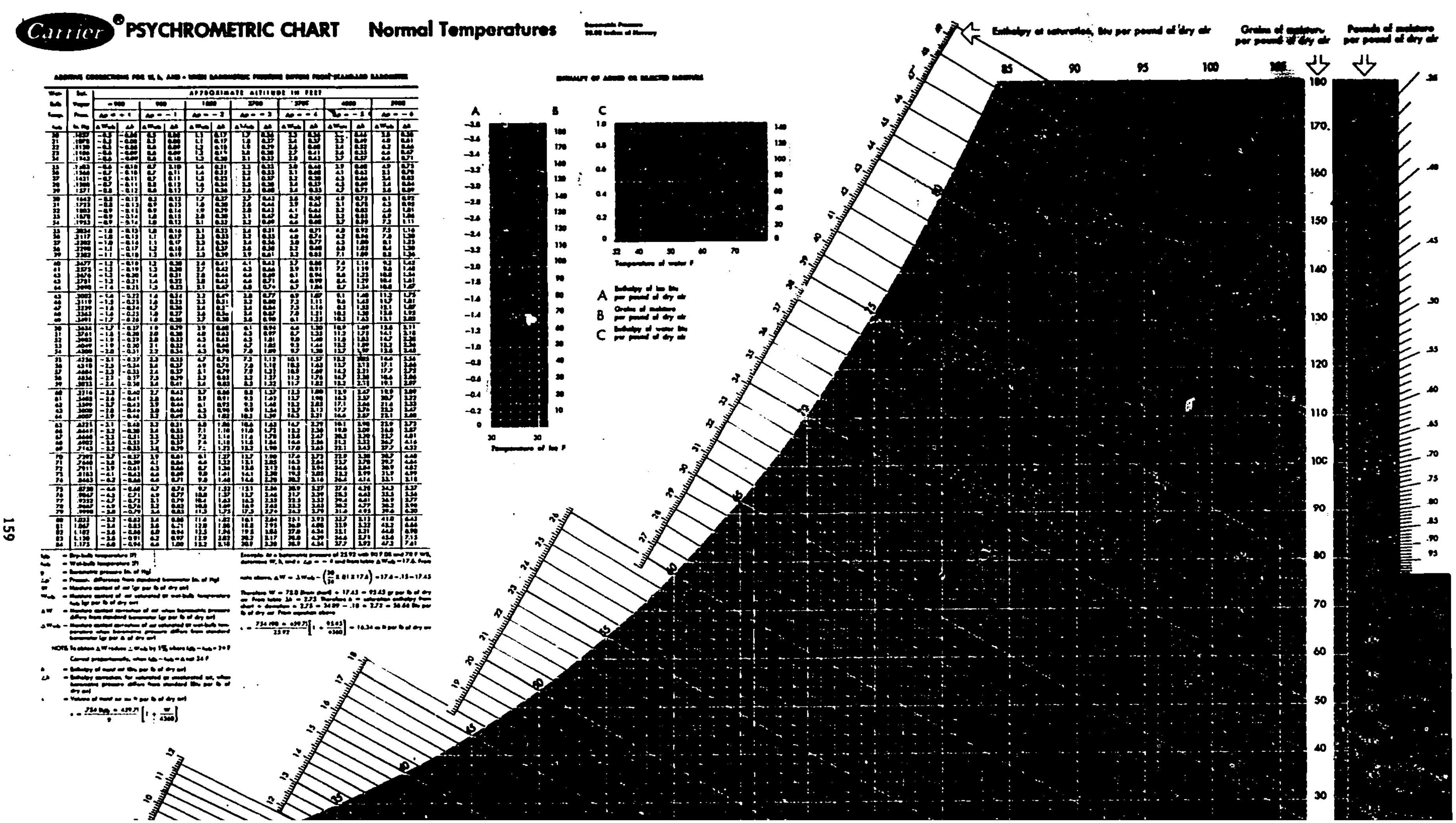
2. With the use of the overhead or opaque projector and transparencies or psychrometric charts, demonstrate that all air properties can be found when two of the conditions can be located by a point on the psychrometric chart.

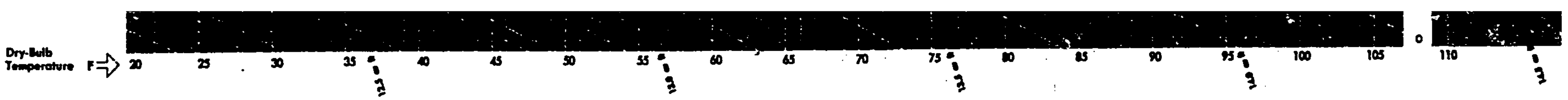
3. Plot locations of air mixtures on the charts.

4. Demonstrate mathematical calculations of air mixtures.

Shop Activity

Assign problems in psychrometry to students.


Carrier PSYCHROMETRIC CHART Normal Temperatures
APPROXIMATE ALTITUDE IN FEET
Enthalpy at saturation, Btu per pound of dry air
Grains of moisture per pound of dry air
Pounds of moisture per pound of dry air
A Enthalpy of ice Btu per pound of dry air
B Grains of moisture per pound of dry air
C Enthalpy of water Btu per pound of dry air
Temperature of water F
Temperature of ice F
1960, 1961 CARRIER CORPORATION PRINTED IN U.S.A. FORM AC531 1267 (81130 2)



Below 32 F, properties and enthalpy deviation lines are for ice.

NOTE: Instructors should refer to the full-size psychrometric chart fold-out (available from the Carrier Corporation.)

UNIT 7 – WINTER AIR CONDITIONING–HEATING

Class Instruction – 25 hours
Laboratory – 10 hours
Shop – 40 hours

Unit Guide

Unit Objectives

To acquaint the students with the various types and components of winter air conditiong systems and designs.

To impart an understanding of the different hydronic, steam, and warm air applications.

To develop a knowledge and understanding of fuels and combustion, comparison of caloric values, and the methods of sizing heating equipment.

Tools and Materials

Text - Chapter 20
Air separator
Expansion tank
Flow control valves
Circulating valves
Air vents
Pressure relief valves
Pressure reducing valves
Gas burner
Shut-off valves
Pressure regulator
Electric gas valve
Safety pilots
Gun-type oil burner
Forced warm air furnace

Most of this equipment will be mock and will have to be explained to the students. The facilities are not available to install such an elaborate set up. Some of the aspects of this unit can be demonstrated to the students by field trips and films. It is also possible to make use of the heating shop to demonstrate any portion of the unit that pertains to oil heat and oil-fired furnaces.

Unit Outline

A. Hot water heating
   1. Gravity circulation-limitations
   2. Forced circulation
      a. Low temperature water systems
      b. Medium temperature water systems
      c. High temperature water systems
      d. Water velocity
      e. System adaptability
      f. Circuit balancing

B. Steam heating
   1. Pressures and temperatures of steam
   2. Volume changes
   3. Enthalpy values
   4. Quantity of steam
   5. One-pipe vacuum systems
   6. Two-pipe vapor systems
      a. Return trap
      b. Condensate pump return
      c. Vacuum return lines
   7. Hartford loop
   8. Air venting
   9. Steam traps
   10. Safety valves

C. Fluid flow
   1. Piping
      a. Series loop
      b. One pipe with single circuit
      c. One-pipe reverse turn
      d. Two-pipe reverse turn
      e. Two-pipe direct turn
      f. Three-and four-pipe
      g. Head loss in a piping system
      h. Expansion tanks
         (1) Location
         (2) Sizing
      i. Air separators and venters
      j. Flow control valves
   2. Circulators
      a. Pressure imposed on pumps
      b. Relationship between circulator and piping
      c. Horsepower requirements
      d. Vacuum systems
   3. Zoning
      a. Individual temperature control
      b. Multiple units for zone control

D. Heat transfer elements
   1. Natural convection units
      a. Radiators
         (1) Floor
         (2) Ceiling mounted
         (3) Effects of finishes
         (4) Effect of enclosures
      b. Convectors
      c. Perimeter-type radiator
         (1) Baseboard
         (2) Along the wall

2. Forced convection units
    a. Unit heaters
        (1) Horizontal
        (2) Down blow
        (3) Cabinet
        (4) Propeller-fan type
    b. Fan coil units
    c. Induction units
    d. Air-handling units

E. Boilers
1. Types
    a. Cast iron
    b. Steel
    c. Copper
    d. Low temperature boilers
    e. High temperature water generators
2. Selection
    a. Equivalent direct radiation (M.B.H.)
    b. I.B.R. ratings
    c. S.B.I. ratings

F. Fuels and consumption
1. Coal
    a. Anthracite
    b. Bituminous
2. Fuel oil
    a. Grades
    b. Caloric values
    c. Storage
        (1) Inside
        (2) Outside
3. Gases
    a. Natural
    b. Liquefied
    c. Manufactured
    d. Mixed
    e. Availability
    f. Burning characteristics
4. Electricity
5. Fuel consumption estimation
    a. Degree days
    b. Interpretation tables
6. Combustion losses
7. Combustion efficiency

G. Space heaters
    1. Room heaters
        a. Vented
        b. Unvented
    2. Wall heaters
    3. Floor furnaces
H. Warm air furnaces
    1. Gravity
        a. Location
            (1) Basement
            (2) Within controlled area
        b. Limitations
        c. Location of warm air registers
        d. Location of return air grilles
I. Heat pumps
    1. Air-to-air
    2. Water-to-air
    3. System heat recovery and additional heat
    4. Heat supplement
        Electrical heaters

Laboratory Activity

Utilize all available fixtures to demonstrate the different types of heating systems available. Use available films and literature to explain various means of supplying heat to a commercial system.

Shop Activity

Have students write information from research on various heating systems as they pertain to air conditioning in the winter.

During the study of this unit the instructor should have the students visit the heating shop and possibly exchange students for part of the unit. If this arrangement is not possible the instructor should use the building equipment to instruct the students on this unit. If possible the instructor should have the various fuel companies send representatives to discuss the aspects of this unit with the students.

Films are available for this unit and should be utilized. Because of the scope of the unit the instructor will have to depend on visual aids and literature that are available.

The students can visit some large plant where various fuels and equipment of the nature encompassed within this unit are used. The instructor should make contact with representatives of these companies and make arrangements for the visits. Utilities companies should be contacted for information pertaining to their particular involvement in this part of the industry.

Manufacturing representatives should be invited to present their equipment to the students.

UNIT 8 – SUMMER AIR CONDITIONING-COOLING

Class Instruction – 30 hours
Laboratory – 13 hours
Shop – 47 hours

Unit Guide

Unit Objectives

To acquaint the students with the calculations necessary for a thorough check of total heat gain.

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

To assist the student in understanding the cooling cycle of heat pumps and also room air conditioners.

To develop a knowledge and understanding of water chillers and also absorption equipment.

Tools and Materials

Text – Chapters 19 through 24
Psychrometric charts and tables
Graph paper
Vacuum pump
Refrigerant
Manifold test sets
Refrigeration tools
Voltmeter
Manufacturers' specs and data sheets
Add-on cooling unit
Room air conditioner
Water chiller and absorption unit (optional)

Unit Outline

A. Sensible heat calculations–conduction, convection, radiation
   1. Windows and doors
      a. With storm sash
      b. Without storm sash
   2. Wall surfaces
   3. Warm ceilings and/or roofs
   4. Warm floors
   5. Warm interior partitions
   6. Appliances
      a. Gas
      b. Electric
   7. Lights
      a. Fluorescent
      b. Incandescent
   8. Machines
   9. Motors
   10. People–degree of activity

11. Ductwork
    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. Latent heat calculations
1. Internal
    a. Appliance
        (1) Gas
        (2) Electric
    b. People – degree of activity
2. External-ventilation air

C. Solar heat calculations
1. Glass
    a. Types
        (1) Ordinary glass
        (2) Plate glass
        (3) Heat-absorbing sheet glass
        (4) Heat-absorbing plate glass
        (5) Glare-reducing glass
    b. Solar angle
        (1) Time of year
        (2) Time of day
        (3) Exposure
        (4) Latitude
    c. Shading
        (1) Exterior awnings, canopies
        (2) Indoor shades, venetian blinds
        (3) Overhang
2. Walls and roofs
    a. Equivalent temperature difference
    b. Color–reflection of rays

D. Moisture calculations
1. Room dew point requirements
2. Conditioned air supply
    a. Dew point temperature
    b. Moisture content-grains per pound
    c. Quantity of air required
    d. Humidity ratio
    e. Lower unit suction pressure
    f. Reheat
        (1) Steam
        (2) Hot water
        (3) Condenser water discharge
        (4) Run-around cycle
        (5) Outdoor air
3. Sources of moisture in building

E. Return and outside air
   1. Desired resulting condition
   2. Air mixture proportions
   3. By-pass return
      a. Mixture with chilled air
      b. No variation in D.B. temperature and humidity
   4. By-pass outside air – mixed with chilled air
   5. By-pass return air and outside air mixture
   6. Psychrometric chart plotting of mixtures
   7. Sensible heat ratio
   8. Standard air
   9. Formulae and table variations
   10. Mathematical calculations

F. Coil sizing and selection
   1. Factors to be considered
      a. Cooling required
      b. Dehumidification required
      c. Temperatures of entering air
      d. Operating temperatures
      e. Air quantity limitations
      f. Space and dimensional limitations
      g. Coil face velocity
      h. Allowable friction resistances
   2. Evaporator coil with blower
   3. Add-on coil with existing blower and duct work

G. Condensing unit selection
   1. Self-contained
      a. Air-cooled
      b. Water-cooled
   2. Remote unit
      a. Air-cooled
      b. Water-cooled
      c. Evaporative condenser
      d. Balance with cooling coil
   3. Pre-charged lines and components

H. Water chillers
   1. Unitary assembly water-cooled condensers
   2. Remote installations
      a. Air-cooled condenser
      b. Water-cooled condenser
      c. Evaporative condenser
   3. Direct expansion
   4. Flooded type
   5. Water coils
      a. Counter flow
      b. Parallel flow

I. Room air conditioners
   1. Window units
      a. Casement windows
      b. Double-hung windows
   2. Wall units
   3. Console or portable units
   4. Heat pump conversion
   5. Current characteristics

J. Heat pumps
   1. Method of rating cooling capacity
   2. Balance point
   3. Cooling cycle
      a. Power requirements
      b. Air volume requirements

K. Absorption equipment
   1. Application situations
      a. Low cost fuel available
      b. High electric rates
      c. Inadequate electric facilities
      d. Central station units
      e. Remote or add-on units
   2. Cycles in common use
      a. Lithium bromide-water
      b. Ammonia-water
   3. Components
      a. Chiller
      b. Absorbers
      c. Generator
      d. Condensers
      e. Heat exchangers
      f. Pumps
      g. System controls
         (1) Capacity control
         (2) Protective devices
   4. Size and selection

Laboratory Activity

1. With the available materials (projectors, transparencies, charts, and other aids) explain the wide variations of co-efficients for different types of constructions.

2. Use charts and graphs to point out the differences between gas and electric appliances.

3. Using charts and other available materials explain the heat transfer through various types of glass, and what part the time of day, the angle of the sun, and the time of year has to do with the amount of heat from solar radiation.

4. Demonstrate what effect shaded windows and color have on the amount of heat being transferred.

5. Use the Chart and explain heat through psychrometry.

6. Using manufacturers' data, show students how coil and condensing unit selections are made.

7. Show on the board how the selection of more than one coil could be possible.

8. Use all available materials to describe and point out the advantages of some types of units over others and how to determine what unit is best suited for any given circumstance.

Shop Activity

1. Have the students use charts and calculate heat loads for various wall constructions.

2. Have the students calculate loads for different situations (restaurants, office space, manufacturing space, etc).

3. Have the students reduce the size of equipment needed for a residence by adding shading, double glass etc.

4. With a psychrometric chart have the students plot various conditions.

5. Using manufacturer's specifications, have the students balance remote components.

6. Have the students start up an air conditioner and make the proper adjustments.

TRANSMISSION HEAT LOAD

For load calculation purposes, the heat transferred through a given wall can be calculated by the basic heat transfer equation:

$$Q = U \times A \times TD$$

Q = Heat Transfer, BTU/hr.

U = Overall heat transfer coefficient, BTU/(hour) (sq. ft.) (°F. TD)

A = Area in square feet

TD = Temperature differential between outside design temperature and refrigerated space design temperature, °F.

For the wall in the previous example, the heat transmission per hour through an area of 90 square feet with an inside temperature of 0° F. and an outside temperature of 80° F. is

$$Q = U \times A \times TD$$
$$= .114 \times 90 \text{ square feet} \times 80^\circ \text{ TD}$$
$$= 821 \text{ BTU/hr.}$$

The entire heat gain by transmission into a given refrigerated space can be found in a similar manner by determining the U factor for each part of the structure surrounding the refrigerated space, and calculating as above.

VALUES OF THERMAL CONDUCTIVITY FOR BUILDING MATERIALS

Extensive testing has been done by many laboratories to determine accurate values for heat transfer through all common building and structural materials. Certain materials have a high resistance to the flow of heat (a low thermal conductivity) and are therefore used as insulation to decrease the heat transfer into the refrigerated space. There are many different types of insulation such as asbestos, glass fiber, cork, reflective metals, and the new foam materials. Most good insulating materials have a thermal conductivity (k) factor of approximately .25 or less, and rigid foam insulations have been developed with thermal conductivity (k) factors as low as .12 to .15.

Heat transmission coefficients for many commonly used building materials are shown in Table 4.

Table 4

TYPICAL HEAT TRANSMISSION COEFFICIENTS

(Extracted from 1967 ASHRAE Handbook of Fundamentals, Reprinted by Permission)

Material	Density lb./cu. ft.	Mean Temp. °F.	Conductivity k	Conductance C	Resistance (R) Per In.	Resistance (R) Overall
BUILDING BOARD						
Asbestos-Cement Board	120	75	4.0		.25	
Gypsum or Plaster, ½"	50	75		2.25		.45
Plywood	34	75	.80		1.25	
Sheathing, Wood	20	75	.38		2.63	
Wood Fiber, Hardboard	65	75	1.40		.72	
BUILDING PAPER						
Felt, Vapor-permeable		75		16.70		.06
Plastic Film, Vapor-seal		75		Negligible		
FLOORING MATERIALS						
Carpet and Fiber Pad		75		.48		2.08
Carpet and Rubber Pad		75		.81		1.23
Cork Tile, ⅛"		75		3.60		.28
Terrazzo, 1"		75		12.50		.08
Tile, Asphalt, Vinyl, Linoleum		75		20.0		.05
Wood Subfloor, 25/32"				1.02		.98
Wood Flooring, ¾"				1.47		.68

Table 4 (cont.)
TYPICAL HEAT TRANSMISSION COEFFICIENTS

Material	Density lb./cu. ft.	Mean Temp. °F.	Conductivity k	Conductance C	Resistance (R) Per In.	Resistance (R) Overall
INSULATING MATERIALS						
Mineral Wool Blanket	0.5	75	.32		3.12	
Fiber Glass Blanket	0.5	75	.32		3.12	
Corkboard	6.5-8.0	0	.25		4.0	
Glass Fiber Board	9.5-11.0	−16	.21		4.76	
Expanded Urethane, R11		0	.17		5.88	
Expanded Polystyrene	1.0	0	.24		4.17	
Mineral Wool Board	15.0	0	.25		4.0	
Insulating Roof Deck, 2"		75		.18		5.56
Mineral Wool Loose Fill	2.0-5.0	0	.23		4.35	
Perlite, Expanded	5.0-8.0	0	.32		3.12	
MASONRY MATERIALS						
Concrete, Sand & Gravel	140		12.0		.08	
Brick, Common	120	75	5.0		.20	
Brick, Face	130	75	9.0		.11	
Hollow Tile, 2 cell, 6"		75		.66		1.52
Concrete Block, Sand and Gravel, 8"		75		.90		1.11
Concrete Block, Cinder, 8"		75		.58		1.72
Gypsum Plaster, sand	105	75	5.6		.18	
ROOFING						
Shingles, Asbestos-Cement	[illegible]	75		4.76		.21
Asphalt Roll Roofing	70	75		6.50		.15
Roofing, Built Up, ⅜"	70	75		3.0		.33
Shingles, Wood		75		1.06		.94
SIDING						
Wood, Bevel, 1 x 8		75		1.23		.81
WOODS						
Maple, Oak, Hardwood	45	75	1.10		.91	
Fir, Pine, Softwood	32	75	.80		1.25	
GLASS						
Flat Glass, Single				.73		1.37
Insulating Glass, Double				.49		2.04
Insulating Glass, Triple				.38		2.63
Storm Windows				.44		2.27
MISCELLANEOUS						
Water			4.2		.24	
Snow			1.2-3.6		.83-.27	
Soil			7.2-12.0		.14-.08	
Sawdust		75	.45		2.22	

UNIT 9 – EQUIPMENT MAINTENANCE
Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To acquaint the students with the operation of components and accessories of heating equipment.

To develop an understanding and knowledge of the various principles concerning gas-fired equipment, and the use of the test equipment used in heating maintenance.

To teach correct safety habits when igniting or testing heating equipment.

Tools and Materials

Text
Gas burner
Gas-fired burner
Gun-type oil burner
Millivolt meter

Unit Outline

A. Heating equipment
  1. Hot water systems
    a. Water treatment
      (1) Inhibitors
      (2) Acidity pH factor
    b. Inspection and cleaning
      (1) Flues
      (2) Traps, air vents
      (3) Safety devices
    c. Input fuels and combustion
  2. Warm air furnaces
    a. Input fuels and combustion
      (1) Primary air
      (2) Flues
      (3) Motor lubrication
      (4) Pressure regulators
    b. Controls
      (1) Gas valves
      (2) Thermocouples
      (3) Fan and limit controls
      (4) Thermostats

B. Cooling equipment
    1. Room and unit air conditioners
        a. Filters
        b. Lubrication
        c. Condenser air flow
        d. Condensate drains
    2. Central units
        a. Electrical
            (1) Starters and contactors
            (2) Protective devices
            (3) Motors
        b. Air handlers
            (1) Filters
            (2) Blowers
            (3) Motors
        c. Refrigerant circuit
            (1) Operating pressures
            (2) Refrigerant charge
            (3) Oil level
            (4) Pressure-control settings
            (5) Current draw
            (6) Condenser coolant quantity
            (7) Expansion valve bulb location

C. Air handling unit
    1. Air filters
        a. Clean
        b. Replace
    2. Fans and blowers
        a. Lubrication of bearings
        b. Fan belts
            (1) Replacement
            (2) Tension

D. Air distribution equipment
    1. Dampers
        a. Check setting
        b. Lubrication of bearings and linkage
    2. Duct
    3. Grilles and registers

Laboratory Activity

1. Show the complete flow of gas through a burner. Utilize available equipment or literature to demonstrate.

2. Figure BTUs for various types of gases.

3. Explain activity of a gas burner and compare it with oil burners.

Shop Activity

Use available equipment to explain the operation of the various units.

SECTION V - AIR DISTRIBUTION

SECTION V

AIR DISTRIBUTION IN EQUIPMENT

Unit	Title	Class	Hours Laboratory	Shop
1	Air Pressures	5	3	7
2	Duct Systems	15	8	22
3	Air Handling Equipment	10	6	14
4	Air System Balancing	5	3	7
	Total	35	20	50

UNIT OUTLINES

Section V – Air Distribution

Unit 1 – Air Pressures

- A. Total pressure
  - 1. Sum of static and velocity pressures
  - 2. Total energy
- B. Static pressures
  - 1. Standard air conditions
  - 2. Condition variations
  - 3. Frictional resistence
    - a. Inches of water column
    - b. Straight run of ducts
    - c. Dynamic losses
      - (1) Changes of direction
      - (2) Changes in cross sectional areas
    - d. Equipment
      - (1) Coils
      - (2) Filters
      - (3) Dampers
      - (4) Registers and grilles
    - e. Aspect ratios
  - 4. Circular equivalent charts
  - 5. Friction-loss charts
- C. Velocity pressure
  - 1. Pressure required to move air in ducts
  - 2. Kinetic energy
  - 3. Divided flow fittings
  - 4. Changed in cross sectional areas
- D. Causes of increase in pressure loss
  - 1. Long length of duct
  - 2. Large air volume
  - 3. High air velocities
  - 4. Small diameter ducts
  - 5. Air flow changes in direction
  - 6. Sudden variations in duct sizes
- E. Measurements
  - 1. Pitot tube
    - a. Static element
    - b. Impact element
  - 2. U-tube manometer
  - 3. Inclined manometer or draft gauge
  - 4. Velocities
    - a. Velometer
    - b. Anemometer
    - c. Anemotherm air meter

Unit 2 – Duct Systems

A. Types
   1. High velocity
   2. Low velocity
      a. Reducing trunk
      b. Extended plenum
      c. Individual ducts
      d. Perimeter loop

B. Design
   1. Preliminaries
      a. Load calculations
         (1) Individual areas
         (2) Total heat loss or gain
      b. Psychrometric resolution
      c. Determination of individual air quantities
      d. Determining of total CFM required
      e. Location of supply and return openings
   2. Velocity reduction method
      a. Arbitrary selection of velocities
         (1) Main duct
         (2) Branch ducts
      b. Total loss of greatest-resistance run
         (1) Straight run
         (2) Fittings–equivalent length
         (3) Register or grille
      c. Balancing dampers
   3. Equal friction method
      a. Main duct velocity sound-level limitations
      b. Determination of main duct friction loss
      c. Maintaining constant static pressure
      d. Automatic reduction of duct velocities
      e. Total loss of greatest resistence run
         (1) Straight duct
         (2) Fittings equivalent length
         (3) Register or grille
   4. Static regain method
      a. Velocity reduction at each duct section
      b. Equivalent length of fittings included
      c. Velocity pressure changed to static pressure
   5. Distribution method
      a. Location of ductwork
         (1) Attic
         (2) Furred-in areas
         (3) Between floors
         (4) Crawl space
         (5) Basement
         (6) Slab floors
         (7) Exterior enclosure

b. Location of supply outlets
   (1) High sidewall
   (2) Low sidewall
   (3) Baseboard
   (4) Floor
   (5) Ceiling
   (6) Window ledge

c. Location of return grilles
   (1) Floor
   (2) Baseboard
   (3) Ceiling
   (4) Sidewall
   (5) Door louvers
   (6) Undercut doors

C. Components
1. Plenums
2. Trunk
3. Branches or feeders
4. Transitions
5. Elbows
6. Tees
7. Reducers
8. Angles
9. Boots
10. Boxes
11. Starting collars
12. Stacks or risers
13. Stackheads
14. Take-offs
15. Off-sets
16. Dampers
17. Clips and drives
18. End caps
19. Registers and grilles
    a. Fixed louvers
    b. Adjustable louvers
    c. Free area
    d. Core area
20. Diffusers
    a. Baffles
    b. Anti-smudge rings
21. Turning blades
22. Outside air intake

D. Fabrication
   1. Materials
      a. Sheet metal
      b. Aluminum
      c. Fiber glass
      d. Plastics
      e. Asbestos
      f. Tile
      g. Cement
      h. Pre-fabricated material
   2. Duct reduction increments
   3. Aspect ratio
   4. Rectangular metal duct
         Diagonal cross-braking
   5. Round metal ducts
   6. Joint connections
E. Installation
   1. Supports
   2. Insulation
   3. Fire dampers

Unit 3 – Air Handling Equipment
A. Fans and blowers
   1. Types
      a. Axial flow
         (1) Propeller
         (2) Tubeaxial
         (3) Vaneaxial
      b. Centrifugal
         (1) Forward curve
         (2) Backward curve
         (3) Air foil
         (4) Fan discharge
         (5) Drive arrangement
         (6) Width
         (7) Inlet
   2. Fan performance
      a. Volume flow rate
      b. Fan total pressure
      c. Fan velocity pressure
      d. Fan static pressure
      e. Power output
      f. Power input
      g. Mechanical efficiency
      h. Static efficiency

3. Fan laws – variables
    a. Size of fan
    b. Speed of fan
    c. Air density
    d. Pressure
    e. Horsepower
4. Outlet velocities
    a. Average velocity at discharge grille
    b. Average velocity at fan inlet
    c. Performance curve
5. Selection
    a. Air quantity
    b. Static pressure
    c. Air density – if other than standard
    d. Available space
    e. Sound level
    f. Use of space served
    g. Nature of load
    h. Air cleanliness required

B. Fan-coil units
1. Features and limitations
2. Systems variations
3. Types
    a. Vertical
        (1) No provision for ventilation
        (2) Damper control, 0-25% outdoor air
        (3) Damper control 0-100% outdoor air
    b. Horizontal
        (1) No floor space needed
        (2) Location above false ceiling
        (3) Furred-in space
4. Controls
5. Maintenance

C. Induction type
1. Low pressure
2. High pressure
3. Unit depression
    a. Primary air plenum
    b. Nozzle
    c. Heating coil
    d. Mixing chamber
    e. Cabinet or enclosure

D. Single and multi-zone units
1. All-air induction system
    a. Smaller air quantities at lower temperature
    b. Elimination of down drafts at windows
    c. Individual rpm control
    d. Low or high velocity
    e. Design procedure

2. Air-water induction system
    a. High velocity, high pressure usage
    b. Both fluids capable of heating or cooling
    c. Space savings
    d. Optimum ventilation
    e. Minimum or no interchange of air between rooms
3. Central station apparatus
4. Piping
    a. Reverse return system
    b. Diversification
    c. Chilled water primary piping circuit
    d. Chilled or heated secondary water circuit
    e. Flushing
    f. Insulation

E. Filtering devices
1. Viscous impingement
    a. Cleanable
    b. Throw away
    c. Frame, panel, or unit type
    d. Moving curtain type
2. Dry strainer type
    a. Cleanable
    b. Throw away
    c. Deep beds of fibers
    d. Thin nonwoven mats
3. Electrostatic precipitators
    a. Charging plates
    b. Collecting plates
    c. Power pack

Unit 4 – Air System Balancing

A. Filters–in place and clean

B. Fan or fans
1. Start fan and check motor amperage
2. Check motor starter and controls

C. Supply and return grilles, assured air movement

D. Dampers
1. Face damper open
2. By-pass damper closed

E. Required outside and return air percentage
1. Pitot tube
2. Anemometer
3. Velometer
4. Anemotherm

F. Convert velocities to volume for each outlet
   1. Total volume handled by fan
   2. If not within 10% of rating, adjust fan blade or speed
G. Main splitter damper
   1. Adjust for correct branch air quantities
   2. Lock in place
H. Individual outlet dampers, adjust for correct air volumes
I. Eliminate all duct and/or register noise
J. Adjust motors and linkage of face and by-pass dampers
K. Place system under automatic control
L. Check individual room temperatures
M. Adjust supply grilles for correct air distribution

UNIT 1 – AIR PRESSURES
Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To have the students gain an understanding of the pressures and frictional resistence encountered in a duct system.

To acquaint the students with the pressure losses encountered in various types of fittings in a duct distribution system.

To develop an understanding of the various instruments and their usage in taking measurements for correct air distribution.

Tools and Materials

Text – Chapter 19
Psychrometric chart
U-tube manometer
Draft gauge
Other air measuring devices

Unit Outline

A. Total pressure
   1. Sum of static and velocity pressures
   2. Total energy
B. Static pressures
   1. Standard air conditions
   2. Condition variations
   3. Frictional resistence
      a. Inches of water column
      b. Straight run of ducts
      c. Dynamic losses
         (1) Changes of direction
         (2) Changes in cross sectional areas
      d. Equipment
         (1) Coils
         (2) Filters
         (3) Dampers
         (4) Registers and grilles
      e. Aspect ratios

4. Circular equivalent charts
5. Friction-loss charts

C. Velocity pressure
    1. Pressure required to move air in ducts
    2. Kinetic energy
    3. Divided flow fittings
    4. Changes in cross sectional areas

D. Causes of increase in pressure loss
    1. Long length of duct
    2. Large air volume
    3. High air velocities
    4. Small diameter ducts
    5. Air flow changes in direction
    6. Sudden variations in duct sizes

E. Measurements
    1. Pitot tube
        a. Static element
        b. Impact element
    2. U-tube manometer
    3. Inclined manometer or draft gauge
    4. Velocities
        a. Velometer
        b. Anemometer
        c. Anemotherm air meter

Laboratory Activity

Using films, graphs, charts and measurement devices, show the students how air velocities are measured.

With the instruments and charts, show how air volumes are measured.

Emphasize that pressure loss is based on 100-foot-equivalent of ductwork at all times.

Emphasize the importance of reading instruments and charts accurately. Also emphasize the importance of the proper air velocity and volume calculations.

Shop Activity

Use available duct work and have the students take measurements to determine if the duct work is correct in size and if the air volumes and velocity are what they should be.

UNIT 2 – DUCT SYSTEMS
Class Instruction – 15 hours
Laboratory – 8 hours
Shop – 22 hours

Unit Guide

Unit Objectives

To acquaint the student with the different types of duct systems.

To emphasize low velocity, low pressure units.

To inform the students of duct-design methods, and the various factors to take into consideration.

To impart an understanding of the various components of a complete duct system for air distribution, and the purpose and location of each component.

To develop a working knowledge of various duct materials and how some of the sheet metal components are fabricated.

Tools and Materials

Text – Chapter 19

Unit Outline

A. Types
  1. High velocity
  2. Low velocity
     a. Reducing trunk
     b. Extended plenum
     c. Individual ducts
     d. Perimeter loop

B. Design
  1. Preliminaries
     a. Load calculations
        (1) Individual areas
        (2) Total heat loss or gain
     b. Psychrometric resolution
     c. Determination of individual air quantities
     d. Determining of total CFM required
     e. Location of supply and return openings

2. Velocity reduction method
   a. Arbitrary selection of velocities
      (1) Main duct
      (2) Branch ducts
   b. Total loss of greatest-resistance run
      (1) Straight run
      (2) Fittings—equivalent length
      (3) Register or grille
   c. Balancing dampers
3. Equal friction method
   a. Main duct velocity sound-level limitations
   b. Determination of main duct friction loss
   c. Maintaining constant static pressure
   d. Automatic reduction of duct velocities
   e. Total loss of greatest resistence run
      (1) Straight duct
      (2) Fittings equivalent length
      (3) Register or grille
4. Static regain method
   a. Velocity reduction at each duct section
   b. Equivalent length of fittings included
   c. Velocity pressure changed to static pressure
5. Distribution method
   a. Location of ductwork
      (1) Attic
      (2) Furred-in areas
      (3) Between floors
      (4) Crawl space
      (5) Basement
      (6) Slab floors
      (7) Exterior enclosure
   b. Location of supply outlets
      (1) High sidewall
      (2) Low sidewall
      (3) Baseboard
      (4) Floor
      (5) Ceiling
      (6) Window ledge
   c. Location of return grilles
      (1) Floor
      (2) Baseboard
      (3) Ceiling
      (4) Sidewall
      (5) Door louvers
      (6) Undercut doors

C. Components
   1. Plenums
   2. Trunk
   3. Branches or feeders
   4. Transitions
   5. Elbows
   6. Tees
   7. Reducers
   8. Angles
   9. Boots
   10. Boxes
   11. Starting collars
   12. Stacks or risers
   13. Stackheads
   14. Take-offs
   15. Off-sets
   16. Dampers
   17. Clips and drives
   18. End caps
   19. Registers and grilles
      a. Fixed louvers
      b. Adjustable louvers
      c. Free area
      d. Core area
   20. Diffusers
      a. Baffles
      b. Anti-smudge rings
   21. Turning blades
   22. Outside air intake

D. Fabrication
   1. Materials
      a. Sheet metal
      b. Aluminum
      c. Fiber glass
      d. Plastics
      e. Asbestos
      f. Tile
      g. Cement
      h. Pre-fabricated material
   2. Duct reduction increments
   3. Aspect ratio
   4. Rectangular metal duct
      Diagonal cross-braking
   5. Round metal ducts
   6. Joint connections

E. Installation
   1. Supports
   2. Insulation
   3. Fire dampers

Laboratory Activity

Visit the sheet metal shop and ask the instructor to show your students various types of metals and various fittings used in duct work.

Shop Activity

Have the students calculate a duct system for a small air conditioning system and size it according to the need.

Assign two students at a time to visit the sheet metal shop and learn what is involved in making ducts and fittings. Explain the making of ducts and fittings.

It is suggested that the instructor make use of the State of New Jersey, Department of Education, Division of Vocational Education book "Basic Comfort Heating", by Chalmer Dempster to supplement any visual aids available to instruct the student in the duct design necessary for the distribution of air.

The text, "Modern Refrigeration and Air Conditioning," provides added information to cover this unit.

It is suggested that sheet metal shop students and the air conditioning students trade places for a time. During this period the sheet metal students could be instructed on the connection between the two trades and what will be expected of them in the field. The close relationship between the two trades could be discussed and a better understanding between the two trades, which is very important, could be stressed to these students. The air conditioning students could learn what is necessary to build duct work and the close relationship necessary between the two trades.

Testing should be a part of this exchange.

UNIT 3 – AIR HANDLING EQUIPMENT
Class Instruction – 10 hours
Laboratory – 6 hours
Shop – 14 hours

Unit Guide

Unit Objectives

To acquaint students with the different types of fans that are used in air conditioning systems.

To teach a knowledge of the variables involved in fan laws, and in the capabilities and limitations as to the performance of fans, and how various fan-coil units are or may be utilized in single-and multiple-zone applications.

Tools and Materials

Different types of fans and blowers
Demonstrator fan coil unit
Filter material of various kinds
Data and specs. from manufacturing

Unit Outline

A. Fans and blowers
  1. Types
    a. Axial flow
      (1) Propeller
      (2) Tubeaxial
      (3) Vaneaxial
    b. Centrifugal
      (1) Forward curve
      (2) Backward curve
      (3) Air foil
      (4) Fan discharge
      (5) Drive arrangement
      (6) Width
      (7) Inlet
  2. Fan performance
    a. Volume flow rate
    b. Fan total pressure
    c. Fan velocity pressure
    d. Fan static pressure
    e. Power output
    f. Power input
    g. Mechanical efficiency
    h. Static efficiency

3. Fan laws—variables
   a. Size of fan
   b. Speed of fan
   c. Air density
   d. Pressure
   e. Horsepower
4. Outlet velocities
   a. Average velocity at discharge grille
   b. Average velocity at fan inlet
   c. Performance curve
5. Selection
   a. Air quantity
   b. Static pressure
   c. Air density – if other than standard
   d. Available space
   e. Sound level
   f. Use of space served
   g. Nature of load
   h. Air cleanliness required

B. Fan-coil units
   1. Features and limitations
   2. Systems variations
   3. Types
      a. Vertical
         (1) No provision for ventilation
         (2) Damper control, 0-25% outdoor air
         (3) Damper control 0-100% outdoor air
      b. Horizontal
         (1) No floor space needed
         (2) Location above false ceiling
         (3) Furred-in space
   4. Controls
   5. Maintenance

C. Induction type
   1. Low pressure
   2. High pressure
   3. Unit depression
      a. Primary air plenum
      b. Nozzle
      c. Heating coil
      d. Mixing chamber
      e. Cabinet or enclosure

D. Single and multi-zone units
   1. All-air induction system
      a. Smaller air quantities at lower temperature
      b. Elimination of down drafts at windows
      c. Individual rpm control
      d. Low or high velocity
      e. Design procedure
   2. Air-water induction system
      a. High velocity, high pressure usage
      b. Both fluids capable of heating or cooling
      c. Space savings
      d. Optimum ventilation
      e. Minimum or no interchange of air between rooms
   3. Central station apparatus
   4. Piping
      a. Reverse return system
      b. Diversification
      c. Chilled water primary piping circuit
      d. Chilled or heated secondary water circuit
      e. Flushing
      f. Insulation

E. Filtering devices
   1. Viscous impingement
      a. Cleanable
      b. Throw away
      c. Frame, panel, or unit type
      d. Moving curtain type
   2. Dry strainer type
      a. Cleanable
      b. Throw away
      c. Deep beds of fibers
      d. Thin nonwoven mats
   3. Electrostatic precipitators
      a. Charging plates
      b. Collecting plates
      c. Power pack

Laboratory Activity

Make use of available materials to show the students all types of air distribution systems and the components that are used for that purpose. Emphasize how important it is to know as much as possible about duct systems and the components necessary to insure proper distribution of air.

Shop Activity

Make students identify all the components that they possibly can in the field of air distribution.

The instructor should utilize available visual aids for this unit. It is suggested that representatives from filter manufacturers be invited to talk to the students.

Students should learn what meters are available to determine quantities and velocities of air. Duct balance should be stressed at this time.

UNIT 4 – AIR SYSTEM BALANCING — Unit Guide

Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Objectives

To acquaint the students with the various aspects that need to be considered in the balancing of air distribution.

To develop an understanding of the procedures that are recommended to be followed in the balancing of air distribution systems.

To develop a positive attitude toward maintaining safety precautions in the use of the test equipment necessary for balancing the air distribution system and around any moving mechanical equipment.

Tools and Materials

Text
Duct system
Films and literature
Measuring devices to measure air and its motion

Unit Outline

A. Filters–in place and clean
B. Fan or fans
   1. Start fan and check motor amperage
   2. Check motor starter and controls
C. Supply and return grilles, assured air movement
D. Dampers
   1. Face damper open
   2. By-pass damper closed
E. Required outside and return air percentage
   1. Pitot tube
   2. Anemometer
   3. Velometer
   4. Anemotherm
F. Convert velocities to volume for each outlet
   1. Total volume handled by fan
   2. If not within 10% of rating, adjust fan blade or speed
G. Main splitter damper
   1. Adjust for correct branch air quantities
   2. Lock in place

H. Individual outlet dampers, adjust for correct air volumes
I. Eliminate all duct and/or register noise
J. Adjust motors and linkage of face and by-pass dampers
K. Place system under automatic control
L. Check individual room temperatures
M. Adjust supply grilles for correct air distribution

Laboratory Activity

Have the students balance an imaginary system on paper.

Have students observe balancing procedure with films and/or actual system.

Shop Activity

Have students learn the usage of all available meters and measuring devices.

SECTION VI - CONTROLS

SECTION VI

CONTROLS

Unit	Title	Hours Class	Laboratory	Shop
1	Fundamentals of Control	10	6	14
2	Fundamentals of Measurements	5	3	7
3	Control Circuits	10	6	14
4	Control of Systems	10	5	15
	Total	35	20	50

UNIT OUTLINES

Section VI – Controls

Unit 1 – Fundamentals of Control
- A. Control devices
  - 1. Controllers
    - a. Thermostats
      - (1) Room
      - (2) Remote bulb
      - (3) Insertion
      - (4) Immersion
    - b. Humidistats
      - (1) Room
      - (2) Insertion
    - c. Pressure type switches
  - 2. Controlled devices
    - a. Automatic valves
      - (1) Steam
      - (2) Water
      - (3) Gas
      - (4) Refrigerant
      - (5) Other fluids
    - b. Valve operators
    - c. Automatic dampers
    - d. Damper operators
    - e. Electric heaters
    - f. Motors
      - (1) Fans
      - (2) Pumps
      - (3) Burners
      - (4) Compressors
    - g. Contactors
    - h. Starters
  - 3. Auxiliaries
    - a. Transformers
    - b. Relays
    - c. Potentiometers
    - d. Manual switches
    - e. Clocks or timers

B. Definitions
   1. Actuator
   2. Bellows
   3. Bimetal strip
   4. Controlled device
   5. Controlled variables
   6. Controller
   7. Control medium
   8. Control point
   9. Control system
   10. Corrective action
   11. Cycling
   12. Deviation
   13. Differential
   14. Floating
   15. Lag
   16. Modulating control
   17. Offset
   18. Potentiometer
   19. Primary element
   20. Proportional
   21. Reset
   22. Sensors
   23. Set point
   24. Throttling range
   25. Transducer

Unit 2 – Fundamentals of Measurement

A. Temperature
   1. Primary element
      a. Bimetal strip
         (1) U-curve
         (2) Spiral
         (3) Helix
      b. Rod and tube
      c. Sealed bellows
      d. Sealed bellows–remote bulb
      e. Resistence wire
   2. Heating
      a. Anticipating
      b. Over-ride
      c. Protector relay
      d. Automatic valves
         (1) Gas
         (2) Steam
         (3) Water

e. Dampers
f. Circulating pump
3. Cooling
a. Small systems
(1) Compressor cycling
(2) Automatic valves
(a) Gas
(b) Steam
(c) Water
(3) Circulating pump
(4) Damper control
b. Large systems, pump down
(1) Solenoid valves
(2) Low pressure controls

B. Relative humidity—humidistats or hydrostats
1. Sensing elements
a. Paper
b. Silk
c. Hair
d. Wood
e. Other fibrous substances
f. Gold-leaf and hygroscopic salt
2. Controlled devices
a. Dampers
b. Gas valves
c. Solenoid valves
d. Steam valves
e. Water valves

Unit 3 – Control Circuits

A. Electric
1. Advantages
a. Electricity readily available
b. Ease of installation
c. Readily amplifies sensed impulse
d. Impulse applied directly
e. Readily permits control from remote point
f. Facility of service
2. Current-regulating devices
3. Current-utilizing devices
4. Two-wire control circuits
a. Line voltage
b. Low voltage
5. Three-wire, two-position control circuit
6. Multi-position control circuits
7. Floating-control circuit
8. Proportional-control circuit
9. Combination controlling

10. Controlled conditions
    a. Conditions of air
    b. Pressure of fluids
    c. Temperature of fluids
    d. Flow rate of various media
11. Controllers
    a. Thermostats
        (1) Room
        (2) Two-position
        (3) Two-temperature
        (4) Proportional
        (5) Insertion and immersion remote bulb
    b. Humidity controls
        (1) Insertion
        (2) Room
        (3) Open-contact
        (4) Mercury switch
        (5) Proportional
    c. Pressure controls
        (1) Two-position
        (2) Proportional
        (3) Static-pressure regulators
    d. Actuators
        (1) Control motors
        (2) Control valves
        (3) Relays
        (4) Safety controls
    e. Accessories

B. Electronic
1. Advantages
    a. Sensitivity
    b. Speed of response
    c. Simple construction of sensing elements
    d. Flexibility
        (1) Combination with other types of circuits
        (2) Stability
        (3) Convenience of adjustments
    e. Low voltage connections
2. System elements
    a. Amplifier
    b. Bridge circuit
    c. Electronic relay
        (1) Two-position
        (2) Proportional
        (3) Pneumatic valve control
    d. Thermostats
    e. Electronic motor
    f. Electronic-pneumatic transducer
    g. Humidity control

C. Pneumatic
  1. Advantages
    a. Adaptable to proportional operation
    b. Trouble free
    c. Operational safety
    d. Simple to trace
    e. Variety of control sequences possible
  2. Elements of control
    a. Air compressor, filter
    b. Pressure reducing station
    c. Air piping distribution system
    d. Controllers
      (1) Bleed and non-bleed
      (2) One-pipe and two-pipe
      (3) Direct and reverse acting
      (4) Positive or proportional
      (5) Master and sub-master
      (6) Thermostats
      (7) Humidistats
      (8) Pressure regulators
    e. Actuators
      (1) Motors
      (2) Relays
      (3) Valves
    f. Pneumatic-control combinations

Unit 4 – Control of Systems
A. Mechanical refrigeration
  1. Capacity control
    a. Suction pressure control
    b. Temperature control of compressor
    c. Temperature-pressure control combination
    d. Stage control of multiple compressors
    e. Sequence control of multiple compressors
    f. Compressor-capacity control
  2. Distribution control
    a. Solenoid valve
    b. Proportional control of coolant
    c. Proportional control of the air flow
    d. Chilled water distribution
B. Residential heating
  1. Gas fired
    a. Preliminaries
      (1) Combustion mixture
      (2) Constant gas pressure
      (3) Required free air
      (4) Primary air adjustment
      (5) Proper orifices

b. Operating controls
   (1) Safety pilot
   (2) Thermostat
   (3) Automatic gas valve
   (4) Fan control (If forced air)
   (5) Limit control
   (6) Blower motor
   (7) Damper motor (if any)

2. Oil fired
   a. Preliminaries
      (1) Condition of combustion chamber
      (2) Combustion mixture
      (3) Vaporization (gun type burner)
      (4) Oil at constant pressure
      (5) Required free air
      (6) Proper nozzle size
      (7) Draft control
      (8) Stack temperature
      (9) Atomization (gun type)
      (10) CO_2 and smoke sample
   b. Operating controls
      (1) Thermostat
      (2) Primary oil burner control
      (3) Fan control (if forced air)
      (4) Limit control
      (5) Damper control
3. Hydronic control
   a. Immersion controller
      (1) Low-limit switch
      (2) High-limit switch
   b. Room thermostat
   c. Combustion equipment
   d. Circulation pump
   e. Outdoor reset control
   f. Mixing valve
   g. Diverting valves
   h. Relief valves

C. Residential cooling – compression refrigeration system
   1. Electric motors
   2. Internal combustion engines
      a. Natural gas
      b. Gasoline
      c. Diesel fuel

3. Operating controls
    a. Cooling thermostat
    b. Relay
    c. Low pressure control
    d. High pressure control
    e. Fan control
    f. Condenser fan motor
    g. Pump motor if water cooled
    h. Motor contractor device

D. Heat pumps
    1. Basic heating operating controls
    2. Basic cooling operating controls
    3. Reversing valves
    4. Combination thermostat
    5. Resistance heaters
    6. Outdoor thermostat
    7. Temperature differential control
    8. Defrost controls

E. Absorption
    1. Direct-firing burner control
    2. Combination room thermostat
    3. Chilled water switch
    4. Low limit switch
    5. Generator high temperature
    6. Three-way solution valve
    7. Condenser high pressure cutout
    8. Failure switch

F. Commercial
    1. Control of heat supply
        a. Tempering systems for ventilation only
        b. Blast systems for heating and ventilating
        c. Pull-through fan in by-pass system
            (1) Face-and-bypass damper
            (2) Valve-and-bypass damper
            (3) Valve with face-and-bypass dampers
        d. Blow-through fan with valve control
        e. Outdoor air-control, pre-heat coil
        f. Mixed-air control
    2. Winter humidification
        a. Water spray humidifier
        b. Pan type humidifier
        c. Steam jet humidifier
        d. Air washer system

3. Cooling systems
   a. Single pass
   b. Face-and-bypass
   c. Return air bypass
   d. Chilled water
      (1) Well water
      (2) Water chiller
      (3) Indirect ice system
   e. Direct expansion
   f. Multiple compressor control
   g. Reheat systems

UNIT 1 – FUNDAMENTALS OF CONTROL
Class Instruction – 10 hours
Laboratory – 6 hours
Shop – 14 hours

Unit Guide

Unit Objectives

To acquaint the student with the different types of controllers that are utilized in the various systems.

To impart further knowledge of the various types of devices to be controlled in a year-round air conditioning unit and duct system.

To inform the students of the terminology and the definitions of the various terms used in the control aspect of the environmental control field.

To develop the proper attitude of safety in the handling and adjusting of the numerous controls with which the students will work in the shop and also in the field.

Tools and Materials

Text – Chapter 27
Different types of controls that can be examined by the student and explained by the instructor
Data and specifications as furnished by manufacturers of controls

Unit Outline

A. Control devices
   1. Controllers
      a. Thermostats
         (1) Room
         (2) Remote bulb
         (3) Insertion
         (4) Immersion
      b. Humidistats
         (1) Room
         (2) Insertion
      c. Pressure type switches
   2. Controlled devices
      a. Automatic valves
         (1) Steam
         (2) Water
         (3) Gas
         (4) Refrigerant
         (5) Other fluids

b. Valve operators
c. Automatic dampers
d. Damper operators
e. Electric heaters
f. Motors
    (1) Fans
    (2) Pumps
    (3) Burners
    (4) Compressors
g. Contactors
h. Starters

3. Auxiliaries
    a. Transformers
    b. Relays
    c. Potentiometers
    d. Manual switches
    e. Clocks or timers

B. Definitions
1. Actuator
2. Bellows
3. Bimetal strip
4. Controlled device
5. Controlled variables
6. Controller
7. Control medium
8. Control point
9. Control system
10. Corrective action
11. Cycling
12. Deviation
13. Differential
14. Floating
15. Lag
16. Modulating control
17. Offset
18. Potentiometer
19. Primary element
20. Proportional
21. Reset
22. Sensors
23. Set point
24. Throttling range
25. Transducer

Laboratory Activity

Demonstrate the operation of as many controls as possible. Demonstrate how to repair or replace parts. Demonstrate the possible dangers when dealing with some of these controls. Show how, at times, it is less expensive to replace a control than to repair it.

Shop Activity

Have students study each control and learn the different parts, the operation of each part, and the control as a unit. Have the students write about the operation of each control as they learn the control.

UNIT 2 – FUNDAMENTALS OF MEASUREMENT

Class Instruction – 5 hours
Laboratory – 3 hours
Shop – 7 hours

Unit Guide

Unit Objectives

To acquaint the students with the basic fundamentals of the measurement of temperature and relative humidity in air distribution systems.

To impart a knowledge and understanding of the various types of temperature and humidity controls used.

To develop the proper attitude toward the safety precautions to be followed in the handling and adjustment of the various types of temperature and humidity controls.

Tools and Materials

Assorted thermostats and humidistats
Cutaway or sample hand-tight models of various valves

Unit Outline

A. Temperature
   1. Primary element
      a. Bimetal strip
         (1) U-curve
         (2) Spiral
         (3) Helix
      b. Rod and tube
      c. Sealed bellows
      d. Sealed bellows–remote bulb
      e. Resistence wire
   2. Heating
      a. Anticipating
      b. Over-ride
      c. Protector relay
      d. Automatic valves
         (1) Gas
         (2) Steam
         (3) Water
      e. Dampers
      f. Circulating pump

3. Cooling
    a. Small systems
        (1) Compressor cycling
        (2) Automatic valves
            (a) Gas
            (b) Steam
            (c) Water
        (3) Circulating pump
        (4) Damper control
    b. Large systems, pump down
        (1) Solenoid valves
        (2) Low pressure controls

B. Relative humidity—humidistats or hydrostats
    1. Sensing elements
        a. Paper
        b. Silk
        c. Hair
        d. Wood
        e. Other fibrous substances
        f. Gold-leaf and hygroscopic salt
    2. Controlled devices
        a. Dampers
        b. Gas valves
        c. Solenoid valves
        d. Steam valves
        e. Water valves

Laboratory Activity

Demonstrate the different elements that are used to sense the change in temperature and humidity. Explain how these elements actuate the elements that control the device. Demonstrate the action that takes place as the change occurs. Point out how important it is for the student to make only very slight adjustments on these controls.

Shop Activity

Have students examine each device and write an explanation of the operation of each of its parts and what takes place when the sensing elements change because of change in temperature or humidity. Have the students draw schematics of the wiring needed when these controls are used in a system. Have them use controls in this building.

UNIT 3 – CONTROL CIRCUITS

Class Instruction – 10 hours
Laboratory – 6 hours
Shop – 14 hours

Unit Guide

Unit Objectives

To acquaint the student with the different types of control circuits used in the environmental control field.

To develop a knowledge and understanding of the various advantages of the electrical, electronic, or pneumatic types of control circuits for a given project.

To impart information concerning those control circuits utilizing a combination of systems.

Tools and Materials

Text
Films
Manufacturer's specifications such as found on part of the packing slip envelope
Control diagrams of specific air conditioning installations

Unit Outline

A. Electric
    1. Advantages
        a. Electricity readily available
        b. Ease of installation
        c. Readily amplifies sensed impulse
        d. Impulse applied directly
        e. Readily permits control from remote point
        f. Facility of service
    2. Current-regulating devices
    3. Current-utilizing devices
    4. Two-wire control circuits
        a. Line voltage
        b. Low voltage
    5. Three-wire, two-position control circuit
    6. Multi-position control circuits
    7. Floating-control circuit
    8. Proportional-control circuit
    9. Combination controlling

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10. Controlled conditions
    a. Conditions of air
    b. Pressure of fluids
    c. Temperature of fluids
    d. Flow rate of various media
11. Controllers
    a. Thermostats
        (1) Room
        (2) Two-position
        (3) Two-temperature
        (4) Proportional
        (5) Insertion and immersion remote bulb
    b. Humidity controls
        (1) Insertion
        (2) Room
        (3) Open-contact
        (4) Mercury switch
        (5) Proportional
    c. Pressure controls
        (1) Two-position
        (2) Proportional
        (3) Static-pressure regulators
    d. Actuators
        (1) Control motors
        (2) Control valves
        (3) Relays
        (4) Safety controls
    e. Accessories

B. Electronic
1. Advantages
    a. Sensitivity
    b. Speed of response
    c. Simple construction of sensing elements
    d. Flexibility
        (1) Combination with other types of circuits
        (2) Stability
        (3) Convenience of adjustments
    e. Low voltage connections
2. System elements
    a. Amplifier
    b. Bridge circuit
    c. Electronic relay
        (1) Two-position
        (2) Proportional
        (3) Pneumatic valve control

d. Thermostats
e. Electronic motor
f. Electronic-pneumatic transducer
g. Humidity control

C. Pneumatic
1. Advantages
a. Adaptable to proportional operation
b. Trouble free
c. Operational safety
d. Simple to trace
e. Variety of control sequences possible
2. Elements of control
a. Air compressor, filter
b. Pressure reducing station
c. Air piping distribution system
d. Controllers
(1) Bleed and non-bleed
(2) One-pipe and two-pipe
(3) Direct and reverse acting
(4) Positive or proportional
(5) Master and sub-master
(6) Thermostats
(7) Humidistats
(8) Pressure regulators
e. Actuators
(1) Motors
(2) Relays
(3) Valves
f. Pneumatic-control combinations

Laboratory Activity

Demonstrate the operation of available controls to the students.

Shop Activity

Use the building system as a model for students to examine and study.

UNIT 4 – CONTROL OF SYSTEMS

Class Instruction – 10 hours
Laboratory – 5 hours
Shop – 15 hours

Unit Guide

Unit Objective

To have the student acquire a knowledge of the control of complete systems in the field of refrigeration and year-round air conditioning.

To have the student understand the inter-dependency between capacity, operating, and distribution systems of control.

To develop a knowledge and understanding of the constant interaction between temperature and humidity controls in those systems designed for close tolerance of conditions.

Tools and Materials

Text
All refrigeration, heating, and cooling equipment available

Unit Outline

A. Mechanical refrigeration
  1. Capacity control
    a. Suction pressure control
    b. Temperature control of compressor
    c. Temperature-pressure control combination
    d. Stage control of multiple compressors
    e. Sequence control of multiple compressors
    f. Compressor-capacity control
  2. Distribution control
    a. Solenoid valve
    b. Proportional control of coolant
    c. Proportional control of the air flow
    d. Chilled water distribution
B. Residential heating
  1. Gas fired
    a. Preliminaries
      (1) Combustion mixture
      (2) Constant gas pressure
      (3) Required free air
      (4) Primary air adjustment
      (5) Proper orifices

b. Operating controls
   (1) Safety pilot
   (2) Thermostat
   (3) Automatic gas valve
   (4) Fan control (If forced air)
   (5) Limit control
   (6) Blower motor
   (7) Damper motor (if any)

2. Oil fired
   a. Preliminaries
      (1) Condition of combustion chamber
      (2) Combustion mixture
      (3) Vaporization (gun type burner)
      (4) Oil at constant pressure
      (5) Required free air
      (6) Proper nozzle size
      (7) Draft control
      (8) Stack temperature
      (9) Atomization (gun type)
      (10) CO_2 and smoke sample
   b. Operating controls
      (1) Thermostat
      (2) Primary oil burner control
      (3) Fan control (if forced air)
      (4) Limit control
      (5) Damper control
3. Hydronic control
   a. Immersion controller
      (1) Low-limit switch
      (2) High-limit switch
   b. Room thermostat
   c. Combustion equipment
   d. Circulation pump
   e. Outdoor reset control
   f. Mixing valve
   g. Diverting valves
   h. Relief valves

C. Residential cooling--compression refrigeration system
   1. Electric motors
   2. Internal combustion engines
      a. Natural gas
      b. Gasoline
      c. Diesel fuel

3. Operating controls
   a. Cooling thermostat
   b. Relay
   c. Low pressure control
   d. High pressure control
   e. Fan control
   f. Condenser fan motor
   g. Pump motor if water cooled
   h. Motor contractor device

D. Heat pumps
   1. Basic heating operating controls
   2. Basic cooling operating controls
   3. Reversing valves
   4. Combination thermostat
   5. Resistance heaters
   6. Outdoor thermostat
   7. Temperature differential control
   8. Defrost controls

E. Absorption
   1. Direct-firing burner control
   2. Combination room thermostat
   3. Chilled water switch
   4. Low limit switch
   5. Generator high temperature
   6. Three-way solution valve
   7. Condenser high pressure cutout
   8. Failure switch

F. Commercial
   1. Control of heat supply
      a. Tempering systems for ventilation only
      b. Blast systems for heating and ventilating
      c. Pull-through fan in by-pass system
         (1) Face-and-bypass damper
         (2) Valve-and-bypass damper
         (3) Valve with face-and-bypass dampers
      d. Blow-through fan with valve control
      e. Outdoor air-control, pre-heat coil
      f. Mixed-air control
   2. Winter humidification
      a. Water spray humidifier
      b. Pan type humidifier
      c. Steam jet humidifier
      d. Air washer system

3. Cooling systems
    a. Single pass
    b. Face-and-bypass
    c. Return air bypass
    d. Chilled water
        (1) Well water
        (2) Water chiller
        (3) Indirect ice system
    e. Direct expansion
    f. Multiple compressor control
    g. Reheat systems

Laboratory Activity

Demonstrate how, in a series of circuit controls, one device may be the source of trouble or part of the trouble.

Demonstrate how improperly adjusted controls may oppose one another and not allow the system to work properly.

Demonstrate how to bypass some of the control devices to check on the faulty operation of these devices.

Shop Activity

Have the students take each refrigeration and air conditioning system in the shop and trace the control circuits and make sketches of their electrical systems. Have them explain in writing the operation of each control in each of the systems.

Each student should be given an assignment which will have him identify and explain as many controls as possible, including their use and the possible trouble that can be encountered with each. This could be part of or their whole final examination.

SECTION VII - TROUBLE SHOOTING

SECTION VII

TROUBLE SHOOTING

Unit	Title	Class	Hours Laboratory	Shop
1	Refrigerant Cycle	5	0	10
2	Main Electrical Circuit	3	0	6
3	Control Circuits	4	0	8
4	Air Distribution System	3	0	6
5	Hydronic Systems	3	0	3
	Total	18	0	33

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Section VII – Trouble Shooting

Unit 1 – Refrigerant Cycle

- A. Compressor short cycles
  - 1. Control differential too close
  - 2. Cut out on overload
    - a. High head pressure
      - (1) Overcharge
      - (2) Insufficient condenser coolant
      - (3) Air or other non-condensable gases in system
      - (4) Improper unit location
      - (5) Restricted hot gas line
    - b. Improper wiring
    - c. High voltage
    - d. Low voltage
    - e. Faulty compressor
    - f. Faulty overload
    - g. Low oil level
  - 3. Undercharge of refrigerant
  - 4. Faulty refrigerant control
  - 5. Restricted refrigerant flow
- B. Compressor runs continuously
  - 1. Undercharge of refrigerant
  - 2. Faulty compressor
  - 3. Faulty refrigerant control
  - 4. Air or other noncondensables in system
  - 5. Unit too small
  - 6. Excessive load on coil
  - 7. Improper wiring
  - 8. Insufficient condenser coolant
  - 9. Oil clogged evaporator coil
- C. Compressor noisy
  - 1. Loose components on condensing unit
  - 2. Vibration lines
  - 3. Fan blades bent on air-cooled condenser
  - 4. Worn fan bearings
  - 5. Low oil level
  - 6. Faulty compressor
  - 7. Overcharge of refrigerant
  - 8. Restriction in lines
  - 9. Oil clogged evaporator coil
- D. Space temperature too high
  - 1. Insufficient air across the coil
  - 2. Unit too small

3. Undercharge of refrigerant
4. Components too small
5. Faulty components
6. Excessive load on coil
7. Restriction in line

E. Evaporator coil freezes
1. Insufficient air across the coil
2. Low temperature air across the coil
3. Faulty refrigerant control
4. Moisture in system
5. Oil clogged evaporator coil
6. Undercharge of refrigerant

F. Head pressure too low
1. Undercharge of refrigerant
2. Too much air across the condenser
3. Low temperature air across the condenser
4. Too much water through the condenser
5. Low temperature water through the condenser

G. Suction pressure too low
1. Insufficient air across the coil
2. Poor air distribution
3. Restricted liquid line
4. Faulty refrigerant control
5. Undersized liquid and/or suction line

H. Hot liquid line
1. Improper refrigerant charge
2. Improper size unit
3. High head pressure
4. Faulty refrigerant control

I. Liquid line frosted
1. Restriction in drier
2. Restriction in liquid line
3. Faulty solenoid valve
4. Partially closed liquid line valve

Unit 2 – Main Electrical circuit

A. No power at the compressor
1. Disconnect switch open
2. Main circuit breaker tripped
3. Blown fuse

B. High voltage

C. Low voltage

D. Improper wiring
1. Improper wire size
2. Broken wire
3. Loose connection

E. Starting capacitor
1. Wrong size
2. Burned out

F. Starting relay
   1. Wrong size
   2. Burned out
G. Running capacitor
   1. Wrong size
   2. Burned out
H. Motor draws too much current
   1. Lack of bearing lubrication
   2. Belt too tight
   3. Out of alignment
   4. Motor overload
      a. Motor too small
      b. Wrong pulley size
I. Start winding stays in circuit
   1. Low voltage
   2. Faulty wiring
   3. Starting and/or run capacitor, starting relay
      a. Wrong size
      b. Burned out
   4. High head pressure
   5. Faulty compressor

Unit 3 – Control Circuits
A. Transformer and relay coil circuits
B. Changeover relays
C. Cooling circuits
D. Damper circuits
E. Fan circuits
F. Heating circuits
G. Humidification
H. Reset circuits
I. Pressure control circuits
J. Reversing relay circuits
K. Thermal relay (delay type)

Unit 4 – Distribution System
A. Diffusers, registers, and grilles
   1. Supply-adjustment
   2. Return
B. Ductwork
   1. Supply
   2. Return
   3. Fresh air
   4. Insulation
   5. Connections

C. Dampers
   1. Volume control
   2. Zone
   3. Face and bypass
   4. Fresh air
D. Blowers
   1. Rotation
   2. Belts
   3. Drive
   4. Lubrication
E. Filters

Unit 5 – Hydronic Systems
A. Servicing forced hot water systems
   1. Insufficient heat throughout system
      a. Boiler capacity
      b. Output of installed radiation
      c. Average water temperature
      d. Pipe or tube size
      e. Pump capacity
      f. Temperature drop throughout system
   2. Insufficient heat in individual rooms
      a. Air within the unit
      b. Air pocket in branch pipe
      c. One-pipe fittings installed incorrectly
      d. Radiation incorrectly installed
      e. Unit at end of series loop
      f. Units on a two-pipe system
   3. Heat distributing units air-bound
   4. Noise in system
      a. Air
      b. Velocity
      c. Expansion
   5. Water level and pressure in system
      a. Pressure reducing valve
      b. Thermometer
      c. Automatic fill valve
      d. Water feeder
   6. Pressure relief valve operations
      a. Limit control failure
      b. Faulty pressure relief valve (do not attempt to adjust)
      c. Water logged air cushion tank
         (1) Location of make-up water line
         (2) Incorrect location of circulator

7. Uneven heating
    a. Proper balancing of system
    b. Check of thermocouple pyrometer, thermometer

B. Servicing steam heating system
    1. Insufficient heat
        a. Size or boiler-firing rate
        b. Size of radiation
        c. Air vents
        d. Float and thermostatic traps
        e. Radiator valves
        f. Clean boiler water
    2. Noise in system
        a. Expansion
        b. Water hammering
            (1) Sag in piping
            (2) Size of pipe
            (3) Insufficient pitch of piping and radiation
            (4) Improperly located vents
    3. Boiler water level
        a. Unsteady water line
        b. No water in glass
        c. Water rises above glass
    4. Loss of water from the boiler
        a. Leak in wet-return
        b. Leak in boiler
        c. Water valve leaking
    5. Water level constantly increasing
        a. Feed level
        b. Indirect water heater

UNIT 1 – REFRIGERANT CYCLE
Class Instruction – 5 hours
Shop – 10 hours

Unit Guide

Unit Objectives

To present some of the problems that are prevalent in the control of refrigeration cycles.

To acquaint the student with the fact that a definite service complaint may be caused by one, or a combination of factors.

To develop an attitude of taking necessary precautions for safety in all service procedures.

Tools and Materials

All equipment in the shop having a refrigerant cycle
Refrigeration tools, test equipment, service manuals

Emphasize to the students:

If the cause of the trouble is not of an electrical nature or is not visibly apparent, the piece of mechanical equipment can only disclose its ailment through its pressures and temperatures.

This is the only way it can tell the doctor where it hurts.

Unit Outline

A. Compressor short cycles
   1. Control differential too close
   2. Cut out on overload
      a. High head pressure
         (1) Overcharge
         (2) Insufficient condenser coolant
         (3) Air or other non-condensable gases in system
         (4) Improper unit location
         (5) Restricted hot gas line
      b. Improper wiring
      c. High voltage
      d. Low voltage
      e. Faulty compressor
      f. Faulty overload
      g. Low oil level

3. Undercharge of refrigerant
4. Faulty refrigerant control
5. Restricted refrigerant flow

B. Compressor runs continously
1. Undercharge of refrigerant
2. Faulty compressor
3. Faulty refrigerant control
4. Air or other noncondensables in system
5. Unit too small
6. Excessive load on coil
7. Improper wiring
8. Insufficient condenser coolant
9. Oil clogged evaporator coil

C. Compressor noisy
1. Loose components on condensing unit
2. Vibration lines
3. Fan blades bent on air-cooled condenser
4. Worn fan bearings
5. Low oil level
6. Faulty compressor
7. Overcharge of refrigerant
8. Restriction in lines
9. Oil clogged evaporator coil

D. Space temperature too high
1. Insufficient air across the coil
2. Unit too small
3. Undercharge of refrigerant
4. Components too small
5. Faulty components
6. Excessive load on coil
7. Restriction in lines

E. Evaporator coil freezes
1. Insufficient air across the coil
2. Low temperature air across the coil
3. Faulty refrigerant control
4. Moisture in system
5. Oil clogged evaporator coil
6. Undercharge of refrigerant

F. Head pressure too low
1. Undercharge of refrigerant
2. Too much air across the condenser
3. Low temperature air across the condenser
4. Too much water through the condenser
5. Low temperature water through the condenser

G. Suction pressure too low
   1. Insufficient air across the coil
   2. Poor air distribution
   3. Restricted liquid line
   4. Faulty refrigerant control
   5. Undersized liquid and/or suction line
H. Hot liquid line
   1. Improper refrigerant charge
   2. Improper size unit
   3. High head pressure
   4. Faulty refrigerant control
I. Liquid line frosted
   1. Restriction in drier
   2. Restriction in liquid line
   3. Faulty solenoid valve
   4. Partially closed liquid line valve

Shop Activity

Have some of the students trouble-shoot some problems artificially induced in a refrigeration system in the shop.

UNIT 2 – MAIN ELECTRICAL CIRCUIT

Class Instruction – 3 hours
Shop – 6 hours

Unit Guide

Unit Objectives

To acquaint the students with some of the problems encountered in the main electrical circuits of environmental systems.

To impart an understanding of the mechanical faults that sometimes cause problems in electrical circuits.

To develop an attitude of necessary safety precautions when working around electrical equipment.

Tools and Materials

All electrical equipment in shop
Electrical test equipment
Refrigeration tools
Service manuals
Text

Unit Outline

A. No power at the compressor
   1. Disconnect switch open
   2. Main circuit breaker tripped
   3. Blown fuse
B. High voltage
C. Low voltage
D. Improper wiring
   1. Improper wire size
   2. Broken wire
   3. Loose connection
E. Starting capacitor
   1. Wrong size
   2. Burned out
F. Starting relay
   1. Wrong size
   2. Burned out
G. Running capacitor
   1. Wrong size
   2. Burned out
H. Motor draws too much current
   1. Lack of bearing lubrication

2. Belt too tight
3. Out of alignment
4. Motor overload
    a. Motor too small
    b. Wrong pulley size

I. Start winding stays in circuit
    1. Low voltage
    2. Faulty wiring
    3. Starting and/or run capacitor, starting relay
        a. Wrong size
        b. Burned out
    4. High head pressure
    5. Faulty compressor

Shop Activity

Troubleshoot electrical problems throughout the shop. Problems should be prepared prior to the students' arrival in the shop.

UNIT 3 – CONTROL CIRCUITS

Class Instruction – 4 hours
Shop – 8 hours

Unit Guide

Unit Objectives

To impart a better understanding of the operation of the components of control circuits in which service problems might arise.

To develop a definite attitude toward safety in working with all types of controls.

Tools and Materials

All equipment in the shop containing circuitry
Necessary tools, test equipment

Unit Outline

A. Transformer and relay coil circuits
B. Changeover relays
C. Cooling circuits
D. Damper circuits
E. Fan circuits
F. Heating circuits
G. Humidification
H. Reset circuits
I. Pressure control circuits
J. Reversing relay circuits
K. Thermal relay (delay type)

Shop Activity

Trouble-shoot control circuits in shop or elsewhere in school, predetermined and misadjusted by instructor.

UNIT 4 – DISTRIBUTION SYSTEM
Class Instruction – 3 hours
Shop – 6 hours

Unit Guide

Unit Objectives

To impart a better knowledge and understanding of the various components of which an air distribution system is comprised.

To develop a further knowledge and understanding through a review of the operating principles of air distribution.

Tools and Materials

Text
All air distribution systems available for trouble-shooting
Necessary tools, test equipment

Unit Outline

A. Diffusers, registers, and grilles
   1. Supply-adjustment
   2. Return
B. Ductwork
   1. Supply
   2. Return
   3. Fresh air
   4. Insulation
   5. Connections
C. Dampers
   1. Volume control
   2. Zone
   3. Face and bypass
   4. Fresh air
D. Blowers
   1. Rotation
   2. Belts
   3. Drive
   4. Lubrication
E. Filters

Shop Activity

Troubleshoot air distribution system problems assigned by the instructor on equipment in the shop and elsewhere in the school. Instructor should cause malfunction in the system prior to assignment of student to problem.

Unit Objectives

To acquaint the students with some of the possible causes of service problems in connection with steam and hot-water heating systems

To present to the students, methods of determining what the service problem or problems might be, and the possible solution to the service complaint.

To develop a definite attitude toward safety in working with all types of mechanical equipment.

Tools and Materials

Pressure-altitude gauge, thermocouple, pyrometer, thermometer, float and thermostatic trap, steam air-vent, water air-vent, radiator trap, and other hydronic heating accesories used in previous classes

Unit Outline

A. Servicing forced hot water systems
   1. Insufficient heat throughout system
      a. Boiler capacity
      b. Output of installed radiation
      c. Average water temperature
      d. Pipe or tube size
      e. Pump capacity
      f. Temperature drop throughout system
   2. Insufficient heat in individual rooms
      a. Air within the unit
      b. Air pocket in branch pipe
      c. One-pipe fittings installed incorrectly
      d. Radiation incorrectly installed
      e. Unit at end of series loop
      f. Units on a two-pipe system
   3. Heat distributing units air-bound
   4. Noise in system
      a. Air
      b. Velocity
      c. Expansion

5. Water level and pressure in system
   a. Pressure reducing valve
   b. Thermometer
   c. Automatic fill valve
   d. Water feeder
6. Pressure relief valve operations
   a. Limit control failure
   b. Faulty pressure relief valve (do not attempt to adjust)
   c. Water logged air cushion tank
      (1) Location of make-up water line
      (2) Incorrect location of circulator
7. Uneven heating
   a. Proper balancing of system
   b. Check of thermocouple, pyrometer, thermometer

B. Servicing steam heating system
1. Insufficient heat
   a. Size or boiler-firing rate
   b. Size of radiation
   c. Air vents
   d. Float and thermostatic traps
   e. Radiator valves
   f. Clean boiler water
2. Noise in system
   a. Expansion
   b. Water hammering
      (1) Sag in piping
      (2) Size of pipe
      (3) Insufficient pitch of piping and radiation
      (4) Improperly located vents
3. Boiler water level
   a. Unsteady water line
   b. No water in glass
   c. Water rises above glass
4. Loss of water from the boiler
   a. Leak in wet-return
   b. Leak in boiler
   c. Water valve leaking
5. Water level constantly increasing
   a. Feed level
   b. Indirect water heater

Shop Activity

Troubleshoot practical problems on the school heating system. Have students solve troubles on sections assigned to them. Instructor initiates problem in the heating system for student activity.

SECTION VIII - CUSTOMER RELATIONS

SECTION VIII

CUSTOMER RELATIONS

		Hours		
Unit	Title	Class	Laboratory	Shop
1	Customer Relations	5	0	4

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UNIT OUTLINE

Section VIII – Customer Relations

Unit 1 – Customer Relations

A. Dress and appearance – first impressions
   1. Clothing
      a. Neat
      b. Clean
   2. Personal appearance
      a. Cleanliness
      b. Personal hygiene
      c. Manner
         (1) Polite
         (2) Tactful

B. Courtesy to the customer
   1. Telephone communications
      a. Courteous
      b. Sincere
      c. Listen
      d. Never argue – but stand on fact
      e. Misunderstandings produce ill will
   2. Association in person
      a. Call customer by name
      b. Pronounce name correctly
      c. Efficient service
      d. Brief, thorough
      e. Satisfy complaint
      f. Enthusiasm about product

C. Customer psychology
   1. Get the customer's story
   2. Agreement and disagreement
   3. Knowledge of equipment
   4. Ignorance kills customer confidence
   5. Show initiative

D. Ethics

UNIT 1 – CUSTOMER RELATIONS

Class Instruction – 5 hours
Shop – 4 hours

Unit Guide

Unit Objectives

To acquaint the students with the importance of maintaining satisfactory business relations with all customers.

To develop an understanding of the importance of favorable first impressions, particularly with a dissatisfied customer.

To develop a comprehension of the customers' viewpoints in regard to the immediate problem.

Unit Outline

A. Dress and appearance – first impressions
   1. Clothing
      a. Neat
      b. Clean
   2. Personal appearance
      a. Cleanliness
      b. Personal hygiene
      c. Manner
         (1) Polite
         (2) Tactful
B. Courtesy to the customer
   1. Telephone communications
      a. Courteous
      b. Sincere
      c. Listen
      d. Never argue – but stand on fact
      e. Misunderstandings produce ill will
   2. Association in person
      a. Call customer by name
      b. Pronounce name correctly
      c. Efficient service
      d. Brief, thorough
      e. Satisfy complaint
      f. Enthusiasm about product
C. Customer psychology
   1. Get the customer's story

2. Agreement and disagreement
3. Knowledge of equipment
4. Ignorance kills customer confidence
5. Show initiative

D. Ethics

Shop Activity

Have the students practice customer-servicemen relations, simulating telephone calls and associations in person.

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