UA S.T.A.R.
CERTIFICATION
STUDY GUIDE
(HVACR)

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UA STAR HVACR

STUDY GUIDE

FORWARD

This Study Guide is designed to assist you in locating information in UA Textbooks that relate to the 12 categories and 68 tasks identified during the DACUM (Develop A CUrriculuM) process administered by Ferris State University. The DACUM is an in-depth job and task analysis that serves as the base for the UA STAR exam.

The 12 categories and 68 tasks identified during the DACUM are included in this Study Guide so that you can see first-hand the results of the study and the items that you can expect to encounter on the UA STAR exam. Each category and task is numbered, and each task is broken into a number of smaller jobs that a technician would be expected to perform in order to complete the task.

> Below each task you will find an underlined paragraph that looks like this and contains general reference to UA textbooks. In some cases, specific pages are cited. In others, chapters, but in most, only general reference is given.

You will find that the UA STAR exam is a comprehensive exam. It is designed to test the knowledge of the experienced technician. As such, this Study Guide is not intended to be a reference for the inexperienced technician to use in preparing for the exam. Nor is it expected that the inexperienced technician will be able to successfully complete the exam based on the Study Guide and the information contained in UA textbooks.

Instead, it is expected that the UA STAR test candidate is the technician who has completed the UA training and has gained several years of experience in the field. Many of the tasks and jobs identified in the DACUM are those that can only be learned by doing. The test candidate that expects to achieve success on the UA STAR exam by merely using the Study Guide to locate information in textbooks will likely be disappointed.

It is recognized that even the best technician does not work in all areas of the service industry. Further, some knowledge can be forgotten through lack of use. As such, it is recommended that you study a number of UA textbooks in preparing for the UA STAR exam. A list is provided below this paragraph. These texts were cited throughout the Study Guide. You may wish to review those texts where you feel you need knowledge. In addition, there are many other excellent books on the market that can serve as reference for you. They are far too numerous to list. You may know of some of them or even own them. Feel free to use them in your studies.

The UA textbooks contain many good questions that provide excellent practice material and act as a learning tool. If you spend time and answer the questions at the back of the texts successfully, you will be successful on the UA STAR exam.

This Study Guide also contains nearly 200 practice questions. All questions are multiple choice, with four possible answers. Most questions contain explanations for each of the correct and incorrect answers. The questions are designed to help you review some of the material that you will need to know when taking the exam.

The UA STAR exam is a tough test. With some hard work, you can be successful in passing it. Good luck!

UA Textbooks used as Reference in this Study Guide

Advanced Plan Reading & Related Drawing
Advanced Plan Reading & Related Drawing Building Specifications
Air Conditioning
Basic Electricity
Conservation and Safe Handling of Refrigerants
Customer Service Skills
Diagrams. Electric Controls for Mechanical Equipment Service
Drawing Interpretation and Plan Reading,
Electric Controls for Mechanical Equipment Service
Electric Controls for Mechanical Equipment Service Troubleshooting Guide
Gas Installations
Hydronic Heating and Cooling
Job Safety and Health
Pumps
Refrigerant Controls
Refrigeration, Volume I & II
Related Mathematics
Related Science
Rigging
Soldering & Brazing
Steam Systems

CONTENTS

Category A: Mechanical Principles

Task 1. Troubleshoot/repair/replace bearings and bushings

Visually inspect for seals, if present, cracks, missing elements, damage, fit/clearances/seating, lubrication, temperature, material type (bushings), support structure/fasteners and cleanliness
Verify vibration analysis as appropriate
Check setscrews for appropriate tightness (proper torque)
Check alignment
Check for over lubrication and correct type of lubrication
Replace
Replace with proper type
Inspect shaft for straightness, wear, damage, dimensions
Verify shaft and bearing surfaces are clean
Prelubricate as appropriate
Using proper tools, install bearing(s); heating, cooling, or pressing as required
Establish proper clearances as appropriate
Inspect oil and lubrication lines
Verify proper alignment and tolerance
Replace fasteners as needed

Reference

Information on typical seals can be found on P. 95 of Refrigeration. See also Chapter 35 of the same text for additional information on bearings and seals.

Page 46 of Pumps contains good graphics and descriptions of both the packing type and mechanical pump seal, as well as packing instructions for the packing type seal.

Lubrication information can also be found on page 46 as well as on page A-14 of Pumps.

Task 2. Troubleshoot/repair/replace shafts

Visually inspect shafts wear, alignment, straightness/runout, keyways, contamination, shoulders, clearance, type of materials, mounting structure and fasteners, polish and surface condition, proper diameter, cracks; rust
Send out for and/or repair shaft
Replace shafts, inspect new shaft for physical condition, measure shaft clearance to match proper component clearance, clean and polish shaft as needed, install; change fasteners as needed, check alignment as needed, check rotation as appropriate, monitor for proper operation; adjust as needed

Reference

No reference to shaft repair could be found in the UA texts listed in the Foreword of this Study Guide.

Task 3. Troubleshoot/repair/replace seals and o-rings

Visually inspect for leaks, cracks, missing components, damage, fit, lubrication, material type, seat and spring tension
Adjust, repair, or replace as appropriate
Prep as appropriate
Check lubrication levels
Check material type compatibility (application)

Reference

Information on typical seals can be found on P. 95 of Refrigeration.

Page 46 of Pumps contains good graphics and descriptions of both the packing type and mechanical pump seal, as well as packing instructions for the packing type seal.

Task 4. Troubleshoot/replace belts, sheaves/pulley

Perform visual inspection:
alignment, wear, belt condition
Check run out on the face of the pulley
Check balance of the pulley
Check setscrews
Check belt tension
Measure belt pulleys for wear
Replace belt or unit as appropriate
Inspect take-up equipment for function
Check fit to shaft
Clean pulley with wire brush and emery cloth
Replace pulley

Reference

Information on alignment of belts and sheaves can be found on P. 96 of Refrigeration. Additional information on belts and belt sizes can be found in Chapter 35 of Refrigeration. Further, The Mechanical Trades Pocket Manual, available through Macmillian is a good source of information the various types of belt drives.

Task 5. Perform alignment and balancing

Align belts and sheaves
Align direct-coupled shafts
Align stationery equipment
Correct soft foot

Reference

See Page 122, Hydronic Heating and Cooling and P. 96 & 97 Refrigeration for information in alignment of couplings.

A procedure for alignment of couplings can be found in Chapter 3 of Pumps and on pages A-4 and A-5 of Pumps.

Information on alignment of belts and sheaves can be found on P. 96 of Refrigeration.

Information on soft foot could be found at http://www.alinemfg.com/softfoot.htm at the time this Study Guide was compiled.

Task 6. Maintain couplings

Perform visual inspection for: wear, damage, lubrication, alignment, proper mounting on shafts, set screws, clearances, safety guards, coupling gap
Lubricate coupling
Replace grids, inserts, lovejoy, spider, gear insert, etc.
Replace chain couplings
Align couplings

Reference

See Page 122, Hydronic Heating and Cooling and P. 96 & 97 Refrigeration for information in alignment of couplings.

A procedure for alignment of couplings can be found in Chapter 3 of Pumps and on pages A-4 and A-5 of Pumps.

Category B: Electrical Principles

Task 7. Demonstrate knowledge of basic electrical

Apply principles of alternating and direct current
Apply principles of series, parallel and compound circuits
Recognize common single and three phase voltage systems, 230 v., 60 hz, single phase, 208v, 60 hz, three phase, 230 v., 60 hz, three phase, 460 v., 60 hz, three phase, 575 v, 60 hz, three phase (Canada)
Apply principles of Ohm's, Kirchhoff's and Watt's law
Read and interpret voltage, ampere, Ohm, megohm, and watt meters

Reference

The complete text Basic Electricity provides information on the fundamentals of electricity. For the technician to obtain knowledge of this subject, it is recommended that the entire text be studied and understood.

Chapter 21 in Refrigeration contains a good overview of electrical fundamentals, including a summary of formulas.

Chapter 6 in Gas Installations also has information on basic electrical principles.

Task 8. Service electrical power and control circuits

Verify operation
Verify voltage and power supply
Verify transformer operation and output
Check control fuses
Check all operational and safety controls
Check voltage drop
Diagnose distribution problems, phase and current imbalance, phase loss, phase reversal, phase shift, power factor

Reference

The Troubleshooting Guide for Electric Controls for Mechanical Equipment Service contains six service procedures, which can be used to troubleshoot electrical problems in HVACR equipment, including many of the objectives listed under this category.

A brief description of power factor can be found on P. 97 of Basic Electricity.

Chapter 7 of Electric Controls for Mechanical Equipment Service contains some information on protection from such faults as phase reversal, phase failure, and current overload.

Chapters 11 & 12 in Basic Electricity contain information on phase shift, capacitance and inductance, concepts that are necessary to understand when discussing phase and power factor.

Chapter 14 continues the discussion on induction and describes the operation of transformers. Various types of transformers can be found in Chapter 4 of Electrical Controls for Mechanical Equipment Service.

Chapter 25 in Refrigeration is another source of information on transformers.

Chapter 6 in Gas Installations should be consulted for information on controls related to gas fired appliances.

Task 9. Install/repair/replace motors (AC)

Install

Determine motor type and requirements (horsepower, voltage, type of wiring, etc.)
Size the motor and frame, if required
Mechanically prepare site (or request that it be done), drill and tap holes, install mountings
Bolt motor in position
Attach motor to device, Attach coupling, pulleys
Align motor to device(s)
Attach wiring per appropriate schematic; verify integrity of wiring
Power equipment and test operate
Verify rotation

Repair/replace

Inspect wiring and insulation with megger
Inspect termination
Check rotation
Inspect coupling
Inspect bearings
Inspect shafts
Check incoming power to unit
Replace motor unit
Replace bearings
Replace rotors
Replace wiring and re-terminate
Clean components

Reference

Chapter 15 & 16, Basic Electricity provides an explanation of how AC motors work and how they are controlled and protected. A fundamental knowledge on which to base the service of motors can be gained from this reading.

Chapters 7 through 11, Electric Controls for Mechanical Equipment Service provide more detailed information about motor controls, starters and safeties.

Chapters 22 & 23, Refrigeration also provide information motors and motor overload protection. While not directly related to the objectives in this category of the Study Guide, the information provides the technician with a better understanding that can contribute to more accurate troubleshooting while in the field.

Information on meggers can be found in several locations, including P. 517, Refrigeration, P. 73/74 Electric Controls for Mechanical Equipment Service and pages 67 & 123 of Basic Electricity

Information on couplings, bearing, etc. can be found in Category A of this Study Guide.

Task 10. Troubleshoot/replace/install circuit boards

Install/replace

Determine function of board or module
Select appropriate board or module (vendor)
Set jumpers or dip switches as required
Follow vendor procedures to install board
Calibrate board or module

Troubleshoot

Perform visual inspection of board
Check blown fuse
Check inputs and outputs
Verify calibration
Program unit
Verify configuration per vendor specifications
Clean contacts
Replace board as above
Replace fuses

Reference

Limited information in circuit ports can be found in the Troubleshooting Guide for Electrical Controls for Mechanical Equipment Service.

Task 11. Operate electrical/electronic test equipment

Operate DVOM
Operate ammeter
Operate megger
Operate millivolt meter
Operate computer terminal
Operate sling psychrometer
Operate power analyzer
Operate phase rotation and sequencer indicator
Operate electronic charging scale
Operate micron gauge
Operate electronic leak detector
Operate milli-amp generator
Operate electronic thermometers
Operate infrared thermometers
Operate electronic manometer
Operate electronic rotating vane (velometers)

Reference

Basic information on meters and their use can be found in Chapter 17 of Basic Electricity. Chapter 33 in Refrigeration provides also provides basic information on meters and their use. The information contained in both locations is basically the same, although the Refrigeration text provides specific applications for the meters, which is more applicable to later sections of this study guide.

Electrical Controls for Mechanical Equipment Service Troubleshooting Guide also provides information on the basic uses of the VOM a DDM, and provides many practical uses for service and troubleshooting.

Information on meggers can be found in several locations, including P. 517, Refrigeration, P. 73/74 Electric Controls for Mechanical Equipment Service and pages 67 & 123 of Basic Electricity

Sling psychrometers and their use is described in Chapter 3 of Air Conditioning.

Page 288 of Refrigeration contains an explanation of phase rotation.

Some information on phase monitors can be found on page 309 of Refrigeration. An explanation of three-phase line monitors can be found on page 373 of the same text.

Chapter 32 in Refrigeration contains information on leak testing, evacuating and charging, including descriptions and operation of leak detectors, electronic vacuum gages, manometers and other vacuum indicating instruments.

For information on testing electrical components, including the use of meters, see Chapter 33 in Refrigeration.

Category C: Controls

Task 12. Install/repair/replace starters

Determine appropriate size of the overload and breaker
Secure appropriate starter required for the job and NEC regulations
Install
Determine current and voltage requirements
Size starter, breaker, overloads
Obtain appropriate starter required for the job
Drill and tap holes to mount starter
Wire in the starter; terminate as appropriate
Set overloads and short circuits on IEC
Install correct size if NEMA
Initiate power and test system
Troubleshoot, Repair or replace
Inspect for burned contacts
Inspect for proper termination of wires; loose wires
Inspect for burned wire
Inspect overload units
Inspect integrity of load wiring
Inspect condition of breaker
Measure coil resistance using DVOM
Replace coil
Replace overload module on IEC
Replace auxiliary contacts on IEC
Replace contacts on NEMA
Replace breaker on starter
Replace overloads on NEMA
Adjust settings on soft start, if required

Reference

Electric Controls for Mechanical Equipment Service is the text to use for reference for starters. Chapters 7 through 11, titled Purpose and Construction of Motor Controllers, Application of Motor Controllers, Starters for Large Motors, Capacitors and Single-Phase Motors, and Push-Button and Relay Applications/Control Action of Magnetic Starters, should be reviewed if you want to refresh your knowledge on motor controls.

Task 13. Troubleshoot/repair/replace/install contactors

Install
Determine current and voltage requirements
Size contactors
Obtain appropriate contactor required for the job
Drill and tap holes to mount contactor
Install contactor
Wire in the contactor; terminate as appropriate
Initiate power and test system

Troubleshoot/repair/replace
Measure coil resistance; contact resistance
Check integrity of wires
Check termination of wires
Check appropriateness of contactor in system
Replace coil or contacts

Reference

While general knowledge of electricity and electrical circuits is prerequisite for controls, specific information on fuses, overloads and starters can be found in Chapters 6 – 11 in Electrical Controls for Mechanical Equipment Service. These chapters refer to some of the diagrams contained in Diagrams for Electrical Controls for Mechanical Equipment Service. There is a lot of information in these chapters, and it would do the reader well to spend time in this area.

Basic overload and motor starter sizing information is can be found on pages 60 and 61. Chapter 16 in Basic Electricity contains a good explanation of motor overload protection.

For information on testing electrical components, see Chapter 33 in Refrigeration. For information on specific components, see the following pages in Refrigeration:

Power supply..507
Fuses 509
Circuit breakers..511
Contactors/starters 512
Relays 513
Internal & external overload protectors and internal thermostats 514
Motor windings, single-phase..515
Motor windings, three-phase 517
Capacitors 517
(see also p. 375 for a photo of and ohmmeter testing a capacitor)
Transformers...518
Solenoid valves..519
Safety controls 519

Information on cleaning contacts and motor control equipment can be found in Chapter 8 of Electric Controls for Mechanical Equipment Service.

Information on NEMA (National Electrical Manufacturer's Association) can be found on-line at http://www.nema.org/

Information on NEC (National Electrical Code) can be found on-line by searching for "National Electrical Code".

Information on IEC (International Electrical Code) can be found on-line by searching for "International Electrical Code".

Task 14. Install/maintain relays

Install
Determine type of relay to use for application (AC, DC, solid state)
Determine number and type of contacts and mounting mechanism
Determine current/voltage rating
Mount and install and wire relay
Determine type of surge suppression required
Program controller
Complete documentation
Power up and test operate

Maintain
Perform visual inspection of unit
Clean or replace contacts
Check wiring and termination
Replace relay if faulty

Reference

See the reference for Category 12 above.

Also, Chapter 6 in Gas Installations contains information on relays.

Task 15. Troubleshoot/repair/replace limit and end switches

Replace limit or end switch
Determine adjustment requirements using DVOM, visual, indicator displays
Adjust lever position mechanically
Inspect contacts for corrosion, high resistance, water, intermittent operation
Inspect/replace rollers and lever arms
Replace stop or cam
Tighten mounting bolts or brackets
Fabricate/design brackets to mount limit switches
Set clearance on end switches

Reference

Information on limit switches can be found in Chapter 13 of Electric Controls for Mechanical Equipment Service.

See also Chapter 6 of Gas Installations.

Task 16. Troubleshoot/repair/replace flow switches or sensor

Set up switch or sensor
Calibrate flow switches or sensors
Install flow switches or sensors
Interface flow sensor to microprocessor or control panel

Repair/replace
Unclog flow sensor
Replace/repair circuit boards
Replace paddle
Replace transducer

Reference

Chapter 6 in Gas Heating contains information on flow switches, as does Chapter 15 in Electric Controls for Mechanical Equipment Service.

Task 17. Troubleshoot/repair/replace temperature sensors

Check primary sensing element
Calibrate temperature sensor
Check and verify polarity
Check connections for looseness
Verify correct type of sensor
Verify controller parameters
Repair/replace
Repair/replace primary sensor
Repair/replace circuit boards
Repair/replace extension wire
Repair/replace well
Clean the exhaust port (nozzle flapper)
Replace the thermostat

Reference

Fundamental information on methods of temperature measurement can be found in Chapter 2 of Electric Controls for Mechanical Equipment Service.

Chapters 12 - 14 in Electric Controls for Mechanical Equipment Service contain information in thermostats and temperature sensing devices.

See also Chapter 6 of Gas Installations.

Chapter 4 in Electric Controls for Mechanical Equipment Service also has good basic information on types of control action, including descriptions of thermostat operation.

Task 18. Troubleshoot/repair/replace pressure sensors

Set up pressure sensors
Calibrate pressure sensors
Replace pressure sensor
Configure or program
Tighten connections and tubing
Inspect electrical connections
Repair/replace
Repair/replace boards
Repair/replace transmitters
Repair/replace sensing unit
Install and "pipe in" a pressure sensor

Reference

Fundamental information on methods of pressure measurement can be found in Chapter 2 of Electric Controls for Mechanical Equipment Service.

Information on pressure sensors, including static pressure, pressure differential and oil pressure can be found in Chapter 15 of Electric Controls for Mechanical Equipment Service.

Task 19. Troubleshoot/repair/replace infrared sensors

Clean lens
Align infrared sensor
Install and setup infrared sensor
Inspect and check power supply and electrical connections
Verify correct output
Verify distance
Repair/replace
Replace unit
Repair/replace circuit boards

Reference

Information on infrared sensors, visible light detectors and ultraviolet flame detectors can be found in Chapter 21 of Electric Controls for Mechanical Equipment Service.

Task 20. Service/maintain operational and safety controls

Service specialty safety controls including but not limited to, smoke detectors, refrigerant monitor, moisture, CO detector, spill alarm, high and low pressure, high and low temperature, pressure differential sensors, flame safeguard, motor protection controls
Service specialty operational controls, ignition controls, flame rectification, infrared, ultraviolet, temperature controls (proportional, etc.), reset controller, pneumatic system controls
Service specialty operational controls, ignition controls, temperature screen, pressure screen, parts picker program screens, parts picker parameter screen, monitor screens

Reference

Information on many of these controls can be found in Chapters 12 – 22 of Electric Controls for Mechanical Equipment Service. Specific information is scattered throughout these chapters. As the introduction paragraph in Chapter 22 points out, there are so many variations of controls that it would be impossible to describe them all. As such, the learner is encouraged to read and study all of the information in order to gain broad knowledge of these controls. Chapter 22 provides an in-depth explanation of the application of combustion controls.

Category D: Air Conditioning and Refrigeration

Task 21. Perform general maintenance on air conditioning and refrigeration systems

Check and adjust belts
Change oil

Check operating conditions, pressure, temperature and temperature split, amperage and voltage
Change filters
Check condenser fan blades
Lubricate
Inspect and tighten all electrical connections and termination
Perform visual inspection including inspecting for leaks
Inspect covers and panels
Check cleanliness and operation of blower, compressors, dampers
Perform general housekeeping on unit, clean coils, clean drain lines and pans
Check and calibrate thermostats

Reference

Information on alignment of belts and sheaves can be found on P. 96 of Refrigeration. Additional information on belts and belt sizes can be found in Chapter 35 of Refrigeration. The Mechanical Trades Pocket Manual, available through Macmillian is a good source of information the various types of belt drives.

Chapters 12 - 14 in Electric Controls for Mechanical Equipment Service contain information on thermostats and temperature sensing devices.

Chapters 5 and 34 in Refrigeration have information in checking, adding and removing oil from air conditioning and refrigeration compressors.

Chapter 17 in Refrigeration provides information on lubrication of multiple compressors.

Task 22. Maintain air conditioning/refrigeration systems

Identify types of air conditioning systems, self-contained, split, built up systems
Identify types of refrigeration systems, medium temperatures, low temperatures, multi-temperature systems, cascade and compound cascade
Identify types of ice machines, large tonnage and small tonnage
Identify types of condensing systems, air-cooled, liquid cooled, evaporative condensers, liquid air cooled
Identify types of evaporators, DX, flooded

Reference

Chapter 16 of Air Conditioning contains descriptions of air conditioning equipment combinations as they are used in industry, including package unitary air conditioners, split systems and associated condensing units, fan coil units, unit ventilators, central station units, roof top units (RTUs) and built-up units.

Chapter 16 of Air Conditioning includes information related to heat pumps including air-to-air, air to water, water to air and water-to-water variations.

See Chapter 7 in Refrigeration for information on the many types of evaporators, including direct expansion (DX), fin-tube, dry expansion chillers and flooded chillers. This chapter describes the application for the various evaporator types as well as basic control strategies and methods.

Chapters 11 – 13 in Refrigeration contains information on condensers. Chapter 11 covers water-cooled condensers including double-pipe (tube-in-tube) and shell-and-tube condensers, flow arrangements, performance, troubleshooting, condenser maintenance and diagnostic tests. Chapter 12 deals exclusively with water-handling issues associated with water-cooled condensers and includes descriptions and operation of various cooling tower arrangements. Chapter 13 provides information in the evaporative condenser and the air-cooled condenser including capacity control and maintenance strategies for each type.

Compound compression systems are described in Chapter 29 of Refrigeration, starting on page 435. This chapter also contains descriptions and information of many commercial refrigeration systems and components.

Task 23. Troubleshoot/repair leak

Lock out and tag; isolate pressure sensitive components
Check charge
Perform visual/auditory inspection of the unit, oil residue, frost, wear on the copper tubing, damaged piping, listen for hissing sound
Assess conditions for selecting method to perform test, weather conditions, size of leak, size of system, environmental conditions, type of refrigerant
Perform test using one of several methods, electronic, soap bubbles, ultraviolet, halide, ultrasonic, sulfur stick, standing vacuum, standing pressure (nitrogen)
Isolate leak and relieve pressure, if appropriate, shut valve(s), pump system down, cross refrigerant over
Recover refrigerant
Prepare surface for repair or replace leaking component, brazing or soldering, replace, weld ammonia system
Pressure test repair using tracer gas and nitrogen

Reference

Lock-out, tag-out procedures can be found on page 311 in Refrigeration, and on pages 43 and 44 of Job Safety and Health.

Refrigerant recovery methods, procedures and regulations can be found in Conservation and Safe Handling of Refrigerants. While the UA STAR does not test specifically for EPA regulations, the all technicians are required to be EPA certified to work with refrigerants. As such, this text is a must for those who are not yet certified. Page 524 in Chapter 34 of Refrigeration has additional information on recovering refrigerant.

Chapter 32 in Refrigeration provides the necessary information on leak testing, evacuating and charging, including using tracer gas (HCFC-22) with nitrogen, methods of leak detection, evacuation and dehydration procedures, a discussion on pressures and their units of measure, charging (vapor and liquid), checking the charge and special precautions to use with a chilled water system.

Chapter 34 in Refrigeration has a good service procedure description for refrigerant pump-down for the purpose of system repair.

Task 24. Evacuate and measure the vacuum level of refrigeration systems

Lock out and tag equipment
Relieve pressure of nitrogen and tracer gases
Verify operation of vacuum pump and insure clean oil in vacuum pump, conduct pull down test using indicating device on pump
Verify removal of refrigerant
Connect vacuum pump to access ports
Confirm tightness of fittings

Install vacuum measuring device, micron gauge, wet bulb indicator, mercury manometer
Evacuate to proper level per mfg. specification verifying proper dehydration
Monitor oil quality in vacuum pump as it is pulling
Isolate vacuum pump
Perform standing vacuum test per mfg. specifications
Change oil as required

Reference

Lock-out, tag-out procedures can be found on page 311 in Refrigeration, and on pages 43 and 44 of Job Safety and Health.

Chapters 5 & 32 in Refrigeration contain information on evacuating and measuring the vacuum level in a refrigeration system. These are the same two chapters referenced in the section above on troubleshooting and leak repair.

Task 25. Perform refrigerant recovery

Lock out and tag
Identify refrigerant and type of recovery tanks required, high pressure, low pressure
Weigh empty tanks; verify evacuation, certification, and cleanliness of tanks
Determine vapor or liquid recovery
Determine quantity of refrigerant to be recovered
Use "push and pull' method with liquid refrigerant
Use 'vapor recovery' method for vapor
Verify water flows to prevent freeze up on chilled water applications
Recover to EPA guidelines
Measure or weigh tanks with recovered refrigerant; filled to maximum of 80%
Label tanks with proper label, content of tank, gross weight of cylinder, location

Reference

Lock-out, tag-out procedures can be found on page 311 in Refrigeration, and on pages 43 and 44 of Job Safety and Health.

All technicians are required by law to be certified according to the Clean Air Act of 1990, Title VI *Stratospheric Ozone Protection* and Section 608 *National Recycling and Emission Reduction Program*, as enforced by the Environmental Protection Agency (EPA). The text Conservation and Safe Handling of Refrigerants contains the information relevant to this regulation and to this section of the UA STAR exam.

Task 26. Charge refrigeration systems

Determine type of system (evaporator and condenser), air medium, water medium
Determine refrigerant level of system
Insure adequate freeze prevention, establish water flows, vapor charge to above freezing (per specifications)
Liquid charge once above freezing point of water
Start machine and charge to proper level, Weigh in refrigerant, meter refrigerant until correct charge, subcooling and superheat

Monitor system, -refrigerant pressures and temperatures for proper temperature splits and operation, -amperage for over or under charges
Trim or adjust charge as required to designed conditions

Reference

A good discussion on superheated vapor can be found on Page 29 of Refrigeration. Page 6 of Refrigerant Controls provides further information on superheat. Information on determining superheat can be found on page 43 of Refrigerant Controls.

A good discussion on subcooling can be found on page 71 of Refrigeration. Information on determining subcooling can be found in Chapter 4 of Refrigerant Controls.

Chapter 32 in Refrigeration is a good source in the UA texts for information on charging.

Task 27. Perform general maintenance on compressors

Identify types of compressors, reciprocating, scroll, helical rotary screw, centrifugal, rotary vane
Identify style of compressor, open drive, semi hermetic, hermetic
Check general operation of compressor, electrical connections; check amperage, mechanical operations, check oil levels, check refrigerant levels, listen for abnormal sounds, measure temperatures for overheating, check pressures, check crank case heater for proper operation, check vibration

Reference

Chapter 8 in Refrigeration contains descriptions and operating principles of compressor types, including rotary (rolling piston and sliding vane) helical-rotary (screw), centrifugal, reciprocating and scroll.

The same chapter describes construction of compressors (open, hermetic and semi-hermetic). Information on compressor drive mechanisms is also contained in Chapter 8, including open compressor drives (belt drive and direct drive - using a coupling).

Chapter 34 in Refrigeration has information in checking, adding and removing oil from air conditioning and refrigeration compressors.

Task 28. Maintain reciprocating compressors

Check internal suction/discharge valves to confirm operation of pump, oil pressure and level, crankcase temperature and superheat
Verify unloader operation
Replace compressor unit on sealed hermetic compressor
Overhaul of reciprocating compressor (semi-hermitic or open drive), valves on semi hermetic or open drive compressor, replace oil pump on semi hermetic or open drive compressor, replace shaft seals, replace valve plates, replace pistons and rings

Reference

Chapter 9 in Refrigeration is dedicated entirely to reciprocating compressors and Chapter 10 is dedicated to capacity control of reciprocating compressors.

While Chapters 9 and 10 in Refrigeration are titled “Reciprocating Compressors” and “Capacity Control of Reciprocating Compressors”, good information is included that applies to all compressors such as compression ratio, effect of discharge and suction pressure on compressor capacity, lubrication problems and the need for capacity control.

Chapter 34 in Refrigeration has information in checking, adding and removing oil from air conditioning and refrigeration compressors.

A good discussion on superheated vapor can be found on Page 29 of Refrigeration. Page 6 of Refrigerant Controls provides further information on superheat. Information on determining superheat can be found on page 43 of Refrigerant Controls.

For a complete understanding of superheat in the vapor compression cycle, read Chapter 6 in Refrigeration. Compressor superheat due to heat of compression is described on page 68 and illustrated on a pressure-enthalpy diagram in Fig. 6-8 on the same page. Complete superheat, due to the evaporator, heat in compressor body and heat of compression is described on pages 72 and 73 and illustrated in Fig. 6-13 and 6-14.

Task 29. Maintain scroll compressors

Check for correct rotation, reverse rotation on shutdown and discharge & suction superheat
Replace unit

Reference

Chapter 8 in Refrigeration contains detailed information regarding scroll compressors and their operating principles, moving parts and advantages. Determination of reverse rotation is also described.

A good discussion on superheated vapor can be found on Page 29 of Refrigeration. Page 6 of Refrigerant Controls provides further information on superheat. Information on determining superheat can be found on page 43 of Refrigerant Controls.

For a complete understanding of superheat in the vapor compression cycle, read Chapter 6 in Refrigeration. Compressor superheat due to heat of compression is described on page 68 and illustrated on a pressure-enthalpy diagram in Fig. 6-8 on the same page. Complete superheat, due to the evaporator, heat in compressor body and heat of compression is described on pages 72 and 73 and illustrated in Fig. 6-13 and 6-14.

Task 30. Maintain helical rotary screw compressors

Check oil differential pressure, pressure drop across oil filters, rotation, discharge superheat and load & unload capacities
Replace unit
Overhaul, replace bearings, rebuild slide valve, replace rotors, replace shaft seals

Reference

Chapter 8 in Refrigeration contains descriptions and operating principles helical-rotary screw compressor, including the slide valve operation for unloading purposes.

Task 31. Maintain centrifugal compressors

Check vibration, capacity control, rotation
Replace unit
Overhaul, replace bearings, replace impellers, replace gears, replace seals, replace motors, replace O-ring and gaskets, rebuild or replace vane assembly

Reference

Chapter 26 in Refrigeration is dedicated to centrifugal compressors and contains detailed information regarding operating principles such as capacity control, single-, two- and three-stage operation, economizers, motor cooling, lubrication and control.

Chapter 34 in Refrigeration contains some service procedures for centrifugal compressors, including considerations concerning adding oil.

The paragraph entitled “Special Precautions for Charging Chilled Water Systems” in Chapter 32 of Refrigeration applies to the type of systems that centrifugal compressors are typically used with.

Task 32. Troubleshoot/install refrigeration valves

Identify types of valves, control (such as head pressure control, check valves, etc.), safety relief valves, isolation valves (such as shut off valves, etc.), solenoid valves
Replace safety relief valves
Rebuild valves, when appropriate, replace o-rings, replace coils, replace diaphragm, replace plunger, replace seat and stem, replace packing material, replace Teflon seat

Reference

Chapters 14 – 16 in Refrigeration are entitled “Refrigerant Expansion Devices”, “Application of the Thermostatic Expansion Valve” and “Miscellaneous Valves and Refrigerant Control Devices”. These three chapters contains detailed and general information on many valves used for refrigeration, including hand valves, high-side and low-side float valves, expansion valves, thermal electric valves, shutoff valves, access/test valves, Schrader valves, check valves, pressure relief valves, solenoid valves, pressure regulator valves, hot-gas bypass valves, condenser head pressure control valves, reversing valves and water regulating valves.

More detailed information can be found throughout the text Refrigerant Controls. This text had many cut-away details of various types of valves, and also includes some service procedures. Thermostatic expansion valve assembly instructions are listed in Chapter 7 of this text, starting on page 49.

Task 33. Troubleshoot/install metering devices

Identify types of metering devices, thermostatic expansion valve, electronic expansion valves, capillary tubes, fixed orifice, hand valve, automatic expansion valve, float valve (high side and low side), variable orifice (such as poppet valve)
Determine refrigerant flow
Assess for proper operation

Measure and adjust superheat; calibrate as required
Rebuild or replace if system not functioning, replace power head, replace push pins, replace springs, clean strainer, replace seat, replace O-ring, replace float, clean orifice, replace capillary tubes if plugged or broken, replace strainer on capillary tube, replace strainer on capillary tube, location

Reference

Chapters 14 – 16 in Refrigeration are entitled "Refrigerant Expansion Devices", "Application of the Thermostatic Expansion Valve" and "Miscellaneous Valves and Refrigerant Control Devices". These three chapters contains detailed and general information on many valves used for refrigeration, including hand valves, high-side and low-side float valves, expansion valves, thermal electric valves, shutoff valves, access/test valves, Schrader valves, check valves, pressure relief valves, solenoid valves, pressure regulator valves, hot-gas bypass valves, condenser head pressure control valves, reversing valves and water regulating valves.

Chapters 1 – 7 in Refrigerant Controls are dedicated to thermostatic expansion valves.

Chapter 8 in Refrigerant Controls also has some information on the electronic expansion valve.

Further information on capillary tube systems and critical charging can be found in Chapter 15 of Refrigerant Controls.

Chapter 16 in Refrigerant Controls contains more information on the high- and low-side float valves.

Other detailed information can be found throughout the text Refrigerant Controls. Many cut-away details of various types of valves are provided, as are some service procedures. Thermostatic expansion valve assembly instructions are listed in Chapter 7 of this text, starting on page 49.

A good discussion on superheated vapor can be found on Page 29 of Refrigeration. Page 6 of Refrigerant Controls provides further information on superheat. Information on determining superheat can be found on page 43 of Refrigerant Controls. The method for adjusting superheat at the thermostatic expansion valve can be found on page 48 of Refrigerant Controls.

Task 34. Troubleshoot/install filters/dryers

Identify types of dryers, shell and core unit (such as liquid line and suction line, etc.), sealed unit
Identify sizing code
Identify function of dryers, dehydrate and clean systems, filter and capture acids and moisture and particles
Identify connection types, flare, solder and sweat
Check pressure and temperature drop across dryer
Replace sealed units when pressure drop exceeds specifications
Replace core on the shell and core units
Clean screen and shell with rag

Reference

Information in filter/driers can be found in Chapter 17 of Refrigeration pages 223 – 225.

Chapter 9 in Refrigerant Controls contains detailed information on filter-driers, including selection and installation of filter-driers and also replacement of filter-drier cartridges.

Task 35. Maintain condenser/evaporator system

Differentiate between high and low pressure side of system
Identify operation of specific components; repair/replace, condenser fan, evaporator fan, condenser cooling water, cooling towers, expansion valves, compressor, heater, accumulator, high pressure cut out
receiver, sight glass, filter dryer
Adjust the extended heating surface of the tube
Charge the system
Repair/replace piping system

Reference

General information on evaporators can be found in Chapter 7 of Refrigeration

General information on condensers and water-cooled condensers can be found in Chapter 11 of Refrigeration, while specific information on troubleshooting and maintenance begins on P. 142.

More detailed information on water-cooled condensers and water supply for water-cooled condensers can be found in Chapter 12 of Refrigeration.

More detailed information on evaporative condensers and air-cooled condensers can be found in Chapter 12 of Refrigeration.

Chapter 36 in Refrigeration contains very detailed information on inspecting, cleaning and repair of heat exchanger tubes used in chillers.

Chapter 32 in Refrigeration is a good source in the UA texts for information on charging.

Chapter 20 in Refrigeration has information about installing and brazing copper tubing.

Task 36. Maintain absorbers

Check pressures and temperatures, operations, specific gravity of solutions, pump operation for leaks, damage
Calculate absorber loss
Identify types of absorbents and refrigerants, water, ammonia, lithium bromide
Dispose of hazardous materials appropriately
Check and purge system

Reference

Chapter 30 in Refrigeration is dedicated to absorption refrigeration and contains information for most of the tasks listed in this category.

Task 37. Maintain cooling towers/evaporative condensers

Clean sump, fill and intake screens and strainers
Check chemistry of water
Maintain float valve or fill valve
Check and adjust fan alignment
Clean and/or replace nozzles
Test approach temperatures
Check sump heater/heat tracing
Verify bleed off operation
Maintain gear boxes and belts
Maintain oil level
Check fan performance
Balance water flow

Inspect for water and refrigerant leaks; repair as appropriate

Clean and descale tubing

Reference

General information on condensers and water-cooled condensers can be found in Chapter 11 of Refrigeration, while specific information on troubleshooting and maintenance begins on P. 142.

More detailed information on water-cooled condensers and water supply for water-cooled condensers can be found in Chapter 12 of Refrigeration.

More detailed information on evaporative condensers and air-cooled condensers can be found in Chapter 12 of Refrigeration.

Category E:Heating

Task 38. Perform general maintenance on heating system

Identify types of heating systems, radiant, convection, conduction
Identify energy sources, electric, solar, gas (oil, propane, fossil fuel, etc.), wood and corn
Identify transfer mediums, water, steam, air
Identify system types, heat pump, forced air (gas, electric, steam, fuel), electric resistant, radiant (hot water or electric)
Troubleshoot combustion controls, gas valves, gas trains
Inspect heat exchanger
Inspect air/fuel mixture; adjust
Clean burners
Check for temperature rise, low water cut off
Check blowers and belts
Replace filters

Reference

Chapter 4 in Air Conditioning is entitled "Principles of Heat Transfer" and discusses the three methods of heat transfer: radiation, convection and conduction.

Chapter 1 in Gas Installations contains a thorough discussion of fuel gasses, chemistry of combustion, proper fuel/air mixture, types of burners, proper flame appearance/adjustment, etc.

Chapter 22 in Hydronic Heating and Cooling is dedicated to solar heating applications.

The UA text Steam Systems is the best source of information for steam. However, Category F of this Study Guide and DACUM is dedicated exclusively to steam. It is recommended that any study of steam systems take place under Category F.

Chapter 15 in Air Conditioning in entitled "Heat Pumps" and contains information in the many different kinds of heat pumps, their operating principles, controls, applications, some service procedures and some troubleshooting procedures.

Chapters 5 & 6 in Gas Installations contains information on combustion controls, gas valves and gas trains. Chapters 21 and 22 in Electric Controls for Mechanical Equipment Service, entitled "Combustion Controls for Fuel Burning Equipment" and "Application of Combustion Controls" should also be reviewed for information on combustion controls.

Appendix C in Gas Installations has seven troubleshooting guides and checklists related to gas fired devices that would be useful to review for the UA STAR exam.

Chapters 1 - 3 in Air Conditioning would be a good review of the fundamentals of air conditioning, the science related to air conditioning, and the properties of air. Chapter 1 in Related Science is also recommended for review of information related to this category of the DACUM.

Task 39. Maintain radiant heating systems

Repair/replace components, radiant panels, circulation pumps, heating element, infrared fire tube
Clean surface

Reference

Information on radiant heating systems can be found throughout Hydronic Heating and Cooling. Chapter 4 contains information in selecting and sizing radiation while Chapter 21 deals with radiant panel systems, installation, balancing, etc.

Task 40. Maintain forced air heating system

Repair/replace components, gas train, blower, heat exchanger, filters, belts, bearings
Lubricate

Reference

Gas Installations is the reference text to use for this category of the DACUM. Nearly all chapters have relevance to this category and should be reviewed. Chapter 7, Appliances, contains descriptions of most kinds of residential forced air appliances.

Although forced air heating systems usually refers to residential style furnaces, Chapters 18 and 19, Single Path All Air Systems and MultiPath All Air Systems in Air Conditioning should also be reviewed. These chapters describe ducting systems used in commercial and industrial applications, which is technically "forced air".

Task 41. Maintain boilers

Identify types of boilers, water tube, fire tube, high and low pressure, hot water boilers, steam boilers
Identify energy sources, electric, solar, gas (oil, propane, fossil fuel, etc.), wood and corn
Identify safety devices on boilers, pressure relief valves, low water cut off, high temperature cut off, high and low gas pressure switch
Replace components, tubes, burners, controls, fans, gas valves, pilot assemblies, gaskets
Clean boilers
Blow down safety

Reference

Chapter 1 in Gas Installations contains a thorough discussion of fuel gasses, chemistry of combustion, proper fuel/air mixture, types of burners, proper flame appearance/adjustment, etc.

The troubleshooting guide found in Appendix C is a good source of typical complaints and possible solutions.

Chapter 22 in Hydronic Heating and Cooling is dedicated to solar heating applications.

The UA text Steam Systems is the best source of information for steam. However, Category F of this Study Guide and DACUM is dedicated exclusively to steam. It is recommended that any study of steam systems take place under Category F.

Chapters 6 – 10 in Hydronic Heating and Cooling, entitled “Equipment Selection and Pipe Sizing”, “Air in the System”, “Hydronic Heating Piping Connections”, “Installation of Equipment” and “Controls” are recommended for review as they have much information that is related to the jobs listed in this category of the DACUM.

Task 42. Maintain hydronic system

Diagnose system problems: perform visual inspection; listen for abnormal sounds, check water return temperature, measure temperature with infrared gun
Replace/repair circulating pumps in the hydronic system
Repair, replace and vent hydronic circulating bleeder vents
Replace/repair pressure regulating valves (PRV)
Grease fittings
Lubricate and pack expansion joints (slide type and loop type)
Repack and reseat valves
Conduct water analysis; adjust chemicals
Check water cleanliness

Reference

Many of the chapters on Hydronic Heating and Cooling contain information related to this category of the DACUM and can be used as primary reference. A troubleshooting guide is included at the back of the text that lists most of the complaints found in hydronic heating.

Task 43. Maintain centrifugal pumps

Check seals
Check connections for leaks
Inspect coupling
Inspect motor
Replace seals
Inspect housing for cracks; repair or replace as required
Inspect inlet strainers; clean if required
Check alignment
Check impeller; replace if required
Check mounting flanges
Check foundation for deterioration
Check fasteners for looseness or corrosion
Verify or perform vibration analysis on motor and pump bearings
Grease motor and pump bearings
Inspect flush lines for proper operation
Inspect gages and record information

Reference

Chapter 9, "Installation of Equipment" in Hydronic Heating and Cooling has information related to the installation of pumps, couplers, flexible connectors, valves, and other hydronic system components.

Chapter 35 in Refrigeration also had good information on pumps and some maintenance procedures.

The best source of information is the UA text Pumps. Details are included in the Appendix for installation, operation, troubleshooting and maintenance procedures.

Task 44. Maintain vacuum pumps

Inspect inlet and outlet filters
Check oil levels; fill as required
Check motor coupling; repair as required
Inspect suction lines for leaks; repair/replace as required
Check motor for proper operation
Check pressure gages
Inspect for oil leaks
Check level control operation

Reference

Information on vacuum pumps can be found on pages 61 & 62 of Pumps and on pages 69 & 70 of Steam Systems. Operating principles are described in both of these books.

Task 45. Maintain gear pumps

Inspect for leaks
Check pressure
Check for wear and defects; replace pump as needed
Inspect gears for proper operation
Inspect bearings and seals for operation and wear
Maintain appropriate oil levels
Inspect motor and gears; replace as needed
Inspect couplings for wear and alignment
Maintain appropriate clearances between gears and housing

Reference

Information on gear pumps can be found in the UA text Pumps.

Task 46. Maintain condensate return system

Inspect vacuum pumps
Inspect traps
Monitor water returns and treat with protective chemicals
Inspect for contaminate and leaks

Inspect condensate tank receiver
Maintain controllers; monitor
Repair/replace water make-up valve
Install gauge glass
Check floats for proper operation
Check piping
Replace/repair steam traps (ball float, thermostatic expansion, impulse, inverted bucket, float)
Adjust controls to verify proper steam flow

Reference

The UA text Steam Systems is the best source for information on steam systems, condensate return systems, steam system components and boilers. Chapters include Properties of Saturated Steam, Basic Equipment in a One-Pipe Steam Heating System, One-Pipe Steam Heating Systems, Steam Traps, Two-Pipe Steam Heating Systems, Vacuum Steam Heating Systems, Vapor Steam Heating Systems, Variable Vacuum (Sub-Atmospheric) Steam Heating Systems, Steam Piping, Heat Transfer Equipment, Steam Heating Unit Connections, Low-Pressure Steam Boilers, Water Feeders, Low-Water Cutoffs and Water Level Controllers, High-Pressure Steam Boilers and Steam generating Plants. Another resource for information on steam basics, steam systems and steam components is the Armstrong Catalog and Solution Source for Steam, Air and Water Systems.

Task 47. Troubleshoot/install/replace gas regulators

Check and adjust gas regulator
Check diaphragm vent
Check for proper operation; adjust as required
Conduct leak test

Reference

Chapter 5, titled Valves and Regulators in the text Gas Installations is the reference to use for this section of the DACUM.

Task 48. Troubleshoot and service electric heat

Check electrical connections
Check elements
Check high limit safety; adjust as required
Check amperage
Check air flow and safety
Check input voltage
Check temperature rise
Check belt and motor for proper operation
Replace components, heating elements, safety components, electrical components, blower motor

Reference

Little or no reference to electric heat could be found in the UA texts listed in the forward of this study guide. Chapter 28 in Refrigeration does make brief mention of the electric resistant heat used as a secondary heat source in heat pumps, but no information is provided on operation or maintenance.

Category F: Steam Systems

Reference

Reference for all of The UA text Steam Systems is the best source for information on steam systems, condensate return systems, steam system components and boilers. Chapters include Properties of Saturated Steam, Basic Equipment in a One-Pipe Steam Heating System, One-Pipe Steam Heating Systems, Steam Traps, Two-Pipe Steam Heating Systems, Vacuum Steam Heating Systems, Vapor Steam Heating Systems, Variable Vacuum (Sub-Atmospheric) Steam Heating Systems, Steam Piping, Heat Transfer Equipment, Steam Heating Unit Connections, Low-Pressure Steam Boilers, Water Feeders, Low-Water Cutoffs and Water Level Controllers, High-Pressure Steam Boilers and Steam generating Plants.

Chapter 9 in Hydronic Heating and Cooling has brief information on vacuum breakers.

Another resource for information on steam basics, steam systems and steam components is the Armstrong Catalog and Solution Source for Steam, Air and Water Systems.

Task 49. Maintain steam traps

Perform ultrasonic test for operation
Check strainers; clean as required
Inspect orifice size; replace, rebuild or clean as required
Rebuild trap
Replace inverted buckets
Replace float, if appropriate
Visually inspect for leaks

Task 50. Maintain steam regulators

Perform visual inspect for leaks
Inspect for air leaks
Measure pressure; adjust as required
Inspect equalizer line for obstruction; clean as required

Task 51. Maintain steam coils

Inspect for leaks and cleanliness; weld or solder to repair
Inspect for fin damage; comb the coils with fin comb
Inspect for proper drainage
Inspect temperature distribution over the coils; clear blockage or replace coils
Inspect for air flow over the coils; clear blockage or replace coils
Remove coils and send for repair; replace if required
Check filters; replace as required
Inspect strainers; clean or replace as required
Inspect mounting hardware; repair as needed
Verify adequacy of pressure; adjust as required

Task 52. Maintain vacuum breakers

Inspect for leaks and proper operation; repair
Replace unit as required

Task 53. Maintain steam flash (vent) tanks

Inspect for cracks; weld as required
Inspect vents for proper operation
Inspect water level controls; repair or replace as needed

Task 54. Maintain insulation systems

Inspect for tears and damage; replace as required
Check for water contamination/damage
Verify appropriate seal

Category G: Ventilation

Task 55. Troubleshoot/install fans and air handling equipment

Visually check for balance
Lubricate bearings
Inspect drive systems
Check for deterioration of outer housing and all components
Tighten, clean and lubricate
Align pulleys and shafts
Check for proper rotation
Check for bent shaft
Inspect fan components for cracks, damage, etc.
Replace filter and check exhaust ducts
Check insulation
Check for duct blockages
Check operation and condition of safety guards
Check for fan wheel to shaft fit
Check for looseness
Check setscrew torque
Check belt tension; replace belts if appropriate
Replace a fan unit
Regulate the humidity in the system
Inspect indoor air quality using air sniffers
Repair/replace modulating motors
Repair/replace coils
Repair/replace louvers and dampers
Calibrate controls on the system
Adjust variable air volume control devices (VAV)
Monitor and clean air wash system, if appropriate
Locate and identify freeze and fire stat; check operation
Lock out and tag
Check system for capacity
Clean drain pans and flush condensate drain line
Confirm adequacy of ducting and fan systems; consequences of improper ducting

Reference

The UA text Air Conditioning is the best source of reference for information related to ventilation and air handling equipment. Chapters 16 – 20 all deal with air handling equipment and systems.

Lock-out, tag-out procedures can be found on page 311 in Refrigeration, and on pages 43 and 44 of Job Safety and Health.

Information on alignment of belts and sheaves can be found on P. 96 of Refrigeration. Additional information on belts and belt sizes can be found in Chapter 35 of Refrigeration.

Category H: Piping

Task 56. Perform pipe cutting, joining and bending

Cut pipe: torch, hacksaw, tube cutter (hand and wheel type)
Join pipe, soldering, brazing and welding, compression fittings, threading, flare and swedge, glue, groove type (Vitaulic)
Bending: manual bending tool, spring type tool, design fittings

Task 57. Service/install piping and tubing and accessories

Measure, cut and specify pipe and tubing
Attach fittings (compression, swage, flare)
Attach support pipe hangers; mounted to ceilings, floors, truss, rafters
Solder ends
Install, specify and maintain valves in the lines, gage valves, globe valves, check valves, expansion valves, hot gas by-pass valve, solenoid valve
Install insulation around piping and tubing, interior, exterior
Repair/replace vents
Service accessories, accumulators, oil separators, discharge mufflers, receiver, evaporator pressure regulator, crank case pressure regulator

Reference.

The UA text Pipe, Fittings, Valves, Supports and Fasteners should be used as reference for this category of the DACUM.

Category I: Lifting Equipment

Task 58. Install rigging

Reference

The text to use for information for Category I of the DACUM is the UA text Rigging. In it you will find information on fiber and wire rope, knots and hitches, slings, helicopter hoisting, cranes and crane signals, hoisting and jacking equipment, rigging hardware and determining load weights. Further, the appendices have information on general rules for finding safe working loads (SWL) and tables of natural and synthetic fiber rope characteristics.

Determine weight of the load to be lifted
Select appropriate slings
Select appropriate lifting device, come along or tug it, chain hoist, cranes, T frame or A frame
Determine appropriate anchor and lift points, alert to center of gravity
Install rope as a tag line to guide load if required
Verify clear area to move load
Confirm equipment disconnected and bolts
Activate lifting device to lift and relocate load
Install skid rollers or use lift trucks to relocate load
Clear area before lifting

Task 59. Operate lifting and moving equipment

Operate chain falls
Operate jacks and portapower
Operate pry bars
Operate come-alongs
Direct operator of cranes and boom trucks
Operate machine dollies
Use hand signals for crane and helicopter lifting
Operate hydraulic lift

Category J: Safety and Environmental

Task 60. Demonstrate knowledge of common mechanical safety principles

The UA text Job Safety and Health should be reviewed for Category J of this DACUM. Many OSHA standards are included and described in the text, especially those that relate to the pipe trades. Standards include General Safety and Health Provisions; Ladders, scaffolding, work Platforms, Arial Devices and Stairways; Personal Protective and Life Saving Equipment; First Aid; Electrical; Tool-Hand and Power; Lifting and Handling Materials;

Fire Protection; Welding and Cutting; Excavations; and Occupational Health and Environmental Controls.

Awareness of surroundings; utilize common safety practices
Confined space hazards
Rotating equipment hazards
Location of exits
Fire extinguishers
CPR
Appropriate life saving equipment
Location of power source for emergency shutdown
Ladders and lifts
Hoist capacities
Evacuation procedures

Task 61. Demonstrate knowledge of lock out and tag

Go to equipment previously locked out by operations
Place on work order and place individual lock/tag on equipment for each trade on job
Determine sources of power and de-energize them related to the problem, mechanical, hydraulic, thermal, electrical
Open up power sources and test operation to confirm de-energized
Make required repairs
Complete documentation
Verify removal of all locks

Lock-out, tag-out procedures can be found on page 311 in Refrigeration, and on pages 43 and 44 of Job Safety and Health.

Task 62. Apply Environmental Protection Agency (EPA) regulations

Demonstrate and apply venting regulations
Demonstrate and apply recovery regulations
Demonstrate and apply reclaiming regulations
Demonstrate knowledge of recycling refrigerants
Demonstrate and apply indoor air quality regulations
Demonstrate and apply proper disposal of refrigerant oil and waste materials
Demonstrate knowledge of storage of refrigerants, approved vessels, ventilated area, away from heat sources

Reference

Refrigerant recovery methods, procedures and regulations can be found in Conservation and Safe Handling of Refrigerants. While the UA STAR does not test specifically for EPA regulations, the all technicians are required to be EPA certified to work with refrigerants. As such, this text is a must for those who are not yet certified.

Task 63. Apply the Department of Transportation (DOT) regulations

Demonstrate knowledge regarding transportation of hazardous materials, properly labeled, properly stored, appropriate quantities transported
Demonstrate knowledge regarding handling of hazardous materials
Maintain log book (Canadian) during transportation
Operate motor vehicles, security of contents vehicle, proper licensure when appropriate, perform vehicle maintenance, adhere to company policies and procedures as appropriate

Reference

No reference to Department of Transportation regulations could be found in the UA texts listed in the Foreword of this Study Guide.

Category K: Applied Math and Blueprint Reading

Task 64. Perform applied math and science operations

Interpret pump and fan curves and laws
Calculate electrical formulas such as Ohm's law, etc.
Use weights and measurements
Interpret pressure and temperature relationships using charts
Interpret charts and graphs
Convert F to C
Calculate volume and pressure relationships
Interpret Psychrometric charts
Interpret pressure enthalpy diagrams
Perform hydronic calculations including psi/ft
Calculate basic load calculations

Reference

UA texts Related Math and Related Science should be reviewed for this category of the DACUM.

Task 65. Interpret blueprints

Identify basic blueprint symbols, different dimension (height, thickness, length, etc.), exploded views, plan and elevation views, isometric
Identify basic mechanical symbols, valves, motors, switches, gearbox, couplings, shafts, doorways
Identify common piping and ductwork symbols, equipment, duct runs and supply and return, fittings (elbows, T's, transitions, etc.), pipe sizes
Identify common electrical symbols and wiring diagrams, motor, switches, relays, transformer, contacts, controls, breakers, fuses, terminals
Identify pneumatic symbols, controls, thermostats, sensors, actuators, relays, valves

Reference

Refer to Drawing Interpretation and Plan Reading, Advanced Plan Reading & Related Drawing and Advanced Plan Reading & Related Drawing Building Specifications for detailed information about this category of the DACUM.

Information can also be found in texts relating to specific aspects of service work. For example, electrical symbols can be found the electrical texts, while piping symbols are found in Pipe, Fittings, Valves, Supports and Fasteners.

Category L: Customer Service

Task 66. Perform recordkeeping

Calculate hourly/daily/weekly reports
Create invoices

Maintain inventory (supplies and materials)
Log EPA and refrigerant use
Calculate estimating costs
Create written description of work performed
Attend site and survey meetings
Create maintenance logs
Demonstrate computer literacy, database, spreadsheet

Task 67. Display professionalism

Read professional journals
Maintain service truck
Demonstrate professional appearance for profession
Display punctuality
Demonstrate leadership
Demonstrate self-confidence and motivation
Respond to customers who are upset

Task 68. Communicate with customers

Demonstrate proficiency of computer communication, e-mail, search Internet for information
Compose proposals and correspondence
Display telephone etiquette
Respond to pagers and cell phone
Maintain communication with dispatcher and supervisor
Convey technical information in easy to understand method to customers

UA STAR HVACR PRACTICE QUESTIONS

Practice Questions

1. For applications where quiet operation and light axial load characteristics are found, the type of bearing normally used is the.

   A. ball bearing.

   B. thrust bearing.

   C. sleeve bearing.

   D. roller bearing.

2. Sleeve bearings with the oil port lubrication system must be lubricated with the proper oil because

   A. oil that is too thin will allow the shaft to run against the bearing surface

   B. oil that is too thick will not run into the clearance between the shaft and the bearing surface.

   C. the correct oil allows the motor shaft to float on a film of oil between the shaft and bearing surface.

   D. All of the above.

3. Too much grease in a grease lubricated ball bearing

   A. is not a problem.

   B. is not possible.

   C. causes overheating.

   D. reduces friction.

4. The maximum desirable operating temperature of a ball bearing is

   A. 180°F.

   B. 212°F

   C. 150°F.

   D. 350°F.

5. Shaft runout can be measured with

   A. a dial indicator.

   B. a runout gage.

   C. a micrometer.

   D. Both A and B.

6. The seal in a compressor is necessary to prevent

   A. refrigerant from leaking out at the rotating shaft.
   B. air from leaking out at the rotating shaft.
   C. oil from leaking out at the rotating shaft.
   D. Both A and C from above.

7. The mating seal surfaces on a sleeve type rotary bellows seal are

   A. two polished steel surfaces.
   B. polished steel surfaces and neoprene.
   C. polished steel surfaces and a carbon ring.
   D. steel grooves and waxed cord.

8. A fan with a 14-inch sheave is connected by belts to a motor. Calculate the fan speed if the motor is operating at 1725 rpm and is fitted with a 5-inch sheave.

   A. 4830
   B. 483
   C. 6161
   D. 616

9. With belt driven equipment, alignment of the motor and driven equipment pulleys

   A. is not critical, since the belts are flexible.
   B. is accomplished using a string or straight edge.
   C. is accomplished when the belts are parallel to one another.
   D. is accomplished using a dial indicator.

10. To correct for soft foot

   A. replace soft material with a material of sufficient hardness.
   B. shim under the high foot with shim stock equal to a reading on the indicator.
   C. replace the resilient material in the coupling.
   D. replace vibration isolators with isolators properly rated for the pump.

11. The two planes of alignment that must be considered when aligning a flexible coupling are

   A. axial and parallel.
   B. parallel and perpendicular.
   C. horizontal and vertical.
   D. parallel and angular.

12. Electrical pressure is measured in

    A. amps

    B. ohms.

    C. watts.

    D. volts.

13. Electricity results from the movement of tiny negatively charged particles called

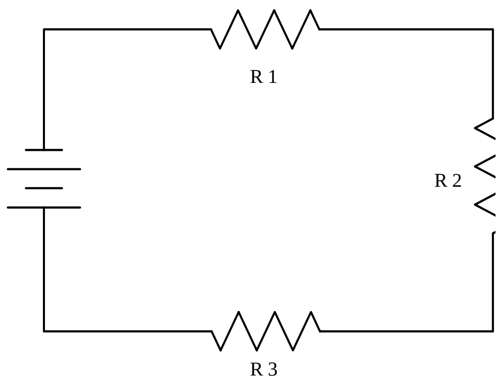
    A. protons.

    B. electrons.

    C. neutrons.

    D. ions.

Use the diagram below to answer the next two questions.



14. Calculate the voltage in the circuit when the total amperage is 10 amps and the resistors have values as follows: R1=10 ohms, R2=15 ohms, R3=20 ohms.

    A. 0.45 volts.

    B. 4.5 volts.

    C. 450 volts.

    D. 0.222 volts.

15. Calculate the value for R3 when the value for R1=150 ohms, R2=500 ohms, the voltage is 120 volts and the amperage is 0.12 amps.

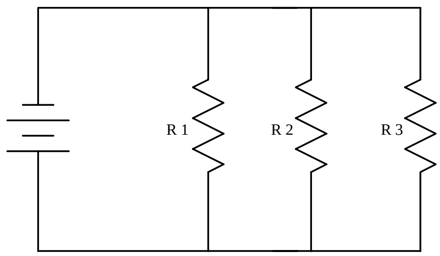
    A. 1000 ohms.

    B. 100 ohms.

    C. 10 ohms.

    D. 350 ohms.

Use the diagram below to answer the next question.



16. Calculate the voltage in the circuit when the total amperage is 20.4 amps and the resistors have values as follows: R1=10 ohms, R2=50 ohms, R3=20 ohms.

    A. 120 volts.

    B. 240 volts.

    C. 1632 volts.

    D. 3.92 volts.

17. What is the maximum safe amperage draw of the secondary winding of a 60 VA transformer output of 12 volts?

    A. 0.2 amps.

    B. 5 amps.

    C. 720 amps.

    D. 7.2 amps.

18. The best way to determine the voltage requirements for an electrical component is to

    A. read line voltage with a digital multimeter.

    B. read the name plate data.

    C. check with the utility company.

    D. determine the capacity of the service panel.

19. Fuses can be checked

    A. with an ohm meter.

    B. with a volt meter.

    C. with an ammeter.

    D. Both A and B from above.

20. Which of the following devices may be wired into the starting circuit of a single phase motor to improve the starting torque?

    A. winding thermostat.

    B. start capacitor.

    C. another winding.

    D. Both B and C above.

21. A single phase motor with an improved power factor, reduced motor current, increased efficiency and high starting torque is the

    A. capacitor start-capacitor run (CSR) motor.

    B. shaded pole motor.

    C. split phase motor.

    D. permanent split-capacitor motor.

22. In a CSR motor with a 10 microfarad run capacitor and a 110 microfarad start capacitor, the total capacitance will be

    A. 60 microfarads.

    B. 120 microfarads.

    C. 9.17 microfarads.

    D. 100 microfarads.

23. The instrument used for finding humidity levels in the atmosphere is the

    A. sling psychrometer

    B. micron gage.

    C. manometer.

    D. infrared thermometer.

24. For reading the lowest vacuum levels, the best instrument to use is

    A. a gage manifold set.

    B. a manometer.

    C. electronic vacuum gage.

    D. wet-bulb type vacuum indicator.

25. A hermetic motor should never be energized or tested with a megger when in a deep vacuum because

    A. electric arcs can contaminate refrigerant in the system.

    B. the motor could draw too much amperage.

    C. the vacuum pump could be damaged.

    D. the dielectric strength of the motor’s insulation would be greatly reduced.

26. Which of the following reduced voltage starters uses a switching arrangement to connect the windings of three-phase motors in different configurations during startup and normal operation?

    A. Autotransformer starters.

    B. Start-run starters.

    C. Star-wye starters.

    D. Star-delta starters.

27. According to NEC (National Electrical Code), a general-use switch may be used as the controller for a stationary motor rated at two horsepower or less and at 300 volts or less if it is rated at not less than

    A. the full-load motor current.

    B. twice the full-load motor current.

    C. three times the full-load motor current.

    D. five times the full-load motor current.

28. Two types of thermal overload relays in common use today are

    A. the bimetal relay and the magnetic relay.

    B. the melting alloy relay and the Mercury bulb.

    C. the bimetal relay and the melting alloy relay.

    D. the bimetal relay and the trimetal relay.

29. A rather common indication of a defective starting relay in a single phase motor

    A. is for the motor to hum but not start.

    B. is for the motor to start, run normally, then shut down after several minutes.

    C. is the motor to start but not come up to speed.

    D. the motor starts but runs in the wrong direction.

30. The level of voltage caused by back electromotive force that opens the contacts on a potential relay in order to take the start capacitor out of the circuit is called

    A. lift voltage.

    B. open voltage.

    C. run voltage.

    D. Pick-up voltage.

31. A type of current relay that uses a bimetal strip to open contacts in both the starting and running contacts is called a

    A. hot-wire relay.

    B. bimetal relay.

    C. start/run relay.

    D. “Gallert” relay.

32. A pneumatic timing relay operates by

    A. receiving air from the pneumatic control system.

    B. filling a bellows with air.

    C. sensing air from a motor's cooling fan.

    D. changing air pressure after a set amount of time.

33. The combination safety limit and fan control on a residential furnace turns the fan on and off by sensing the furnace air temperature. If the furnace temperature rises too high, the safety limit de-energizes the

    A. fan and main gas valve.

    B. fan.

    C. gas valve.

    D. igniter.

34. Some codes require a manual reset device on a safety limit

    A. so that the cause of the safety shutdown can be investigated prior to re-start.

    B. so that the equipment will not short-cycle.

    C. so that more technicians are needed, which helps the economy.

    D. because automatic reset is more costly.

35. In order to protect a load, safety limit devices are most often wired

    A. in parallel.

    B. in series.

    C. upstream.

    D. downstream.

36. A flow switch safety control is used to

    A. control the amount of flow of a fluid (liquid or gas).

    B. turn on a pump or fan.

    C. divert fluid flow during unsafe conditions.

    D. prove that flow is occurring.

37. What is a disadvantage of the mercury bulb switch?

    A. They are unreliable.

    B. They must be level.

    C. They tend to burn contacts.

    D. They tend to "chatter", which cycles the load on and off.

38. A thermostat is properly calibrated when

    A. set point and control point are equal.

    B. room temperature is comfortable.

    C. there is no deadband.

    D. control point and thermostat reading agree.

39. With a change in temperature, a thermistor will change

    A. resistance.

    B. voltage.

    C. current.

    D. impedance.

40. One type of pressure sensing device uses a flattened metal tube, which is bent into a part-circle with one end fixed in place and connected to a system to be measured. The other end of the tube is closed and free to move. An increase in pressure tends to straighten the tube. The movement of the free end of the tube is connected to a dial that reads pressure. This type of gage is called a

    A. Whiskey tube.

    B. bimetal tube.

    C. Bourdon tube.

    D. flat-tube gage.

41. A pressure sensing device that relies on a fluid, such as oil, to provide a frictionless seal is the

    A. Whiskey tube

    B. oil pressure gage.

    C. inverted bell.

    D. inverted bucket.

42. An advantage of a diaphragm is that it can produce a large force when acted upon by only a small pressure. Calculate the total force exerted by an 8" diaphragm with a pressure of 1.8 psig applied to the diaphragm.

    A. 362 pounds.

    B. 90.5 pounds.

    C. 56.54 pounds.

    D. 14.4.

43. The photo cell in an infrared sensor is made of

    A. lead sulfide.

    B. cadmium sulfide.

    C. a sealed gas-filled chamber.

    D. zinc sulfide.

44. Aiming of infrared sensors is critical. Why must they be aimed directly at the flame?

    A. Since they see light, they can be fooled by the bright area surrounding the flame.

    B. Since they see heat, they can be fooled by the hot air surrounding the flame.

    C. Since they see heat, they can be fooled by hot refractory.

    D. Since they see heat, their sensitivity can be reduced by hot refractory.

45. A type of two-position control that provides for "intermediate" positions as well as the "all-on" and "all-off" positions is the

    A. timed two-position control.

    B. deviation control.

    C. percentage control.

    D. floating control.

46. While proportional control action has the disadvantage of control point shift but has no time-lag factor, floating action has the disadvantage of time lag influence but has no control point shift. What control action combines the advantages of both?

    A. Proportional integral.

    B. Proportional with feedback.

    C. Floating proportional control.

    D. single-speed floating action.

47. A flame sensing strategy that takes advantage of the fact that hot gasses in a flame become ionized and conduct electricity is called a

    A. cad cell.

    B. thermocouple.

    C. flame rod.

    D. ion sensor.

48. Checking amperage on a system during general maintenance

    A. is a waste of time and should be avoided.

    B. should only be done if a problem is suspected.

    C. can indicate a problem with the system.

    D. should only be done with the power off for safety reasons.

49. When changing or adding oil to a compressor

    A. it is best to buy the smallest possible containers and use the entire contents at once.

    B. avoid pouring the oil from a container into the compressor.

    C. use an oil charging pump.

    D. all of the above.

50. As the evaporating temperature of any vapor compression system is lowered,

    A. compressor suction vapor density increases.

    B. the volume of the suction vapor decreases.

    C. compressor capacity is lowered.

    D. flash gas in the liquid line is likely to occur.

51. As a "rule of thumb", for every 12,000 btuh of cooling capacity in an open compressor air conditioning system, the heat rejection is roughly

    A. 12,000 btuh, or 1.0 times the net refrigeration effect.
    B. 9,000 btuh, or 0.75 times the net refrigeration effect.
    C. 15,000 btuh, or 1.25 times the net refrigeration effect.
    D. none of the above

52. The difference in temperature between condensing temperature and entering water or air temperature is known as

    A. temperature split
    B. Subcooling
    C. Superheat
    D. temperature rise

53. A decrease in condensing temperature will

    A. increase condensing pressure, increase suction temperature and increase system capacity.
    B. decrease condensing pressure, increase suction temperature and increase system capacity.
    C. decrease condensing pressure, decrease suction temperature and increase system capacity.
    D. decrease condensing pressure, decrease suction temperature and decrease system capacity.

54. Subcooling in the condenser will

    A. increase system capacity.
    B. decrease system capacity.
    C. not affect system capacity.
    D. increase the flash gas loss.

55. Compressor capacity controlled by the cylinder unloading method

    A. may result in compressor overheating
    B. is only used with hermetic compressors.
    C. does not provide energy savings.
    D. is only used with systems charged with ammonia.

56. 10 in.Hg. vacuum is approximately equivalent to

    A. 5 psig.
    B. 5 psia.
    C. 10 psig.
    D. 10 psia.

57. After repairing a leak, it is permissible to pressure test a system using nitrogen with a small amount of _______ added as a trace gas.

    A. helium.
    B. oxygen.
    C. CFC 12.
    D. HCFC 22.

58. When charging a system, the refrigerant cylinder pressure may drop too low for further charging. Which of the following methods should *not* be used to increase the pressure?

    A. Heat the cylinder with a torch.
    B. Heat the cylinder with a heat lamp.
    C. Heat the cylinder by immersing it in a tub of warm water.
    D. Heat the cylinder by wrapping it in a specially built electric heater.

59. A term used to rate vacuum pumps is used to describe the pump's ability to draw a vacuum. Essentially, the pump must create a vacuum within itself that is lower than in the system, so that gases will flow from the system to the pump. The point at which a pump can no longer create a pressure difference is called

    A. dead head pressure.
    B. blank-off pressure.
    C. blocked tight static pressure.
    D. point of no pressure difference.

60. Vacuum pump oil is a special oil because

    A. it won't absorb water.
    B. it has a low vapor pressure to ensure that it won't vaporize at low pressures.
    C. it rarely needs changing.
    D. it is non-toxic and can be disposed of easily.

61. Which of the following methods will not decrease the time needed to evacuate a large refrigeration system?

    A. Using large diameter fittings.
    B. Keeping hose lengths as short as possible.
    C. Triple evacuation.
    D. Using multiple vacuum pumps.

62. A danger with leaving a vacuum pump running all night is

    A. pulling more than 30 in.Hg. vacuum.
    B. exceeding the pumps running time capabilities.
    C. pump oil could be lost during a power outage.
    D. Both B and C from above.

63. Vacuum pump oil that is fresh

    A. has a smooth milky appearance.

    B. has a clear appearance.

    C. has a somewhat cloudy appearance.

    D. is very thick and heavy.

64. A refillable refrigerant cylinder must not be filled above _____ percent of its capacity by weight.

    A. 100%

    B. 90%

    C. 80%

    D. 70%

65. A refrigerant with the ANSI/ASHRAE Standard 34-1992 safety classification of A1 has

    A. high toxicity and high flammability.

    B. low toxicity and no flame propagation.

    C. low toxicity and high flammability.

    D. high toxicity and no flame propagation.

66. All appliances containing more than 50 lbs. of refrigerant (except commercial and industrial process refrigeration) must be repaired when the annual leak rate exceeds

    A. 5%

    B. 15%

    C. 25%

    D. 35%

67. When charging a chilled water system, charging is usually done as a liquid. However, if the machine is in a deep vacuum, the initial charge should be as a vapor. Why?

    A. Charging as a vapor is faster for chillers because the system is in a deep vacuum.

    B. Charging as a vapor allows system pressure to stabilize and prevents thermal shock to the system.

    C. Charging as a vapor until the system reaches ambient temperature prevents condensation inside the system.

    D. Charging as a vapor until the system temperature has risen above 32°F prevents freezing of water in the tubes.

68. When charging a system, several methods are available for checking the refrigerant charge. In order to charge by monitoring the subcooling, one must

    A. monitor discharge pressure and liquid line temperature close to the metering device and charge until the liquid line temperature falls below the discharge saturation temperature by the expected amount of subcooling.

    B. monitor discharge temperature and liquid line temperature close to the metering device and charge until the discharge temperature falls below the liquid line temperature by the expected amount of subcooling.

    C. monitor saturated suction temperature and suction gas temperature and charge until saturated suction temperature falls below the suction gas temperature by the expected amount of subcooling.

    D. monitor saturated suction temperature and suction gas temperature and charge until suction gas temperature falls below the saturated suction temperature by the expected amount of subcooling.

69. Insufficient refrigerant will cause

    A. excessive head pressure.

    B. low suction pressure and insufficient cooling.

    C. low suction pressure and over cooling.

    D. high discharge temperature.

70. Most compressors are positive displacement machines. Name a compressor that is not a positive displacement machine.

    A. Reciprocating.

    B. Helical-rotary (screw)

    C. Rotary.

    D. Centrifugal.

71. The ratio of the actual volume of refrigerant vapor pumped to the theoretical displacement volume is known as

    A. volumetric efficiency.

    B. volumetric ratio.

    C. compression efficiency.

    D. compression ratio.

72. A compressor in which the compressor and motor are both sealed within the same pressurized housing is known as a

    A. sealed compressor.

    B. pressurized compressor.

    C. hermetic compressor.

    D. hermenet compressor.

73. The passage of liquid refrigerant through the compressor suction and discharge valves should be avoided and is known as

    A. choking the compressor.
    B. slugging the compressor.
    C. kicking the compressor.
    D. shocking the compressor.

74. Modern high-speed reciprocating compressors typically operate at

    A. 1750 rpm.
    B. 3450 rpm.
    C. 5250 rpm.
    D. Both A and B from above.

75. Compressor capacity decreases as

    A. discharge pressure increases.
    B. suction pressure decreases.
    C. compressor speed decreases.
    D. All of the above.

76. An advantage of the scroll compressor is

    A. smooth, quiet operation.
    B. low torque variation through overlapping compression cycles.
    C. few moving parts.
    D. All of the above.

77. How can you identify reverse operation with a scroll compressor?

    A. The compressor will not compress.
    B. The compressor will stop on motor overload.
    C. You can see it running backwards.
    D. Both A and B from above.

78. During scroll compression,

    A. refrigerant vapor enters from the outside of the scroll and exits at the center.
    B. refrigerant vapor enters from the center of the scroll and exits at the outside.
    C. refrigerant vapor enters from one side of the scroll and exits from the other side.
    D. Both A and C from above.

79. Capacity control on a helical-rotary (screw) compressor is obtained using

    A. inlet vanes.
    B. hot gas bypass.
    C. variable speed motors.
    D. a sliding valve.

80. The screw-type impellers used in helical-rotary compressors are also known as

    A. rotors.
    B. scrolls.
    C. a helix.
    D. vanes.

81. The component in a centrifugal compressor that actually does the compressing is known as

    A. an impeller.
    B. a rotor.
    C. a centrifuge.
    D. a centripetal.

82. A centrifugal compressor controls capacity through the use of

    A. variable speed.
    B. on-off control.
    C. vortex dampers.
    D. Both A and C from above.

83. Bearings in a centrifugal compressor can be checked by

    A. sliding the impeller back and forth to check for slop.
    B. trying to move the shaft at right angles to the bearing.
    C. checking the temperature of the oil returning from the bearing.
    D. manually spinning the impeller while listening for grinding noises.

84. A small access valve which is similar to the air valve used on tires is known as a

    A. Schriber valve.
    B. Schrader valve.
    C. Schreuder valve
    D. Schroder valve.

85. A valve used to prevent flow of liquid refrigerant to the evaporator and to avoid flood back to the compressor during off cycles is the

A. check valve.

B. bypass valve.

C. relief valve.

D. solenoid valve.

86. A special valve used to prevent evaporator temperature from falling below a predetermined minimum temperature regardless of suction pressure is the

A. evaporator pressure regulator.

B. pressure reducing valve.

C. suction pressure regulator.

D. None of the above.

87. A metering device with the characteristic of feeding liquid into the evaporator at the same rate at which the liquid flows from the condenser is the

A. thermostatic expansion valve.

B. high-side float valve.

C. low-side float valve.

D. constant pressure expansion valve.

88. In a thermostatic expansion valve, three forces act on the diaphragm in the power head, which is connected to the valve. Evaporator pressure acts to ________ the valve, spring pressure acts to _______ the valve and bulb pressure from the bulb attached to the evaporator outlet acts to _______.the valve.

A. open; open; close.

B. close; close; open.

C. close; open; open.

D. open; close; close.

89. The metering device that actually measures temperature rather than pressure or liquid levels is the

A. temperature activated expansion valve.

B. thermostatic temperature valve.

C. capillary tube.

D. thermal electric valve.

90. Suction line filter-driers should be installed whenever

A. a system is serviced.

B. a leak has occurred.

C. a hermetic compressor motor burnout has occurred.

D. a thermostatic expansion valve has been replaced.

91. Filter-driers and driers are filled with a material that is able to catch and retain moisture and acid. This material is called

   A. water dry.

   B. desiccant.

   C. dry-out.

   D. moisture dry.

92. Suction line filter-driers are usually equipped with gage connections so that pressure drops can be determined. Why?

   A. So that accurate superheat calculations can be made.

   B. To ensure that excessive load is not imposed on the compressor.

   C. To ensure that flash gas does not occur in the filter-drier.

   D. So that you can determine when to change the filter-drier.

93. In general, the greater the number of rows in an evaporator

   A. the more closely the leaving air temperature will be to that of the refrigerant.

   B. the more dehumidification can take place.

   C. the colder the leaving air will be.

   D. All of the above.

94. Increasing air flow over an evaporator

   A. increases evaporator capacity.

   B. decreases evaporator capacity.

   C. does not affect evaporator capacity.

   D. None of the above.

95. Capacity control of a lithium bromide-water absorption machine is accomplished

   A. with a slide valve mechanism, similar to that used in a helical-rotary compressor.

   B. by controlling the heat input to the generator.

   C. by controlling the amount of lithium bromide allowed into the system.

   D. using the absorption expansion valve (AEV).

96. Crystallization may occur in a lithium bromide-water absorption chiller

   A. if power fails while the machine is under a heavy load.

   B. if condenser water is allowed to get too cold.

   C. if the machine overcools during a shut-down period.

   D. All of the above.

97. The heat source for adsorption liquid chillers could be

   A. solar panels.
   B. steam.
   C. hot water.
   D. All of the above.

98. The purge units on absorption liquid chillers are designed to

   A. remove salt crystals that precipitate out of the lithium bromide solution.
   B. prevent the system from running in a vacuum.
   C. expel noncondensable gases.
   D. None of the above.

99. A possible cause for high head pressure is

   A. dirty condenser tubes.
   B. insufficient water flow through the condenser.
   C. air and noncondensables in the condenser.
   D. All of the above.

100. Approach temperature is the difference between

   A. condensing temperature and leaving water temperature.
   B. condensing temperature and entering water temperature.
   C. entering water temperature and leaving water temperature.
   D. condensing temperature and liquid line temperature.

101. Calculate the amount of water needed per ton of refrigeration in a water-cooled condenser assuming a heat rejection rate of 15,000 btuh per ton and a 20°F water temperature rise through the condenser.

   A. 0.15 gpm.
   B. 1.5 gpm.
   C. 0.45 gpm.
   D. 4.5 gpm.

102. What are the three ingredients necessary to start and sustain combustion?

   A. fuel, oxygen and an ignition source.
   B. fuel, energy and oxygen.
   C. fuel, oxygen and heat.
   D. fuel, an ignition source and heat.

103. What are the products of perfect combustion using oxygen and a hydrocarbon fuel?

A. Carbon monoxide and heat.

B. Carbon dioxide, heat and water.

C. Carbon monoxide, heat and water.

D. Carbon dioxide, heat, water and nitrogen.

104. Describe the appearance of a properly adjusted natural gas flame in an atmospheric burner.

A. Mostly blue flickering flame with yellow tips and no inner cone.

B. Bright yellow flame, waving lazily back and forth or flickering rapidly.

C. Steady blue flame with a smaller lighter blue inner cone, resting on the burner port.

D. Blue flame with a smaller lighter blue inner cone, lifted slightly off the burner port.

105. Radiant tubing/piping should be pressure tested to at least ________ times the expected operating pressure.

A. 1.5

B. 2

C. 3

D. 5

106. When filling a radiant heating system, it is recommended to fill

A. quickly from the high point so that velocity and gravity carries water to all low points and air will bubble out.

B. slowly from the high point so that gravity carries the water to all low points and air will bubble out.

C. slowly from the low point so that the tendency for air pockets to form is reduced.

D. quickly from the low point so that the tendency for air pockets to form is reduced.

107. Infrared heaters use burning gas to heat a specific radiating surface instead of using the infrared energy from the open flame because

A. heated surfaces are better heat radiators than open flame.

B. heated surfaces are better heat conductors than open flame.

C. heated surfaces are better heat convectors than open flame.

D. None of the above.

108. High efficiency (condensing) furnaces achieve an efficiency of up 95% by

A. adding an induced draft fan for positive venting.

B. cooling the exhaust gasses to below dew point and recovering some of the latent heat of condensation.

C. re-combusting the exhaust gasses in a secondary combustion chamber to more completely burn the fuel, much like an afterburner on a jet fighter.

D. All of the above.

109. Calculate the efficiency of a furnace with a 95,000 btuh input burner that produces 76,000 of useable heat.

    A. 80%

    B. 85%

    C. 90%

    D. 95%

110. Safety controls on a high efficiency (condensing) furnace include

    A. high limit, flame proving and door switch

    B. high limit and flame proving

    C. high limit, flame proving, door switch, and induced draft pressure switch

    D. high limit, flame proving, door switch, condensate flow switch

111. The purpose of a boiler low limit control is to

    A. shut off the boiler when boiler water temperature drops below a certain value.

    B. start the boiler when boiler water temperature drops below a certain value.

    C. shut off the boiler when room temperature drops below a certain value.

    D. start the boiler when room temperature drops below a certain value.

112. In order for fuel oil to be burned, it must be atomized. This is done by forcing it through a nozzle under a pressure of

    A. 10 psi.

    B. 50 psi.

    C. 100 psi.

    D. 500 psi.

113. A method of sensing flame in older style fuel oil furnaces and boilers was the stack switch, which sensed heat in the stack. This required the fuel to ignite, then heat the stack. A trial for ignition took up to 90 seconds. A newer and quicker safety control that "sees" the bright yellow flame has all but replaced the stack switch in fuel oil burners. What is this photo cell safety control?

    A. An infrared sensor made of lead sulfide.

    B. A cad cell using cadmium sulfide as the sensor.

    C. An ultraviolet flame detector using a sealed gas-filled chamber as a sensor.

    D. A flame rod with flame rectifier circuitry.

114. The practice of adjusting boiler water temperature so that water temperature is hottest on the coldest days and coolest on warmer days is known as

    A. return air reset.

    B. outdoor air based boiler water temperature (OABBWT).

    C. outdoor reset.

    D. Air/water balance. (AWB)

115. A compression tank is provided in a hydronic system

   A. so that higher pressures can be built up, thereby raising the boiling point.

   B. so that room is provided for heated water to expand.

   C. to provide a cushion against sudden pressure changes and water hammer shock.

   D. All of the above.

116. Expansion joints are needed in hydronic systems

   A. so that room is provided for heated water to expand.

   B. to allow for expansion and contraction of the piping.

   C. to allow for the expansion and contraction of the building.

   D. to allow for future expansions to the hydronic system.

117. In order to reduce water turbulence at the suction end of a pump, a suction diffuser should be used or a length of straight pipe equal to ______times the diameter of the pipe.

   A. 15

   B. 10

   C. 5

   D. 2½.

118. Premature bearing wear on floor mounted pumps could be caused by

   A. suction or discharge lines that were forced into position when the pump was installed.

   B. water temperatures that are too high.

   C. corrosive materials in the water.

   D. Both B and C from above.

119. A stuffing box type of shaft seal on a centrifugal pump needs periodic maintenance. If the seal is found to be leaking excessively, the technician should

   A. replace the carbon washer and/or tension the spring.

   B. replace the entire seal as this is cheaper than repairing a leaking seal.

   C. tighten the packing gland and/or replace the packing.

   D. replace the pump, as the seal is an integral part of the pump and not easily replaced or repaired.

120. Cavitation can destroy a centrifugal pump, is noisy and is caused by

   A. inlet pressure that is too high.

   B. inlet pressure that is too low.

   C. outlet pressure that is too low.

   D. outlet pressure that is too high.

121. The vacuum pump used in vacuum steam heating systems that creates a vacuum using high velocity water is the

   A. velocity pump.

   B. jet type pump.

   C. turbine pump.

   D. lift pump.

122. Vacuum pumps used in vacuum steam heating systems can be destroyed if they are made to pump

   A. air.

   B. steam.

   C. water.

   D. Both A and B from above.

123. If a vacuum pump in a vacuum steam heating system burns out, a very common cause is

   A. incorrect voltage to the pump.

   B. backward rotation.

   C. a failed vacuum breaker.

   D. a failed steam trap.

124. The type of pump found in a fuel oil burner is the

   A. propeller.

   B. centrifugal pump.

   C. inline pump.

   D. gear pump.

125. A gear pump is a type of

   A. centrifugal pump.

   B. rotary pump.

   C. double acting pump.

   D. axial pump.

126. Effective recovery of condensate reduces the following cost of making steam:

   A. Fuel/energy costs associated with producing steam.

   B. Boiler water make-up and sewage treatment.

   C. Boiler water chemical treatment.

   D. All of the above.

127. A symptom of a failed steam trap is

   A. a trap that is colder than steam temperature.

   B. a trap that is colder than condensate temperature.

   C. a trap that is warmer than condensate temperature.

   D. A trap that is warmer than steam temperature.

128. After the first heating season, cleaning a dirt pocket by removing the cap on the bottom of a dirt pocket

   A. should be done annually.

   B. should be done bi-annually.

   C. is usually not required.

   D. None of the above.

129. The average house line pressure for Natural Gas is

   A. 3.5 psi.

   B. 3.5 " W.C.

   C. 7 psi.

   D. 7" W.C.

130. The pressure is measured on a residential gas regulator using a

   A. Bourdon tube gage.

   B. Mercury manometer.

   C. Water manometer.

   D. Either B or C from above.

131. The purpose of the gas regulator vent is to

   A. allow air to enter above the diaphragm.

   B. allow air to escape above the diaphragm.

   C. allow gas to escape if the diaphragm ruptures.

   D. All of the above.

132. An advantage of the inverted bucket trap is that

   A. there are no moving parts to wear.

   B. it can be installed in any position.

   C. its design prevents it being damaged due to freezing.

   D. it also vents air and carbon dioxide continuously at steam pressure.

133. Flash steam is caused by

   A. pipe friction.

   B. reduced pressure.

   C. a vertical rise in a condensate line.

   D. All of the above.

134. The purpose of a drip leg in a steam line is to

   A. create a venturi to pull condensate out of a trap.

   B. let condensate escape by gravity from the fast-moving steam.

   C. store condensate until it can be discharged through the steam trap.

   D. Both B and C from above.

135. Inadequate trapping of steam mains often leads to

   A. water hammer and damaging slugs of condensate.

   B. condensate flowing in one direction while steam flows in the opposite.

   C. loss of steam energy by conduction through the walls of the pipe.

   D. excessively low temperature condensate.

136. Pressure in a vertical condensate pipe will drop 1 psi for every ______ feet in elevation. This is an important factor, since boiling temperature drops as pressure drops. When elevating condensate, this drop in pressure can cause flash steam.

   A. 1.08

   B. 2.31

   C. 8.33

   D. 10

137. When using a listening device to test a steam trap, what would the technician listen for that could indicate a problem.

   A. Continuous condensate discharge.

   B. Intermittent condensate discharge.

   C. High velocity sound.

   D. Gurgling and bubbling.

138. If an inverted bucket steam trap is blowing live steam, what might the trouble be?

   A. The valve may have failed to seat because of wear or a piece of dirt or scale.

   B. The trap may have lost its prime.

   C. The bucket is stuck or has a hole in it.

   D. All of the above.

139. The ________________ drains the condensate from the steam header and returns it to the boiler below the water line while preventing the boiler water from flowing out of the boiler into the return main.

   A. equalizing line

   B. Hartford Loop

   C. wet return

   D. steam header

140. The _____________ is designed to protect boilers against the loss of water due to leaks in the wet return line.

   A. equalizing line

   B. Hartford Loop

   C. check valve

   D. steam header

141. The control valve in a sub-atmospheric steam heating system is limited to approximately _____% change per minute.

   A. 12

   B. 9

   C. 6

   D. 3

142. A vacuum breaker is installed between equipment and a steam trap to

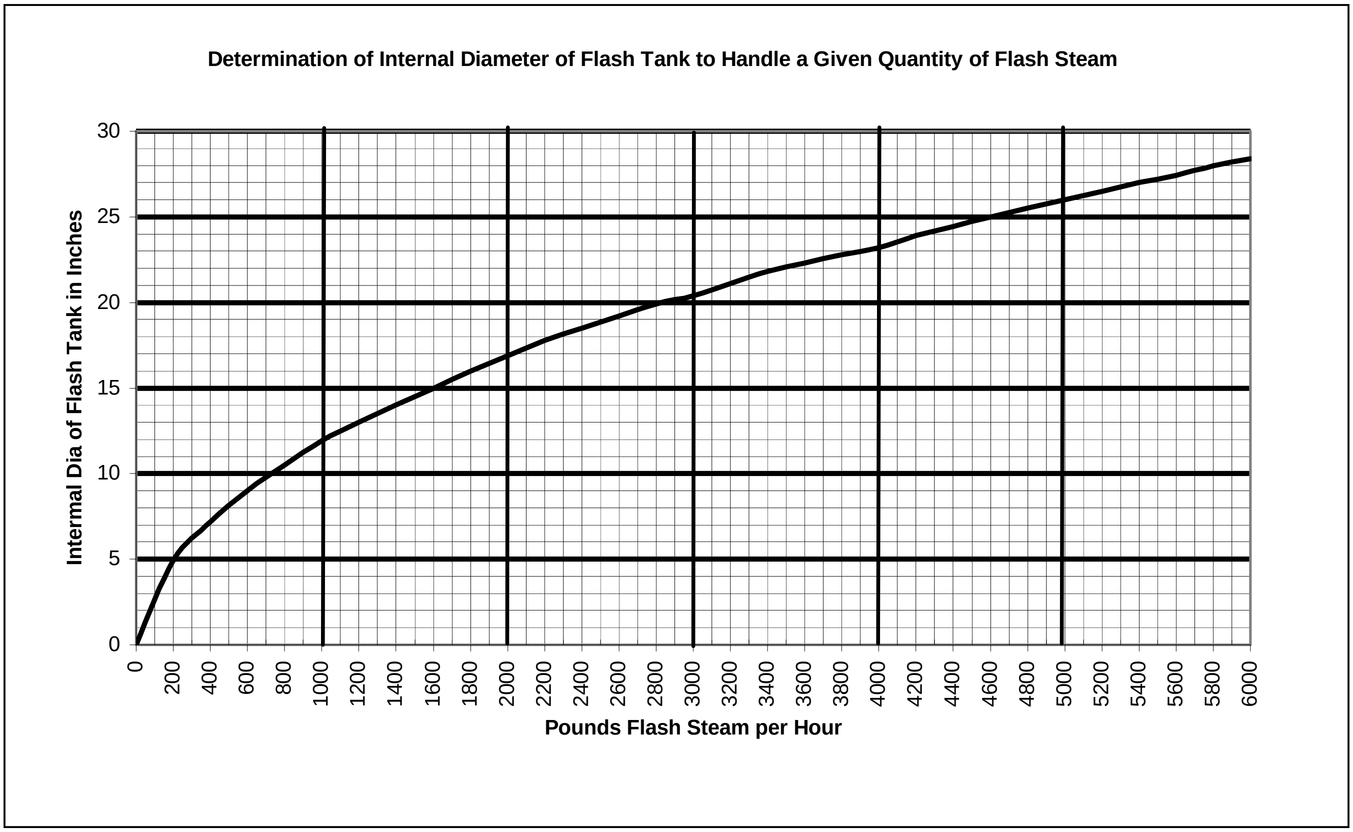
   A. allow a vacuum to be pulled on the system.

   B. allow condensate to drain after the steam has been shut off.

   C. prevent condensate from draining after the steam has been shut off.

   D. trip on low pressure cutoff.

143. Determine the diameter of a flash tank using the following chart for a system with 2800 pounds of flash steam available per hour.



A. 15"

B. 18"

C. 20"

D. 22"

144. The most commonly used inspection used on fans and air handling equipment is

A. ultrasound.

B. vibration analysis.

C. infrared.

D. visual.

145. Which air distribution system includes both warm air duct and a cool air duct and utilizes mixing boxes near the zone to mix the cool air and warm air streams to achieve the desired temperature while delivering the air at a near constant volume?

A. multizone.

B. dual duct.

C. mixing box system.

D. dual temperature system.

146. Which duct system delivers constant temperature air at variable volumes?

A. VAV.

B. Multizone.

C. Dual duct.

D. single zone.

147. When soldering, solder is drawn into the joint by

A. the heat of the torch.

B. capillary action.

C. gravity.

D. flux.

148. Which of the following best describes the difference between brazing and welding?

A. Welding is an adhesive process while brazing is cohesive.

B. Welding is a cohesive process while brazing is adhesive.

C. Brazing is done on non-ferrous metals. Welding is done on ferrous metals.

D. B and C from above.

149. The practice of installing flanges on pipe and fittings so that the top bolt hole in the right hand and left hand section of the flange are level with each other is known as

A. two-holing.

B. flange-leveling.

C. mirroring.

D. hole-leveling.

150. Of the valves listed below, which provides the best throttling action?

A. Ball valve.

B. Globe valve.

C. Gate valve.

D. Plug valve.

151. A rating of 125 lb S-200 lb W.O.G. stamped on a valve means that the valve

A. weighs 125 pounds and can withstand operating pressures up to 200 psi.

B. has a standard rating of 125 psi and a Working Over-Gage (W.O.G.) rating of 200 psi.

C. has a nominal system rating of 125 psi range but can withstand 200 psi with a wide open gate (W.O.G.).

D. has a steam rating of 125 psi and a cold water/oil/gas rating of 200 psi.

152. A device designed to protect pipe insulation against damage because of pipe movement is called a

A. pipe sleeve.

B. pipe saddle.

C. vibration isolator.

D. insulation isolator.

153. The safe working load of a fiber or wire rope can be calculated using the formula

$$\text{Safe Working Load (SWF)}\frac{\text{Breaking Strength (BS)}}{\text{Safety Factor (SF)}},$$

where the safety factor for hoisting material is required by OSHA to be

A. 2.

B. 4.

C. 5.

D. 10.

154. Calculate the safe working load of a 2-leg bridle using 1 5/8" wire rope with a bridle length (L) of 12' and a height (H) of 10', according to the drawing and formulas given below.

1. Calculate the SWL for a single wire rope lifting straight up and down (vertically)

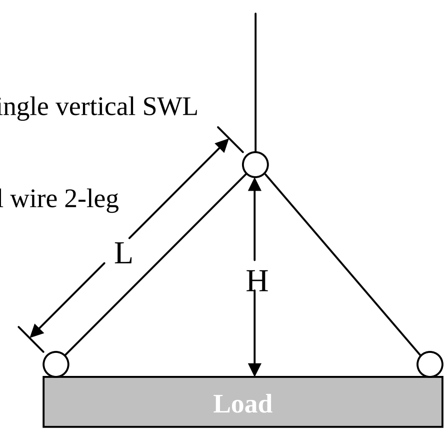
Safe working load (SWL) rule of thumb for plow steel wire rope, when a single rope is used to lift vertically (tons):

$$\text{Single Vertical SWL} = (\text{Rope dia})^2 \times 8$$

2. Calculate the SWL for a 2-leg bridle sling, using the single vertical SWL calculated from the formula above.

Save working load (SWL) rule of thumb for plow steel wire 2-leg bridle sling (tons):

$$\text{2 - Leg Bridle SWL} = \text{Single Vertical SWL} \times \frac{\text{H}}{\text{L}} \times 2$$



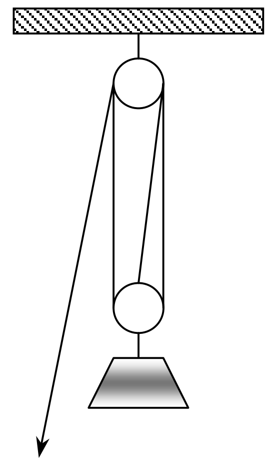
A. 21 tons.

B. 42 tons.

C. 35 tons.

D. 43 tons.

155. Calculate the amount of weight that could be lifted in a force of 100 pounds is exerted in the direction of the arrow.



A. 100 pounds.

B. 200 pounds.

C. 300 pounds.

D. 400 pounds.

156. The weakest portion of a chain hoist is the

A. chain.

B. lower hook.

C. upper hook.

D. spur gear.

157. An overload of most cable hoists (come-alongs) is prevented

A. by a clutch mechanism.

B. by a load hook that bends.

C. by a pressure relief spring.

D. by a handle that bends.

158. When using a jack to lift a load,

A. chocks should be used.

B. use wood softeners.

C. do not place the jack directly on the ground.

D. All of the above.

159. Unless equipped with OSHA or Canadian Standards Association (CSA) approved ground-fault circuit interrupters, portable electric lighting used in wet and-or other conductive locations as, for example, drums, tanks and vessels, shall be operated at _____ volts or less.

A. 12

B. 24

C. 120

D. None of the above.

160. A ladder must extend above the edge of a roof by at least _______ _________.

A. one foot.

B. two feet.

C. three feet.

D. four feet.

161. The proper angle for a ladder is achieved when the distance of the ladder from the building at the base is about __________ the working length (height) of the ladder.

A. one half.

B. one third

C. one fourth.

D. one fifth

162. A lock and tag may only be removed by the employee that applied it, unless the employee is absent from the workplace, then the lock or tag may be removed by a qualified person designated by the employer to perform this task provided that the employer ensures that

A. the employee who applied the lock or tag is employed by his company and under his jurisdiction.

B. the employee who applied the lock or tag is not available at the workplace.

C. the employee who applied the lock or tag is aware that it has been removed before he or she resumes work at that workplace.

D. Both B and C from above.

163. Section 608 of the Act prohibits you from knowingly venting ozone-depleting compounds used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (appliances). The prohibition took affect

A. July 13, 1993

B. November 14, 1994

C. July 1, 1992

D. November 1995

164. When working on a HCFC-22 appliance, or isolated component of such appliance, normally containing 200 pounds or more of refrigerant and using recovery or recycling equipment manufactured or imported on or after November 15, 1993, you are required to evacuate to a level of

A. 10 in.Hg.

B. 4 in.Hg.

C. 0 in.Hg.

D. 25 in.Hg.

165. If a compressor burn has occurred, the refrigerant must be

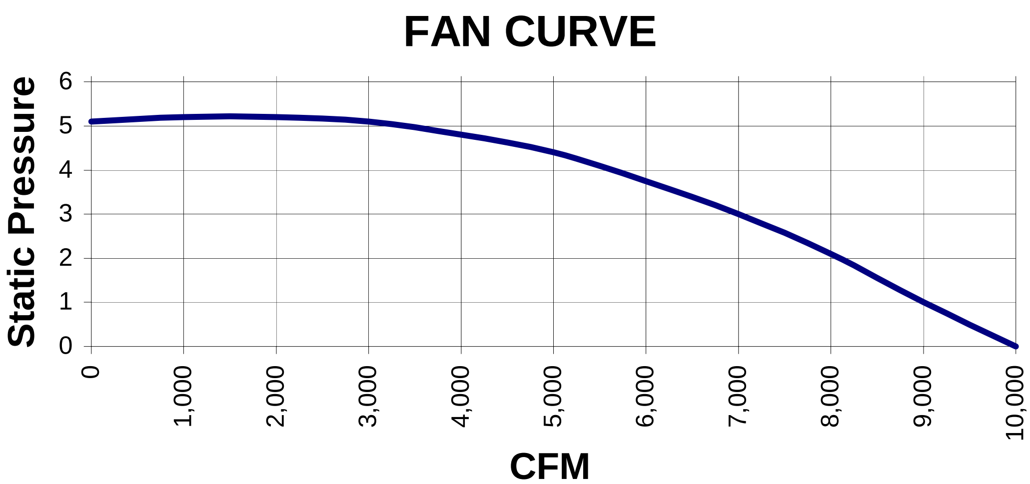
A. recovered.

B. reclaimed.

C. recycled.

D. Both A and B from above,

166. Plot a system curve on the fan curve chart below. Use an operating point of 8000 cfm at a static pressure of 4 in. water column as a basis for your calculations. What will the static pressure be at 7000 cfm?



A. 3 in. water column.

B. 3.5 in. water column.

C. 2.7 in. water column.

D. 5.22 in. water column.

167. Calculate the volume in gallons of a cylindrical tank having a base diameter of 46" and a height of 70".

A. 2014 gallons.

B. 808 gallons.

C. 504 gallons.

D. 67 gallons.

168. Calculate the velocity of air measured in feet per minute (fpm) in a 36 x 32 duct with 48,000 cfm of air flow.

A. 0.00017 fpm.

B. 41.7 fpm.

C. 0.024 fpm.

D. 6000 fpm.

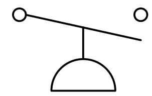
169. The symbol below would be used to indicate a ________ _________ switch that ________ on a rising signal.

A. pressure actuated, closes

B. temperature actuated, closes

C. pressure actuated, opens

D. temperature actuated, opens



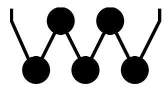
170. This symbol below represents a

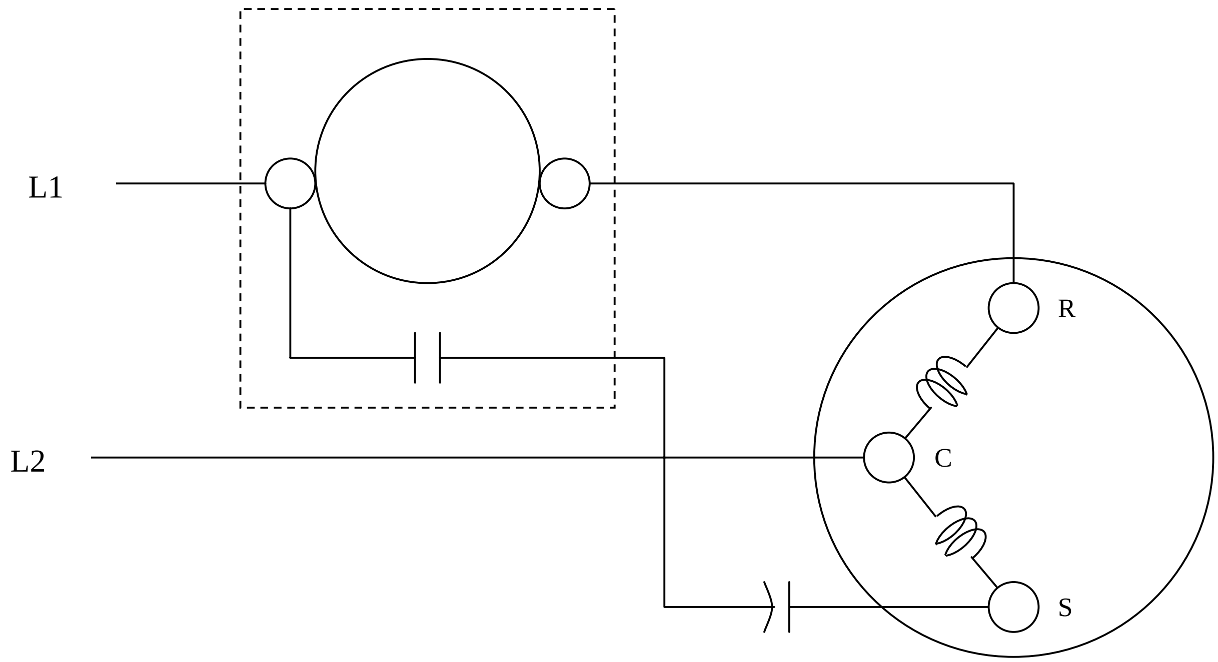
A. transformer.

B. bimetallic sensor.

C. thermopile.

D. thermocouple.





171. The circuit shown above represents a

A. current relay.

B. potential relay.

C. time delay relay.

D. lockout relay.

UA STAR HVACR PRACTICE QUESTIONS WITH EXPLANATIONS

Practice Questions with Explanations

1. A1 For applications where quiet operation and light axial load characteristics are found, the type of bearing normally used is the.

   A. ball bearing.

   Incorrect. Ball bearings are relatively noisy. Further, they can handle high loads and are generally considered to be too expensive to use in light load situations.

   B. thrust bearing.

   Incorrect. Thrust bearings are used in situations where the load is trying to push or pull the shaft.

   C. *sleeve bearing.

   Correct. Sleeve bearings are reliable bearings when used for small motors with light loads. Further, they offer quiet operation, which is important when used in applications close to the conditioned space.

   D. roller bearing.

   Incorrect. Roller bearings are used where large axial loads are present.

2. A1 Sleeve bearings with the oil port lubrication system must be lubricated with the proper oil because

   A. oil that is too thin will allow the shaft to run against the bearing surface

   Partially correct.

   B. oil that is too thick will not run into the clearance between the shaft and the bearing surface.

   Partially correct.

   C. the correct oil allows the motor shaft to float on a film of oil between the shaft and bearing surface.

   Partially correct

   D. *All of the above.

   Correct.

3. A1 Too much grease in a grease lubricated ball bearing

   A. is not a problem.

   Incorrect. Too much grease does create a problem in a bearing, just as too little grease does.

   B. is not possible.

   Incorrect. It is possible, and a common problem, to over grease a ball bearing.

   C. *causes overheating.

   Correct. In fact, the most common cause of overheating in a ball bearing is excess grease.

D. reduces friction.

Incorrect. Too much grease does not reduce friction, and should not be added to a properly greased bearing.

4. A1 The maximum desirable operating temperature of a ball bearing is

A. *180°F.

Correct. A bearing hotter than 180°F is an indication of possible trouble. Infrared thermometers can be used to quickly check for hot bearings.

B. 212°F

Incorrect. This temperature is higher than maximum desirable operating temperature.

C. 150°F.

Incorrect. This temperature is lower than maximum desirable operating temperature. A bearing running at 150°F is an indication of normal operation and is no cause for concern.

D. 350°F.

Incorrect. This is way too hot for a bearing under normal conditions and is an indication that a problem has developed.

5. A2 Shaft runout can be measured with

A. a dial indicator.

Partially correct. A runout gage is also used for measuring runout.

B. a runout gage.

Partially correct. A dial indicator is also used for measuring runout.

C. a micrometer.

Incorrect. A micrometer can be used for checking shaft diameter, but will not indicate runout.

D. *Both A and B.

Correct.

6. A3 The seal in a compressor is necessary to prevent

A. refrigerant from leaking out at the rotating shaft.

Correct, a function of a seal is to keep the refrigerant inside the system.

B. air from leaking out at the rotating shaft.

Incorrect. It is the function of the seal to keep air from leaking *in* at the rotating shaft and contaminating the refrigerant.

C. oil from leaking out at the rotating shaft.

Correct, a function of a seal is to keep the oil inside the system.

D. *Both A and C from above.

Correct.

7. A3 The mating seal surfaces on a sleeve type rotary bellows seal are

A. two polished steel surfaces.

Incorrect. Steel on steel makes a poor seal.

B. polished steel surfaces and neoprene.

Incorrect. While neoprene is used in the sleeve type rotary bellows seal, it is not the actual seal.

C. *polished steel surfaces and a carbon ring.

Correct. It is the mating surfaces of the steel and carbon ring that form the seal in this type of seal.

D. steel grooves and waxed cord.

Incorrect. This type of seal is sometimes used as a low pressure oil seal in applications such as automotive engines, but not in the sleeve type rotary bellows seal.

8. A4 A fan with a 14-inch sheave is connected by belts to a motor. Calculate the fan speed if the motor is operating at 1725 rpm and is fitted with a 5-inch sheave.

A. 4830

Incorrect.

B. 483

Incorrect.

C. 6161

Incorrect.

D. *616

Correct. $$\text{Fan RPM} = \frac{\text{Motor RPM X Motor Sheave Diameter}}{\text{Fan Pulley Diameter}}$$

9. A4 With belt driven equipment, alignment of the motor and driven equipment pulleys

A. is not critical, since the belts are flexible.

Incorrect. Misaligned pulleys will cause excessive wear on belts, pulleys and bearings.

B. *is accomplished using a string or straight edge.

Correct. A straight edge or string can be used to run from one pulley to the other. Alignment is complete when the string or straight edge touches both pulleys in two places at once.

C. is accomplished when the belts are parallel to one another.

Incorrect. The belts will always be parallel to one another, even when the pulleys are not aligned.

D. is accomplished using a dial indicator.

Incorrect. A dial indicator will not show misalignment between two pulleys.

10. A5 To correct for soft foot

A. replace soft material with a material of sufficient hardness.

Incorrect. Soft foot is a condition in which one of the feet of a piece of machinery does not set flat on the base.

B. *shim under the high foot with shim stock equal to a reading on the indicator.

Correct. The indicator is set up to read any movement as a mounting bolt is loosened. If loosing the bolt allows a foot to rise up, there is a soft foot condition, and shims must be added below the foot before the bolt is retightened.

C. replace the resilient material in the coupling.

Incorrect. Soft foot is a condition in which one of the feet of a piece of machinery does not set flat on the base and does not apply to couplings.

D. replace vibration isolators with isolators properly rated for the pump.

Incorrect. Soft foot is a condition in which one of the feet of a piece of machinery does not set flat on the base and distorts the equipment when bolted down. There are no vibration isolators located between the equipment and the base.

11. A6 (P. 96 in Refrigeration.) The two planes of alignment that must be considered when aligning a flexible coupling are

A. axial and parallel.

Incorrect. Axial and parallel mean the same thing in reference to a shaft. However, the shafts must be aligned parallel to one another, which is the same as saying that they must be aligned axially. This means that their centerlines must line up.

B. parallel and perpendicular.

Incorrect. While it is true enough that the shafts must be aligned parallel to one another, they cannot be perpendicular to one another.

C. horizontal and vertical.

Incorrect.

D. *parallel and angular.

Correct. Shafts must be aligned so that the centerlines meet each other exactly in the center (parallel to one another, or axially), and they must be aligned so that they have no angular difference between them (also called radial alignment).

12. B7 Electrical pressure is measured in

A. amps

Incorrect. Amperage is a measure of flow, not pressure.

B. ohms.

Incorrect. Ohms are a measure of resistance, not pressure.

C. watts.

Incorrect. Watts is a measure of power, not pressure.

D. *volts.

Correct.

13. B7 Electricity results from the movement of tiny negatively charged particles called

A. protons.

Incorrect. Protons, while part of the atom, are positively charged and exist in the nucleus but do not make electrical current.

B. *electrons.

Correct.

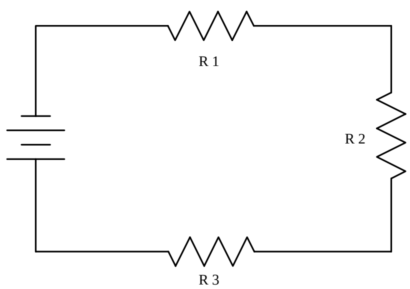
C. neutrons.

Incorrect. Neutrons, while part of the atom, carry a neutral charge and exist in the nucleus but do not make electrical current.

D. ions.

Incorrect. Ions are atoms that carry a charge, either negative or positive. When an electron leaves an atom, that atom becomes a positively charged ion since it now has positively charged protons that outnumber the negatively charged electrons. It is the movement of the free electron that causes electricity.

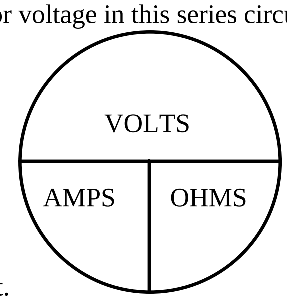
Use the diagram below to answer the next two questions.



14. B7 Calculate the voltage in the circuit when the total amperage is 10 amps and the resistors have values as follows: R1=10 ohms, R2=15 ohms, R3=20 ohms.

A. 0.45 volts.

Incorrect. Use Ohm's Law to calculate the value for voltage in this series circuit.

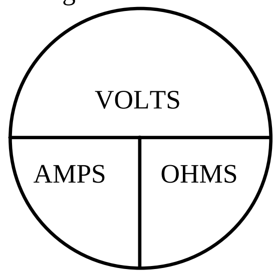


Remember that resistances add up in a series circuit.

$$R_T = R_1 + R_2 + R_3$$

4.5 volts.

Incorrect. Use Ohm's Law to calculate the value for voltage in this series circuit.



Remember that resistances add up in a series circuit.

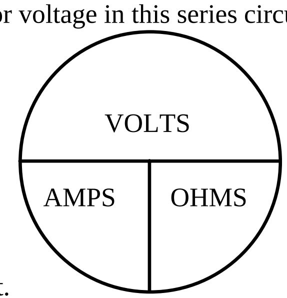
$$R_T = R_1 + R_2 + R_3$$

B. *450 volts.

Correct.

C. 0.222 volts.

Incorrect. Use Ohm's Law to calculate the value for voltage in this series circuit.



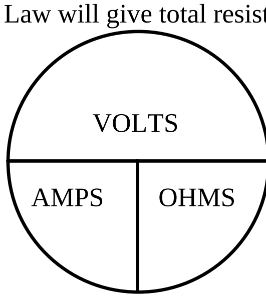
Remember that resistances add up in a series circuit.

$$R_T = R_1 + R_2 + R_3$$

15. B7 Calculate the value for R3 when the value for R1=150 ohms, R2=500 ohms, the voltage is 120 volts and the amperage is 0.12 amps.

A. 1000 ohms.

Incorrect. Use Ohm's Law to calculate the value for resistance in this series circuit. Remember that Ohm's Law will give total resistance. In this case, the value for only one resistor is needed..



$$R_T = 150 + 500 + R_3$$

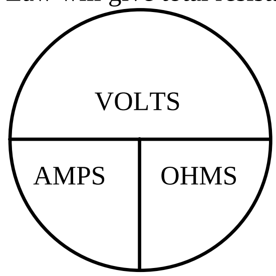
Volts = Amps X Ohms (R_T) **OR** Ohms (R_T) = Volts ÷ Amps

1000 (R_T) = 120 ÷ 0.12

$R_3 = R_T - (R_1 + R_2)$

B. 100 ohms

Incorrect. Use Ohm’s Law to calculate the value for resistance in this series circuit. Remember that Ohm’s Law will give total resistance. In this case, the value for only one resistor is needed..



$R_T = 150 + 500 + R_3$

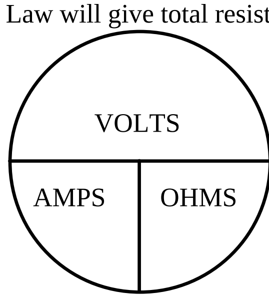
Volts = Amps X Ohms (R_T) **OR** Ohms (R_T) = Volts ÷ Amps

1000 (R_T) = 120 ÷ 0.12

$R_3 = R_T - (R_1 + R_2)$

C. 10 ohms.

Incorrect. Use Ohm’s Law to calculate the value for resistance in this series circuit. Remember that Ohm’s Law will give total resistance. In this case, the value for only one resistor is needed..



$R_T = 150 + 500 + R_3$

Volts = Amps X Ohms (R_T) **OR** Ohms (R_T) = Volts ÷ Amps

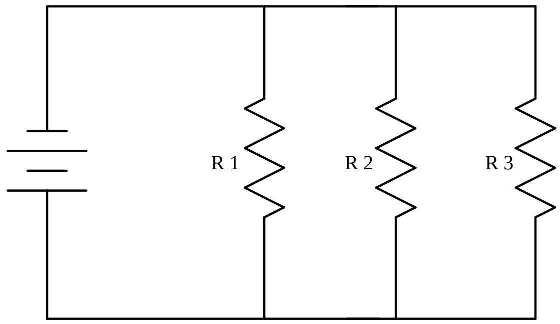
1000 (R_T) = 120 ÷ 0.12

$R_3 = R_T - (R_1 + R_2)$

D. *350 ohms.

Correct.

Use the diagram below to answer the next question.



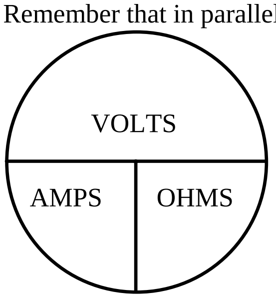
16. B7 Calculate the voltage in the circuit when the total amperage is 20.4 amps and the resistors have values as follows: R1=10 ohms, R2=50 ohms, R3=20 ohms.

A. *120 volts.

Correct.

B. 240 volts.

Incorrect. Use Ohm's Law to calculate the value for voltage in this parallel circuit. Remember that in parallel circuits, current is additive, resistance is not.



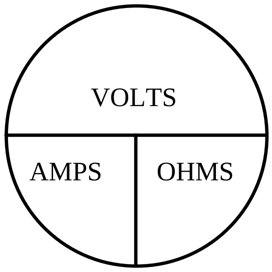
C. 1632 volts.

Incorrect. Use Ohm's Law to calculate the value for voltage in this parallel circuit. Remember that in parallel circuits, current is additive, resistance is not. If 1632 was your answer, you treated this circuit as a series circuit. Remember that you can find total resistance in a parallel circuit by finding the reciprocal of the sum of the reciprocals of each resister.

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

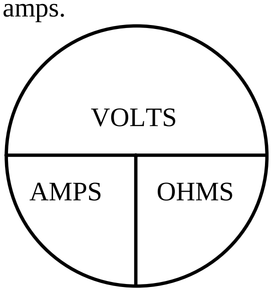
or

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$



D. 3.92 volts.

Incorrect. Use Ohm's Law to calculate the value for voltage in this parallel circuit. Remember that in parallel circuits, current is additive, resistance is not. If you chose this as your answer, you added resistance as if this were a series circuit, then divided by amps.



17. B8 What is the maximum safe amperage draw of the secondary winding of a 60 VA transformer output of 12 volts?

A. 0.2 amps.

Incorrect. Divide VA by volts to obtain the correct answer.

B. *5 amps.

Correct

C. 720 amps.

Incorrect. Divide VA by volts to obtain the correct answer.

D. 7.2 amps.

Incorrect. Divide VA by volts to obtain the correct answer.

18. B8 The best way to determine the voltage requirements for an electrical component is to

A. read line voltage with a digital multimeter.

Incorrect. Line voltage will merely show what is connected to the component. It may or may not be the correct voltage.

B. *read the name plate data.

Correct.

C. check with the utility company.

Incorrect. The utility company will not know what is required for a specific component without reading the name plate or consulting with the manufacturer.

D. determine the capacity of the service panel.

Incorrect. The capacity of the service panel is typically several times greater than the needs of an electrical component. Further, while service panels must have the required voltage, they are rated in amperage at a certain voltage.

19. B8 Fuses can be checked

A. with an ohm meter.

Partially correct, although not the best answer. On a dead circuit or with the fuse removed from the circuit, an ohm meter will read 0 ohms across the fuse if the fuse is good. If the fuse is bad, the reading will be ∞ ohms.

B. with a volt meter.

Partially correct, although not the best answer. On a live circuit, a volt meter will register no reading across a good fuse. A bad fuse will return a reading of line voltage.

C. with an ammeter.

Incorrect. An ammeter can only indicate how much current is flowing. If the circuit is live, the ammeter will show a reading if the fuse and all other components are operating correctly. However, if a component has failed and caused an interruption in current flow, the ammeter will not read and may cause the technican to think the fuse is bad. There is not a way to isolate the fuse for testing using only an ammeter.

D. *Both A and B from above.

Correct. This is the best answer.

20. B9. Chapter 22 <u>Refrigeration.</u> Which of the following devices may be wired into the starting circuit of a single phase motor to improve the starting torque?

A. winding thermostat.

Incorrect.

B. start capacitor.

Partially correct, although not the best answer. Start capacitors do improve starting torque

C. another winding.

Partially correct, although not the best answer. Start windings are used in all single phase induction motors to get them started. However, start windings provide only a small amount of torque. When used without start capacitors, split-phase motors are limited to low-starting-torque applications.

D. *Both B and C above.

Correct. This is the best answer, as both starting windings and start capacitors improved starting torque, although start capacitors provide more torque than start windings.

21. B9 Chapter 22 Refrigeration. A single phase motor with an improved power factor, reduced motor current, increased efficiency and high starting torque is the

A. *capacitor start-capacitor run (CSR) motor.

Correct. Because of the run and start capacitor, this motor offers the advantages listed above. The down side is additional cost.

B. shaded pole motor.

Incorrect. This motor has very low starting torque and is limited to small low-torque applications such as small fans and pumps.

C. split phase motor.

Incorrect. This motor has low to medium starting torque and is limited to fractional horsepower applications. No capacitors are used in the motor for either starting or running.

D. permanent split-capacitor motor.

Incorrect. This motor has high efficiency but low starting torque. It features a run capacitor wired in series with the start winding and in parallel with the run winding.

22. B9 Chapter 22 Refrigeration. In a CSR motor with a 10 microfarad run capacitor and a 110 microfarad start capacitor, the total capacitance will be

A. 60 microfarads.

Incorrect. The capacitance of capacitors, when wired in parallel as in a CSR motor, are added together the same as resistors in a series circuit.

B. *120 microfarads.

Correct. The capacitance of capacitors, when wired in parallel as in a CSR motor, are added together the same as resistors in a series circuit.

C. 9.17 microfarads.

Incorrect. The capacitance of capacitors, when wired in parallel as in a CSR motor, are added together the same as resistors in a series circuit.

D. 100 microfarads.

Incorrect. The capacitance of capacitors, when wired in parallel as in a CSR motor, are added together the same as resistors in a series circuit.

23. B11 The instrument used for finding humidity levels in the atmosphere is the

A. *sling psychrometer

Correct. This instrument provides both web bulb and dry bulb readings that can be used with the Psychrometric Chart to determine the properties of the air just sampled.

B. micron gage.

Incorrect. This device is used to measure deep vacuums in refrigeration systems.

C. manometer.

Incorrect. This instrument is used for determining pressure.

D. infrared thermometer.

Incorrect. This instrument is used for determining temperature.

24. B11. For reading the lowest vacuum levels, the best instrument to use is

A. a gage manifold set.

Incorrect. The compound gage on the gage manifold can only read to an accuracy of 1 in.Hg. Compressor manufactures are calling for evacuation levels down to 500 microns or less. Since there 25.4 millimeters in an inch, and 1000 microns in a millimeter, 1 in.Hg. becomes 25,400 microns. In other words, each inch of vacuum on the compound gage is the same as 25,400 microns! 500 microns is approximately 1/50 of 25,400, so a technician trying to read 500 microns on the compound gage would have to divide the increment between 29 and 30 on the gage into 50 parts and read when the needle reached the last mark.

B. a manometer.

Incorrect. This gage reads in mm.Hg. so it is 25.4 times more accurate than the compound gage, which reads in in.Hg. However, compressor manufactures are calling for evacuation levels down to 500 microns or less. Since there are 1,000 microns in a millimeter, a reading of 500 microns is equal to ½ millimeter. It is not possible to read this accurately on a manometer.

C. *electronic vacuum gage.

Correct. Electronic vacuum gages are sufficiently accurate to measure pressures below 2000 microns.

D. wet-bulb type vacuum indicator.

Incorrect. While this instrument can be very accurate under perfect conditions, it is not reliable enough for the technician to count on it as dependable.

25. B11 A hermetic motor should never be energized or tested with a megger when in a deep vacuum because

A. electric arcs can contaminate refrigerant in the system.

Incorrect. During a deep vacuum, the refrigerant is no longer in the system.

B. the motor could draw too much amperage.

Incorrect. Very little amperage would be drawn due to the lack of load on the motor.

C. the vacuum pump could be damaged.

Incorrect. The system compressor would have no effect on the vacuum pump.

D. *the dielectric strength of the motor's insulation would be greatly reduced.

Correct. Deep vacuums have the effect of greatly reducing the dielectric strength of hermetic compressor motors insulation. Therefore, a hermetic compressor motor should never be energized, no matter how briefly, while it is in a deep vacuum. This would include performing a megger test of the motor's insulation while it is in a deep vacuum.

26. C12 Which of the following reduced voltage starters uses a switching arrangement to connect the windings of three-phase motors in different configurations during startup and normal operation?

A. Autotransformer starters.

Incorrect. The autotransformer uses a transformer to reduce the voltage during startup. Once the motor has accelerated, the transformer is taken out of the circuit and the motor continues to run on full voltage.

B. Start-run starters.

Incorrect. There is no such thing as a start-run starter.

C. Star-wye starters.

Incorrect. Star and wye mean the same thing when referring to three-phase configurations.

D. *Star-delta starters.

Correct. Star-delta starters connect the motor in a star (or wye) arrangement during startup, which reduces starting voltage to approximately 58% of line voltage. This limits starting current to about one third that of what it would be if the windings were connected in delta at startup. Once the motor has accelerated, the wiring configuration is switched to delta, and the motor continues to run under full voltage.

27. C12 According to NEC (National Electrical Code), a general-use switch may be used as the controller for a stationary motor rated at two horsepower or less and at 300 volts or less if it is rated at not less than

A. the full-load motor current.

Incorrect. Motors draw more current during startup than at full-load, so switch damage or failure could occur during the startup cycle if the switch is rated only for full-load.

B. *twice the full-load motor current.

Correct.

C. three times the full-load motor current.

Incorrect. While it is true that motors can draw several times more current during startup than during full-load, NEMA does not require the switch rating to be three times the full-load motor current.

D. five times the full-load motor current.

Incorrect. While it is true that motors can draw several times more current during startup than during full-load, NEMA does not require the switch rating to be five times the full-load motor current.

28. C12 Two types of thermal overload relays in common use today are

A. the bimetal relay and the magnetic relay.

Incorrect. The magnetic relay is another type of overload that uses the principle of magnetism instead of heat to protect the motor.

B. the melting alloy relay and the Mercury bulb.

Incorrect. Mercury bulbs are commonly used as switches in thermostats, but are not used for overload protection.

C. *the bimetal relay and the melting alloy relay.

Correct.

D. the bimetal relay and the trimetal relay.

Incorrect. There is no such thing as a trimetal relay.

29. C13 A rather common indication of a defective starting relay in a single phase motor

A. *is for the motor to hum but not start.

Correct.

B. is for the motor to start, run normally, then shut down after several minutes.

Incorrect. The starting relay has done its job in this situation. Other problems could be causing the motor to stop, such as a defective overload relay or an overloaded motor.

C. is the motor to start but not come up to speed.

Incorrect. The starting relay has energized the motor but something else is preventing it from coming up to speed such as a bad start capacitor.

D. the motor starts but runs in the wrong direction.

Incorrect. The motor has been wired incorrectly.

30. C14 The level of voltage caused by back electromotive force that opens the contacts on a potential relay in order to take the start capacitor out of the circuit is called

A. lift voltage.

Incorrect. Lift voltage is a made up term. Refer to the UA text or consult with an instructor or technician to find the correct answer.

B. open voltage.

Incorrect. Open voltage is a made up term. Refer to the UA text or consult with an instructor or technician to find the correct answer.

C. run voltage.

Incorrect. Run voltage is a made up term. Refer to the UA text or consult with an instructor or technician to find the correct answer.

D. *Pick-up voltage.

Correct.

31. C14 A type of current relay that uses a bimetal strip to open contacts in both the starting and running contacts is called a

A. *hot-wire relay.

Correct.

B. bimetal relay.

Incorrect. Although a bimetal strip is used to sense heat, the relay is not called a bimetal relay.

C. start/run relay.

Incorrect. Although the relay takes the starting winding out of the circuit once the motor comes up to speed and acts as an overload device once the motor is running, it is not called a start/run relay.

D. “Gallert” relay.

Incorrect. “Gallert” is a name chosen radomly from a phone book and has nothing to do with starting relays.

32. A pneumatic timing relay operates by

A. receiving air from the pneumatic control system.

Incorrect. the pneumatic timing relay is not connected to a pneumatic control system.

B. *filling a bellows with air.

Correct. When energized, a bellows fills with air, which takes time. The time can be adjusted by a needle valve, which regulates the rate at which the bellows fills. When fully expanded, the bellows operates a snap-action switch.

C. sensing air from a motor's cooling fan.

Incorrect. The pneumatic timing relay can be mounted remotely from the motor and is not affected by air flow.

D. changing air pressure after a set amount of time.

Incorrect. The pneumatic timing relay is not connected to a pressure device and does not alter the pressure of any component.

33. C15 The combination safety limit and fan control on a residential furnace turns the fan on and off by sensing the furnace air temperature. If the furnace temperature rises too high, the safety limit de-energizes the

A. fan and main gas valve.

Incorrect. The fan is allowed to continue running in order to cool the furnace.

B. fan.

Incorrect. The fan is allowed to continue running in order to cool the furnace.

C. *gas valve.

Correct. The gas valve is shut off while the fan is allowed to continue running in order to cool the furnace.

D. igniter.

Incorrect. On many furnaces, the ignitor is de-energized as soon as the main burner ignites. If the furnace has gotten too hot, the main burner would already be ignited and the ingnitor would likely already be off. Further, it is the main burner, not the ignitor (or pilot) that is the source of heat causing the overheating.

34. C15 Some codes require a manual reset device on a safety limit

A. * so that the cause of the safety shutdown can be investigated prior to re-start.

Correct.

B. so that the equipment will not short-cycle.

Incorrect. While it is true that a manual reset requires a person to reset the safety and would help to prevent short-cycle operation, the code is written so that the root cause of the safety shutdown can be identified.

C. so that more technicians are needed, which helps the economy.

Incorrect. Code officials do not consider the impact on the economy when writing code.

D. because automatic reset is more costly.

Incorrect. Code officials are concerned with safety and not cost.

35. C15 In order to protect a load, safety limit devices are most often wired

A. in parallel.

Incorrect. Parallel wiring would allow the load to be energized even if one safety tripped.

B. *in series.

Correct. Series wiring de-energizes the load when any one of several safeties trips.

C. upstream.

Incorrect. It doesn't matter if the safety limit is "upstream" or "downstream" of the load. What does matter is if it is in series or parallel.

D. downstream.

Incorrect. It doesn't matter if the safety limit is "upstream" or "downstream" of the load. What does matter is if it is in series or parallel.

36. C16 A flow switch safety control is used to

A. control the amount of flow of a fluid (liquid or gas).

Incorrect. The purpose of this switch is simply to prove that flow is occurring.

B. turn on a pump or fan.

Incorrect. The purpose of this switch is to prove that flow is occurring. The fan or pump would already have to be energized in order for the switch to sense flow.

C. divert fluid flow during unsafe conditions.

Incorrect. The purpose of this switch is simply to prove that flow is occuring.

D. *prove that flow is occurring.

Correct. These switches prove that flow is occurring, such as in water piping to hot water boilers to verify that the pumps are operating and water is flowing before the main gas valve is opened, or to ensure that water is flowing through chiller barrels before energizing the compressor.

37. C17 What is a disadvantage of the mercury bulb switch?

A. They are unreliable.

Incorrect. Mercury bulb sensors are very reliable.

B. *They must be level.

Correct. In order to operate correctly, the thermostat must be mounted absolutely level.

C. They tend to burn contacts.

Incorrect. Mercury bulb sensors last for years without ever burning contacts.

D. They tend to "chatter", which cycles the load on and off.

Incorrect. Because the mass of mercury flows from one end of the bulb to the other, the contact is made very rapidly. The switch cannot "chatter" because of the inertia contained in the mass of mercury.

38. C17 A thermostat is properly calibrated when

A. *set point and control point are equal.

Correct. Set point refers to the manual setting of the thermostat while control point refers to the actual temperature of the space. The difference between the two is known as offset. When set point and control point are equal, offset is zero and the thermostat is said to be “satisfied”. If the temperature agrees with an acurate thermometer, it's calibrated.

B. room temperature is comfortable.

Incorrect. Room temperature comfort is subjective and varies from person to person.

C. there is no deadband.

Incorrect. In many cases, deadband is a desirable condition and occurs whether the thermostat is calibrated or not.

D. control point and thermostat reading agree.

Incorrect. This would indicate the thermometer is calibrated

39. C17 With a change in temperature, a thermistor will change

A. *resistance.

Correct.

B. voltage.

Incorrect. Thermistors are variable resistors that change with temperature.

C. current.

Incorrect. Thermistors are variable resistors that change with temperature.

D. impedance.

Incorrect. Thermistors are variable resistors that change with temperature.

40. C18 One type of pressure sensing device uses a flattened metal tube, which is bent into a part-circle with one end fixed in place and connected to a system to be measured. The other end of the tube is closed and free to move. An increase in pressure tends to straighten the tube. The movement of the free end of the tube is connected to a dial that reads pressure. This type of gage is called a

A. Whiskey tube.

Incorrect.

B. bimetal tube.

Incorrect. Bimetal is used to sense temperature, not pressure.

C. *Bourdon tube.

Correct.

D. flat-tube gage.

Incorrect.

41. C18 A pressure sensing device that relies on a fluid, such as oil, to provide a frictionless seal is the

A. Whiskey tube

Incorrect. The Whiskey tube is not a pressure sensing device.

B. oil pressure gage.

Incorrect. While oil is commonly used to provide the fluid and frictionless seal, oil pressure is normally not sensed with this type of device.

C. *inverted bell.

Correct. This device is suitable on only very low pressure, such as static pressure in an air duct, where pressures usually do not exceed several inches of water.

D. inverted bucket.

Incorrect. The inverted bucket is used in steam trap design, but is not used for pressure sensing.

42. C18 An advantage of a diaphragm is that it can produce a large force when acted upon by only a small pressure. Calculate the total force exerted by an 8" diaphragm with a pressure of 1.8 psig applied to the diaphragm.

A. 362 pounds.

Incorrect. Area of a circle is $A = \pi r^2$. Don't forget to divide the diameter by two before calculating the area of the circle.

B. *90.5 pounds.

Correct.

C. 56.54 pounds.

Incorrect. Hint:

$$\begin{aligned} Force &= Area \times Pressure \\ &= sq.in. \times \frac{pound}{sq.in.} \\ &= \pi r^2 \times psig \end{aligned}$$

D. 14.4.

Incorrect. Hint:

$$\begin{aligned} Force &= Area \times Pressure \\ &= sq.in. \times \frac{pound}{sq.in.} \\ &= \pi r^2 \times psig \end{aligned}$$

43. C19 The photo cell in an infrared sensor is made of

A. *lead sulfide.

Correct. Lead sulfide is a semiconductor having the property of decreasing in electrical resistance when exposed to radiation of certain wave lengths.

B. cadmium sulfide.

Incorrect. Cadmium sulfide is used as a photocell in a visible light detector.

C. a sealed gas-filled chamber.

Incorrect. Ultraviolet flame detectors use a sealed gas-filled chamber containing two electrodes. When the gas is exposed to ultraviolet light, the gas becomes conductive and current pulses from one electrode to the other, thus sensing the flame.

D. zinc sulfide.

Incorrect.

44. C19 Aiming of infrared sensors is critical. Why must they be aimed directly at the flame?

A. Since they see light, they can be fooled by the bright area surrounding the flame.

Incorrect. Infrared sensors do not see visible light, so they are not fooled by light.

B. Since they see heat, they can be fooled by the hot air surrounding the flame.

Incorrect. Infrared sensors are not fooled by hot combustion products.

C. Since they see heat, they can be fooled by hot refractory.

Incorrect. Infrared sensors can be fooled by hot refractory, so the sensing circuits are built to eliminate this problem. Flames flicker and the circuit responds to the rapidly changing resistance caused by the flicker. The steady glow of a hot refractory does not flicker, so the circuit does not respond.

D. *Since they see heat, their sensitivity can be reduced by hot refractory.

Correct. The steady glow of a hot refractory will cause some decrease in resistance of the photocell material, which reduces the sensitivity of the system. For this reason, the photocell should be installed so that it does not directly "see" the refractory.

45. C20 A type of two-position control that provides for "intermediate" positions as well as the "all-on" and "all-off" positions is the

A. timed two-position control.

Incorrect. Timed two-position control refers the practice of using heating and/or cooling anticipators to provide smaller amounts of heating or cooling at more frequent intervals to prevent wide temperature differentials.

B. deviation control.

Incorrect. Deviation is a term for the difference between the desired value and the actual value of the controlled variable.

C. percentage control.

Incorrect. The concept of "percentage" control does exist, but is called proportional control and allows a controlled device to stop at any point along its throttling range (also called proportional band).

D. *floating control.

Correct.

46. C20. While proportional control action has the disadvantage of control point shift but has no time-lag factor, floating action has the disadvantage of time lag influence but has no control point shift. What control action combines the advantages of both?

A. Proportional integral.

*Correct. PI control has no time lag factor and maintains a single control point.

B. Proportional with feedback.

Incorrect. All proportional control includes feedback. To say proportional with feedback is to be redundant.

C. Floating proportional control.

Incorrect. Proportional is considered to be a type of floating control in and of itself.

D. single-speed floating action.

Incorrect. Single-speed floating action is considered to be a type of floating control in and of itself and carries with it the disadvantages of floating control.

47. C20 A flame sensing strategy that takes advantage of the fact that hot gasses in a flame become ionized and conduct electricity is called a

A. cad cell.

Incorrect. Cad cells "see" flame if it is colored yellow, as is fuel oil flame. Cad cells do not work for the blue flame of natural gas systems.

B. thermocouple.

Incorrect. Thermocouples produce small voltage (about 30 millivolts DC) when heated in a flame. They use the principle that two dissimilar metals that are fused together at one end to form a "hot" junction, and open at the opposite end to form a "cold" junction, will generate electrical voltage when heating.

C. *flame rod.

Correct. Flame rods are designed so that current is conducted in the flame is much stronger in one direction (half cycle) than in the other, which produces a rectified signal.

D. ion sensor.

Incorrect.

48. D21 Checking amperage on a system during general maintenance

A. is a waste of time and should be avoided.

Incorrect. Amperage readings can indicate problems with a system that appears to be operating normally.

B. should only be done if a problem is suspected.

Incorrect. Taking and recording amperage readings during maintenance periods provides a history of the system. If an amperage reading falls out of the normal range, a problem may be developing that is not otherwise apparent.

C. *can indicate a problem with the system.

Correct. Amperage readings that are too high or too low can be an indication of electrical, mechanical or refrigerant charge problems with the system.

D. should only be done with the power off for safety reasons.

Incorrect. The system must be running in order to read amperage.

49. D21 When changing or adding oil to a compressor

A. it is best to buy the smallest possible containers and use the entire contents at once.

Partially correct. Purchasing large containers of oil may be cheaper, but will likely lead to contamination of the oil, which could lead to system problems. A special oil charging pump can help eliminate this problem if it is put on a can of oil and left there until all of the oil has been pumped out.

B. avoid pouring the oil from a container into the compressor.

Partially correct. Pouring the oil through the atmosphere will admit water and air to the system.

C. use an oil charging pump.

Partially correct. When possible, the use of an oil charging pump will eliminate the introduction of water, air and other contaminants into the compressor. These pumps are fitted with a filter dryer that keeps the oil free of dirt and moisture.

D. *all of the above.

Correct.

50. As the evaporating temperature of any vapor compression system is lowered,

A. compressor suction vapor density increases.

Incorrect. At lower evaporating temperature, there is a corresponding lower pressure, which decreases vapor density.

B. the volume of the suction vapor decreases.

Incorrect. At lower evaporating temperature, there is a corresponding lower pressure, which increases vapor volume.

C. *compressor capacity is lowered.

Correct.

D. flash gas in the liquid line is likely to occur.

Incorrect. The evaporator is on the low side of the system while the liquid line is on the high side of the system. As evaporator temperature lowers, evaporator pressure lowers, decreasing the capacity of the compressor and the amount of refrigerant that is flowing. Flash gas in the liquid line is often caused by friction due to excessive velocity. When compressor capacity is reduced, less refrigerant flows, meaning lower velocities in the liquid line, and less likelihood of flash gas.

51. D22. As a "rule of thumb", for every 12,000 btuh of cooling capacity in an open compressor air conditioning system, the heat rejection is roughly

A. 12,000 btuh, or 1.0 times the net refrigeration effect.

Incorrect. The heat of rejection will always be greater than the net refrigeration effect due to superheat and compressor cooling.

B. 9,000 btuh, or 0.75 times the net refrigeration effect.

Incorrect. The heat of rejection must be at least equal to the net refrigeration effect, and is in fact greater.

C. *15,000 btuh, or 1.25 times the net refrigeration effect.

Correct. Like any rule of thumb, this number can vary. However, as a basis for estimation, it has long been considered that the heat rejection from an air conditioning system is about 15,000 Btuh for every 12,000 Btuh of cooling capacity. This assumes open-type compressors, where the refrigerant suction vapor does not receive any heat from the compressor motor as it does in hermetic motor-compressors.

D. none of the above

Incorrect.

52. D22 The difference in temperature between condensing temperature and entering water or air temperature is known as

A. *temperature split

Correct. The condensing temperature should be at least 15 or 20 degrees higher than the temperature of the entering water or air to avoid the need for an unreasonably large and costly condenser.

B. Subcooling

Incorrect. Subcooling is the process of cooling refrigerant below condensing temperature, for a given pressure. A good discussion on subcooling can be found on page 71 of Refrigeration. Information on determining subcooling can be found in Chapter 4 of Refrigerant Controls.

C. Superheat

Incorrect. Superheated vapor is vapor that is above its saturation temperature. A good discussion on superheated vapor can be found on Page 29 of Refrigeration. Page 6 of Refrigerant Controls provides further information on superheat. Information on determining superheat can be found on page 43 of Refrigerant Controls.

D. temperature rise

Incorrect. Temperature rise is a generic term sometimes used to describe the difference in temperature between entering and leaving fluid flows conditions, i.e. the air temperature rise as it flow across a heating coil.

53. D22 A decrease in condensing temperature will

A. increase condensing pressure, increase suction temperature and increase system capacity.

Incorrect. A decrease in condensing temperature will result in a decrease in condensing pressure. As long as the refrigerant is in a state of constant quality (part vapor, part liquid), any change in temperature will result in a corresponding change in pressure. This can be seen on a pressure-enthalpy diagram of any refrigerant.

B. decrease condensing pressure, increase suction temperature and increase system capacity.

Incorrect. As condensing pressure drops, so will suction pressure.

C. *decrease condensing pressure, decrease suction temperature and increase system capacity.

Correct. A decrease in condensing temperature affects the entire system, and will cause a drop in evaporator pressure. The drops in both condensing and evaporator pressures (and temperatures) result in a higher system capacity.

D. decrease condensing pressure, decrease suction temperature and decrease system capacity.

Incorrect. A decrease in condensing temperature will decrease both condensing and suction pressure and will increase system capacity.

54. D22 Subcooling in the condenser will

A. *increase system capacity.

Correct. An increase in subcooling will increase the net refrigeration effect by reducing the flash gas loss.

B. decrease system capacity.

Incorrect. Subcooling will increase the net refrigeration effect by reducing the flash gas loss.

C. not affect system capacity.

Incorrect. Subcooling will increase the net refrigeration effect by reducing the flash gas loss.

D. increase the flash gas loss.

Incorrect. Subcooling will actually reduce the flash gas loss, and will increase net refrigeration effect in the process.

55. D22 Compressor capacity controlled by the cylinder unloading method

A. *may result in compressor overheating

Correct. As fewer cylinders are used, less refrigerant is pumped resulting in less refrigerant vapor available for cooling the compressor.

B. is only used with hermetic compressors.

Incorrect. This method is only used with reciprocating compressors.

C. does not provide energy savings.

Incorrect. Energy savings are provided as cylinders are unloaded, since the compressor does less work.

D. is only used with systems charged with ammonia.

Incorrect. This method can be used with many refrigerants.

56. D23 10 in.Hg. vacuum is approximately equivalent to

A. 5 psig.

Incorrect. A perfect vacuum is approximately 30 in. Hg. vacuum and 0 psia, while atmospheric pressure is 0 in. Hg. vacuum and roughly 15 psia. Use interpolation to estimate what the pressure would be at 10 in. Hg.

B. 5 psia.

Incorrect. A perfect vacuum is approximately 30 in. Hg. vacuum and 0 psia, while atmospheric pressure is 0 in. Hg. vacuum and roughly 15 psia. Use interpolation to estimate what the pressure would be at 10 in. Hg.

C. 10 psig.

Incorrect. A perfect vacuum is approximately 30 in. Hg. vacuum and 0 psia, while atmospheric pressure is 0 in. Hg. vacuum and roughly 15 psia. Use interpolation to estimate what the pressure would be at 10 in. Hg.

D. *10 psia.

Correct. Absolute pressure is zero at a perfect vacuum of approximately 30 in. Hg. Meanwhile, atmospheric pressure is approximately 15 psia while vacuum in 0 in. Hg. The table shows the relationship. Basically, every unit of 5 on the psia scale is equal to a unit of 10 on the vacuum scale. As vacuum increases by 10, pressure reduces by 5.

	Pressure psia	Vacuum in.Hg.
Perfect vacuum	0	30
	5	20
	10	10
Atmospheric pressure	15	0

57. D23 After repairing a leak, it is permissible to pressure test a system using nitrogen with a small amount of _______ added as a trace gas.

A. helium.

Incorrect. Helium would not be detected by leak detectors.

B. oxygen.

Incorrect. Oxygen should never be added to a system. Oxygen causes corrosion and can cause explosions when in contact with oil under pressure.

C. CFC 12.

Incorrect. CFC 12 is not allowed as a trace gas.

D. *HCFC 22.

Correct. HCFC may be used as a trace gas when mixed with nitrogen for pressure testing, then vented into the atmosphere as it is not being used as a refrigerant.

58. D23 When charging a system, the refrigerant cylinder pressure may drop too low for further charging. Which of the following methods should *not* be used to increase the pressure?

A. *Heat the cylinder with a torch.

Correct. You should never heat a cylinder with a torch, and should never raise the temperature above 125°F.

B. Heat the cylinder with a heat lamp.

Incorrect. Using a heat lamp is an acceptable method for heating a cylinder. Care should be taken never to raise the temperature above 125°F.

C. Heat the cylinder by immersing it in a tub of warm water.

Incorrect. Immersing a refrigerant cylinder in a tub of warm water (80°F to 110°F) is an acceptable method to use for heating a cylinder. Care should be taken never to raise the temperature above 125°F.

D. Heat the cylinder by wrapping it in a specially built electric heater.

Incorrect. Using a specially built electric heater is an acceptable method for heating a cylinder. Care should be taken never to raise the temperature above 125°F.

59. D24 A term used to rate vacuum pumps is used to describe the pump's ability to draw a vacuum. Essentially, the pump must create a vacuum within itself that is lower than in the system, so that gases will flow from the system to the pump. The point at which a pump can no longer create a pressure difference is called

A. dead head pressure.

Incorrect. The term dead head (or shut-off head) refers to blocking off a centrifugal pump to read the pressure differential across it.

B. *blank-off pressure.

Correct.

C. blocked tight static pressure.

Incorrect. Blocked tight static pressure refers to the pressure developed by a fan when the outlet is blocked off.

D. point of no pressure difference.

Incorrect. The point of no pressure difference refers to the point on a hydronic system where the pressure tank is connected to the system.

60. D24 Vacuum pump oil is a special oil because

A. it won't absorb water.

Incorrect. In fact, vacuum pump oil will absorb water, which is why it is so important to change the oil before each evacuation to ensure that no water is entrained in it.

B. *it has a low vapor pressure to ensure that it won't vaporize at low pressures.

Correct. Note that the UA text Refrigeration on page 488 incorrectly states that vacuum pump oil has a high vapor pressure. This would cause it to easily evaporate at even high temperatures. As an example, gasoline has a higher vapor pressure than water, and evaporates more quickly.

C. it rarely needs changing.

Incorrect. Vacuum pump oil should be changed frequently since it absorbs water and other contaminants.

D. it is non-toxic and can be disposed of easily.

Incorrect. In fact, used vacuum pump oil is considered a toxic waste and must be disposed of accordingly.

61. D24 Which of the following methods will not decrease the time needed to evacuate a large refrigeration system?

A. Using large diameter fittings.

Incorrect. The use of large diameter fittings is recommended to speed up the process.

B. Keeping hose lengths as short as possible.

Incorrect. Using short hoses is recommended to speed up the process.

C. *Triple evacuation.

Correct. Triple evacuation is a method that is no longer recommended since it vented refrigerant into the atmosphere. Further, it did not reduce evacuation time at all, but was a method used to dilute any contaminants within the system as much as possible.

D. Using multiple vacuum pumps.

Incorrect. The use of multiple pumps of moderate capacity is recommended over using one large capacity pump for evacuating large systems such as a water chiller.

62. D24 A danger with leaving a vacuum pump running all night is

A. pulling more than 30 in. Hg. vacuum.

Incorrect. It is impossible to pull a vacuum below 30 in. Hg. since no pressure exists at 30 in. Hg.

B. exceeding the pumps running time capabilities.

Partially correct. The pump manufacturer's instructions should be consulted to ensure that the pump can safely run that long.

C. pump oil could be lost during a power outage.

Partially correct. Once a vacuum has been pulled on the system, it becomes a large volume of low pressure, and can pull the oil from the vacuum pump if the pump is shut off and not isolated from the system.

D. *Both B and C from above.

Correct.

63. D24 Vacuum pump oil that is fresh

A. has a smooth milky appearance.

Incorrect, This is an indication that the oil has moisture in it.

B. *has a clear appearance.

Correct. New oil has a clean and clear appearance. If it looks otherwise, it should be changed.

C. has a somewhat cloudy appearance.

Incorrect. This is an indication that the oil has moisture in it.

D. is very thick and heavy.

Incorrect. Vacuum pump oil is light.

64. D25 A refillable refrigerant cylinder must not be filled above _____ percent of its capacity by weight.

A. 100%

Incorrect.

B. 90%

Incorrect.

C. *80%

Correct

D. 70%

Incorrect.

65. D25 A refrigerant with the ANSI/ASHRAE Standard 34-1992 safety classification of A1 has

A. high toxicity and high flammability.

Incorrect. A means lower toxicity, B means higher toxicity. 1 means no flame propagation while 3 means higher flammability.

B. *low toxicity and no flame propagation.

Correct.

C. low toxicity and high flammability.

Incorrect. A means lower toxicity, B means higher toxicity. 1 means no flame propagation while 3 means higher flammability.

D. high toxicity and no flame propagation.

Incorrect. A means lower toxicity, B means higher toxicity. 1 means no flame propagation while 3 means higher flammability.

66. D25 All appliances containing more than 50 lbs. of refrigerant (except commercial and industrial process refrigeration) must be repaired when the annual leak rate exceeds

A. 5%

Incorrect. EPA requires that all appliances containing more than 50 lbs. of refrigerant (except commercial and industrial process refrigeration) must be repaired when the annual leak rate exceeds 15%, and commercial and industrial process refrigeration must be repaired when the annual leak rate exceeds 35%.

B. *15%

Correct. EPA requires that all appliances containing more than 50 lbs. of refrigerant (except commercial and industrial process refrigeration) must be repaired when the annual leak rate exceeds 15%, and commercial and industrial process refrigeration must be repaired when the annual leak rate exceeds 35%.

C. 25%

Incorrect. EPA requires that all appliances containing more than 50 lbs. of refrigerant (except commercial and industrial process refrigeration) must be repaired when the annual leak rate exceeds 15%, and commercial and industrial process refrigeration must be repaired when the annual leak rate exceeds 35%.

D. 35%

Incorrect. EPA requires that all appliances containing more than 50 lbs. of refrigerant (except commercial and industrial process refrigeration) must be repaired when the annual leak rate exceeds 15%, and commercial and industrial process refrigeration must be repaired when the annual leak rate exceeds 35%.

67. D26 When charging a chilled water system, charging is usually done as a liquid. However, if the machine is in a deep vacuum, the initial charge should be as a vapor. Why?

A. Charging as a vapor is faster for chillers because the system is in a deep vacuum.

Incorrect. Vapor charging takes longer for all types of systems. The real danger when charging a system is damage to the tubes from water freezing and bursting the tubes. This is what needs to be prevented.

B. Charging as a vapor allows system pressure to stabilize and prevents thermal shock to the system.

Incorrect. The real danger when charging a system is damage to the tubes from water freezing and bursting the tubes. This is what needs to be prevented.

C. Charging as a vapor until the system reaches ambient temperature prevents condensation inside the system.

Incorrect. No moisture exists in the system, so condensation cannot form. The real danger when charging a system is damage to the tubes from water freezing and bursting the tubes. This is what needs to be prevented.

D. *Charging as a vapor until the system temperature has risen above 32°F prevents freezing of water in the tubes.

Correct. The system must be charged as a vapor until the system pressure has reached a pressure corresponding to a temperature higher than 32°F.

68. D26 When charging a system, several methods are available for checking the refrigerant charge. In order to charge by monitoring the subcooling, one must

A. *monitor discharge pressure and liquid line temperature close to the metering device and charge until the liquid line temperature falls below the discharge saturation temperature by the expected amount of subcooling.

Correct.

B. monitor discharge temperature and liquid line temperature close to the metering device and charge until the discharge temperature falls below the liquid line temperature by the expected amount of subcooling.

Incorrect. Subcooling occurs when the liquid line temperature falls below discharge saturation temperature.

C. monitor saturated suction temperature and suction gas temperature and charge until saturated suction temperature falls below the suction gas temperature by the expected amount of subcooling.

Incorrect. This is a method for checking superheat, not subcooling.

D. monitor saturated suction temperature and suction gas temperature and charge until suction gas temperature falls below the saturated suction temperature by the expected amount of subcooling.

Incorrect. This is a method for checking superheat. Further, suction gas temperature cannot be lower than saturated suction temperature. It will either be equal or higher.

69. D26 Insufficient refrigerant will cause

A. excessive head pressure.

Incorrect. Excessive head pressure is a symptom of too much charge.

B. *low suction pressure and insufficient cooling.

Correct.

C. low suction pressure and over cooling.

Incorrect. Suction pressure will be low, but cooling capacity will also be low.

D. high discharge temperature.

Incorrect. High discharge temperature is a symptom of too much charge.

70. D27 Most compressors are positive displacement machines. Name a compressor that is not a positive displacement machine.

A. Reciprocating.

Incorrect. The reciprocating compressor is of the positive displacement type.

B. Helical-rotary (screw)

Incorrect. The helical-rotary (screw) compressor is of the positive displacement type.

C. Rotary.

Incorrect. The rotary compressor is of the positive displacement type.

D. *Centrifugal.

Correct.

71. D27 The ratio of the actual volume of refrigerant vapor pumped to the theoretical displacement volume is known as

A. *volumetric efficiency.

Correct.

B. volumetric ratio.

Incorrect. There is no term known as volumetric ratio.

C. compression efficiency.

Incorrect. There is no term known as compression efficiency.

D. compression ratio.

Incorrect. $\text{Compression ratio} = \dfrac{\text{Discharge pressure, psia}}{\text{Suction pressure, psia}}$

72. D27 A compressor in which the compressor and motor are both sealed within the same pressurized housing is known as a

A. sealed compressor.

Incorrect. There is no term known as a sealed compressor.

B. pressurized compressor.

Incorrect. There is no term know as a pressurized compressor.

C. *hermetic compressor.

Correct.

D. hermenet compressor.

Incorrect. There is no term know as a hermenet compressor.

73. D28 The passage of liquid refrigerant through the compressor suction and discharge valves should be avoided and is known as

A. choking the compressor.

Incorrect.

B. *slugging the compressor.

Correct.

C. kicking the compressor.

Incorrect.

D. shocking the compressor.

Incorrect.

74. D28 Modern high-speed reciprocating compressors typically operate at

A. 1750 rpm.

Partially correct. There is another common speed also.

B. 3450 rpm.

Partially correct. There is another common speed also.

C. 5250 rpm.

Incorrect.

D. *Both A and B from above.

Correct. Modern high-speed reciprocating compressors typically operate at 1750 rpm and 3450 rpm.

75. D28 Compressor capacity decreases as

A. discharge pressure increases.

Partially correct. Other factors decrease compressor capacity also.

B. suction pressure decreases.

Partially correct. Other factors decrease compressor capacity also.

C. compressor speed decreases.

Partially correct. Other factors decrease compressor capacity also.

D. *All of the above.

Correct.

76. D29 An advantage of the scroll compressor is

A. smooth, quiet operation.

Partially correct. Other advantages exist also.

B. low torque variation through overlapping compression cycles.

Partially correct. Other advantages exist also.

C. few moving parts.

Partially correct. Other advantages exist also.

D. *All of the above.

Correct.

77. D29 How can you identify reverse operation with a scroll compressor?

A. The compressor will not compress.

Partially correct. There are other symptoms.

B. The compressor will stop on motor overload.

Partially correct. There are other symptoms.

C. You can see it running backwards.

Incorrect. The moving parts are sealed from view, so it is not possible to see operation.

D. *Both A and B from above.

Correct.

78. D29 During scroll compression,

A. *refrigerant vapor enters from the outside of the scroll and exits at the center.

Correct.

B. refrigerant vapor enters from the center of the scroll and exits at the outside.

Incorrect. Refer to page 94 of Refrigeration for an explanation of scroll operation.

C. refrigerant vapor enters from one side of the scroll and exits from the other side.

Incorrect. Refer to page 94 of Refrigeration for an explanation of scroll operation.

D. Both A and C from above.

Incorrect. Refer to page 94 of Refrigeration for an explanation of scroll operation.

79. D30 Capacity control on a helical-rotary (screw) compressor is obtained using

A. inlet vanes.

Incorrect. Inlet vanes are used for capacity control on a centrifugal compressor.

B. hot gas bypass.

Incorrect. Hot gas bypass is used for reciprocating compressors.

C. variable speed motors.

Incorrect. Screw compressors are intended to operate at constant speed.

D. *a sliding valve.

Correct.

80. D30 The screw-type impellers used in helical-rotary compressors are also known as

A. *rotors.

Correct.

B. scrolls.

Incorrect. Scrolls are used in scroll compressors, which operate using a different principle.

C. a helix.

Incorrect. The screws are not known by this name.

D. vanes.

Incorrect. Vanes are terms used with rotary vane compressors.

81. D31 The component in a centrifugal compressor that actually does the compressing is known as

A. *an impeller.

Correct.

B. a rotor.

Incorrect. Rotors are used in helical-rotary compressors and rotary compressors.

C. a centrifuge.

Incorrect. A centrifuge is an apparatus that rotates at high speed and separates substances of different densities.

D. a centripetal.

Incorrect. Centripetal is actually an adjective and is used to describe the force acted upon a body moving along a curved path, that is directed toward the center of the curved path (opposed to centrifugal).

82. D31 A centrifugal compressor controls capacity through the use of

A. variable speed.

Partially correct. There is another common method for controlling capacity.

B. on-off control.

Incorrect. On-off control is not acceptable for centrifugals because of the high current draw and excessive motor heat created at startup.

C. vortex dampers.

Partially correct. There is another method for controlling capacity in addition to vortex dampers (also called inlet guide vane dampers or pre-rotation vanes).

D. *Both A and C from above.

Correct.

83. D31 Bearings in a centrifugal compressor can be checked by

A. sliding the impeller back and forth to check for slop.

Incorrect. It is not easy to get to the impeller to make such a check, and is cost prohibitive.

B. trying to move the shaft at right angles to the bearing.

Incorrect. It is not easy to get to the impeller to make such a check, and is cost prohibitive.

C. *checking the temperature of the oil returning from the bearing.

Correct. A high temperature in the oil indicates a bearing with a large amount of friction, indicating that a problem existe.

D. manually spinning the impeller while listening for grinding noises.

Incorrect. It is not easy to get to the impeller to make such a check, and is cost prohibitive. It is also unlikely that anything could be heard in a noisy mechanical room.

84. D32 A small access valve which is similar to the air valve used on tires is known as a

A. Schriber valve.

Incorrect.

B. *Schrader valve.

Correct.

C. Schreuder valve

Incorrect.

D. Schroder valve.

Incorrect.

85. D32 A valve used to prevent flow of liquid refrigerant to the evaporator and to avoid flood back to the compressor during off cycles is the

A. check valve.

Incorrect. Check valves prevent flow in the wrong direction.

B. bypass valve.

Incorrect. The bypass valve is used for capacity control with reciprocating compressors.

C. relief valve.

Incorrect. A relief valve is a safety device designed to prevent pressure from exceeding a safe level.

D. *solenoid valve.

Correct. Solenoid valves have many applications in refrigeration systems, the principle one being to prevent flow of liquid refrigerant to the evaporator and to avoid flood back to the compressor during off cycles.

86. D32 A special valve used to prevent evaporator temperature from falling below a predetermined minimum temperature regardless of suction pressure is the

A. *evaporator pressure regulator.

Correct. An example of an application for this valve is on systems with multiple evaporators operating at different temperatures.

B. pressure reducing valve.

Incorrect. Pressure reducing valves are commonly used on compressed air systems, but not to prevent low pressure in an evaporator.

C. suction pressure regulator.

Incorrect. Although it sounds like this valve would be used to control pressure in the evaporator, its purpose is actually to limit the suction pressure at the compressor to a maximum value.

D. None of the above.

Incorrect.

87. D33 A metering device with the characteristic of feeding liquid into the evaporator at the same rate at which the liquid flows from the condenser is the

A. thermostatic expansion valve.

Incorrect. The TEV meters refrigerant based on the suction line temperature and maintains a constant superheat.

B. *high-side float valve.

Correct. This valve consists of a float and a needle valve, which creates the pressure drop separating the high-side from the low-side of the system. As the liquid level from the condenser raises, the float rises and opens the needle valve, forcing refrigerant into the evaporator. As the liquid level from the condenser drops, the float drops also and closes the needle valve, restricting the flow to the evaporator.

C. low-side float valve.

Incorrect. The low-side float valve functions to maintain a constant level of liquid refrigerant in a flooded evaporator.

D. constant pressure expansion valve.

Incorrect. The constant pressure expansion valve functions to maintain a constant pressure in the evaporator, which serves to maintain a constant suction pressure and load on the compressor.

88. D33 In a thermostatic expansion valve, three forces act on the diaphragm in the power head, which is connected to the valve. Evaporator pressure acts to ________ the valve, spring pressure acts to _______ the valve and bulb pressure from the bulb attached to the evaporator outlet acts to _______ the valve.

A. open; open; close.

Incorrect. It is true that the force of the suction pressure from the bulb opposes the other two pressures, but not in the manner described by this choice.

B. *close; close; open.

Correct. Both the evaporator pressure and the spring pressure act to close the valve, while the suction pressure from the bulb acts to open the valve.

C. close; open; open.

Incorrect. The pressure from the evaporator and the spring act in the same direction and oppose the force of the suction pressure from the bulb.

D. open; close; close.

Incorrect. The pressure from the evaporator and the spring act in the same direction and oppose the force of the suction pressure from the bulb.

89. D33 The metering device that actually measures temperature rather than pressure or liquid levels is the

A. temperature activated expansion valve.

Incorrect. There is no valve known by this name.

B. thermostatic temperature valve.

Incorrect. There is no valve known by this name.

C. capillary tube.

Incorrect. The capillary tube actually meters refrigerant by restricting the flow through the small inner diameter of the tube.

D. *thermal electric valve.

Correct.

90. D34 Suction line filter-driers should be installed whenever

A. a system is serviced.

Incorrect. It is only necessary to install a suction line filter-drier when something has occurred that would contaminate the system.

B. a leak has occurred.

Incorrect. After the leak has been repaired, the liquid line filter-drier will be sufficient to pick up any remaining moisture left in the system.

C. *a hermetic compressor motor burnout has occurred.

Correct. Suction line filter-driers should be installed whenever a hermetic compressor motor burnout has occurred to filter out debris and carbon char and to neutralize system acid, which is usually generated.

D. a thermostatic expansion valve has been replaced.

Incorrect. There is not need to install a suction line filter-drier when replacing a TXV.

91. D34 Filter-driers and driers are filled with a material that is able to catch and retain moisture and acid. This material is called

A. water dry.

Incorrect.

B. *desiccant.

Correct.

C. dry-out.

Incorrect.

D. moisture dry.

Incorrect.

92. D34 Suction line filter-driers are usually equipped with gage connections so that pressure drops can be determined. Why?

A. So that accurate superheat calculations can be made.

Incorrect. While it is true that a pressure drop through a suction line filter-drier will affect superheat calculations, the difference is slight and of little consequence.

B. To ensure that excessive load is not imposed on the compressor.

Incorrect. Suction line filter-driers are designed with low pressure drops so as not to affect the system.

C. To ensure that flash gas does not occur in the filter-drier.

Incorrect. The refrigerant is already in a vapor state in the suction line, so flash gas cannot occur and is of no concern.

D. *So that you can determine when to change the filter-drier.

Correct. Manufacturers publish tables that specify permissible core pressure drops. When the drop exceeds recommendations the core should be replaced.

93. D35 In general, the greater the number of rows in an evaporator

A. the more closely the leaving air temperature will be to that of the refrigerant.

Partially correct. Other factors exist with greater number of rows.

B. the more dehumidification can take place.

Partially correct. Other factors exist with greater number of rows.

C. the colder the leaving air will be.

Partially correct. Other factors exist with greater number of rows.

D. *All of the above.

Correct.

94. D35 Increasing air flow over an evaporator

A. *increases evaporator capacity.

Correct. The more air that flows past an evaporator, the more energy is absorbed by the refrigerant. Using the formula for sensible heat transfer (below), it can be seen that if the temperature difference between the air and the refrigerant remains the same, an increase in air flow (cfm) will result in an increase of energy transfer (btuh).

$$Btuh = cfm \times 1.08 \times \Delta T$$

B. decreases evaporator capacity.

Incorrect. The more air that flows past an evaporator, the more energy is absorbed by the refrigerant. Using the formula for sensible heat transfer (below), it can be seen that if the temperature difference between the air and the refrigerant remains the same, an increase in air flow (cfm) will result in an increase of energy transfer (btuh).

$$Btuh = cfm \times 1.08 \times \Delta T$$

C. does not affect evaporator capacity.

Incorrect. The more air that flows past an evaporator, the more energy is absorbed by the refrigerant. Using the formula for sensible heat transfer (below), it can be seen that if the temperature difference between the air and the refrigerant remains the same, an increase in air flow (cfm) will result in an increase of energy transfer (btuh).

$$Btuh = cfm \times 1.08 \times \Delta T$$

D. None of the above.

Incorrect.

95. D35 Capacity control of a lithium bromide-water absorption machine is accomplished

A. with a slide valve mechanism, similar to that used in a helical-rotary compressor.

Incorrect. No compressor is used in an absorption machine, so no slide valve is needed to throttle incoming vapor.

B. *by controlling the heat input to the generator.

Correct. More heat results in an increased amount of refrigerant boiled out of the solution in the generator, creating more refrigeration effect. Less heat results in less refrigeration effect.

C. by controlling the amount of lithium bromide allowed into the system.

Incorrect. The amount of lithium bromide remains constant through all operating conditions. The strength of the lithium bromide-water solution does vary with the load.

D. using the absorption expansion valve (AEV).

Incorrect. A valve is not known by this name.

96. D36 Crystallization may occur in a lithium bromide-water absorption chiller

A. if power fails while the machine is under a heavy load.

Partially correct.

B. if condenser water is allowed to get too cold.

Partially correct.

C. if the machine overcools during a shut-down period.

Partially correct.

D. *All of the above.

Correct.

97. D36 The heat source for adsorption liquid chillers could be

A. solar panels.

Partially correct.

B. steam.

Partially correct.

C. hot water.

Partially correct.

D. *All of the above.

Correct.

98. D36 The purge units on absorption liquid chillers are designed to

A. remove salt crystals that precipitate out of the lithium bromide solution.

Incorrect. Salt crystals are formed when the lithium bromide solution is allowed to become too concentrated. They are reabsorbed by the water as the machine continues to operate and the solution becomes more dilute and/or warms up.

B. prevent the system from running in a vacuum.

Incorrect. An absorption liquid chiller using water as a refrigerant must run in a vacuum of about 29.67 in. Hg. in order for water to evaporate at 40°F.

C. *expel noncondensable gases.

Correct.

D. None of the above.

Incorrect.

99. D37 A possible cause for high head pressure is

A. dirty condenser tubes.

Partially correct. Dirty tubes reduce the ability of the condenser to reject heat, resulting in higher condensing temperatures and pressures.

B. insufficient water flow through the condenser.

Partially correct. Low water flow reduces the ability of the condenser to reject heat, resulting in higher condensing temperatures and pressures.

C. air and noncondensables in the condenser.

Partially correct. Air and non-condensables in the condenser cause a pressure that is higher than the pressure associated with the saturation temperature of the refrigerant in the condenser. Any time a system is running with abnormally high pressure, air in the system is a prime suspect.

D. *All of the above.

Correct.

100. D37 Approach temperature is the difference between

A. *condensing temperature and leaving water temperature.

Correct. Calculate approach temperature by subtracting the leaving water temperature from the condensing temperature.
Example: $105°\text{F Condensing temp.} - 95°\text{ leaving water temp.} = 10°\text{ F approach}$

B. condensing temperature and entering water temperature.

Incorrect. Calculate approach temperature by subtracting the leaving water temperature from the condensing temperature.

C. entering water temperature and leaving water temperature.

Incorrect. Calculate approach temperature by subtracting the leaving water temperature from the condensing temperature.

D. condensing temperature and liquid line temperature.

Incorrect. The difference between condensing temperature and liquid line temperature is subcooling. Calculate approach temperature by subtracting the leaving water temperature from the condensing temperature.

101. D37 Calculate the amount of water needed per ton of refrigeration in a water-cooled condenser assuming a heat rejection rate of 15,000 btuh per ton and a 20°F water temperature rise through the condenser.

A. 0.15 gpm.

Incorrect. Use the formula: $\text{gpm} = \dfrac{\text{btuh}}{500 \times \text{TD}}$

B. *1.5 gpm.

Correct.

C. 0.45 gpm.

Incorrect. Use the formula: $\text{gpm} = \dfrac{\text{btuh}}{500 \times \text{TD}}$

D. 4.5 gpm.

Incorrect. Use the formula: $gpm = \frac{btuh}{500 \times TD}$

102. E38 What are the three ingredients necessary to start and sustain combustion?

A. fuel, oxygen and an ignition source.

Incorrect. Combustion does not need an ignition source in order to take place.

B. fuel, energy and oxygen.

Incorrect. Fuel contains the energy needed for combustion.

C. *fuel, oxygen and heat.

Correct.

D. fuel, an ignition source and heat.

Incorrect. Without oxygen, there can be no combustion.

103. E38 What are the products of perfect combustion using oxygen and a hydrocarbon fuel?

A. Carbon monoxide and heat.

Incorrect. Carbon monoxide is not created if the chemical reaction for combustion is balanced.

B. *Carbon dioxide, heat and water.

Correct. Perfect combustion produces only heat, carbon dioxide and water (in the form of vapor).

C. Carbon monoxide, heat and water.

Incorrect. Carbon monoxide is not created if the chemical reaction for combustion is balanced.

D. Carbon dioxide, heat, water and nitrogen.

Incorrect. Nitrogen comprises about 80% of the atmosphere. When air is part of the combustion process, nitrogen "passes" through the combustion process without reacting, since it is an inert gas. However, this question asked about the products of combustion using oxygen, not air. As such, nitrogen is not a part of the equation.

104. E38 Describe the appearance of a properly adjusted natural gas flame in an atmospheric burner.

A. Mostly blue flickering flame with yellow tips and no inner cone.

Incorrect. This is the description of an improper flame, caused by insufficient primary air and possibly dirt in the burner.

B. Bright yellow flame, waving lazily back and forth or flickering rapidly.

Incorrect. This is the description of an improper flame, caused by insufficient primary air and possibly dirt in the burner.

C. *Steady blue flame with a smaller lighter blue inner cone, resting on the burner port.

Correct.

D. Blue flame with a smaller lighter blue inner cone, lifted slightly off the burner port.

Incorrect. This is the description of an improper flame, caused by too much gas for the size of the burner port.

105. E39 Radiant tubing/piping should be pressure tested to at least _______ times the expected operating pressure.

A. 1.5

Incorrect.

B. *2

Correct.

C. 3

Incorrect.

D. 5

Incorrect.

106. E39 When filling a radiant heating system, it is recommended to fill

A. quickly from the high point so that velocity and gravity carries water to all low points and air will bubble out.

Incorrect. This can create air pockets that can cause circulation problems later.

B. slowly from the high point so that gravity carries the water to all low points and air will bubble out.

Incorrect. This can create air pockets that can cause circulation problems later.

C. *slowly from the low point so that the tendency for air pockets to form is reduced.

Correct. The idea is to add the water slowly so that air is "chased" to the top of the system so that air pockets do not form.

D. quickly from the low point so that the tendency for air pockets to form is reduced.

Incorrect. The velocity created by quick filling can leave air pockets trapped in the system, which could lead to circulating problems later on.

107. E39 Infrared heaters use burning gas to heat a specific radiating surface instead of using the infrared energy from the open flame because

A. *heated surfaces are better heat radiators than open flame.

Correct.

B. heated surfaces are better heat conductors than open flame.

Incorrect. Infrared heaters work on the principle of radiant heat, not conducted heat.

C. heated surfaces are better heat convectors than open flame.

Incorrect. Infrared heaters work on the principle of radiant heat, not convection heating.

D. None of the above.

Incorrect.

108. E40 High efficiency (condensing) furnaces achieve an efficiency of up 95% by

A. adding an induced draft fan for positive venting.

Incorrect. While it is true that condensing furnaces include an induced (or forced) draft fan, this does not improve efficiency.

B. *cooling the exhaust gasses to below dew point and recovering some of the latent heat of condensation.

Correct. These high efficiency (condensing) furnaces cool exhaust gasses to below 130°F. This temperature is below the dew point, and gains of an additional 1000 btu for every pound of water condensed is realized. The exhaust gasses are cooled to the point where they will not rise up the vent on their own, so an induced for forced draft fan must be added. Further, a drain must be installed to take away the condensed water from the exhaust gasses.

C. re-combusting the exhaust gasses in a secondary combustion chamber to more completely burn the fuel, much like an afterburner on a jet fighter.

Incorrect. No secondary combustion chambers are included.

D. All of the above.

Incorrect.

109. E40 Calculate the efficiency of a furnace with a 95,000 btuh input burner that produces 76,000 of useable heat.

A. *80%

Correct.

B. 85%

Incorrect. Use the formula $\text{Efficiency} = \frac{\text{Ouput}}{\text{Input}}$

C. 90%

Incorrect. Use the formula $\text{Efficiency} = \frac{\text{Ouput}}{\text{Input}}$

D. 95%

Incorrect. Use the formula $\text{Efficiency} = \frac{\text{Ouput}}{\text{Input}}$.

110. E40 Safety controls on a high efficiency (condensing) furnace include

A. high limit, flame proving and door switch

Incorrect. This is an incomplete list.

B. high limit and flame proving

Incorrect. This is an incomplete list.

C. *high limit, flame proving, door switch, and induced draft pressure switch

Correct. In order for a high efficiency (condensing) furnace to operate, these four safety devices must be "made".

D. high limit, flame proving, door switch, condensate flow switch

Incorrect. There is no condensate flow switch.

111. E41 The purpose of a boiler low limit control is to

A. shut off the boiler when boiler water temperature drops below a certain value.

Incorrect.

B. *start the boiler when boiler water temperature drops below a certain value.

Correct. Low limit maintains boiler water temperature, even when the thermostat is not calling for heat. This feature is necessary when using the boiler to heat domestic hot water.

C. shut off the boiler when room temperature drops below a certain value.

Incorrect. Low limit control senses boiler water temperature.

D. start the boiler when room temperature drops below a certain value.

Incorrect. Low limit control senses boiler water temperature.

112. E41 In order for fuel oil to be burned, it must be atomized. This is done by forcing it through a nozzle under a pressure of

A. 10 psi.

Incorrect.

B. 50 psi.

Incorrect.

C. *100 psi.

Correct.

D. 500 psi.

Incorrect.

113. E41 A method of sensing flame in older style fuel oil furnaces and boilers was the stack switch, which sensed heat in the stack. This required the fuel to ignite, then heat the stack. A trial for ignition took up to 90 seconds. A newer and quicker safety control that "sees" the bright yellow flame has all but replaced the stack switch in fuel oil burners. What is this photo cell safety control?

A. An infrared sensor made of lead sulfide.

Incorrect. Lead sulfide is a semiconductor having the property of decreasing in electrical resistance when exposed to radiation of certain wavelengths. As such, it senses heat, not light.

B. *A cad cell using cadmium sulfide as the sensor.

Correct. Cadmium sulfide is used as a photocell in a visible light detector. It has the property of offering low resistance when exposed to light and high resistance when there is no light. Cad cells work well with fuel oil flame because it is bright yellow. Natural gas and propane burn with a blue colored flame and do not produce much light, so cad cells do not work well with those fuels.

C. An ultraviolet flame detector using a sealed gas-filled chamber as a sensor.

Incorrect. Ultraviolet flame detectors use a sealed gas-filled chamber containing two electrodes. When the gas is exposed to ultraviolet light, the gas becomes conductive and current pulses from one electrode to the other, thus sensing the flame.

D. A flame rod with flame rectifier circuitry.

Incorrect. Flame rods are common with gas-fired appliances, but are not used with fuel oil.

114. E42 The practice of adjusting boiler water temperature so that water temperature is hottest on the coldest days and coolest on warmer days is known as

A. return air reset.

Incorrect. Return air reset is based on the temperature of the return air, not the outside air temperature. In a boiler system, it is possible that there is no return air to sense.

B. outdoor air based boiler water temperature (OABBWT).

Incorrect. There is no term known as outdoor air based boiler water temperature.

C. *outdoor reset.

Correct.

D. Air/water balance. (AWB)

Incorrect. There is no term known as air/water balance.

115. E42 A compression tank is provided in a hydronic system

A. so that higher pressures can be built up, thereby raising the boiling point.

Partially correct. There are other reasons for using a compression tank.

B. so that room is provided for heated water to expand.

Partially correct. There are other reasons for using a compression tank.

C. to provide a cushion against sudden pressure changes and water hammer shock.

Partially correct. There are other reasons for using a compression tank.

D. *All of the above.

Correct.

116. E42 Expansion joints are needed in hydronic systems

A. so that room is provided for heated water to expand.

Incorrect. Providing room for heated water to expand is the job of the expansion tank.

B. *to allow for expansion and contraction of the piping.

Correct. Copper tubing expands 1.66" per hundred feet with a 150°F temperature rise. Steel expands 1.17" under the same conditions. Allowances must be made for this movement, or leaks will develop and pipes/fittings may crack.

C. to allow for the expansion and contraction of the building.

Incorrect. Buildings expand and contract very little compared to the metal in the pipes. It is the pipe expansion and contraction that is of concern.

D. to allow for future expansions to the hydronic system.

Incorrect. Expansion in this context does not refer to the additions that may be made to the hydronic system in the future. Rather, expansion refers to the movement of pipes due to thermal expansion.

117. E43 In order to reduce water turbulence at the suction end of a pump, a suction diffuser should be used or a length of straight pipe equal to ______times the diameter of the pipe.

A. 15

Incorrect.

B. 10

Incorrect.

C. *5

Correct.

D. 2½.

Incorrect.

118. E43 Premature bearing wear on floor mounted pumps could be caused by

A. *suction or discharge lines that were forced into position when the pump was installed.

Correct. The torque of the pipes on the bearings causes excessive stress and could easily lead to early bearing failure.

B. water temperatures that are too high.

Incorrect. Pumps are designed to handle the high water temperatures associated with hydronic heating.

C. corrosive materials in the water.

Incorrect. The pumps are designed so that the bearings do not come in contact with the fluid being pumped.

D. Both B and C from above.

Incorrect.

119. E43 A stuffing box type of shaft seal on a centrifugal pump needs periodic maintenance. If the seal is found to be leaking excessively, the technician should

A. replace the carbon washer and/or tension the spring.

Incorrect. The carbon washer and spring are components of the mechanical shaft seal.

B. replace the entire seal as this is cheaper than repairing a leaking seal.

Incorrect. Periodic maintenance is expected with stuffing box seals and they're easy to maintain.

C. *tighten the packing gland and/or replace the packing.

Correct. In most cases, simply tightening the packing gland will minimize the leakage. Remember that this type of seal is designed to leak slightly, as the water acts as a lubricant. If tightening the packing gland does not minimize the leak, the packing itself may be worn and need replacing.

D. replace the pump, as the seal is an integral part of the pump and not easily replaced or repaired.

Incorrect. The seal is an inexpensive part of an expensive pump. It is far more cost effective to tighten the seal than to replace the pump.

120. E43 Cavitation can destroy a centrifugal pump, is noisy and is caused by

A. inlet pressure that is too high.

Incorrect.

B. *inlet pressure that is too low.

Correct. Inlet pressure that falls below the manufacturer's recommended net positive suction head (NPSH) will cause water to boil due to the low pressure, causing bubbles and cavitation.

C. outlet pressure that is too low.

Incorrect.

D. outlet pressure that is too high.

Incorrect.

121. E44 The vacuum pump used in vacuum steam heating systems that creates a vacuum using high velocity water is the

A. velocity pump.

Incorrect.

B. *jet type pump.

Correct. The jet pump forces water through an injector that increases its velocity, creating a correspondingly low pressure around it, creating a suction that causes water to flow.

C. turbine pump.

Incorrect.

D. lift pump.

Incorrect.

122. E44 Vacuum pumps used in vacuum steam heating systems can be destroyed if they are made to pump

A. air.

Partially correct. The pumps used are centrifugal pumps, which can be destroyed by cavitation.

B. steam.

Partially correct. A common reason for pump failure is live steam entering the pump due to failed steam traps. The cause of the pump failure must be corrected at the same time the pump is repaired or replace. If bad steam traps allowed the steam to reach the pump, the steam traps must be repaired or replaced or the new pump will soon fail again.

C. water.

Incorrect. The pump is designed to pump water through the pump's centrifugal impeller into an injector, where the high velocity discharge creates a low pressure that draws condensate into the tank.

D. *Both A and B from above.

Correct. Both air and steam can destroy a vacuum pump. However, through the design of vacuum steam heating vacuum pumps, air typically does not enter the pump. The intake of these pumps draw from a tank that is vented to the atmosphere. The vent is to allow air to escape. The pump intake is near the bottom of the tank, so only water is drawn into the pump. Further, pump cavitation is caused by low suction pressure. Since the intake of the pump is connected to a tank under atmospheric pressure, the pump does not see low suction pressures. Steam can reach the pump, however, if the steam traps allow live steam to blow by and enter the condensate lines.

123. E44 If a vacuum pump in a vacuum steam heating system burns out, a very common cause is

A. incorrect voltage to the pump.

Incorrect. While this will cause a pump motor to fail, it is not a very common cause of failure. Further, the pump will likely fail very soon if supplied with improper voltage.

B. backward rotation.

Incorrect. The centrifugal type pump used as a vacuum pump will pump even when rotating backwards. While this affects the ability of the pump to move water, it usually does not harm this type of pump.

C. a failed vacuum breaker.

Incorrect. A vacuum breaker is designed to prevent the pressure in the condensate return from dropping too low. If system pressure drops below 15 in. Hg., the breaker opens and lets air into the system. Since the pump draws from a tank that is vented to the atmosphere (to allow air to escape), it will typically see atmospheric pressure at the inlet and will be unaffected by system pressure. See Fig. 6-10 on page 70 of Steam Systems.

D. *a failed steam trap.

Correct. A failed steam trap will allow live steam to blow by. If the steam makes it to the vacuum pump, it can destroy the pump. In buildings with many steam traps and poor maintenance procedures, failed steam traps are a common cause of vacuum pump failure.

124. E45 The type of pump found in a fuel oil burner is the

A. propeller.

Incorrect.

B. centrifugal pump.

Incorrect.

C. inline pump.

Incorrect.

D. *gear pump.

Correct.

125. E45 A gear pump is a type of

A. centrifugal pump.

Incorrect. A centrifugal pump relies on the spinning of the impeller to create centrifugal force. This force "throws" fluid to the outside of the impeller, creating a low pressure near the center, which draws in more fluid. A gear pump does not rely on centrifugal force. Rather, it moves fluid trapped within the teeth of the gears by rotating the gears.

B. *rotary pump.

Correct

C. double acting pump.

Incorrect. Double acting pumps are of the reciprocating type, and are so named because the piston pumps on both strokes.

D. axial pump.

Incorrect. A propeller pump would be an example of an axial pump.

126. E46 Effective recovery of condensate reduces the following cost of making steam:

A. Fuel/energy costs associated with producing steam.

Partially correct. Other costs are also saved.

B. Boiler water make-up and sewage treatment.

Partially correct. Other costs are also saved.

C. Boiler water chemical treatment.

Partially correct. Other costs are also saved

D. *All of the above.

Correct.

127. E46 A symptom of a failed steam trap is

A. a trap that is colder than steam temperature.

Incorrect. Actually, this is the condition that you would expect, as the trap is normally partially filled with condensate at a slightly lower temperature than the saturated steam.

B. a trap that is colder than condensate temperature.

Incorrect. This would indicate a blockage further upstream of the trap. The only way a trap could be colder than the condensate is if no condensate or steam reached the trap.

C. *a trap that is warmer than condensate temperature.

Correct. A trap that is warmer than condensate temperature indicates that steam is flowing freely through it, meaning that the trap is not trapping the steam as it is designed to do.

D. A trap that is warmer than steam temperature.

Incorrect. It would not be possible for a trap to become warmer than the steam inside.

128. E46 After the first heating season, cleaning a dirt pocket by removing the cap on the bottom of a dirt pocket

A. should be done annually.

Incorrect. After the first year, dirt pockets usually do not require cleaning.

B. should be done bi-annually.

Incorrect. After the first year, dirt pockets usually do not require cleaning.

C. *is usually not required.

Correct. The dirt pocket should be cleaned several times during the first heating season to remove heavy foreign material such as scale and pipe cuttings. Thereafter, such attention is usually not required.

D. None of the above.

Incorrect

129. E47 The average house line pressure for Natural Gas is

A. 3.5 psi.

Incorrect. Residential gas pressure is less than 0.5 psi.

B. 3.5 " W.C.

Incorrect. While manifold pressure may be adjusted to 3.5" W.C., line pressure is higher.

C. 7 psi.

Incorrect. Residential gas pressure is less than 0.5 psi.

D. *7" W.C.

Correct.

130. E47 The pressure is measured on a residential gas regulator using a

A. Bourdon tube gage.

Incorrect. The Bourdon tube is not accurate at the low pressures used in gas lines. Further, gas pressures are not listed for the type of reading that a Bourdon tube is capable of reading.

B. Mercury manometer.

Incorrect. Gas pressures are usually not calibrated for Mercury manometers.

C. *Water manometer.

Correct. A water manometer provides a cheap and accurate way to measure the low pressures encountered in residential gas systems. Gas valves report pressure settings in inches of water column, which is read with the water manometer.

D. Either B or C from above.

Incorrect.

131. E47 The purpose of the gas regulator vent is to

A. allow air to enter above the diaphragm.

Partially correct. As the diaphragm moves down, air must be allowed to fill the cavity above it to prevent a vacuum and allow free movement.

B. allow air to escape above the diaphragm.

Partially correct. As the diaphragm moves up, air must be allowed to escape the cavity above it to prevent a build up of pressure and allow free movement.

C. allow gas to escape if the diaphragm ruptures.

Partially correct. Sometimes the gas is allowed to vent to the atmosphere. In other cases, it must be vented to the combustion chamber to be burned or to the outside. Local codes must be consulted to find what applies.

D. *All of the above.

Correct. The vent allows free movement of air into and out of the chamber above the diaphragm, thus allowing free movement of the diaphragm itself. The vent is also a safety device designed to allow gas to escape if the diaphragm were to rupture.

132. F49 An advantage of the inverted bucket trap is that

A. there are no moving parts to wear.

Incorrect. The bucket is constantly moving up and down and the valve is opening and closing. The bucket, the valve and other associated parts are all susceptible to wear.

B. it can be installed in any position.

Incorrect. It must be installed with the bucket in the inverted position in order to operate.

C. its design prevents it being damaged due to freezing.

Incorrect. Some inverted bucket traps are designed to withstand freeze-ups, but most can be damaged by freezing.

D. *it also vents air and carbon dioxide continuously at steam pressure.

Correct. During operation, steam, air and CO_2 rise to top of the inverted bucket. The steam condenses, but the air and CO_2 remain a gas. When the valve at the top of the trap opens, the air and CO_2 are the first to leave the trap.

133. F49 Flash steam is caused by

A. pipe friction.

Partially correct. The friction of steam and condensate flowing along the pipe creates heat that re-flashes some of the condensate back to steam.

B. reduced pressure.

Partially correct. A drop in system pressure will lower the boiling point of the condensate and cause some of it to flash into steam.

C. a vertical rise in a condensate line.

Partially correct. A vertical rise will lower the pressure of the condensate, thus lowering the boiling point, causing some of it to flash into steam.

D. *All of the above.

Correct.

134. F49 The purpose of a drip leg in a steam line is to

A. create a venturi to pull condensate out of a trap.

Incorrect. This is undesirable and can actually happen if the drip leg is small.

B. let condensate escape by gravity from the fast-moving steam.

Partially correct. There is another purpose.

C. store condensate until it can be discharged through the steam trap.

Partially correct. There is another purpose.

D. *Both B and C from above.

Correct.

135. F49 Inadequate trapping of steam mains often leads to

A. *water hammer and damaging slugs of condensate.

Correct. Steam and condensate flowing in the same pipe can cause water hammer and in severe cases, actually destroy piping components leading to the discharge of live steam into the atmosphere.

B. condensate flowing in one direction while steam flows in the opposite.

Incorrect.

C. loss of steam energy by conduction through the walls of the pipe.

Incorrect. The only way to prevent/minimize this loss is through pipe insulation.

D. excessively low temperature condensate.

Incorrect.

136. F49 Pressure in a vertical condensate pipe will drop 1 psi for every ______ feet in elevation. This is an important factor, since boiling temperature drops as pressure drops. When elevating condensate, this drop in pressure can cause flash steam.

A. 1.08

Incorrect.

B. *2.31

Correct. 2.31 feet of head is equal to 1 psi. This is the same factor used in pumping calculations.

C. 8.33

Incorrect.

D. 10

Incorrect.

137. F49 When using a listening device to test a steam trap, what would the technician listen for that could indicate a problem.

A. Continuous condensate discharge.

Incorrect. Some traps, such as the float and thermostatic (F&T) trap, operate with continuous discharge. Others, such as the inverted bucket (IB) and disc traps should have an intermittent discharge. Meanwhile, thermostatic traps can be either continuous or intermittent, depending on the load.

B. Intermittent condensate discharge.

Incorrect. Some traps, such as the float and thermostatic (F&T) trap, operate with continuous discharge. Others, such as the inverted bucket (IB) and disc traps should have an intermittent discharge. Meanwhile, thermostatic traps can be either continuous or intermittent, depending on the load.

C. *High velocity sound.

Correct. Escaping steam will have a higher velocity sound than normal operation of the trap, be it continuous or intermittent. An electronic listening device can be used for this, although a simple screwdriver, with one end held against the trap and the other against your ear, works just as well. In either case, experience is required to distinguish between sounds of the trap and other sounds in the system.

D. Gurgling and bubbling.

Incorrect. Gurgling and bubbling are normal sounds in traps, as steam is constantly bubbling up through the condensate.

138. F49 If an inverted bucket steam trap is blowing live steam, what might the trouble be?

A. The valve may have failed to seat because of wear or a piece of dirt or scale.

Partially correct. A piece of dirt could be lodged between the valve and the valve seat, preventing the valve from closing and allowing steam to blow by.

B. The trap may have lost its prime.

Partially correct. A sudden or frequent drop in steam pressure is usually the cause of prime loss. The installation of a check valve upstream of the trap can prevent this problem.

C. The bucket is stuck or has a hole in it.

Partially correct. If the bucket is stuck in the down position for some reason, steam can fill it then blow by under the bottom of the bucket. If the bucket vent becomes oversized, steam can blow through the top of the bucket and blow out of the trap.

D. *All of the above.

Correct.

139. F50 The ________________ drains the condensate from the steam header and returns it to the boiler below the water line while preventing the boiler water from flowing out of the boiler into the return main.

A. *equalizing line

Correct. The water level in the equalizing line is the same as in the boiler, because the steam pressure on the top of both lines is the same. This prevents the boiler water from flowing out of the boiler into the return main.

B. Hartford Loop

Incorrect. The function of the Hartford Loop is not to return condensate to the boiler.

C. wet return

Incorrect. The wet return does return condensate to the boiler, but does not prevent water from flowing back out of the boiler.

D. steam header

Incorrect. The steam header connects outlet risers into a common pipe.

140. F50 The ______________ is designed to protect boilers against the loss of water due to leaks in the wet return line.

A. equalizing line

Incorrect. The equalizing line prevents the boiler water from flowing out of the boiler into the return main.

B. *Hartford Loop

Correct. The Hartford Loop prevents water from dropping more than 2" to 4" below the normal operating water line (NOWL) through the condensate wet return line by breaking the siphoning effect once the water reaches that level.

C. check valve

Incorrect. Check valves were found to be ineffective against loss of water due to a leak in the wet return line, since the check valves were by necessity installed at a low point in the system and were often stuck open with dirt from the system.

D. steam header

Incorrect. The steam header connects outlet risers into a common pipe.

141. F50 The control valve in a sub-atmospheric steam heating system is limited to approximately _____% change per minute.

A. 12

Incorrect. The control valve is designed with a small percentage of change so there are no radical changes in the pressure and steam temperature in the system piping.

B. 9

Incorrect. The control valve is designed with a small percentage of change so there are no radical changes in the pressure and steam temperature in the system piping.

C. 6

Incorrect. The control valve is designed with a small percentage of change so there are no radical changes in the pressure and steam temperature in the system piping.

D. *3

Correct. The control valve is designed with a small percentage of change so there are no radical changes in the pressure and steam temperature in the system piping.

142. F52 A vacuum breaker is installed between equipment and a steam trap to

A. allow a vacuum to be pulled on the system.

Incorrect.

B. *allow condensate to drain after the steam has been shut off.

Correct. Once the steam supply has been shut off, steam will condense and will be unable to drain because of the vacuum. The vacuum breaker provides a vent and allows the condensate to drain.

C. prevent condensate from draining after the steam has been shut off.

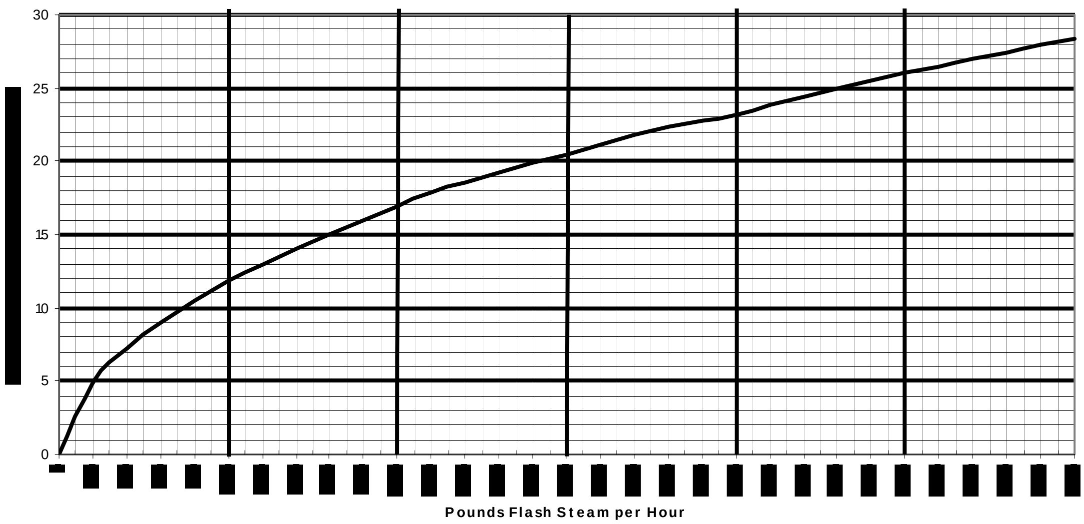
Incorrect. It is necessary to remove the condensate from certain parts of the system during off cycles to prevent freezing.

D. trip on low pressure cutoff.

Incorrect.

143. F53 Determine the diameter of a flash tank using the following chart for a system with 2800 pounds of flash steam available per hour.

Determination of Internal Diameter of Flash Tank to Handle a Given Quantity of Flash Steam



A. 15"

Incorrect.

B. 18"

Incorrect.

C. *20"

Correct.

D. 22"

Incorrect.

144. G55 The most commonly used inspection used on fans and air handling equipment is

A. ultrasound.

Incorrect.

B. vibration analysis.

Incorrect. Although vibration analysis is a good way to predict failure of equipment, it is not the most common inspection method.

C. infrared.

Incorrect. Although infrared readings of bearings can be a great way to find a "hot" bearing, it is not the most common inspection method.

D. *visual.

Correct. There is nothing like a good old walk around. An experienced technician can spot trouble without needing expensive equipment, although specialized equipment can confirm that a problem exists.

145. G55 Which air distribution system includes both warm air duct and a cool air duct and utilizes mixing boxes near the zone to mix the cool air and warm air streams to achieve the desired temperature while delivering the air at a near constant volume?

A. multizone.

Incorrect.

B. *dual duct.

Correct.

C. mixing box system.

Incorrect.

D. dual temperature system.

Incorrect.

146. G55 Which duct system delivers constant temperature air at variable volumes?

A. *VAV.

Correct.

B. Multizone.

Incorrect.

C. Dual duct.

Incorrect.

D. single zone.

Incorrect.

147. H56 When soldering, solder is drawn into the joint by

A. the heat of the torch.

Incorrect. The heat of the torch melts the solder but does not draw it into the joint.

B. *capillary action.

Correct. Capillary action is the flow of a liquid when it is drawn into a small space between wetted surfaces. This is the same action that draws colored water into flowers during Biology experiences and allows trees to get water from the roots to the crown.

C. gravity.

Incorrect. Many times, solder must actually be drawn uphill.

D. flux.

Incorrect. Flux certainly does help the solder to flow, but does not draw it into the joint.

148. H56 Which of the following best describes the difference between brazing and welding?

A. Welding is an adhesive process while brazing is cohesive.

Incorrect. Brazing is a process much like gluing in which the "glue" is filler metal (brazing rod) and actually seeps into the pores of the base metal and upon drying, bonds the base metals together. This is why a flux must be used, to clean the oxides off the base metal so that the brazing rod (or solder) can bond. Welding, on the other hand, needs no filler metal (although one is usually used) and actually fuses the two pieces of base material together, making them one. Brazing can be compared to gluing two pieces of wood together. The wood pieces remain separate pieces of wood, but are bonded together with the glue. Welding can be compared to connecting PVC pipe with solvent. The solvent actually melts the two PVC pieces. When they dry, they are no longer two separate pieces, but one, fused together at the joint.

B. *Welding is a cohesive process while brazing is adhesive.

Correct. Brazing is a process much like gluing in which the "glue" is filler metal (brazing rod) and actually seeps into the pores of the base metal and upon drying, bonds the base metals together. This is why a flux must be used, to clean the oxides off the base metal so that the brazing rod (or solder) can bond. Welding, on the other hand, needs no filler metal (although one is usually used) and actually fuses the two pieces of base material together, making them one. Brazing can be compared to gluing two pieces of wood together. The wood pieces remain separate pieces of wood, but are bonded together with the glue. Welding can be compared to connecting PVC pipe with solvent. The solvent actually melts the two PVC pieces. When they dry, they are no longer two separate pieces, but one, fused together at the joint.

C. Brazing is done on non-ferrous metals. Welding is done on ferrous metals.

Incorrect. Both brazing and welding can be done on ferrous and non-ferrous metals alike.

D. B and C from above.

Incorrect.

149. H56 The practice of installing flanges on pipe and fittings so that the top bolt hole in the right hand and left hand section of the flange are level with each other is known as

A. *two-holing.

Correct. This practice makes leveling of fittings and piping easy. The bolt holes in the flanges on flanged fittings and valves are drilled according to this rule.

B. flange-leveling.

Incorrect.

C. mirroring.

Incorrect.

D. hole-leveling.

Incorrect. Although this is indeed what is being done, the practice is not known as hole-leveling.

150. H57 Of the valves listed below, which provides the best throttling action?

A. Ball valve.

Incorrect. The ball valve is a quick-operating shut off valve.

B. *Globe valve.

Correct. The flow through a globe valve changes course through two 90° turns, causing increased resistance to flow and sometimes a considerable pressure drop.

C. Gate valve.

Incorrect. A gate valve should be used as a stop valve – either fully opened or fully closed.

D. Plug valve.

Incorrect. Like a gate valve, a plug valve should be used as a stop valve – either fully opened or fully closed.

151. H57 A rating of 125 lb S-200 lb W.O.G. stamped on a valve means that the valve

A. weighs 125 pounds and can withstand operating pressures up to 200 psi.

Incorrect.

B. has a standard rating of 125 psi and a Working Over-Gage (W.O.G.) rating of 200 psi.

Incorrect.

C. has a nominal system rating of 125 psi range but can withstand 200 psi with a wide open gate (W.O.G.).

Incorrect.

D. *has a steam rating of 125 psi and a cold water/oil/gas rating of 200 psi.

Correct. This rating means the valve can be used with steam up to 125 psi, provided that the temperature does not exceed the value established by the manufacturer. It can also be used with cold water, oil or gas up to 200 psi at ambient temperatures.

152. H57 A device designed to protect pipe insulation against damage because of pipe movement is called a

A. pipe sleeve.

Incorrect.

B. *pipe saddle.

Correct.

C. vibration isolator.

Incorrect.

D. insulation isolator.

Incorrect.

153. I58 The safe working load of a fiber or wire rope can be calculated using the formula

$$\text{Safe Working Load (SWF)} \frac{\text{Breaking Strength (BS)}}{\text{Safety Factor (SF)}},$$

where the safety factor for hoisting material is required by OSHA to be

A. 2.

Incorrect. The safety factor must be larger than 2.

B. 4.

Incorrect. The safety factor must be larger than 4

C. *5.

Correct. This means that a rope with a breaking strength of 10,000 pounds can safely lift 2,000 pounds.

D. 10.

Incorrect. The safety factor does not need to be this high for lifting material. However, if fiber rope is used to hoist or support personnel, then the safety factor must be 10.

154. I58 Calculate the safe working load of a 2-leg bridle using 1 5/8" wire rope with a bridle length (L) of 12' and a height (H) of 10', according to the drawing and formulas given below.

1. Calculate the SWL for a single wire rope lifting straight up and down (vertically)

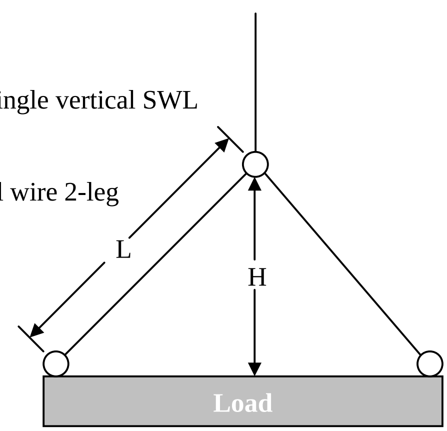
Safe working load (SWL) rule of thumb for plow steel wire rope, when a single rope is used to lift vertically (tons):

$$\text{Single Vertical SWL} = (\text{Rope dia})^2 \times 8$$

2. Calculate the SWL for a 2-leg bridle sling, using the single vertical SWL calculated from the formula above.

Save working load (SWL) rule of thumb for plow steel wire 2-leg bridle sling (tons):

$$\text{2 - Leg Bridle SWL} = \text{Single Vertical SWL} \times \frac{H}{L} \times 2$$



A. 21 tons.

Incorrect. 21 tons is the single vertical SWL.

B. 42 tons.

Incorrect. 42 tons is double the single vertical SWL.

C. *35 tons.

Correct.

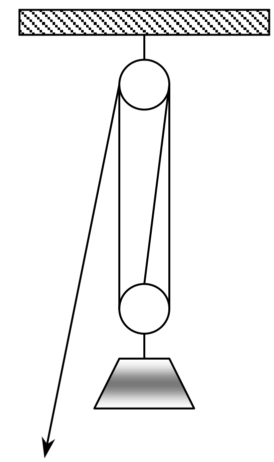
D. 43 tons.

Incorrect. If this is the answer you arrived at, check your math. You probably doubled the diameter of the rope instead of squaring it.

155. I58 Calculate the amount of weight that could be lifted in a force of 100 pounds is exerted in the direction of the arrow.

A. 100 pounds.

Incorrect. A block and tackle provides mechanical advantage, allowing more weight to be lifted than the force exerted.



B. 200 pounds.

Incorrect. To find how much weight can be lifted, multiply the force exerted by the number of ropes supporting the load.

C. *300 pounds.

Correct. There are three ropes supporting the load in the drawing. Multiplying the force exerted by the number of supporting ropes results in the amount of weight that can be lifted.

D. 400 pounds.

Incorrect. To find how much weight can be lifted, multiple the force exerted by the number of ropes supporting the load.

156. I59 The weakest portion of a chain hoist is the

A. chain.

Incorrect. If the chain were to break, the load would fall and personal injury could result.

B. *lower hook.

Correct. The lower hook is designed to spread when over loaded. The inner contour of the load hook is an arc of a circle, and any deviation from this circle is evidence of overloading.

C. upper hook.

Incorrect. If the upper hook were to fail, the entire chain hoist would fall.

D. spur gear.

Incorrect. The spur gear is designed to handle the load and is not designed to fail.

157. I59 An overload of most cable hoists (come-alongs) is prevented

A. by a clutch mechanism.

Incorrect. There is no clutch mechanism in a cable hoist.

B. by a load hook that bends.

Incorrect. There is another safety device that activates before the load hook will bend.

C. by a pressure relief spring.

Incorrect. A device that relieves the lifting pressure could cause the load to slip or fall.

D. *by a handle that bends.

Correct. The manufacturer designs the lever handle to bend before an unsafe load can be lifted. This handle should not be replaced with a stronger bar, nor should cheater devices be used, as both practices will bypass the safety feature.

158. I59 When using a jack to lift a load,

A. chocks should be used.

Partially correct. Chocks should be used to prevent the jack from kicking out.

B. use wood softeners.

Partially correct. Never jack metal against metal. Instead, place a piece of wood between the jack and the load.

C. do not place the jack directly on the ground.

Partially correct. The jack should always be set on a solid base. Placing it on the ground can cause it to sink or tilt, which can in turn cause the load to fall.

D. *All of the above.

Correct.

159. J60 Unless equipped with OSHA or Canadian Standards Association (CSA) approved ground-fault circuit interrupters, portable electric lighting used in wet and-or other conductive locations as, for example, drums, tanks and vessels, shall be operated at _____ volts or less.

A. *12

Correct.

B. 24

Incorrect. 24 volts is not acceptable.

C. 120

Incorrect. Unless equipped with approved ground-fault circuit interrupters, 120 volt lighting is not acceptable.

D. None of the above.

Incorrect.

160. J60 A ladder must extend above the edge of a roof by at least _______ _________.

A. one foot.

Incorrect.

B. two feet.

Incorrect.

C. *three feet.

Correct.

D. four feet.

Incorrect.

161. J60 The proper angle for a ladder is achieved when the distance of the ladder from the building at the base is about __________ the working length (height) of the ladder.

A. one half.

Incorect. The ladder would be too horizontal under this condition, and would be weakened.

B. one third

Incorect. The ladder would be too horizontal under this condition, and would be weakened.

C. *one fourth.

Correct.

D. one fifth

Incorrect. The ladder would be too steep under this condition.

162. J61 A lock and tag may only be removed by the employee that applied it, unless the employee is absent from the workplace, then the lock or tag may be removed by a qualified person designated by the employer to perform this task provided that the employer ensures that

A. the employee who applied the lock or tag is employed by his company and under his jurisdiction.

Incorrect. An employer does not have the right to unilaterally decide to remove a lock or tag of an employee, since the employee could be in danger in injury if not aware that the circuit has been energized.

B. the employee who applied the lock or tag is not available at the workplace.

Partially correct. The employer must confirm that the employee is not at the workplace to ensure, among other things, that the employee is not in danger of injury when the circuit is energized.

C. the employee who applied the lock or tag is aware that it has been removed before he or she resumes work at that workplace.

Partially correct. The employer must ensure that the employee is aware that a circuit that he/she knew to be locked out is now energized.

D. *Both B and C from above.

Correct.

163. J62 Section 608 of the Act prohibits you from knowingly venting ozone-depleting compounds used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (appliances). The prohibition took affect

A. July 13, 1993

Incorrect. As of July 13, 1993, all systems in general that are opened to the atmosphere for any reason, including disposal, must have the refrigerant recovered and must be evacuated to the levels set forth by EPA.

B. November 14, 1994

Incorrect. Technician certification became a requirement on November 14, 1994, as did Sales Restrictions. Class I or Class II substances could only be sold to certified technicians after November 14, 1994.

C. *July 1, 1992

Correct.

D. November 1995

Incorrect. After this date, it was illegal to vent *substitutes* for CFC and HCFC refrigerants (unless EPA determines that it does not pose a threat to the environment).

164. J62 When working on a HCFC-22 appliance, or isolated component of such appliance, normally containing 200 pounds or more of refrigerant and using recovery or recycling equipment manufactured or imported on or after November 15, 1993, you are required to evacuate to a level of

A. *10 in. Hg.

Correct.

B. 4 in. Hg.

Incorrect. 4 in. Hg. is the required evacuation level when working on a HCFC-22 appliance, or isolated component of such appliance, normally containing 200 pounds or more of refrigerant and for recovery or recycling equipment manufactured before November 15, 1993.

C. 0 in. Hg.

Incorrect. 0 in. Hg. is the required level of evacuation for HCFC appliances containing less than 200 pounds of refrigerant when using recovery or recycling equipment regardless of when it was manufactured.

D. 25 in. Hg.

Incorrect. 25 in. Hg. is the required evacuation level for recovery or recycling equipment manufactured or imported before November 15, 1993 when used on a low-pressure appliance (CFC-11, HCFC-123).

165. J62 If a compressor burn has occurred, the refrigerant must be

A. recovered.

Partially correct. The refrigerant must be recovered from the system before the system can be repaired.

B. reclaimed.

Partially correct. If a compressor burn has occurred, you should have the refrigerant reclaimed.

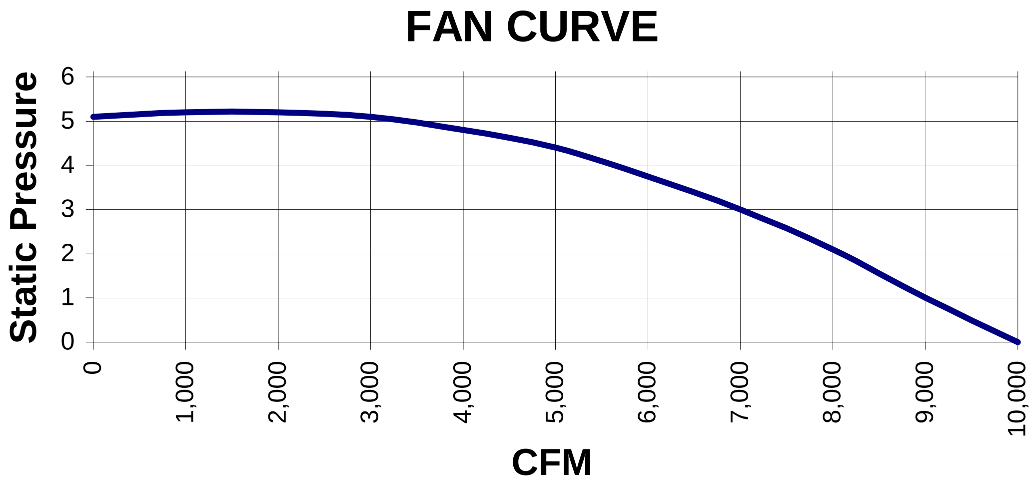
C. recycled.

Incorrect. After a compressor burn, the refrigerant should be cleaned to a higher standard than can be attained through recycling.

D. *Both A and B from above,

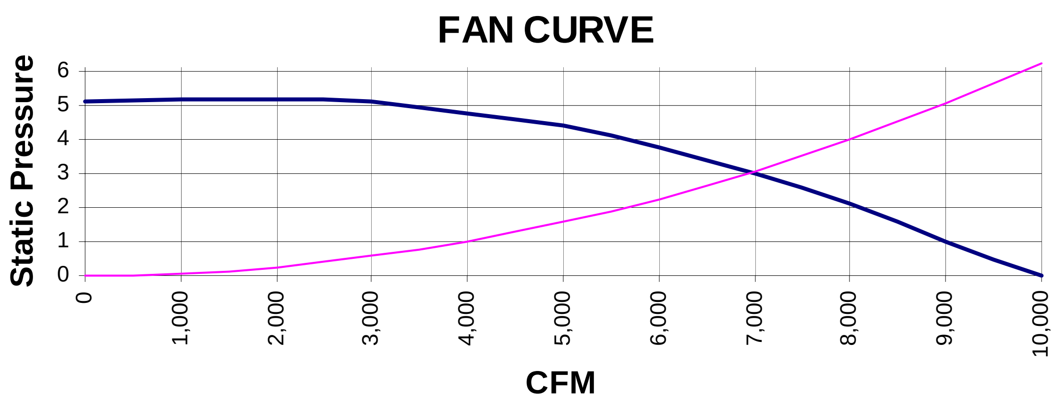
Correct.

166. K64 Plot a system curve on the fan curve chart below. Use an operating point of 8000 cfm at a static pressure of 4 in. water column as a basis for your calculations. What will the static pressure be at 7000 cfm?



A. *3 in. water column.

Correct. Using the formula $\text{Static}_2 = \text{Static}_1 \times \left(\frac{\text{cfm}_2}{\text{cfm}_1}\right)^2$ yields a static pressure of 3.06 in. water column. Plotting the system curve shows an operating point at the intersection of the fan and system curves, as shown below.



B. 3.5 in. water column.

Incorrect. If you arrived at 3.5 in. water column for an answer, you probably forgot to square the ratio of cfm_2 to cfm_1. Use the formula $\text{Static}_2 = \text{Static}_1 \times \left(\frac{\text{cfm}_2}{\text{cfm}_1}\right)^2$ to find the correct answer.

C. 2.7 in. water column.

Incorrect. If you arrived at 2.7 in. water column for an answer, you probably cubed the ratio of cfm_2 to cfm_1. Remember that static pressure varies as the square of the difference in airflow ratio, while brake horsepower varies as the cube of the difference in airflow ratio. Use the formula $\text{Static}_2 = \text{Static}_1 \times \left(\frac{\text{cfm}_2}{\text{cfm}_1}\right)^2$ to find the correct answer.

D. 5.22 in. water column.

Incorrect. If you arrived at 5.22 in. water column for an answer, you probably divided cfm_1 by cfm_2 instead of cfm_2 by cfm_1. Use the formula $\text{Static}_2 = \text{Static}_1 \times \left(\frac{\text{cfm}_2}{\text{cfm}_1}\right)^2$ to find the correct answer.

167. K64 Calculate the volume in gallons of a cylindrical tank having a base diameter of 46" and a height of 70".

A. 2014 gallons.

Incorrect. If this was your answer, you probably squared the diameter of the tank instead of the radius when calculating volume. To find the correct answer, use the formula

$$\text{Gallons} = r^2 h\pi \times \frac{gallon}{231 cu.in.}$$

where r = radius in inches

h = height in inches

B. 808 gallons.

Incorrect. If this was your answer, you probably divided the volume of the tank by 144 instead of 231 cu. in./gallon. To find the correct answer, use the formula

$$\text{Gallons} = r^2 h\pi \times \frac{gallon}{231 cu.in.}$$

where r = radius in inches

h = height in inches

C. *504 gallons.

Correct.

D. 67 gallons.

Incorrect. If this was your answer, you probably divided the volume of the tank by 1728 instead of 231 cu. in./gallon. To find the correct answer, use the formula

$$\text{Gallons} = r^2 h\pi \times \frac{gallon}{231 cu.in.}$$

where r = radius in inches

h = height in inches

168. K64 Calculate the velocity of air measured in feet per minute (fpm) in a 36 x 32 duct with 48,000 cfm of air flow.

A. 0.00017 fpm.

Incorrect. If this was your answer, you probably divided area by cfm instead of cfm by area. Use the formula $fpm = \frac{cfm}{area}$, but remember that all units must be in feet.

B. 41.7 fpm.

Incorrect. If this was your answer, you probably forgot to divide the area of the duct by 144 to convert from sq. in. to sq. ft. Use the formula $fpm = \frac{cfm}{area}$, but remember that all units must be in feet.

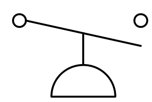
C. 0.024 fpm.

Incorrect. If this was your answer, you probably forgot to divide the area of the duct by 144 to convert from sq. in. to sq. ft. and you divided area by cfm instead of cfm by area Use the formula $fpm = \frac{cfm}{area}$, but remember that all units must be in feet.

D. *6000 fpm.

Correct.

169. K65 The symbol below would be used to indicate a _________ __________ switch that _________ on a rising signal.



A. *pressure actuated, closes

Correct.

B. temperature actuated, closes

Incorrect.

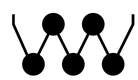
C. pressure actuated, opens

Incorrect.

D. temperature actuated, opens

Incorrect.

170. K65 This symbol below represents a



A. transformer.

Incorrect.

B. bimetallic sensor.

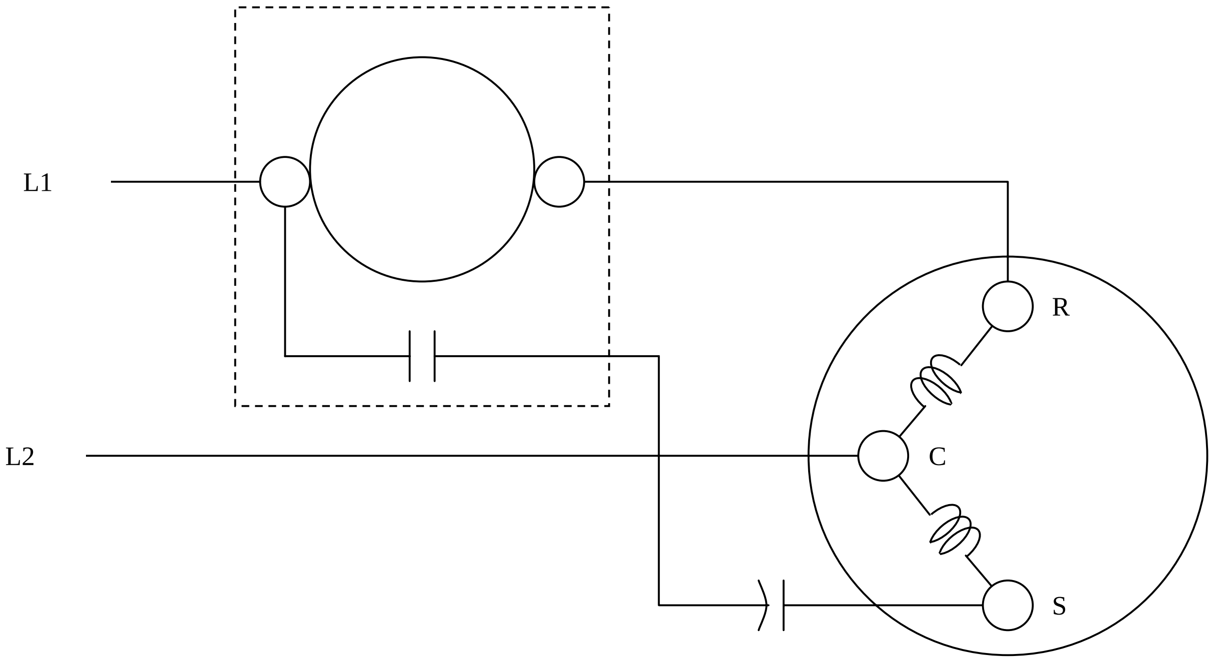
Incorrect.

C. *thermopile.

Correct.

D. thermocouple.

Incorrect.



171. K65 The circuit shown above represents a

A. *current relay.

Correct.

B. potential relay.

Incorrect.

C. time delay relay.

Incorrect.

D. lockout relay.

Incorrect

Energy Calculations

$Q_{(Total)} = 4.5 \times CFM \times \Delta h$
$Q_{(Latent)} = 4840 \times CFM \times \Delta g$
$Q_{(Sensible)} = 1.10 \times CFM \times \Delta T$
Q = BTUH
Δh = difference in enthalpy
Δg = difference in grains of moisture
ΔT = difference in temperature

Heat transfer

$BTUH = LB. \times \Delta T \times \text{Specific heat}$ (for any substance)
$BTUH = CFM \times \Delta T \times 1.08$ (for standard air)
$BTUH = GPM \times \Delta T \times 500$ (for water)

Force exerted by a round diaphragm with a pressure applied and measured in psig

$$\begin{aligned} \text{Force} &= \text{Area} \times \text{Pressure} \\ &= \text{sq.in.} \times \frac{\text{pound}}{\text{sq.in.}} \\ &= \pi r^2 \times \text{psig} \end{aligned}$$

Pressure conversions

1 psi = 2.31 feet of head
1 psi = 27.7 in. w.c.
1 psi = 2.04 in. Hg.
1 atmosphere = 34 feet of head
1 atmosphere = 29.9 in. Hg.
1 atmosphere = 14.7 psi
w.c. = water column
in. Hg. = inches Mecury

Air pressure in ducts

$$V = 4005\sqrt{VP}$$

$$VP = \left(\frac{V}{4005}\right)^2$$

Airflow in duct:

$Q = A \times V$
Q = CFM
A = Cross sectional area of duct (ft2)
V-Velocity of air (feet per minute – FPM)
VP = inches water gage, "WG

Mixed air temperature (MAT)

$MAT = OAT \times \%OA + RAT \times \%RA$

Percent of outside air

$$\%OA = \frac{RAT - MAT}{RAT - OAT}$$

MA=Mixed air
OA=Outside air
RA=Return air

Hydronic Pressure (Total Head)

Total Head = Static Head + Friction Head + Velocity Head

Static Head

Static Head = Static Discharge Head - Static Suction Head (calculated distance above pump as positive, distance below pump as negative)

Velocity Head (VH)

$$VH = \frac{V^2}{2g}$$

g = 32.2 ft/sec^2 (acceleration due to gravity)
V = Velocity of liquid

Total Dynamic Head

TDH = (DSH-SSH)+(DVH-SVH)
TDH = Total dynamic head
DSH = Discharge static head
SSH = Suction static head
DVH = Discharge velocity head
SVH = Suction velocity head

Flow Coefficient (Cv) rating of valve

$$Cv = \frac{Q}{\sqrt{H}}$$

Q = flow rate in gpm
H = head loss (pressure drop) in PSI
Cv = flow coefficient with valve wide open, equal to gpm of flow at a 1 PSI pressure drop across the valve. Cv decreases as the valve closes.

Temperature conversions

$$°F \text{ (Fahrenheit)} = °C \times \frac{9}{5} + 32$$

$$°C \text{ (Celsius)} = (°F - 32) \times \frac{5}{9}$$

°R (Rankine) = °F = 460
°K (kelvin) = °C = 273

Ohm's Law

Volts = Amps x Ohms
or
E=I x R

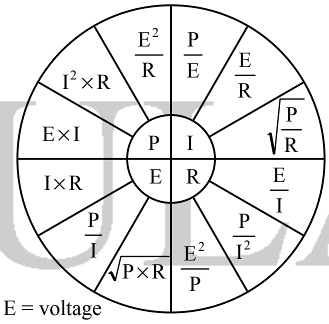
Watt's Law

Watts = Volts x Amps
or
P = E x I

Energy formula

W = P x t

Formula Circle for Ohm's and Watt's Laws



E = voltage
I = current (amps)
P = power (watts)
R = resistance (ohms)
W = energy (kWh, or kilowatt-hour)
t = time (hours)

Sum of resistance

Series circuits

$$R_T = R_1 + R_2 + R_3$$

Parallel circuits

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Sum of capacitance (C)

Series circuits

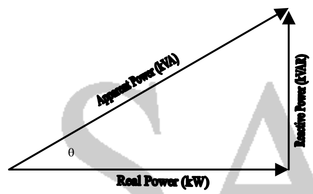
$$C_t = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Parallel circuits

$$C_T = C_1 + C_2 + C_3$$

Power factor calculations

$$\text{Power Factor} = \frac{\text{true power (kW)}}{\text{apparent power (kVA)}} = \cos\theta$$



$$\text{3 - phase apparent power } (\text{kVA}) = \frac{\text{Volts} \times \text{Amps} \times 1.73}{1000}$$

$$\text{single phase apparent power } (\text{kVA}) = \frac{\text{Volts} \times \text{Amps}}{1000}$$

$$\text{Reactive power } (\text{kVAR}) = \sqrt{\text{kVA}^2 - \text{kW}^2}$$

Percent of motor load

$$\%\text{ load} = \frac{\text{MA} - 0.5\text{NPA}}{0.5\text{NPA}} \times \frac{\text{MV}}{\text{MPV}}$$

MA = Measured amps
MPA = Nameplate amps
MV = Measured volts
MPV = Nameplate volts

Transformer voltage/winding calculation

$$E_S = E_P \times \frac{N_S}{N_P}$$

E_S = secondary voltage
E_P = primary voltage
N_S = number of secondary turns
E_P = number of primary turns

Brake horsepower of a fan

$$\text{Bhp} = \text{NPhp} \times \frac{\text{MA}}{\text{NPA}} \times \frac{\text{MV}}{\text{MPV}} \times \text{LF}$$

NPHP = Nameplate horsepower
MA = Measured amps
NPA = Nameplate amps (FLA)
MV = Measured volts
NPV = Nameplate volts
LF = Load factor (by table)

Brake horsepower of a pump

$$\text{Bhp} = \frac{\text{GPM} \times \text{TDH}}{3960 \times \text{Eff}} \times \text{specific gravity}$$

$$\text{Bhp} = \frac{\text{kW} \times \text{Eff}}{0.746}$$

$$\text{Pump efficiency} = \frac{\text{Total head} \times \text{GPM}}{3960 \times \text{Bhp}} \times \text{specific gravity}$$

TDH = Total dynamic head
Eff = Pump efficiency
kW = real input power

Speed Calculation

Calculate new sheave diameter, changing motor sheave

$$\text{Dia}_{\text{new}} = \text{Dia}_{\text{old}} \times \frac{\text{RPM}_{\text{new}}}{\text{RPM}_{\text{old}}}$$

Compression ratio (R)

$$R = \frac{\text{Absolute discharge pressure}}{\text{Absolute suction pressure}}$$

Calculate new sheave diameter, changing fan or pump sheave

$$\text{Dia}_{\text{new}} = \text{Dia}_{\text{old}} \times \frac{\text{RPM}_{\text{old}}}{\text{RPM}_{\text{new}}}$$ **Fan Laws**

$$\text{CFM}_{\text{new}} = \text{CFM}_{\text{old}} \times \frac{\text{RPM}_{\text{new}}}{\text{RPM}_{\text{old}}}$$

$$\text{SP}_{\text{new}} = \text{SP}_{\text{old}} \times \left(\frac{\text{CFM}_{\text{new}}}{\text{CFM}_{\text{old}}}\right)^2 = \text{SP}_{\text{old}} \times \left(\frac{\text{RPM}_{\text{new}}}{\text{RPM}_{\text{old}}}\right)^2$$

$$\text{BHP}_{\text{new}} = \text{BHP}_{\text{old}} \times \left(\frac{\text{CFM}_{\text{new}}}{\text{CFM}_{\text{old}}}\right)^3 = \text{BHP}_{\text{old}} \times \left(\frac{\text{RPM}_{\text{new}}}{\text{RPM}_{\text{old}}}\right)^3$$

Pump Laws

$$\text{GPM}_{\text{new}} = \text{GPM}_{\text{old}} \times \frac{D_{\text{new}}}{D_{\text{old}}} = \text{GPM}_{\text{old}} \times \frac{\text{RPM}_{\text{new}}}{\text{RPM}_{\text{old}}}$$

$$\Delta P_{\text{new}} = \Delta P_{\text{old}} \times \left(\frac{\text{GPM}_{\text{new}}}{\text{GPM}_{\text{old}}}\right)^2 = \Delta P_{\text{old}} \times \left(\frac{D_{\text{new}}}{D_{\text{old}}}\right)^2 = \Delta P_{\text{old}} \times \left(\frac{\text{RPM}_{\text{new}}}{\text{RPM}_{\text{old}}}\right)^2$$

$$\text{BHP}_{\text{new}} = \text{BHP}_{\text{old}} \times \left(\frac{\text{GPM}_{\text{new}}}{\text{GPM}_{\text{old}}}\right)^3 = \text{BHP}_{\text{old}} \times \left(\frac{D_{\text{new}}}{D_{\text{old}}}\right)^3 = \text{BHP}_{\text{old}} \times \left(\frac{\text{RPM}_{\text{new}}}{\text{RPM}_{\text{old}}}\right)^3$$

General Gas Law

$pV = mRT$

Boyle's Law and Charles' Law

$T_1 p_2 = T_2 p_1$ (Charles' Law with constant volume)

$T_1 V_2 = T_2 V_1$ (Charles' Law with constant pressure)

$p_1 V_1 = p_2 V_2$ (Boyle's Law with constant temperature)

p=absolute pressure in pounds per square foot
V=volume in cubic feet
m=mass in pounds
R=gas constant of the particular gas (foot-pounds per pound per degree Rankine)
T=absolute temperature in degrees Rankine

Gas	*R*	Gas	*R*
Air	53.5	Hydrogen	765.9
Ammonia	90.5	Nitrogen	55.1
Carbon dioxide	35.1	Oxygen	48.3
Carbon monoxide	55.1	Sulfur dioxide	24.1

Notes: