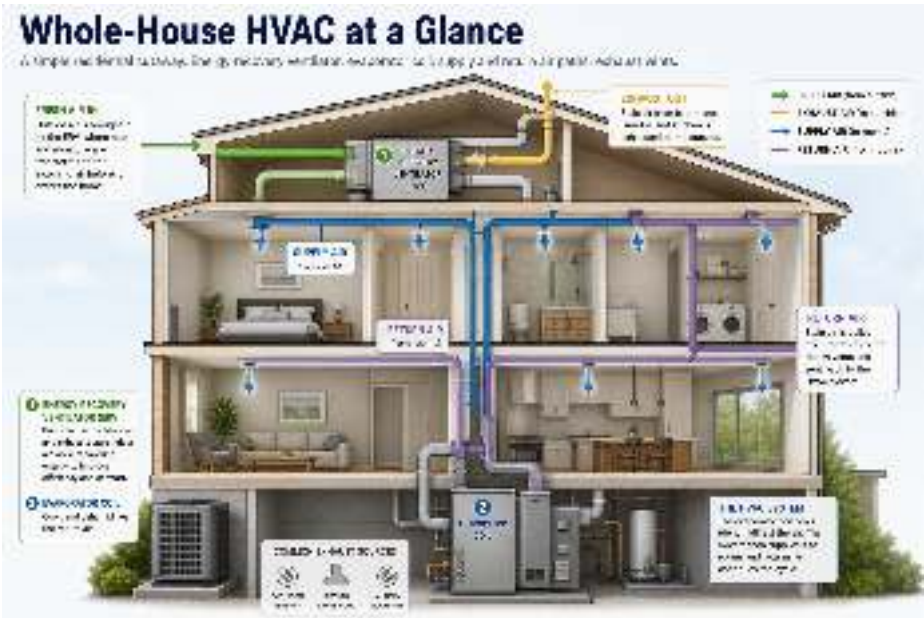


HVAC License Prep Guide

Your Complete Handbook for Passing the HVAC Trade Exam

By Grant Beckett



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Preface

This book was written for HVAC apprentices, technicians, and professionals preparing to earn their license. The HVAC trade is a critical part of the built environment, and licensing ensures both safety and professionalism. This guide combines technical knowledge, practice questions, and real-world examples to help you succeed.

About the Author

Grant Beckett is a licensed mechanical contractor, author, and trainer with 20+ years of field experience in HVAC design, installation, and inspection. Grant Beckett has trained hundreds of technicians through trade schools, apprenticeships, and continuing education courses.

Abbreviations and Acronyms

- HVAC – Heating, Ventilation, and Air Conditioning
- EPA – Environmental Protection Agency
- IMC – International Mechanical Code
- NFPA – National Fire Protection Association
- BTU – British Thermal Unit
- VFD – Variable Frequency Drive
- CFM – Cubic Feet per Minute
- LOTO – Lockout/Tagout

SEER2 – Seasonal Energy Efficiency Ratio 2 (updated DOE M1 test procedure)

AFUE – Annual Fuel Utilization Efficiency (gas furnace efficiency rating)

HSPF2 – Heating Seasonal Performance Factor 2 (heat pump heating efficiency)

NEC – National Electrical Code (NFPA 70)

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

ACCA – Air Conditioning Contractors of America

AHJ – Authority Having Jurisdiction

MCA – Minimum Circuit Ampacity

MOCP – Maximum Overcurrent Protection

GWP – Global Warming Potential

TXV – Thermostatic Expansion Valve

HFC – Hydrofluorocarbon (refrigerant class)

HCFC – Hydrochlorofluorocarbon (ozone-depleting refrigerant class)

ACH – Air Changes per Hour

ODP – Ozone Depletion Potential

Glossary

- Latent Heat – Heat energy absorbed or released during a change of state (e.g., liquid to vapor) without temperature change.
- Superheat – The number of degrees a refrigerant vapor exceeds its saturation (boiling) temperature at a given pressure. Formula: Suction Line Temp – Saturation Temp. Typical target: 8–15°F for fixed-orifice systems.
- Subcooling – The number of degrees a liquid refrigerant is cooled below its saturation (condensing) temperature at a given pressure. Formula: Saturation Temp – Liquid Line Temp. Typical target: 10–20°F.
- Split System – An HVAC system with separate indoor and outdoor units.
- Static Pressure – Resistance to airflow in a duct system.

Disclaimer

This book is intended for educational and informational purposes only. While every effort has been made to ensure accuracy and alignment with the code, this publication is not a substitute for any code or for professional judgment.

The author and publisher assume no liability for errors or omissions, nor for any loss, injury, or damage resulting from the use of information contained in this book. HVAC systems must always be designed, installed, and inspected in compliance with the most current edition of the Code, as well as local codes, utility requirements, and jurisdictional regulations.

Users of this book are responsible for verifying the applicability of all Code references and calculations for their specific projects and conditions. Always consult with a licensed professional, or authority having jurisdiction (AHJ) when in doubt.

This book is an independent educational resource and is not affiliated with, endorsed by, or sponsored by any organization or authority.

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Book Overview: Parts and Chapters

Part I – Exam Orientation and Success Strategies

This section helps you understand the licensing journey, exam structure, and how to prepare effectively.

1. **Understanding the HVAC Licensing Process**
Overview of apprentice, journeyman, and master licenses; licensing bodies; and why it matters.
2. **Exam Format and Content Areas**
Explains the number of questions, test format, topics covered, and open-book policies.
3. **Study Plan and Test-Taking Strategies**
Offers a step-by-step weekly plan, time management tips, and strategies for reducing test anxiety.
4. **Reference Materials and Open Book Use Tips**
Covers the best way to tab, mark, and use codebooks and standards efficiently during exams.

Part II – HVAC Theory and Fundamentals

Builds a strong foundation of technical knowledge critical to both the field and the exam.

5. **HVAC Fundamentals**
Introduces heat transfer, psychrometrics, and basic principles of air movement.
6. **HVAC System Components**
Reviews compressors, coils, expansion devices, air handlers, furnaces, and thermostats.

7. **Electrical Fundamentals for HVAC**

Covers Ohm's Law, circuit types, relays, fuses, capacitors, and electrical safety.

8. **Piping, Ductwork, and Sheet Metal Basics**

Discusses copper and PVC piping, duct sizing, fittings, and common installation practices.

Part III – Code Compliance and Safety

Focuses on major code areas commonly tested in HVAC exams, plus job site safety.

9. **Mechanical Code (IMC) Essentials**

Key mechanical code provisions for HVAC design and installation.

10. **Fuel Gas Code and Venting**

Covers combustion air, appliance clearances, flue sizing, and venting requirements.

11. **Refrigerant Handling and EPA 608 Rules**

Rules on refrigerant types, recovery, record-keeping, and technician certification.

12. **Safety Codes and Procedures (OSHA, NFPA, LOTO)**

Covers PPE, lockout/tagout, ladder safety, confined spaces, and hazard communication.

Part IV – HVAC Design and Calculations

Provides essential calculations and system design processes expected in licensing exams.

13. **Manual J Load Calculations**

Walks through the process of calculating heating and cooling loads for residential spaces.

14. Duct Sizing and Design (Manual D)

Explains friction rate, static pressure, duct layout, and equivalent length calculations.

15. Equipment Sizing and Selection

Guides you in matching equipment to building loads, including SEER and tonnage considerations.

16. Electrical Load and Wire Sizing

Includes conductor sizing, ampacity charts, breaker selection, and derating factors.

Part V – Troubleshooting and Real-World Scenarios

This section prepares you for hands-on field problems you may encounter or be tested on.

17. HVAC Troubleshooting Techniques

Logical steps to diagnose and solve issues with system operation or controls.

18. Common Residential HVAC Problems

Case-based review of airflow issues, thermostat problems, refrigerant leaks, and more.

19. Commercial HVAC Diagnostics

Focus on RTUs, VAV systems, economizers, and BMS faults.

20. Service Call Scenarios and Solutions

Walk-through of real service calls and how to identify and fix issues under time pressure.

Part VI – Practice Exams and Study Tools

Helps you test your readiness with practice questions and study aids.

21. **Full-Length Practice Exam #1 (Timed)**

Simulates a real test experience, with mixed-topic questions.

22. **Full-Length Practice Exam #2 (Timed)**

Another full test to solidify learning and improve confidence.

23. **Code Look-Up Practice and Open-Book Drills**

Exercises that build speed and accuracy when finding answers in your codebooks.

24. **Answer Keys and Rationales**

Detailed explanations for each practice question so you understand why the answer is correct.

25. **Flashcards and Reference Sheets**

Print-friendly pages with formulas, definitions, code tables, and quick-reference diagrams.

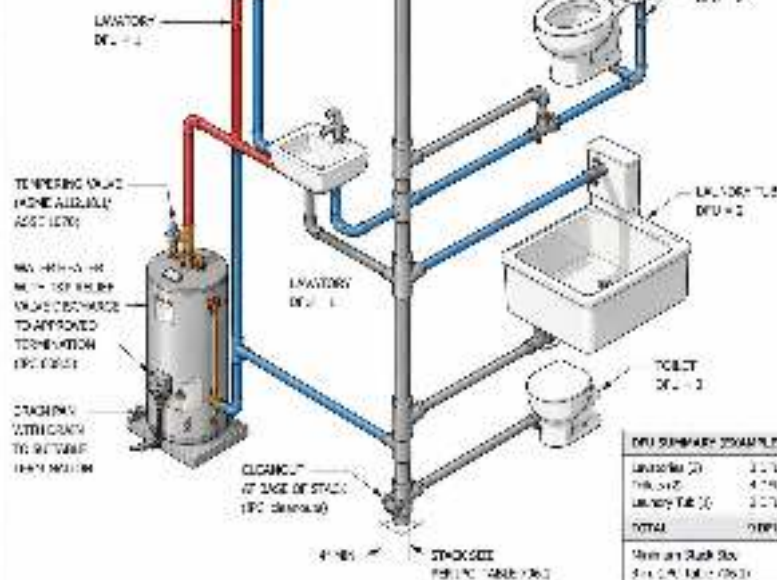
PLUMBING ISOMETRIC RISER

SUPPLY HOT/COLD AND SANITARY/VENT STACKS
WITH DFUs

- Hot Water (HW)
- Cold Water (CW)
- Sanitary/Vent (SWV)

PIPE MATERIAL TYPE	
Hot Water	Type L Copper (ASTM B88)
Cold Water	Schedule 40 PVC (ASTM D3025)
Sanitary/Vent	Schedule 40 PVC (ASTM D3025)

DFU = Drainage Fixture Unit
See IPC Table 903.1



GENERAL NOTES

1. Install all pipes in accordance with the International Plumbing Code (IPC) and the manufacturer's instructions.
2. Support all copper PEX piping and all other materials per manufacturer's instructions.
3. All pipe required cleanouts for fixtures and cleanouts for the system.
4. All cleanouts must be installed in accordance with the manufacturer's instructions.
5. Pressure test the system in accordance with IPC Section 903.10.
6. All materials must be approved for use in the jurisdiction.

CODE REFERENCES

- IPC 903.1
- IPC Chapter 9, Section 903.1 (Drainage and Venting)
- IPC Chapter 9, Section 903.1 (Drainage and Venting)
- IPC Chapter 9, Section 903.1 (Drainage and Venting)
- IPC Chapter 9, Section 903.1 (Drainage and Venting)
- IPC Chapter 9, Section 903.1 (Drainage and Venting)
- IPC Chapter 9, Section 903.1 (Drainage and Venting)
- IPC Chapter 9, Section 903.1 (Drainage and Venting)

Part I – Exam Orientation and Success Strategies

Chapter 1: Introduction to the HVAC Licensing Process

Overview

Licensing ensures that HVAC professionals are equipped with the knowledge and skill to perform their work safely and correctly. This chapter provides a roadmap to understanding the licensing process and exam format.

1.1 Why Licensing Matters

- Public and occupant safety
- Legal work authorization in many states
- Increased credibility and income potential

1.2 Types of HVAC Licenses

- **Apprentice** – Learning stage; usually requires supervision
- **Journeyman** – Can work independently under a master's license
- **Master** – Can own a business, pull permits, and supervise other techs

1.3 Common Exam Topics

- Electrical fundamentals
- Refrigeration cycle
- Duct design and airflow
- Combustion and venting
- EPA 608 regulations
- Mechanical and fuel gas codes

1.4 Exam Format

- Usually multiple choice
- Some are open book (with IMC or local codebook allowed)

- Time limits vary (2–4 hours typical)
- Passing scores: 70% or higher, depending on jurisdiction

1.5 Study Strategy

- Break study into sections by topic
- Practice with simulated timed exams
- Know your codebook's layout
- Focus on both understanding **and** memorization

Chapter 2: Exam Format and Content Areas

Understanding the structure and scope of your HVAC licensing exam is essential for targeted preparation. Most HVAC exams follow a standardized structure, though exact details may vary by state or certifying agency.

2.1 Types of HVAC Exams

- State HVAC Journeyman or Master Exams
- EPA Section 608 Certification Exam (Core + Type I, II, III or Universal)
- Local municipal or union certification tests

2.2 General Exam Structure

- Multiple-choice questions (typically 80 to 150 questions)
- Time limit ranges from 2 to 4 hours
- Most require a minimum score of 70% to pass

- Some allow open-book format with approved materials (e.g., IMC, IFGC)

2.3 Core Exam Content Areas

1. HVAC Fundamentals

- Heat transfer
- Psychrometrics
- Thermodynamics
- Airflow dynamics

2. System Components

- Refrigeration cycle
- Compressors, coils, TXVs, metering devices
- Furnaces, air handlers, thermostats

3. Electrical Knowledge

- Ohm's Law
- Series and parallel circuits
- Motor control and wiring diagrams
- Safety devices

4. Duct and Piping Systems

- Duct layout and sizing (Manual D)
- Static pressure and airflow balancing
- Refrigerant piping, condensate drains, gas lines

5. Code Compliance

- IMC: Ventilation, combustion air, appliance location

- IFGC: Fuel piping, appliance connectors, venting
- EPA 608 refrigerant regulations
- OSHA/NFPA 70E safety procedures

6. HVAC Design and Sizing

- Load calculations (Manual J)
- Equipment selection
- Wire sizing and breaker selection
- Energy efficiency standards (SEER, AFUE)

7. Troubleshooting and Service

- Diagnostic process
- Pressure-temperature relationships
- Common failure scenarios
- Service call documentation

2.4 EPA 608 Certification Focus Areas

- **Core:** Safety, refrigerant properties, ozone depletion
- **Type I:** Small appliances
- **Type II:** High-pressure systems
- **Type III:** Low-pressure systems
- **Universal:** Covers all three types

2.5 Open Book Exam Guidelines

- Commonly allowed books: IMC, IFGC, Uniform Mechanical Code (UMC)
- No notes or handwritten tabs (check state-specific rules)

- Use color-coded tabs and indexes (if permitted)
- Time management is key — practice looking up topics quickly

Exam Format and Content Areas

Exam Types

- State Licensing Exam (Journeyman / Master)
- EPA Section 608 Exam
- Local or union certification

Exam Structure

- 80-150 multiple-choice questions
- Time: 2 to 4 hours
- Passing score: 70% (varies by state)

Main Content Areas

1 HVAC Fundamentals

- Heat transfer
- Thermodynamics
- Psychrometrics
- Airflow principles

2 System Components

- Refrigeration cycle
- Compressors, coils
- Metering devices
- Furnaces • Blowers
- Thermostats

3 Electrical

- Ohm's Law
- Motors and relays
- Control wiring diagrams

6 Code Compliance

- IMC: Mechanical Code topics
- IFGC: Fuel gas piping & wiring
- EPA 608 regulations
- OSHA safety

2 Ductwork & Piping

- Duct sizing (Manual D)
- Static pressure
- Refrigerant and gas piping

4 Design & Sizing

- Load calculations (Manual J)
- Wire sizing & breakers
- Equipment selection

7 Troubleshooting & Field

- Common faults
- PT charts
- Diagnostic methods

Open Book Tips

- Know your codebook layout
- Tab major sections (if allowed)
- Practice timed look-ups
- Don't over-rely on book—memorize core content

Chapter 3: Study Plan and Test-Taking Strategies

Success on the HVAC licensing exam comes down to consistent preparation and smart test-taking techniques. This chapter offers a structured study plan and proven strategies to help you perform confidently on exam day.

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3.1 Create a Study Timeline

- Break your study into 4–8 weeks depending on your availability.
- Assign specific topics to each week.
- Include review days and practice exams in your schedule.
- Be realistic: aim for 1–2 hours per study session.

3.2 Weekly Study Structure Example

Week 1:

- HVAC fundamentals
- Thermodynamics
- Refrigeration cycle

Week 2:

- Electrical basics
- Control wiring diagrams
- Safety procedures

Week 3:

- Duct design (Manual D)
- Load calculations (Manual J)
- Equipment selection

Week 4:

- Code review (IMC, IFGC, EPA 608)
- Practice code look-up drills
- Review key formulas and definitions

Week 5:

- Full-length practice exam
- Review wrong answers
- Focused review on weak areas

3.3 Study Best Practices

- Study in a quiet, well-lit space.
- Use active recall: quiz yourself often.
- Practice using reference books under time limits.
- Track your progress in a study log.

CREATE A STUDY TIMELINE

- Break a study into 4-8 weeks depending on your availability.
- Assign specific topics to each week. Include review days and practice exams.
- Be realistic; aim for 1-2 hours per study per session.

WEEKLY STUDY STRUCTURE EXAMPLE

Week 1	HVAC Fundamentals	 MEMORIZATION TOOLS • Flashcards for key terms and code references • Diagrams and system charts • Printable cheat sheets for equations and wire sizes
Week 2	Thermodynamics	
Week 3	Refrigeration cycle	
Week 4	Load design (Manual J) Load calculations (Manual S) Equipment selection	
Week 5	Code review (IRC, TCC, EPA, ENE) Practice code look-up skills Review key formulas and definitions	

STUDY BEST PRACTICES

- Study in a quiet, well-lit space.
- Use active recall to your advantage.
- Practice using under time limits with reference books.
- Track your progress in a study log.

MEMORIZATION TOOLS

- Know codebook's layout
- Use colored coded markers if allowed
- Practice timed code look-ups regularly

TEST-TAKING STRATEGIES

3.4 Memorization Tools

- Flashcards for key terms and code references
- Diagrams and system charts
- Printable cheat sheets for equations and wire sizes

3.5 Test-Taking Strategies

1. Read the entire question carefully.

2. **Rule out wrong answers immediately.**
3. **Watch the clock.** Don't spend more than 1–2 minutes per question.
4. **Answer what you know first, mark the rest for review.**
5. **For open-book exams:**
 - Know your codebook's layout.
 - Use tabs and colored markers if allowed.
 - Practice timed code look-ups regularly.

Chapter 4: Reference Materials and Open Book Use Tips

Open-book exams can be misleading—they still require deep understanding and quick access to code information. This chapter helps you prepare to use references effectively during the test.

4.1 Commonly Allowed Reference Materials

- International Mechanical Code (IMC)
- International Fuel Gas Code (IFGC)
- Uniform Mechanical Code (UMC)
- EPA Section 608 study guide (for refrigerant certification)
- State-specific code amendments (if applicable)

Always verify with your licensing board what materials are allowed.

4.2 How to Prepare Your Codebooks

- Use only printed, official versions (no digital books unless specified)
- Highlight key sections such as:
 - Combustion air

- Venting
 - Duct installation
 - Equipment clearances
- Use pre-approved adhesive tabs (color-coded by topic)

4.3 Codebook Tab Suggestions

1. General Provisions
2. Definitions
3. Equipment Requirements
4. Duct Systems
5. Fuel Piping
6. Venting and Combustion Air
7. Inspections and Permits
8. Safety Standards
9. Appendix A or Manufacturer Guidelines

4.4 Fast Look-Up Practice

- Practice weekly with a timer (e.g., “Find vent clearance for gas appliance in under 90 seconds.”)
- Simulate open-book testing with questions requiring you to cite the section number.
- Create a reference chart with section numbers and topics for faster access.

4.5 Open-Book Exam Strategies

- Don't rely on the book for everything—memorize common rules.
- Use your index efficiently—know terms like “combustion,” “clearance,” and “support.”
- Avoid flipping randomly—train your eyes to scan for headings.
- Label major code sections with sticky notes if allowed.

4.6 Tools You May Bring (If Permitted)

- Calculator (non-programmable)
- Ruler or scale
- Pencil and scratch paper
- Tabbed codebook(s)

REFERENCE MATERIALS AND OPEN BOOK USE TIPS

Common Reference Materials (Confirm with Board)

- International Mechanical Code (IMC)
- International Fuel Gas Code (IFGC)
- Uniform Mechanical Code (UMC)

Prepare Your Codebooks

- Use printed copies only
- Highlight key sections (e.g., combustion air, venting)
- Apply pre-approved adhesive tabs

Codebook Tab Suggestions

- 1 General Provisions
- 2 Definitions
- 3 Equipment Requirements
- 4 Duct Systems
- 5 Fuel Piping
- 6 Venting and Combustion Air
- 7 Inspections and Permits
- 8 Safety Standards
- 9 Appendix A or Manufacturer Guidelines

Fast Look-Up Practice

- Use a timer (e.g., "find clearance in 90 sec.")
- Simulate open book exam questions
- Make a code section reference chart

Tools You May Bring (If Approved)



Calculator



Ruler



Pencil and
Paper



Tabbed Codebook

Tools You May Bring (If Approved)

Part II – HVAC Theory and Fundamentals

This part builds the essential technical foundation you'll need to pass the exam and succeed on the job. It focuses on HVAC principles, components, electrical systems, and mechanical basics.

Chapter 5: HVAC Fundamentals

Understanding the core principles of heating, ventilation, and air conditioning is critical for troubleshooting, design, and installation. This chapter covers the science that drives system behavior and performance.

5.1 Principles of Heat Transfer

- **Conduction:** Heat movement through solid materials (e.g., metal ducts).
- **Convection:** Heat transfer through liquids or gases (e.g., air blowing over a coil).
- **Radiation:** Heat transfer through electromagnetic waves (e.g., heat from the sun).

5.2 The Refrigeration Cycle

1. **Evaporation** (Low pressure): Refrigerant absorbs heat inside the evaporator coil.
2. **Compression** (Rising pressure): Compressor increases pressure and temperature.
3. **Condensation** (High pressure): Heat is released in the condenser coil.
4. **Expansion** (Pressure drop): Expansion valve cools refrigerant before repeating the cycle.

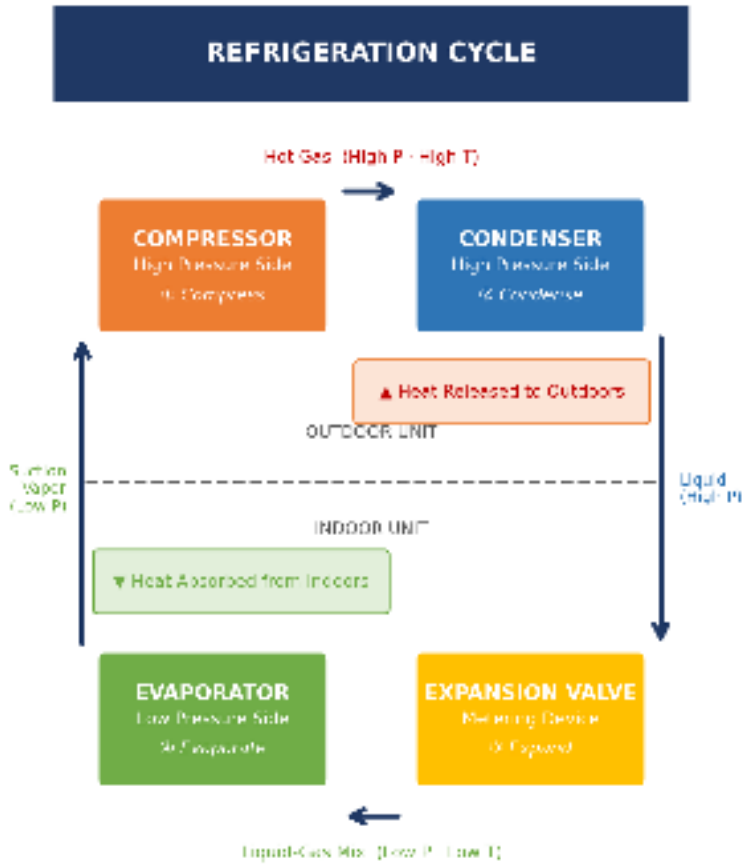


Figure 5-2: Standard Vapor-Compression Refrigeration Cycle

Figure 5-1: Refrigeration Cycle Schematic

5.3 Sensible vs. Latent Heat

- **Sensible Heat:** Changes temperature, measurable by a thermometer.

- **Latent Heat:** Changes the state (e.g., liquid to vapor) without temperature change.

5.4 Psychrometrics and Air Properties

- **Dry Bulb Temperature:** Regular air temperature (°F or °C).
- **Wet Bulb Temperature:** Measures humidity influence.
- **Relative Humidity:** Amount of moisture in the air as a percentage of maximum capacity.
- **Dew Point:** Temperature at which air becomes saturated and condensation begins.

5.5 Airflow and Pressure Concepts

- **CFM (Cubic Feet per Minute):** Volume of air movement.
- **Static Pressure:** Resistance to airflow in ducts.
- **Velocity Pressure:** Related to the speed of moving air.
- **Total Pressure** = Static + Velocity

5.6 Heat Load Concepts

- **BTU (British Thermal Unit):** Amount of energy needed to raise 1 lb of water by 1°F.
- **Load Calculation:** Total BTUs required to heat/cool a space.
- **Factors:** Insulation, occupancy, sun exposure, infiltration.

HVAC FUNDAMENTALS

PRINCIPLES OF HEAT TRANSFER

Conduction

Heat movement through solid materials



Convection

Heat transfer through electromagnetic waves



Latent Heat

Changes state (e.g.) liquid to vapor without temperature change

THE REFRIGERATION CYCLE

1. Evaporation

Absorbs heat inside evaporator coil

COMPRESSION

Increases pressure and temperature

EVAPORATION

4. Expansion

Refrigerant cools before re-entering heat cycle

4. Expansion

Cools refrigerant before re-entering cycle

HIGH PRESSURE

AIRFLOW AND PRESSURE CONCEPTS

CFM

Volume of air movement

Tapt Lock-up
Pressure

Static Pressure

Resistance to air flow in ducts

Velocity
Pressure

Total
Pressure

Psychrometrics and Air Properties

Dry Bulb Temperature

Regular air temperature (F°/C°)



Wet Bulb Temperature

Measuring humidity influence



Relative Humidity

Amount of moisture in the air as a percentage of maximum



Dew Point

Temperature at which air becomes saturated and condensation begins



HEAT LOAD CONCEPTS

BTU (British Thermal Unit)

Amount of air water (e.g.) 1 lb (4.186 - 1)



Chapter 6: HVAC System Components

Understanding the key components in heating and cooling systems is critical for both diagnostics and licensing exams. This chapter provides an overview of core equipment and their functions.

6.1 Main HVAC System Types

- **Split System:** Outdoor condenser + indoor evaporator (most common residential system).
- **Packaged Unit:** All components in one outdoor unit (common in rooftops).
- **Ductless Mini-Split:** No ductwork, uses one or more indoor heads with a single outdoor unit.
- **Heat Pump:** Provides heating and cooling by reversing refrigerant flow via a four-way reversing valve. In heating mode, the outdoor coil acts as the evaporator and the indoor coil acts as the condenser. Includes a defrost cycle and auxiliary/emergency heat for cold weather operation.

6.2 Core Components

1. **Compressor**
 - The heart of the system.
 - Increases refrigerant pressure and moves it through the cycle.
2. **Condenser Coil**
 - Located outdoors.
 - Releases heat to the environment as refrigerant condenses.
3. **Evaporator Coil**
 - Located inside the air handler or furnace.
 - Absorbs heat from indoor air as refrigerant evaporates.
4. **Expansion Valve or Capillary Tube**

- Drops pressure and temperature of refrigerant before it enters evaporator.

6.3 Air Movement Components

- **Blower Fan (Indoor)**
 - Circulates air through return and supply ducts.
- **Outdoor Fan**
 - Moves air across the condenser coil.
- **Duct System**
 - Delivers conditioned air to rooms and returns air to the system.

6.4 Control Components

- **Thermostat**
 - User interface to set desired temperature.
 - Sends control signals to system.
- **Contactor**
 - Electrical switch that controls compressor/fan power.
- **Capacitors**
 - Provide startup and running power to motors.

6.5 Safety and Accessory Devices

- **Filters** – Trap dust and particles.
- **Drain Pan / Condensate Pump** – Collect or move away water from evaporator.

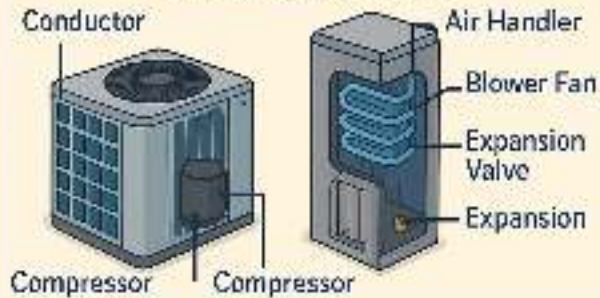
- **Pressure Switches / Limit Switches** – Prevent system damage or unsafe operation.

HVAC SYSTEM COMPONENTS

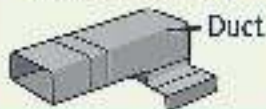
MAIN HVAC SYSTEM TYPES

- Split System
- Packaged Unit
- Ductless Mini-Split
- Air Handler
- Evaporator Coil

CORE COMPONENTS



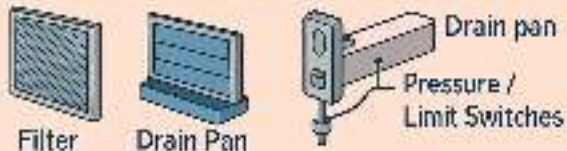
AIR MOVEMENT COMPONENTS



CONTROL COMPONENTS



SAFETY AND ACCESSORY DEVICES



Chapter 7: Electrical Fundamentals for HVAC

A solid understanding of basic electrical theory is essential for any HVAC technician. Most equipment issues involve electrical components, and licensing exams often include detailed electrical questions.

7.1 Basic Electrical Terms

- **Voltage (V):** The pressure that pushes electrical current.
- **Current (Amps):** The flow of electrons through a wire.
- **Resistance (Ohms):** Opposition to current flow.
- **Wattage (Watts):** The rate of energy usage ($\text{Watts} = \text{Volts} \times \text{Amps}$).

7.2 Ohm's Law

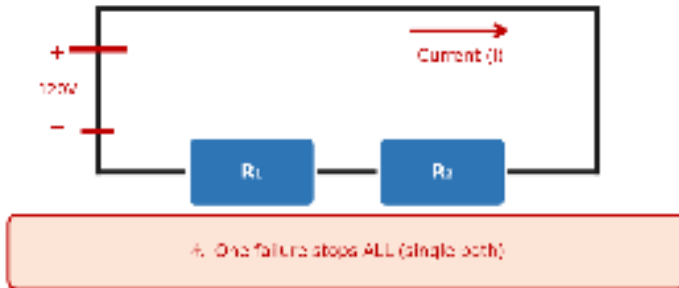
- **Formula:** $V = I \times R$
(Voltage = Current $\times$ Resistance)
- **Used to calculate safe operating values and troubleshoot faults.**

7.3 Series vs. Parallel Circuits

- **Series Circuit:** One path for current; if one component fails, all stop.
- **Parallel Circuit:** Multiple paths; one component failure doesn't stop others.
- **Most HVAC controls use parallel wiring.**

SERIES vs. PARALLEL CIRCUITS

SERIES CIRCUIT



PARALLEL CIRCUIT

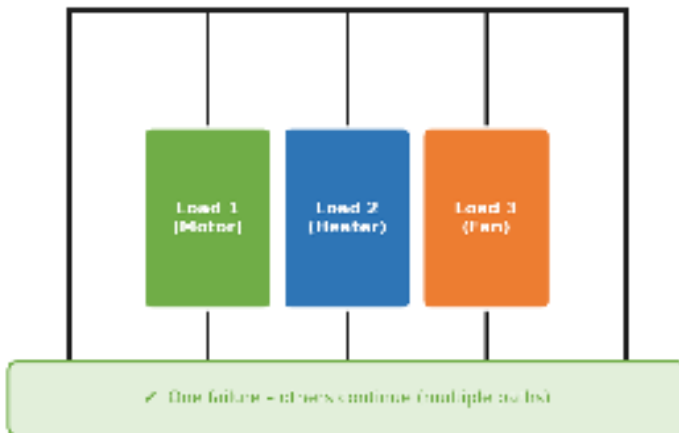


Figure 7-1: Series vs. Parallel Circuits – HVAC Application

Figure 7-1: Series vs. Parallel Circuits – HVAC Application

7.4 Common Electrical Components

- **Capacitor:** Starts or maintains motor rotation.

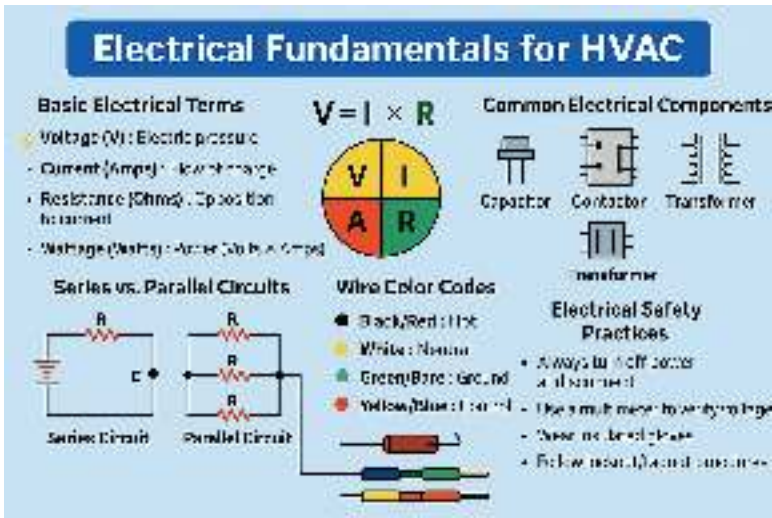
- **Contactor:** Electrically operated switch for compressor or fan.
- **Relay:** Electrically controlled switch.
- **Transformer:** Steps voltage down (e.g., from 240V to 24V for control circuits).

7.5 Wire Color Codes (U.S. Standards)

- **Black/Red:** Hot (line voltage)
- **White:** Neutral
- **Green/Bare:** Ground
- **Yellow/Blue:** Often used in control wiring (e.g., Y = cooling, G = fan)

7.6 Electrical Safety Practices

- Always turn off power at the disconnect.
- Use a multimeter to verify voltage is absent.
- Wear insulated gloves when testing live circuits.
- Follow lockout/tagout procedures.



Chapter 8: Piping, Ductwork, and Sheet Metal Basics

Proper piping and ductwork are essential for efficient system performance. This chapter introduces the materials, installation practices, and layout principles used for refrigerant piping and air distribution systems.

8.1 HVAC Piping Types and Uses

- **Copper Tubing (Type L, Type M):** Common for refrigerant lines.
- **PVC/CPVC:** Used in condensate drainage.
- **Black Iron / Steel Pipe:** For natural gas and propane systems.
- **PEX or Flexible Lines:** For hydronic heating systems.

8.2 Refrigerant Piping

- **Suction Line (larger, insulated):** Carries low-pressure vapor to the compressor.

- **Liquid Line (smaller):** Carries high-pressure liquid refrigerant to expansion device.
- **Line Set:** Both lines together, often pre-packaged.
- **Proper Slope:** Ensures oil return to compressor.
- **Brazing vs. Flare Fittings:** Brazing is preferred for leak-free joints.

8.3 Condensate Drainage

- **Primary Drain Pan:** Under evaporator coil.
- **Secondary Pan (Auxiliary):** Required in attics or above living space.
- **Traps and Vents:** Prevent siphoning and allow proper drainage.
- **Condensate Pump:** Used when gravity drainage isn't possible.

8.4 Ductwork Types

- **Sheet Metal (Galvanized):** Durable, low resistance.
- **Flex Duct:** Easier to install, but higher resistance.
- **Fiberglass Duct Board:** Quiet and insulated.

8.5 Duct Design Concepts

- **Supply vs. Return Air:** Supply pushes conditioned air; return pulls it back.
- **Plenum:** Main supply/return air distribution chamber.
- **Registers and Grilles:** End-point delivery and air return points.
- **Static Pressure:** Key factor in duct sizing and efficiency.

- **Balancing Dampers:** Help adjust airflow to different rooms.

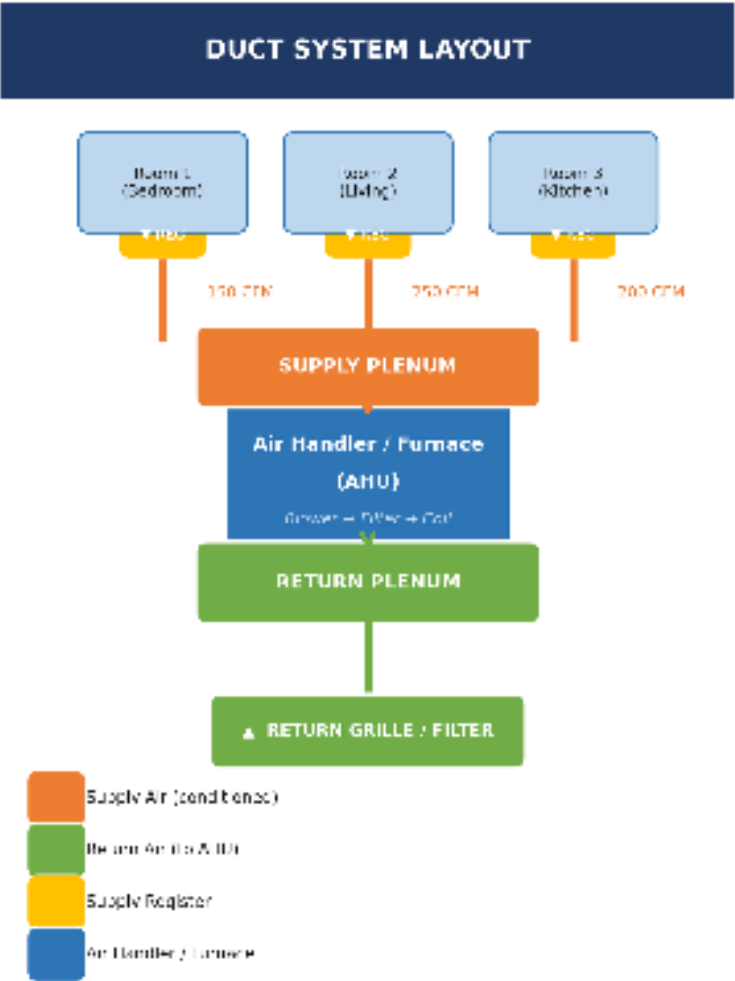


Figure 8-1: Residential Duct System – Supply & Return Layout

Figure 8-1: Residential Duct System – Supply and Return Layout

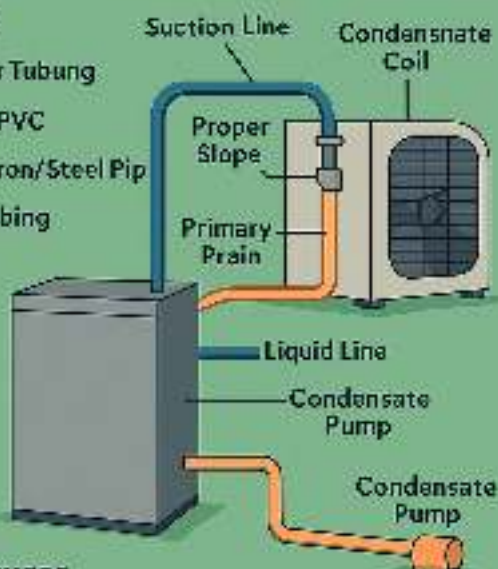
PIPING, DUCTWORK, AND SHEET METAL BASICS

HVAC PIPING

-  Copper Tubing
-  PVC/CPVC
-  Black Iron/Steel Pipe
-  PEX Tubing

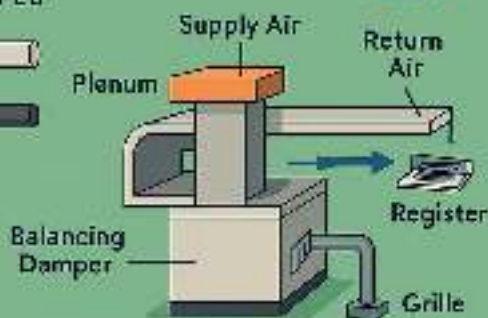
Type Types

- Sheet Metal
- Flex Duct
- Fiberglass
- Duct Board



DUCTWORK TYPES

-  Flex Duct
-  Fiberglass Duct



Part III – Code Compliance and Safety

Chapter 9: Mechanical Code (IMC) Essentials

The International Mechanical Code (IMC) sets standards for the safe design and installation of HVAC systems. This chapter introduces the most relevant code sections and principles you'll need to understand for both your exam and the field.

9.1 What Is the IMC?

- Published by the International Code Council (ICC)
- Widely adopted across U.S. states and local jurisdictions
- Ensures safety, health, and comfort through regulated HVAC installation

9.2 Scope of the IMC

- Applies to heating, cooling, ventilation, exhaust, duct systems, combustion air, and mechanical equipment
- Excludes refrigeration-specific systems (covered under IRC or other codes)

9.3 Key Code Sections

1. **Chapter 3 – General Regulations**
 - Clearances around appliances
 - Mechanical room access and lighting

- Labeling and anchoring of equipment

2. **Chapter 4 – Ventilation**

- Outdoor air requirements per occupancy
- Exhaust systems for kitchens, bathrooms, garages
- Makeup air provisions

3. **Chapter 5 – Exhaust Systems**

- Grease ducts and hoods
- Clothes dryer exhausts
- Hazardous exhaust systems (labs, chemical storage)

4. **Chapter 6 – Duct Systems**

- Duct materials and installation
- Fire/smoke damper requirements
- Insulation, sealing, and support

5. **Chapter 7 – Combustion Air**

- Air supply for fuel-burning appliances
- Indoor vs. outdoor combustion air
- Sizing methods (using tables)

6. **Chapter 9 – Specific Appliances**

- Fireplaces, boilers, furnaces
- Evaporative coolers and infrared heaters

9.4 Installation Requirements

- Support and bracing of equipment (roof and ceiling-mounted)
- Condensate disposal and secondary drains
- Clearances to combustibles
- Vibration isolation where required

9.5 Code Inspection Tips

- Verify equipment data plates match plans
- Check for proper duct sealing and insulation
- Confirm makeup air is provided for exhaust systems
- Ensure mechanical fasteners are used properly

? Mechanical Code (IMC) Essentials

What is the IMC?

- Published by the International Code Council (ICC)
- Widely adopted across U.S. states & local jurisdictions
- Ensures safety, health, and comfort through required HVAC installation

Key Code Sections

- Chapter 3 – General Regulations, Clearances
 - Access, Alarms
- Chapter 4 – Ventilation
 - Outdoor Air, Exhaust
- Chapter 5 – Exhaust Systems & Exhaust Ducts
 - Fans
- Chapter 6 – Duct Systems, Materials, Joints, Supports
 - Fire
- Chapter 7 – Combustion Air, Air Supply, Sealing
 - Fire
- Chapter 9 – Specific Appliances, Appliances, Furnaces, Boilers
 - Fire

Installation Requirements

- Support and bracing of equipment
- Condensate disposal
- Clearances to combustibles
- Vibration isolation where required

Scope

- Applies to heating, cooling, ventilation, exhaust duct systems

Includes refrigerant-specific

Code Inspection Tips

- Verify equipment data plates match plans
- Check for proper duct sealing and insulation
- Confirm makeup air provided for exhaust systems

Chapter 10: Fuel Gas Code and Venting

Safe installation of gas-fired appliances depends on proper fuel gas piping and venting. This chapter summarizes key requirements from the **International Fuel Gas Code (IFGC)** and best practices for combustion safety.

10.1 What Is the IFGC?

- Published by the International Code Council (ICC)
- Focuses on fuel gas systems: natural gas, propane, and related appliances
- Addresses piping, combustion air, venting, and appliance clearances

10.2 Common Gas Piping Materials

- **Black Steel Pipe:** Most common for rigid installations
- **Corrugated Stainless Steel Tubing (CSST):** Flexible and easy to route; requires equipotential bonding per IFGC Section 310.1.1 and manufacturer instructions to protect against lightning-induced arc damage
- **Copper (where allowed):** Limited use, often prohibited in some jurisdictions
- **Polyethylene (PE):** For underground exterior piping only

10.3 Sizing Gas Piping

- Use **IFGC Chapter 6 tables**
- Based on:
 - Total BTU demand
 - Length of pipe run

- Pressure drop limits
- Number of appliances on branch

10.4 Combustion Air Requirements

- **Two Opening Method:** One opening within 12" of ceiling and one within 12" of floor; each sized at minimum 1 sq in per 1,000 BTU/hr of total appliance input (confined spaces)
- **Indoor vs. Outdoor Air:** Varies by room volume and air infiltration
- **Direct Vent Appliances:** Pull air from outside, often exempt from room volume rules

10.5 Venting Categories

1. **Category I:** Negative pressure, low-temp flue gas (e.g., 80% furnaces)
2. **Category II:** Negative pressure, corrosive condensate (rare)
3. **Category III:** Positive pressure, non-condensing
4. **Category IV:** Positive pressure, condensing (e.g., 90%+ furnaces)

GAS APPLIANCE VENTING CATEGORIES				
CAT	PRESSURE	CONDENSATE	VENT TYPE	EXAMPLE
I	Negative	No	Type B Gas Vent (ALU20-40)	Non-Condensing Furnace
II	Negative	Yes	Type B Vent (Listed)	Condensing Furnace
III	Positive	No	Manifold Mount or B/W Vent	Pressure-Positive W/ Heater
IV	Positive	Yes	PWC / CPWC Manifold Mount	90%+ AFUE Furnace
KEY INSTALLATION NOTES				
• Cat. I: Most common – Type B double wall metal vent • Cat. II: Use ALU 40 PWC or CPWC (condensate neutral) • Never mix vent categories in the same flue • Horizontal runs slope 1/2"ft toward appliances (Cat. I & II) • Termination: ≥12' above roofline (Type B) – verify with AHJ				

Figure 10-1: Gas Appliance Venting Categories (IFGC / NFPA 54)

Figure 10-1: Gas Appliance Venting Categories (IFGC / NFPA 54)

10.6 Venting Materials

- **Type B Vent:** For gas appliances (non-condensing)

- **PVC/CPVC:** For condensing appliances only
- **Stainless Steel:** Used in positive-pressure or corrosive flue gas applications

10.7 Key Safety Rules

- Maintain **clearances to combustibles**
- Ensure **proper slope** for vent pipes (minimum 1/4" per foot for horizontal runs, sloping back toward the appliance for Category I and II)
- Use **approved termination caps** and spacing
- Never mix vent types in the same system unless listed to do so

Fuel Gas Code and Venting

What is the IFGC?

- International Fuel Gas Code
- Focuses on fuel gas systems
- Piping, combustion air, venting appliances

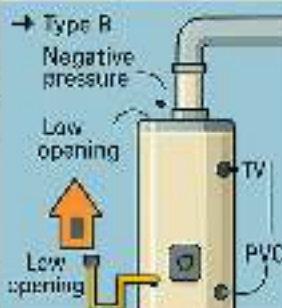
Common Gas Piping Materials



Combustion Air Requirements

- Two opening method
- Indoor vs. outdoor air
- Direct vent appliances

Venting Categories



Sizing Gas Piping

- Total BTU demand
- Length of pipe run
- Pressure drop limits
- Number of appliances



- Total of derouge
- Length, pipe run

Key Safety Rules

- Clearances to combustibles
- Proper slope of vent pipes
- Approved termination
- Do not mix vent types



The U.S. Environmental Protection Agency (EPA) regulates how HVAC technicians handle refrigerants to protect the ozone layer and reduce environmental harm. This chapter focuses on **EPA Section 608 certification** and proper refrigerant management.

11.1 What Is EPA Section 608?

- Mandated by the **Clean Air Act**
- Requires certification for anyone handling **refrigerants** — originally ozone-depleting substances (CFCs, HCFCs), and expanded via the 2023 AIM Act to cover HFCs due to their high global warming potential (GWP)
- Divided into **four types** of certification depending on the systems you work on

11.2 Types of Certification

1. **Type I:** Small appliances (5 lbs. or less of refrigerant)
2. **Type II:** High-pressure systems (split systems, rooftop units)
3. **Type III:** Low-pressure systems (centrifugal and chiller systems)
4. **Universal:** Covers all three types

11.3 Core Exam Topics (All Types)

- Refrigerant properties and safety
- Ozone depletion and global warming
- Recovery and recycling procedures
- Leak detection and repair rules
- Recordkeeping requirements

- Prohibited practices (venting refrigerants)

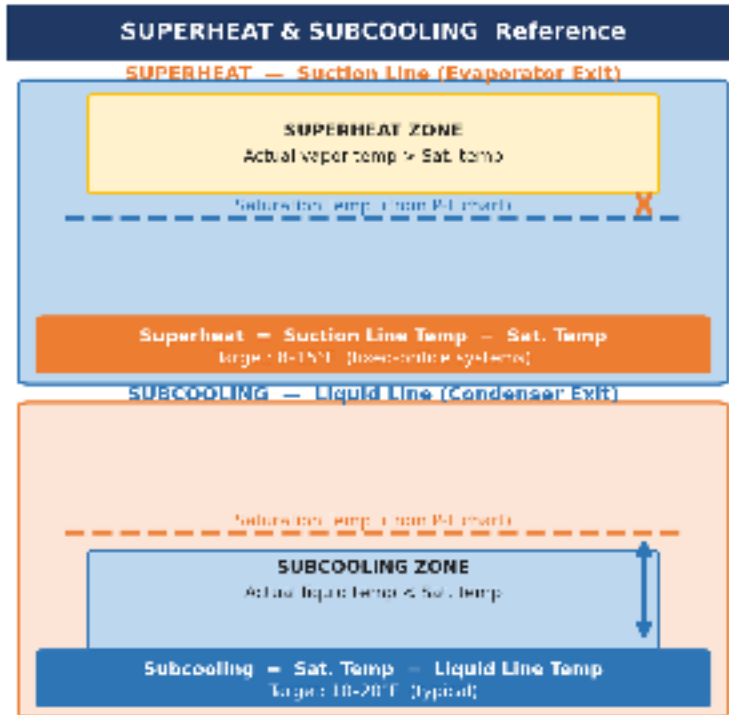


Figure 11-2: Superheat and Subcooling Measurement Reference

11.3A R-410A Phase-Down and A2L Refrigerant Transition (2025 Update)

The American Innovation and Manufacturing (AIM) Act, signed December 2020, directs the EPA to implement an 85% phasedown of HFC production and consumption by 2036. This directly affects refrigerant availability, and which refrigerants are used in new equipment.

January 1, 2025 — AIM Act Milestone: R-410A production allowances were reduced by approximately 40%. New HVAC equipment for residential and light commercial applications is now manufactured with lower-GWP refrigerant alternatives. Technicians must be prepared to work with A2L (mildly flammable) refrigerants in the field.

R-410A Replacement Refrigerants:

R-454B (Opteon XL41 / Puron Advance) — GWP: 466 | Classification: A2L | The leading replacement for R-410A in U.S. residential and light commercial systems. Requires A2L-rated recovery equipment, manifold gauges, hoses, and leak detectors.

R-32 — GWP: 675 | Classification: A2L | Widely adopted globally in mini-split and multi-split systems. Higher flammability than R-454B; requires dedicated tools and ventilation protocols.

R-466A — GWP: 733 | Classification: A1 (Non-flammable) | Designed as a non-flammable alternative to R-410A. Limited U.S. market adoption as of 2025.

A2L Safety Requirements: A2L refrigerants (ASHRAE Class A2L — mildly flammable, LFL $>3.5\%$ v/v, burning velocity ≤ 10 cm/s) require: A2L-rated recovery equipment; elimination of ignition sources during service; proper ventilation; and use of A2L-compatible manifold sets, hoses, and leak detection. Consult ASHRAE Standard 15 (Safety Standard for Refrigeration Systems) and ASHRAE Standard 34 (Refrigerant Designation and Safety Classification) for complete guidance. Always verify local AHJ requirements before servicing A2L systems.

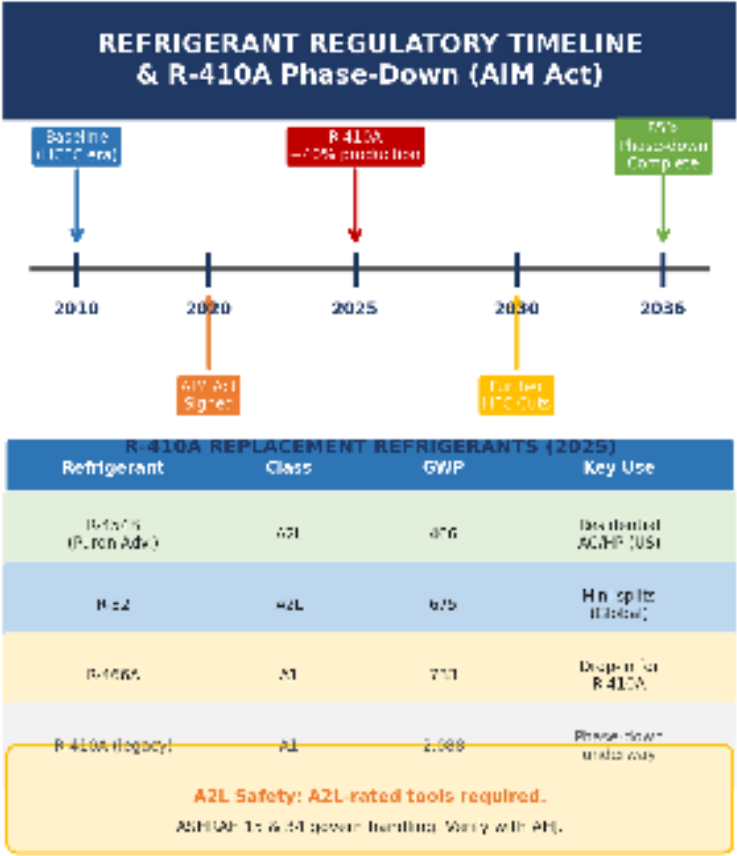


Figure 11-1: HFC Phase-Down Timeline & R-410A Replacements

Figure 11-1: HFC Phase-Down Timeline and R-410A Replacements

11.4 Refrigerant Recovery Rules

- Must use **EPA-certified recovery equipment**
- Recovery levels vary by system type and refrigerant

- Appliances >50 lbs. must be repaired if leak rate exceeds:
 - **Commercial refrigeration:** 20%
 - **Comfort cooling:** 10% (ODS refrigerants, e.g., R-22) / 20% (HFC refrigerants, e.g., R-410A, per 2023 AIM Act expansion)
 - **Industrial process refrigeration:** 30%

11.5 Safe Handling Procedures

- Always wear **gloves and goggles**
- Use a **recovery machine** before opening any sealed system (ASHRAE Standard 15 also governs refrigerant safety in machinery rooms)
- Weigh and label recovered refrigerant properly
- Never mix refrigerants

11.6 Recordkeeping Requirements

- Maintain logs of:
 - Date and amount of refrigerant recovered or added
 - Type of equipment and refrigerant used
 - Disposal method (if applicable)

Refrigerant Handling and EPA 608 Rules

What Is EPA Section 608?

- Mandated by the Clean Air Act
- Requires certification for ozone-depleting refrigerants (CFCs, HCFCs, R22, R123, R113, R114)

Core Exam Topics (All Types)

- Refrigerant properties and safety
- Ozone depletion and global warming
- Recovery and recycling procedures
- Leak detection and repair rules
- Recordkeeping requirements
- Prohibited practices (venting refrigerants)

Safe Handling Procedures

- Always wear gloves and goggles
- Use a recovery machine before opening any sealed system
- Weigh and label recovered refrigerant properly

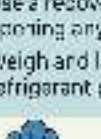
Types of Certification

Type I Small appliances	Type II High-pressure systems
Type III Low-pressure systems	Universal Cover all three types

Refrigerant Recovery Rules

- Use EPA-certified recovery equipment
- Recovery levels vary by system type and refrigerant
- Appliances >50 lbs: 20%
- Comfort cooling: 10%
- Industrial process refrigeration: 30%





Wear Gloves



Recordkeeping Requirements

- Date and amount of refrigerant recovered or added



Chapter 12: Safety Codes and Procedures (OSHA, NFPA, LOTO)

HVAC technicians work with electricity, pressurized systems, ladders, and confined spaces. This chapter reviews the most critical **safety regulations**

and procedures based on standards from OSHA, NFPA 70E, and industry best practices.

12.1 OSHA Overview

- **OSHA** = Occupational Safety and Health Administration
- Sets federal safety standards for all trades
- Requires:
 - Proper PPE (personal protective equipment)
 - Hazard communication (HAZCOM)
 - Fall protection over 6 feet
 - Confined space entry protocol

12.2 Lockout/Tagout (LOTO)

- Prevents accidental energizing of equipment during service
- Must:
 1. **Turn off power**
 2. **Lock the disconnect** with a padlock
 3. **Tag** with your name, company, and date
 4. **Test for voltage** before beginning work
- Required for all electrical work involving energized systems



Figure 12-1: LOTO Seven-Step Procedure (OSHA 29 CFR 1910.147)

Figure 12-1: LOTO Seven-Step Procedure (OSHA 29 CFR 1910.147)

12.3 NFPA 70E – Electrical Safety

- Standard for arc flash and electrical hazard protection

- Requires:
 - Proper voltage-rated gloves and tools
 - Flame-resistant (FR) clothing
 - Limited approach boundaries (shock/arc flash protection zones)
 - Safety signs and warnings

12.4 Personal Protective Equipment (PPE)

- **Gloves:** Insulated for electrical, cut-resistant for metalwork
- **Safety Glasses / Face Shield:** For brazing, grinding, or cutting
- **Hard Hat:** Required at commercial job sites
- **Respirator:** If exposed to refrigerant vapors or dust

12.5 Ladder and Lifting Safety

- Use **3-point contact** on ladders
- Only use **rated ladders** (Type I or higher)
- Lift with legs, not back — ask for help with heavy units
- Secure tools when working overhead

12.6 Confined Spaces and Hazard Communication

- Confined space: A space with limited entry/exit, not designed for continuous occupancy
- Must follow entry permit process if required
- Know the **SDS (Safety Data Sheet)** for chemicals and refrigerants

SAFETY CODES AND PROCEDURES

OSHA Overview

- OSHA - Occupational Safety and Health Administration



Lockout/Tagout (LOTO)

- Turn off power
- Lock the disconnect
- Tag with your info
- Test for voltage



NEPA 70E - Electrical Safety

- Proper voltage rated gloves and tools
- Flame-resistant (FR) clothing
- Limited approach boundaries
- Safety signs and warning



Personal Protective Equipment (PPE)

- Insulated cut gloves
- Safety Face Shield
- Hard hat



Respirator

Prismatic

Ladder and Lifting Safety

- use 3-point contact on ladders
- Only use rated ladders
- Lift with legs, not back



Confined Spaces and Hazard Communication

- Confined space permit process
- Know the SDS for chemicals/refrigerants



Part IV – HVAC Design and Calculations

This part focuses on the principles and practices of sizing, selecting, and designing HVAC systems. These topics are heavily tested on licensing exams and are essential for real-world system performance.

Chapter 13: Manual J Load Calculations

Manual J is the industry standard for determining heating and cooling loads in residential buildings. Accurate load calculation ensures systems are neither oversized (wasteful) nor undersized (underperforming).

13.1 What Is Manual J?

- Developed by **ACCA** (Air Conditioning Contractors of America)
- Used to calculate **heat loss** in winter and **heat gain** in summer
- Factors in building materials, location, insulation, occupancy, and more

13.2 Why Load Calculations Matter

- Avoids oversizing equipment
- Improves comfort and efficiency
- Ensures ductwork and airflow are properly matched
- Required by code in many jurisdictions

13.3 Inputs Required for Manual J

- **Climate zone**
- **Square footage and ceiling height**
- **Insulation values (R-values)**

- **Window type, area, orientation**
- **Air infiltration and ventilation rate**
- **Occupancy and internal loads (appliances, lighting)**

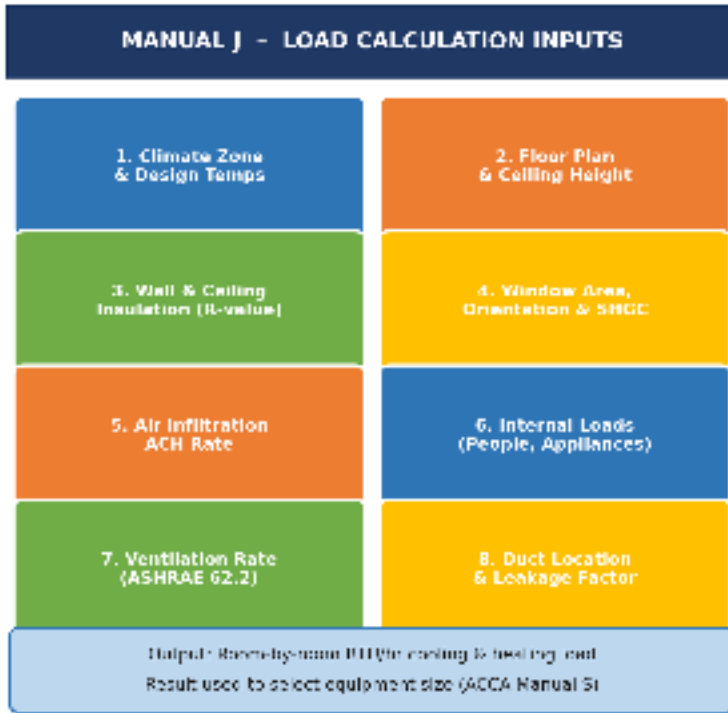


Figure 13-1: Manual J – Eight Key Load Calculation Inputs

Figure 13-1: Manual J – Eight Key Load Calculation Inputs

13.4 Steps in Performing Manual J

1. **Gather building envelope data**
2. **Calculate heat loss and heat gain for each room**
3. **Add internal loads (people, appliances)**
4. **Adjust for ventilation or duct losses**
5. **Total the room-by-room loads into system capacity needs (BTU/h)**

13.5 Typical Load Ranges

- **Cooling Load:** ~15–25 BTU/hr per sq. ft. (varies by climate)
- **Heating Load:** ~25–40 BTU/hr per sq. ft.

13.6 Using Software vs. Manual Worksheets

- Manual J software (e.g., Wrightsoft, Cool Calc) streamlines the process
- Paper worksheets are still used for learning and field exams



Manual J Load Calculation – Practice Exercise

This exercise helps reinforce the process by walking through a simplified version of what you may encounter on an exam or in the field.

Scenario

You are tasked with performing a **cooling load calculation** for a **single-room home office** located in **Dallas, TX** (Hot-Humid Climate Zone 2).

Room Details

- **Room Size:** 15 ft × 20 ft
- **Ceiling Height:** 8 ft
- **Windows:** 2 double-pane windows, each 4 ft × 5 ft, facing west
- **Insulation:**
 - Walls: R-13
 - Ceiling: R-30
- **Construction Type:** Wood-framed
- **Occupancy:** 1 person regularly uses the room
- **Appliances:** Desktop computer and printer
- **Air Infiltration:** Moderate (older window seals)
- **Ventilation:** 50 CFM of fresh air (per ASHRAE 62.2 residential ventilation standard)

Step-by-Step Instructions

Step 1: Calculate Room Volume

Volume = $15 \times 20 \times 8 = 2,400$ cu ft

Step 2: Estimate Cooling Load from Envelope

1. **Walls:**
Approx. 2 exterior walls $(15 \text{ ft} + 20 \text{ ft}) \times 8 \text{ ft} = 280$ sq ft
Use 6 BTU/hr per sq ft (Dallas, wood frame, R-13)

Wall Load = $280 \times 6 = 1,680$ BTU/hr

2. **Ceiling:**

$$15 \times 20 = 300 \text{ sq ft} \times 4 \text{ BTU/hr (R-30)}$$

$$\text{Ceiling Load} = 300 \times 4 = 1,200 \text{ BTU/hr}$$

3. **Windows:**

$$2 \text{ windows} \times (4 \times 5) = 40 \text{ sq ft}$$

$$\text{West-facing, double-pane} = 40 \times 40 \text{ BTU/hr}$$

$$\text{Window Load} = 1,600 \text{ BTU/hr}$$

Step 3: Add Internal Loads

- **Occupant:** 230 BTU/hr
- **Appliances (light computer load):** 300 BTU/hr
- **Lighting (assume 3 W/sq ft $\times$ 300 sq ft):** $300 \times 3 = 900 \text{ W} \times 3.413 = 3,072 \text{ BTU/hr}$

$$\text{Internal Load} = 230 + 300 + 3,072 \approx 3,602 \text{ BTU/hr}$$

Step 4: Add Infiltration and Ventilation

- Infiltration: Estimated at **200 BTU/hr**
- Ventilation: $50 \text{ CFM} \times 1.1 \times \Delta T$ (assume 20°F difference)

$$\text{Ventilation Load} = 50 \times 1.1 \times 20 = 1,100 \text{ BTU/hr}$$

Step 5: Total Cooling Load Estimate

Load Source	BTU/hr
Walls	1,680

Load Source	BTU/hr
Ceiling	1,200
Windows	1,600
Internal (People + Equipment)	837
Infiltration	200
Ventilation	1,100
Total	9,382

Answer:

The estimated cooling load for this room is approximately **9,382 BTU/hr**, so you would typically recommend a **9,000–10,000 BTU/hr** cooling unit (about a **3/4-ton to 1-ton system**).

MANUAL J LOAD CALCULATION

PRACTICE EXERCISE

ROOM DETAILS

- Room Size: 15 x 20 x 8
- Ceiling Height: 8 ft
- Location: Dallas, TX
- 2 wo. double-pane windows (4 %2) west
- Insulation: R-13
- Occupancy: 1 person
- Appliances: desktop computer, pr. fresh
- Air Infiltration
- Moderate



STEP 1: CALCULATE ROOM VOLUME

Volume = 15 x 20 x 8 = 2,400 cu ft

STEP 2: ESTIMATE COOLING LOAD FROM ENVELOPE



Walls 1,680 BTU/hr



Ceiling 1,200 BTU/hr



Windows 1,600 BTU/hr

STEP 3: ADD INTERNAL LOADS



Occupancy 230 BTU/hr



Appliances 300 BTU/hr

Lighting 307 BTU/hr

TOTAL 6,617 BTU/hr

STEP 4: ADD INFILTRATION AND VENTILATION ADV



Infiltration 200 BTU/hr

Ventilation 1,100 BTU/hr

TOTAL COOLING LOAD ESTIMATE

6,617 BTU/hr

Chapter 14: Duct Sizing and Design (Manual D)

Proper duct design ensures that airflow matches the system's capacity and delivers comfort efficiently. Manual D provides the standard method for residential duct design.

14.1 What Is Manual D?

- Developed by **ACCA (Air Conditioning Contractors of America)**
- Establishes methods for **sizing and laying out ducts**
- Works with **Manual J** (load calc) and **Manual S** (equipment selection)

14.2 Why Duct Design Matters

- Ensures each room receives correct airflow (measured in **CFM**)
- Prevents noise, pressure drops, and system inefficiency
- Required by energy codes in many areas

14.3 Key Concepts in Duct Design

1. **CFM (Cubic Feet per Minute)**
 - Target airflow based on Manual J calculations
 - Rule of thumb: ~400 CFM per ton of cooling
2. **Friction Rate**
 - Resistance to airflow caused by duct material, fittings, and length
 - Affects how large ducts need to be
3. **Total Effective Length (TEL)**
 - Actual duct length + equivalent length of all fittings (elbows, boots, etc.)
4. **Static Pressure**
 - Pressure available to push air through the ducts

- Too low = not enough airflow; too high = noise, strain on blower

14.4 Duct Material Types

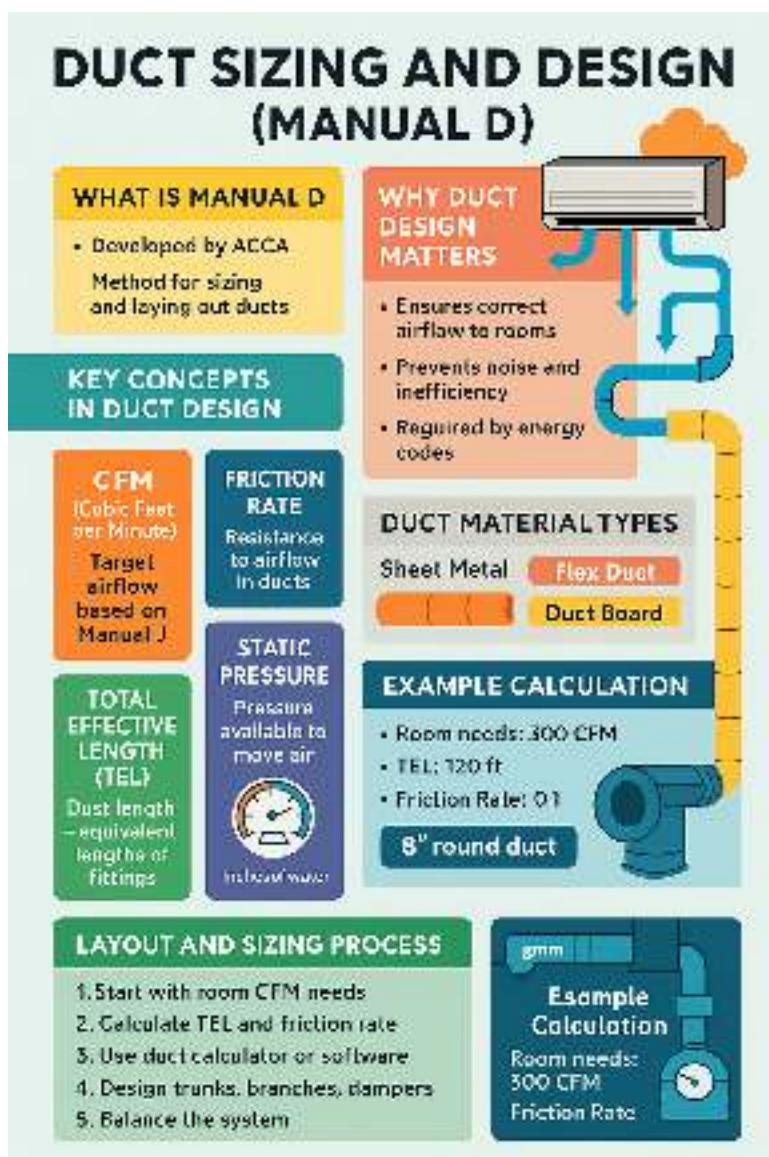
- **Sheet Metal:** Durable, low resistance
- **Flex Duct:** Easy to install but adds friction
- **Duct Board:** Pre-insulated, used for trunks/plenums

14.5 Layout and Sizing Process

1. **Start with Room CFM Needs (from Manual J)**
2. **Calculate TEL and friction rate**
3. **Use a duct calculator or software to size each run**
4. **Design trunks, branches, dampers, and registers**
5. **Balance the system using dampers or grille selection**

14.6 Example Calculation

- Room needs: 300 CFM
- TEL: 120 ft
- Friction Rate: 0.1
- Use a ductulator (wheel or software) → **8" round duct** required



Chapter 15: Equipment Sizing and Selection

Once loads are calculated using Manual J, the next step is selecting properly sized heating and cooling equipment based on those loads. This chapter covers **Manual S** guidelines and best practices for system selection.

15.1 What Is Manual S?

- Developed by **ACCA**
- Provides the procedure for **selecting HVAC equipment** that matches the building load
- Ensures that selected equipment aligns with **Manual J results** (not just square footage)

15.2 Why Proper Sizing Is Crucial

- **Oversized equipment:** Short cycles, poor humidity control, inefficient
- **Undersized equipment:** Can't keep up with demand
- **Proper sizing:** Maximizes comfort, longevity, and efficiency

15.3 Sizing Tolerances (Cooling & Heating)

- **Cooling equipment:** Must not be undersized; may be oversized by no more than 15% of sensible **within 15%** of sensible cooling load (up to 25% total capacity per ACCA Manual S guidelines)
 - Example: If load is 30,000 BTU/hr, acceptable size is 30,000–34,500 BTU/hr
- **Heating equipment:** Match **100–140%** of heating load
 - Allows buffer for defrost, extremely cold temps

15.4 Selection Criteria

1. **Total Capacity (BTU/hr):** From Manual J
2. **Sensible vs. Latent Load Match:** Use manufacturer performance tables
3. **SEER / EER / HSPF Ratings:** Higher = more efficient
4. **Voltage and Circuit Sizing:** Confirm compatibility

5. **Airflow (CFM):** Should be around 400 CFM per ton of cooling

15.5 Equipment Types

- **Air Conditioners:** Cooling only
- **Heat Pumps:** Heating + cooling
- **Gas Furnaces:** Paired with A/C or heat pumps
- **Packaged Units:** All-in-one systems (roof or pad-mounted)
- **Mini-Splits:** No ducts, zone-based comfort

15.6 Selection Example

- Manual J Cooling Load: 32,000 BTU/hr
- Latent Load: 6,000 BTU/hr
- Chosen Unit:
 - Capacity: 33,000 BTU/hr
 - Sensible: 26,000 BTU/hr
 - Latent: 7,000 BTU/hr
 - SEER: 16 (approximately 15.2 SEER2; verify compliance with current regional minimums) **correctly sized** and efficient.

EQUIPMENT SIZING AND SELECTION

WHAT IS MANUAL J?

- Developed by ACCA
- Provides procedure for selecting HVAC equipment that matches building load
- Ensures selected equipment aligns with Manual J results

WHY PROPER SIZING IS CRUCIAL

- Oversized equipment: short cycles, poor humidity control, inefficient
- Undersized equipment: match 100–140% of heating load. Allowing buffer for defrost, extremely cold temps

SIZING TOLERANCES

1. Total Capacity (BTU/hr) from Manual J
2. Sensible vs. Latent Load Match: using manufacturer performance tables
3. SEER / EER / HSPF Ratings (Higher = more efficient)
4. Voltage & Circuit Sizing confirm compatibility
5. Airflow (CFM): around 400 CFM per ton of cooling

COMMON EQUIPMENT TYPES



Air conditioner



Heat pumps



Gas furnace



Packaged units
All-in-one
cool & heat mode



Mini-splits
No ducts, zone
based comfort

SELECTION EXAMPLE

Manual J Cooling Load
32,000 BTU/hr
Latent Load 6,000 bu/hr
Chosen Unit:
Capacity 33,000 BTU/hr
Sensible 26,000 BTU/hr
Latent 7,000 bu/hr

SELECTION EXAMPLE

Manual J Cooling Load
32,000 BTU/hr
Latent Load 6,000 bu/hr
Chosen Unit:
 THIS UNIT PRECTLY SIZED
AND EFFICIENT

Chapter 16: Electrical Load and Wire Sizing

Correct electrical sizing is vital for HVAC system safety and performance. This chapter covers how to calculate electrical load and select proper wire sizes, breakers, and disconnects for common HVAC equipment.

16.1 Importance of Proper Electrical Sizing

- Prevents overheating, tripped breakers, and fire risk
- Ensures equipment starts and runs reliably
- Required for code compliance (NEC, local codes)

16.2 Key Terms

- **Ampacity:** The maximum current a wire can carry safely
- **Voltage Drop:** Loss of voltage over a long wire run
- **MCA (Minimum Circuit Ampacity):** Found on equipment nameplate
- **MOCP (Maximum Overcurrent Protection):** Max breaker size

16.3 Sizing Electrical Circuits

1. **Check Equipment Nameplate**
 - Find MCA and MOCP
2. **Wire Sizing**
 - Use **NEC Table 310.16**
 - Match wire size to MCA (e.g., 10 AWG for 30A)
3. **Breaker Sizing**
 - Use the MOCP or round up to the next standard size
4. **Conduit and Disconnects**
 - Size per wire fill rules and NEC Article 440 (HVAC equipment), Article 430 (motors), and Article 220 (load calculations)

16.4 Voltage and Phase

- Residential: 120V or 240V, single-phase
- Light commercial: 208V, 240V, or 277V
- Large commercial: 480V, 3-phase systems

16.5 Common Wire Sizes

Wire Size (AWG) Ampacity (Copper, 75°C)

14 AWG	15 amps
12 AWG	20 amps
10 AWG	30 amps
8 AWG	40 amps
6 AWG	55 amps

Note: Always check derating factors and ambient temperature adjustments per NEC.

16.6 Example

- Equipment Nameplate:
 - MCA = 24A
 - MOCP = 40A
- Solution:
 - Use **10 AWG wire** (30A ampacity)
 - Use **40A breaker**
 - Conduit sized for 3 wires + ground

ELECTRICAL LOAD AND WIRE SIZING

IMPORTANCE OF PROPER ELECTRICAL SIZING

- Prevents overheating, tripped breakers, and fire risk
- Ensures equipment operates safely and efficiently
- Required for code compliance (NEC, local codes)

VOLTAGE AND HASE

Residential: 120V or 240V single-phase
 Light commercial: 208V, 240V, or 277V
 Large commercial: 480V 3-phase systems

SIZING ELECTRICAL CIRCUITS

- Check Equipment Nameplate: Find MCA and MCCP
- Wire Sizing: Use NEC Table 310.15(B)(16) - Match wire size to MCA (e.g., 10 AWG for 30A)
- Breaker Sizing: Use the MCCP or round up to the next standard size
- Conducting Disconnections: Follow NEC Article 404

Wire Size (AWG) - Amps		
14	15	15 amps
12	20	20 amps
10	30	30 amps
8	40	40 amps
6	55	55 amps

COMMON WIRE SIZES

Wire Size (AWG)	Amps
14	15 amps
12	20 amps
10	30 amps
8	40 amps
6	55 amps

Note: Always check local codes and manufacturer ratings.

EXAMPLE

Equipment Nameplate:
 MCA = 20A
 MCCP = 40A
Solution: Use 10 AWG wire (30A permitted), 40A breaker.
 Conductors not to be used as ground.

Part V – Troubleshooting and Real-World Scenarios

This part prepares you to apply HVAC knowledge in the field. It focuses on diagnosing problems, resolving service issues, and handling real-world scenarios that reflect what you may see on the job or in the exam.

Chapter 17: HVAC Troubleshooting Techniques

Diagnosing HVAC problems efficiently requires a structured approach. This chapter introduces a step-by-step process and common symptoms to help you quickly isolate faults in residential and light commercial systems.

17.1 The Diagnostic Process

1. Talk to the Customer

- Ask what the symptoms are (no heat, noisy, not cooling, etc.)

2. Visual Inspection

- Look for burnt wires, dirty filters, disconnected ducts

3. Test for Power

- Use a multimeter at the disconnect and control board

4. Check Airflow

- Inspect filters, blower motor, dampers

5. Sequence of Operation

- Follow startup steps: thermostat → board → motor → compressor

17.2 Common Cooling System Symptoms

Symptom	Likely Cause
---------	--------------

No cooling	Thermostat, capacitor, contactor, refrigerant low
------------	---

Short cycling	Oversized unit, bad sensor, dirty coil
---------------	--

Freezing coil	Low airflow, dirty filter, refrigerant undercharge
---------------	--

Warm air	Reversing valve stuck, low refrigerant
----------	--

17.3 Common Heating System Symptoms

Symptom	Likely Cause
No heat	Ignition failure, flame sensor dirty, limit switch
Blower runs nonstop	Limit switch stuck, control board error
Burning smell	Dust on elements, overheating
Delayed ignition	Dirty burners, weak igniter

17.4 Useful Tools

- Multimeter (volts, ohms, continuity)
- Clamp meter (amps)
- Refrigerant gauges or digital manifold
- Combustion analyzer (for furnaces)
- Leak detector (electronic or soap bubble)

17.5 Pro Tip: Always Check the Basics First

- Is the unit plugged in?
- Is the thermostat on and calling for heating/cooling?
- Is the breaker tripped?
- Is the filter dirty or coil frozen?

HVAC TROUBLESHOOTING TECHNIQUES

DIAGNOSTIC PROCESS

-  Talk to the Customer
-  Visual Inspection
-  Test for Power
-  Check Airflow
-  Sequence of Operation

COMMON HEATING SYSTEM SYMPTOMS

Symptom	Likely Cause
No heat	Ignition failure, flame sensor dirty, limit switch
Blower runs nonstop	Limit switch stuck, control board error
Burning smell	Dust on elements overheating
Delayed ignition	Dirty burners, weak igniter

COMMON COOLING SYSTEM SYMPTOMS

Symptom	Likely Cause
No cooling	Thermostat, capacitor, refrigerant low
Short cycling	Oversized unit, bad sensor, dirty coil
Freezing coil	Low airflow, dirty filter, refrigerant
Warm air	Reversing valve stuck, low refrigerant

USEFUL TOOLS



PRO TIP: ALWAYS CHECK THE BASICS FIRST

- Is the unit plugged in?
- Is the thermostat on and calling for heating/cooling?
- Is the breaker tripped?
- Is the filter dirty or coil frozen?

Residential HVAC systems often show repeat patterns of failure due to wear, poor maintenance, or installation errors. This chapter covers frequently encountered problems, their symptoms, and how to resolve them effectively.

18.1 Poor Airflow

- **Symptoms:**
 - Weak air from vents
 - Uneven temperature in rooms
- **Common Causes:**
 - Dirty air filter
 - Blower motor failure
 - Collapsed flex duct
 - Closed or blocked supply registers
- **Fix:**

Replace filters, check blower capacitor, inspect ductwork

18.2 Thermostat Issues

- **Symptoms:**
 - System not responding
 - Inaccurate room temperature
- **Common Causes:**
 - Dead batteries
 - Miswiring
 - Incorrect settings (e.g., fan set to ON instead of AUTO)

- **Fix:**
Replace batteries, verify wiring, reprogram thermostat

18.3 Refrigerant Leaks

- **Symptoms:**
 - Poor cooling
 - Ice buildup on evaporator coil
- **Common Causes:**
 - Damaged coil
 - Loose flare fittings
 - Rub-out points in copper line set
- **Fix:**
Locate leak (electronic or soap test), repair or replace line, recharge refrigerant per EPA rules

18.4 Dirty Coils

- **Symptoms:**
 - Inefficient cooling or heating
 - High energy bills
- **Common Causes:**
 - Outdoor coil clogged with debris
 - Indoor coil fouled with dust
- **Fix:**
Clean coils with coil cleaner and water rinse, inspect condensate drain afterward

18.5 Drainage Problems

- **Symptoms:**
 - Water leaking around air handler
 - Musty odor or mold
- **Common Causes:**
 - Clogged condensate drain line
 - Disconnected drain pipe
 - No trap on drain line
- **Fix:**

Clear line with vacuum or air pressure, check slope and trap, add float switch if needed

COMMON RESIDENTIAL HVAC PROBLEMS

POOR AIRFLOW

Symptoms:

- Weak air from vents
- Uneven temperature in rooms

Common Causes

- Dirty air filter
- Blower motor failure
- Collapsed flex duct
- Closed or blocked supply registers

Fix:

Replace filter, check blower capacitor, inspect ductwork



THERMOSTAT ISSUES

Symptoms:

- Dead batteries
- Miswiring

Common Causes

- Incorrect settings (e.g., fan set to ON instead of AUTO)

Fix:

Replace batteries, verify wiring, reprogram thermostat.



REFRIGERANT LEAKS

Symptoms:

- Poor cooling
- Ice buildup on evaporator coil

Common Causes

- Damaged coil
- Loose flare fittings
- Rub-out points in copper line set

Fix:

Locate leak (electronic or soap test), repair or replace line, recharge refrigerant per EPA rules



DIRTY COILS

Symptoms:

- Inefficient cooling or heating
- High energy bills

Common Causes

- Outdoor coil clogged with debris
- Indoor coil fouled with dust

Fix:

Clean coils with coil cleaner and water/rinse, inspect condensate drain afterward



Commercial HVAC systems are larger, more complex, and often integrated with control systems. This chapter focuses on diagnosing problems in rooftop units (RTUs), variable air volume (VAV) systems, and economizers.

19.1 Rooftop Unit (RTU) Issues

- **Symptoms:**
 - No cooling or heating
 - Excessive fan noise or vibration
 - Water leaking inside the building
- **Common Causes:**
 - Tripped disconnect or breaker
 - Failed blower motor or belt
 - Dirty evaporator or condenser coils
 - Drain line clog or pan overflow
- **Fix:**

Reset power, check motors/belts, clean coils, clear drain lines

19.2 Economizer Failures

- **Symptoms:**
 - Ventilation air not cooling space
 - System runs even when outdoor air is ideal
- **Common Causes:**
 - Stuck dampers
 - Faulty temperature or enthalpy sensor

- Disconnected linkage
- **Fix:**
Test actuator and sensor, reset damper position, recalibrate controls

19.3 Variable Air Volume (VAV) Issues

- **Symptoms:**
 - Zones too hot or too cold
 - Constant fan noise or air complaints
- **Common Causes:**
 - Malfunctioning VAV box actuator
 - Damaged or miscalibrated thermostat
 - Control signal failure from Building Management System (BMS)
- **Fix:**
Test actuator operation, verify control signal, check damper position

19.4 Refrigerant Management in Commercial Systems

- Larger refrigerant charges require:
 - EPA tracking logs
 - Regular leak detection
 - Isolation of zones for pressure testing
- Use refrigerant scales and digital manifolds for precise servicing

19.5 Pro Tip: Know the Sequence of Operation

- For each commercial unit, learn the order of operations:
Thermostat call → BMS activation → Damper movement → Compressor/fan staging
- This helps pinpoint exactly where the failure occurs

COMMERCIAL HVAC DIAGNOSTICS

RTU ISSUES



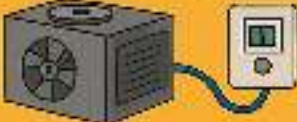
- **Symptoms:**
No cooling or heating
Excessive fan noise or vibration
Water leaking inside the building
- **Gripes/Complaints:**
Broken
Failed blower motor or condensate
Drain line clog or pan overflow
- **Fix:**
Reset power, check motors/belts,
clean coils, clear drain lines

ECONOMIZER FAILURES



- **Symptoms:**
Ventilation air not cooling space
System runs even when outdoor air is ideal
- **Stuck dampers:**
Faulty temperature or enthalpy sensor, disconnected linkage
- **Fix:**
Test actuator and sensor, reset damper position, recalibrate controls

VARIABLE AIR VOLUME (VAV) ISSUE



- **Symptoms:**
Zones too hot or too cold
Constant fan noise or air complaints
- **Malfunctioning VAV box actuator:**
Damaged or miscalibrated thermostat

REFRIGERANT MANAGEMENT IN COMMERCIAL SYSTEMS



- **Larger refrigerant charges require:**
EPA tracking logs
Regular leak detection

Chapter 20: Service Call Scenarios and Solutions

This chapter walks you through real-world service call situations. Each scenario demonstrates how to apply a structured diagnostic process to resolve HVAC issues effectively—just like on the licensing exam or in the field.

20.1 Scenario 1: No Cooling in Residential Home

Complaint: AC is running but house is still warm

Inspection:

- Thermostat set to 72°F, fan is ON
- Indoor unit running; outdoor unit silent
- Checked contactor — pitted and not engaging

Solution:

Replaced contactor, verified 24V signal from thermostat. System restored.

20.2 Scenario 2: Water Leaking from Ceiling

Complaint: Water dripping from ceiling below attic air handler

Inspection:

- Found primary drain line clogged
- Secondary pan overflowing
- No float switch installed

Solution:

Cleared primary line, installed new float switch, added proper slope. Customer advised to check filter regularly.

20.3 Scenario 3: Commercial RTU – No Heat

Complaint: Office space too cold; heat not coming on

Inspection:

- Rooftop unit showed lockout code
- Flame sensor dirty

Solution:

Cleaned flame sensor, reset lockout, tested heat cycle successfully.

20.4 Scenario 4: VAV Zone Too Cold

Complaint: One conference room too cold while others are comfortable

Inspection:

- Found VAV box damper stuck open
- Pneumatic actuator diaphragm cracked

Solution:

Replaced actuator, tested airflow balance. Zone temperature normalized.

20.5 Scenario 5: System Blowing Warm Air in Cooling Mode

Complaint: System runs but air is warm

Inspection:

- Thermostat calling for cooling
- Compressor amps normal
- Found reversing valve stuck in heating mode

Solution:

Tapped valve to release, tested solenoid coil, replaced faulty solenoid. Cooling restored.

SERVICE CALL SCENARIOS AND SOLUTIONS

NO COOLING IN RESIDENTIAL HOME



Complaint:
AC running but house warm

Inspection

- Thermostat set to 72°F on ON
- Contactor pitted, not engaging

Solution

- Replaced contactor, checked 24V signal

WATER LEAKING FROM CEILING



Complaint:
Water dripping from ceiling

Inspection

- Primary drain line clogged
- No float switch installed

Solution

- Cleared drain, installed float switch

COMMERCIAL RTU—NO HEAT



Complaint:
Office space too cold

Inspection

- Unit in lockout
- Dirty flame sensor

Solution

- Cleaned sensor, reset unit

VAV ZONE TOO COLD



Complaint:
One room too cold

Inspection

- Damper stuck open
- Faulty actuator

Solution

- Replaced actuator, tested

SYSTEM BLOWING WARM AIR IN COOLING MODE



Complaint:
System runs but air warm

Part VI – Practice Exams and Study Tools

This final part of the book helps you prepare for the real test with realistic questions, code look-up drills, and study aids that reinforce your learning and build confidence.

Chapter 21: Full-Length Practice Exam #1 (Timed)

This 50-question multiple-choice practice test is modeled after common HVAC licensing exams and covers a broad range of topics, including fundamentals, code, electrical, design, and troubleshooting.

Instructions

- Time Limit: **90 minutes**
- Choose the **best answer** for each question
- No reference books allowed (closed-book simulation)
- Mark your answers and compare with the key in Chapter 24

Full-Length Practice Exam #1 (50 Questions)

Time Limit: 90 minutes

Closed Book – No References Allowed

1–10: HVAC Fundamentals & Principles

1. What is the typical airflow rate required per ton of cooling?
A. 200 CFM B. 300 CFM C. 400 CFM D. 600 CFM

2. What is the latent heat of vaporization of water?
A. 144 BTU/lb B. 970 BTU/lb C. 1 BTU/lb D. 540 BTU/lb
3. Which method of heat transfer occurs through direct contact?
A. Convection B. Radiation C. Condensation D. Conduction
4. Which tool is best for measuring air velocity in a duct?
A. Anemometer B. Psychrometer C. Manometer D. Clamp meter
5. The pressure difference between supply and return ducts is called:
A. Total pressure B. Static pressure C. Differential pressure D. Atmospheric pressure
6. What happens if a system is overcharged with refrigerant?
A. Higher efficiency B. Compressor damage C. Evaporator freeze
D. More cooling output
7. What is the standard temperature for superheat measurement at the evaporator?
A. Suction pressure converted to temperature
B. Outdoor dry bulb temperature
C. Return air temperature
D. Supply air temperature
8. What property does a psychrometer measure?
A. Voltage and current B. Humidity C. CO levels D. Refrigerant pressure
9. What happens when static pressure in a duct system is too high?
A. Improved airflow B. Blower strain and noise
C. Refrigerant leaks D. System shuts down
10. Which term defines heat that causes a temperature rise without a phase change?
A. Latent heat B. Sensible heat C. Total heat D. Superheat

11–20: Electrical and Controls

11. A 10 AWG copper wire with 75°C insulation is rated for how many amps?
A. 20 B. 25 C. 30 D. 35
12. Which of the following is used to reduce 240V to 24V for controls?
A. Contactor B. Capacitor C. Transformer D. Relay
13. What is the resistance of a 120V circuit drawing 10 amps?
A. 10 ohms B. 12 ohms C. 8 ohms D. 6 ohms
14. The color typically used for ground conductors is:
A. Red B. Green or bare C. White D. Yellow
15. What does a capacitor do in an HVAC motor circuit?
A. Increase amperage B. Reduce voltage
C. Start and/or run the motor D. Stop power surges
16. Which device opens or closes a circuit when energized?
A. Thermistor B. Contactor C. Transformer D. Switch
17. What reading indicates a short circuit in a component?
A. 120V B. 0 ohms C. Infinite ohms D. 24V
18. What tool is used to measure amps?
A. Manometer B. Psychrometer C. Clamp meter D. Anemometer
19. A thermostat set to "Auto" will:
A. Run continuously
B. Turn off the blower only
C. Turn on the fan only when cooling or heating is needed
D. Lock the unit
20. Which terminal on a thermostat typically controls the cooling contactor?
A. W B. R C. G D. Y

21–30: Code and Safety

21. The IMC requires a secondary drain pan if the unit is located where?
A. In a basement B. In an attic or ceiling space
C. Outdoors D. Under a crawlspace
22. What is the minimum slope for horizontal refrigerant lines?
A. 1/8" per foot B. 1/4" per foot
C. No slope needed D. 1" per foot
23. EPA 608 requires which certification for technicians working on high-pressure systems?
A. Type I B. Type II C. Type III D. Universal
24. A lockout/tagout procedure is used to:
A. Prevent lost tools
B. Secure access panels
C. Protect against accidental startup during service
D. Restrict customer access
25. NFPA 70E covers safety related to:
A. Asbestos B. Combustion air
C. Fire sprinklers D. Electrical hazards
26. When must a permit be pulled for HVAC work?
A. Only if customer requests
B. When installing new equipment
C. For filter changes
D. Never
27. Fuel gas vents must terminate at least how far above the roof line?
A. 6 inches B. 12 inches C. 24 inches D. Flush with roof
28. What is the maximum allowed leak rate for comfort cooling systems over 50 lbs. per EPA?
A. 10% B. 20% C. 15% D. 25%
29. Which of the following is NOT allowed to be vented into a crawlspace?
A. Condensate line B. Dryer exhaust
C. Furnace exhaust D. All of the above

30. What is required on all refrigerant cylinders according to EPA rules?
A. A seal B. DOT sticker
C. Warning label D. Proper color coding

31–40: Duct Design and Airflow

31. What is the typical friction rate used in residential duct design?
A. 0.1 in w.c. B. 1.0 in w.c.
C. 0.05 in w.c. D. 2.0 in w.c.
32. Which tool helps measure airflow in CFM?
A. Anemometer B. Manometer C. Thermometer D. Ammeter
33. What does a balancing damper do?
A. Blocks refrigerant
B. Adjusts airflow
C. Reduces compressor speed
D. Prevents return air
34. What is the formula for CFM?
A. $\text{Velocity} \times \text{Area}$
B. $\text{Voltage} \div \text{Resistance}$
C. $\text{BTU} \div 3.41$
D. $\text{Amps} \times \text{Resistance}$
35. Manual D refers to:
A. Drainage design
B. Electrical diagrams
C. Duct design
D. Dehumidification control
36. Static pressure in ducts is measured in:
A. PSI
B. BTU/hr
C. In. of water column (in. w.c.)
D. Amps

37. Which duct material has the **least** resistance to airflow?
- A. Flex duct
 - B. Fiberglass duct board
 - C. Sheet metal
 - D. Vinyl duct
38. The return duct is responsible for:
- A. Ventilating crawlspaces
 - B. Delivering cooled air
 - C. Bringing air back to the system
 - D. Reducing refrigerant flow
39. What happens if ducts are undersized?
- A. Faster cooling
 - B. Reduced SEER
 - C. High static pressure
 - D. Low compressor amps
40. Which Manual covers HVAC equipment selection?
- A. Manual J
 - B. Manual D
 - C. Manual S
 - D. Manual L

41–50: Troubleshooting and Service

41. What's the first step in troubleshooting a no-cool call?
- A. Replace the compressor
 - B. Check the filter
 - C. Measure superheat
 - D. Pull a vacuum
42. A high superheat reading indicates:
- A. Overcharge
 - B. Restriction
 - C. Undercharge
 - D. Dirty condenser

43. Low suction pressure and low head pressure suggest:
- A. Overcharge
 - B. Non-condensables
 - C. Undercharge
 - D. Defective TXV
44. What does a dirty flame sensor cause?
- A. Short cycling
 - B. Blower runs nonstop
 - C. Furnace lockout
 - D. Weak airflow
45. Which tool is best to test a capacitor?
- A. Clamp meter
 - B. Multimeter with microfarad setting
 - C. Manometer
 - D. Volt stick
46. If a compressor hums but doesn't start, the likely cause is:
- A. Low refrigerant
 - B. Faulty contactor
 - C. Weak start capacitor
 - D. Dirty coil
47. The most common cause of airflow imbalance in a new install is:
- A. Bad TXV
 - B. Unbalanced dampers
 - C. Dirty coil
 - D. Undersized wire
48. What's the first component to check if an outdoor unit won't turn on?
- A. Blower motor
 - B. Circuit breaker
 - C. TXV
 - D. Return duct
49. What refrigerant was the most common choice for new residential systems prior to the 2025 phase-down?
50. What is the best method to confirm a low refrigerant charge?
- A. Check pressure only
 - B. Check temperature only
 - C. Check superheat or subcooling
 - D. Shake the refrigerant tank

Annotated Whole-House Diagram

The same residential layout with airflow paths color-coded — return air, supply air, refrigerant, exhaust.



PRACTICE EXAM – ANSWER SHEET

- | | | |
|---------|-----------|-----------|
| 1. A C | 13. A B C | 16. A B C |
| 2. C C | 14. B C D | 17. B C D |
| 3. B C | 15. A B C | 18. A B C |
| 4. A B | 16. C D A | 19. A B C |
| 5. C C | 17. B C D | 20. B C A |
| 6. B C | 18. A B C | 21. A B C |
| 7. C D | 19. B C C | 22. C D A |
| 8. A B | 20. C D D | 23. B C D |
| 9. C C | 21. A B C | 24. C B C |
| 10. B C | 22. B C D | 25. A B C |
| 11. C D | 23. C D A | 26. C B C |
| 12. C B | 24. D A B | 27. D C A |
| 13. D C | 25. A C D | 28. C B C |
| 14. B C | 26. B C D | 29. A B C |
| 15. C D | 27. C D A | 30. C D A |

HVAC Practice Exam #1 – Answer Key

1–10: HVAC Fundamentals

1. C – 400 CFM
2. B – 970 BTU/lb
3. D – Conduction
4. A – Anemometer
5. C – Differential pressure
6. B – Compressor damage
7. A – Suction pressure converted to temperature
8. B – Humidity
9. B – Blower strain and noise
10. B – Sensible heat

11–20: Electrical and Controls

11. C – 30 amps
12. C – Transformer
13. B – 12 ohms ($V=IR \rightarrow 120V \div 10A = 12 \text{ ohms}$)
14. B – Green or bare
15. C – Start and/or run the motor
16. B – Contactor
17. B – 0 ohms
18. C – Clamp meter
19. C – Turns on the fan only when needed
20. D – Y

21–30: Code and Safety

- 21. B – In an attic or ceiling space
- 22. B – 1/4" per foot (minimum slope for suction line oil return on horizontal runs)
- 23. B – Type II
- 24. C – Prevent accidental startup during service
- 25. D – Electrical hazards
- 26. B – When installing new equipment
- 27. B – 12 inches
- 28. A – 10%
- 29. D – All of the above
- 30. D – Proper color coding

31–40: Duct Design and Airflow

- 31. A – 0.1 in w.c.
- 32. A – Anemometer
- 33. B – Adjusts airflow
- 34. A – $\text{Velocity} \times \text{Area}$
- 35. C – Duct design
- 36. C – In. of water column (in. w.c.)
- 37. C – Sheet metal

- 38. C – Bringing air back to the system
- 39. C – High static pressure
- 40. C – Manual S

41–50: Troubleshooting and Service

- 41. B – Check the filter
- 42. C – Undercharge
- 43. C – Undercharge
- 44. C – Furnace lockout
- 45. B – Multimeter with microfarad setting
- 46. C – Weak start capacitor
- 47. B – Unbalanced dampers
- 48. B – Circuit breaker
- 49. C – R-410A
- 50. C – Check superheat or subcooling

Chapter 22: Full-Length Practice Exam #2 (Timed)

This second full-length practice test gives you another opportunity to test your readiness under realistic exam conditions. It covers all major HVAC exam topics with 50 multiple-choice questions.

Instructions

- **Time Limit:** 90 minutes

- **Closed Book:** No reference materials allowed
- **Mark only one answer per question**
- **Answer key provided in Chapter 24**

Topics Covered

- HVAC Fundamentals
- Electrical and Controls
- Code and Safety
- Duct Design & Sizing
- Troubleshooting & Service

Full-Length Practice Exam #2

Time Limit: 90 minutes

Closed Book – No References Allowed

1–10: HVAC Fundamentals

1. Which component absorbs heat from the indoor air?
A. Condenser coil B. Compressor
C. Evaporator coil D. Expansion valve
2. Which method of heat transfer occurs through fluid or gas movement?
A. Radiation B. Conduction
C. Convection D. Diffusion
3. Which refrigerant is a high-pressure type used in many modern systems?
A. R-22 B. R-134a
C. R-410A D. R-12

4. What does sensible heat affect?
A. Humidity only B. Volume only
C. Temperature only D. Phase change
5. What is the function of a TXV (thermostatic expansion valve)?
A. Measure airflow
B. Control refrigerant flow into the evaporator
C. Convert low-pressure gas to liquid
D. Maintain oil circulation
6. Which of the following best defines superheat?
A. Temperature of the liquid line
B. Temperature of refrigerant above saturation point
C. Pressure at condenser outlet
D. Difference between dry and wet bulb
7. How many BTUs are in one ton of cooling?
A. 9,600 B. 10,000
C. 18,000 D. 12,000
8. What tool is used to read wet bulb temperature?
A. Psychrometer B. Thermocouple
C. Clamp meter D. Anemometer
9. What happens if a coil is dirty?
A. Increased airflow
B. Decreased heat transfer
C. Lower static pressure
D. Improved SEER rating
10. What is the standard pressure unit used in HVAC for refrigerants?
A. PSI B. Inches of mercury
C. Inches of water column D. Volts

11–20: Electrical and Controls

11. What does Ohm's Law state?
A. $V = A \times W$ B. $A = V \div R$
C. $V = R \div A$ D. $V = P \times R$
12. Which device stores electrical energy for motor starting?
A. Relay B. Transformer
C. Capacitor D. Contactor
13. What is the purpose of a fuse?
A. Start compressor
B. Step down voltage
C. Prevent overheating
D. Protect the circuit from overcurrent
14. A multimeter reading of "OL" on resistance mode means:
A. Closed circuit B. Shorted component
C. Open circuit D. Normal operation
15. What tool is used to measure circuit resistance?
A. Clamp meter B. Multimeter
C. Ammeter D. Pressure gauge
16. Which color typically represents a neutral wire in residential wiring?
A. Black B. Red
C. White D. Green
17. What happens when a capacitor fails?
A. High voltage output
B. System runs better
C. Motor may hum but not start
D. Low refrigerant pressure
18. What is the voltage between two hot legs of a standard 240V single-phase system?
A. 120V B. 0V
C. 240V D. 480V

19. What happens when a contactor's coil is energized?
- A. Circuit opens
 - B. Circuit closes
 - C. Thermostat resets
 - D. Circuit is grounded
20. Which control wire activates the fan in a typical residential HVAC system?
- A. R B. W C. Y D. G

21–30: Code and Safety

21. What is required when installing a furnace in an attic?
- A. Nothing special
 - B. Platform with 30" clearance
 - C. Secondary drain pan
 - D. Disconnect switch
22. A fuel gas vent must have how much clearance from combustibles?
- A. 0 inches B. 1 inch
 - C. 3 inches D. 6 inches
23. EPA 608 certification is required for:
- A. Electrical troubleshooting
 - B. Duct sealing
 - C. Refrigerant handling
 - D. Appliance repair
24. A confined space with fuel-burning appliances requires:
- A. No ventilation
 - B. Natural draft
 - C. Adequate combustion air
 - D. GFCI protection
25. OSHA requires fall protection for work above:
- A. 4 feet B. 6 feet
 - C. 10 feet D. 12 feet

26. Which of the following must be provided for rooftop HVAC equipment?
- A. Ground rod
 - B. Thermostat
 - C. Service receptacle
 - D. Earth bonding wire
27. The minimum working clearance in front of electrical panels is:
- A. 24 inches B. 30 inches
 - C. 36 inches D. 48 inches
28. Vent piping must slope a minimum of:
- A. 1/8 inch per foot B. 1/4 inch per foot
 - C. 1/2 inch per foot D. 1 inch per foot
29. According to IMC, combustion air openings must be located:
- A. Near floor and ceiling
 - B. On roof
 - C. Behind unit
 - D. Inside return duct
30. Which is required for all gas appliance installations?
- A. PEX tubing
 - B. Condensate pump
 - C. Drip leg
 - D. Heat recovery unit

31–40: Design & Load Calculations

31. Manual J is used for:
- A. Equipment selection
 - B. Load calculation
 - C. Duct layout
 - D. Vent pipe sizing
32. What is the formula for watts?
- A. Amps $\times$ Volts B. BTU $\div$ 3.41
 - C. Area $\times$ Flow D. Volts $\div$ Resistance

33. Which Manual is used for equipment sizing?
A. Manual J B. Manual S
C. Manual D D. Manual L
34. Which component is used to adjust room-by-room airflow?
A. Balancing damper B. TXV
C. Contact relay D. Draft hood
35. What is the most efficient duct layout?
A. Longest possible runs
B. Central return with branch supplies
C. Multiple returns per room
D. Radial with smooth transitions
36. Which type of duct has the highest static pressure loss?
A. Sheet metal
B. Flex duct
C. Round duct
D. Duct board
37. What is total system airflow for a 3-ton AC system?
A. 900 CFM B. 1,000 CFM
C. 1,200 CFM D. 1,400 CFM
38. What causes high static pressure in a duct system?
A. Oversized ducts
B. Too many dampers open
C. Dirty filter or undersized return
D. Increased refrigerant charge
39. What is the unit of measurement for heating and cooling loads?
A. Amps B. CFM
C. PSI D. BTU/hr
40. If return air temperature is 75°F and supply air is 55°F, what is the temperature split?
A. 15°F B. 10°F
C. 20°F D. 25°F

41–50: Troubleshooting and Service

41. An evaporator coil freezing is often due to:
 - A. Dirty condenser
 - B. High refrigerant charge
 - C. Low airflow
 - D. High static pressure
42. A compressor running with high amperage and tripping is likely caused by:
 - A. Low refrigerant
 - B. Bad capacitor
 - C. Dirty evaporator
 - D. Undersized breaker
43. A PSC blower motor hums but does not turn—what is likely the cause?
 - A. Faulty thermostat
 - B. Weak run capacitor
 - C. Dirty coil
 - D. Tripped high-pressure switch
44. When charging by superheat, which condition must apply?
 - A. Fixed orifice
 - B. TXV metering
 - C. Low ambient
 - D. Variable speed compressor
45. How is subcooling calculated?
 - A. Liquid line temp – suction line temp
 - B. Saturation temp – liquid line temp
 - C. Liquid line temp – saturation temp
 - D. Suction line temp – saturation temp
46. A system with high head and low suction pressure indicates:
 - A. Overcharge
 - B. Dirty filter
 - C. Restriction
 - D. Undercharge

47. A furnace goes into lockout mode. What should you check first?
- A. Blower wheel
 - B. Flame sensor
 - C. Contactor
 - D. High-pressure switch
48. A condenser fan motor running slowly may indicate:
- A. Dirty filter
 - B. Reversing valve stuck
 - C. Faulty capacitor
 - D. Oversized breaker
49. What causes a contactor to chatter?
- A. Dirty coil
 - B. Low 24V voltage
 - C. Overcurrent
 - D. Bad capacitor
50. What is the correct superheat for a fixed-orifice system on a 75°F day?
- A. 8°F B. 10°F
 - C. 12°F D. Refer to chart and conditions

PRACTICE EXAM – ANSWER SHEET

- | | | |
|-------------|-----------------|-----------------|
| 1. (A) (C) | 13. (A) (B) (C) | 16. (A) (B) (C) |
| 2. (C) (C) | 14. (B) (C) (D) | 17. (B) (C) (D) |
| 3. (B) (C) | 15. (A) (B) (C) | 18. (A) (B) (C) |
| 4. (A) (B) | 16. (C) (D) (A) | 19. (A) (B) (C) |
| 5. (C) (C) | 17. (B) (C) (D) | 20. (B) (C) (A) |
| 6. (B) (C) | 18. (A) (B) (C) | 21. (A) (B) (C) |
| 7. (C) (D) | 19. (B) (C) (C) | 22. (C) (D) (A) |
| 8. (A) (B) | 20. (C) (D) (D) | 23. (B) (C) (D) |
| 9. (C) (C) | 21. (A) (B) (C) | 24. (C) (B) (C) |
| 10. (B) (C) | 22. (B) (C) (D) | 25. (A) (B) (C) |
| 11. (C) (D) | 23. (C) (D) (A) | 26. (C) (B) (C) |
| 12. (C) (B) | 24. (D) (A) (B) | 27. (D) (C) (A) |
| 13. (D) (C) | 25. (A) (C) (D) | 28. (C) (B) (C) |
| 14. (B) (C) | 26. (B) (C) (D) | 29. (A) (B) (C) |
| 15. (C) (D) | 27. (C) (D) (A) | 30. (C) (D) (A) |

HVAC Practice Exam #2 – Answer Key

1–10: HVAC Fundamentals

1. C – Evaporator coil
2. C – Convection
3. C – R-410A
4. C – Temperature only
5. B – Control refrigerant flow into the evaporator
6. B – Temperature of refrigerant above saturation point
7. D – 12,000
8. A – Psychrometer
9. B – Decreased heat transfer
10. A – PSI

11–20: Electrical and Controls

11. B – $A = V \div R$
12. C – Capacitor
13. D – Protect the circuit from overcurrent
14. C – Open circuit
15. B – Multimeter
16. C – White
17. C – Motor may hum but not start
18. C – 240V
19. B – Circuit closes
20. D – G

21–30: Code and Safety

- 21. C – Secondary drain pan
- 22. C – 3 inches
- 23. C – Refrigerant handling
- 24. C – Adequate combustion air
- 25. B – 6 feet
- 26. C – Service receptacle
- 27. C – 36 inches
- 28. B – 1/4 inch per foot
- 29. A – Near floor and ceiling
- 30. C – Drip leg

31–40: Design & Load Calculations

- 31. B – Load calculation
- 32. A – Amps $\times$ Volts
- 33. B – Manual S
- 34. A – Balancing damper
- 35. D – Radial with smooth transitions
- 36. B – Flex duct
- 37. C – 1,200 CFM
- 38. C – Dirty filter or undersized return

- 39. D – BTU/hr
- 40. C – 20°F (75°F – 55°F)

41–50: Troubleshooting and Service

- 41. C – Low airflow
- 42. B – Bad capacitor
- 43. B – Weak run capacitor
- 44. A – Fixed orifice
- 45. B – Saturation temp – liquid line temp
- 46. C – Restriction
- 47. B – Flame sensor
- 48. C – Faulty capacitor
- 49. B – Low 24V voltage
- 50. D – Refer to chart and conditions

Chapter 23: Code Look-Up Practice and Open-Book Drills

Many licensing exams allow limited open-book use, particularly for **IMC**, **IFGC**, or **EPA reference materials**. This chapter helps you practice finding answers quickly and accurately under pressure.

23.1 Why Code Look-Up Practice Matters

- Boosts your **speed and confidence** in using codebooks
- Helps you understand **structure and layout** of technical standards

- Reinforces memory of **frequently tested sections**

23.2 Recommended Materials

- **IMC (International Mechanical Code)**
- **IFGC (International Fuel Gas Code)**
- **EPA 608 Technician Manual**
- **NEC Article 440** (optional, for electrical code drills)

23.3 Look-Up Exercise Instructions

- Set a timer (30–60 seconds per question)
- Use only the **index and table of contents** to locate answers
- Write down the **section number and correct answer**
- Repeat weekly to improve speed

Code Look-Up Practice Questions

1. What section in the IMC covers condensate disposal for cooling equipment?

→ Book: IMC

→ Answer: _____

→ Section: _____

2. What is the required clearance above a gas vent terminal per IFGC?

→ Book: IFGC

→ Answer: _____

→ Section: _____

3. According to EPA 608, what recovery method is allowed for small appliances with less than 5 lbs. of refrigerant?

→ Book: EPA Manual
→ Answer: _____
→ Section: _____

4. In the IMC, where are requirements for combustion air openings listed?

→ Book: IMC
→ Answer: _____
→ Section: _____

5. What type of vent pipe is required for Category IV appliances per IFGC?

→ Book: IFGC
→ Answer: _____
→ Section: _____

6. Which EPA 608 section explains leak repair requirements for systems over 50 lbs.?

→ Book: EPA Manual
→ Answer: _____
→ Section: _____

7. What is the minimum working clearance in front of mechanical equipment per IMC?

→ Book: IMC
→ Answer: _____
→ Section: _____

8. According to IFGC, how must appliance connectors be secured to prevent strain?

→ Book: IFGC
→ Answer: _____
→ Section: _____

9. Where in IMC is the sizing table for outdoor air ventilation located?

→ Book: IMC
→ Answer: _____
→ Section: _____

10. In EPA 608, what is the maximum leak rate allowed for comfort cooling systems?

→ Book: EPA Manual

→ Answer: _____

→ Section: _____

CODE LOOK-UP PRACTICE QUESTIONS

1. Which section in IMC covers condensate disposal for cooling equipment?

→ Book: IMC

Answer: _____

Section: _____

2. What is required clearance above a gas vent terminal per IFGC/IFGC 308 n.b. q

→ Book: IPA Manual

Answer: _____

Section: _____

3. According EPA 608, regulatory method allowance for opening's for systems over 50 lbs?

→ Book: IMC

Answer: _____

Section: _____

4. What is minimum work clearance in front of mechanical equipment per I

→ Book: IMC

Answer: _____

Section: _____

5. In EPA 608, maximum leak rate allowed for comfort cooling systems per IMC

→ EPA Manual

Answer: _____

Section: _____

6. According to IMC, work requirement for power and maximums for fans for systems over 5 tons

→ Book: IMC

Answer: _____

Section: _____

Answer: _____

Section: _____

Chapter 24: Answer Keys and Rationales

This chapter provides the **answer keys** for Practice Exam #1 and #2, along with clear **rationales** explaining why each correct answer is right. This helps reinforce your understanding and identify areas needing review.

How to Use This Chapter

- Review each missed question
- Read the explanation to understand the concept
- Look up related code sections or illustrations if needed
- Retake the exam after studying your weak areas

Sample Rationales – Practice Exam #1

Question 1:

What is the typical airflow rate required per ton of cooling?

Correct Answer: C – 400 CFM

Rationale: Standard airflow for most systems is 400 CFM per ton to ensure proper heat transfer and comfort.

Question 6:

What happens if a system is overcharged with refrigerant?

Correct Answer: B – Compressor damage

Rationale: Overcharging causes high head pressure and potential compressor overheating.

Question 23:

EPA 608 requires which certification for technicians working on high-pressure systems?

Correct Answer: B – Type II

Rationale: Type II certification covers high-pressure systems like split units and rooftop units.

Question 33:

Which Manual is used for equipment sizing?

Correct Answer: C – Manual S

Rationale: Manual S is used after load calculation (Manual J) to select properly sized HVAC equipment.

Question 50:

What is the best method to confirm a low refrigerant charge?

Correct Answer: C – Check superheat or subcooling

Rationale: Pressure alone is not sufficient. Superheat/subcooling gives an accurate picture of system charge.

Sample Rationales – Practice Exam #2**Question 5:**

What is the function of a TXV?

Correct Answer: B – Controls refrigerant flow into the evaporator

Rationale: A TXV modulates flow to maintain consistent superheat at the evaporator outlet.

Question 12:

Which device stores energy for motor starting?

Correct Answer: C – Capacitor

Rationale: Start and run capacitors store and discharge electrical energy to assist motors.

Question 22:

Required clearance above gas vent terminals per IFGC?

Correct Answer: C – 3 inches

Rationale: IFGC requires a 1" minimum clearance to combustibles and 3" from roof surface unless specified otherwise.

Question 38:

What causes high static pressure in a duct system?

Correct Answer: C – Dirty filter or undersized return

Rationale: These create airflow restrictions that raise static pressure and reduce system efficiency.

Question 49:

What causes a contactor to chatter?

Correct Answer: B – Low 24V voltage

Rationale: Inconsistent control voltage causes the magnetic coil to rapidly open/close.

Chapter 25: Flashcards and Reference Sheets

This chapter provides essential **quick-reference material** and printable flashcards to reinforce core concepts, formulas, and code facts. These are excellent for last-minute review or portable study sessions.

How to Use This Chapter

- Review a few flashcards each day
- Print reference sheets for your study binder
- Focus on **weak areas** before the exam
- Pair with **practice questions** for spaced repetition

Flashcard Categories

1. Key HVAC Terms

- **Superheat:** Temperature of vapor above its boiling point
- **Latent Heat:** Heat involved in a phase change (no temp change)
- **BTU:** Energy to raise 1 lb. of water by 1°F

2. Electrical Formulas

- **Ohm's Law:** $V = I \times R$
- **Watts:** $W = V \times A$

- **Amps:** $A = W \div V$

3. Airflow & Load

- **1 Ton of Cooling** = 12,000 BTU/hr
- **Airflow Rule:** 400 CFM per ton
- **Manual J:** Load calculations
- **Manual D:** Duct design
- **Manual S:** Equipment selection

4. Code Basics

- **IMC Drain Pan Rule:** Required if unit is above conditioned space
- **IFGC Vent Clearance:** 1" from combustibles
- **EPA 608 Leak Limit:** 10% annually for comfort cooling (>50 lbs.)

Printable Reference Sheet – Quick Formulas

Topic	Formula / Rule
Voltage	$V = I \times R$
Current	$I = V \div R$
Power	$W = V \times A$
CFM (airflow)	Velocity $\times$ Area
Duct Friction Rate	Manual D default: 0.1 in. w.c.
Subcooling	Sat. temp – liquid line temp
Superheat	Suction line temp – sat. temp

KEY HVAC TERMS

Superheat: Temperature of vapor above its boiling point

Latent Heat: Heat involved in phase change (no temp change)

BTU: Energy to raise 1 lb. of water by 1°F

AIRFLOW & LOAD

1 Ton of Cooling =
12,000 BTU/hr

Airflow Rule: 400 CFM
per ton

Manual J: Load calculations

Manual D: Duct design

Manual S: Equipment
selection

Voltage $V = I \times R$

Current $I = V \div R$

Power $W = V \times A$

CFM (airflow) Velocity

Duct Friction Rate

Manual D default: 0.1 in. w.c.

ELECTRICAL FORMULAS

Ohm's Law: $V = I \times R$

Watts: $W = V \times A$

Amps: $A = W \div V$

CODE BASICS

IMC Drain Pan Rule:
Required if unit is above
conditioned space

IFGC Vent Clearance:
1" from combustibles

EPA 608 Leak Limit:
10% annually for comfort
cooling (> 50 lbs.)

PRINTABLE REFERENCE SHEET

QUICK FORMULAS

Voltage $V = I \times R$

Superheat 1 sat. temp

Suction line temp - sat.
temp

Final Words Before the Exam

You've made it through the entire guide—from core HVAC fundamentals to real-world service calls, detailed load calculations, safety codes, and two full-length practice exams. That's a tremendous achievement.

As you head into your licensing exam, keep these final thoughts in mind:

- **Mastery comes through repetition.** Revisit areas you struggled with, review your flashcards, and redo any questions you missed.
 - **Practice like it's real.** Use a timer, simulate field calls in your mind, and work with your codebook as if it were the real exam.
 - **Confidence is built, not gifted.** You've put in the time. Trust your training, stay calm, and approach each question with logic and care.
 - **Respect the trade.** Licensing isn't just a formality—it represents safety, skill, and professionalism. Carry that pride into your work every day.
-

You're Ready.

Now go out there and **earn your license**. The HVAC industry needs sharp, reliable professionals—and you're about to become one of them.

Good luck—and stay cool.

— *Grant Beckett*