Canadian Gas Technician - Learning Module 14

Electricity for Gas Technicians

Electrical systems are integral to modern gas heating equipment. From simple thermostats to complex electronic control boards, gas technicians must understand electrical fundamentals to properly install, maintain, and troubleshoot heating systems.

Module Overview

Learning Objectives

Upon completion of this chapter, you will be able to:

Core Competencies

Understand

Fundamental electrical theory including voltage, current, resistance, and power calculations

Apply

Ohm's Law to solve electrical circuit problems

Demonstrate

Safe electrical work practices and lockout/tagout procedures

Technical Skills

1

Use electrical measurement tools

Including multimeters and clamp meters

2

Identify electrical components

Commonly found in gas heating systems

3

Analyze control circuits

And wiring diagrams

4

Install and troubleshoot

Thermostats and control devices

Advanced Competencies

Diagnose

Motor problems and understand motor control systems

Interpret

Ladder diagrams and schematic symbols

Follow

Canadian Electrical Code requirements relevant to gas installations

Why Electrical Knowledge Matters

While gas technicians are not electricians, understanding electricity is essential for:

- Troubleshooting control circuits
- Installing thermostats and controls
- Diagnosing motor failures
- Ensuring safe operation of gas equipment
- Coordinating with electricians when necessary

Chapter 14.1

Basic Electrical Theory

Understanding the fundamental concepts that govern electrical systems

Understanding Electricity

Electricity is the flow of electrons through a conductor. To understand electrical systems in gas equipment, we need to grasp four fundamental concepts:

Voltage (E or V)

The electrical pressure or potential difference. Measured in volts (V). Similar to water pressure in a pipe.

Current (I)

The flow of electrons. Measured in amperes (amps or A). Similar to water flow rate.

Resistance (R)

Opposition to current flow. Measured in ohms (Ω). Similar to pipe restrictions in water systems.

Power (P)

The rate of doing work. Measured in watts (W). Calculated as: $P = V \times I$

Common Voltages in HVAC

24VAC

Control circuits

115/120VAC

Standard equipment

208/230VAC

Larger equipment

460VAC

Commercial/industrial

Types of Current

Direct Current (DC)

Flows in one direction

Used in:

- Electronic control boards (rectified)
- Flame sensors (microamps DC)
- Some smart thermostats
- Battery backup systems

Alternating Current (AC)

Reverses direction periodically

Used in:

- Most HVAC equipment
- Control transformers
- Motors and compressors
- Standard electrical supply

Resistance Factors

Factors affecting resistance:

Material Type

Copper vs. steel

Wire Length

Longer = more resistance

Wire Diameter

Smaller = more resistance

Temperature

Higher = more resistance in most conductors

Common Power Ratings

Blower motors	1/4 to 1 HP (186-746W)
Inducer motors	50-150W
Transformers	20-75VA

Ohm's Law

$$E = I \times R$$

Ohm's Law describes the relationship between voltage, current, and resistance

E = Voltage

Measured in volts

I = Current

Measured in amps

R = Resistance

Measured in ohms

Variations of Ohm's Law

Finding Current

$$I = \frac{E}{R}$$

Finding Resistance

$$R = \frac{E}{I}$$

Finding Voltage

$$E = I \times R$$

Practical Applications

Example 1: Finding Current

A 24V transformer supplies power to a gas valve with 12Ω resistance.

> **Solution:** $I = E/R = 24V \div 12\Omega = 2A$

Example 2: Finding Resistance

A blower motor draws 5A at 115V.

> **Solution:** $R = E/I = 115V \div 5A = 23\Omega$

Example 3: Voltage Drop

A long thermostat wire has 2Ω resistance carrying 0.5A.

> **Solution:** $E = I \times R = 0.5A \times 2\Omega = 1V$ drop

Power Calculations

Basic Power Formula:

$$P = E \times I$$

Combined with Ohm's Law:

$$P = I^2 \times R$$

$$P = \frac{E^2}{R}$$

Three-Phase Power:

$$P = \sqrt{3} \times E \times I \times PF$$

Where PF = Power Factor (typically 0.8-0.95 for motors)

Power Calculation Examples

Single-Phase Motor

- Voltage: 115V
- Current: 4.5A
- Power: $P = 115V \times 4.5A = 517.5W$

Heating Element

- Voltage: 230V
- Resistance: 25Ω
- Power: $P = E^2/R = 230^2 \div 25 = 2{,}116W$

Key AC Concepts

Standard frequency: 60 Hz in North America

Peak Voltage

Maximum instantaneous value

RMS Voltage

Root Mean Square (effective value). 120VAC RMS = 170V peak

Frequency

60 cycles per second (60 Hz)

Phase

Single-phase or three-phase power

Series Circuits

Characteristics

- Single path for current flow
- Current same throughout circuit
- Voltage divides across loads
- Total resistance: RT = R1 + R2 + R3...

Applications in HVAC

- Safety control circuits
- Limit switches in series
- Thermostat circuits

Parallel Circuits

Characteristics

- Multiple paths for current
- Voltage same across all branches
- Current divides between branches
- Total resistance: $1/R_T = 1/R_1 + 1/R_2 + 1/R_3\ldots$

Applications in HVAC

- Operating circuits
- Multiple motors or loads
- Control relay contacts

Series-Parallel Combinations

Most HVAC circuits combine both:

Safety Controls

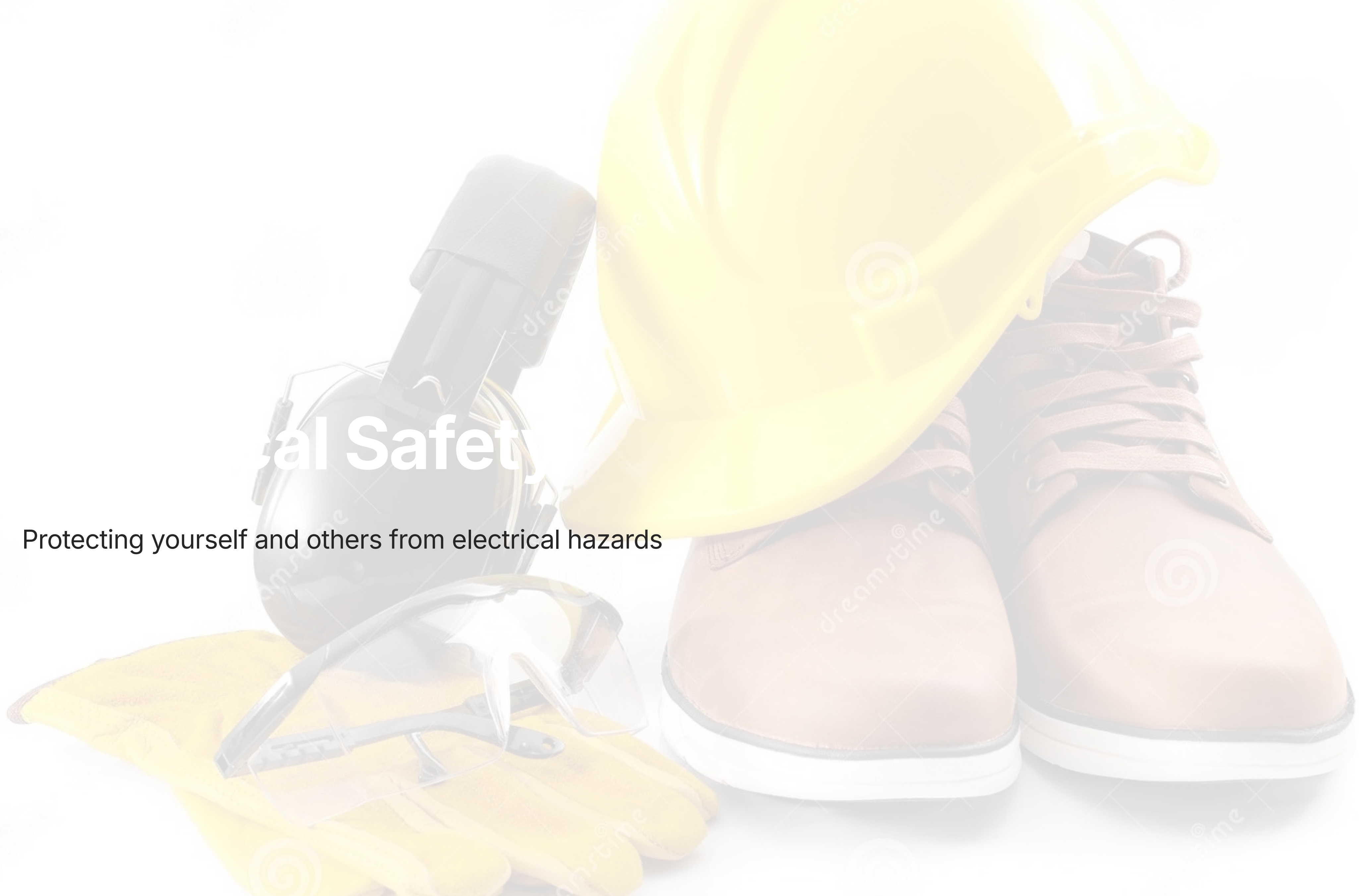
Wired in series

Operating Loads

Wired in parallel

Control and Power

Circuits kept separate



cal Safety

Protecting yourself and others from electrical hazards

Electrical Hazards in Gas Work

Gas technicians face unique electrical hazards:

Shock Hazards

- Working in confined spaces
- Wet or damp conditions
- Metallic ductwork and piping
- Mixed voltages (24V to 600V)

Arc Flash Risks

- Opening electrical panels
- Testing live circuits
- Motor disconnects
- Control panel work

Secondary Hazards

- Falls from ladders due to shock
- Fires from electrical faults
- Explosion risks in gas environments
- Burns from heated components

Pre-Work Safety

Hazard Assessment

- Identify all electrical sources
- Check for water or moisture
- Assess workspace conditions
- Review equipment specifications

Planning

- Determine required PPE
- Gather proper tools
- Plan lockout procedures
- Coordinate with other trades

Safe Working Practices During Work

Voltage Verification

1. Test meter on known source
2. Check circuit with meter
3. Test meter again
4. Treat all circuits as live until proven otherwise

Tool Usage

- Use insulated tools
- Inspect tools before use
- Use proper meter settings
- Never bypass safety devices

Safe Positioning

1. Stand on dry, insulated surface
2. Keep one hand free when possible
3. Position body to side of panels
4. Maintain clear escape route

Lockout/Tagout Procedures

Standard LOTO Process:

01

Preparation

Identify all energy sources, notify affected personnel, gather locks and tags

02

Shutdown

Follow normal shutdown procedure, turn off disconnect switches, close manual gas valves

03

Isolation

Open electrical disconnects, close and lock gas valves, disconnect control power

04

Lockout/Tagout

Apply personal lock, attach warning tag, each worker applies own lock, keep key in personal possession

LOTO Process Continued

01

Stored Energy Release

Discharge capacitors, bleed gas lines, allow motors to stop, release spring tension

02

Verification

Attempt normal startup, test with meter, verify zero energy state

03

Work Performance

Complete required work, maintain locks throughout

04

Restoration

Remove tools and materials, reinstall guards, verify safe conditions, remove locks in reverse order, test operation

Canadian Electrical Code Basics

Relevant CEC Sections for Gas Technicians:

Section 2	General Rules - Electrical room access, working clearances, disconnect requirements
Section 4	Conductors - Wire sizing for motors, temperature ratings, voltage drop limits
Section 10	Grounding and Bonding - Equipment grounding, bonding gas piping, CSST bonding requirements
Section 14	Protection and Control - Overcurrent protection, motor protection, control circuit protection
Section 26	Installation of Electrical Equipment - Furnace connections, appliance requirements, disconnect switches
Section 28	Motors and Generators - Motor installations, overload protection, motor controllers

Key CEC Requirements

Disconnect Location

Within sight and 3m of furnace

Wire Sizing

Proper wire sizing for load

Overcurrent Protection

Proper sizing required

Grounding

All equipment must be grounded

Junction Boxes

Proper junction box usage

Clearances

Maintain manufacturer clearances

Personal Protective Equipment

Minimum PPE for Electrical Work:

Safety Glasses

Side shields required. Arc-rated for panel work.

Insulated Gloves

Class 0 minimum (1000V). Inspected before each use. Leather protectors worn over.

Arc-Rated Clothing

Minimum 8 cal/cm². No synthetic materials. Long sleeves required.

Safety Footwear

CSA approved. Electrical hazard rated. Non-conductive soles.

Additional PPE When Required: Face shield for arc flash risk, insulating mats, hot stick for remote operation, voltage-rated tools

Arc Flash Awareness

Arc Flash Basics

- Temperature can exceed 19,000°C
- Pressure wave can exceed 2,000 lbs/sq.ft
- Sound can exceed 140 dB
- Duration typically 1-5 cycles

Protection Measures

1. Maintain Safe Distance

- Work de-energized when possible
- Use remote racking
- Install barriers

2. PPE Selection

- Based on incident energy
- Follow arc flash labels
- Higher PPE for higher risk

Arc Flash Work Practices

- Minimize exposed live parts
- Use insulated tools
- Position body safely
- Have escape route planned

Chapter 14.3

Electrical Measurement

Using meters and tools to diagnose electrical systems

Using Multimeters

Digital Multimeter Components

- Display (LCD/LED)
- Function selector
- Input jacks
- Test leads
- Range selector (auto/manual)

Basic Functions

- Voltage (AC/DC)
- Current (limited)
- Resistance
- Continuity
- Capacitance (some models)
- Temperature (some models)

Multimeter Safety Ratings

CAT I

Electronic circuits

CAT II

Household receptacles

CAT III

Distribution panels

CAT IV

Utility connections

HVAC work typically requires CAT III 600V minimum

Voltage Testing

AC Voltage Measurement:

01

Preparation

Select VAC function, insert leads (black to COM, red to V), select appropriate range (if manual)

02

Testing Procedure

Test meter on known source, place leads on test points, read display, document reading

03

Common Measurements

Line voltage: 115V, 208V, 230V, 460V. Control voltage: 24VAC. Voltage drop across components

DC Voltage and Safety

DC Voltage Measurement

- Select VDC function
- Observe polarity

Common in:

- Flame sensors (microvolts)
- Electronic boards (5V, 12V, 24V)
- Battery systems

Safety Practices

- Never exceed meter ratings
- Start with highest range
- Keep fingers behind guards
- One hand operation when possible

Continuity Testing

Purpose

- Check for complete circuit path
- Verify switch operation
- Find broken wires
- Test fuses

Procedure

1. Ensure Power is OFF
2. Isolate component if possible
3. Select continuity (Ω or •)))
4. Zero meter if required
5. Test across component
6. Listen for beep or check reading

Interpreting Continuity Results

Continuity

< 1Ω (beep sounds)

No Continuity

OL or infinite

High Resistance

Numerical value displayed

Common Applications:

- Limit switch testing
- Thermostat contacts
- Fuse testing
- Wire tracing
- Motor winding checks

Resistance Measurement

Applications in HVAC

- Motor windings
- Heating elements
- Thermistors
- Solenoid coils
- Sensor resistance

Measurement Procedure

1. Power OFF and verified
2. Disconnect component
3. Select ohms (Ω)
4. Choose appropriate range
5. Zero meter if needed
6. Measure resistance
7. Compare to specifications

Typical Resistance Values

Gas valve solenoid	10-50Ω
Blower motor winding	2-20Ω
Inducer motor	10-50Ω
Transformer primary	1-5Ω
Transformer secondary	0.1-1Ω
Limit switch (closed)	< 1Ω
Flame sensor	Infinite (clean)

Current Measurement

In-Line Current (Multimeter)

- Limited to 10A typically
- Requires breaking circuit
- Used for small loads only

Clamp Meter Advantages

- No circuit interruption
- Safer operation
- Higher current ranges
- Quick measurements

Clamp Meter Procedure

01

Select AC amps

02

Zero meter if needed

03

Open clamp jaws

04

Clamp around single conductor

05

Read display

06

Compare to nameplate

Important Notes: Clamp single conductor only. Not around entire cable. Can multiply turns for low current. Some measure DC current.

Typical Current Draws

1/3 HP blower	3.5-4.5A
1/2 HP blower	4.5-6A
Inducer motor	0.5-1.5A
Gas valve	0.2-0.5A
Hot surface igniter	3-5A
Control transformer	0.3-0.7A

Measurement Safety Precautions

Before Testing

- Inspect meter and leads
- Check meter battery
- Verify meter ratings
- Select correct function
- Wear appropriate PPE

During Testing

- Keep leads separated
- Don't exceed ratings
- Be aware of surroundings
- Maintain stable position
- Watch for unexpected readings

After Testing

- Remove leads from circuit first
- Then remove from meter
- Store properly
- Document readings

Common Measurement Mistakes

- Wrong function selected
- Measuring resistance on live circuit
- Exceeding meter ratings
- Using damaged leads
- Improper range selection
- Not zeroing meter
- Testing without PPE

Chapter 14.4

Electrical Components in Gas Systems

Understanding the key electrical parts in HVAC equipment

Transformers

Purpose: Convert line voltage (115V/230V) to control voltage (24V)

Types

1. Control Transformers

- 40VA most common
- 20VA to 75VA range
- Class 2 (current limited)

2. Multi-Tap Transformers

- Multiple primary voltages
- 115/208/230V common
- Allows field voltage selection

Specifications

- **VA Rating:** Volt-Ampere capacity
- **Primary Voltage:** Input voltage
- **Secondary Voltage:** Output voltage (typically 24VAC)
- **Frequency:** 60 Hz standard
- **Temperature Rise:** 55°C typical

Testing Transformers

01

Primary Voltage Check

Measure across primary terminals. Should match nameplate.

02

Secondary Voltage Check

Measure across secondary. Should be 24-28VAC (no load).

03

VA Load Test

Measure secondary current. Calculate: VA = 24V × Current. Should not exceed rating.

Common Problems: Open primary winding, shorted windings, overloaded (overheating), incorrect wiring, wrong voltage tap

Relays and Contactors

Relays

Electromagnetic switches for control circuits

Components:

- Coil (24V typical)
- Contacts (NO, NC, or both)
- Armature
- Spring return

Types:

1. General Purpose - SPDT, DPDT configurations, 24V coil typical, contacts rated 10-30A

2. Fan Relays - Controls blower motor, 24V coil, heavy-duty contacts

3. Sequencing Relays - Time delay built-in, stages heating elements, prevents power surge

Contactors

Heavy-duty relays for large loads

Specifications:

- Higher current ratings (20-100A+)
- 24V or line voltage coils
- Multiple pole configurations
- Designed for frequent cycling

Applications:

- Electric heating elements
- Large blower motors
- Compressors
- Commercial equipment

Testing Relays

10-50Ω

Coil Resistance

Typical range for relay coils

24VAC

Coil Voltage

Applied voltage for testing

<1Ω

Contact Resistance

When contacts are closed

Switches

Limit Switches - Safety devices that open on high temperature

Primary Limit

- Manual reset
- 200°F typical
- Prevents overheating

Fan Limit

- Auto reset
- Controls blower operation
- 90°F ON, 120°F OFF typical

Rollout Switch

- Detects flame rollout
- Manual or auto reset
- Multiple locations

Testing: Continuity when cold, opens at rated temperature, check for proper location, verify secure mounting

Pressure and Flow Switches

Pressure Switches

1. Furnace Pressure Switch

- Proves inducer operation
- Differential type
- 0.2" to 1.5" W.C. typical

2. Gas Pressure Switch

- High/low gas pressure
- Safety shutdown
- Manual reset often

Testing: Continuity at rest (NO or NC), operation at rated pressure, tubing connections, diaphragm integrity

Flow Switches

- Prove air or water flow
- Paddle or differential type
- Used in commercial systems

Manual Switches

- Disconnect switches
- Service switches
- Door interlock switches

Thermostats Overview

Detailed coverage in Section 14.7

Functions

- Temperature sensing
- Switching control circuits
- System mode selection
- Fan control

Types

- Mechanical (bimetal)
- Electronic
- Programmable
- Smart/WiFi

Solenoids

Gas Valve Solenoids

Operation

- Electromagnetic coil
- Opens valve when energized
- Spring return when de-energized
- 24VAC typical

Types

1. **Single Stage** - One solenoid, full capacity only

2. **Two Stage** - Two solenoids, low and high fire

3. **Modulating** - Variable position, precise control

Testing

- Coil resistance: 10-50Ω
- Current draw: 0.2-0.5A
- Mechanical operation
- No leakage when closed

Other Solenoids

- Pilot valves
- Zone valves
- Oil valves
- Refrigerant valves

Motors Overview

Blower Motors

PSC (Permanent Split Capacitor)

- Single-phase
- Capacitor run
- Multiple speeds (taps)
- 1/4 to 1 HP typical

ECM (Electronically Commutated Motor)

- Variable speed
- High efficiency
- Built-in controls
- Constant airflow

Inducer Motors

- Shaded pole or PSC
- 3000-3450 RPM
- 0.5-2.0 amps typical
- Sealed bearings

Testing Motors: Winding resistance, current draw, capacitor check, bearing condition, rotation direction

Detailed motor coverage in Section 14.8

Capacitors

Run Capacitors

- Continuous duty
- Oil-filled
- Metal case
- 370V or 440V rating
- 5-80 μF typical

Start Capacitors

- Intermittent duty
- Electrolytic
- Plastic case
- 125V or 250V rating
- 50-500 μF typical

Testing Capacitors

01

Visual Inspection

Check for bulging case, oil leakage, burn marks

02

Capacitance Test

Discharge first, use capacitor tester, within ±10% of rating

03

Resistance Test

Should charge then decay, infinite resistance final

Safety: Always discharge before handling. Use insulated screwdriver. Short terminals together. Wait 60 seconds.

Chapter 14.5

Control Circuits

Understanding how electrical controls work together

24V Control Systems

Advantages of 24V Controls:

- Safer to work with
- Lower current requirements
- Smaller wire sizes
- Less expensive components
- Code compliance easier