Canadian Gas Technician - Learning Module 19

Troubleshooting and Diagnostics

Learning Objectives

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

01

Apply systematic troubleshooting methodology to diagnose gas equipment problems

02

Select and use diagnostic tools appropriately for various testing requirements

03

Diagnose common heating system problems using logical sequences

04

Troubleshoot water heater issues efficiently and safely

05

Identify and resolve gas supply problems at various system points

06

Diagnose venting problems and their effects on equipment operation

07

Test and verify control system components systematically

08

Read and interpret wiring diagrams for troubleshooting purposes

09

Apply advanced diagnostic techniques for complex problems

10

Recognize when problems exceed scope of practice and require referral

19.1 Systematic Troubleshooting Approach

Successful troubleshooting requires a methodical approach that eliminates guesswork and ensures efficient problem resolution.

The Diagnostic Process

A systematic approach saves time, reduces callbacks, and ensures customer satisfaction.

Overview of Systematic Troubleshooting

Key Principles:

Never assume

Verify every piece of information

One change at a time

Isolate variables

Document everything

Create a clear record

Safety first

Never bypass safety devices

Understand before acting

Know the system

Verify the repair

Ensure complete resolution

Benefits of Systematic Approach:

- Faster diagnosis
- Fewer parts changed unnecessarily
- Better customer communication
- Reduced liability
- Professional reputation
- Training documentation

Common Mistakes to Avoid:

- Jumping to conclusions
- Changing multiple parts
- Ignoring customer input
- Skipping verification
- Poor documentation
- Not testing after repair

Gathering Information

The foundation of accurate diagnosis is comprehensive information gathering.

Customer Interview

Essential Questions:

1. Problem Description:

- "What exactly is happening?"
- "When did it start?"
- "Has it happened before?"
- "What were you doing when it occurred?"
- "Have you noticed any patterns?"

2. System History:

- "How old is the equipment?"
- "When was last service?"
- "Any recent repairs?"
- "Any other work done recently?"
- "Has it always worked this way?"

3. Environmental Factors:

- "Any unusual sounds?"
- "Any strange odors?"
- "Changes in utility bills?"
- "Other appliances affected?"
- "Recent weather events?"

Visual Inspection

Initial Observations:

- Equipment condition
- Installation quality
- Obvious damage
- Modifications
- Environmental conditions
- Safety hazards

Detailed Inspection Points:

Component	Check For
Furnace exterior	Rust, damage, labels
Venting	Corrosion, gaps, slope
Gas piping	Leaks, support, sizing
Electrical	Burn marks, loose connections
Filters	Condition, type, fit
Thermostat	Level, location, settings
Combustion area	Soot, debris, damage
Drainage	Clogs, traps, slope

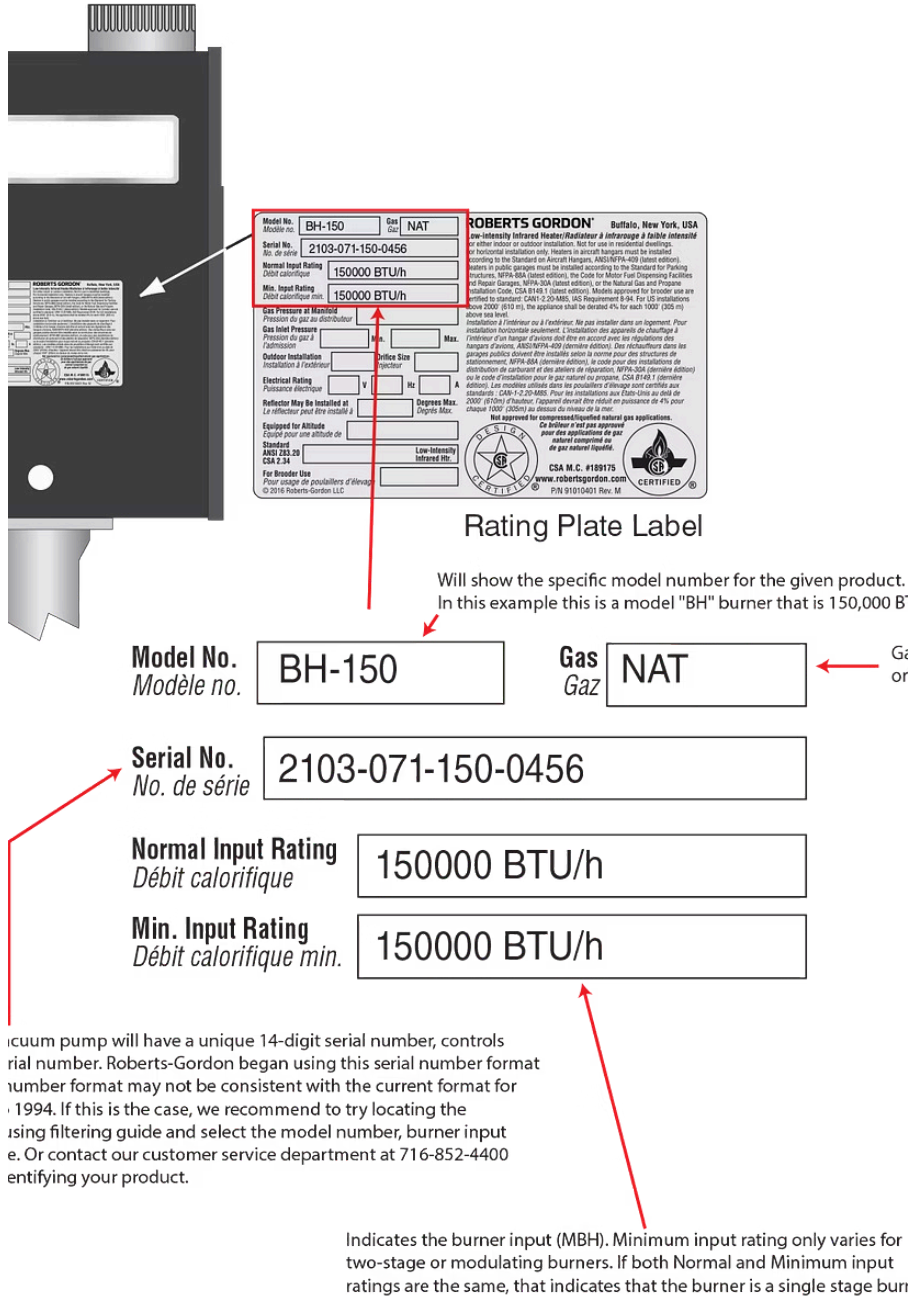
Equipment History Review

Documentation Sources:

- Service records
- Installation manual
- Previous invoices
- Warranty information
- Equipment data plate
- Error code history

Critical Information:

- Model and serial numbers
- Manufacturing date
- BTU rating
- Electrical requirements
- Gas type
- Previous problems



Understanding Normal Operation

Cannot diagnose abnormal without understanding normal.

Sequence of Operation Knowledge

Standard Furnace Sequence:

Thermostat Call

R to W closed
24V to control board
Board initiates sequence

Inducer Start

Inducer motor energized
Pressure switch proves
Pre-purge period

Ignition Sequence

Igniter energized
Gas valve opens
Flame detected
Igniter de-energized

Blower Operation

Blower-on delay
Speed selection
Continuous operation
Blower-off delay

Satisfied Call

Gas valve closes
Inducer continues
Post-purge
Blower-off delay

Normal Operating Parameters

Typical Values:

Parameter	Normal Range
Temperature rise	40-70°F
Supply temperature	110-140°F
Return temperature	65-75°F
Gas pressure (NG)	7" W.C.
Manifold pressure	3.5" W.C.
Draft pressure	-0.02" to -0.05" W.C.
Flame sensor	2-6 µA DC
Inducer amp draw	80% of nameplate

Normal Sounds:

- Inducer startup whoosh
- Igniter clicking or glow
- Gas valve click
- Burner ignition whoosh
- Blower motor hum
- Expansion/contraction ticking

Normal Timing:

- Inducer pre-purge: 30-60 seconds
- Igniter warm-up: 15-45 seconds
- Trial for ignition: 4-7 seconds
- Blower-on delay: 30-90 seconds
- Blower-off delay: 60-180 seconds

Isolating the Problem

Systematic isolation narrows the possibilities.

Problem Classification

Categories:

1. No Operation:

- Complete failure
- No response
- Dead system

2. Partial Operation:

- Starts but stops
- Intermittent operation
- Some functions work

3. Poor Performance:

- Inadequate heating
- High bills
- Comfort issues

4. Safety Issues:

- CO production
- Gas odors
- Electrical problems

Isolation Techniques

Divide and Conquer:

1. System Level:

- Power supply OK?
- Gas supply OK?
- Thermostat calling?

2. Circuit Level:

- Control voltage present?
- Safety circuit complete?
- Operating controls functioning?

3. Component Level:

- Individual component tests
- Resistance checks
- Voltage measurements

Using Process of Elimination:

- List all possibilities
- Test easiest first
- Eliminate confirmed good
- Focus on remaining
- Verify assumptions

Voltage Testing Path:

1. Line voltage at disconnect
2. Line voltage at unit
3. Transformer primary
4. Transformer secondary
5. Through safety circuit
6. To operating controls
7. To loads

Testing Hypotheses

Develop and test theories systematically.

Hypothesis Development

Based on Symptoms:

Symptom	Possible Causes
No heat, no blower	No power, bad transformer
Blower only	No gas, failed ignition
Cycles on limit	Airflow, gas pressure
Short cycles	Thermostat, flame sensor
Won't ignite	Gas valve, igniter

Prioritizing Tests:

1. **Most likely** based on symptoms
2. **Easiest to test** first
3. **Least invasive** tests
4. **Most dangerous** last
5. **Most expensive** last

Test Procedures

Safe Testing Practices:

- Lock out/tag out
- Verify meter operation
- Use proper PPE
- One hand rule
- Insulated tools
- Know escape route

Component Testing:

1. **Visual inspection**
2. **Mechanical operation**
3. **Electrical continuity**
4. **Resistance values**
5. **Voltage presence**
6. **Current draw**
7. **Functional test**

Recording Results:

- Test performed
- Expected value
- Actual value
- Pass/fail
- Time/date
- Conditions

Making Repairs

Execute repairs professionally and safely.

Repair Preparation

Parts Acquisition:

- Verify correct part
- Check availability
- Consider upgrades
- Have backup plan
- Price approval

Customer Communication:

- Explain problem clearly
- Describe solution
- Provide options
- Get authorization
- Set expectations

Safety Considerations:

- Shut off power
- Close gas valve
- Allow cooling
- Ventilate area
- Protect property

Repair Execution

Best Practices:

1. **Follow manufacturer procedures**
2. **Use correct tools**
3. **Take photos before**
4. **Label wires/connections**
5. **Clean as you go**
6. **Check related components**

Common Repair Procedures:

Component	Key Points
Flame sensor	Clean with steel wool
Igniter	Handle carefully, check position
Gas valve	Don't force, check voltage
Pressure switch	Check tubing first
Blower motor	Check capacitor too
Transformer	Verify voltage rating

Quality Control:

- Proper torque
- Secure mounting
- Wire routing
- No gas leaks
- Electrical safety
- Clean work area

Verification

Confirm complete problem resolution.

Operational Verification

Complete Test Cycle:

01

Initial Power-Up:

- Check for errors
- Listen for abnormal sounds
- Watch sequence
- Verify ignition
- Monitor operation

02

Full Cycle Test:

- Normal startup
- Steady operation
- Proper temperatures
- Normal shutdown
- Post-purge completion

03

Multiple Cycles:

- Three minimum
- Consistent operation
- No error codes
- Proper timing
- Customer satisfaction

Performance Verification

Measurements Required:

- Temperature rise
- Gas pressure
- Manifold pressure
- Amp draws
- Combustion analysis
- Draft test
- CO in space

Comparing to Specifications:

Parameter	Specification	Actual	Pass/Fail
Temp rise	40-70°F	55°F	Pass
Gas pressure	7" W.C.	7.2"	Pass
CO	<100 ppm	35 ppm	Pass

Safety Verification

Critical Checks:

- [ ] All safeties operational
- [ ] No gas leaks
- [ ] Proper venting
- [ ] Electrical safety
- [ ] CO levels safe
- [ ] Proper combustion

Safety First: Never compromise on safety verification. All safety devices must be tested and proven operational before leaving the job site.

Documentation

Complete records protect everyone involved.

Service Report Contents

Required Information:

1. Customer Data:

- Name and address
- Phone numbers
- Email address
- Account number
- Service address

2. Equipment Data:

- Make and model
- Serial number
- Age
- Location
- Accessories

3. Problem Description:

- Customer complaint
- Symptoms found
- Diagnostic steps
- Root cause
- Contributing factors

4. Work Performed:

- Parts replaced
- Adjustments made
- Cleaning done
- Tests performed
- Results achieved

5. Recommendations:

- Additional repairs
- Maintenance needs
- Safety concerns
- Upgrade options
- Follow-up required

Technical Documentation

Test Results:

- Before and after readings
- All measurements taken
- Combustion analysis
- Electrical values
- Temperature readings
- Pressure measurements

Parts Information:

- Part numbers
- Descriptions
- Warranty status
- Cost
- Source

Photos/Diagrams:

- Problem areas
- Before repair
- After repair
- Model/serial plates
- Unusual conditions

Legal Documentation

Liability Protection:

- Work authorization
- Safety notifications
- Code violations noted
- Recommendations declined
- Warranty terms
- Payment received

Follow-Up Requirements:

- Warranty registration
- Callback scheduled
- Parts ordered
- Permits required
- Inspection needed
- Customer training

19.2 Diagnostic Tools and Their Use

Professional diagnostic tools are essential for accurate troubleshooting.

Multimeters

The most versatile diagnostic tool for HVAC technicians.

Types and Features

Digital Multimeters (DMM):

Essential Features:

- Auto-ranging
- True RMS
- Min/Max recording
- Backlight
- CAT III 600V minimum
- Temperature probe capability

Measurements Capabilities:

- AC/DC voltage
- AC/DC current
- Resistance
- Continuity
- Capacitance
- Frequency
- Temperature
- Diode test

Specialty Features:

- Clamp-on amp probe
- Data logging
- Wireless connectivity
- Ghost voltage elimination
- Low impedance mode
- Non-contact voltage

Proper Use Procedures

Safety First:

01

Inspect before use:

- Leads not damaged
- Probes intact
- Display functional
- Battery good
- Correct CAT rating

02

Test on known source:

- Verify operation
- Correct reading
- Proper function
- Lead continuity

03

Select correct function:

- Voltage type (AC/DC)
- Expected range
- Proper terminals
- Special functions

Voltage Measurements:

AC Voltage Testing:

- Set to AC voltage
- Start high range
- Black to neutral/ground
- Red to hot
- Read display
- Note ghost voltages

DC Voltage Testing:

- Set to DC voltage
- Observe polarity
- Common HVAC: 24VDC controls
- Flame sensors: microamps DC
- Some motors: DC

Testing Sequence:

1. Power supply voltage
2. Transformer primary
3. Transformer secondary
4. Control voltage
5. Load voltage
6. Voltage drops

Resistance Testing:

Safety Critical:

- POWER OFF
- Discharge capacitors
- Isolate component
- Zero meter if needed

Common Tests:

Component	Expected Resistance
Transformer primary	5-50Ω
Transformer secondary	0.5-5Ω
Gas valve coil	10-50Ω
Igniter (hot surface)	40-200Ω
Flame sensor	Open (clean)
Limit switch	0Ω (closed)
Pressure switch	0Ω (closed)

Continuity Testing:

- Audible beep helpful
- Less than 1Ω typical
- Check switches
- Verify fuses
- Test wiring
- Find opens

Current Measurements:

Clamp-On Method:

- Single conductor only
- Perpendicular to wire
- Centered in jaws
- Away from other fields
- Stable reading

In-Line Method:

- Break circuit
- Series connection
- Proper range
- Start high
- Safety precautions

Common Current Draws:

Component	Typical Amps
Inducer motor	0.5-2.0A
Blower motor	3.0-15.0A
Hot surface igniter	3.5-5.5A
Gas valve	0.5-1.0A

Manometers

Essential for pressure measurements in gas systems.

Types of Manometers

U-Tube Manometer:

- Simple and reliable
- No calibration needed
- Reads directly
- Limited range
- Fragile

Inclined Manometer:

- More sensitive
- Easier reading
- Draft measurements
- Portable
- Moderate cost

Digital Manometer:

- High accuracy
- Multiple scales
- Data logging
- Differential pressure
- Easy reading

Magnehelic Gauge:

- Analog display
- Permanent installation
- Various ranges
- Reliable
- No power needed

Pressure Measurements

Gas Pressure Testing:

Equipment Setup:

1. Select proper port
2. Install test fitting
3. Connect tubing
4. Zero gauge
5. Open test port
6. Read pressure

Test Points:

Location	Purpose	Expected
Meter outlet	Supply pressure	7" W.C. (NG)
Appliance inlet	After regulator	7" W.C.
Manifold	Burner pressure	3.5" W.C.
Propane tank	Tank pressure	Varies

Testing Procedures:

1. Static Pressure:

- All appliances off
- Maximum available
- Identify restrictions

2. Operating Pressure:

- All appliances on
- Actual working pressure
- Identify undersizing

3. Lockup Pressure:

- Appliance cycles off
- Regulator performance
- Should match static

Draft Measurements:

Natural Draft:

- Over-fire draft
- Breach draft
- Stack draft
- Room pressure
- Typical: -0.02" to -0.05" W.C.

Induced Draft:

- Pressure switch setting
- Heat exchanger pressure
- Venting pressure
- Combustion air pressure

Static Pressure Testing:

Supply Static:

- Before filter
- After filter
- After coil
- At furthest register
- Calculate total

Return Static:

- At grille
- Before filter
- At furnace
- Total return
- Compare to specs

Total External Static:

- Supply + Return
- Compare to blower table
- Identify restrictions
- Verify airflow

Combustion Analyzers

Critical for safety and efficiency testing.

Analyzer Components

Basic Features:

- O_2 sensor
- CO sensor
- Temperature probes
- Draft measurement
- Calculated values

Advanced Features:

- NO/NOx sensors
- CO_2 direct measurement
- Printer capability
- Data logging
- Wireless connectivity

Sensor Types:

Sensor	Life Expectancy	Calibration
O_2	2-4 years	Annual
CO	3-5 years	Annual
NO	2-3 years	Annual
Temperature	5+ years	As needed

Combustion Testing Procedures

Test Preparation:

01

Equipment Warmup:

- Analyzer on 5 minutes
- Auto-zero in fresh air
- Check battery
- Verify calibration date
- Print header

02

Appliance Preparation:

- Run 10 minutes minimum
- Steady state operation
- Drill test holes if needed
- Seal around probe
- Record conditions

Sampling Locations:

Appliance Type	Sample Point
Natural draft	Above draft hood
Induced draft	Before inducer
Condensing	Exhaust terminal
Power vent	Before vent motor

Test Procedure:

1. Insert probe
2. Wait for stable reading
3. Record all values
4. Test multiple rates
5. Print results
6. Seal test holes

Interpreting Results

Acceptable Ranges:

Parameter	Natural Draft	Induced	Condensing
O_2	6-9%	5-9%	4-7%
CO	<100 ppm	<100 ppm	<100 ppm
CO_2	6-9%	7-9.5%	8-10%
Efficiency	75-80%	78-83%	90-98%
Stack temp	350-500°F	300-450°F	80-120°F

Problem Indicators:

Reading	Indicates
High O_2	Excess air, leaks
Low O_2	Insufficient air
High CO	Incomplete combustion
Low efficiency	Needs service
High stack temp	Scale, soot

Adjustments:

- Air shutter position
- Gas pressure
- Baffle position
- Inducer speed
- Orifice sizing

Temperature Measurement

Various methods for different applications.

Temperature Measurement Tools

Thermometers Types:

Digital Pocket:

- Quick checks
- ±1°F accuracy
- Supply/return air
- Water temperature
- Ambient readings

Infrared (IR):

- Non-contact
- Surface temperature
- Spot ratio important
- Emissivity affects
- Quick scanning

Thermocouple Meters:

- Type K common
- Wide range
- Fast response
- Multiple inputs
- Data logging

Clamp-On Pipe:

- Pipe surface
- No penetration
- Insulate sensor
- Allow stabilization
- Good contact essential

Measurement Applications

Air Temperatures:

Location	Purpose	Typical Range
Return air	System input	65-75°F
Supply air	System output	100-140°F
Room ambient	Comfort check	68-78°F
Outside air	Reference	Varies
Mixed air	Economizer	Calculated

Surface Temperatures:

- Heat exchanger
- Refrigerant lines
- Pipe temperatures
- Motor housing
- Electrical connections

Temperature Rise Calculation:

- Supply - Return = Rise
- Compare to nameplate
- Indicates airflow
- Affects efficiency

Example:

- Supply: 120°F
- Return: 70°F
- Rise: 50°F
- Nameplate: 45-75°F
- Status: Normal

Amp Meters

Essential for motor and electrical diagnostics.

Clamp-On Amp Meters

Features:

- AC/DC capability
- Auto-ranging
- Peak hold
- Inrush current
- Min/Max recording

Proper Use:

1. Select AC or DC
2. Zero if needed
3. Open jaws fully
4. Center conductor
5. Close completely
6. Read display

Applications:

Component	Purpose
Blower motor	Verify operation, check load
Inducer motor	Confirm operation
Compressor	Check operation
Electric heat	Verify elements
Transformers	Check loading

Current Analysis

Motor Diagnostics:

Normal vs. Abnormal:

Condition	Current Draw
Normal	80-100% FLA
Overloaded	>110% FLA
Worn bearings	105-115% FLA
Low voltage	>100% FLA
High voltage	<100% FLA
Single phasing	150-200% FLA

Locked Rotor Amps:

- Starting current
- 4-6× running
- Duration important
- Hard start conditions
- Capacitor problems

Power Factor:

- Watts ÷ (Volts × Amps)
- Normal: 0.7-0.9
- Low indicates problems
- Capacitor issues
- Motor problems

Gas Leak Detectors

Critical safety equipment for gas technicians.

Types of Detectors

Electronic Combustible Gas:

- Semiconductor sensor
- Heated element
- PPM sensitivity
- Audible/visual alarm
- Requires warmup

Ultrasonic:

- Detects turbulence
- Works all gases
- No calibration
- Noisy environments difficult
- Expensive

Bubble Solution:

- Visual confirmation
- Pinpoints exact location
- No false positives
- Temperature limited
- Time consuming

Proper Use Procedures

Electronic Detector Use:

01

Calibration:

- Fresh air zero
- Test with known source
- Adjust sensitivity
- Verify battery

02

Search Pattern:

- Start at meter
- Work toward appliances
- Check all joints
- Test valves
- Include flex connectors

03

When Leak Found:

- Verify with bubbles
- Mark location
- Determine severity
- Take appropriate action
- Document

Leak Classification:

Class	Reading	Action
Grade 1	>1% gas	Immediate repair
Grade 2	<1% gas, hazardous	Scheduled repair
Grade 3	<1% gas, not hazardous	Monitor

Safety Protocol:

- No ignition sources
- Ventilate area
- Evacuate if needed
- Call gas company
- Document everything

19.3 Common Heating System Problems

Understanding common failures speeds diagnosis and repair.

No Heat Calls

The most common service call requires systematic diagnosis.

Power Supply Issues

Electrical Problems:

No Power:

- Tripped breaker
- Blown fuse
- Disconnect off
- Emergency switch off
- Power outage

Diagnostic Steps:

1. Check breaker/fuse
2. Verify disconnect on
3. Test line voltage
4. Check door switch
5. Test transformer primary

Low Voltage:

- Affects performance
- Increased amp draw
- Motor overheating
- Control problems
- Voltage drop calculations

Control Power Problems

Transformer Failures:

Testing:

1. Primary voltage present
2. Secondary voltage output
3. VA rating adequate
4. Proper grounding
5. No shorts

Common Causes:

- Shorted secondary
- Overloaded
- Primary voltage high
- Age/heat damage
- Water damage

Fuse Issues:

- 3-5 amp typical
- Automotive type
- Check holder
- Proper rating
- Find short cause

Thermostat Problems

No Call for Heat:

- Dead batteries
- Programming error
- Set to cooling
- Temperature satisfied
- Anticipator problem

Testing:

1. Jump R to W
2. Check voltage R-C
3. Verify W output
4. Test cable continuity
5. Check programming

Safety Circuit Opens

Common Safety Switches:

Switch	Purpose	Test Method
Limit	Overheat protection	Continuity, temperature
Rollout	Flame rollout	Continuity, manual reset
Pressure	Vent blockage	Tubing, continuity
Door	Cover interlock	Continuity, adjustment

Diagnostic Process:

1. Identify which safety
2. Test continuity
3. Determine why open
4. Fix root cause
5. Test operation

Insufficient Heat

System runs but doesn't maintain temperature.

Sizing Issues

Undersized Equipment:

- Heat loss exceeds capacity
- Runs continuously
- Never reaches setpoint
- High utility bills
- Comfort complaints

Calculations:

- Perform heat loss
- Compare to output
- Check actual input
- Verify altitude derating
- Consider additions/changes

Airflow Problems

Restricted Airflow Causes:

Filter Issues:

- Dirty filter
- Wrong size
- Collapsed filter
- Missing filter
- Restrictive type

Duct Problems:

- Closed dampers
- Crushed flex
- Disconnected runs
- Undersized ducts
- Blocked registers

Blower Issues:

- Wrong speed
- Dirty wheel
- Belt slipping
- Motor weak
- Capacitor bad

Testing Airflow:

Method	Application
Temperature rise	Quick check
Static pressure	Detailed analysis
Anemometer	Actual CFM
Flow hood	Register flow

Gas Pressure Problems

Low Gas Pressure:

Symptoms:

- Yellow flames
- Delayed ignition
- Low input
- Poor heating
- Flame lifting

Causes:

- Meter/regulator problem
- Undersized piping
- Other loads operating
- Supply issue
- Restrictions

Testing:

1. Static pressure test
2. Operating pressure
3. Manifold pressure
4. Multiple appliances
5. Document readings

Short Cycling

Frequent on/off cycling indicates problems.

Thermostat-Related Causes

Location Issues:

- Near supply register
- On outside wall
- Near heat source
- Drafty location
- Direct sunlight

Anticipator Problems:

- Set too low (mechanical)
- Cycles per hour (digital)
- Swing setting
- Differential adjustment
- Smart recovery

Solutions:

- Relocate thermostat
- Adjust anticipator
- Change CPH setting
- Increase differential
- Disable smart features

Limit Switch Trips

High Limit Causes:

Airflow Restriction:

- Dirty filter
- Blocked returns
- Closed registers
- Duct problems
- Blower failure

Overfiring:

- High gas pressure
- Wrong orifices
- Altitude issues
- Improper conversion

Testing:

1. Check temperature rise
2. Measure static pressure
3. Verify gas pressure
4. Test limit operation
5. Inspect heat exchanger

Flame Sensor Issues

Weak Signal:

- Dirty sensor
- Poor ground
- Wrong position
- Wire problems
- Control board issue

Testing:

- Measure microamps
- Clean sensor
- Check ground
- Test wire
- Replace if needed

Normal: 2-6 µA DC

Blower Problems

Critical for heat distribution and system protection.

Motor Failures

Types of Motors:

Type	Characteristics	Common Problems
PSC	Single speed, capacitor	Capacitor, bearings
ECM	Variable speed, efficient	Module, programming
Shaded pole	Simple, low power	Bearings, overheating

Diagnostic Tests:

1. Electrical:

- Voltage present
- Amp draw
- Capacitor test
- Winding resistance
- Ground test

2. Mechanical:

- Free spinning
- Bearing noise
- Shaft play
- Balance
- Coupling

Belt Drive Issues

Belt Problems:

- Loose belt
- Worn belt
- Wrong size
- Misalignment
- Pulley wear

Adjustment:

- 1/2" deflection
- Proper tension
- Parallel alignment
- Same plane
- Correct belt type

Bearing Failures

Symptoms:

- Noise
- High amp draw
- Hot running
- Vibration
- Intermittent operation

Testing:

- Spin freely
- Lateral play
- End play
- Temperature
- Sound

Lubrication:

- Oil type
- Oil amount
- Frequency
- Over-oiling problems
- Sealed bearings

Ignition Failures

Various ignition types require different diagnostics.

Hot Surface Igniter Problems

Testing HSI:

Test	Specification
Resistance	40-200Ω
Amp draw	3.5-5.5A
Voltage	120VAC
Position	1/4" from burner
Condition	No cracks

Common Failures:

- Cracked element
- Contamination
- Wrong position
- Voltage problems
- Control board issue

Spark Ignition Issues

Spark Problems:

- No spark
- Weak spark
- Wrong gap
- Grounding issue
- Module failure

Testing:

1. Gap: 1/8" typical
2. Spark rate: 1-2/second
3. Ground: Good connection
4. Insulator: Not cracked
5. Wire: Good condition

Direct Ignition Problems

System Components:

- Igniter/sensor combo
- Control module
- Gas valve
- Flame sensing circuit

Diagnostics:

- Spark present
- Gas valve opens
- Flame established
- Sensing circuit works
- Proper timing

Flame Sensor Issues

Critical for safe operation and preventing nuisance shutdowns.

Flame Sensing Principles

Flame Rectification:

- AC applied to sensor
- Flame conducts to ground
- DC component created
- Microamp signal generated
- Control board detects

Requirements:

- Good ground
- Clean sensor
- Proper position
- Adequate flame
- Control board function

Common Problems

Dirty Sensor:

- Carbon buildup
- Oxidation
- Contamination
- Silicon coating
- Corrosion

Position Issues:

- Too far from flame
- Too close
- Wrong angle
- Loose mounting
- Bent sensor

Cleaning:

- Steel wool
- Fine sandpaper
- No chemicals
- Gentle pressure
- Check porcelain

Proper Position:

- In flame path
- 1/2" typical
- Stable mounting
- Good flame contact
- Away from metal

Testing and Measurement

Microamp Testing:

1. Meter in series
2. DC microamps scale
3. Burner operating
4. Read display
5. Compare to spec

Specifications:

Condition	Reading
Good	4-6 µA
Marginal	2-4 µA
Replace	<2 µA

Improving Signal:

- Clean sensor
- Check ground
- Verify gas pressure
- Adjust position
- Replace if needed

Limit Switch Trips

Safety device protecting against overheating.

Types of Limit Switches

Primary Limit:

- Main high limit
- Auto reset typical
- 160-200°F typical
- Bimetal or bulb
- Series with gas valve

Secondary Limit:

- Backup protection
- Manual reset often
- Higher temperature
- Redundant safety
- Code required

Rollout Switch:

- Flame rollout protection
- Manual reset
- Multiple locations
- Very high temp
- Serious problem indicator

Diagnostic Procedures

Why Limit Trips:

1. Restricted Airflow:

- Most common cause
- Filter/duct/register
- Blower problems
- High static pressure

2. Overfiring:

- Gas pressure high
- Wrong orifices
- Improper conversion

3. Heat Exchanger:

- Restricted passages
- Scaled/sooted
- Damaged baffles

Testing:

1. Check temperature rise
2. Measure static pressure
3. Verify blower operation
4. Test actual limit temp
5. Inspect heat exchanger

Resetting Procedures

Auto Reset:

- Cools down automatically
- Resets itself
- Find root cause
- Don't bypass

Manual Reset:

- Push button reset
- Must cool first
- Investigation required
- Document cause
- Safety concern

Never Bypass Safety Limits!

Inducer Motor Problems

Critical component for safe venting and combustion.

Motor Types and Issues

Shaded Pole:

- Simple design
- Low cost
- Limited life
- Bearing problems
- Not repairable

PSC Motor:

- Capacitor run
- More efficient
- Repairable
- Bearing/capacitor issues

ECM Motor:

- Variable speed
- High efficiency
- Module problems
- Expensive
- Programming issues

Common Failures

Mechanical:

Problem	Symptoms
Bearings	Noise, binding
Wheel damage	Vibration, reduced flow
Housing cracks	Leaks, CO risk
Coupling	Slipping, noise
Water damage	Corrosion, freezing

Electrical:

- Open windings
- Shorted windings
- Capacitor (PSC)
- Module (ECM)
- Connections

Testing Procedures

Electrical Tests:

1. Voltage to motor
2. Amp draw test
3. Resistance check
4. Capacitor test (PSC)
5. Ground test

Mechanical Tests:

1. Free spinning
2. End play
3. Bearing condition
4. Wheel integrity
5. Housing seal

Pressure Switch Test:

1. Tubing clear
2. Port clean
3. Proper vacuum
4. Switch contacts
5. Electrical continuity

19.4 Common Water Heater Problems

Water heater diagnosis requires understanding of various systems.

No Hot Water

No Hot Water - Complete Diagnosis

Complete lack of hot water indicates major component failure.

Gas Supply Issues

No Gas Flow:

- Shut-off closed
- Meter off
- Propane empty
- Service interrupted
- Locked valve

Diagnostic Steps:

1. Verify pilot lit
2. Check shut-off valve
3. Test gas pressure
4. Check other appliances
5. Call gas company if needed

Pilot System Problems

Pilot Won't Light:

Causes:

- No gas
- Air in line
- Thermocouple bad
- Dirty orifice
- Wrong gas type

Lighting Procedure:

1. Turn to pilot
2. Push button down
3. Light pilot
4. Hold 30-60 seconds
5. Release slowly
6. Turn to ON

Pilot Won't Stay Lit:

Problem	Test	Solution
Thermocouple bad	Millivolt test	Replace
Loose connection	Tighten	Secure
Dirty pilot	Visual	Clean
Drafts	Observe	Shield
Gas valve	Replace valve	New valve

Electronic Ignition Failures

Hot Surface Ignition:

- Igniter cracked
- No voltage
- Control board
- Sensor problems
- Wiring issues

Testing:

1. Voltage to igniter
2. Resistance test
3. Visual inspection
4. Amp draw
5. Control outputs

Spark Ignition:

- No spark
- Weak spark
- Gap issues
- Ground problems
- Module failure

Control Problems

Thermostats:

- Contacts stuck open
- Wrong setting
- Wiring problems
- Digital failure
- Programming error

Testing:

- Voltage to valve
- Coil resistance
- Manual operation
- Inlet pressure
- Outlet flow

Gas Valve:

- Coil open
- Mechanical failure
- No voltage
- Safety lockout
- Regulator problem

Inadequate Hot Water

System produces some hot water but not enough.

Capacity Issues

Undersized Tank:

- Family size increased
- Usage patterns changed
- Added fixtures
- Simultaneous use

Calculations:

Family Size	Tank Size (Gas)
1-2	30-40 gallons
2-3	40 gallons
3-4	50 gallons
4+	75+ gallons

First Hour Rating:

- Tank capacity
- Plus recovery
- More accurate sizing
- Matches peak demand

Recovery Problems

Low BTU Input:

Causes:

- Low gas pressure
- Dirty burner
- Wrong orifice
- Altitude derating
- Improper air

Testing:

1. Clock gas meter
2. Calculate BTU/hr
3. Compare to rating
4. Check gas pressure
5. Inspect burner

Recovery Rates:

BTU Input	Gallons/Hour (100°F rise)
30,000	30
40,000	40
50,000	50
75,000	75

Temperature Settings

Thermostat Issues:

- Set too low
- Out of calibration
- Sensing bulb problem
- Differential too wide
- Scale buildup

Proper Settings:

- 120°F recommended
- 140°F maximum residential
- Check with thermometer
- Both thermostats same
- Adjust as needed

Dip Tube Problems

Broken Dip Tube:

- Cold water short-circuits
- Reduced hot water
- Plastic particles
- Common in certain years
- Replace required

Symptoms:

- Short draws OK
- Long draws cold
- Intermittent temperature
- Plastic in aerators
- Age 5-15 years

Pilot Problems

Pilot issues are common in older water heaters.

Pilot Outages

Common Causes:

Cause	Test Method	Solution
Drafts	Observe flame	Shield pilot
Condensation	Check venting	Improve venting
Thermocouple	Millivolt test	Replace
Gas pressure	Manometer	Adjust/repair
Dirty pilot	Visual	Clean assembly

Thermocouple Testing

Millivolt Test:

1. Remove from gas valve
2. Heat with pilot
3. Measure DC millivolts
4. Should read 20-30 mV
5. Under 20 mV replace

Resistance Test:

- Should read <1Ω
- Open = bad
- High resistance = bad

Pilot Assembly Service

Cleaning Procedure:

1. Turn off gas
2. Remove assembly
3. Clean orifice
4. Clean hood
5. Check thermocouple
6. Reassemble
7. Adjust flame

Proper Pilot Flame:

- Blue cone
- Soft blue mantle
- Wraps thermocouple
- Steady flame
- 1-1.5" total height

Burner Issues

Main burner problems affect heating efficiency.

Delayed Ignition

Causes:

- Dirty burner ports
- Low gas pressure
- Improper air mixture
- Pilot position
- Control valve slow

Solutions:

- Clean burner
- Adjust gas pressure
- Check pilot position
- Service control valve
- Verify venting

Dangers:

- Mini explosion
- Flame rollout
- Component damage
- CO production
- Safety hazard

Flame Characteristics

Normal Flame:

- Soft blue
- Minimal yellow tips
- Even distribution
- Stable flame
- No lifting

Abnormal Flames:

Appearance	Cause	Solution
Yellow	Lack of air	Clean, adjust
Lifting	Excess air	Reduce air
Loud	Resonance	Adjust
Flashback	Low pressure	Increase

Burner Maintenance

Cleaning:

1. Remove burner
2. Brush ports clean
3. Clear venturi
4. Check for rust
5. Reinstall properly
6. Test operation

Relief Valve Discharge

T&P valve discharge indicates serious conditions.

Temperature Relief

Causes:

- Thermostat stuck on
- Excessive temperature
- High inlet temperature
- Closed system expansion
- Solar heating

Testing:

- Check water temperature
- Test thermostat operation
- Verify elements/burner off
- Check mixing valves
- Monitor cycling

Pressure Relief

Causes:

- Thermal expansion
- High supply pressure
- Water hammer
- Closed system
- PRV failure

Solutions:

Problem	Solution
Water hammer	Install arrestors
Thermal expansion	Install expansion tank
High pressure	Install/adjust PRV
Closed system	Add expansion tank

Valve Testing

Manual Test:

- Lift lever
- Water should flow
- Release lever
- Flow should stop
- If not, replace

> **Never Plug Relief Valve!**

Temperature Control Problems

Maintaining proper temperature is critical for safety and comfort.

Thermostat Failures

Gas Valve Thermostat:

Testing:

1. Check continuity
2. Test at temperature
3. Verify differential
4. Check ECO function
5. Calibration check

Problems:

- Contacts stuck
- Out of calibration
- Sensing bulb leak
- Capillary damage
- Mechanical failure

Electric Thermostat:

Testing:

1. Continuity test
2. Temperature test
3. Check both stats
4. ECO function
5. Manual reset test

Stack Temperature Issues

High Stack Temperature:

Causes:

- Scale buildup
- Baffle missing
- Soot accumulation
- Overfiring
- Poor heat transfer

Effects:

- Low efficiency
- High bills
- Premature failure
- Venting problems
- Safety issues

Testing:

- Measure stack temp
- Normal: 350-450°F
- High: >500°F
- Calculate efficiency
- Inspect flue baffle

Mixing Valve Problems

Thermostatic Mixing Valves:

Purpose:

- Prevent scalding
- Maintain temperature
- Increase capacity
- Safety device
- Code required (commercial)

Problems:

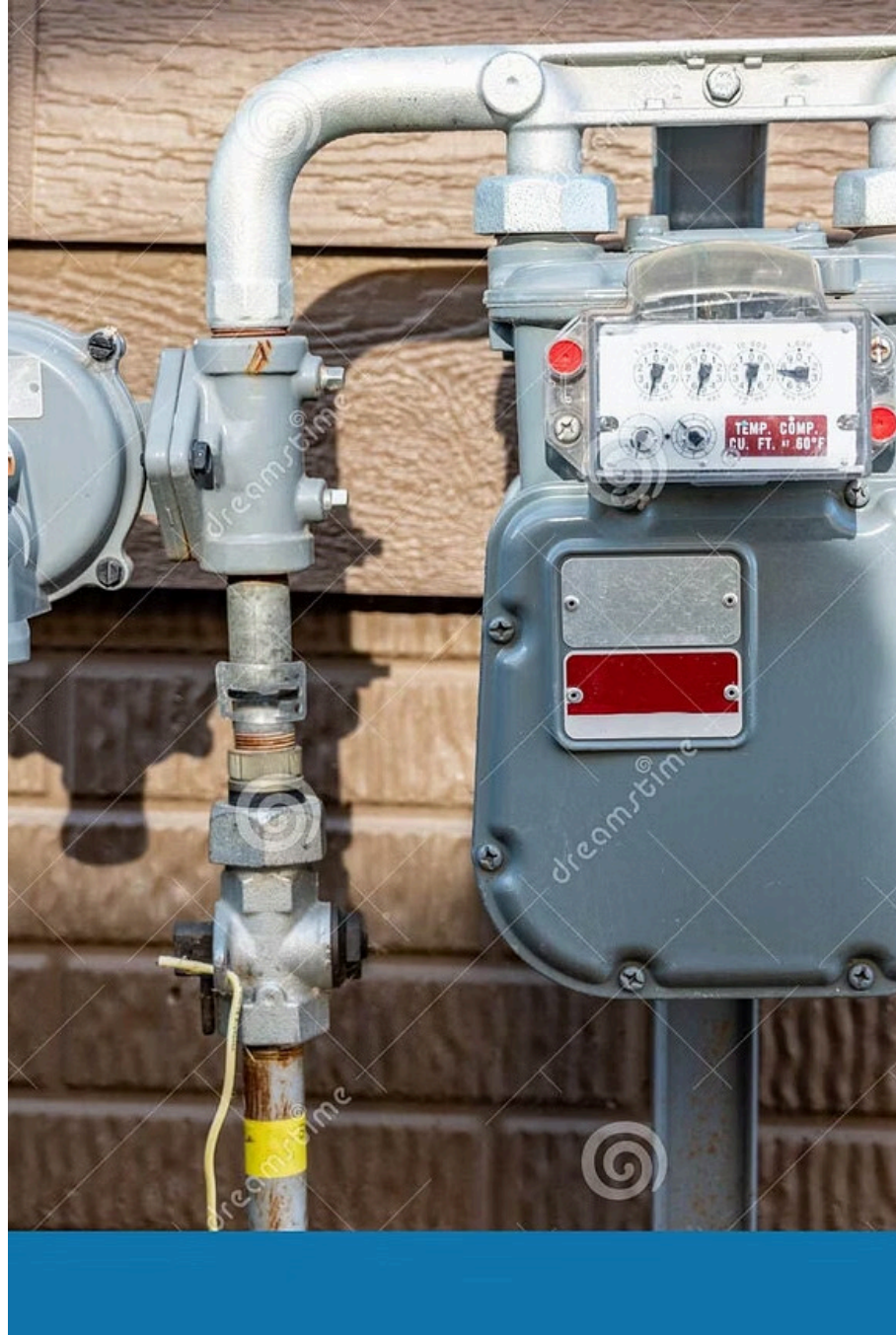
- Stuck valve
- Wrong setting
- Failed element
- Check valve stuck
- Debris blockage

Testing:

1. Check inlet temps
2. Verify outlet temp
3. Adjust setting
4. Flow test
5. Service/replace

19.5 Gas Supply Problems

Gas pressure and delivery issues affect all gas appliances.



Low Gas Pressure

Insufficient pressure causes poor performance and safety issues.

Symptoms of Low Pressure

Visual Indicators:

- Yellow flames
- Lazy flames
- Delayed ignition
- Flame lifting
- Incomplete combustion

Performance Issues:

- Low input
- Poor heating
- Long recovery
- Pilot outages
- Intermittent operation

Causes at Various Points

Utility Supply:

- System problems
- Peak demand
- Regulator issues
- Service interruption
- Meter problems

Building System:

Location	Common Causes
Meter	Undersized, regulator
Piping	Undersized, long runs
Regulators	Failed, wrong setting
Valves	Partially closed
Appliance	Blocked orifice

Diagnostic Procedures

Systematic Testing:

01

Utility Supply:

- Test at meter outlet
- Static pressure
- All appliances off
- Should be 7" W.C. (NG)
- Document reading

02

Operating Pressure:

- All appliances on
- Test at each appliance
- Calculate pressure drop
- Should maintain 5" minimum
- Identify restrictions

03

Individual Appliance:

- Test at appliance inlet
- Appliance operating
- Compare to requirement
- Check manifold pressure
- Verify orifice size

Problem Identification:

Test Result	Indicates
Low static	Utility problem
Static OK, operating low	Piping/meter issue
Gradual drop	Undersized piping
Sudden drop	Restriction
One appliance only	Local problem

High Gas Pressure

Excessive pressure creates dangerous conditions.

Dangers of High Pressure

Safety Hazards:

- Flame lifting
- Delayed ignition
- Flashback
- CO production
- Component damage
- Fire risk

Equipment Effects:

- Overfiring
- Overheating
- Limit trips
- Valve damage
- Control problems
- Noise

Causes and Solutions

Regulator Problems:

Type	Problem	Solution
Meter regulator	Failed open	Utility repair
Line regulator	Adjustment wrong	Readjust
Appliance reg	Bypassed	Reinstall
Vent blocked	Can't relieve	Clear vent

Testing:

1. Check at meter
2. Test at appliances
3. Monitor during operation
4. Check relief function
5. Verify venting

Maximum Pressures:

- Residential: 14" W.C.
- Appliance rating: 13.9" W.C.
- Test pressure: 14" W.C.
- Relief setting: 2 psi typical