CHAPTER 20

Maintenance and Service

Learning Objectives

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

1. Develop and implement comprehensive preventive maintenance programs
2. Perform thorough furnace maintenance following manufacturer specifications
3. Complete water heater maintenance procedures safely and effectively
4. Service boiler systems including water treatment and component maintenance
5. Execute seasonal start-up and shut-down procedures properly
6. Conduct combustion testing and make appropriate adjustments
7. Create and manage maintenance contracts professionally
8. Document all maintenance activities for liability protection
9. Communicate maintenance needs effectively to customers
10. Schedule and prioritize maintenance tasks efficiently

20.1 Preventive Maintenance Programs

Well-designed preventive maintenance programs extend equipment life, improve efficiency, and prevent costly breakdowns.

Importance of Regular Maintenance

Maintenance is not optional—it's essential for safety, efficiency, and reliability.

Safety Benefits

Preventing Hazards:

- Carbon monoxide prevention
- Fire hazard reduction
- Gas leak detection
- Electrical safety
- Venting integrity
- Component reliability

Statistics:

Hazard	Maintenance Impact
CO incidents	75% reduction with annual service
House fires	60% reduction in HVAC-related
Gas leaks	80% found during maintenance

Hazard	Maintenance Impact
Premature failure	50% reduction with PM

Critical Safety Points:

- Heat exchanger cracks detected early
- Venting problems identified
- Gas leaks found and repaired
- Electrical hazards corrected
- Safety controls verified
- Documentation for liability

Efficiency Benefits

Energy Savings:

- 5-15% efficiency improvement
- Lower utility bills
- Reduced carbon footprint
- Optimal performance
- Consistent comfort
- Extended equipment life

Performance Metrics:

Maintenance Level	Efficiency Loss/Year
None	3-5%
Basic	1-2%
Comprehensive	<1%

Cost Analysis:

Annual Maintenance: $150-250 Annual Savings: $100-300 Prevented Repairs: $500-2000 Extended Life: 5-10 years

Reliability Benefits

Breakdown Prevention:

- 90% of failures preventable
- Predictable replacement
- Planned downtime
- No emergency calls
- Customer satisfaction
- Professional reputation

Common Prevented Failures:

Component	Failure Rate Without PM	With PM
Inducer motor	15%/year	3%/year
Igniter	20%/year	5%/year
Flame sensor	25%/year	2%/year
Blower motor	10%/year	2%/year

Comfort Advantages:

- Consistent temperatures
- Proper humidity
- Quiet operation
- Better air quality
- No surprises
- Peace of mind

Seasonal Maintenance Tasks

Different seasons require specific maintenance focus.

Spring Maintenance

Cooling Preparation:

1. **Air Conditioning:**
    - Clean condenser coil
    - Check refrigerant
    - Test capacitors
    - Verify controls
    - Check drainage
2. **Ventilation:**
    - Clean/replace filters
    - Check dampers
    - Test exhaust fans
    - Verify air flow
    - Balance system
3. **Dehumidification:**
    - Test humidistat
    - Clean dehumidifier
    - Check drainage
    - Verify operation

Heating Wind-Down:

- Final combustion test
- Document readings
- Note any issues
- Schedule repairs
- Clean up area

Summer Maintenance

Off-Season Heating Work:

Task	Benefit
Deep cleaning	Better access
Major repairs	No heat needed
Upgrades	Time available
Replacements	Planned timing
Duct sealing	Complete access

Water Heater Focus:

- Tank flushing ideal
- Anode rod inspection
- Element testing
- Vacation settings
- Efficiency checks

Fall Maintenance

Heating Preparation:

Priority Tasks:

1. **Combustion Equipment:**
    - Clean burners
    - Check heat exchanger
    - Test ignition
    - Verify safeties
    - Combustion analysis
2. **Air Handling:**
    - Replace filters
    - Clean blower
    - Check belts
    - Lubricate bearings
    - Test operation
3. **Controls:**
    - Calibrate thermostat

    - Test limits
    - Verify sequences
    - Check programming
    - Update settings

Customer Communication:

- Schedule early
- Avoid rush
- Better availability
- Prevent no-heat calls
- Time for repairs

Winter Maintenance

Emergency Prevention:

Limited Service:

- Visual inspections
- Filter changes
- Minor adjustments
- Emergency repairs
- Safety checks

Focus Areas:

Task	Frequency
Filter check	Monthly
Condensate lines	Monthly
Snow/ice removal	As needed
Vent inspection	After storms
Emergency response	24/7

Planning:

- Schedule for fall
- Emergency parts stock
- On-call rotation
- Weather monitoring
- Customer alerts

Manufacturer Recommendations

Following manufacturer guidelines maintains warranties and ensures proper operation.

Warranty Requirements

Typical Requirements:

- Annual professional service
- Certified technician
- Genuine parts
- Documentation
- Proper procedures

Documentation Needed:

Document	Purpose
Service invoice	Proof of maintenance
Part receipts	Warranty claims
Test results	Performance verification
Technician certification	Qualified service
Date stamps	Timing compliance

Specific Procedures

High-Efficiency Equipment:

Special Requirements:

- Condensate system service
- Venting inspection critical
- Heat exchanger cleaning
- Combustion analysis mandatory
- Control calibration

Manufacturer Variations:

Brand	Specific Requirement
Carrier	Annual filter change minimum
Lennox	Combustion test required
Rheem	Inducer inspection
Goodman	Electrical check
Trane	Control update check

Service Intervals:

Component Schedules:

Component	Interval
Filters	1-3 months
Burners	Annual
Heat exchanger	Annual inspection
Blower	Annual
Igniter	Inspect annual
Flame sensor	Clean annual
Venting	Annual
Controls	Test annual

Extended Warranties:

- May require bi-annual service
- Specific dealer service
- Online registration
- Enhanced documentation
- Premium parts

Creating Maintenance Schedules

Organized scheduling ensures comprehensive service delivery.

Customer Database Development

Information to Track:

Customer Data:

- Name and address
- Phone numbers
- Email address
- Equipment details
- Service history
- Preferences
- Contract status

Equipment Records:

Field	Purpose
Make/Model	Parts and procedures
Serial number	Warranty tracking
Install date	Age tracking
BTU rating	Performance specs

Field	Purpose
Efficiency	Baseline data
Location	Access planning

Service History:

- Dates of service
- Work performed
- Parts replaced
- Test results
- Technician notes
- Recommendations
- Follow-up needed

Scheduling Systems

Annual Rotation:

Monthly Distribution:

- Balance workload
- Geographic grouping
- Customer preferences
- Equipment types
- Contract priorities

Example Monthly Plan:

Month	Focus	Customer Count
January	Repairs	50
February	Commercial	75
March	Spring prep	100
April	AC prep	125
May	AC service	150
June	Off-season	75
July	Installations	50
August	Pre-season	100
September	Heating prep	175
October	Heating service	200
November	Heating service	150
December	Emergency	50

Reminder Systems:

Methods:

- Email reminders
- Text messages
- Phone calls
- Postal mail
- Online portals
- Apps

Timing:

- 30 days advance
- 14 days reminder
- 7 days confirmation
- Day before alert
- Follow-up if missed

Route Optimization:

- Geographic clustering
- Drive time minimization
- Multiple stops
- Emergency slots
- Weather contingencies

Documentation and Record Keeping

Proper documentation protects all parties and ensures continuity.

Service Reports

Required Information:

Header:

- Company information
- License numbers
- Date and time
- Weather conditions
- Customer information
- Equipment data

Work Performed:

1. **Inspection Results:**
    - Visual observations

    - Measurements taken
    - Problems found
    - Safety concerns
    - Recommendations
2. **Maintenance Tasks:**
    - Cleaning completed
    - Adjustments made
    - Parts replaced
    - Tests performed
    - Results achieved
3. **Test Data:**

Test	Reading	Acceptable
Gas pressure	7.2" W.C.	Yes
Temperature rise	55°F	Yes
CO level	35 ppm	Yes
Draft	-0.03"	Yes

Digital Documentation

Advantages:

- Searchable records
- Automatic backups
- Photo integration
- Signature capture
- Instant delivery
- Report generation

Software Features:

- Customer management
- Equipment tracking
- Service history
- Inventory control
- Scheduling
- Invoicing
- Reporting

Implementation:

1. Choose platform
2. Import data
3. Train staff
4. Establish procedures

5. Regular backups
6. Security measures

Legal Considerations

Record Retention:

Document Type	Retention Period
Service records	7 years minimum
Safety tests	10 years
Incident reports	Permanent
Warranties	Life of warranty
Contracts	7 years after end
Training records	Employment + 5 years

Liability Protection:

- Detailed documentation
- Photo evidence
- Customer signatures
- Safety notifications
- Recommendation records
- Follow-up attempts

Compliance Documentation:

- Code compliance
- Permit records
- Inspection reports
- Certification copies
- Insurance records
- License documentation

20.2 Furnace Maintenance Procedures

Comprehensive furnace maintenance ensures safety, efficiency, and reliability.

Annual Inspection Checklist

A systematic approach ensures nothing is missed.

Pre-Inspection Setup

Safety Preparation:

1. Customer notification
2. Area protection
3. Tool preparation
4. Safety equipment
5. Documentation ready
6. Test instruments

Initial System Check:

- Current operation
- Thermostat settings
- Error codes
- Customer concerns
- Visual inspection
- Safety assessment

Visual Inspection Points

External Inspection:

Component	Check For
Cabinet	Rust, damage, labels
Venting	Corrosion, separation, slope
Gas piping	Leaks, support, protection
Electrical	Burn marks, loose wires
Condensate	Clogs, traps, drainage
Combustion air	Obstructions, sizing
Area	Clearances, combustibles

Internal Inspection:

Access and Examine:

1. **Burner Compartment:**
    - Rust or corrosion
    - Debris accumulation
    - Burner condition
    - Manifold integrity
    - Gas valve condition
2. **Heat Exchanger:**
    - Visible cracks
    - Rust/scale
    - Soot deposits
    - Flame impingement

    - Baffle condition
3. **Blower Compartment:**
    - Wheel condition
    - Motor mounts
    - Belt condition
    - Bearing wear
    - Cleanliness

Operational Testing

Sequence Verification:

1. Initiate heat call
2. Observe inducer start
3. Verify pressure switch
4. Watch ignition
5. Confirm flame sense
6. Time blower start
7. Monitor operation
8. Check shutdown

Performance Measurements:

Parameter	Specification	Actual
Temperature rise	40-70°F	_____
Gas pressure	7" W.C.	_____
Manifold pressure	3.5" W.C.	_____
Amp draws	Per nameplate	_____
CO levels	<100 ppm	_____

Burner Cleaning and Adjustment

Clean burners ensure safe, efficient combustion.

Burner Removal

Procedure:

1. **Shutdown:**
    - Turn off gas
    - Turn off power
    - Allow cooling
    - Lock out/tag out
2. **Disassembly:**
    - Remove manifold screws

    - Disconnect gas valve
    - Remove igniter
    - Extract burners
    - Note orientation

Common Burner Types:

Type	Characteristics
In-shot	Individual tubes
Ribbon	Continuous strip
Mono-port	Single orifice
Multi-port	Multiple openings

Cleaning Procedures

Methods:

Mechanical Cleaning:

- Wire brush (brass)
- Compressed air
- Vacuum extraction
- Pick/scraper
- Avoid damage

Chemical Cleaning:

- Mild detergent
- Degreasing solution
- Rinse thoroughly
- Dry completely
- No residue

Areas to Clean:

1. Burner ports
2. Venturi throat
3. Primary air openings
4. Crossover channels
5. Igniter area
6. Flame sensor location

Inspection During Cleaning:

- Cracks or splits

- Rust through
- Warping
- Port erosion
- Crossover damage

Adjustment Procedures

Primary Air Adjustment:

Process:

1. Install burners
2. Light burners
3. Observe flame
4. Adjust shutters
5. Achieve blue flame
6. Minimize yellow tips
7. Ensure stability
8. Lock adjustment

Optimal Flame Characteristics:

Characteristic	Proper	Improper
Color	Blue	Yellow
Tips	Slight yellow OK	Excessive yellow
Stability	Steady	Lifting/flashback
Sound	Soft roar	Loud/resonant
Distribution	Even	Uneven

Manifold Pressure:

- Connect manometer
- Fire burners
- Read pressure
- Compare to spec
- Adjust if needed
- Document reading

Heat Exchanger Inspection

Critical for safety and carbon monoxide prevention.

Inspection Methods

Visual Inspection:

Tools Required:

- Flashlight
- Mirror
- Camera/borescope
- Smoke generator
- CO detector

Procedure:

1. Remove burners
2. Inspect from bottom
3. Check from top
4. Look for daylight
5. Check for rust/scale
6. Note any cracks
7. Document findings

Common Failure Points:

Location	Cause
Crimp areas	Stress concentration
Welds	Manufacturing defect
Bends	Metal fatigue
Fire side	Flame impingement
Water side	Condensation

Advanced Testing

Smoke Test:

1. Seal registers
2. Introduce smoke
3. Run blower only
4. Check for leaks
5. Document results

Dye Penetrant:

- Spray on surface
- Allow penetration
- Wipe excess
- Apply developer
- Cracks visible

Tracer Gas:

- Expensive method
- Very accurate
- Professional equipment
- Definitive results
- Documentation provided

Failure Criteria

Must Condemn:

- Visible cracks
- Holes/perforations
- Severe rust through
- Separated seams
- Evidence of CO

May Monitor:

- Surface rust
- Minor scale
- Discoloration
- Small dimples
- Age considerations

Red Tag Procedures:

1. Shut down immediately
2. Disconnect gas
3. Tag equipment
4. Notify customer
5. Document thoroughly
6. Provide options

Blower Maintenance

Proper air flow is essential for comfort and efficiency.

Motor Service

Motor Types:

Type	Maintenance
PSC	Lubricate, check capacitor
ECM	Check module, connections

Type	Maintenance
Shaded pole	Lubricate if possible
Belt drive	Lubricate, adjust belt

Lubrication:

Procedure:

1. Locate oil ports
2. Clean area
3. Add proper oil
4. 3-5 drops typical
5. Don't over-oil
6. Run motor
7. Check for leaks

Oil Specifications:

- SAE 20 non-detergent
- Electric motor oil
- No automotive oil
- No WD-40
- Annual service

Wheel Cleaning

Importance:

- Reduced airflow 25-50%
- Increased amp draw
- Reduced efficiency
- Noise increase
- Premature failure

Cleaning Methods:

1. **In-Place:**
    - Vacuum carefully
    - Brush gently
    - Compressed air
    - Shop vac
2. **Removal:**
    - Better cleaning
    - Complete access
    - Balance check
    - Bearing inspection

Procedure:

1. Remove wheel
2. Soak if needed
3. Brush clean
4. Rinse/dry
5. Check balance
6. Reinstall
7. Test operation

Belt Maintenance

Inspection:

Check	Good	Replace
Cracks	None	Any visible
Glazing	Matte finish	Shiny
Fraying	None	Edges worn
Tension	1/2" deflection	Loose/tight

Adjustment:

1. Check deflection
2. Loosen motor mount
3. Adjust position
4. Tension properly
5. Align pulleys
6. Tighten mounts
7. Recheck

Filter Replacement Schedules

Filters are the first line of defense for system protection.

Filter Types and Intervals

Standard Filters:

Type	MERV	Replace Interval
Fiberglass	1-4	Monthly
Pleated	5-8	3 months
Extended	9-12	6 months
HEPA	13-16	Annual
Electronic	N/A	Clean quarterly

Factors Affecting Frequency:

- Pets in home
- Occupancy
- Outdoor air quality
- Construction nearby
- Smokers
- Home activities

Customer Education

Teaching Points:

1. Filter location
2. Direction arrow
3. Size notation
4. Quality options
5. Change frequency
6. Impact of dirty filter

Consequences of Neglect:

- Reduced airflow
- Frozen coils
- Heat exchanger damage
- Higher bills
- Comfort complaints
- System failure

Filter Program Setup:

- Automatic delivery
- Email reminders
- Seasonal changes
- Bulk purchasing
- Service inclusion

Control Testing

Controls coordinate all furnace operations.

Safety Control Testing

Limit Switches:

1. **Test Procedure:**

    - Block return air
    - Monitor temperature
    - Should trip at rating
    - Verify shutdown
    - Clear blockage
    - Auto reset
    - Document

Pressure Switches:

1. Check tubing
2. Test with manometer
3. Verify set point
4. Clean ports
5. Test contacts
6. Document results

Flame Sensor:

- Measure microamps
- Clean if <3 μA
- Replace if <2 μA
- Check position
- Verify ground
- Test wire

Operating Control Tests

Thermostat:

Test	Procedure
Calibration	Compare to thermometer
Anticipator	Check setting
Switching	Test all functions
Programming	Verify schedule
Batteries	Replace annual

Gas Valve:

- Input voltage
- Coil resistance
- Pressure regulation
- Safety shutoff
- Leak test

Control Board:

- LED indicators
- Fault codes
- Input/output test
- Timing verification
- Safety circuit

Combustion Analysis

Essential for safety and efficiency optimization.

Test Procedure

Equipment Setup:

1. Analyzer preparation
2. Calibration check
3. Probe installation
4. Seal penetration
5. Run 10 minutes
6. Take readings

Measurements Required:

Parameter	Target	Action Level
O_2	6-9%	Adjust if outside
CO	<50 ppm	>100 requires action
CO_2	8.5-10%	Indicates efficiency
Stack temp	350-450°F	High needs cleaning
Efficiency	>78%	<75% needs service

Adjustments:

If CO High:

1. Increase primary air
2. Clean burners
3. Check gas pressure
4. Verify venting
5. Retest

If Efficiency Low:

1. Clean heat exchanger

2. Adjust gas pressure
3. Check temperature rise
4. Service burners
5. Retest

Documentation:

- Print results
- Customer copy
- File copy
- Note adjustments
- Schedule follow-up

Safety Device Testing

Never compromise on safety device functionality.

Required Safety Tests

Rollout Switch:

- Manual reset type
- Very high temperature
- Multiple locations
- Test with jumper removal
- Never bypass

Inducer Proving:

- Pressure switch operation
- Proper vacuum level
- Tubing clear
- Contacts reliable
- Safety circuit complete

Ignition Safety:

- Trial for ignition timing
- Flame failure response
- Lockout function
- Reset procedure
- No gas leaks

Documentation Requirements

Test Results:

Safety Device	Test Method	Result	Pass/Fail
Primary limit	Temperature test	Opens at 180°F	Pass
Rollout	Continuity	Open (tripped)	Reset/Pass
Pressure switch	Vacuum test	-0.65" W.C.	Pass
Flame sensor	Microamp test	4.2 µA	Pass
Gas valve	Shutoff test	Closes complete	Pass

Follow-Up:

- Any failed safety = priority repair
- Document customer notification
- Red tag if necessary
- Schedule repair
- Verify completion

20.3 Water Heater Maintenance

Water heater maintenance extends life and ensures safe operation.

Inspection Procedures

Systematic inspection identifies problems early.

Visual Inspection

External Check:

Component	Inspect For
Tank exterior	Rust, leaks, damage
T&P valve	Corrosion, discharge
Piping	Leaks, corrosion, support
Venting	Rust, separation, clearances
Combustion air	Obstructions, adequate size
Area	Clearances, combustibles
Data plate	Model, serial, age

Top Inspection:

- Vent connector condition
- Draft hood alignment
- Spillage signs
- Burn marks
- Proper rise

Bottom Inspection:

- Combustion chamber
- Burner condition
- Pilot assembly
- Drain valve
- Signs of leaking

Operational Inspection

Performance Check:

1. Current temperature setting
2. Actual water temperature
3. Recovery rate
4. Cycling pattern
5. Fuel consumption
6. Noise/unusual sounds

Safety Testing:

- T&P valve operation
- Gas leak check
- CO testing
- Draft verification
- Spillage test
- Electrical safety

Age Assessment:

Age	Maintenance Focus
0-5 years	Preventive
5-10 years	Comprehensive
10-15 years	Evaluation
15+ years	Replacement planning

Anode Rod Service

The sacrificial anode protects the tank from corrosion.

Anode Rod Function

Corrosion Protection:

- Sacrificial metal

- Protects tank steel
- Dissolves preferentially
- Extends tank life
- Critical component

Types:

Material	Characteristics
Magnesium	Standard, most active
Aluminum	Hard water, less odor
Zinc	Reduces sulfur smell
Powered	No replacement needed

Inspection Procedure

Removal Steps:

1. Turn off gas/power
2. Turn off water
3. Relieve pressure
4. Locate anode fitting
5. Break loose carefully
6. Remove completely
7. Inspect condition

Tools Required:

- 1-1/16" socket
- Breaker bar
- Impact wrench helpful
- Teflon tape
- New anode if needed

Condition Assessment:

Condition	Action
>50% remaining	Reinstall
<50% remaining	Replace
Wire exposed	Replace immediately
Broken off	Replace with flexible

Replacement Procedure

Installation:

1. Select proper anode
2. Apply Teflon tape
3. Thread carefully
4. Tighten securely
5. Don't overtighten
6. Restore water
7. Check for leaks
8. Document service

Special Situations:

- Low clearance: Use flexible anode
- Hard access: Consider powered anode
- Softened water: May need more frequent replacement
- Well water: Check every 2 years

Expected Life:

- Normal water: 3-5 years
- Soft water: 1-2 years
- Hard water: 5-7 years
- Varies significantly

Tank Flushing

Sediment removal improves efficiency and extends tank life.

Flushing Procedure

Preparation:

1. Turn off gas/power
2. Close cold inlet
3. Open hot faucet
4. Attach drain hose
5. Route to drain
6. Open drain valve

Flushing Process:

Full Flush:

1. Drain completely
2. Open cold inlet
3. Flush until clear
4. Close drain

5. Refill tank
6. Restore operation
7. Check for leaks

Partial Flush:

1. Drain 5 gallons
2. Stir sediment
3. Drain again
4. Repeat until clear
5. Less disruption
6. Quarterly recommended

Sediment Indicators:

Amount	Indicates
Minimal	Good maintenance
Moderate	Annual flushing OK
Heavy	Increase frequency
Excessive	Consider replacement

Problems from Sediment:

- Reduced capacity
- Longer recovery
- Rumbling noises
- Overheating bottom
- Premature failure
- Bacterial growth

Burner and Combustion Chamber Cleaning

Clean combustion ensures efficiency and safety.

Burner Service

Removal and Cleaning:

1. **Shutdown:**
    - Gas off
    - Cool down
    - Remove access
2. **Burner Removal:**
    - Disconnect thermocouple
    - Remove pilot tube

    - Extract burner
    - Note orientation
3. **Cleaning:**
    - Brush ports clean
    - Clear venturi
    - Vacuum debris
    - Check for damage

Inspection Points:

- Port condition
- Rust/corrosion
- Warping
- Cracks
- Proper color

Pilot Assembly Service

Cleaning:

1. Remove assembly
2. Clean orifice
3. Clean hood
4. Check thermocouple
5. Adjust if needed
6. Reinstall
7. Test operation

Proper Pilot Flame:

- Steady blue
- Wraps thermocouple
- 1/2" to 3/4" tall
- No yellow
- No lifting

Combustion Chamber

Cleaning:

1. Vacuum thoroughly
2. Remove scale/rust
3. Check for damage
4. Clear air openings
5. Inspect floor
6. Document condition

Chamber Problems:

Problem	Solution
Heavy rust	Monitor closely
Scale buildup	Clean thoroughly
Burn through	Replace heater
Blocked openings	Clear obstructions

Vent System Inspection

Proper venting ensures safe exhaust removal.

Vent Connector Inspection

Check Points:

- Proper material
- Correct size
- Adequate rise
- Secure connections
- No holes/gaps
- Proper clearances

Common Problems:

Issue	Correction
Single wall	Upgrade to B-vent
Improper slope	Reinstall correctly
Too long	Shorten run
Wrong size	Resize per code
Loose joints	Secure with screws

Draft Hood Function

Testing:

1. Run water heater
2. Check for spillage
3. Match/smoke test
4. Feel for draft
5. Mirror test
6. Document results

Spillage Causes:

- Blocked vent
- Negative pressure
- Improper termination
- Downdrafts
- Deteriorated vent

Common Vent Systems

Inspection Requirements:

- Proper sizing for all appliances
- Adequate connectors
- Table compliance
- No obstruction
- Proper termination

Orphaned Water Heater:

When furnace removed/replaced:

- May need liner
- Resize vent
- Check draft
- Monitor for condensation
- Consider power vent

Relief Valve Testing

Temperature and pressure relief valve is critical safety device.

T&P Valve Function

Protection Against:

- Excessive temperature (210°F)
- Excessive pressure (150 psi)
- Tank rupture
- Steam explosion
- Property damage

Testing Procedure

Manual Test:

1. **Preparation:**
    - Warn occupants

    - Position bucket
    - Clear discharge area
2. **Testing:**
    - Lift lever fully
    - Water should flow
    - Release lever
    - Flow should stop
    - If not, replace valve

Frequency:

- Manufacturer: Annual
- Reality: May cause failure
- Alternative: Visual inspection
- Document decision

Discharge Piping

Requirements:

Feature	Requirement
Material	Rated for temperature
Size	Same as valve outlet
Support	Every 4 feet
Termination	6" above floor
Direction	Downward

Never:

- Reduce size
- Thread end
- Install valve
- Connect directly to drain
- Trap discharge

Replacement Criteria

Replace When:

- Continuous dripping
- Won't reset
- Heavy corrosion
- Missing discharge
- Wrong rating
- Over 5 years old

Installation:

1. Drain tank partially
2. Remove old valve
3. Apply tape/compound
4. Install new valve
5. Attach discharge
6. Test operation
7. Document

Control Verification

Controls maintain temperature and ensure safety.

Thermostat Testing

Gas Control Valve:

1. **Temperature Check:**
    - Current setting
    - Actual temperature
    - Differential
    - Calibration
    - Adjustment
2. **Operation:**
    - On/off cycling
    - Pilot maintenance
    - Main burner control
    - Safety shutoff

Electric Thermostat:

- Upper element priority
- Lower element operation
- Temperature setting
- ECO function
- Reset if needed

Temperature Settings

Recommended Settings:

Application	Temperature
Residential	120°F
Anti-scald	120°F maximum

Application	Temperature
Dishwasher	140°F if required
Commercial	140°F typical
Legionella	140°F minimum

Energy Savings:

- 10°F reduction = 3-5% savings
- Vacation setting available
- Timer installation option
- Mixing valve allows lower tank temperature

High Limit Testing

ECO Function:

- Energy Cut Off
- 160-180°F typical
- Should never trip normally
- Manual reset type
- Test not recommended

If Tripped:

1. Investigate cause
2. Check thermostat
3. Test elements
4. Verify wiring
5. Reset if safe
6. Monitor operation

20.4 Boiler Maintenance

Boiler systems require specialized maintenance procedures.

Inspection Procedures

Comprehensive inspection ensures safe, efficient operation.

Visual Inspection

External Inspection:

Component	Check For
Jacket	Rust, damage, leaks

Component	Check For
Piping	Leaks, corrosion, insulation
Valves	Operation, leaks
Pumps	Leaks, noise, operation
Expansion tank	Pressure, waterlogging
Pressure relief	Discharge, corrosion
Venting	Condition, clearances
Combustion air	Adequate, unobstructed

Combustion Chamber:

- Refractory condition
- Burner alignment
- Chamber floor
- Target wall
- Soot accumulation

Heat Exchanger:

- Cast iron sections
- Push nipples
- Gaskets/seals
- Corrosion
- Scale buildup
- Stress cracks

Operating Parameters

Pressure and Temperature:

Parameter	Normal Range
Operating pressure	12-15 psi cold
Operating pressure	15-25 psi hot
Supply temperature	140-180°F
Return temperature	120-160°F
Delta T	20°F typical
Stack temperature	300-450°F

Performance Indicators:

- Short cycling
- Slow heating
- Uneven heating

- Noise/kettling
- High fuel use

Safety Testing

Required Tests:

1. **Pressure Relief:**
    - 30 psi typical
    - Manual test
    - Discharge check
2. **Low Water Cutoff:**
    - Test function
    - Float type: blow down
    - Probe type: test button
    - Document operation
3. **High Limit:**
    - Temperature setting
    - Cutout operation
    - Auto/manual reset
    - Verify shutdown

Cleaning Procedures

Proper cleaning maintains efficiency.

Fireside Cleaning

Tube Cleaning (Fire-tube):

1. Access doors open
2. Brush tubes thoroughly
3. Vacuum debris
4. Check baffles
5. Inspect for scale
6. Document condition

Tools Required:

- Tube brushes
- Vacuum
- Scraper
- Mirror
- Flashlight
- Safety equipment

Water-tube Boilers:

- External cleaning
- Soot removal
- Scale removal
- Check refractory
- Inspect tubes

Cast Iron Sections:

Cleaning Between Sections:

1. Remove jacket panels
2. Access cleanout
3. Brush/vacuum between
4. Check push nipples
5. Look for leaks
6. Reassemble

Burner Cleaning

Gas Burners:

- Remove and clean
- Check ports
- Inspect manifold
- Clean pilot
- Verify ignition
- Check flame pattern

Oil Burners:

- Change nozzle
- Clean electrodes
- Replace filter
- Check pump pressure
- Clean fan
- Adjust air

Control Testing

Boiler controls require careful calibration.

Operating Controls

Aquastat:

Settings:

Control	Setting
High limit	180-200°F
Low limit	140-160°F
Differential	10-20°F

Testing:

1. Check calibration
2. Verify switching
3. Test differential
4. Check immersion
5. Clean well

Pressure Controls:

- Operating pressure
- Cut-in/cut-out
- Differential
- Manual reset types
- Additive differential

Zone Controls:

- Valve operation
- End switch function
- Pump controls
- Thermostat operation
- Priority settings

Safety Controls

Low Water Cutoff:

Float Type:

1. **Test Procedure:**
    - Blow down monthly
    - Open valve slowly
    - Water should discharge
    - Burner should stop
    - Close valve
    - Burner restarts
2. **Maintenance:**

    - Disassemble annually
    - Clean float
    - Check linkage
    - Replace gaskets
    - Test operation

Probe Type:

- Test button weekly
- Clean probe annually
- Check wiring
- Verify operation
- Replace if questionable

Stack Control:

- Clean bimetal
- Check calibration
- Verify timing
- Test safety
- Adjust if needed

Water Treatment

Proper water chemistry prevents corrosion and scale.

Water Testing

Parameters to Test:

Parameter	Ideal Range
pH	8.5-10.5
TDS	<3000 ppm
Hardness	<1 grain
Chlorides	<50 ppm
Iron	<0.3 ppm
Conductivity	<3500 µmhos

Test Frequency:

- New systems: Monthly
- Established: Quarterly
- Problem systems: Weekly
- After work: Immediately

Chemical Treatment

Common Chemicals:

Chemical	Purpose
Sodium sulfite	Oxygen scavenger
Sodium hydroxide	pH adjustment
Phosphates	Scale prevention
Nitrite	Corrosion inhibitor
Biocides	Biological control

Application:

1. Test water first
2. Calculate dosage
3. Add to system
4. Circulate fully
5. Retest
6. Document
7. Schedule follow-up

System Flushing

When Required:

- New installation
- Major repairs
- Severe contamination
- Annual service
- Chemical cleaning

Procedure:

1. Drain system
2. Flush with water
3. Add cleaning chemical
4. Circulate
5. Drain again
6. Flush clean
7. Refill
8. Add treatment

Circulator Maintenance

Pumps are the heart of hydronic systems.

Pump Types

Type	Maintenance
Wet rotor	Minimal, check operation
Dry rotor	Lubricate, align
In-line	Check mounting
Base mounted	Check alignment
Multi-speed	Verify setting

Bearing Maintenance

Lubrication:

1. **Oil-Lubricated:**
    - Check level
    - Add as needed
    - Change annually
    - Use specified oil
2. **Grease-Lubricated:**
    - Grease fittings
    - Pump slowly
    - Stop at resistance
    - Don't over-grease

Motor Maintenance

Checks:

- Temperature
- Vibration
- Amp draw
- Noise
- Coupling
- Alignment

Electrical:

- Connections tight
- Insulation good
- Starter contacts
- Overload settings
- Ground connection

Performance Testing

Flow Verification:

- Design flow rate
- Actual flow
- Pressure differential
- Temperature rise
- Valve positions

Problems:

Symptom	Cause
No flow	Air bound, closed valve
Low flow	Plugged, wrong speed
Noise	Cavitation, air, bearing
Vibration	Misalignment, balance
Overheating	Overload, no flow

Safety Device Testing

Critical for preventing catastrophic failures.

Pressure Relief Valve

Testing:

1. **Visual Inspection:**
    - Corrosion
    - Discharge evidence
    - Proper size
    - Rating tag
    - Discharge piping
2. **Manual Test:**
    - Lift lever
    - Steam/water discharge
    - Release lever
    - Should reseat
    - No continuous leak

ASME Requirements:

- 30 psi maximum
- BTU rating match
- Annual test
- No valve between
- Discharge piped

Low Water Cutoff Testing

McDonnell Miller #67:

Test Procedure:

1. Monthly test required
2. Open blow down
3. Water discharges
4. Burner stops
5. Close valve
6. Water returns
7. Burner restarts

Maintenance:

- Annual tear down
- Clean thoroughly
- Replace gaskets
- Check float
- Test switches
- Document service

Feed Water Systems

Automatic Feeder:

- Pressure setting
- Fast fill lever
- Strainer clean
- Valve operation
- Backflow prevention

Manual Feed:

- Valve operation
- Pressure gauge
- Instructions posted
- Training provided
- Log maintained

20.5 Seasonal Start-Up and Shut-Down

Proper seasonal transitions ensure reliable operation.

Pre-Season Equipment Checks

Preparation prevents emergency calls.

Fall Heating Preparation

System Inspection:

Two Weeks Before Season:

1. **Visual Inspection:**
    - Equipment condition
    - Venting integrity
    - Gas connections
    - Electrical connections
    - Safety devices
2. **Operational Test:**
    - Run through cycle
    - Check sequences
    - Verify safeties
    - Test limits
    - Check pressures

Customer Communication:

- Schedule service
- Explain benefits
- Offer priorities
- Book appointments
- Send reminders

Common Pre-Season Issues

Typical Problems Found:

Problem	Frequency	Prevention
Dirty flame sensor	25%	Annual cleaning
Weak batteries	20%	Annual replacement
Dirty filter	35%	Regular changes
Pilot out	15%	Proper shutdown
Thermostat issues	10%	Annual check

Parts to Stock:

- Flame sensors
- Igniters
- Thermocouples

- Filters
- Batteries
- Common capacitors

Spring Cooling Preparation

AC System Checks:

1. **Condenser Unit:**
    - Clean coil
    - Check fan
    - Test capacitor
    - Verify contactor
    - Check refrigerant
2. **Evaporator:**
    - Clean if accessible
    - Check drain
    - Verify airflow
    - Test cooling
    - Check temperatures

Changeover Procedures:

- Thermostat settings
- Damper positions
- Humidifier off
- Cover adjustments
- Customer education

Start-Up Procedures

Safe, systematic start-up ensures proper operation.

Heating Start-Up

Pre-Start Checklist:

1. ☐ Power off
2. ☐ Gas off
3. ☐ Visual inspection complete
4. ☐ Filters clean/new
5. ☐ Venting clear
6. ☐ Combustion air adequate
7. ☐ Thermostat set low
8. ☐ Tools ready

9. ☐ Test instruments ready
10. ☐ Documentation ready

Start-Up Sequence:

Step-by-Step:

1. **Power On:**
    - Check voltage
    - Verify fuses
    - Test transformer
    - Check controls
2. **Gas On:**
    - Open slowly
    - Check for leaks
    - Verify pressure
    - Test shut-offs
3. **Initial Operation:**
    - Set thermostat
    - Observe ignition
    - Check flame
    - Verify sensor
    - Monitor cycle

Performance Verification:

Test	Specification	Actual	Pass/Fail
Gas pressure	7" W.C.	__	__
Manifold	3.5" W.C.	__	__
Temperature rise	40-70°F	__	__
CO level	<100 ppm	__	__
Draft	-0.02 to -0.05"	__	__

Boiler Start-Up

Additional Steps:

1. **Fill System:**
    - Open valves
    - Bleed air
    - Check pressure
    - 12-15 psi cold
    - Check for leaks
2. **Purge Air:**
    - Zone by zone

    - High points
    - Radiators
    - Air separators
    - Expansion tank
3. **Test Operation:**
    - All zones
    - Pump operation
    - Control function
    - Safety devices
    - Balance system

Water Heater Start-Up

Tank Type:

1. Fill tank completely
2. Purge air lines
3. Check T&P valve
4. Light pilot/power on
5. Set temperature
6. Check operation
7. Test for leaks
8. Verify draft

Tankless:

- Additional steps
- Flush heat exchanger
- Check flow sensor
- Verify minimum flow
- Test all fixtures
- Adjust if needed

End-of-Season Procedures

Proper shutdown prevents problems.

Heating Shutdown

Spring Shutdown:

For Maintenance Access:

1. **Customer Notification:**
    - Explain benefits
    - Schedule convenient

    - Prepare instructions
2. **System Shutdown:**
    - Thermostat off/cool
    - Pilot off (if desired)
    - Power on for fan
    - Document settings

Benefits:

- No accidental operation
- Gas savings (pilot)
- Access for service
- Prevents short cycling
- Component rest

Cooling Shutdown

Fall Procedures:

1. **Condenser:**
    - Power off
    - Clean coil
    - Cover if desired
    - Check refrigerant
    - Secure unit
2. **Indoor:**
    - Thermostat to heat
    - Check filter
    - Close registers
    - Humidifier service
    - Set for heating

System Winterization

Protecting systems from freeze damage.

When Required

Situations:

- Vacant properties
- Seasonal homes
- Extended absence
- No heat maintained
- Renovation projects

Equipment Affected:

- Hydronic systems
- Water heaters
- Humidifiers
- Condensate systems
- Water piping

Hydronic Winterization

Antifreeze Method:

1. **Calculate Volume:**
    - Boiler
    - Piping
    - Radiation
    - Expansion tank
    - Total gallons
2. **Mix Ratio:**

Temperature	Glycol %
20°F	20%
10°F	30%
0°F	38%
-10°F	45%
-20°F	50%

3. **Procedure:**
    - Drain water percentage
    - Add antifreeze
    - Circulate thoroughly
    - Test concentration
    - Document

Drain Method:

1. System off and cool
2. Open all drains
3. Open vents
4. Blow out with air
5. Leave valves open
6. Tag system
7. Document

Water Heater Winterization

Tank Type:

1. Turn off gas/power
2. Close water supply
3. Open hot taps
4. Connect hose
5. Open drain
6. Open T&P
7. Drain completely
8. Leave valves open

Tankless:

- Follow manufacturer
- Usually antifreeze
- Isolation valves
- Pump kit
- Circulate solution
- Drain if specified

Spring Reactivation

System Restart:

1. **Antifreeze Systems:**
    - Test concentration
    - Add if needed
    - Check pH
    - Verify inhibitors
    - Start normally
2. **Drained Systems:**
    - Close drains
    - Fill slowly
    - Purge all air
    - Check for leaks
    - Test operation
    - Chemical treatment

Documentation:

- Date winterized
- Method used
- Who performed
- Special instructions
- Reactivation needs

20.6 Combustion Testing and Adjustment

Proper combustion ensures safety and efficiency.

When Testing is Required

Understanding when combustion testing is mandatory or recommended.

Mandatory Testing

Code Requirements:

Situation	Requirement
New installation	Required
Equipment replacement	Required
Venting changes	Required
After repairs	Required
Complaint/concern	Required
Incident/accident	Required

Manufacturer Requirements:

- Initial commissioning
- Annual service
- Warranty compliance
- Efficiency verification
- Adjustment validation

Recommended Testing

Service Situations:

- Annual maintenance
- Efficiency complaints
- High bills
- Sooting problems
- Odor complaints
- Performance issues

Problem Indicators:

Symptom	Test Needed
Yellow flames	Immediate
Soot deposits	Immediate

Symptom	Test Needed
CO alarm	Immediate
Odors	Priority
High bills	Scheduled
Comfort issues	Scheduled

Using Combustion Analyzers

Professional equipment provides accurate measurements.

Analyzer Preparation

Pre-Test Setup:

1. **Calibration Check:**
    - Last calibration date
    - Sensor condition
    - Battery status
    - Zero in fresh air
    - Verify operation
2. **Equipment Check:**
    - Probe condition
    - Hose integrity
    - Filter clean
    - Printer paper
    - Temperature probe

Proper Sampling

Sample Location:

Equipment Type	Sample Point
Natural draft	Above draft hood
80% furnace	Before draft hood
90% furnace	In vent pipe
Boiler	Breach or stack
Water heater	Above draft hood

Probe Installation:

1. Drill test hole
2. Install probe
3. Seal around probe
4. Proper insertion depth

5. Stable position

Test Procedure

Standard Test:

1. **Equipment Preparation:**
    - Run 10-15 minutes
    - Steady state
    - Normal operation
    - All zones calling
2. **Measurements:**
    - O_2 percentage
    - CO ppm
    - Stack temperature
    - Ambient temperature
    - Calculate CO_2
    - Calculate efficiency
3. **Documentation:**
    - Print results
    - Record adjustments
    - Customer copy
    - File copy

Multi-Point Testing:

- Low fire
- High fire
- Modulation points
- Each stage
- Document all

Interpreting Results

Understanding what measurements indicate.

Oxygen Levels

Interpretation:

O_2 Level	Indicates	Action
<4%	Insufficient air	Increase air
4-6%	Optimal range	Document
6-9%	Acceptable	May adjust
9-11%	Excess air	Reduce air

O_2 Level	Indicates	Action
>11%	Too much air	Adjust required

Effects:

- Low O_2: High CO, soot
- High O_2: Low efficiency
- Optimal: Safe and efficient

Carbon Monoxide

CO Levels:

CO (air-free)	Condition	Action
0-50 ppm	Excellent	Document
50-100 ppm	Good	Monitor
100-200 ppm	Marginal	Adjust
200-400 ppm	Poor	Repair required
>400 ppm	Dangerous	Shut down

CO Causes:

- Insufficient air
- Flame impingement
- Overfiring
- Poor mixing
- Blocked exchanger

Efficiency Calculations

Stack Efficiency:

- Measures heat up stack
- 75-83% typical
- Higher is better
- Affected by temperature
- Excess air impact

Steady State Efficiency:

- Operating efficiency
- Includes cycling losses
- 2-5% lower than AFUE
- More accurate

- Real-world number

Making Adjustments

Proper adjustment optimizes performance.

Air Adjustments

Primary Air:

1. **Atmospheric Burners:**
    - Shutter adjustment
    - Start closed
    - Open gradually
    - Blue flame target
    - Lock position
2. **Power Burners:**
    - Air damper
    - Linkage adjustment
    - Follow curve
    - Test all rates
    - Document settings

Target Values:

Adjustment Goal	O_2	CO
Natural gas	6-9%	<100 ppm
Propane	7-10%	<100 ppm
Oil	3-6%	<100 ppm

Gas Pressure Adjustments

Manifold Pressure:

1. Connect manometer
2. Fire equipment
3. Read pressure
4. Compare to spec
5. Adjust if needed
6. Retest combustion
7. Document

Effects of Pressure:

Pressure	Effect
Too low	Low input, yellow flame
Correct	Proper input, good flame
Too high	Overfiring, CO possible

Multi-Stage Adjustments

Two-Stage Equipment:

1. **Low Fire First:**
    - Adjust for clean combustion
    - Document settings
    - Lock adjustments
2. **High Fire:**
    - Adjust separately
    - Verify both stages
    - Check transition

Modulating Equipment:

- Multiple test points
- Follow manufacturer
- Use combustion curve
- Electronic adjustments
- Professional training

Documentation Requirements

Proper records protect all parties.

Test Reports

Required Information:

Header Information:

- Date and time
- Location
- Equipment data
- Technician name
- Company info
- License numbers

Test Results:

Parameter	Before	After	Target
O_2	11.2%	7.8%	6-9%
CO	248 ppm	45 ppm	<100
CO_2	5.8%	9.2%	8-10%
Stack temp	485°F	425°F	<450°F
Efficiency	72%	79%	>75%

Adjustments Made:

1. Primary air adjusted
2. Gas pressure verified
3. Burners cleaned
4. Venting checked

Electronic Records

Benefits:

- Searchable database
- Trend analysis
- Automatic calculations
- Photo attachment
- Instant delivery
- Cloud backup

Implementation:

- Software selection
- Data migration
- Staff training
- Procedure development
- Customer acceptance

Customer Communication

Report Explanation:

1. **Safety First:**
    - CO levels explained
    - Safety assured
    - Or problems identified
    - Actions required
2. **Efficiency:**
    - Current efficiency
    - Improvement made

    - Savings potential
    - Recommendations
3. **Follow-Up:**
    - Next service
    - Repairs needed
    - Improvements possible
    - Questions answered

20.7 Maintenance Contracts

Service agreements benefit both customers and contractors.

Types of Agreements

Different contract types serve various needs.

Basic Maintenance Plans

Coverage Includes:

- Annual inspection
- Cleaning
- Adjustment
- Safety testing
- Priority service
- Discount on repairs

Typical Pricing:

System	Annual Cost
Furnace only	$150-200
AC only	$100-150
Combined	$200-300
Boiler	$200-300
Water heater	$75-100

Benefits:

- Predictable cost
- Regular service
- Early problem detection
- Extended life
- Priority response

Comprehensive Plans

Additional Coverage:

- Parts included
- Labor included
- Emergency service
- No overtime charges
- Multiple calls
- Filters included

Pricing Factors:

- Equipment age
- Equipment type
- System complexity
- Location
- Competition
- Company overhead

Exclusions:

- Refrigerant
- Major components
- Abuse/neglect
- Acts of God
- Modifications
- Other contractor work

Commercial Contracts

Service Levels:

Level	Coverage
Inspection only	Annual/semi-annual
Preventive	PM plus minor repairs
Full service	All parts and labor
Performance	Guaranteed operation

Special Considerations:

- Multiple units
- Roof access
- After-hours needs
- Tenant coordination
- Budget cycles
- Insurance requirements

Scope of Services

Clear definition prevents misunderstandings.

Included Services

Standard Inclusions:

Heating Service:

1. Visual inspection
2. Combustion test
3. Clean burners
4. Check exchanger
5. Test controls
6. Verify safeties
7. Clean blower
8. Replace filter
9. Check venting
10. Document service

Cooling Service:

1. Clean condenser
2. Check refrigerant
3. Test capacitor
4. Verify controls
5. Check drainage
6. Test temperatures
7. Clean/replace filter
8. Document

Excluded Services

Typical Exclusions:

Category	Examples
Major repairs	Heat exchanger, compressor
Modifications	Ductwork, piping
Code upgrades	Venting, gas piping
Cosmetic	Painting, insulation
Abuse	Lack of filter changes
External causes	Power issues, gas problems

Clear Communication:

- Written list
- Customer acknowledgment
- Annual review
- Update as needed
- Explain thoroughly

Optional Services

Add-On Services:

- Duct cleaning
- IAQ products
- Humidifier service
- Filter delivery
- Water heater service
- Emergency coverage

Pricing Structure:

- Bundle discounts
- Loyalty rewards
- Referral benefits
- Prepayment discount
- Multi-year agreements

Pricing Considerations

Setting profitable, competitive prices.

Cost Analysis

Direct Costs:

Item	Cost
Labor	$50-75
Vehicle	$15-25
Parts/supplies	$10-20
overhead	30-40%
Total cost	$100-150

Markup Requirements:

- Profit margin: 20-30%
- Covers slow periods
- Equipment investment

- Training costs
- Insurance increases

Market Factors

Competitive Analysis:

- Survey competition
- Mystery shopping
- Customer feedback
- Value proposition
- Differentiation

Value-Added Services:

- 24/7 support
- Online scheduling
- Maintenance reminders
- Energy reports
- Priority service
- Warranty extensions

Contract Structures

Payment Options:

Method	Pros	Cons
Annual	Simple, paid upfront	Large payment
Monthly	Affordable, recurring	Administration
Auto-pay	Reliable, convenient	Setup required
Prepay discount	Cash flow, loyalty	Reduced margin

Renewal Strategies:

- Automatic renewal
- Advance notice
- Loyalty benefits
- Price protection
- Upgrade options

Customer Communication

Effective communication ensures satisfaction.

Initial Sales

Presentation Points:

1. **Value Proposition:**
    - Cost savings
    - Convenience
    - Peace of mind
    - Priority service
    - Professional care
2. **ROI Demonstration:**
    - Energy savings
    - Prevented breakdowns
    - Extended equipment life
    - Avoided emergencies
    - Budget protection

Materials Needed:

- Professional brochures
- Agreement forms
- Reference list
- Warranty info
- Company credentials

Service Delivery

Scheduling:

- Advance notice
- Confirmation calls
- Arrival windows
- On-time arrival
- Rescheduling options

During Service:

- Professional appearance
- Customer interaction
- Explain work
- Show findings
- Recommendations

Post-Service:

- Complete report
- Photos if applicable
- Next service date

- Thank you
- Follow-up call

Renewal Communications

Retention Strategy:

Timeline:

- 60 days: Initial notice
- 30 days: Renewal reminder
- 14 days: Final notice
- 7 days: Phone call
- After: Win-back campaign

Renewal Incentives:

- Price lock
- Loyalty discount
- Upgraded coverage
- Additional services
- Referral bonus

Legal Considerations

Protecting business and customer interests.

Contract Elements

Essential Terms:

1. **Parties:**
    - Company name/license
    - Customer name/address
    - Property address
    - Contact information
2. **Services:**
    - Detailed scope
    - Frequency
    - Exclusions
    - Standards
3. **Payment:**
    - Amount
    - Terms
    - Late fees
    - Increases

4. **Duration:**
    - Start date
    - Term length
    - Renewal terms
    - Cancellation

Liability Limitations

Protection Clauses:

- Limited warranty
- Consequential damages
- Force majeure
- Indemnification
- Insurance requirements

Example Language:

"Service provider's liability limited to the contract value. Not responsible for consequential damages, pre-existing conditions, or circumstances beyond reasonable control."

Regulatory Compliance

Requirements:

Aspect	Compliance Need
Licensing	Current and valid
Insurance	Adequate coverage
Permits	When required
Codes	Current standards
Safety	OSHA compliance
Environmental	EPA regulations

Documentation:

- Signed agreements
- Change orders
- Service records
- Correspondence
- Payment records
- Dispute resolution

Dispute Resolution

Prevention:

- Clear communication
- Written agreements
- Documentation
- Regular updates
- Problem solving

Resolution Process:

1. Direct negotiation
2. Supervisor involvement
3. Written correspondence
4. Mediation
5. Legal action (last resort)

Chapter Review

Summary

This chapter covered comprehensive maintenance and service procedures:

Preventive Maintenance Programs:

- Regular maintenance essential for safety and efficiency
- Seasonal tasks maximize performance
- Manufacturer requirements maintain warranties
- Proper scheduling ensures coverage
- Documentation protects all parties

Equipment-Specific Maintenance:

- Furnaces require annual comprehensive service
- Water heaters need tank protection focus
- Boilers demand water treatment attention
- Each system has unique requirements
- Safety testing is never optional

Seasonal Procedures:

- Pre-season preparation prevents failures
- Proper start-up ensures safe operation
- Correct shutdown prevents damage
- Winterization protects vacant properties
- Documentation guides next service

Combustion Testing:

- Required for safety and efficiency
- Proper equipment essential
- Understanding results critical
- Adjustments optimize performance
- Documentation mandatory

Service Agreements:

- Various types serve different needs
- Clear scope prevents disputes
- Proper pricing ensures profitability
- Communication maintains relationships
- Legal compliance protects business

Key Maintenance Principles:

1. Safety always comes first
2. Prevention costs less than repair
3. Documentation protects everyone
4. Customer communication is essential
5. Professional service builds reputation
6. Continuous training maintains competence
7. Quality work ensures customer retention
8. Systematic approach ensures completeness
9. Regular maintenance extends equipment life
10. Professional maintenance ensures safe operation

Maintenance Checklist Creation

Annual Furnace Maintenance Checklist

Customer Information:

- [ ] Name: _____
- [ ] Address: _____
- [ ] Phone: _____
- [ ] Email: _____

Equipment Data:

- [ ] Make: _____
- [ ] Model: _____
- [ ] Serial: _____
- [ ] Age: _____

Visual Inspection:

- [ ] Cabinet condition
- [ ] Venting system
- [ ] Gas piping
- [ ] Electrical connections
- [ ] Condensate drainage
- [ ] Combustion air
- [ ] Area clearances

Operational Tests:

- [ ] Thermostat operation
- [ ] Ignition sequence
- [ ] Flame characteristics
- [ ] Blower operation
- [ ] Safety controls
- [ ] Limit switches
- [ ] Pressure switches

Measurements:

- [ ] Gas pressure: _____ " W.C.
- [ ] Manifold pressure: _____ " W.C.
- [ ] Temperature rise: _____ °F
- [ ] Static pressure: _____ " W.C.
- [ ] Amp draws: _____ A
- [ ] CO level: _____ ppm
- [ ] O_2: _____ %
- [ ] Efficiency: _____ %

Maintenance Performed:

- [ ] Cleaned burners
- [ ] Cleaned flame sensor
- [ ] Cleaned/replaced filter
- [ ] Cleaned blower
- [ ] Checked heat exchanger
- [ ] Tested safeties
- [ ] Lubricated motors
- [ ] Adjusted gas pressure
- [ ] Performed combustion test

Recommendations:

Technician: _____ Date: _____

Customer: _____ Date: _____

Procedure Documentation

Example Service Report

Service Date: November 15, 2024

Customer: John Smith **Address:** 123 Main St **Phone:** 555-1234

Equipment: Carrier 58STA090 **Serial:** 123456789 **Age:** 8 years

Service Performed:

1. Completed visual inspection - no deficiencies noted
2. Cleaned burners - light carbon buildup removed
3. Cleaned flame sensor - improved from 2.1 to 4.5 μA
4. Replaced 16x25x1 filter
5. Cleaned blower wheel - moderate dust accumulation
6. Tested all safety controls - operating properly
7. Performed combustion analysis:
    - O_2: 7.8%
    - CO: 45 ppm
    - Efficiency: 81%
8. Verified temperature rise: 58°F (within 40-70°F spec)

Recommendations:

1. Consider upgrading to media filter
2. Seal return air leaks noted
3. Schedule duct cleaning
4. Humidifier service needed

Next Service Due: November 2025

Technician: Bob Jones, License #12345 **Customer Signature:** John Smith

Service Planning Exercises

Exercise 1: Route Planning

Monday Schedule:

Time	Customer	Service Type	Location
8:00	Smith	Annual	North zone
10:00	Jones	Annual	North zone

Time	Customer	Service Type	Location
1:00	Johnson	Repair	Central
3:00	Williams	Annual	North zone

Optimization:

- Geographic grouping
- Travel minimized
- Lunch break included
- Emergency slot available

Exercise 2: Seasonal Planning

September Planning:

Week 1: Commercial accounts Week 2: Priority customers Week 3: Regular maintenance Week 4: Follow-up repairs

Staffing:

- 2 technicians maintenance
- 1 technician repairs
- 1 on-call rotation
- Overtime approved

Customer Communication Scenarios

Scenario 1: Major Repair Needed

"Mrs. Johnson, during our inspection we discovered a crack in your heat exchanger. This is a serious safety concern that requires immediate attention. I've shut down your furnace for your safety. Your options are heat exchanger replacement for $1,200 or a new furnace for $3,500. I recommend replacement due to the age of your unit."

Scenario 2: Maintenance Benefits

"Mr. Smith, your annual maintenance saved you from a breakdown. The flame sensor was marginal and would have failed soon. Because you have our service agreement, this cleaning was included, saving you an emergency call of $200 plus the inconvenience."

Scenario 3: Upgrade Recommendation

"Your 18-year-old furnace is operating safely but at only 72% efficiency. A new 95% efficient furnace would save approximately $300 annually on gas bills and includes a 10-year warranty. With current rebates, your investment would be $3,200."

Key Terms and Definitions

AFUE: Annual Fuel Utilization Efficiency rating.

Anode Rod: Sacrificial metal protecting water heater tank.

Anticipator: Thermostat component controlling cycle timing.

Blowdown: Draining water from boiler low water cutoff.

Combustion Analysis: Testing combustion products for safety and efficiency.

Delta T: Temperature difference across system.

ECO: Energy Cut-Off - high limit safety on water heaters.

Heat Exchanger: Component separating combustion from air stream.

Hydronic: Heating system using water as medium.

Maintenance Agreement: Contract for regular service.

PM: Preventive Maintenance.

Preventive Maintenance: Regular service preventing breakdowns.

Refractory: Heat-resistant material in combustion chambers.

Service Contract: Agreement for maintenance and/or repairs.

Temperature Rise: Supply minus return air temperature.

T&P Valve: Temperature and Pressure relief valve.

Winterization: Protecting systems from freeze damage.

End of Chapter 20

This comprehensive chapter on Maintenance and Service provides the essential knowledge and procedures for maintaining gas equipment professionally and safely. Regular maintenance is not optional—it's essential for safety, efficiency, reliability, and customer satisfaction.

Students should understand that professional maintenance requires systematic procedures, proper documentation, clear communication, and business acumen. The ability to perform thorough maintenance, explain its value to customers, and manage service agreements creates successful careers in the gas fitting industry.

As equipment becomes more complex and efficient, maintenance requirements evolve, but fundamental principles remain constant: safety first, systematic approach, thorough documentation, and professional service. Regular training updates and commitment to excellence ensure technicians provide valuable services that protect customers and build successful businesses.