CHAPTER 7

Gas Meters and Regulators

Learning Objectives

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

1. Identify different types of gas meters and explain their operation
2. Read gas meters accurately and calculate consumption
3. Understand meter capacity ratings and sizing
4. Describe service regulator types and their functions
5. Explain the difference between first-stage and second-stage regulation
6. Select appropriate regulators for different applications
7. Adjust regulator outlet pressure correctly
8. Test regulator lock-up pressure per code requirements
9. Diagnose common regulator problems
10. Understand overpressure protection requirements

7.1 Gas Meters

Gas meters measure the volume of gas consumed for billing purposes and provide information about system capacity.

Purpose of Gas Meters

Primary Functions:

1. **Billing:** Measure consumption for customer billing
2. **Capacity:** Indicate maximum flow rate available
3. **System monitoring:** Track usage patterns
4. **Leak detection:** Unusual consumption indicates leaks

Ownership:

- Utility owns meter (natural gas)
- Propane supplier may own or lease meter
- Customer never owns utility meter
- Tampering with meter is illegal

Diaphragm Meters (Displacement Meters)

Most Common Type for Residential and Small Commercial

Construction:

- Metal case housing
- Internal diaphragms (flexible chambers)
- Valves directing gas flow
- Mechanical counter (register)
- Inlet and outlet connections

Operation:

1. Gas enters meter
2. Valves direct gas into first chamber
3. Diaphragm expands, filling chamber with measured volume
4. Valve switches, directs gas to second chamber
5. First chamber empties through outlet
6. Cycle repeats continuously
7. Each cycle = specific volume
8. Mechanical linkage counts cycles
9. Register displays total volume

Advantages:

- Accurate
- Reliable
- No power required
- Long service life (20-30 years)
- Wide range of sizes
- Proven technology

Disadvantages:

- Moving parts (diaphragms, valves)
- Can freeze if moisture present
- Requires periodic recalibration
- Size/weight for large capacities
- Pressure drop through meter

Capacity Range:

- Residential: 175-250 CFH (1.75-2.5 m^3/h) typical
- Small commercial: Up to 10,000 CFH
- Larger for industrial applications

Reading Diaphragm Meters:

Dial Configuration:

- Multiple dials (typically 4-6)
- Each dial represents place value
- Rightmost = ones
- Next left = tens, hundreds, thousands, etc.
- Some dials rotate clockwise, others counterclockwise

Reading Procedure:

1. Start with leftmost (largest value) dial
2. Read each dial from left to right
3. If pointer between numbers, use lower number
4. Record all digits
5. Note units (cubic feet, cubic meters)

Example:

```
[1000s] [100s] [10s] [1s]
   4       7      3    6
```

Reading: 4,736 cubic feet (or cubic meters, depending on meter)

Test Dials:

- Some meters have test dials
- Complete rotation = specific volume (e.g., 1/2 cubic foot)
- Used for leak testing
- Useful for monitoring small flows

Rotary Meters

Used for Larger Commercial/Industrial Applications

Construction:

- Rotating impellers/vanes
- Precision-machined case
- Electronic or mechanical register
- Larger capacity than diaphragm meters

Operation:

- Gas flow turns impellers

- Rotation speed proportional to flow rate
- Counter records rotations
- More compact than large diaphragm meters

Advantages:

- Higher capacity
- Smaller size for capacity
- Lower pressure drop
- More accurate at high flows

Disadvantages:

- More expensive
- May require filtration
- More maintenance
- Not as common in residential

Capacity Range:

- 3,000 to 100,000+ CFH
- Commercial and industrial applications

Turbine Meters

High-Capacity Applications

Construction:

- Turbine wheel in gas stream
- Electronic sensor counts rotations
- Digital register
- High-flow, low pressure drop

Operation:

- Gas flow spins turbine
- Speed proportional to flow rate
- Electronic counter
- Very accurate at design flow

Applications:

- Large commercial
- Industrial facilities
- High-volume users

- Usually utility-specified

Ultrasonic Meters

Modern Technology

Operation:

- Sound waves measure gas velocity
- No moving parts
- Electronic measurement
- Very accurate

Advantages:

- No moving parts (no wear)
- Wide measurement range
- Low pressure drop
- Long service life
- Remote monitoring capable

Disadvantages:

- Expensive
- Requires power
- Complex technology

Applications:

- Large commercial/industrial
- Where accuracy critical
- Modern installations
- Growing in use

Meter Sizing and Capacity

Meter Capacity Rating:

- Maximum continuous flow rate
- Expressed in cubic feet per hour (CFH) or cubic meters per hour (m^3/h)
- Must handle peak demand
- Oversizing creates minimal penalty
- Undersizing causes pressure drop

Sizing Considerations:

Total Connected Load:

- Sum all appliance inputs
- Convert to CFH (BTU/hr ÷ heating value)
- Add safety factor (typically 25-50%)

Example:

- Connected load: 240,000 BTU/hr
- Natural gas: 240,000 ÷ 1,000 = 240 CFH
- Safety factor: 240 × 1.25 = 300 CFH
- Select meter: 250-400 CFH capacity

Utility Determination:

- Utilities typically size and install meters
- Based on connected load or projected usage
- May limit capacity to control costs
- Upgrades available if needed

Pressure Drop Through Meter:

- All meters create pressure drop
- Greater at higher flows
- Must account for in system design
- Typically 0.25-0.5" W.C. at rated capacity

Meter Installation Requirements

Location (CSA B149.1):

Outdoors Preferred:

- Protected from physical damage
- Accessible for reading and service
- Away from ignition sources
- Adequate clearances
- Protected from weather (overhead cover)

Indoors (where permitted):

- Well-ventilated space
- Accessible location
- Not in sleeping areas
- Not in bathrooms
- Away from electrical equipment

- Adequate clearances

Clearances (Minimum):

- 3 ft (1 m) from ignition sources
- 3 ft (1 m) from electric meters
- 3 ft (1 m) from building openings (below)
- 1 ft (0.3 m) from building openings (to side)
- 10 ft (3 m) from above-ground propane tank

Installation Details:

- Level and plumb
- Properly supported
- Protected from damage (vehicle guards if needed)
- Unions or flanges for removal
- Valves on both sides (utility typically installs)
- Proper venting if regulator integral
- Drip leg at inlet (condensation)

Meter Numbering:

- Each meter has unique serial number
- Used for billing and tracking
- Never remove or alter
- Record for documentation

Meter Reading and Consumption Calculation

Reading for Consumption:

1. Record initial reading: 4,736 cubic feet
2. Record final reading (1 month later): 5,921 cubic feet
3. Calculate consumption: 5,921 - 4,736 = 1,185 cubic feet
4. Convert to therms or GJ for billing:
    - 1 therm = 100,000 BTU = 100 cubic feet (approximately)
    - 1,185 cubic feet ÷ 100 = 11.85 therms

Temperature and Pressure Correction:

- Gas volume varies with temperature and pressure
- Utilities apply correction factors
- Billing at standard conditions
- Customer sees corrected usage

Estimating Appliance Consumption:

Example: Furnace

- Input: 100,000 BTU/hr
- Consumption: 100,000 ÷ 1,000 = 100 CFH when running
- Runs 8 hours per day average in winter
- Daily consumption: 100 × 8 = 800 cubic feet
- Monthly: 800 × 30 = 24,000 cubic feet

7.2 Service Regulators

Regulators reduce gas pressure and maintain constant outlet pressure despite varying inlet pressure or flow demand.

Regulator Function

Purpose:

- Reduce high pressure to usable pressure
- Maintain constant outlet pressure
- Protect appliances from over-pressure
- Compensate for supply pressure variations
- Allow proper appliance operation

How Regulators Work:

Basic Components:

1. **Diaphragm:** Flexible membrane sensing outlet pressure
2. **Spring:** Provides force to set outlet pressure
3. **Valve:** Opens/closes to control flow
4. **Vent:** Allows diaphragm to sense atmospheric pressure

Operation Principle:

1. Spring pushes diaphragm down
2. Diaphragm connected to valve
3. Valve opens, allowing gas flow
4. Outlet pressure builds
5. Outlet pressure pushes diaphragm up against spring
6. When outlet pressure = spring force, valve holds steady position
7. If outlet pressure drops (demand increases), spring pushes valve open more
8. If outlet pressure rises (demand decreases), pressure pushes valve closed
9. Self-regulating balance maintains setpoint

This is automatic and continuous - no external power needed.

Types of Service Regulators

Single-Stage Regulators

Function:

- Reduce pressure in one step
- From supply pressure directly to appliance pressure

Natural Gas Single-Stage:

- Inlet: 60 PSI to 5 PSI (varies by utility)
- Outlet: 5-7" W.C. (typically 7" W.C.)
- One regulator does entire pressure reduction

Propane Single-Stage:

- Inlet: Tank pressure (varies with temperature, 20-250+ PSIG)
- Outlet: 11" W.C. (residential) or 13" W.C. (mobile home)
- Handles wide inlet pressure variation

Advantages:

- Simple
- Fewer components
- Lower cost
- Adequate for many applications

Disadvantages:

- Outlet pressure varies with inlet pressure changes
- Less precise control
- Greater pressure drop under high flow
- Not ideal for large inlet pressure variations

Applications:

- Small propane systems (where not much better option)
- Natural gas where inlet pressure stable
- Simple installations
- Low-demand systems

Two-Stage Regulation

Modern Standard for Propane, Common for Natural Gas

First-Stage Regulator:

Location:

- At or near supply source
- Propane: at tank
- Natural gas: at meter or service entry

Function:

- Reduce high/variable pressure to intermediate pressure
- Buffer between supply and distribution

Propane First-Stage:

- Inlet: Tank pressure (20-250+ PSIG)
- Outlet: 10 PSI (27.7" W.C.) typical
    - Sometimes 15 PSI for long distribution runs
- Handles wide inlet variation
- Maintains constant intermediate pressure

Natural Gas First-Stage:

- Inlet: Utility delivery pressure (60 PSI or higher)
- Outlet: 2 PSI (55" W.C.) typical for larger systems
- Used in large commercial/industrial
- Allows higher-pressure distribution (smaller pipe)

Second-Stage Regulator:

Location:

- At or near building
- After first-stage reduction
- Just before entering structure

Function:

- Reduce intermediate pressure to appliance pressure
- Final pressure control
- Protects appliances

Second-Stage Outlet Pressures:

- Natural gas: 7" W.C. typical (appliances rated 7" or 7" ±)
- Propane (residential dwelling): **11" W.C.**
- Propane (mobile/manufactured home): **13" W.C.**

Why Two Stages:

- More stable outlet pressure
- Better flow characteristics
- Protects against first-stage failure
- Allows smaller distribution piping (higher intermediate pressure)
- Industry standard for quality installations

Line Pressure Regulators:

Definition:

- Integral two-stage in one body
- Or high-capacity single-stage line regulators
- Mounted at tank or building

Function:

- Single device, two-stage function internally
- Or robust single-stage design

Applications:

- Residential propane (common)
- Small commercial
- Simpler installation
- Where two separate regulators not desired

Limitations:

- Fixed capacity
- All pressure drop at one location
- Limited by piping downstream
- May not work for complex systems

Appliance Regulators

Built into Appliances:

- Most appliances have internal regulator
- Reduces supply pressure (7" W.C. or 11" W.C.) to manifold pressure
- Natural gas: 3.5" W.C. manifold typical

- Propane: 10" W.C. manifold typical
- Adjustable spring or fixed

Not All Appliances:

- Some rely on supply pressure being correct
- Check appliance specifications
- Conversion kits change appliance regulator

7.3 Regulator Selection and Sizing

Selecting the correct regulator ensures proper system operation and appliance performance.

Capacity Requirements

Calculate System Demand:

- Sum all appliance inputs (BTU/hr)
- Convert to CFH (natural gas ÷ 1,000, propane ÷ 2,500)
- Add safety factor (10-25%)

Example:

- Total load: 240,000 BTU/hr
- Natural gas: 240,000 ÷ 1,000 = 240 CFH
- With 20% safety factor: 240 × 1.20 = 288 CFH
- Select regulator rated ≥ 288 CFH

Manufacturer Ratings:

- Regulators rated in CFH at specific conditions
- Rating usually at outlet pressure setpoint
- Check capacity curves for flow vs. pressure

Oversizing Considerations:

- Moderate oversizing acceptable
- Excessive oversizing can cause instability
- Usually stay within 2-3 times required capacity
- Follow manufacturer recommendations

Inlet Pressure Requirements

First-Stage Regulators:

- Must handle maximum inlet pressure
- Propane: design for 250-300 PSIG minimum
- Natural gas: per utility supply pressure
- Check regulator rating

Second-Stage Regulators:

- Inlet matches first-stage outlet
- Typically 10 PSI for propane systems
- Must not exceed regulator inlet rating

Outlet Pressure Requirements

Match Appliance Requirements:

Natural Gas:

- Most appliances: 5-7" W.C. supply pressure
- Check appliance rating plate
- Standard: 7" W.C.

Propane:

- Residential dwellings: 11" W.C.
- Mobile/manufactured homes: 13" W.C.
- Appliances designed for these pressures

Adjustable vs. Fixed:

- Adjustable regulators: spring tension adjustable
- Fixed regulators: non-adjustable spring
- Adjustable allows field setup
- Fixed simpler but less flexible

Vent Requirements

Why Regulators Vent:

- Diaphragm chamber must be vented to atmosphere
- Allows diaphragm to sense atmospheric pressure
- Reference point for regulation
- Small amounts of gas may vent during operation or diaphragm failure

Vent Location (CSA B149.2 for Propane):

- Must terminate outdoors
- Minimum 3 m (10 ft) from ignition sources
- Minimum 3 m (10 ft) from building openings below vent
- Minimum 1.5 m (5 ft) from mechanical ventilation intakes
- Turn downward or screened to prevent insect/water entry
- Not obstructed

Vent Limiting Devices (VLD):

- Special internal vent design
- Limits gas release if diaphragm fails
- May allow indoor installation in some cases
- Must meet specific standards
- Not common in Canada

First-Stage Regulators:

- Vent at tank location
- Outdoor location typically
- Integrated with relief valve sometimes

Second-Stage Regulators:

- Must vent per code
- Often point of inspection failure
- Critical safety requirement

Special Applications

High-Capacity Regulators:

- Commercial/industrial
- May require pilot-operated designs
- Multiple regulators in parallel
- Consult with supplier/engineer

Overpressure Protection:

- Some applications require overpressure shutdown devices
- Monitors outlet pressure
- Shuts off flow if excessive
- Required by code in some jurisdictions for larger systems

7.4 Regulator Installation

Proper installation ensures safe, reliable operation.

Location Requirements

First-Stage (Propane at Tank):

- Attached to tank valve or nearby
- Outdoor location
- Accessible for service
- Protected from physical damage
- Vent properly oriented
- Relief valve outlet oriented correctly

Second-Stage (at Building):

- Exterior of building preferred
- Just before entering structure
- Protected from weather (overhang helpful)
- Accessible for service
- Vent properly terminated
- Upstream of building piping

Line Pressure (Integral Two-Stage):

- Can be at tank or building
- Outdoor location
- Adequate capacity for entire system
- Piping sized for supply pressure delivered

Mounting and Support

Support Requirements:

- Adequate support for weight
- No stress on connections
- Level installation
- Protected from vibration
- Rigid mounting

Connections:

- Proper pipe sizing inlet and outlet
- Unions for service removal
- No strain on regulator
- Valves for isolation
- Drip leg at inlet (if condensation possible)

Pressure Testing Considerations

Testing Around Regulators:

- Regulators can be damaged by excessive pressure
- May need isolation during testing
- Check manufacturer limits
- Remove or bypass for high-pressure tests
- Reinstall/reopen after testing

Test Plugs:

- Some regulators have test plugs for pressure measurement
- 1/8" NPT taps
- Use for setting and verifying pressure
- Seal properly after testing

7.5 Regulator Adjustment and Testing

Proper adjustment ensures correct outlet pressure for appliance operation.

Outlet Pressure Adjustment

Tools Required:

- Manometer (digital or U-tube)
- Screwdriver (for adjustment)
- Wrenches (if cover removal needed)

Procedure:

1. Preparation:

- Ensure appliances off or minimal load
- Connect manometer to test port (or downstream pressure tap)
- Manometer to sense outlet pressure

2. Access Adjustment:

- Some regulators: cap removal required
- Some regulators: external adjustment screw
- Note seal (may need inspector verification after adjustment)

3. Initial Reading:

- Start appliances to create flow (or note static pressure)
- Read outlet pressure
- Compare to target:
    - Natural gas: typically 7" W.C.
    - Propane residential: 11" W.C.
    - Propane mobile home: 13" W.C.

4. Adjustment:

- Turn adjustment screw:
    - Clockwise = increase pressure (tighten spring)
    - Counter-clockwise = decrease pressure (loosen spring)
- Small adjustments (1/4 turn at a time)
- Allow pressure to stabilize
- Check reading

5. Verification:

- Cycle appliances on/off
- Verify pressure stable
- Check at various loads (low and high)
- Verify no excessive droop (pressure drop under load)

6. Lock-Up Pressure Test:

- Turn off all appliances (no flow)
- Pressure rises slightly
- Should not exceed:
    - Natural gas: typically 10-12" W.C. maximum
    - Propane residential: typically 14" W.C. maximum
    - Propane mobile home: typically 16" W.C. maximum
- Excessive lock-up indicates regulator problem

7. Documentation:

- Record inlet pressure
- Record outlet pressure (no load and under load)
- Record lock-up pressure
- Date and technician signature

Lock-Up Pressure

Definition:

- Outlet pressure when no gas flows
- Regulator valve fully closed
- Normal for pressure to rise slightly

Acceptable Lock-Up:

- Should be close to setpoint
- CSA B149.1/B149.2 specify maximums:
    - Second-stage: typically no more than 2" W.C. above setpoint
    - First-stage: per manufacturer

Testing Procedure:

1. Set outlet pressure under flow
2. Close all appliance valves (no flow)
3. Wait for pressure to stabilize
4. Read and record maximum pressure
5. Verify within acceptable range

Excessive Lock-Up Causes:

- Regulator valve not seating properly
- Damaged valve seat
- Debris in valve
- Spring tension too high
- Regulator failure

Excessive Lock-Up Consequences:

- Over-fires appliances
- Damages appliance components
- Safety concern
- Failed inspection

Correction:

- Check for debris
- Clean if possible
- Replace regulator if damaged
- Do not attempt repair of sealed regulators
- Verify correction with retest

Common Adjustment Problems

Pressure Won't Adjust:

- Adjustment screw may be seized
- Limit of adjustment range reached
- Wrong regulator for application
- Internal failure

Pressure Unstable:

- Hunting (pressure oscillates)
- Regulator undersized
- Vent obstructed
- Diaphragm damage
- Debris in valve

Pressure Drops Under Load:

- Undersized regulator
- Restricted inlet
- Failing regulator
- Excessive demand

7.6 Regulator Testing and Maintenance

Regular testing ensures continued safe operation.

Periodic Testing

When to Test:

- Initial installation
- Annual maintenance
- After any repairs
- If performance issues
- Code-required intervals

Test Sequence:

1. Visual Inspection:

- Physical damage
- Corrosion
- Vent clear and properly oriented
- Connections tight
- No gas odor
- Diaphragm housing intact

2. Inlet Pressure:

- Measure and record
- Verify adequate for regulator
- Compare to expected

3. Outlet Pressure (Operating):

- With appliances running
- Various load conditions
- Record pressure

4. Outlet Pressure (Lock-Up):

- All appliances off
- Maximum no-flow pressure
- Record and verify acceptable

5. Droop Test:

- Pressure difference between lock-up and full load
- Should be minimal
- Excessive droop indicates undersizing or failure

6. Vent Operation:

- Verify vent clear
- Check for gas leakage at vent
- Slight venting normal during operation
- Excessive venting indicates diaphragm failure

Maintenance

Customer-Accessible Maintenance:

- None - regulators are sealed units
- Only technicians should service
- Never attempt repairs

Technician Maintenance:

- External cleaning
- Vent inspection and clearing
- Pressure testing and adjustment
- Leak testing connections
- Visual inspection

When to Replace:

- Excessive lock-up (unfixable)
- Unstable operation
- Physical damage
- Corrosion
- Vent damage
- Age (typically 15-20 years)
- Failed testing
- After fire exposure

Replacement Procedure:

1. Shut off gas supply
2. Relieve pressure downstream
3. Disconnect old regulator
4. Inspect piping
5. Install new regulator with proper orientation
6. Pressure test connections
7. Restore gas service
8. Set outlet pressure
9. Test lock-up pressure
10. Document replacement

7.7 Troubleshooting Regulators

Insufficient Gas Pressure/Flow

Symptoms:

- Appliances won't light or operate poorly
- Yellow flames
- Pilot outages
- Low heat output

Possible Causes:

1. Low Inlet Pressure:

- Empty propane tank
- Undersized first-stage regulator
- Restricted supply line
- Utility supply problem (natural gas)
- Check: Measure inlet pressure

2. Failed Regulator:

- Diaphragm rupture
- Spring failure
- Valve seat damage
- Frozen regulator (moisture/propane)
- Check: Measure outlet pressure, replace if low

3. Undersized Regulator:

- Insufficient capacity for demand
- Pressure drops under load
- Check: Calculate actual demand vs. regulator capacity

4. Obstructed Vent:

- Regulator cannot regulate properly
- Insects, ice, debris blocking vent
- Check: Inspect and clear vent

5. Restricted Piping:

- Downstream blockage
- Undersized piping creating excessive drop
- Check: Pressure at regulator vs. at appliances

Excessive Gas Pressure

Symptoms:

- Appliances over-fire
- Rollout or lockout
- Noisy combustion
- Excessive short cycling

Possible Causes:

1. Excessive Lock-Up:

- Regulator not closing valve completely
- Adjustment too high
- Failed valve seat
- Check: Lock-up pressure test

2. Wrong Regulator:

- Natural gas regulator on propane
- Wrong outlet pressure setting
- Check: Verify regulator specifications

3. Failed Regulator:

- Stuck open
- Spring failure
- Diaphragm damage
- Check: Outlet pressure under all conditions

4. First-Stage Failure (Two-Stage System):

- First stage not regulating
- Full tank pressure to second stage
- Second stage overwhelmed
- Check: Measure between stages

Pressure Fluctuations

Symptoms:

- Pressure varies during operation
- Appliances cycle
- Inconsistent performance

Possible Causes:

1. Hunting:

- Regulator oscillating
- Oversized regulator
- Vent problem
- Internal regulator issue
- Check: Observe pressure with continuous monitoring

2. Demand Changes:

- Normal slight variation
- Other appliances cycling
- May be normal if minor

3. Supply Variations:

- First-stage problem (two-stage system)
- Utility supply fluctuation (natural gas)

- Check: Monitor inlet pressure

Frozen Regulator

Propane Specific Problem:

Cause:

- High gas flow causes cooling (Joule-Thomson effect)
- Moisture in gas freezes at regulator
- Ice blocks regulator operation
- External moisture freezes on cold regulator body

Prevention:

- Proper tank sizing (adequate vaporization)
- Dry gas (proper processing)
- Regulator covers in cold weather
- Heating tape if necessary (commercial)

Symptoms:

- Pressure drop during operation
- Frost formation on regulator
- Appliances lose performance

Correction:

- Reduce demand or increase supply
- Allow regulator to thaw
- Address root cause (undersized tank, wet gas)

7.8 Overpressure Protection

Some installations require overpressure protection devices.

When Required

CSA B149.1 Requirements:

- Check current code edition
- Some larger commercial/industrial installations
- When specified by engineer

- Where failure creates excessive hazard
- Check local authorities

Purpose:

- Protect against regulator failure
- Prevent excessive pressure at appliances
- Additional safety layer

Types of Overpressure Devices

1. Overpressure Shut-Off Valve (OPSV):

- Monitors outlet pressure
- Automatically closes if pressure exceeds setpoint
- Requires manual reset
- Installed downstream of regulator

2. Relief Valves:

- Vents gas if pressure excessive
- Does not shut off flow
- Protects piping
- Required on propane tanks

3. Monitoring Regulator:

- Second regulator in series
- Normally wide open (no regulation)
- Closes if senses excessive pressure
- Backup to main regulator

4. Slam-Shut Device:

- Closes immediately if pressure excessive
- Protects downstream equipment
- Requires reset

Installation

Location:

- Downstream of main regulator
- Upstream of appliances
- Accessible for testing and reset
- Properly vented if device vents

Setting:

- Set above normal operating pressure
- Below appliance maximum rating
- Typical: 25-50% above normal
- Per manufacturer and code

Testing:

- Initial installation
- Annually
- After any system changes
- Simulate overpressure condition
- Verify operation and reset

Chapter Summary

Gas meters measure consumption for billing and indicate system capacity. Diaphragm meters are most common for residential use, with rotary and turbine meters for larger applications. Meters are sized based on total connected load plus safety factor, typically by the utility.

Service regulators reduce gas pressure and maintain constant outlet pressure for appliance operation. Single-stage regulators reduce pressure in one step, while two-stage regulation provides more stable pressure control. Modern propane installations use two-stage regulation: first stage at tank reduces to 10 PSI, second stage at building reduces to 11" W.C. (residential) or 13" W.C. (mobile home).

Regulator selection requires calculating system demand, verifying inlet pressure compatibility, and matching outlet pressure to appliance requirements. All regulators must be properly vented per code. Installation requires proper location, support, and orientation.

Regulator adjustment involves setting outlet pressure under load and verifying acceptable lock-up pressure. Excessive lock-up indicates regulator failure requiring replacement. Regular testing ensures continued safe operation. Common problems include insufficient pressure (undersized or failed regulator), excessive pressure (failed regulation), and pressure fluctuations (hunting or vent obstruction).

Review Questions

Multiple Choice

1. The most common type of gas meter for residential use is:
    - a) Rotary meter
    - b) Turbine meter
    - c) Diaphragm meter
    - d) Ultrasonic meter
2. A propane first-stage regulator typically reduces tank pressure to:
    - a) 11" W.C.
    - b) 7" W.C.
    - c) 10 PSI
    - d) 20 PSI
3. The outlet pressure for a propane second-stage regulator in a residential dwelling should be:
    - a) 7" W.C.
    - b) 10" W.C.
    - c) 11" W.C.
    - d) 13" W.C.
4. Lock-up pressure is measured when:
    - a) All appliances are operating
    - b) No gas is flowing
    - c) One appliance is operating
    - d) Gas is being delivered at maximum rate
5. To increase regulator outlet pressure, turn the adjustment screw:
    - a) Clockwise
    - b) Counter-clockwise
    - c) Either direction
    - d) Do not adjust - call manufacturer
6. Regulator vents must terminate:
    - a) Indoors for monitoring
    - b) In crawl space
    - c) Outdoors per code requirements
    - d) Back into gas supply
7. A frozen propane regulator is typically caused by:
    - a) Cold weather only
    - b) High flow causing cooling and moisture freezing
    - c) Defective regulator
    - d) Wrong gas type
8. When reading a diaphragm gas meter, if the pointer is between two numbers:
    - a) Use the higher number
    - b) Use the lower number
    - c) Estimate halfway
    - d) Round to nearest number
9. The outlet pressure for a propane second-stage regulator in a mobile home should be:
    - a) 7" W.C.
    - b) 10" W.C.
    - c) 11" W.C.
    - d) 13" W.C.

10. Excessive regulator lock-up pressure indicates:
    - a) Normal operation
    - b) Regulator needs adjustment
    - c) Regulator failure requiring replacement
    - d) Inlet pressure too high

True or False

11. Gas meters are owned by the customer in natural gas installations.
12. Two-stage regulation provides more stable outlet pressure than single-stage.
13. All gas appliance regulators require external venting to outdoors.
14. Lock-up pressure should be significantly higher than operating pressure.
15. Regulator adjustment should only be performed by qualified technicians.

Short Answer

16. Explain the difference between first-stage and second-stage regulation in a propane system. Include inlet and outlet pressures for each stage. (5 marks)
17. List four symptoms that would indicate a failed or undersized regulator. (4 marks)
18. Why must regulator vents terminate outdoors? Where must they be located relative to building openings? (4 marks)
19. Describe the procedure for testing regulator lock-up pressure. (4 marks)
20. What is regulator "hunting" and what causes it? (3 marks)

Long Answer

21. Describe the complete procedure for adjusting a propane second-stage regulator outlet pressure in a residential installation. Include:
    - Required tools and equipment
    - Safety precautions
    - Step-by-step adjustment procedure
    - Testing and verification
    - Acceptable pressure ranges
    - Documentation requirements (12 marks)
22. A customer complains that their furnace "doesn't heat well" and sometimes shuts down. You measure the gas pressure at the furnace and find it's 4" W.C. during operation (should be 7" W.C.). Describe your systematic troubleshooting approach. Include:
    - Possible causes of low pressure
    - Tests and measurements you would perform
    - How to isolate the problem
    - Likely solutions
    - How to verify correction (15 marks)
23. Compare single-stage and two-stage pressure regulation systems. Include:
    - How each system operates
    - Pressure levels at each stage
    - Advantages and disadvantages of each

- Applications where each is appropriate
- Why two-stage is preferred for modern propane installations
- Cost and complexity considerations (15 marks)

Practical Exercises

Exercise 1: Meter Reading

Practice reading various gas meters:

1. Dial-type meters (various configurations)
2. Record readings accurately
3. Calculate consumption between readings
4. Convert to therms or GJ
5. Estimate costs

Exercise 2: Regulator Pressure Testing

On training equipment or actual installation:

1. Connect manometer to test point
2. Measure inlet pressure
3. Measure outlet pressure (under load)
4. Measure lock-up pressure (no flow)
5. Calculate pressure droop
6. Document all readings
7. Determine if regulator acceptable

Exercise 3: Regulator Adjustment

Under supervision, adjust regulator:

1. Measure initial outlet pressure
2. Access adjustment screw
3. Make calculated adjustment
4. Verify new pressure
5. Test lock-up pressure
6. Cycle appliances to verify stability
7. Document final settings

Exercise 4: Regulator Capacity Calculation

Calculate and select regulator:

1. Given appliance loads
2. Calculate total CFH demand
3. Add safety factor
4. Select appropriate regulator from catalog
5. Verify capacity adequate
6. Document selection rationale

Exercise 5: Two-Stage System Testing

On propane two-stage system:

1. Measure tank pressure (inlet to first stage)
2. Measure between stages (outlet first stage / inlet second stage)
3. Measure final outlet pressure (outlet second stage)
4. Verify each stage operating correctly
5. Test lock-up at second stage
6. Document complete system pressures

Exercise 6: Troubleshooting Simulation

Given problem scenarios:

1. Low pressure at appliances
2. High pressure causing rollout
3. Pressure fluctuations
4. Frozen regulator

For each:

- List possible causes
- Describe diagnostic steps
- Identify most likely cause
- Recommend solution
- Verify correction method

Case Studies

Case Study 1: Undersized Regulator

Scenario: A homeowner complains that when they run hot water while cooking on the range, the furnace flame gets very small and sometimes shuts off on limit. Gas pressure measurement shows:

- At meter outlet: 11" W.C. (propane residential, correct)
- At furnace (with all appliances on): 6" W.C.
- Lock-up pressure at meter: 12" W.C. (acceptable)

The system has a line pressure (integral two-stage) regulator rated 300 CFH. Total connected load is 285,000 BTU (114 CFH propane).

Questions:

1. What is causing the low pressure at the furnace?
2. Is the regulator undersized based on BTU load?
3. What else could cause this pressure drop?
4. How do you diagnose further?
5. What is the solution?
6. How do you size the replacement regulator?
7. Could piping be the problem instead?
8. How do you verify the correction?

Case Study 2: Excessive Lock-Up

Scenario: During annual inspection, you test a propane second-stage regulator:

- Outlet pressure (under load): 11" W.C. (correct)
- Lock-up pressure (no flow): 18" W.C.
- Acceptable maximum: 14" W.C.

The homeowner says everything works fine and doesn't want to spend money on repairs.

Questions:

1. Is this a code violation?
2. What are the risks of excessive lock-up?
3. What could happen to the appliances?
4. Can you adjust the regulator to fix this?
5. What is the proper correction?
6. Can the system remain in service?
7. What do you tell the homeowner?
8. What documentation is required?
9. What if the homeowner refuses repairs?

Case Study 3: Wrong Regulator Installed

Scenario: You're called for a "furnace problem." You find:

- System is propane
- Building is a manufactured (mobile) home

- Second-stage outlet pressure: 11" W.C.
- Should be: 13" W.C. for mobile homes

The furnace is rated for 13" W.C. supply. It lights but doesn't produce full heat. The system was installed 6 months ago.

Questions:

1. What is wrong with this installation?
2. Why does the furnace light but not heat properly?
3. What pressure should be supplied to mobile home appliances?
4. Is this a code violation?
5. What correction is required?
6. Who is responsible (original installer, supplier, homeowner)?
7. Are other appliances affected?
8. How do you verify all appliances after correction?

Case Study 4: Frozen Regulator

Scenario: On a cold winter day (-25°C), a customer calls saying they have no heat. You arrive and find:

- Propane system
- 250-gallon tank, gauge shows 35%
- Heavy frost on regulator body
- No gas pressure at appliances
- System was working fine in warmer weather
- Total demand: 180,000 BTU (furnace 100,000, water heater 40,000, range 40,000)

Questions:

1. What is causing the frozen regulator?
2. Why does this happen in cold weather but not warm?
3. Is the tank too small?
4. Calculate approximate vaporization capacity at -25°C
5. What is the immediate solution?
6. What is the long-term solution?
7. Could a vaporizer help?
8. What do you tell the customer?

Case Study 5: Vent Obstruction

Scenario: You're called to investigate "strange pressure problems." You find:

- Second-stage regulator vent is blocked by wasp nest
- Outlet pressure fluctuates wildly (8-15" W.C.)

- Appliances operate erratically
- Sometimes cycling, sometimes over-firing
- Homeowner painted regulator and vent last summer

Questions:

1. How does a blocked vent affect regulator operation?
2. Why is the pressure unstable?
3. What damage could have occurred?
4. What is the immediate action?
5. Can the regulator be salvaged?
6. What testing is required after clearing vent?
7. How do you prevent recurrence?
8. What do you tell the homeowner about painting gas equipment?

Case Study 6: First-Stage Failure in Two-Stage System

Scenario: Multiple appliances over-firing and shutting down on high limit. You measure:

- Propane tank pressure: 150 PSIG (normal for temperature)
- Between first and second stage: 150 PSIG (should be 10 PSI)
- Second-stage outlet: Fluctuating 12-20" W.C. (should be stable 11")

Questions:

1. Which regulator has failed?
2. Why is the second stage unable to regulate properly?
3. Is this an emergency/safety issue?
4. Can the system operate safely?
5. What is the proper repair?
6. Could the second-stage regulator also be damaged?
7. What testing is required after replacement?
8. How do you prevent this type of failure?

Key Terms

Diaphragm Meter: Positive displacement meter using flexible chambers to measure gas volume.

Droop: Pressure decrease from lock-up to operating pressure under load.

First-Stage Regulator: Reduces high supply pressure to intermediate pressure (typically 10 PSI for propane).

Hunting: Regulator oscillation causing pressure fluctuations.

Line Pressure Regulator: Single device providing two-stage function or high-capacity single-stage regulation.

Lock-Up Pressure: Maximum outlet pressure when no gas flows; indicates regulator health.

Overpressure Shut-Off Valve (OPSV): Safety device that closes if pressure exceeds setpoint.

Regulator: Device that reduces gas pressure and maintains constant outlet pressure.

Relief Valve: Safety valve that vents gas if pressure excessive.

Rotary Meter: Gas meter using rotating impellers for high-capacity measurement.

Second-Stage Regulator: Reduces intermediate pressure to appliance supply pressure (11" W.C. or 13" W.C. for propane).

Single-Stage Regulator: Reduces pressure in one step from supply to appliance pressure.

Two-Stage Regulation: Pressure reduction in two steps for better control and stability.

Vent Limiting Device (VLD): Special regulator vent design limiting gas release during failure.

End of Chapter 7