CHAPTER 3

Tools and Equipment

Learning Objectives

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

1. Identify and properly use hand tools common to gas fitting work
2. Select appropriate tools for specific tasks
3. Operate power tools safely and effectively
4. Use testing and measurement equipment accurately
5. Perform basic tool maintenance and calibration checks
6. Apply proper safety procedures for all tools and equipment
7. Select piping tools appropriate for different materials
8. Interpret measurements from test instruments
9. Maintain tools to ensure accuracy and longevity
10. Understand quality tool selection criteria

3.1 Hand Tools

Hand tools form the foundation of a gas technician's toolkit. Quality tools, properly maintained and correctly used, increase efficiency, safety, and work quality.

Wrenches

Pipe Wrenches (Stillson Wrenches)

The most essential tool for gas pipe work.

Description:

- Adjustable jaw with toothed gripping surfaces
- Angled jaw design for leverage
- Heel jaw (fixed) and hook jaw (adjustable)
- Available in multiple sizes

Common Sizes:

- 10" (250 mm) - Small piping, tight spaces
- 14" (350 mm) - General purpose, most common
- 18" (450 mm) - Larger pipe, more leverage
- 24" (600 mm) - Large commercial pipe
- 36" (900 mm) and larger - Industrial applications

Proper Use:

- Direction of force opens jaw (self-tightening)
- Always pull, never push when possible
- Use two wrenches on threaded joints (one to hold, one to turn)
- Adjust jaw tension properly (not too loose or too tight)
- Position wrench to maximize leverage
- Keep jaws parallel to pipe
- Use appropriate size (wrench should fit 2/3 of jaw on pipe)

Safety Considerations:

- Pulling reduces risk of injury if wrench slips
- If must push, use open palm
- Stand with stable footing
- Worn or damaged jaws can slip
- Don't extend with cheater bars (use larger wrench)
- Don't use on nuts or finished surfaces (will damage)

Maintenance:

- Clean jaws after use
- Light oil on moving parts
- Keep adjustment nut free
- Replace if jaws worn smooth
- Check for cracks in handle

Adjustable Wrenches (Crescent Wrenches)

Open-end wrench with adjustable jaw.

Common Sizes:

- 6" (150 mm)
- 8" (200 mm)
- 10" (250 mm)
- 12" (300 mm)

Proper Use:

- Turn adjustment to fit snugly
- Apply force to fixed jaw side
- Position jaw flush against flats
- Don't use if jaw loose
- Use for hex fittings, union nuts, flare nuts

Applications in Gas Work:

- Flare fittings
- Union nuts
- Gas valve packing nuts
- Regulator connections
- Meter connections

Basin Wrench

Specialized wrench for confined spaces.

Description:

- Long shaft (10-17")
- Pivoting jaw at end
- Spring-loaded gripper
- T-handle at top

Applications:

- Water heater connections in tight spaces
- Under-sink connections
- Any fitting in confined space
- Coupling nuts behind fixtures

Proper Use:

- Jaw pivots to grip in either direction
- Spring maintains grip
- Long handle provides access
- Limited torque capability

Strap Wrenches

Flexible strap for gripping round objects without damage.

Types:

- Rubber strap with metal handle

- Chain with handle
- Heavy-duty nylon strap

Applications:

- Chrome-plated pipe
- Plastic pipe (ABS, PVC where permitted)
- Fragile fittings
- Polished surfaces
- Removing filter canisters

Socket Sets and Ratchets

While primarily automotive tools, useful for gas work.

Common Uses:

- Gas valve operators
- Mounting bolts
- Control brackets
- Equipment assembly
- Appliance service

Types:

- Standard (imperial) - common in North America
- Metric - some imported equipment
- Deep sockets - for recessed nuts
- Universal joints - for angles

Key sizes for gas work:

- 7/16" (11mm) - common gas valve size
- 1/2" (13mm) - mounting bolts
- 9/16" (14mm) - larger valves
- 3/8" and 1/4" drive - most versatile

Box-End and Open-End Wrenches

Fixed-size wrenches for hex fittings.

When to Use:

- More torque than adjustable
- Better fit prevents rounding
- Two wrenches for unions

- Flare fitting assembly
- Critical torque applications

Combination Wrenches:

- Box end one side, open end other
- Same size both ends
- Most versatile

Torque Wrenches

Measure and limit applied torque.

Types:

- Click-type (most common)
- Beam-type
- Digital

Applications in Gas Work:

- Flare fittings (prevent over-tightening)
- Union connections
- Critical gas valve connections
- Manufacturer specifications

Common Torque Values:

- 1/4" flare: 10-12 ft-lbs
- 3/8" flare: 15-18 ft-lbs
- 1/2" flare: 25-30 ft-lbs
- 5/8" flare: 35-40 ft-lbs
- (Always verify manufacturer specifications)

Cutting Tools

Pipe Cutters (Wheel-Type)

Standard tool for cutting steel pipe.

Components:

- Cutting wheel (hardened steel)
- Pressure rollers (2 or 3)
- Adjustment knob
- Frame

Sizes:

- 1/8" to 2" (most common)
- Heavy-duty models to 4"
- Close-quarters models (short handle)

Proper Use:

1. Mark cut line on pipe
2. Open jaws and position cutter
3. Tighten until wheel contacts pipe firmly
4. Rotate cutter around pipe once
5. Tighten slightly (1/4 to 1/2 turn)
6. Continue rotating and tightening gradually
7. Don't over-tighten (damages wheel, deforms pipe)

Benefits:

- Clean, square cut
- No sparks (safe around gas)
- Minimal burr
- Quiet operation
- Works in confined spaces

Maintenance:

- Replace cutting wheel when dull
- Keep rollers clean
- Oil pivot points
- Don't drop (damages wheel)

Internal Pipe Reamer

Removes burr from inside of pipe after cutting.

Types:

- Cone-style (most common)
- Folding pocket style
- Spiral design

Importance:

- Burrs restrict gas flow
- Can catch debris
- Create turbulence

- Required for quality installation

Use:

- Insert and rotate after each cut
- Remove burr completely
- Don't over-ream (weakens pipe end)
- Clean shavings from pipe

Hacksaws

Backup cutting method or for materials pipe cutter can't handle.

Frame Types:

- Fixed frame
- Adjustable length
- Close-quarters (short)

Blade Specifications:

- 14, 18, 24, 32 teeth per inch (TPI)
- 18 TPI most versatile for pipe
- 24-32 TPI for thin wall tubing
- Bi-metal blades most durable

Proper Use:

- Install blade with teeth forward
- Tension blade properly
- Support pipe adequately
- Use steady, full-stroke cuts
- Let blade do the work
- Cuts on push stroke

When to Use:

- CSST or corrugated tubing (where cutting allowed)
- Plastic pipe (where permitted)
- Materials that damage pipe cutter wheels
- Where pipe cutter won't fit
- Emergency situations

Tubing Cutters

Smaller version for copper and thin-wall tubing.

Sizes:

- 1/8" to 1-1/8" common range
- Mini-cutters for tight spaces

Features:

- Smaller cutting wheel
- Built-in reamer (triangular point)
- Roller guide bearings

Applications:

- Copper tubing (where permitted for gas)
- Control tubing
- Sensing lines
- Small diameter piping

Threading Tools

Threading pipe is essential for black iron installations.

Pipe Threading Dies

Create external threads on pipe.

Components:

- Die head with cutting teeth
- Guide teeth (first threads)
- Cutting teeth (main threads)
- Sizing teeth (final pass)

Types:

- Drop-head dies (receding)
- Solid dies (fixed)
- Ratcheting dies

Thread Standards:

- NPT (National Pipe Taper) - standard for gas pipe
- NPTF (Fuel) - tighter tolerance, not required for gas
- Tapered 3/4" per foot
- Threads seal on taper, not thread bottom

Die Sizes:

- 1/8" through 2" in hand sets
- Larger sizes machine-powered

Stocks and Handles

Hold dies and provide leverage.

Types:

- Ratcheting stocks (most efficient)
- Solid stocks
- Power drive adapters

Sizes:

- Small stock: 1/8" to 1/2"
- Medium stock: 1/2" to 1-1/4"
- Large stock: 1-1/2" to 2"

Proper Threading Procedure:

1. **Cut Pipe to Length**
    - Measure accurately
    - Cut square
    - Ream thoroughly
2. **Secure Pipe**
    - Use pipe vise
    - Adequate support
    - End close to vise (minimize deflection)
3. **Apply Cutting Oil**
    - Generously on die teeth
    - Continuously during threading
    - Threading oil, not motor oil
    - Lubricates and cools
4. **Start Die**
    - Align die square to pipe
    - Push firmly while turning
    - Die should bite and advance
    - If slipping, check die condition
5. **Thread Pipe**
    - Turn clockwise (standard right-hand thread)
    - Use steady pressure
    - Back off 1/4 turn periodically to break chips
    - Apply oil frequently

    - Thread until proper length
6. **Thread Length:**
    - Must engage fitting completely
    - Follow table in CSA B149.1
    - General guide: thread length = 1/2 to 2/3 of fitting depth
    - 1/2" pipe: approximately 10 threads
    - 3/4" pipe: approximately 10 threads
    - 1" pipe: approximately 10-11 threads
7. **Inspect Threads**
    - Clean threads
    - Check for damage
    - Threads should be sharp and clean
    - Test-fit in fitting (hand tight should start easily)

Threading Problems and Solutions:

Problem	Cause	Solution
Die won't start	Dull die, no oil, not square	Sharpen/replace die, add oil, realign
Threads rough	Insufficient oil, die worn	Add more oil, replace die
Threads taper wrong	Damaged die	Replace die
Threads galled	No oil, forcing	Use plenty of oil, reduce pressure
Pipe bends	Inadequate support	Better support, closer to vise

Die Maintenance:

- Clean after use
- Store in cases
- Oil lightly for storage
- Sharpen or replace when dull
- Keep guide teeth sharp (critical for starting)

Pipe Vises

Hold pipe securely for threading and assembly.

Types:

Chain Vise:

- Portable
- Mounts to table or stand
- Chain wraps around pipe
- Self-tightening
- Various chain lengths for different pipe sizes

Yoke Vise:

- Bench-mounted or stand
- Fixed or hinged design
- Very strong grip
- Best for threading
- Supports pipe well

Tripod Vise (Portable):

- Three-leg stand
- Chain vise at top
- Portable for field work
- Less stable than fixed vise
- Adequate for small pipe

Proper Use:

- Secure pipe near working end
- Jaws/chain tight enough to prevent rotation
- Don't over-tighten (can damage pipe)
- Support long pipe sections
- Vise at comfortable working height

Flaring and Swaging Tools

Used for copper tubing connections (where permitted for gas).

Flaring Tool

Creates a 45° flare on tubing end for flare fittings.

Components:

- Flaring bar (clamp)
- Flaring cone
- Screw mechanism

Procedure:

1. Cut tubing square
2. Ream inside and outside
3. Slide flare nut on tubing
4. Clamp tubing in bar (extends slightly above)
5. Center cone over tubing
6. Turn screw to form flare

7. Check for cracks or unevenness
8. Lubricate flare before assembly

Quality Flare Characteristics:

- Smooth, even surface
- No cracks
- Proper angle (45°)
- Concentric to tubing

Common Problems:

- Uneven flare - tubing not perpendicular in bar
- Cracked flare - over-formed or dirty tubing
- Rough surface - insufficient reaming or dirty cone

Swaging Tool

Expands tube end to accept another tube.

Types:

- Punch-type (hammer-driven)
- Lever-type
- Hydraulic

Use in Gas Work:

- Limited applications
- Some older systems
- Generally not used in modern installations

Tube Bending Tools

Hand Benders (Lever-Type)

Create smooth bends without kinking tubing.

Sizes:

- 1/4", 3/8", 1/2", 5/8" common
- Specific to tubing size

Proper Use:

- Mark bend location

- Insert tubing fully in bender
- Make bend slowly and smoothly
- Don't exceed minimum bend radius
- Check for kinks or flattening

Minimum Bend Radius:

- 1/4": 2"
- 3/8": 3"
- 1/2": 4"
- 5/8": 5" (Generally 6-8 times tube diameter)

Spring-Type Benders

Flexible spring slips over tubing to prevent kinking.

Use:

- Gentle bends
- Small tubing
- Limited control
- Better for soft copper

Applications:

- Control tubing
- Thermocouple leads
- Small sensing lines

Measuring and Layout Tools

Tape Measures

Essential for all measurements.

Sizes:

- 25' (7.6m) most common
- 16' (4.9m) convenient carry
- 35' (10.6m) for longer runs

Features:

- Metric and imperial markings
- Locking mechanism
- Belt clip

- Magnetic tip (some models)

Reading Measurements:

- To nearest 1/16" typically
- Metric to nearest mm
- Account for hook at end (moves to compensate for inside/outside measurement)

Proper Use:

- Hook securely on edge
- Keep tape flat and straight
- Read perpendicular to tape
- For inside measurements, add case width if printed on case
- Don't drop (damages return spring and hook)

Levels

Ensure proper pipe slope and appliance installation.

Types:

Torpedo Level (9-12"):

- Compact
- Magnetic models stick to pipe
- Most versatile for gas work
- 3 vials (level, plumb, 45°)

Box Level (24-48"):

- Longer span for accuracy
- Check appliance level
- Verify long pipe runs
- More accurate over distance

Digital Levels:

- Electronic reading
- Displays degree of slope
- More expensive
- Batteries required

Proper Use:

- Clean surface before placing

- Read bubble centered in vials
- Check calibration periodically
- Protect from damage (vials fragile)

Squares

Check and mark right angles.

Types:

- Combination square (most versatile)
- Speed square (rafting square)
- Try square

Uses:

- Mark cut lines
- Check square cuts
- Layout offsets
- Mark angles

Chalk Lines

Mark long straight lines.

Use:

- Layout pipe runs
- Mark support locations
- Straight reference lines
- Wall and ceiling marks

Markers and Pencils

- Carpenter's pencils (don't roll)
- Soapstone markers (metal)
- Permanent markers (plastic)
- Silver markers (dark surfaces)

3.2 Power Tools

Power tools increase efficiency but require additional safety considerations and training.

Drills

Corded Drills

Constant power for demanding applications.

Advantages:

- Unlimited runtime
- More power than battery
- Consistent torque
- Lower cost

Disadvantages:

- Requires electrical outlet
- Cord management
- Limited mobility
- GFCI protection required in damp locations

Battery-Powered Drills

Most common for service work.

Advantages:

- Portability
- No cord management
- Safer in damp locations
- Quick setup

Disadvantages:

- Limited runtime
- Battery weight
- Battery replacement cost
- Power decreases as battery depletes

Voltage and Power:

- 12V - Light duty, compact
- 18V - Standard for most work
- 20V - Heavy duty (note: marketing voltage, 18V nominal)

Features:

Clutch Settings:

- Numbered settings (1-20 typical)
- Limit torque to prevent over-driving screws
- Drill setting for full power
- Use appropriate setting for task

Two-Speed Gearbox:

- Low speed/high torque (0-400 RPM)
- High speed/low torque (0-1500 RPM)
- Select based on application

Chuck Size:

- 3/8" adequate for most gas work
- 1/2" for larger bits and heavy duty
- Keyless chucks most convenient
- Metal chuck more durable than plastic

Safety:

- Remove chuck key before starting (keyed chucks)
- Secure work piece
- Don't wear gloves (can catch)
- Maintain balance
- Eye protection required
- Keep cord clear of bit

Common Applications:

- Drilling pilot holes
- Mounting brackets
- Installing appliances
- Driving screws
- Mixing (with paddle attachment)

Drill Bits:

Twist Bits:

- General purpose
- Metal, wood, plastic
- High-speed steel (HSS) for metal
- Titanium-coated for longer life
- Cobalt for hard metals

Masonry Bits:

- Carbide tip
- For concrete, brick, block
- Use hammer drill mode if available
- Keep cool, withdraw frequently

Spade Bits:

- Flat blade for wood
- Quick rough holes
- Sizes 1/4" to 1-1/2"
- Not for metal

Hole Saws:

- Cut large diameter holes
- Arbor with pilot bit
- Various diameters
- For gas line penetrations
- Wood and metal versions

Step Bits (Unibit):

- Cone-shaped, stepped
- Multiple diameters in one bit
- Excellent for sheet metal
- Self-starting
- More expensive but versatile

Reciprocating Saws (Sawzalls)

Versatile cutting for demolition and rough work.

Uses in Gas Work:

- Cutting out old equipment
- Demo work
- Access holes
- Cutting steel (with proper blade)
- Emergency repairs

Blades:

- Metal cutting (bi-metal, 18-24 TPI)
- Wood cutting (6-10 TPI)
- Demo blades (mixed materials)
- Match blade to material

Safety:

- Maintain firm grip (vibration)
- Let blade stop before setting down
- Keep blade clear of body
- Check for utilities before cutting
- Eye protection essential
- Hearing protection recommended

Threading Machines

Power threading for larger production or commercial work.

Types:

Portable Threaders:

- RIDGID 300 series common
- Thread 1/8" to 2"
- Transportable to job site
- Oiler system

Stationary Machines:

- Shop installations
- Larger capacities
- Better support
- Higher production

Components:

- Drive motor
- Chuck (pipe grip)
- Die head
- Oiling system
- Reamer

Operation:

1. **Secure Pipe:**
    - Insert in chuck
    - Tighten firmly
    - Support long sections
2. **Select Die:**
    - Correct size for pipe
    - Install per manufacturer

    - Check die condition
3. **Set Up Oiler:**
    - Fill with threading oil
    - Adjust flow rate
    - Aim at die head
4. **Thread:**
    - Start machine
    - Engage die head
    - Monitor progress
    - Machine stops at proper length automatically (if equipped)
    - Or count turns for manual machine
5. **Retract and Shut Down:**
    - Open die head
    - Reverse to clear
    - Stop machine
    - Remove pipe

Safety:

- Training required before use
- Guards in place
- Loose clothing secured
- No gloves
- Eye protection
- Hearing protection
- Emergency stop accessible
- Proper electrical grounding

Grinders

Angle Grinders (4-1/2" most common)

Uses:

- Cutting steel
- Grinding welds (if welding done)
- Removing rust
- Sharpening tools
- Cutting bolts

Discs:

- Cutting discs (thin, reinforced)
- Grinding discs (thicker)
- Wire wheels (rust removal)
- Match to material and task

Safety:

- Most dangerous portable power tool
- Face shield required (plus safety glasses)
- Hearing protection
- Gloves for grip (but aware of catch hazard)
- Secure work piece
- Keep disc guard in place
- Check disc for cracks before use
- Don't exceed rated RPM
- Sparks fly long distance (fire hazard)
- Extreme kickback potential

When to Use in Gas Work:

- Limited applications
- Cutting in demolition
- Emergency situations
- Generally avoid if possible

Hammer Drills

Combines rotation with hammering action.

Use:

- Drilling masonry
- Installing anchors
- Concrete penetrations
- Service line entry

Types:

- Regular hammer drill (light duty)
- Rotary hammer (heavy duty, larger holes)
- SDS bits and chucks (heavier models)

Proper Use:

- Hammer mode for masonry only
- Drill mode for metal and wood
- Let tool do work (don't force)
- Withdraw frequently to clear dust
- Use proper bit type

3.3 Testing and Measurement Equipment

Accurate testing and measurement are critical for safety, code compliance, and proper system operation.

Manometers

Measure gas pressure and draft.

Types:

U-Tube Manometer (Water Column)

Traditional liquid-filled manometer.

Construction:

- Clear tube bent in U-shape
- Filled with water or oil
- Scale marked in inches
- Reference marks at zero

Reading:

- Measures pressure difference
- One side to pressure, other to reference
- Read height difference
- Typically inches of water column ("W.C. or in. W.C.)

Range:

- 0-15" W.C. typical
- Suitable for low-pressure gas (< 14" W.C.)
- Not for high pressure

Advantages:

- Simple, reliable
- No batteries
- Accurate
- Low cost

Disadvantages:

- Breakable
- Water can spill

- Slower response
- Less convenient

Digital Manometer

Electronic pressure measurement.

Features:

- LCD display
- Multiple pressure units (in. W.C., PSI, kPa, mbar)
- Auto-ranging
- Hold function
- Min/max recording
- Backlight
- Data logging (some models)

Ranges:

- Dual range typical
- Low: 0-60" W.C.
- High: 0-35 PSI (some models higher)
- Select appropriate range for measurement

Advantages:

- Durable
- Fast response
- Easy to read
- Records data
- Multiple measurements

Disadvantages:

- Requires batteries
- More expensive
- Can drift (requires calibration)
- Electronic failure possible

Common Measurements:

Manifold Pressure:

- Gas pressure at appliance
- Natural gas: typically 3.5" W.C.
- Propane: typically 10" W.C.

- Verify in appliance specifications

Inlet Pressure (Supply Pressure):

- Pressure entering appliance or building
- Natural gas: typically 5-7" W.C.
- Propane (residential dwelling): typically 11" W.C.
- Propane (mobile home): typically 13" W.C.
- Propane 1st stage outlet (where 2-stage): typically 10 PSI

Regulator Lock-Up:

- Maximum pressure when no flow
- Should not exceed rating
- Test per CSA B149.1

Draft:

- Negative pressure in vent
- Induced draft: -0.01 to -0.10" W.C.
- Natural draft: -0.02 to -0.04" W.C.

Using a Manometer:

1. **Select Appropriate Range/Port:**
    - Low range for "W.C. measurements
    - High range for PSI measurements
2. **Connect Hose:**
    - Secure to port
    - Other end to pressure point
    - Use probe or adapters as needed
3. **Zero (Digital):**
    - Both ports open to atmosphere
    - Zero or tare function
    - Verify zero reading
4. **Take Measurement:**
    - Connect to pressure source
    - Allow stabilization
    - Read display
    - Record reading
5. **Safety:**
    - Don't exceed range
    - Watch for leaks at connections
    - Relieve pressure before disconnecting
    - Follow manufacturer procedures

Maintenance:

- Calibrate annually (digital)
- Replace batteries as needed
- Protect from impact
- Store in case
- Keep clean and dry
- Check hoses for leaks

Pressure Gauges

Measure higher pressures.

Types:

Bourdon Tube Gauges:

- Mechanical, no power required
- Curved tube straightens under pressure
- Moves pointer via linkage
- Various ranges available

Common Ranges for Gas Work:

- 0-15 PSI (propane first stage, test pressure)
- 0-30 PSI (test gauge)
- 0-100 PSI (high-pressure systems)

Test Gauge:

- High accuracy (1% or better)
- Used for pressure testing
- Calibrated regularly
- Large dial for precision
- Often 0-30 or 0-60 PSI

Accuracy Classes:

- Grade A: ±1% (test instruments)
- Grade B: ±2% (general use)
- Grade C: ±3-4% (indication only)

Using Pressure Gauges:

- Select appropriate range (reading in middle third most accurate)
- Install per manufacturer (typically vertical)

- Check for damage before use
- Isolate before removing
- Don't exceed range
- Calibrate periodically

Multimeters (Digital Multimeter - DMM)

Measure electrical properties.

Functions:

Voltage (V):

- AC voltage (VAC) - household power
- DC voltage (VDC) - batteries, control circuits
- Ranges: typically 0-600V

Current (A):

- AC and DC current
- milliamps (mA) for control circuits
- Amps for loads
- Usually requires different meter connection

Resistance (Ω):

- Ohms
- Tests continuity
- Checks components
- Must de-energize circuit

Continuity:

- Beeps when resistance low
- Tests for complete circuit
- Quick testing
- Wire and switch testing

Features to Look For:

- Auto-ranging (selects scale automatically)
- Backlit display
- Hold function
- Min/max recording
- True RMS (for AC measurements with variable frequency)
- CAT rating (safety for voltage level)

CAT Ratings (Safety):

- CAT I: Low voltage, protected circuits
- CAT II: Outlets and appliances (residential gas work)
- CAT III: Distribution panels
- CAT IV: Service entrance

Common Uses in Gas Work:

Testing Voltage:

- 24VAC thermostat circuit
- 115VAC appliance power
- Transformer output
- Control board voltage

Testing Continuity:

- Limit switches
- Pressure switches
- Thermostat contacts
- Wiring connections
- Fuses

Testing Resistance:

- Igniter resistance (HSI typically 40-120 ohms)
- Thermocouple output (millivolts)
- Sensor circuits
- Ground continuity

Safe Use:

- Set correct function before connecting
- Start with highest range if manual ranging
- Connect black lead to common (COM)
- Red lead to appropriate jack
- Don't measure voltage with leads in current jacks
- Assume all circuits live until proven otherwise
- One hand operation in live panels
- Don't exceed meter ratings

Maintenance:

- Test against known voltage regularly
- Replace batteries when low

- Check test leads for damage
- Calibrate if accuracy questionable
- Store in case

Clamp Meters

Measure current without breaking circuit.

Function:

- Clamp around single conductor
- Measures current via magnetic field
- No electrical contact needed
- Safe and convenient

Types:

- AC only (most common, least expensive)
- AC/DC (more expensive)

Uses in Gas Work:

Motor Current:

- Blower motors
- Inducer motors
- Circulator pumps
- Compare to nameplate rating
- Diagnose motor problems

Total Current:

- Appliance amp draw
- Verify circuit capacity
- Diagnose electrical loads

Taking Measurements:

1. Set meter to AC amps
2. Select appropriate range
3. Clamp around ONE conductor only
4. Hot wire only (not neutral)
5. Center conductor in jaw
6. Read stabilized value

Common Measurements:

- Induced draft motor: 0.5-1.5 amps typical
- PSC blower motor: 3-8 amps typical
- ECM blower: 0.5-3 amps typical
- Igniter: 3-4 amps typical

Important Notes:

- Clamping both hot and neutral gives zero (cancels out)
- Must clamp only one conductor
- Accuracy decreases with small currents
- Position conductor in center of jaw

Combustion Analyzers

Essential for verifying proper combustion and carbon monoxide levels.

Functions:

Oxygen (O_2):

- Percentage in flue gas
- Indicates excess air
- Normal range: 5-9%

Carbon Dioxide (CO_2):

- Percentage in flue gas
- Indicates combustion completeness
- Natural gas: 8-10% typical
- Propane: 10-12% typical

Carbon Monoxide (CO):

- Parts per million (ppm)
- Air-free measurement (adjusted)
- CSA B149.1 limit: 100 ppm air-free
- Lower is better

Stack Temperature:

- Temperature of flue gases
- Indicates heat exchanger efficiency
- Used in efficiency calculations

Calculated Values:

- Efficiency (combustion efficiency)
- Excess air percentage
- Air-free CO (corrected for O_2)

Types:

Basic Analyzers:

- O_2 and CO sensors
- Stack temperature
- Calculate efficiency
- Print capability (some models)

Advanced Analyzers:

- Add CO_2 sensor
- Draft measurement
- Multiple probe capability
- Data logging
- Bluetooth connectivity
- More accurate

Sensor Types:

Electrochemical Cells:

- O_2, CO, and toxic gas sensors
- Limited lifespan (typically 2-3 years)
- Require periodic replacement
- Environmental conditions affect life
- Most accurate

NDIR (Non-Dispersive Infrared):

- CO_2 measurement
- Longer life
- More stable
- More expensive

Using a Combustion Analyzer:

Preparation:

1. Fresh air calibration (bump test)
2. Verify sensors within life
3. Install probe and sampling hose

4. Allow warm-up period

Measurement:

1. Insert probe in flue per manufacturer (typically 1-2 pipe diameters downstream of appliance)
2. Allow readings to stabilize (1-2 minutes)
3. Record all readings
4. Print or document
5. Interpret results

Acceptable Readings (General Guidelines):

- O_2: 5-9% (lower indicates less excess air, higher efficiency)
- CO: < 100 ppm air-free (CSA B149.1), ideally < 50 ppm
- CO_2: Natural gas 8-10%, Propane 10-12%
- Stack temp: Varies by appliance (typically 300-500°F for non-condensing)
- Efficiency: 78-83% non-condensing, 90-98% condensing

Common Problems Indicated:

High CO:

- Insufficient combustion air
- Improper burner adjustment
- Flame impingement
- Heat exchanger problems
- Venting problems

Low O_2 (High CO_2):

- Insufficient air
- Can cause high CO
- Incomplete combustion risk

High O_2 (Low CO_2):

- Excess air
- Lower efficiency
- Proper combustion but wasteful

Low Stack Temperature:

- Condensing in non-condensing appliance
- Vent sizing issues
- May indicate backdrafting

High Stack Temperature:

- Dirty heat exchanger
- Poor heat transfer
- Lower efficiency

Maintenance:

- Replace sensors per schedule
- Calibrate annually
- Fresh air bump test before each use
- Clean probe regularly
- Replace filters
- Store properly
- Protect from moisture

Documentation:

- Record readings on every service call
- Compare to baseline or previous readings
- Note any corrections made
- Provide copy to customer
- Maintain records per regulatory requirements

Gas Leak Detectors

Electronic detection of combustible gases.

Types:

Combustible Gas Indicator (CGI):

- Detects all combustible gases
- Displays as % LEL
- Not specific to natural gas or propane
- Most common type

Heated Diode (Semiconductor):

- Fast response
- Very sensitive
- Less expensive
- Responds to many gases (less specific)

Catalytic Bead:

- Burns gas on heated catalyst
- Measures temperature change
- Requires oxygen
- Can be "poisoned" by silicones

Infrared:

- Detects by light absorption
- Specific to hydrocarbon gases
- More stable
- More expensive
- No poisoning

Using Gas Detectors:

1. **Calibrate:**
    - Per manufacturer schedule
    - With known gas concentration
    - Document calibration
2. **Zero:**
    - In fresh air
    - Before each use
    - Verify zero reading
3. **Warm Up:**
    - Allow specified time
    - Typically 30-60 seconds
    - Critical for accuracy
4. **Survey:**
    - Move probe slowly (2-3 cm/sec)
    - Work systematically
    - Check all connections
    - Check from multiple angles
5. **Response:**
    - Audible alarm at preset level (typically 10-20% LEL)
    - Visual indication
    - Quantitative reading

Limitations:

- Other gases can trigger alarm (solvents, etc.)
- Require calibration and maintenance
- Sensors have limited life
- Wind and ventilation affect readings
- Not substitute for bubble test

Maintenance:

- Replace sensors per schedule
- Calibrate regularly
- Keep probe clean
- Protect from moisture
- Test functionality regularly
- Store properly

Thermometers

Types:

Dial Thermometers:

- Bi-metal coil
- No batteries
- Slower response
- Durable

Digital Thermometers:

- Fast response
- Easy to read
- Min/max functions
- Various probe types

Infrared Thermometers:

- Non-contact
- Surface temperature
- Laser pointer
- Quick spot checks

Pipe Thermometers:

- Clamp or strap to pipe
- Read surface temperature
- Boiler piping
- Temperature verification

Uses in Gas Work:

Temperature Rise (Furnace):

- Supply vs. return air temperature
- Verify proper operation
- Compare to rating plate

Boiler Supply Temperature:

- Verify control setpoints
- Check for overheating
- Aquastat function

Flue Temperature:

- Part of combustion analysis
- Efficiency indicator
- Verify proper operation

Ambient Temperature:

- Room conditions
- Combustion air temperature
- Documentation

Proper Use:

- Allow time for stabilization
- Shield from radiant heat (for air temp)
- Ensure probe contact (surface measurements)
- Calibrate periodically (check ice water = 32°F/0°C)

3.4 Specialized Gas Equipment

Purging Equipment

Purge Point Adapters:

- Install at pipe test points
- Allow controlled purging
- Various fitting sizes
- Hose connections

Purge Volume Calculation:

- 3 times system volume minimum
- CSA B149.1 requirements
- Verify complete purge

Vent Extensions:

- Direct purge gas outside safely
- Prevent indoor accumulation
- Extend purge point to exterior

Piping Tools and Accessories

Pipe Support Installation:

- Pipe strap cutters
- Ceiling anchor installation tools
- J-hook installation tools
- Clevis hanger tools

CSST Tools:

Cutters:

- Specific for CSST
- Clean, square cut
- Don't use standard pipe cutters

Strikers (Manifold Tools):

- Install fittings on CSST
- Compress fitting
- Manufacturer-specific tools
- Critical for proper installation

Bonding Clamps:

- Install grounding per code
- Proper electrical connection
- CSA B149.1 requirement
- Various sizes for different CSST

Polyethylene Pipe Tools:

Fusion Equipment:

- Heat plate
- Clamps and jigs
- Temperature control
- Cooling fixtures

Scraper:

- Clean pipe before fusion
- Remove oxidation
- Critical for proper joint

3.5 Tool Safety and Maintenance

General Tool Safety

Before Each Use:

- Inspect for damage
- Check operation
- Verify guards in place
- Test safety features
- Ensure proper accessories

During Use:

- Use for intended purpose only
- Maintain focus
- Keep work area clean
- Proper body position
- Adequate lighting
- Secure work piece
- Proper PPE

After Use:

- Clean tools
- Inspect for damage
- Store properly
- Report problems
- Charge batteries
- Organize storage

Power Tool Safety

Electrical:

- Inspect cords before use
- GFCI protection in damp areas
- Don't carry by cord
- Unplug before adjustments
- Three-prong or double-insulated

- Proper voltage

Battery Tools:

- Use manufacturer's batteries
- Charge per instructions
- Store batteries properly
- Don't short terminals
- Remove before adjustments
- Don't use damaged batteries

Guarding:

- Keep guards in place
- Don't disable safety features
- Replace missing guards
- Verify operation

Tool Maintenance

Hand Tools:

- Clean after use
- Light oil on metal
- Keep cutting edges sharp
- Tighten loose handles
- Replace damaged tools
- Proper storage (toolbox, organized)

Power Tools:

- Follow manufacturer maintenance schedule
- Keep air vents clear
- Lubricate per instructions
- Replace brushes (brushed motors)
- Inspect cords
- Professional repair for major issues

Testing Equipment:

Calibration:

- Manometers: annually
- Combustion analyzers: annually
- Gas detectors: per manufacturer (often 6 months)
- Test gauges: annually

- Multimeters: verify function regularly

Sensor Replacement:

- Combustion analyzer sensors: 2-3 years
- Gas detector sensors: per manufacturer
- Mark installation date
- Track hours of use
- Replace before end of life

Documentation:

- Calibration certificates
- Service records
- Sensor replacement dates
- Maintain equipment log

Tool Organization

Benefits:

- Save time
- Prevent loss
- Easier inventory
- More professional appearance
- Know what you have
- Identify missing tools

Methods:

Toolbox:

- Organized compartments
- Heavy items on bottom
- Frequently used items accessible
- Secure latches
- Weatherproof if outdoor use

Tool Bags:

- Lighter weight than toolbox
- Open-top access
- Multiple pockets
- Shoulder strap
- Canvas or nylon

Rolling Carts:

- Large capacity
- Organized drawers
- Mobile
- Locks
- Work surface
- Shop/van use

Shadow Boards:

- Wall-mounted
- Tool outline
- Quick visual inventory
- Shop organization
- Shows missing tools

Service Vehicles:

- Secure storage
- Organized shelving
- Parts inventory
- Equipment protection
- Accessible layout

Chapter Summary

Quality tools properly used and maintained are essential for professional gas work. Hand tools including wrenches, cutters, and threading equipment form the foundation of the gas fitter's toolkit. Power tools increase efficiency but require additional safety training and precautions.

Testing and measurement equipment ensures safe, code-compliant installations. Manometers measure gas pressure and draft, while combustion analyzers verify proper combustion and detect carbon monoxide. Multimeters and clamp meters diagnose electrical problems.

Proper tool maintenance includes regular cleaning, inspection, calibration, and documentation. Safety practices including inspection before use, appropriate PPE, and proper storage prevent injuries and extend tool life. Organized tool storage saves time, prevents loss, and presents a professional image.

Investment in quality tools pays dividends through better work quality, increased efficiency, fewer callbacks, and enhanced reputation. Understanding tool selection, use, and maintenance separates professional gas technicians from amateurs.

Review Questions

Multiple Choice

1. When using a pipe wrench, you should:
    - a) Always push the wrench
    - b) Always pull the wrench when possible
    - c) Use a cheater bar for more leverage
    - d) Tighten the jaw as tight as possible
2. The proper TPI (teeth per inch) for a hacksaw blade when cutting steel pipe is:
    - a) 14 TPI
    - b) 18 TPI
    - c) 24 TPI
    - d) 32 TPI
3. When threading pipe, you should:
    - a) Use motor oil as lubricant
    - b) Back off 1/4 turn periodically while threading
    - c) Thread continuously without stopping
    - d) Use maximum pressure to speed up threading
4. Digital manometers should be calibrated:
    - a) Weekly
    - b) Monthly
    - c) Annually
    - d) Only when they appear inaccurate
5. Natural gas manifold pressure is typically:
    - a) 3.5" W.C.
    - b) 7" W.C.
    - c) 11" W.C.
    - d) 5 PSI
6. When using a combustion analyzer, acceptable air-free CO for most appliances per CSA B149.1 is:
    - a) Under 35 ppm
    - b) Under 100 ppm
    - c) Under 200 ppm
    - d) Under 400 ppm
7. A clamp meter measures current by clamping around:
    - a) Both hot and neutral wires together
    - b) The ground wire only
    - c) A single conductor
    - d) The entire cable
8. Pipe threads per NPT standard taper:
    - a) 1/4" per foot
    - b) 1/2" per foot
    - c) 3/4" per foot

    - d) 1" per foot
9. The most dangerous common portable power tool is:
    - a) Drill
    - b) Reciprocating saw
    - c) Angle grinder
    - d) Circular saw
10. Combustion analyzer sensors typically need replacement every:
    - a) 6 months
    - b) 1 year
    - c) 2-3 years
    - d) 5 years

True or False

11. A basin wrench is designed for working in tight spaces under sinks and fixtures.
12. You should use gloves when operating a threading machine.
13. Pipe thread compound should be applied to both male and female threads.
14. A manometer reading of 3.5" W.C. is the same as 0.125 PSI.
15. Flare fittings should be tightened to maximum torque without a torque wrench.

Short Answer

16. List four safety considerations when using an angle grinder. (4 marks)
17. Explain the proper procedure for threading 1/2" steel pipe. Include the steps from securing the pipe through inspecting the finished threads. (6 marks)
18. What is the difference between a catalytic bead sensor and an infrared sensor in gas detectors? (4 marks)
19. List the four primary measurements taken by a combustion analyzer and explain what each indicates. (8 marks)
20. Explain why threading oil is important and what problems occur when it is not used properly. (4 marks)

Long Answer

21. You are setting up a job to install 50 feet of 3/4" black iron pipe in a commercial building. List all the tools and equipment you would need, organized by category (hand tools, power tools, testing equipment, etc.). Explain why each tool is necessary. (12 marks)
22. A combustion analyzer shows the following readings on a natural gas furnace: O_2 = 4%, CO = 250 ppm air-free, CO_2 = 11%, Stack temp = 425°F. Interpret these readings. What do they indicate about the furnace operation? What are the likely problems? What would you check or adjust? (12 marks)
23. Describe a complete tool maintenance program for a service technician's toolkit. Include daily, weekly, monthly, and annual tasks. Discuss calibration requirements for testing equipment and how to document maintenance activities. (15 marks)

Practical Exercises

Exercise 1: Tool Identification

Instructor provides 20 common gas fitting tools. Students must:

1. Identify each tool by name
2. State primary use
3. Identify safety considerations
4. Demonstrate proper use (selected tools)

Exercise 2: Pipe Threading

Under supervision, students will:

1. Cut pipe to specified length
2. Ream pipe end
3. Secure in vise
4. Thread pipe to proper length
5. Inspect threads
6. Document thread count and quality
7. Test-fit in coupling

Exercise 3: Manometer Use

Students will:

1. Set up digital manometer
2. Perform zero calibration
3. Measure manifold pressure on test appliance
4. Measure inlet pressure
5. Calculate pressure drop
6. Document all readings
7. Compare to specifications

Exercise 4: Combustion Analysis

On operating appliance, students will:

1. Set up combustion analyzer
2. Perform fresh air calibration
3. Insert probe properly
4. Record all measurements

5. Interpret readings
6. Determine if appliance within specifications
7. Document findings with printed results

Exercise 5: Electrical Testing

Using multimeter on trainer or de-energized equipment:

1. Measure voltage (AC and DC)
2. Test continuity on switches
3. Measure resistance of components
4. Identify proper meter settings
5. Practice safe procedures
6. Document findings

Exercise 6: Gas Leak Detection

On test piping system with known leak:

1. Use electronic gas detector to locate general area
2. Use soap solution to pinpoint exact leak location
3. Document leak location
4. Estimate leak severity
5. Recommend repair method

Case Studies

Case Study 1: The Wrong Tool

Scenario: An apprentice is asked to tighten a flare nut on a water heater gas connection. Unable to find an appropriate wrench, he uses a pipe wrench. The fitting is damaged, begins leaking, and must be replaced.

Questions:

1. What tool should have been used?
2. Why is a pipe wrench inappropriate for this application?
3. What damage likely occurred?
4. What safety risks were created?
5. What is the proper way to tighten flare fittings?
6. How could this situation have been prevented?

Case Study 2: Combustion Testing Reveals Problems

Scenario: During annual maintenance, you perform combustion testing on a 10-year-old induced draft furnace. Your combustion analyzer shows: O_2 = 11%, CO = 450 ppm air-free, CO_2 = 6%, Stack temp = 525°F. The customer mentions they've had frequent headaches this winter.

Questions:

1. What do these readings indicate?
2. Is this an emergency situation?
3. What are the immediate actions required?
4. What are the likely causes of these readings?
5. What diagnostic steps would you perform?
6. What would you tell the customer?
7. What documentation is required?
8. Could the headaches be related? How?

Case Study 3: Calibration Matters

Scenario: A technician uses his manometer to test manifold pressure on a furnace. The reading shows 4.2" W.C., which seems high. He adjusts the gas valve down to 3.5" W.C. The furnace now operates poorly with incomplete combustion. He learns later that his manometer has been reading 0.7" W.C. high due to lack of calibration.

Questions:

1. What was the actual manifold pressure before adjustment?
2. What is it after adjustment?
3. What problems will this cause?
4. How often should manometers be calibrated?
5. How can you verify a manometer is reading correctly?
6. What are the consequences of inaccurate testing equipment?
7. Who is liable for problems caused by this error?

Case Study 4: Threading Machine Accident

Scenario: An experienced technician is threading 1" pipe on a power threading machine. His loose shirt sleeve catches on the rotating chuck. He attempts to pull free but is drawn toward the machine. A co-worker hits the emergency stop before serious injury occurs.

Questions:

1. What safety rules were violated?
2. What injuries could have occurred?
3. What is proper attire for threading machine operation?
4. What other safety features should be present?
5. What should happen after this incident?
6. How could this be prevented in future?

7. What training should be provided?

Case Study 5: Tool Investment Decision

Scenario: A newly licensed G2 technician is starting service work for a large company. The employer provides a service van and major testing equipment but expects the technician to provide personal hand tools. The technician must decide between:

- Option A: Budget tool set ($500) - basic tools, lower quality, 1-year warranty
- Option B: Professional tool set ($2,000) - high quality, lifetime warranty, complete selection
- Option C: Build gradually - Buy tools as needed over first year

Questions:

1. What are the advantages and disadvantages of each option?
2. What tools are absolutely essential to start?
3. What tools can wait?
4. How does tool quality affect work quality and efficiency?
5. What is the true cost of cheap tools?
6. What would you recommend and why?
7. What financing options might be available?

Key Terms

Basin Wrench: Specialized wrench with long shaft and pivoting jaw for tight spaces.

Bourdon Tube: Curved tube that straightens under pressure, used in mechanical pressure gauges.

CAT Rating: Safety category rating for electrical test equipment indicating voltage level safely measured.

Chuck: Gripping device on drill or threading machine that holds bit or pipe.

Combustion Analyzer: Electronic device measuring flue gas composition and calculating efficiency.

Die: Cutting tool that creates external threads on pipe.

Electrochemical Sensor: Chemical cell that generates electrical signal in presence of specific gas.

Flaring Tool: Tool that creates 45° flare on tube end for flare fittings.

LEL (Lower Explosive Limit): Minimum gas concentration that will ignite (natural gas 5%, propane 2.1%).

Manometer: Device for measuring gas pressure, typically in inches of water column.

NPT (National Pipe Taper): Standard tapered pipe thread used in North America (3/4" per foot taper).

Pipe Wrench: Adjustable wrench with toothed jaws for gripping pipe.

Reamer: Tool that removes burrs from inside of cut pipe.

Stock: Handle that holds threading die and provides leverage.

Threading Oil: Specialized lubricant for cutting threads, provides cooling and lubrication.

Torque Wrench: Wrench that measures and limits applied torque.

TPI (Teeth Per Inch): Measurement of hacksaw blade tooth density (18 TPI common for pipe).

True RMS: Multimeter feature providing accurate AC measurements with varying waveforms.

Water Column (W.C.): Pressure measurement unit; inches of water column height (natural gas typically 3.5" W.C.).

End of Chapter 3