CSA Unit 8 - Intro to Piping and Tubing Systems

Chapter 1
Piping and Tubing Systems

A gas technician/fitter must know how to select and use the different types of piping, tubing, valves, and connectors for constructing gas distribution systems. This guide covers the requirements, specifications, and proper installation methods for various piping materials used in gas systems.

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Objectives and Terminology

Objectives

At the end of this Chapter, you will be able to:

- describe requirements of piping, tubing, and connectors
- describe valves and fittings

Key Terminology

Understanding the following terms is essential for gas technicians:

- Connector - Tubing or hose with a fitting at each end for connecting an appliance with piping
- CSST - Corrugated stainless steel tubing with PVC covering
- Flexible metallic hose - All-metallic flexible gas conduit
- NPT - National Pipe Thread Taper standard for threaded pipes
- NPS - Nominal Pipe Size standard for pipe dimensions

Piping Material Requirements

Steel Gas Piping

Must conform to ASTM specification A53 or A106. Gas technicians most commonly use black pipe for gas with pipe fittings of steel or malleable iron.

Copper Tubing

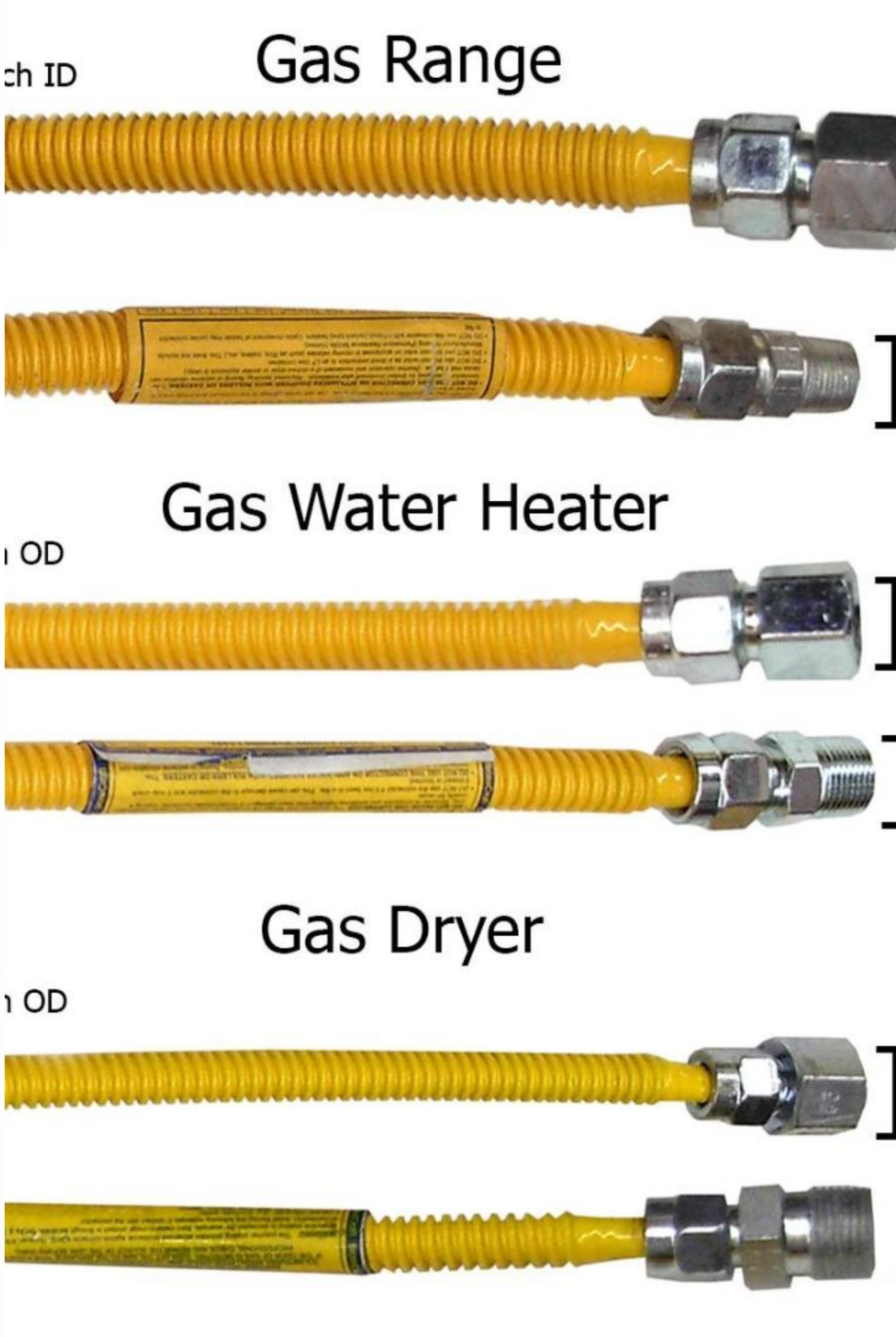
Must conform to ASTM B837 for G tube and ASTM B88 for type K and L tube. Type M copper tubing cannot be used in gas systems due to insufficient wall thickness.

Corrugated Stainless Steel Tubing

Consists of continuous, flexible, stainless steel pipe with exterior PVC covering. Available for installation on gas systems up to 5 psig.

Polyethylene Pipe

Used for underground gas piping. Must conform to CSA B137.4 for distribution mains, house service lines, and after meter kits.

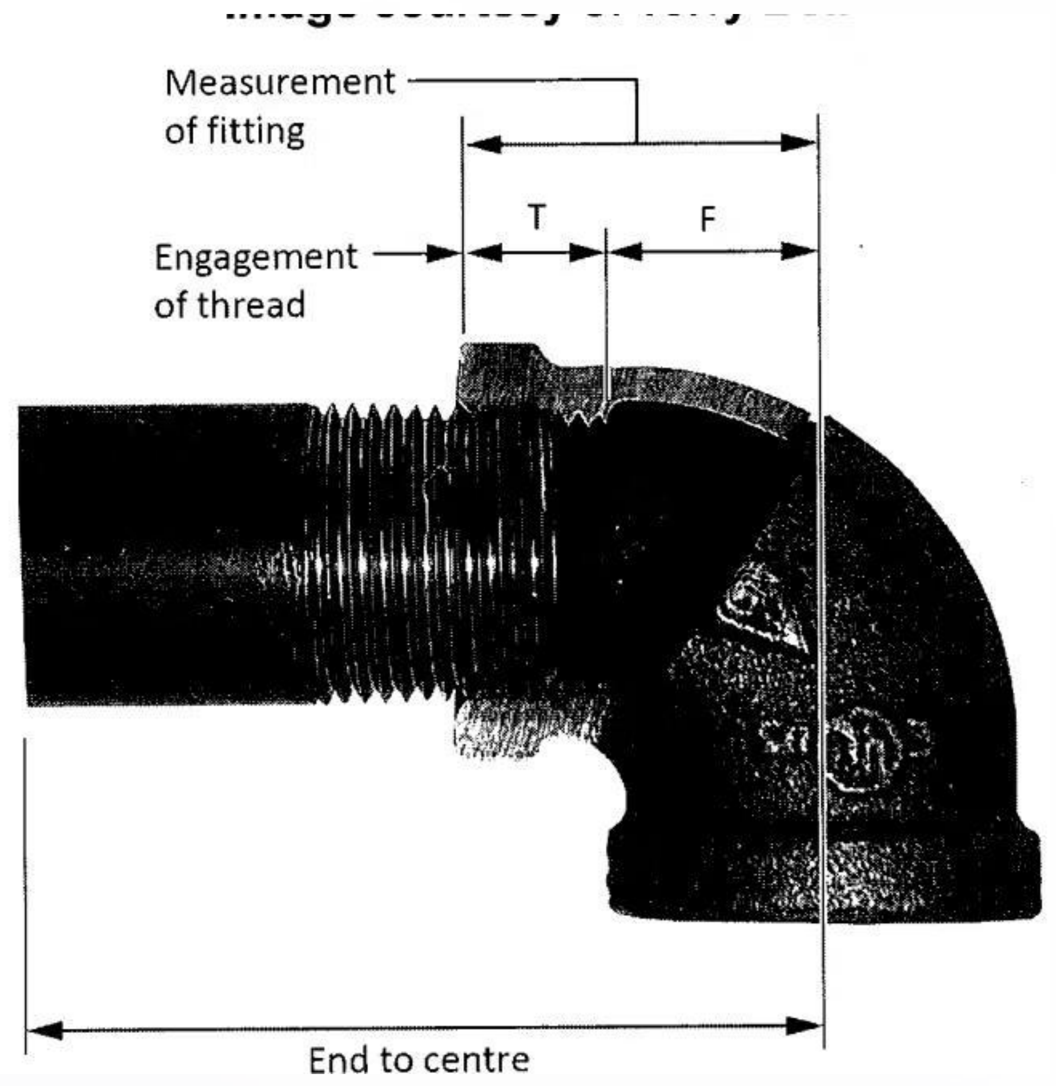


Pipe Sizing and Measurement

Nominal Pipe Size (NPS)

The gas industry sizes black pipe using the Nominal Pipe Size (NPS). For any nominal size of pipe, the outside diameter (OD) remains the same and the inside diameter (ID) changes as the wall thickness increases.

Nominal size is a designation used for general identification. Pipe is threaded on the outside only, therefore, the OD must remain constant.



Pipe measurement - end-to-center measurement

Threading and Pipe Ends

NPT Threading

Gas piping utilizes a tapered thread (NPT) cut on a pipe threading machine or hand tool. The taper on NPT threads allows them to form a seal when torqued as the flanks of the threads compress against each other.

Types of Pipe Ends

Gas piping and tubing ends may be finished in the following ways, depending on the application: plain, grooved, bevelled, and threaded.

Wall Thickness

Steel pipe used for gas systems is either Schedule 40 (standard) or Schedule 80 (extra heavy), with Schedule referring to the wall thickness of the pipe. Both have the same outside diameter.

Copper Pipe and Tubing

Advantages of Copper Pipe

- Flexibility and ease of bending
- Low weight
- Ease of making connections
- Corrosion resistance
- Available in long lengths
- Requires fewer and smaller tools to install
- Cleaner than steel pipe

These factors combine to make copper systems easier and quicker to install. In multi-Chapter buildings, the long lengths of tubing are safer because they require fewer joints.

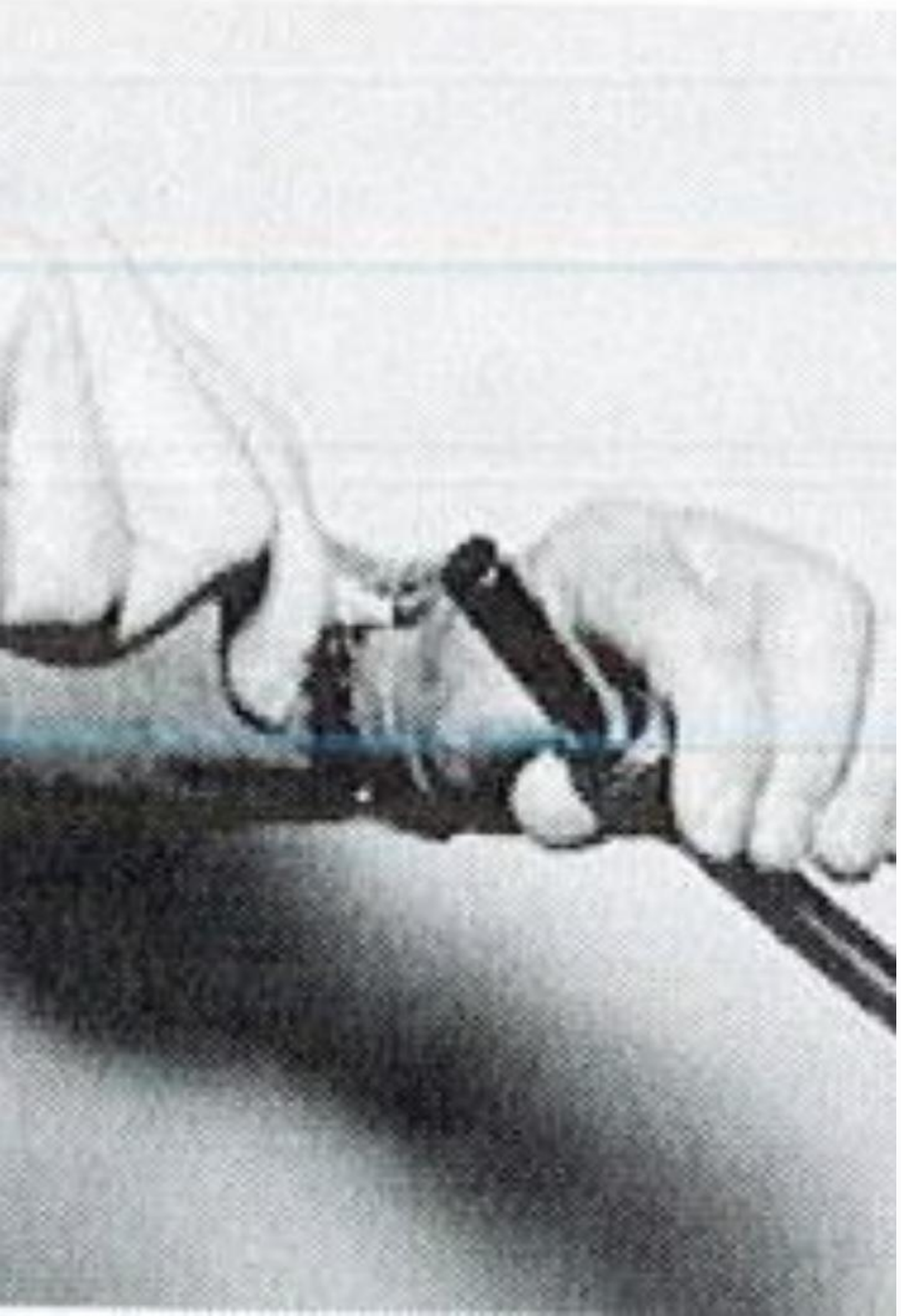
Types of Copper Tubing

Copper tubing for gas systems must conform to:

- ASTM B837 for G tube
- ASTM B88 for type K and L tube (seamless water tube)

Two basic kinds of copper tubing:

- Soft drawn (soft temper annealed) - Supplied in coils, most commonly used for gas systems
- Hard drawn (hard temper) - Comes in straight lengths, used when larger pipe sizes are required



Joining Copper Tubing

Brazing Method

Use phosphorous-free material having a melting point in excess of 1000°F (525°C). This creates a strong, permanent connection suitable for gas systems.

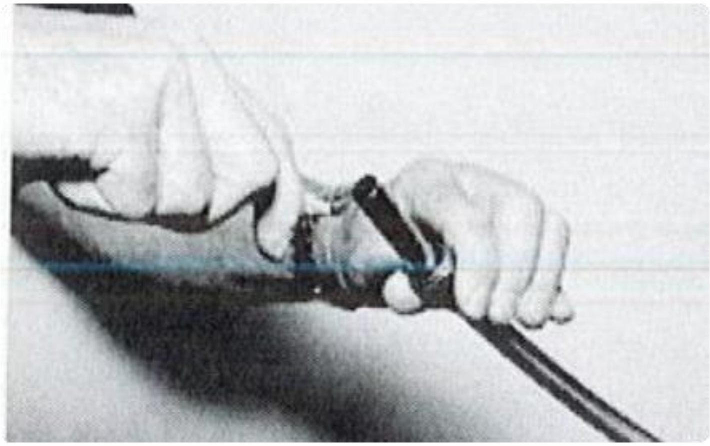
45° Brass Flare Connectors

Use an appropriate flaring tool that matches the OD of the tube and has the appropriate 45° flare angle. The tool usually consists of flaring bars with openings for various tube sizes, a yoke with flaring cone, and a clamp.

Flaring Process

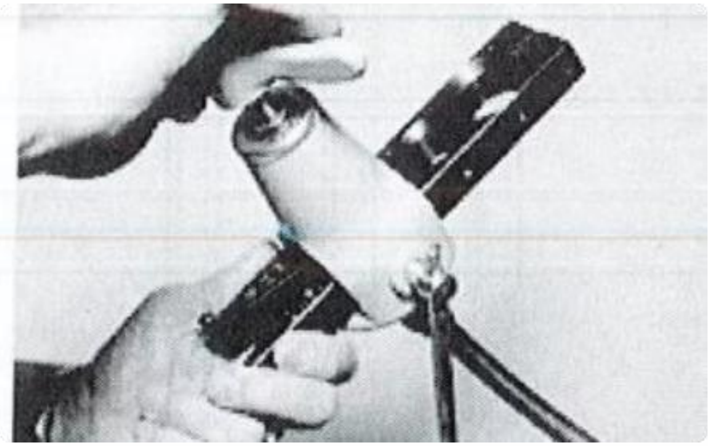
Cut the copper tube square using an appropriate tubing cutter. After cutting, ream the tube to the full ID leaving no inside burr. Resize tube that is out of round prior to flaring back to round.

Flaring Copper Tubing



Reaming the Tubing

After cutting the copper tube square, it must be reamed to remove any burrs that could restrict gas flow or create turbulence in the system.



Flaring the Tubing

The flaring tool creates a precise 45° flare that will mate perfectly with the flare fitting to create a gas-tight seal when properly tightened.

Completed 45° Flare

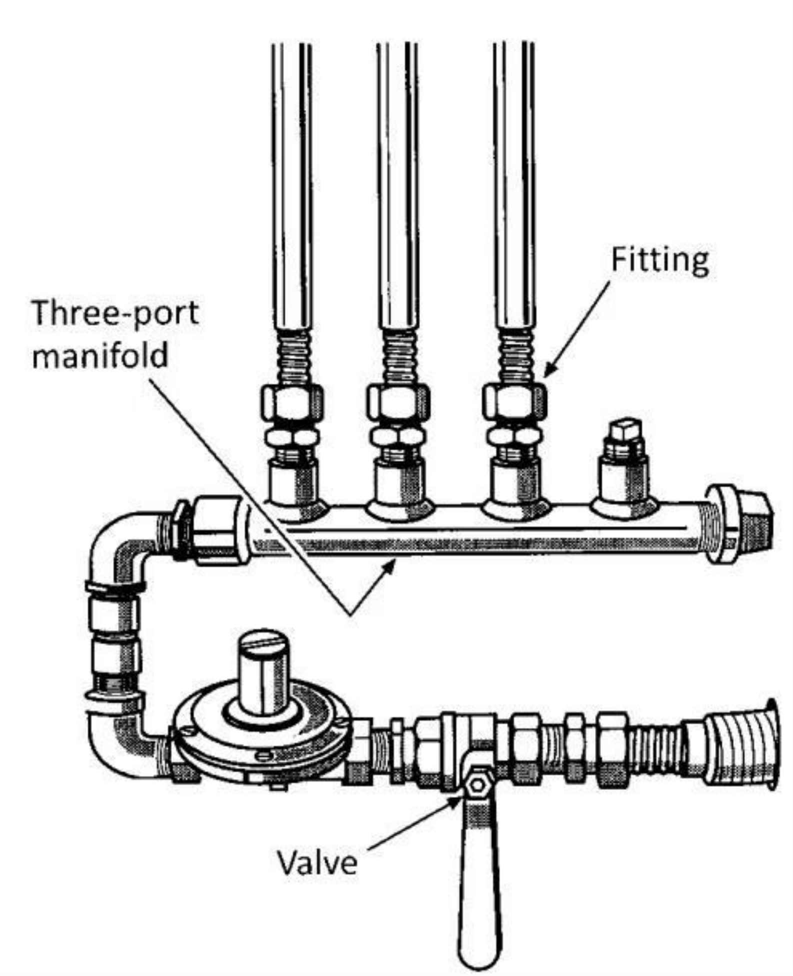
The finished flare should be smooth, without cracks or thin spots, and should seat properly against the fitting to ensure a leak-free connection.

Corrugated Stainless Steel Tubing (CSST)

CSST Characteristics

Corrugated stainless steel gas tubing consists of a continuous, flexible, stainless steel pipe with an exterior PVC covering. The piping comes in coils that have undergone air-testing for leaks.

Most often installed in a central manifold configuration (also called parallel configuration) with lines that extend to gas appliances. CSST is lightweight and requires fewer connections than traditional gas piping, because it can be bent easily and routed around obstacles.



Components of the Titeflex CSST system

Flexible stainless-steel tubing is approved and available for installation on gas systems up to 5 psig. It can be purchased in rolls up to 250 ft. (70 m) in length and in diameters of 3/8 in to 1 in.

CSST Installation Requirements

1 Meter Support

CSST must not be tied directly to a gas meter without first ensuring that the meter assembly is independently supported, since CSST would not lend the same level of support as iron piping tie.

2 Manufacturer Systems

Examples of CSST manufacturers are ProFlex/WardFlex, Track Pipe, Gas Tite, and Titeflex, all of which incorporate corrugated semi-rigid stainless-steel tubing and all metal components, including fittings, valves, and multiport manifolds.

3 Identification

The tubing comes with a continuous yellow polyethylene coating for easy identification. It can be field measured, cut, and installed using approved fittings.

4 System Benefits

The multiport manifold allows for easy, future expansion of the system for room additions or additional appliances. CSST has the potential for higher levels of system safety, because connections and joints behind the wall, common in black iron pipe, are essentially eliminated.

Aluminum and Polyethylene Piping

Aluminum Tubing Applications

- Pilot tubing
- Venting of regulators
- Regulator vent tube within the enclosure of an appliance

Aluminum tubing is joined by means of compression fittings.

Polyethylene (PE) Piping

Gas technicians often install underground gas piping using polyethylene piping. A gas technician must be able to recognize types of polyethylene piping materials, operate the specialized equipment, and perform the different joining methods.

Polyethylene is a thermoplastic that softens when heated and solidifies when cooled, without any chemical reaction taking place. PE piping can be fused by applying heat and pressure, normally with electricity-powered heating irons.

Polyethylene Pipe Applications

Underground Applications

The plastic pipe or tubing used for gas distribution systems must conform to CSA B137.4. Installations where you can use this include distribution mains, house service lines, and after meter kits.

Outdoor Appliances

Plastic pipe or tubing can be installed underground to feed outdoor gas-fired appliances such as pool heaters and BBQs, or as a customer supply line from one building on a property to another on the same property.

Installation Limitations

Due to the fragile nature of plastic pipe, it cannot be used as above-grade supply piping. Special certified sleeves protect the piping as it extends above grade to make the transition to the building supply piping or the appliance connection.

Polyethylene Pipe Markings

Required Markings

In accordance with CSA B137.4, any polyethylene piping shall have a clear marking, in a colour that contrasts with the pipe and at intervals not greater than 4.9 ft (1.5 m), that contains the following information:

- The manufacturer's name or trademark
- The minimum wall thickness or standard dimension ratio (SDR)
- The date of manufacture or date code
- The nominal size of the pipe (e.g., NPS 2)
- The designation B137.4
- The word "gas"

Material Specification Codes

There are many different grades of polyethylene (PE) used in plastic pipeline systems. Each pipe has a marking containing the grade of PE and a four-digit code:

- The first number denotes the density of the pipe
- The second number is the melt index rating
- The last two numbers indicate the design strength for density

Examples include PE 2306 (medium density) and PE 3406 (high density).

Polyethylene Pipe Joining Equipment

Pipe Cutter

Has a thin cutting wheel or blade that helps cut plastic pipe cleanly and squarely.

Heating Iron

Usually uses electrical heating and comes with Teflon coating or a similar non-stick coating to prevent the molten plastic from sticking to the heating plate.

Butt Fusion Joining Machine

Has a pipe facer attachment for simultaneously shaving off the ends of two pipes and clamps for separately gripping and aligning pipes or fittings during fusing.

Temperature Control

Heating irons must be set to the desired temperature, 500°F ± 7°F (260°C ± 4°C), and allowed to stabilize before use.

Polyethylene Pipe Joining Process

Cutting Pipe Ends

Cut pipe ends square and ensure that surfaces to be joined are properly aligned. This is critical for creating a strong, leak-free joint.

Cleaning Components

Remove water, dirt, grease, oil, fingerprints, and cuttings. Wipe the inside and outside of the pipes with a clean, lint-free cloth or a good quality paper towel and some soap and water.

Adjusting Heating Iron Temperature

Set the thermoswitch to the desired temperature, allow it to stabilize, then check the temperature with a tempilstik. Turn the thermoswitch adjustment screw to make adjustments as needed.

Applying Heat

Apply the heating iron to the surface of the mating components until each surface melts but does not burn. Before starting installation, determine the length of time required to heat a joint and use this time interval systematically.

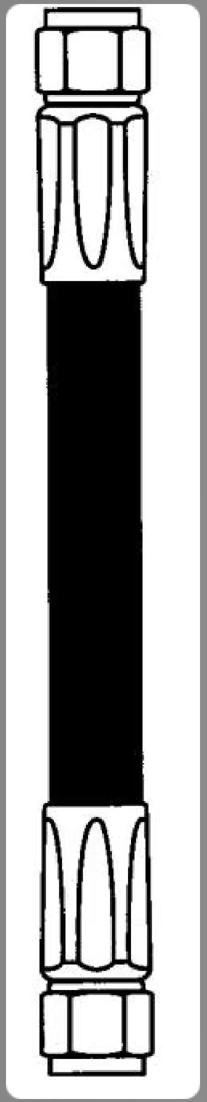
Static Electricity in Polyethylene Piping

Static Electricity Generation

The generation of static electricity by gas flow through polyethylene piping is a well-documented phenomenon. The voltage generated on discharge is at times sufficient to cause pinholes in pipe walls as well as supplying a source of ignition if you cut open or repair the line.

Safety Procedures

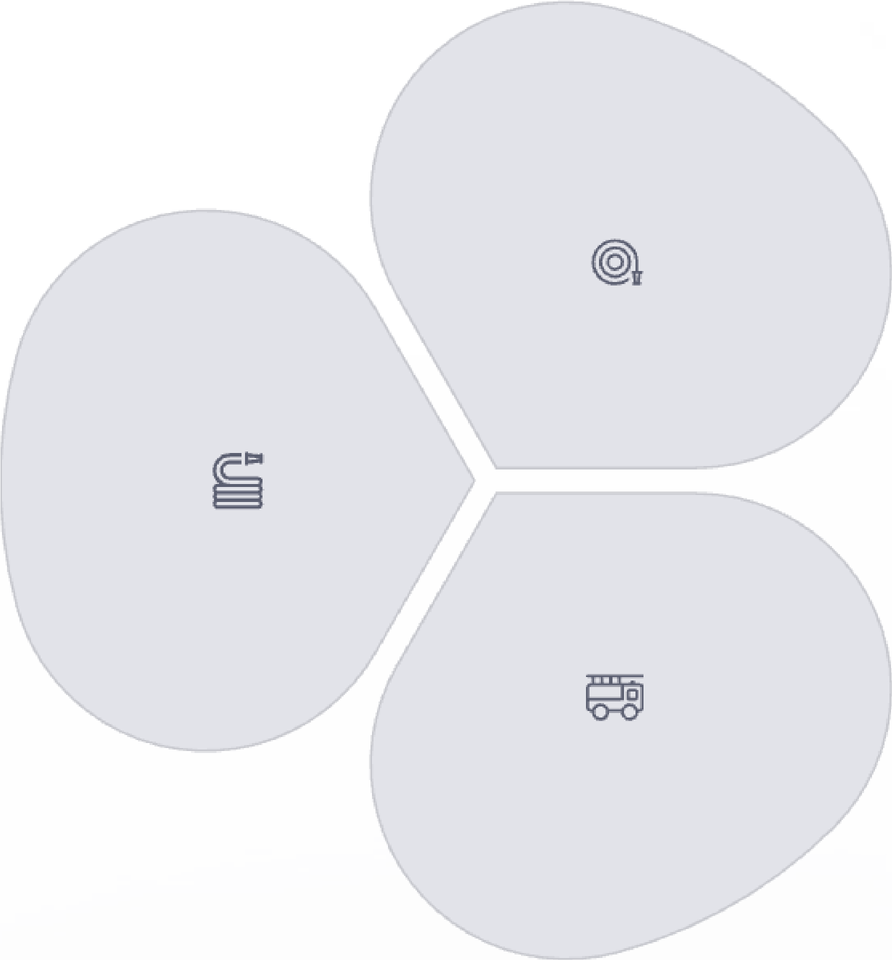
There are procedures for dealing with this occurrence in a gaseous atmosphere. Although these procedures are beyond the scope of this learning task, the gas technician/fitter must be aware there are steps that they must follow if faced with this event.



Flexible Hoses and Connectors

Term	Definition
Hose	Flexible conduit
Connector	Tubing or hose with a fitting at each end for connecting an appliance or equipment with piping or tubing
Metal connector	Corrugated or semi-rigid conduit made entirely of metal
Hose connector	Flexible, assembled conduit not exceeding 6 ft (2 m) in length
Flexible metallic hose	All-metallic flexible gas conduit

Elastomeric Hose Types



Type I Hose

Maximum operating pressure: 350 psig (2.4 MPa)

Minimum burst pressure: 1750 psig (12.1 MPa)

Has a tubing made of oil-resistant elastomer, with a minimum thickness of 0.047 in (0.12 mm)

Type II Hose

Maximum operating pressure: 350 psig (2.4 MPa)

Minimum burst pressure: Ranges from 1750 psig to 12,000 psig depending on size

Has a tubing made of oil-resistant elastomer with cotton or synthetic braided cover

Type III Hose

Maximum operating pressure: 350 psig (2.4 MPa)

Minimum burst pressure: Ranges from 1750 psig to 12,000 psig depending on size

Has a tube or lining made of oil-resistant material with low permeability

All elastomeric hose types must comply with CAN/CGA-8.1 and have certification and marking indicating type, maximum working pressure of 350 psig (2400 kPa), and a date code.

Thermoplastic Hose and Flexible Connectors

Thermoplastic Hose

Thermoplastic hose has a minimum working pressure of 350 psig (2.4 MPa) and a minimum burst strength of five times the rated working pressure. It has an inner tube made of seamless thermoplastic with tube reinforcement consisting of one or more plies of synthetic fiber or stainless-steel wire.

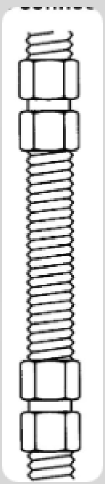
The outer surface of the hose is weather resistant. This hose must have certification of compliance with CAN1-8.3. Markings include the symbol of the certification agency, hose ID size, date code, and maximum working pressure.

Flexible Connectors

Flexible connectors approved for use with natural gas and propane must conform to ANSI Z21.69/CSA 6.16, Connectors for movable gas appliances. They are for use with:

- Gas-fired commercial cooking equipment mounted on casters
- Equipment that may need to be moved for cleaning
- Other large, heavy gas-fired equipment that may need to be moved

They are for use with piping systems having fuel gas pressures not in excess of 0.5 psig (3.4 kPa) and are not more than 6 ft (1.83 m) in nominal length.



Corrugated Metal Connectors

Construction

Corrugated metal connectors are made of new, unused parts and materials, consisting of corrugated tubing. They have nominal internal diameters of 1/4, 3/8, 1/2, 5/8, 3/4, and 1 in.

Fittings

They have fittings at both ends provided with tapered pipe threads for connection to gas appliances and to house piping.

Approval

Corrugated metal connectors that have approval for use with natural gas and propane must conform to ANSI Z21.69/CSA 6.16.

Pipe Joining Sealants

Effective Sealant Requirements

To be effective, a joint sealant must:

- Flow to match the piping surfaces and seal tightly
- Be non-hardening
- Withstand the required temperatures and pressures
- Not be corroded by, or leach into, the piping contents
- Prevent rusting and corrosion
- Lubricate when necessary

Certification Requirements

Sealants used with gas piping systems must receive certification for such use from one of the following agencies:

- Underwriters' Laboratories of Canada
- CSA Group

The sealant container will bear a label stating the name of the agency and that the material is a Listed Joint Compound.

Types of Joint Sealants

Joint sealants include:

- Thread compound (commonly called "pipe dope")
- Approved Teflon pipe tape

Applying Joint Sealants

Apply to Male Threads Only

Pipe dope and pipe tape help seal joints in piping systems. Apply them only to the male threads of pipes and fittings. Using them on female threads may cause an obstruction to flow, as they may be forced into the pipe.

Leave First Threads Free

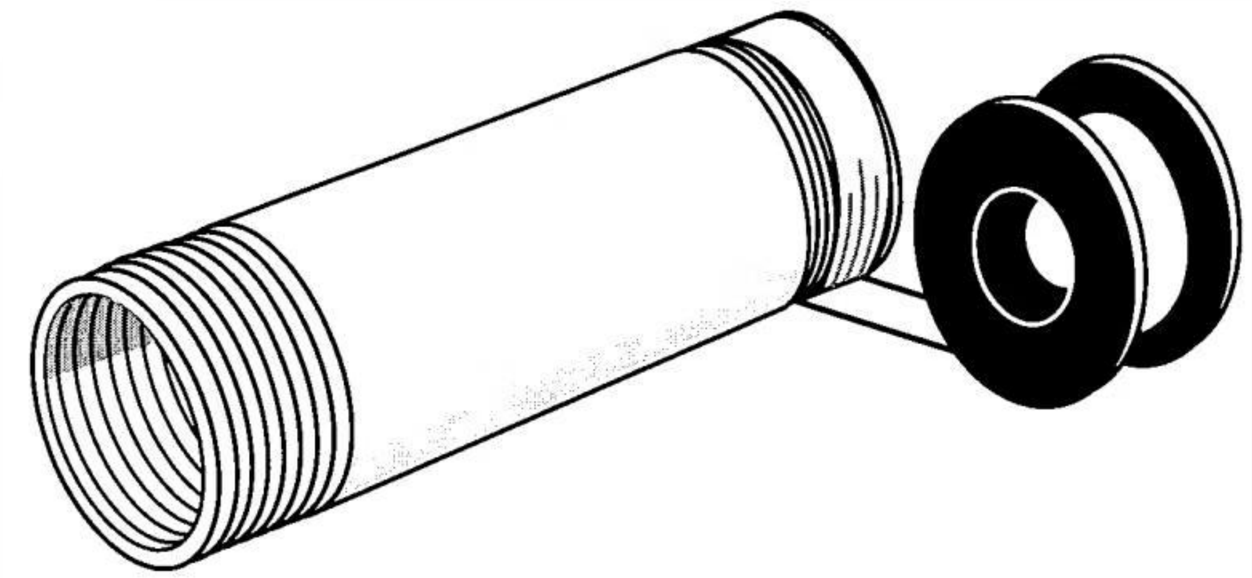
Leave the first two threads of pipes and fittings free of dope or tape to prevent the sealant from entering the piping system and potentially damaging gas valves and components downstream.

Apply Pipe Dope Evenly

Apply the pipe dope evenly to all but the first two threads, with sufficient coverage to seal the joint. Pipe dope also acts as a lubricant, helping keep temperatures down and reducing the amount of wrench needed to run up the threads.

Apply Pipe Tape Correctly

Stretch and apply the pipe tape to the pipe in a clockwise direction, with a 50% overlap between wraps. Only grades of Teflon pipe tape that are identified by their listing as "Approved for Gas" and often manufactured in a different color such as orange or red are approved for use with natural gas and propane.



Expansion and Contraction in Piping Systems

Temperature Fluctuations

In locations that experience wide fluctuations in temperature, piping installations must be able to accommodate expansion and contraction.

Accommodation Methods

This can be accomplished through:

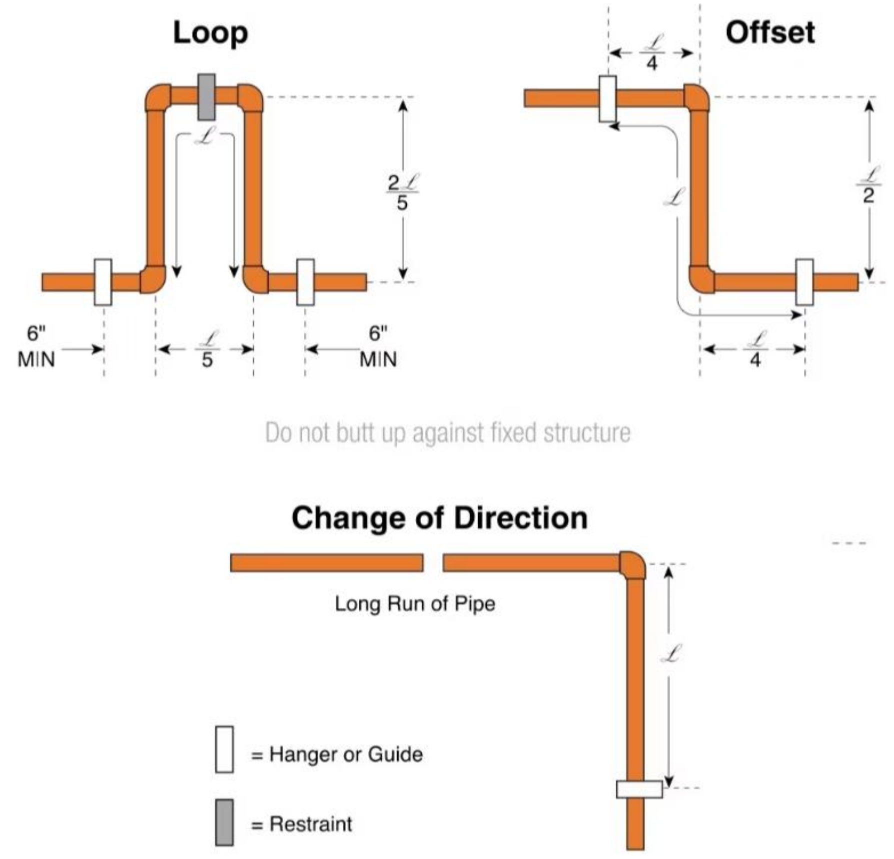
- Expansion loops
- Offsets
- Swing joints

Purpose

These types of piping configurations allow a system to stress and flex at fitting joints rather than experience a break of pipe or fitting when piping settles or moves.

Securing Piping

Anchor or secure piping at critical points in order to control the direction of expansion and contraction.



Expansion Loop and Offset Configuration

Hazardous Locations for Gas Piping

Prohibited Locations

You cannot install gas piping and tubing in locations where you can expect diffusion of the gas throughout the building if a gas leak occurred. This includes areas such as:

- Stairwells of multi-Chapter dwellings (more than two Chapters)
- Heating and ventilation ducts
- Elevator shafts
- Dumb waiters
- Chimneys

Corrosive Environments

You cannot install gas piping and tubing in locations where:

- Large quantities of corrosive chemicals are used
- It is in contact with corrosive cinders

Underground Gas Piping Requirements

Minimum Size

Piping cannot be smaller than NPS 1/2.

Depth Requirements

Minimum depth of installation must be:

- 24 in (600 mm) under commercial driveways or parking lots
- 15 in (400 mm) in other locations

Placement Restrictions

It must not pass beneath foundations, walls, or buildings.

Corrosion Protection

Except for Type K copper, it must have an approved, corrosion-resistant coating or covering.

Joint Requirements

All piping joints must be welded or be approved compression fittings. All copper tubing joints and connections must be brazed.

Runs Between Buildings and Copper Protection

Runs Between Buildings

Gas piping and tubing run between buildings must have a shut-off valve where it exits the first building and one at the point where it enters the second.

This ensures that gas flow can be stopped at either end of the run in case of emergency or for maintenance purposes.

Protection of Copper Tubing

Where copper tubing runs through concrete, cement block walls, or in places where contact with another surface could cause corrosion of the pipe, the pipe must have external corrosion protection in the form of:

- Paint
- Anti-corrosion coating
- Double layer of certified protective tape

Copper tubing used in underground applications must be either Type G or Type L with an external approved coating, or Type K.

Rooftop Piping Considerations

Support Requirements

When installing piping on commercial rooftops, give special considerations to support along the piping length and at threaded connections.

Corrosion Protection

Ensure that piping exposed to the elements has protection against corrosion and linear expansion.

Expansion Provisions

When a rooftop piping run extends beyond 100 feet in straight length, provide provisions for linear expansion in the form of piping offsets or engineered expansion joints.

Stress Management

These piping techniques take the stress of expansion away from the rigid piping length, preventing potential leaks or failures.

Indoor Gas Piping Requirements

1. **Minimum Pipe Size**

   The minimum pipe size for indoor applications is 1/2 in diameter; however, 3/8 in diameter tubing may be used for branch lines that are 25 ft (7.5 m) or less in length and that do not supply more than 15,000 Btu/h (4.5 kW).

2. **Piping Orientation**

   Gas system piping and tubing can run parallel, diagonal, or at right angles to floor joists, with specific mounting requirements for each orientation.

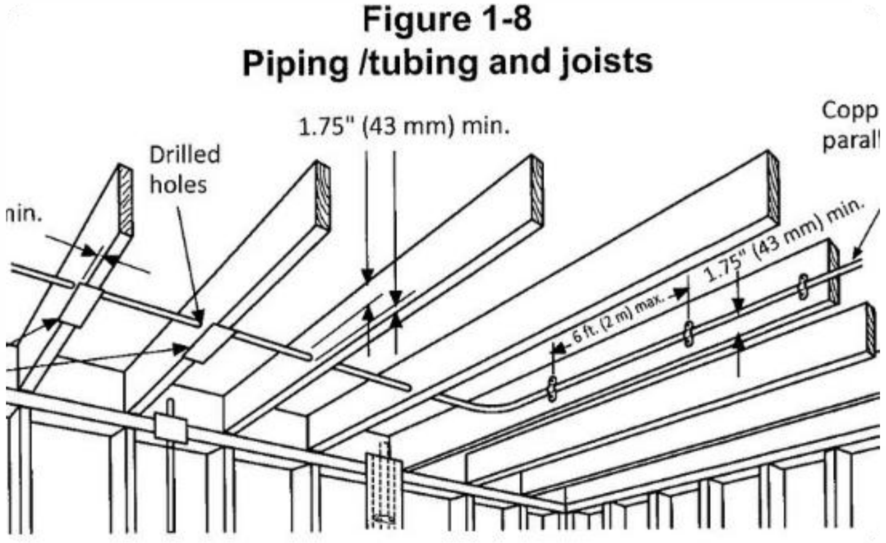
3. **Parallel Runs**

   When running pipe or tubing parallel to joists, fasten it to the center of the vertical face of the joist.

4. **Diagonal or Perpendicular Runs**

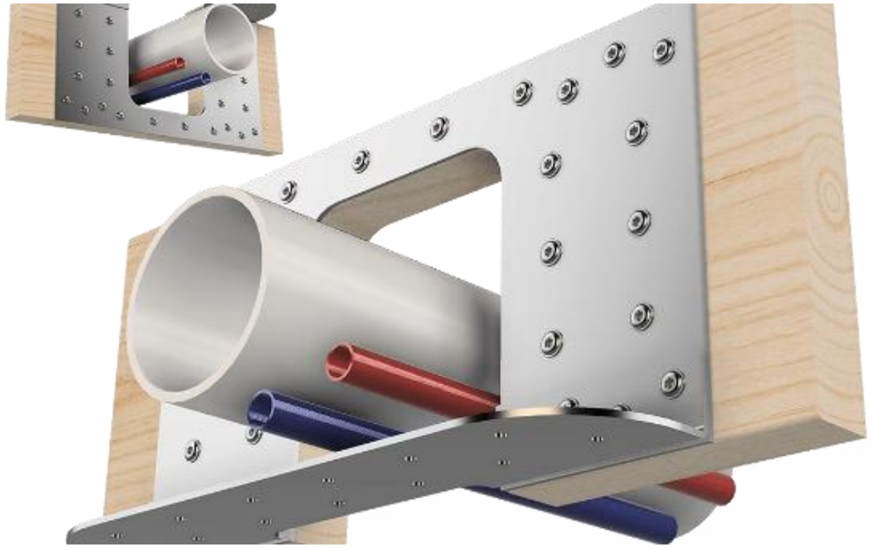
   When running pipe or tubing diagonally or at right angles to joists, fasten it to the bottom of the joist or install it through holes drilled in the center of the joists.

Piping and Joist Orientation



Parallel to Joists

When gas piping runs parallel to floor joists, it must be fastened to the center of the vertical face of the joist for proper support and protection.



Perpendicular to Joists

When gas piping runs at right angles to joists, it can be installed through holes drilled in the center of the joists, providing a clean installation that doesn't interfere with finishing materials.

Attached to Bottom of Joists

When running diagonally or at right angles to joists, piping can also be fastened to the bottom of the joists, preferably close to water pipes, conduits, ductwork, or support beams.

Concealed Piping Requirements

Location Restrictions

Concealed gas piping and tubing must not be in a location where an undetected leak could allow gas to accumulate.

Testing Requirements

It must undergo testing and inspection in the final location before you conceal it.

Joint Restrictions

It should not have unions or swing joints made up of a combination of fittings.

Size Limitations

You may not conceal gas piping less than NPS 1/2.

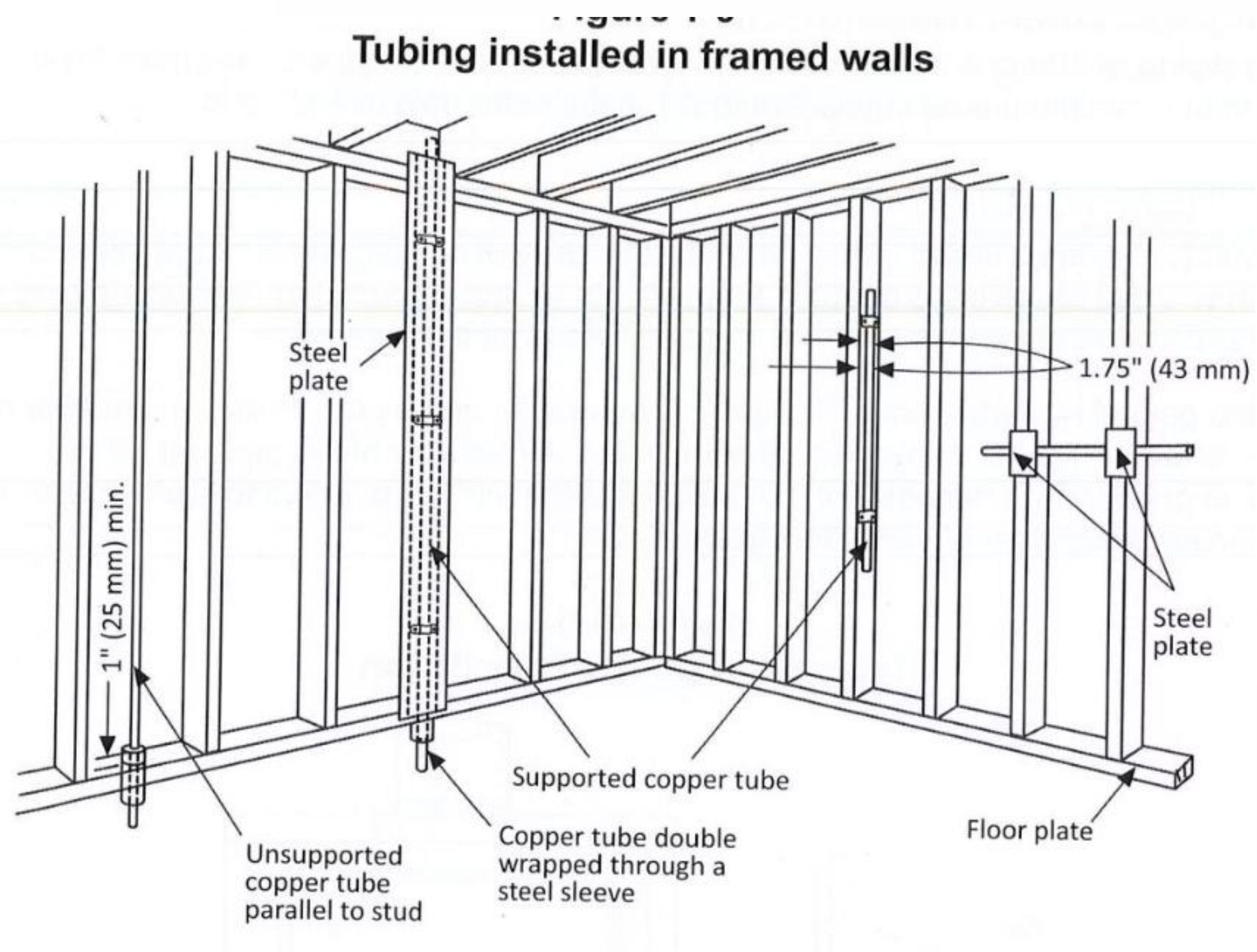
Tubing in Framed Walls

Protection Requirements

Copper tubing installed in framed walls must have a metal sleeve or other similar means of protection at the point where it passes through a sill plate or other structural members.

The protective sleeve must project at least 4 in (10 cm) on either side of the structural member.

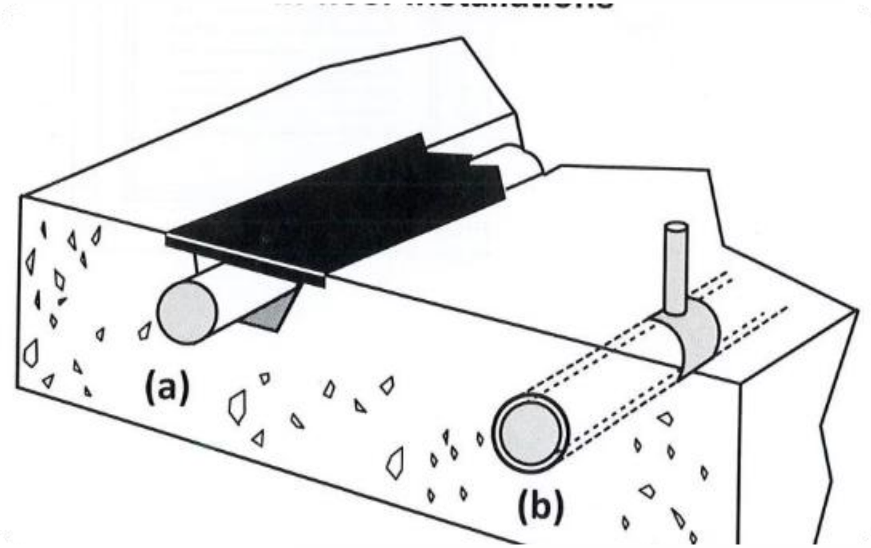
It must also have sufficient slack to allow for expansion, contraction, and some movement.

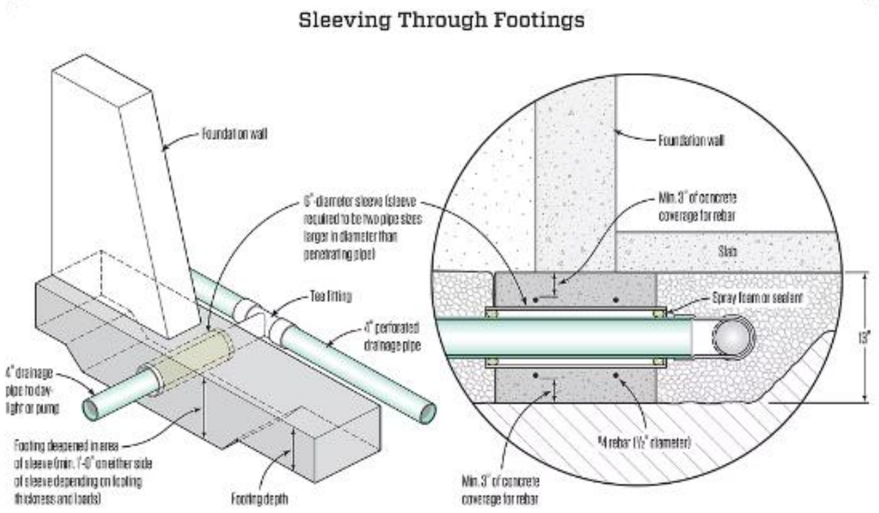


When tubing runs horizontally across studs notched to accommodate the tubing, it must be protected where it crosses each stud by a 16-gauge (USG) steel plate extending at least 2 in (5 cm) on either side of the tubing.

Notches cut into studs must be large enough to accommodate the tubing without forcing, but not so large as to weaken the stud.

In-Floor Gas Piping Installations





Channel with Removable Cover

When installed in concrete or other solid types of floor, gas piping and tubing can be located in a channel or chase with a removable, protective access cover.

Ventilated Sleeve

Another approved method for in-floor installations is placing the gas piping in a ventilated sleeve under the floor, which allows for inspection and prevents gas accumulation in case of leaks.

Vertical Pipe Chase

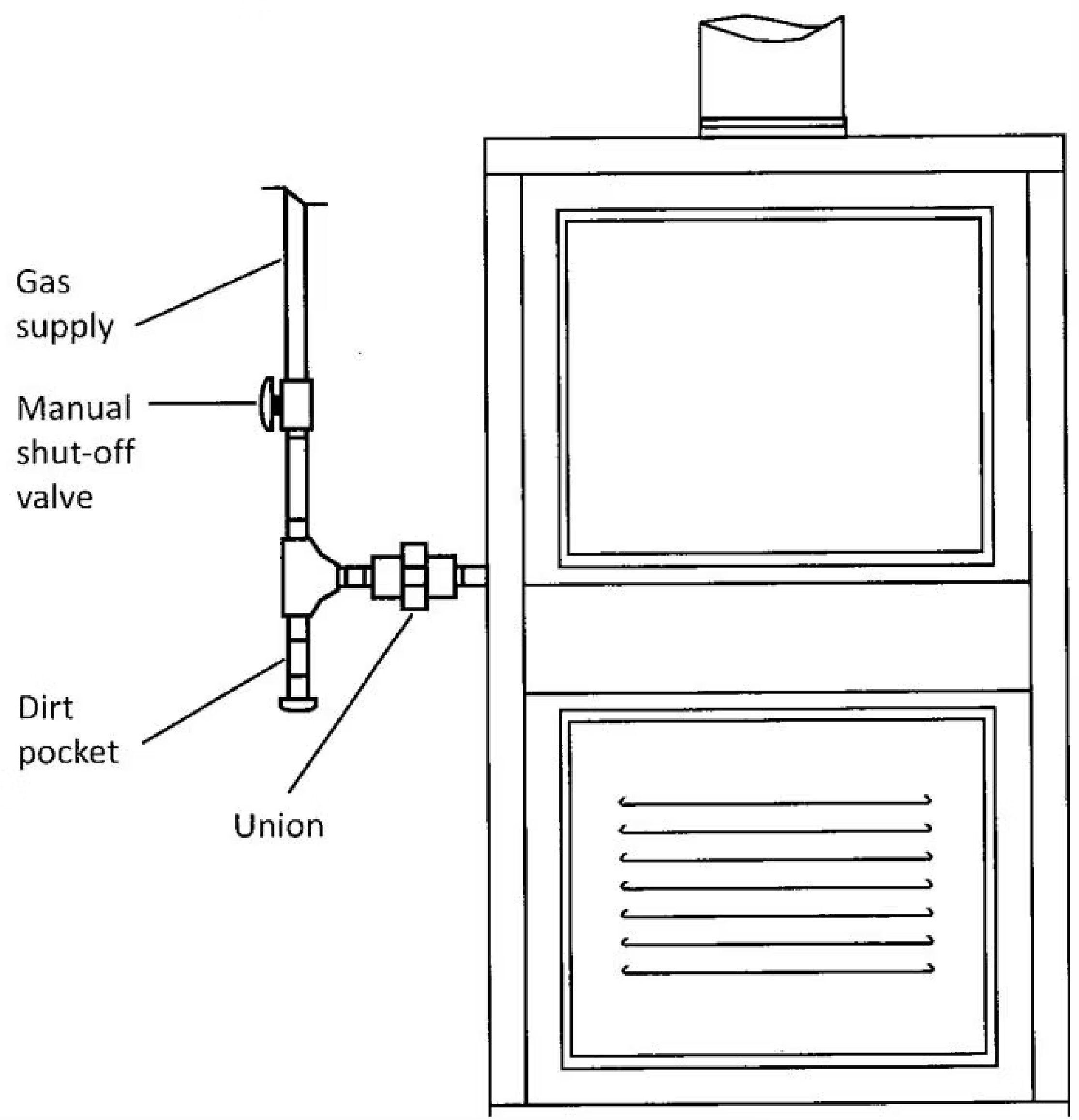
When gas piping or tubing is installed in a vertical pipe chase, the pipe chase must have openings with a minimum area equivalent to a 1 in diameter hole at each end to provide ventilation.

Dirt and Drip Pockets

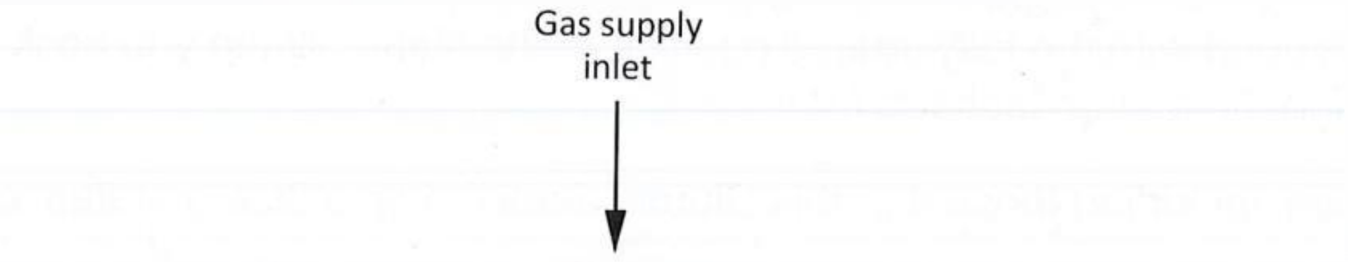
Purpose and Construction

A dirt pocket (sometimes called a dust pocket) is an area in a piping system that collects dirt and from which you can remove the dirt. A drip pocket is an area in a piping system that collects condensate and from which you can remove the condensate.

A dirt or drip pocket is made from a "T" fitting, short nipple, and a cap. Its size makes the depth of the pocket either 3 in (75 mm) or equal to the internal diameter of the piping it serves, whichever is greater.



Typical dirt pocket installation



Dirt and Drip Pocket Applications

Installation Location

Install a dirt pocket at the bottom of any piping or tubing on the final drop serving most appliances. Some specific appliances do not require dirt pockets (see Clause 6.13.1 of CSA B149.1).

Condensation Collection

A piping system where condensation may collect, as may be a result of the piping being exposed to wide ranges or sudden change in temperature, must have a drip pocket.

Sizing Requirements

The diameter of the pocket is either NPS 2 or equal to the diameter of the piping it serves, whichever is less.

Prohibited Piping Practices

Nesting of Bushings

The relatively thin walls of bushings can easily lead to fractures when a nest of bushings is tightened. The likelihood of leakage when a number of bushings are nested is also significantly higher.

Field Bending of Pipe

This is prohibited because it may induce stresses that can lead to rupture and leakage.

Mixed Thread Directions

Fittings containing both left- and right-hand threads are susceptible to the loosening of one end when the other is being tightened.

Thread Protectors and Running Threads

These do not allow for proper seating and thread lock-up, thereby increasing the likelihood of leakage.

Concealed Swing Joints

Since swing joints are susceptible to loosening at the joints over time, you cannot install them in concealed locations.

More Prohibited Practices

Electrical Grounding

You cannot use piping or tubing as a ground because it does not comply with the applicable requirements of the Canadian Electrical Code and may potentially result in an electrical hazard. Bonding of piping or tubing is permitted; however, when doing this, you must connect the bond to an approved electrical ground.

Close Nipples

Close nipples do not have a shoulder, resulting in a lack of seating that can lead to leakage.

Street Elbows and Tees

Street elbows and tees are not permitted because these fittings have both male and female threaded ends. This makes alignment of the piping difficult since the direction of the piping does not always correspond with the fully seated position of the fitting. When you back off the connection to align the piping, leakage may result.

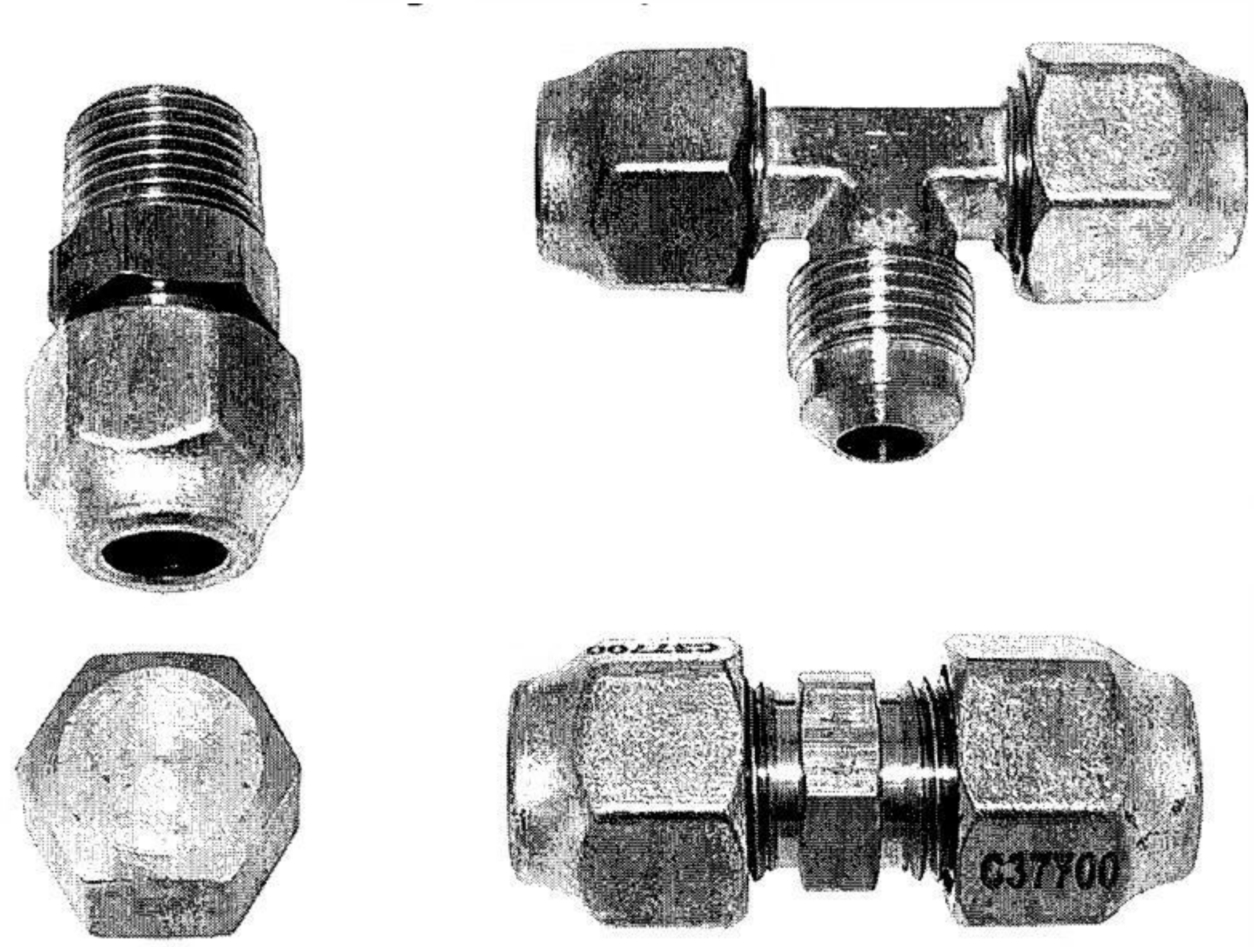
Gas Tubing Fittings

Approved Fittings

You may connect copper and other tubing with forged, brass, 45° flare fittings as well as approved compression fittings such as SWAGELOK®. Note that although there are many types and manufacturers of compression fittings, not all are approved.

You can make connections between tubing and steel pipe by means of threaded-to-tubing adaptors.

Never use tubing fittings for pressures higher than those that local codes permit.



Approved tubing fittings: (a) 45° flare fitting and (b) SWAGELOK® compression fitting

Steel Piping and Tubing Fittings

Construction Requirements

Steel pipe fittings must be of malleable iron or steel construction and have approval for use with gas systems.

Common Types

Steel pipe fittings consist of:

- 45° and 90° elbows
- Straight and reducing couplings
- Nipples and unions
- Bushings
- Normal and reducing tees
- Plugs and caps

Common Steel Gas System Fittings









Steel gas system fittings include 90° elbows, reducing tees, plugs, bushings, reducing couplings, standard couplings, tees, and unions. Each has a specific purpose in creating gas distribution systems.

Prohibited Fittings

Close Nipple

Close nipples do not have a shoulder, resulting in a lack of seating that can lead to leakage. They are prohibited for use in gas systems.

Street Elbow

Street elbows have both male and female threaded ends, making alignment difficult. When you back off the connection to align the piping, leakage may result.

Running Threads

Fittings with running threads do not allow for proper seating and thread lock-up, thereby increasing the likelihood of leakage in gas systems.

Gas Valves Overview

Purpose

Gas valves control the flow of gas to different appliances and to main and pilot burners at various points along a piping system. With different valves, the gas technician/fitter can make a complete shutdown or regulate the flow at a specific location.

Selection Factors

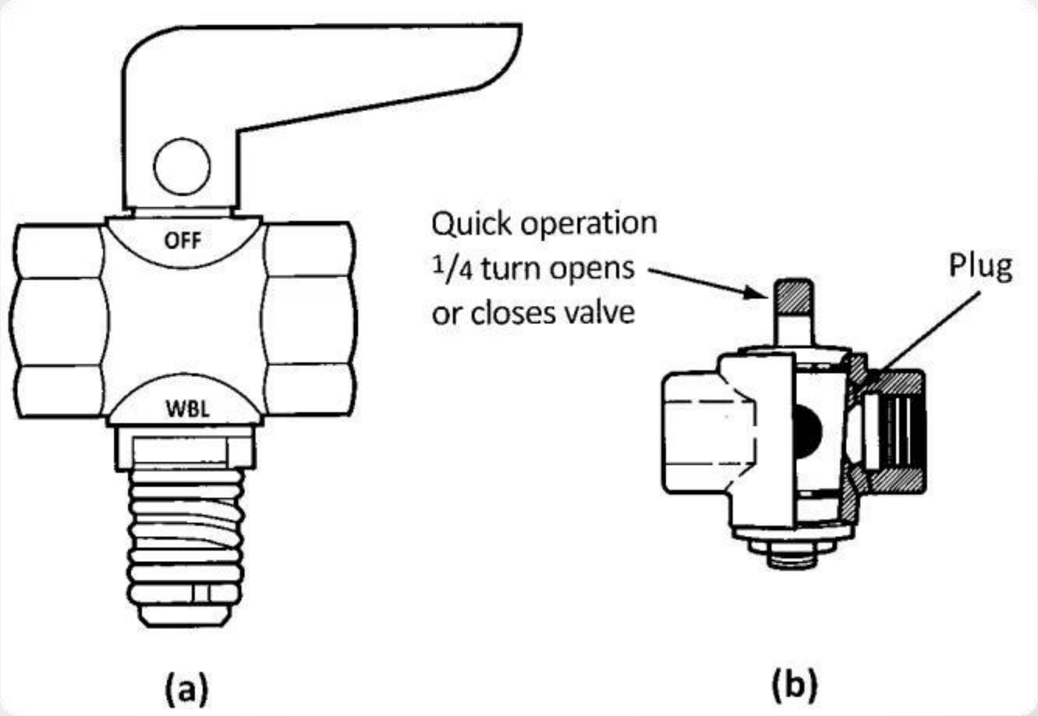
The gas technician/fitter must take care in selecting the correct valve for the job, since valve size, gas pressure, and location are all important factors for consideration.

Installation Considerations

The gas technician/fitter must also allow for the valve's removal for repair or replacement.

Code Requirements

CSA B149.1 outlines specific locations and applications for installing manual gas valves in Clause 6.18.



Manual Gas Shut-Off Valves

Installation Methods

Manual gas valves are incorporated into the piping system in different ways. In most cases, the size of the valve dictates the jointing method used:

- Larger valves are usually flanged in place
- Mid-range sizes are threaded
- Smaller sizes, when used with copper tubing, are connected using flare fittings

Valve Categories

Manual gas shut off valves fall into three categories:

- Plug type
- Ball type
- Eccentric type

Plug Type Valves

Operation

Plug type valves fully open or close with a quarter turn of a handle.

Types

There are two basic types common to the gas industry:

1. Spring-loaded valve - Made of brass and approved only for indoor use with sizes reaching up to 1 in diameter
2. Lubricated plug valve - Made of malleable iron and approved for indoor or outdoor use. Commonly named Lubeseal. Designed to be lubricated and maintained with the valve in place and with no interruption of service

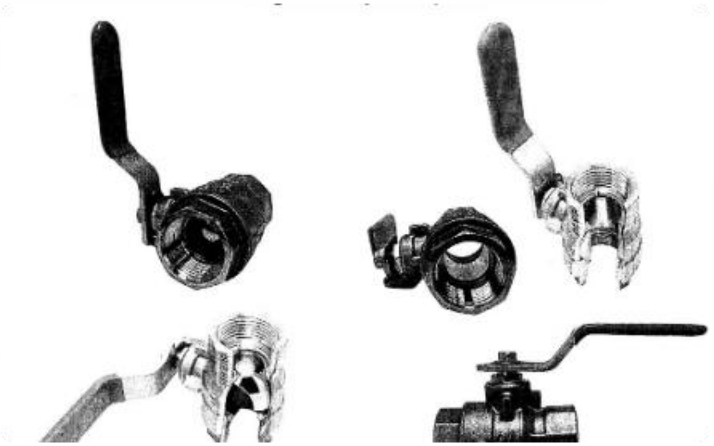
For outdoor use, you may also obtain the lubricated plug valve with a removable handle and a locking accessory for security.

Lubricated plug valve for gas systems

Eccentric and Ball Valves

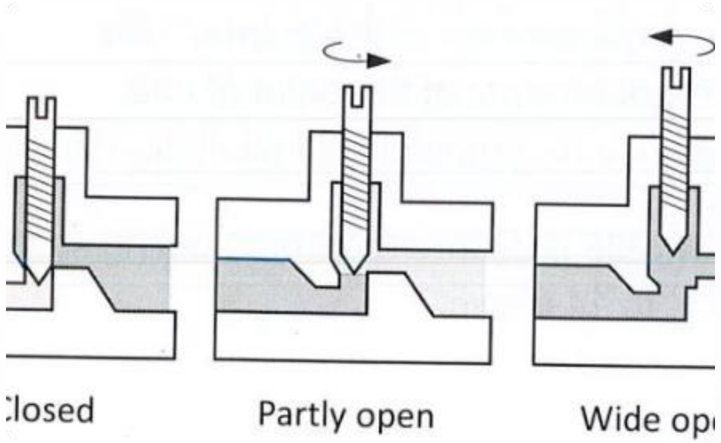
Eccentric Valve

The rotating-eccentric valve has a spherically faced plug that rotates through approximately 50° from the fully-open to fully-closed position. The eccentric motion of the plug reduces operating torque requirements and produces no sliding friction between the plug and seat, reducing seat wear and seating torque.



Ball Valve

Ball-type valves also open and close with a quarter turn of a handle and have approval for indoor or outdoor use. They have a Teflon seat and a stainless-steel sealing ball. To control the flow, the ball has a hole drilled through its center and fits tightly against the Teflon seat in the closed position.



Needle Valve

Needle valves are used for smaller applications and internal valve control. They are simple restrictors of flow, which you usually open or close with a screwdriver. When slightly unscrewed, flow is limited. Full flow occurs when the needle is screwed out to its fullest extent.

Master Shut-Off Valves

Code Requirements

Clause 6.18.10 of CSA B149.1 contains the Code requirements for master shut-off valves.

Multiple Outlets

According to the Code, when multiple outlets are installed in a classroom, laboratory, or similar facility, a clearly identified master shut-off valve must control them.

Location

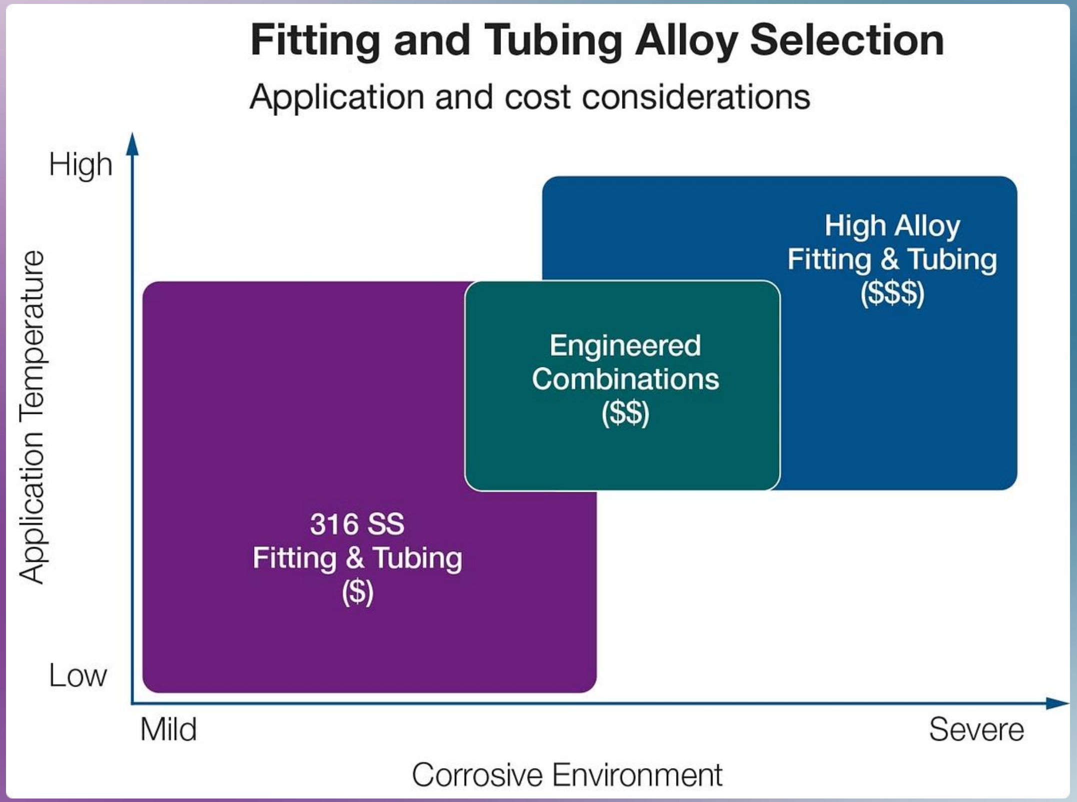
The master shut-off valve must be located within the room containing the multiple outlets.

Identification

The master shut-off valve must be clearly identified to ensure it can be quickly located in case of emergency.

Pipe and Tubing Material Selection

Type of pipe or tubing	Type of fittings	Type of connections
Iron pipe	Malleable iron	Threaded
Steel	Welded	Compression, Flanged, Mechanical, Connector w/forged nut, Ring, flange, and bolts
Polyethylene	Hub to hub, Pipe to pipe, Saddle, Slip on	Hot iron socket fusion, Butt fusion, Saddle fusion, Compression slip lock
Copper tube	Copper to copper, Flared, Compression	Brazing over 1000°F (525°C), Single 45° flare, Not ball sleeve
Steel tube	Flared, Compression	Single 45° flare, Not ball sleeve
CSST	Specialized manufacturer fittings	Specific to manufacturer of tubing



Elastomeric Hose Specifications

Hose type	Maximum operating pressure	Minimum burst pressure	Description
Type I	350 psig (2.4 MPa)	1750 psig (12.1 MPa)	Has a tubing made of oil-resistant elastomer, with a minimum thickness of 0.047 in (0.12 mm). Has a polychloroprene or similar cover reinforced with rubber-impregnated cotton or synthetic fibers or stainless steel.
Type II	350 psig (2.4 MPa)	Ranges from 1750 psig (12.1 MPa) for size 40 to 12,000 psig for size 4	Has a tubing made of oil-resistant elastomer, with a minimum thickness of 0.047 in (0.12 mm). May have a cotton or synthetic braided cover, but must be polychloroprene-impregnated for weather protection. Must be reinforced with stainless steel wire braid and/or an outer braid of cotton or synthetic fibers.
Type III	350 psig (2.4 MPa)	Ranges from 1750 psig (12.1 MPa) for size 40 to 12,000 psig for size 4	Has a tube or lining made of oil-resistant material with low permeability and low leaching properties. Must be perforated, oil-resistant elastomeric, or thermoplastic. Must be reinforced with stainless steel wire braid and/or an outer braid of cotton or synthetic fibers.

Polyethylene Pipe Joining Process

Preparation

Cut pipe ends square and ensure that surfaces you will join are properly aligned.

Cleaning

Remove water, dirt, grease, oil, fingerprints, and cuttings. Wipe the inside and outside of the pipes with a clean, lint-free cloth.

Temperature Setting

Set the thermoswitch to 500°F ± 7°F (260°C ± 4°C). Allow the temperature to stabilize, then check with a tempilstik.

Heating

Apply the heating iron to the surface of the mating components until each surface melts but does not burn.

Joining

Remove the heating irons and press the surfaces together with the appropriate pressure until the joint cools and solidifies.

Flexible Connector Requirements

Certification

Must conform to ANSI Z21.69/CSA 6.16

Pressure Rating

For use with systems not exceeding 0.5 psig (3.4 kPa)

Size Options

Nominal IDs of 1/2, 3/4, 1, 1-1/4, and 1-1/2 in

Length Limitation

Not more than 6 ft (1.83 m) in nominal length

Connection Type

Standard taper pipe threads at each end

Copper Tubing Protection in Walls

Metal Sleeve Protection

Required where tubing passes through structural members

Steel Plate Guards

16-gauge plates protect tubing crossing studs

Proper Notching

Notches must accommodate tubing without forcing

Expansion Allowance

Sufficient slack for expansion and contraction

Pipe Joining Sealant Application

Select Approved Sealant

Use only pipe dope or Teflon pipe tape that is specifically approved for gas applications. Approved Teflon pipe tape is often manufactured in a different color such as orange or red.

Prepare the Threads

Ensure threads are clean and free from debris before applying sealant. Dirty threads can prevent proper sealing even with the correct sealant.

Apply to Male Threads Only

Apply sealant only to the male threads, leaving the first two threads free of dope or tape to prevent the sealant from entering the piping system.

Apply Tape Correctly

When using tape, stretch and apply it to the pipe in a clockwise direction, with a 50% overlap between wraps to ensure complete coverage and effective sealing.

Underground Gas Piping Protection

24 in

Commercial Depth

Minimum depth under driveways or parking lots

15 in

Standard Depth

Minimum depth in other locations

100%

Corrosion Protection

Required for all underground piping except Type K copper

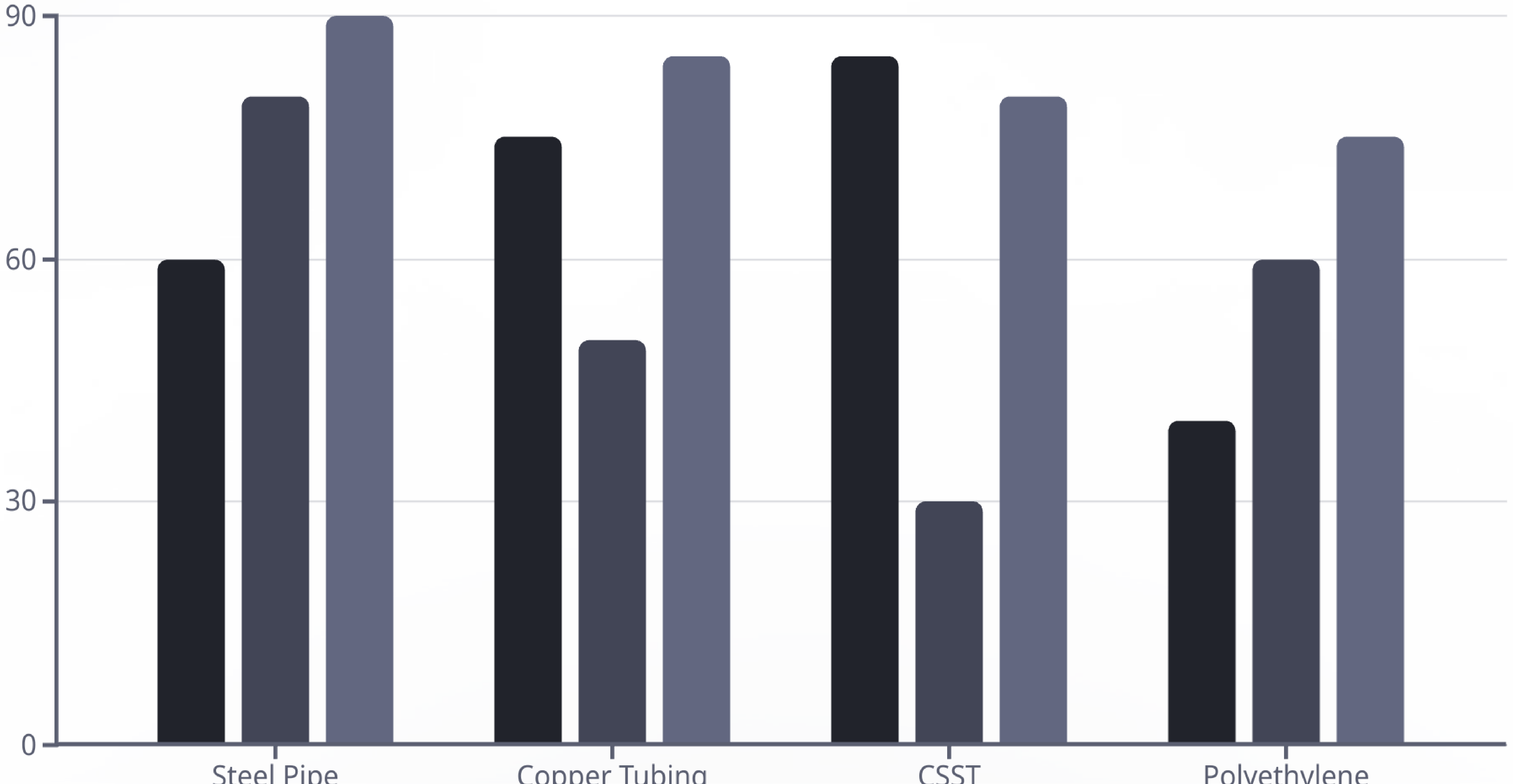
0

Foundation Crossings

Number of times piping can pass beneath foundations

Gas Valve Selection Guide

Piping Material Comparison



Pipe Sizing Requirements

1/2 in

Minimum Indoor Size

Standard minimum pipe diameter for indoor applications

3/8 in

Branch Line Minimum

Allowed for branch lines ≤25 ft serving ≤15,000 Btu/h

1/2 in

Minimum Underground

Minimum pipe size for underground installations

0

Concealed Small Pipes

Pipes smaller than NPS 1/2 cannot be concealed

GAS PIPE SIZING CHART

NATURAL GAS

PIPE LENGTH (feet)	1/2"	3/4"	1"	1 - 1/4"	1 - 1/2"	2"	2 - 2 1/2"	3"	4"
10	108	230	387	793	1237	2259	3640	6434	-
20	75	160	280	569	877	1610	2613	5236	9521
30	61	129	224	471	719	1335	2165	4107	7859
40	52	110	196	401	635	1143	1867	3258	6795
50	46	98	177	364	560	1041	1680	2936	6142
60	42	89	159	336	513	957	1559	2684	5647
70	38	82	149	317	476	896	1447	2492	5250
80	36	76	140	239	443	840	1353	2315	4900
90	33	71	133	275	420	793	1288	2203	4667
100	32	68	126	266	411	775	1246	2128	4518
125	28	60	117	243	369	700	1143	1904	4065
150	25	54	105	215	327	625	1008	1689	3645
175	23	50	93	196	303	583	993	1554	3370
200	22	47	84	182	280	541	877	1437	3160
300	17	37	70	145	224	439	686	1139	2539

Natural Gas (NG) flow is given in thousands of BTU/hr. One cubic foot of NG gas - 1000 BTU.

Nominal pressure at the burner for Natural Gas is 3.5" of water column. (Typical machine supply 5" - 7").

Pipe length must include additional length for all fittings. Add approximately 5 feet of pipe per fitting.

Natural Gas Example: A machine with a burner that requires 440,000 BTU would need a 1 - 1/4" pipe for a 20' long run.

LIQUID PROPANE

PIPE LENGTH (feet)	1/2"	3/4"	1"	1 - 1/4"	1 - 1/2"	2"	2 - 2 1/2"	3"	4"
10	275	567	1071	2205	3307	6221	10140	17990	35710
20	189	393	732	1496	2299	4331	7046	12510	25520
30	152	315	590	1212	1858	3465	5695	10110	20620
40	129	267	504	1039	1559	2992	4778	8481	17300
50	114	237	448	913	1417	2646	4343	7708	15730
60	103	217	409	834	1275	2394	3908	6936	14150
70	89	185	346	724	1086	2047	3329	5908	12050
80	78	162	307	630	976	1811	2991	5309	10830
90	69	146	275	567	866	1606	2654	4711	9613
100	63	132	252	511	787	1496	2412	4281	8736
125	54	112	209	439	665	1282	2083	3618	7382
150	48	100	185	390	590	1138	1808	3210	6549
175	43	90	168	353	534	1030	1637	2905	5927
200	40	83	155	325	491	947	1505	2671	5450
300	37	77	144	303	458	887	1404	2492	5084

Liquid Propane (LP) flow is given in thousands of BTU/hr. One cubic foot of NG gas - 2516 BTU.

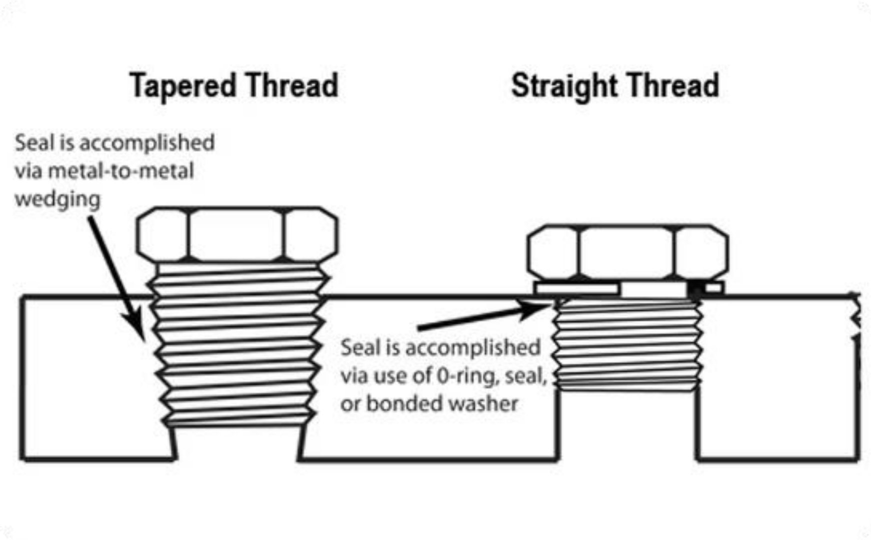
This chart refers to low pressure LP, after regulation, standard nominal pressure at the burner for Liquid Propane Gas is 11" of water column

Pipe length must include additional length for all fittings. Add approximately 5 feet of pipe per fitting.

Liquid Propane Example: A machine with a burner that requires 440,000 BTU would need a 1" pipe for a 20' long run.

NOTE: The sizing charts above list the specific pipe sizes required for the amount of BTU's for a new gas line installations. If you are using an existing gas line you must take into consideration the existing gas line capacities to ensure you will have proper pressure. This chart is for reference only, we recommend you consult with a Licensed Plumber/Gas Fitter or NFPA54 (National Fuel Gas Code - current edition) for more details.

Pipe Threading and Joining Methods

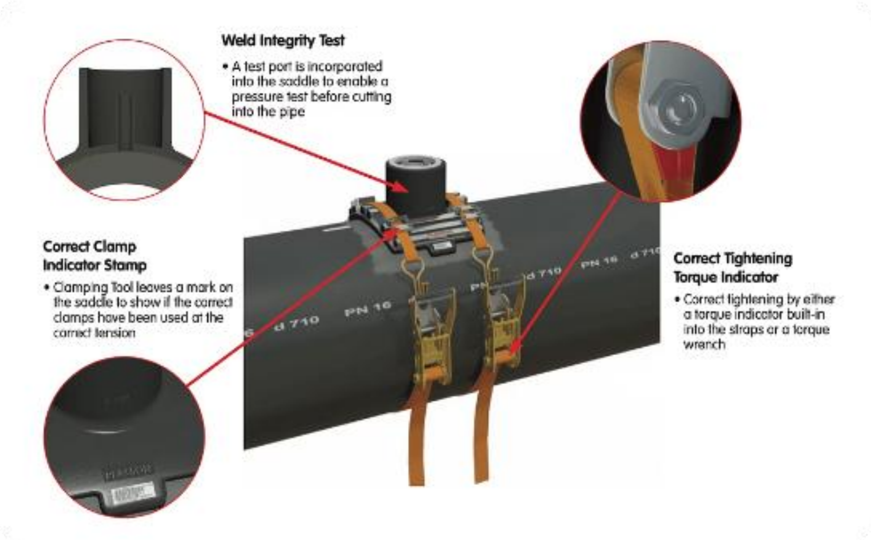


NPT Threading

Gas piping utilizes a tapered thread (NPT) cut on a pipe threading machine or hand tool. The taper allows threads to form a seal when torqued as the flanks compress against each other.

Copper Flaring

Copper tubing is joined using 45° brass flare connectors. The flaring tool creates a precise angle that mates with the fitting to create a gas-tight seal.



Polyethylene Fusion

Polyethylene piping is fused by applying heat and pressure. As the surfaces melt, the heating irons are removed and the surfaces are pressed together to form a strong joint.

Gas System Installation Safety

Material Verification

Ensure all materials are approved for gas applications and have proper certification markings.

Pressure Testing

Test all piping and tubing in the final location before concealing it to verify there are no leaks.

Proper Ventilation

Install gas piping in ventilated spaces and never in locations where leaking gas could accumulate.

Physical Protection

Protect piping from physical damage with proper sleeves, plates, and support methods.

Accessible Shut-offs

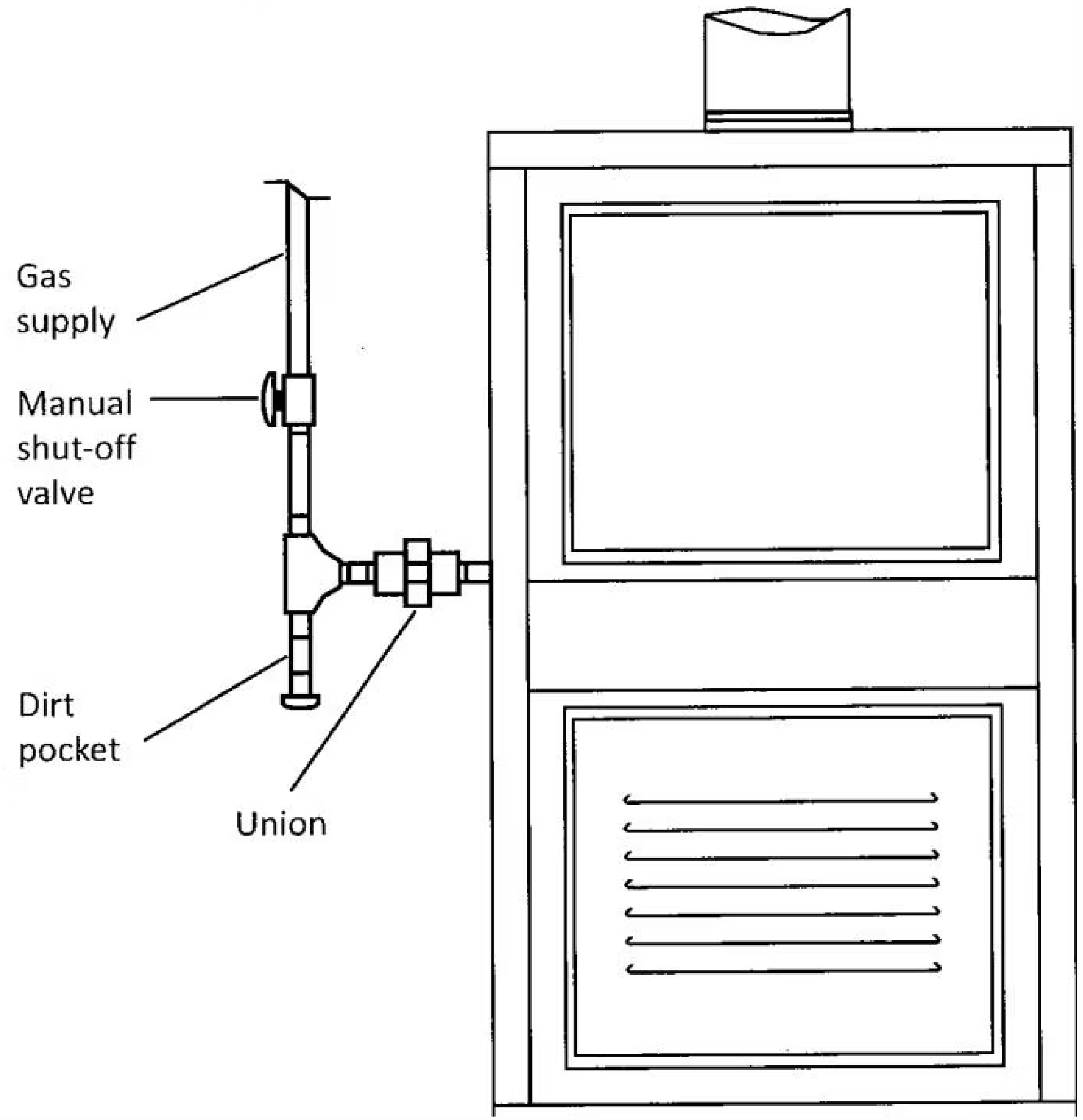
Install shut-off valves in accessible locations to allow quick gas isolation in emergencies.

Dirt Pocket Installation

Purpose of Dirt Pockets

Dirt pockets (sometimes called dust pockets) collect dirt and debris from the gas system, preventing it from reaching and potentially damaging appliance components. They are installed at the bottom of any piping or tubing on the final drop serving most appliances.

The design allows solid particles to fall into the pocket rather than continuing to the appliance. The cap at the bottom can be removed for periodic cleaning to maintain system efficiency and safety.



A typical dirt pocket installation consists of a "T" fitting, short nipple, and a cap. The depth of the pocket is either 3 in (75 mm) or equal to the internal diameter of the piping it serves, whichever is greater. The diameter is either NPS 2 or equal to the diameter of the piping it serves, whichever is less.

Piping System Maintenance

Clean Dirt Pockets

Remove and clean dirt pockets to prevent debris accumulation in the system.

Leak Testing

Perform leak tests after any system modifications or repairs.

Valve Maintenance

Lubricate and service valves according to manufacturer specifications.

Check Supports

Verify that pipe supports remain secure and properly positioned.

Regular Inspection

Periodically check piping systems for signs of corrosion, damage, or leaks.

Code Compliance and Certification

CSA B149.1 Requirements

Clause 6 of CSA B149.1 details requirements for piping material and fittings. It also outlines the proper connecting methods and the many piping practices that gas technicians/fitters must follow.

Material Certification

All piping, tubing, valves, and fittings used in gas systems must have proper certification from recognized agencies such as CSA Group or Underwriters' Laboratories of Canada.

Installer Certification

Gas technicians/fitters should ensure they have successfully completed manufacturer's certified installation training programs, especially for specialized systems like polyethylene piping or CSST.

Inspection Requirements

All gas piping installations must be inspected and tested according to local code requirements before being placed into service.

CSA Unit 8

Chapter 2
Code Requirements for Testing Gas Piping Systems

A gas technician/fitter must know how to interpret applicable codes in order to properly test gas piping systems and gas-fired appliances and equipment so that they operate in a safe, and efficient manner.

Purpose of Testing Gas Piping Systems

Safety

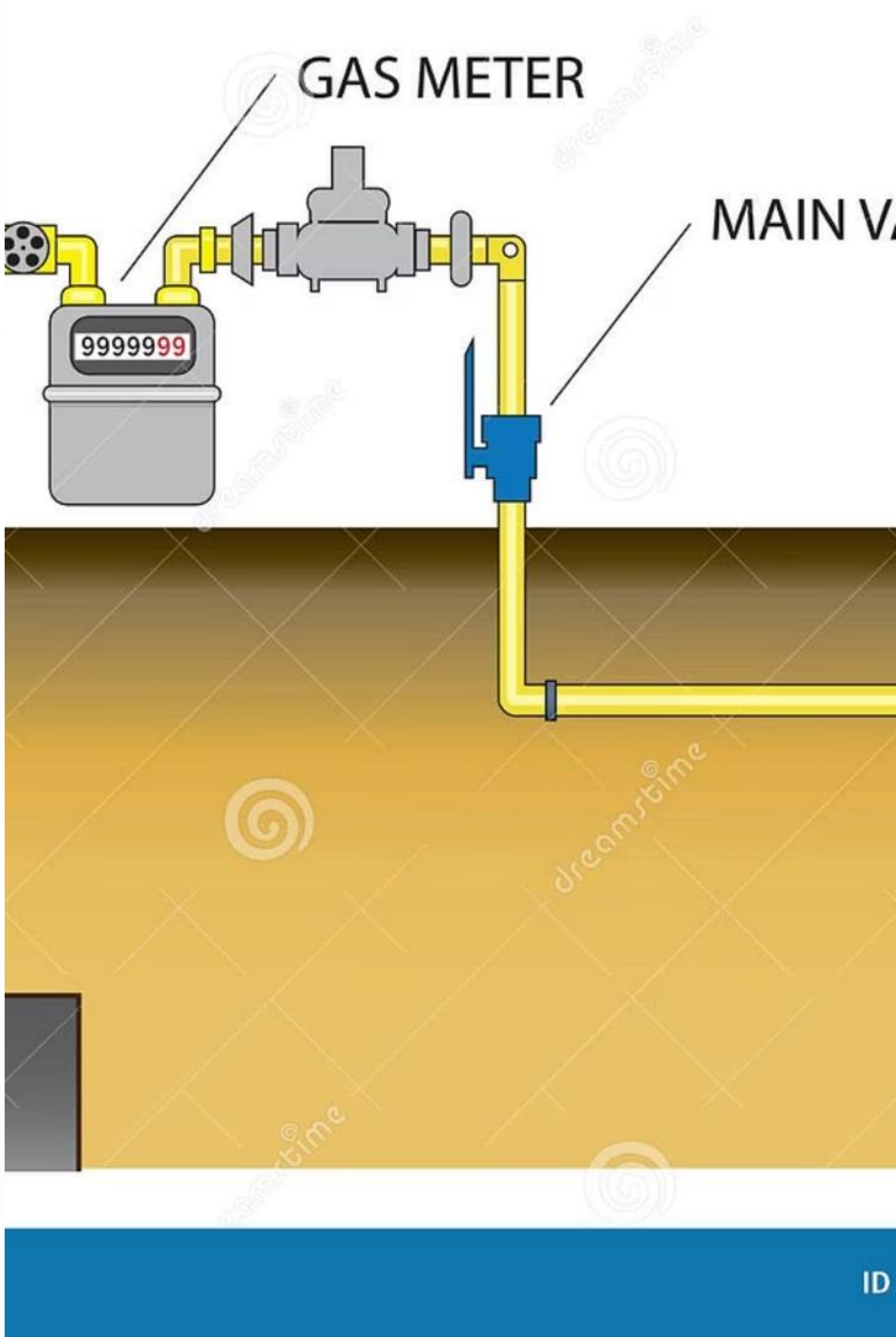
Ensure gas piping systems operate safely without leaks

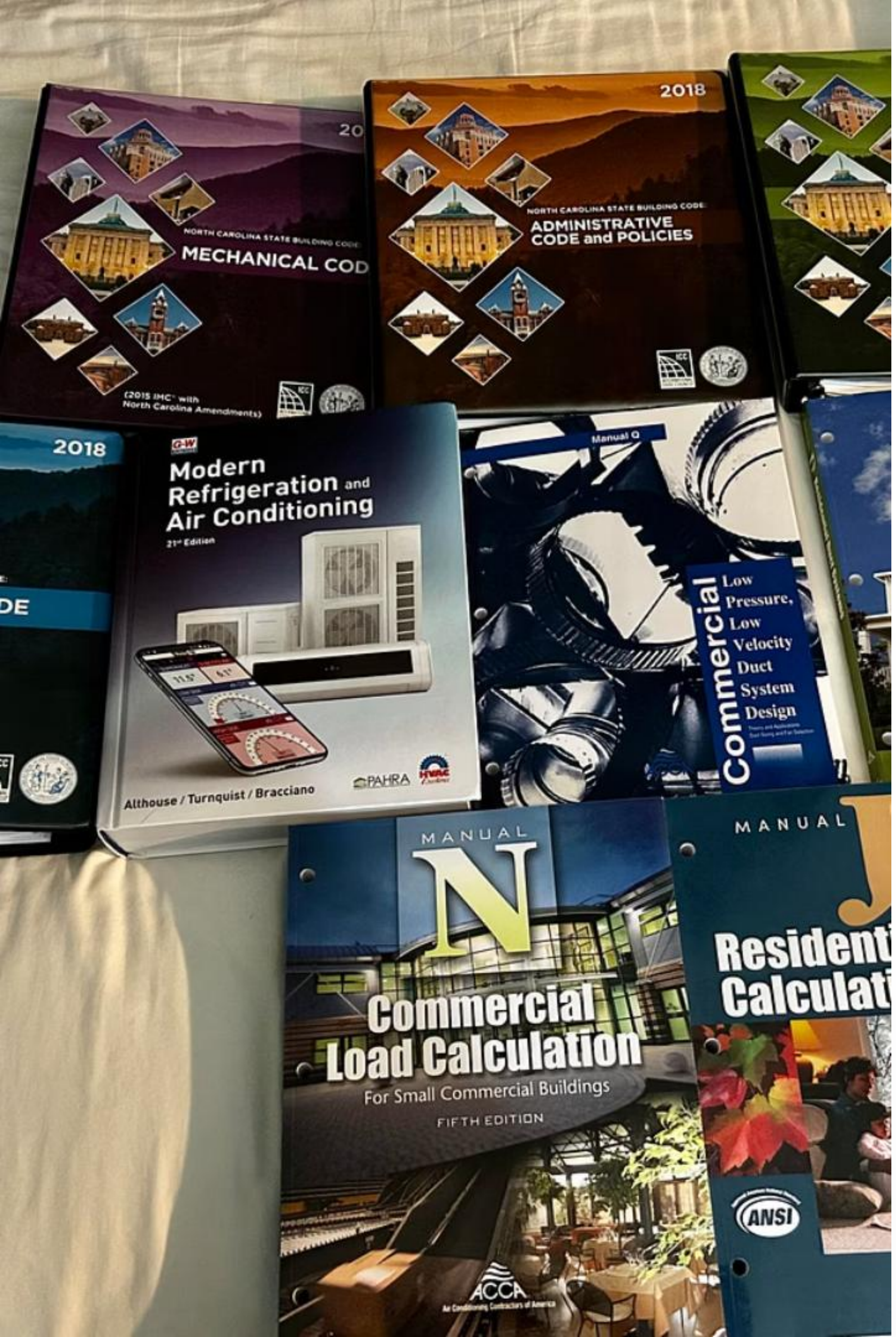
Compliance

Meet all applicable code requirements and regulations

Efficiency

Verify systems operate efficiently as designed





Learning Objectives

Interpret codes as they apply to testing piping systems

Understand and apply relevant code requirements for proper testing procedures

Describe how to document test results on test tag

Learn the proper documentation methods for recording test results

Key Terminology

Term	Abbreviation (symbol)	Definition
Pressure test tag	-	Tag attached to the system, in a prominent place, after testing that includes location, testing, and tester information

Testing Requirements Overview

Install Piping System

Complete the gas piping system installation according to code

Pressure Test Before Appliance Installation

Test the system before connecting any appliances (CSA B149.1, Clause 6.22.2)

Pressure Test After Appliance Installation

Test the system after connecting appliances (CSA B149.1, Clause 6.22.3)

Pressure Test Device Calibration

For Working Pressure 0.5-5 psig (3.5-35 kPa)

Pressure gauge or equivalent device shall undergo calibration to read in increments of not greater than 1 ounce of pressure (0.5 kPa)

For Working Pressure Exceeding 5 psig (35 kPa)

Pressure gauge or equivalent device shall undergo calibration to read in increments of not greater than either 2 psig (14 kPa) or 2% of the maximum dial reading of the gauge, whichever is less

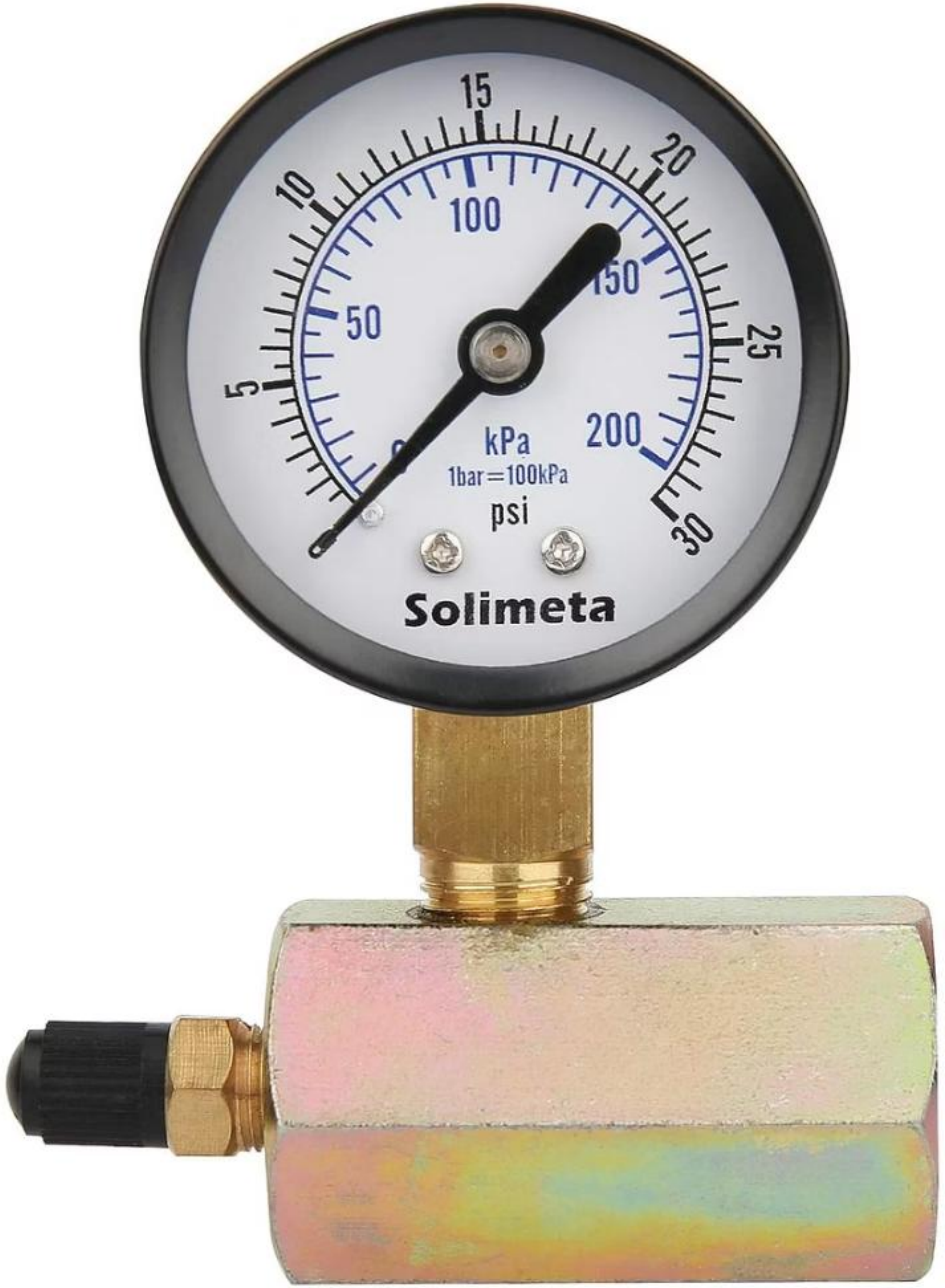
Pressure Gauge Requirements

Minimum Size

When you use a pressure gauge, it must be a minimum of 3 in (75 mm) diameter

Range Requirements

The maximum range must exceed the test pressure by at least 15% but not more than 300%



Visual Inspection Process

Inspect During Installation

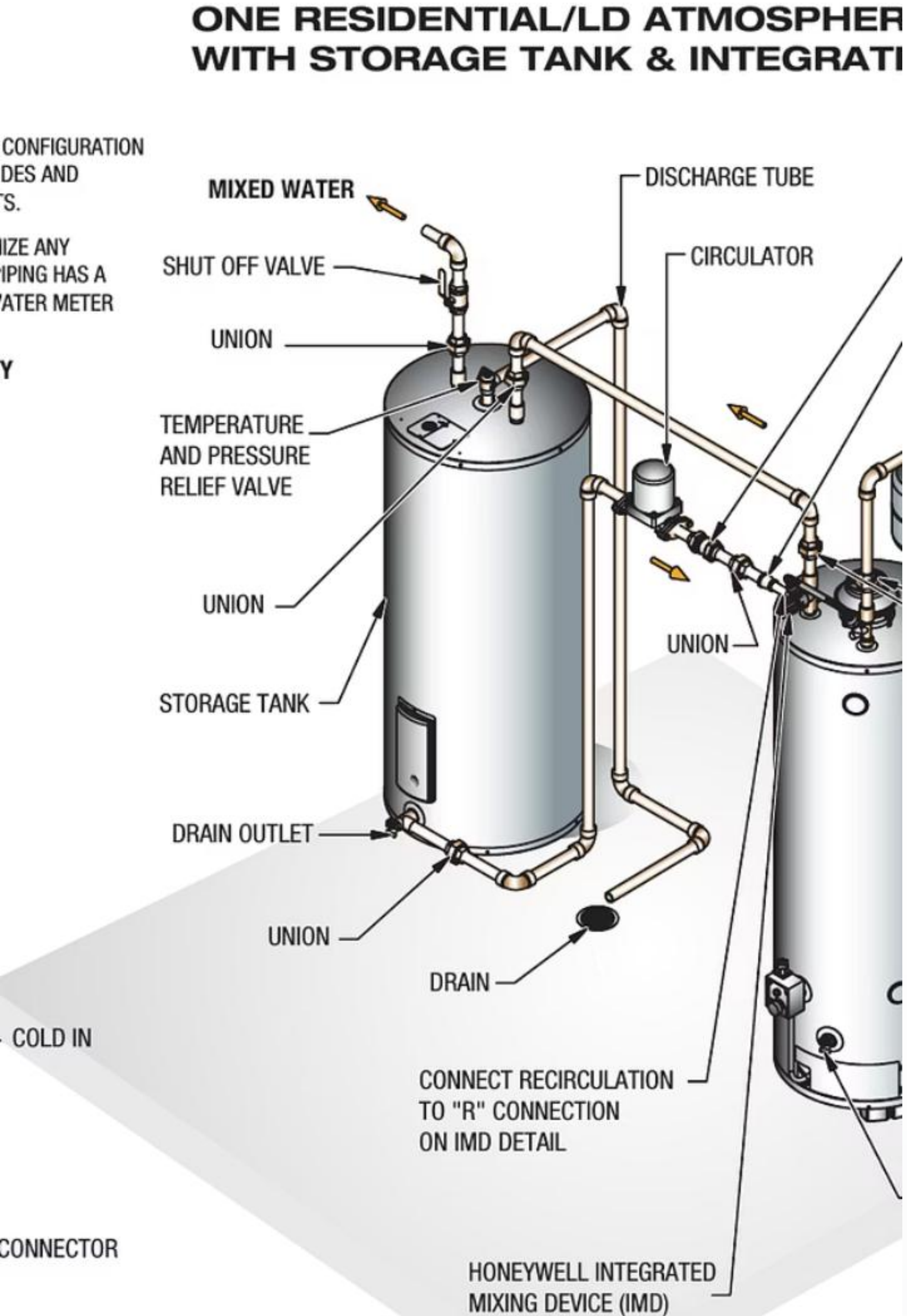
During installation of piping and tubing and before pressure testing, visually inspect piping and tubing

Check for Defects

Look for cuts, abrasion, and any other defect that may cause leaking or failure of the system when it is under pressure

Inspect Before Concealment

Remember that you must inspect and test all piping and components to be concealed before you conceal them



Testing Before Installation of Appliances

Isolate Components

Before testing, isolate or remove any components of the system that have a pressure rating below the test pressure

Cap Open Ends

Isolate the piping system that you will test by capping or plugging all open ends

Insert Pressure Gauge

Insert a pressure gauge at one end of the system

Pressurize System

Pressurize the system with air or inert gas (nitrogen or carbon dioxide) to the specified test pressure

Pressure Measurement Requirements

Calibrated Gauge

Measure the pressure with a pressure gauge calibrated in 14 kPa (2 psig) increments or less

Alternative Calibration

Or use a gauge calibrated to 2% of the full-scale reading of the gauge, whichever is greater

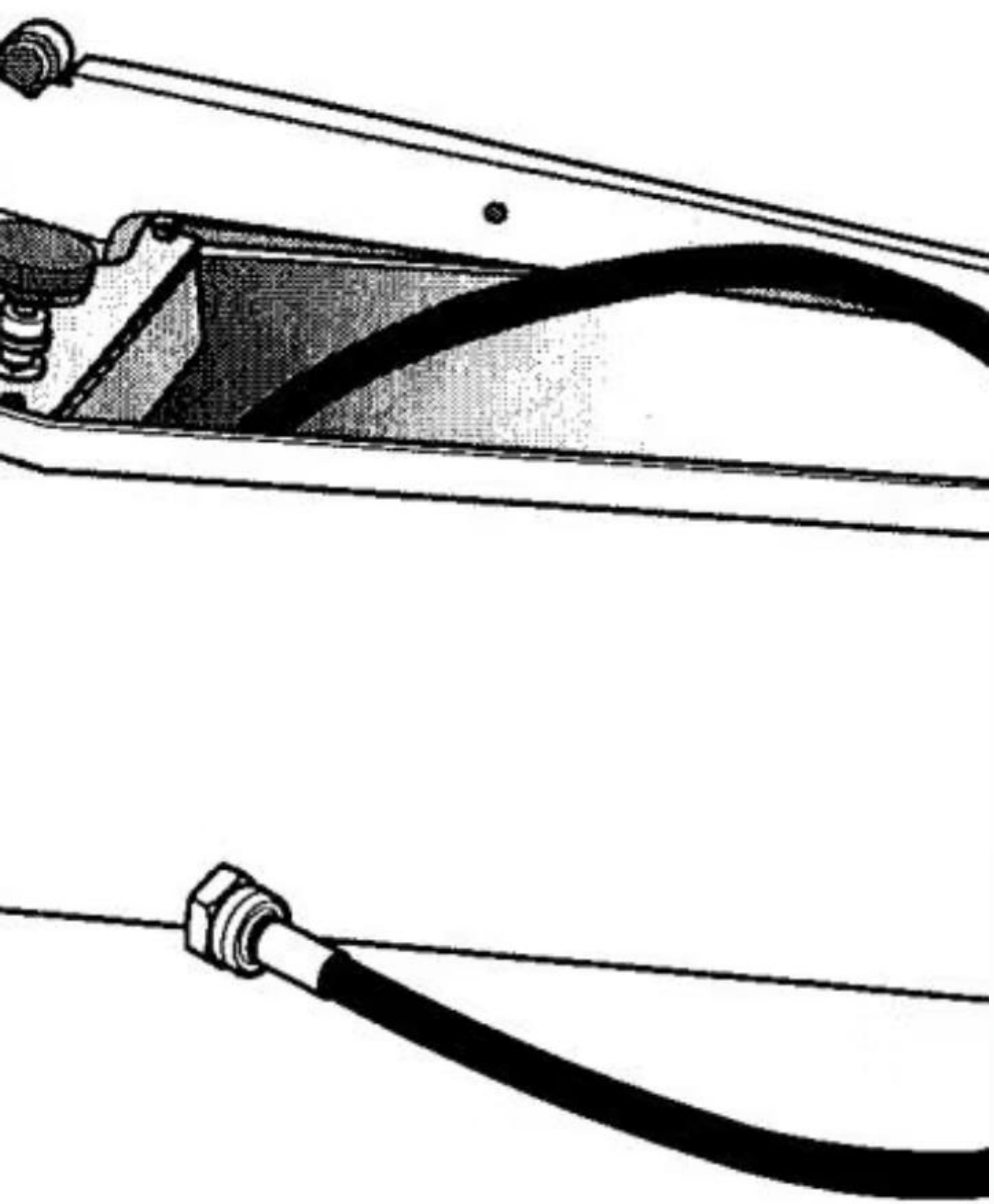


Figure 2-2
Pressure test pump

CSA B149.1 Table 6.3 - Pressure Test Requirements

Test Pressure Factors

Test pressure requirements vary based on pipe diameter, length, and system type

Test Duration

Test durations range from 15 minutes to 180 minutes depending on system specifications

Special Requirements

Wrapped and factory-coated piping systems have specific test pressure requirements

Leak Detection Process

Identify Pressure Drop

If a drop-in pressure in the system indicates a leak, you will need to do a "soap test" to locate the source of the leak

Apply Leak Detector Solution

Wipe each joint or fitting in the suspect portion of the system with the leak detector solution (soap and water)

Observe for Bubbles

A leak will cause the solution to form bubbles at its source

Testing After Installation of Appliances

Visual Inspection

After the installation of appliances, check the system visually to ensure there are no openings in the system from which gas could escape

Calibrated Equipment

You must calibrate the manometer or pressure gauge that you used for this test in 1 in w.c. (250 kPa) increments or less

Follow Procedure

Perform the pressure test according to the specified steps

Post-Appliance Installation Test Procedure

Shut Off Appliances

Shut off the appliances and install a manometer or pressure gauge at the gas meter outlet

Introduce Gas

Introduce gas into the system, listen for the gas flow to stop, and monitor the gas meter test dial to ensure that no gas is escaping

Turn Off Meter Valve

Turn off the meter valve. The system contains the gas under pressure

Monitor Pressure

Maintain the gas pressure indicated on the manometer or pressure test gauge for a minimum of 10 minutes

Final Leak Test

Upon successfully completing the test, perform a leak test on all untested control valves and appliance piping using soap solution under normal operating pressure

Checking for Shut-Off Valve Seepage

Purpose

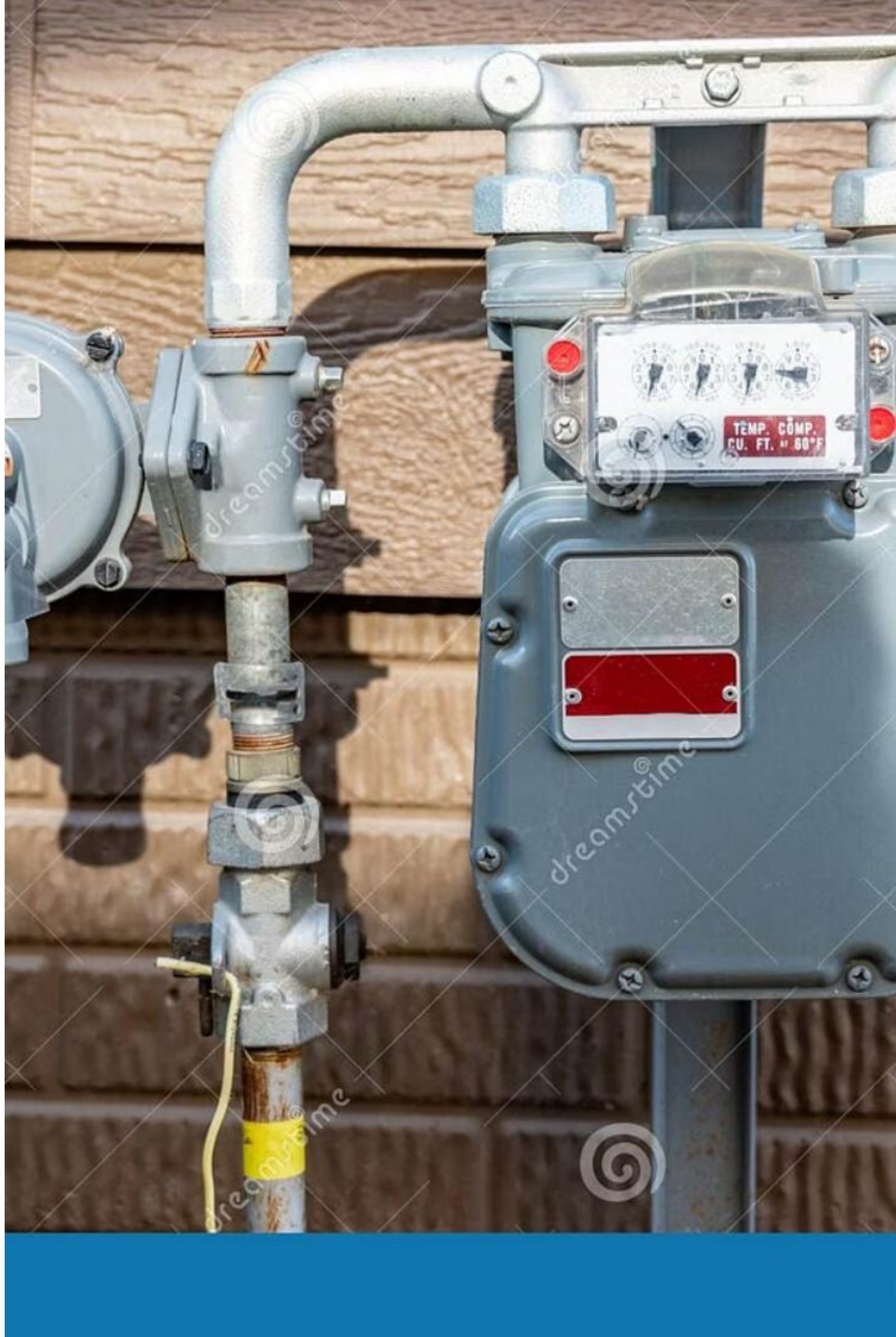
Perform this test to ensure that gas seepage from the meter valve is not masking any undetected gas leaks

Valve Seepage Issue

A gas meter valve may sometimes seep gas if its sealing grease becomes dry and hardened

Test Validity

If the valve passes gas in this way, the system test will not be accurate and results will be invalid



Shut-Off Valve Seepage Test Procedure

Create Static Pressure

When the system is brought to a static pressure condition, release a small amount of the contained gas pressure

Quick Release Method

Quickly remove, then replace, the manometer or pressure gauge tubing

Test Service Regulator

This action opens the service regulator, allowing the testing of the system back to the gas meter shut-off valve

Observe Pressure

If, after this action, the gas pressure increases slowly to static pressure, the meter valve is seeping gas and should undergo servicing before testing proceeds

Propane System Testing Overview

Two-Stage Testing

Propane system testing is also in two stages:

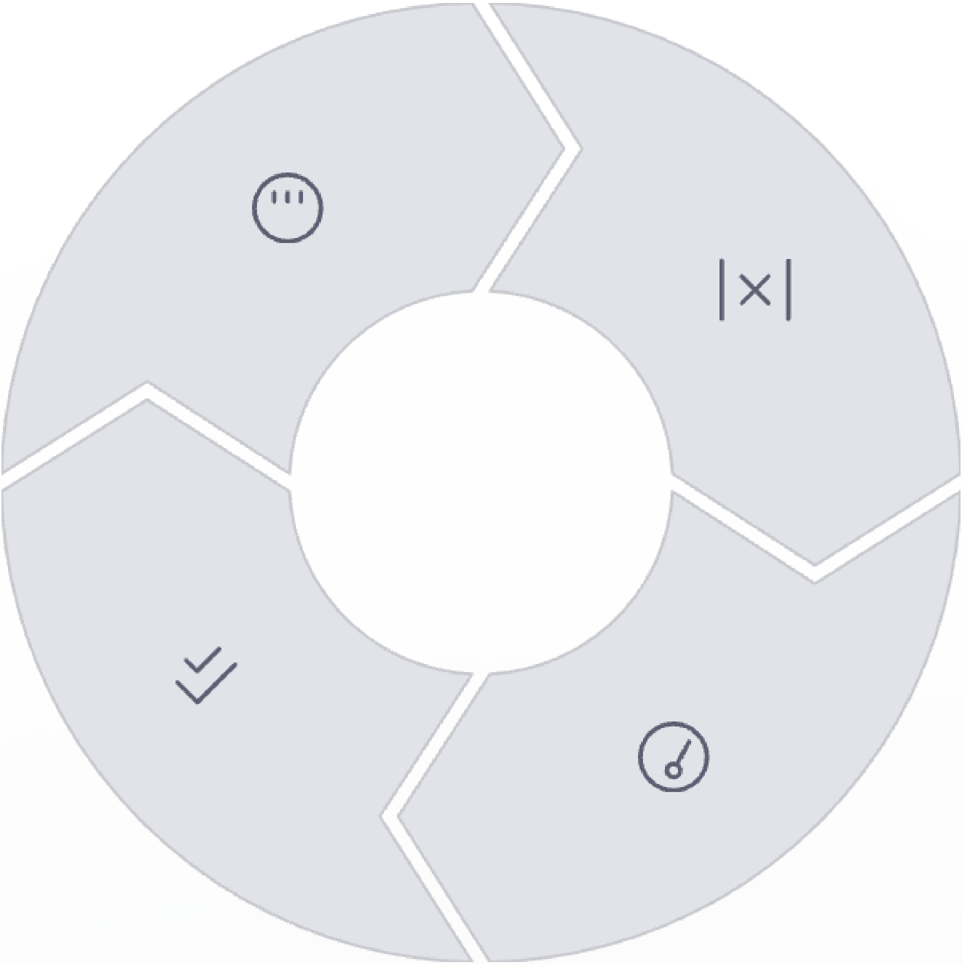
1. Before the installation of appliances
2. After installation of appliances

Before Appliance Installation

This is the same procedure as for natural gas.

Refer to Testing before installation of appliances section.

Propane System Testing After Appliance Installation



With Meter

If a meter is installed on the propane system, this test follows the same procedure as natural gas

Without Meter

If no meter is installed, perform a main manual shut-off valve seepage test

Pressure Testing

Place a pressure gauge on the system according to CSA B149.1 requirements

System Verification

Pressurize the system and observe for leakage

Two-Stage Propane System Testing

Place Pressure Gauges

Place another pressure gauge on the second stage. You can use a manometer in place of a pressure gauge on low-pressure systems

Seepage Test

Perform a seepage test on the manual shut-off valve at the second-stage regulator

Pressurize System

Pressurize the system by opening the manual valves on each stage

Close Valves

When the system is up to pressure, close the manual valves

Monitor Pressure

Mark the pressure gauges and observe for leakage

Propane System Leak Detection

Identify Pressure Drop

If a drop in pressure in the system indicates a leak

Apply Soap Solution

Wipe each joint or fitting in the suspect portion of the system with the leak detector solution (soap and water)

Locate Leak Source

A leak will cause the solution to form bubbles at its source

Documenting Test Results

Jurisdictional Requirements

In some jurisdictions, the gas technician/fitter is required to attach a test tag to the system in a prominent position after completing testing on a natural gas or propane system

Tag Placement

The tag must be attached in a prominent position where it can be easily seen

Permanent Record

The test tag serves as a permanent record of the testing performed on the system

Test Tag Required Information

Location Information

Address of test

Contractor Details

Contractor's name

Contractor's registration number

Test Information

Date of test

Test pressure

Test duration

System Specifications

Total pipe length

Pipe size

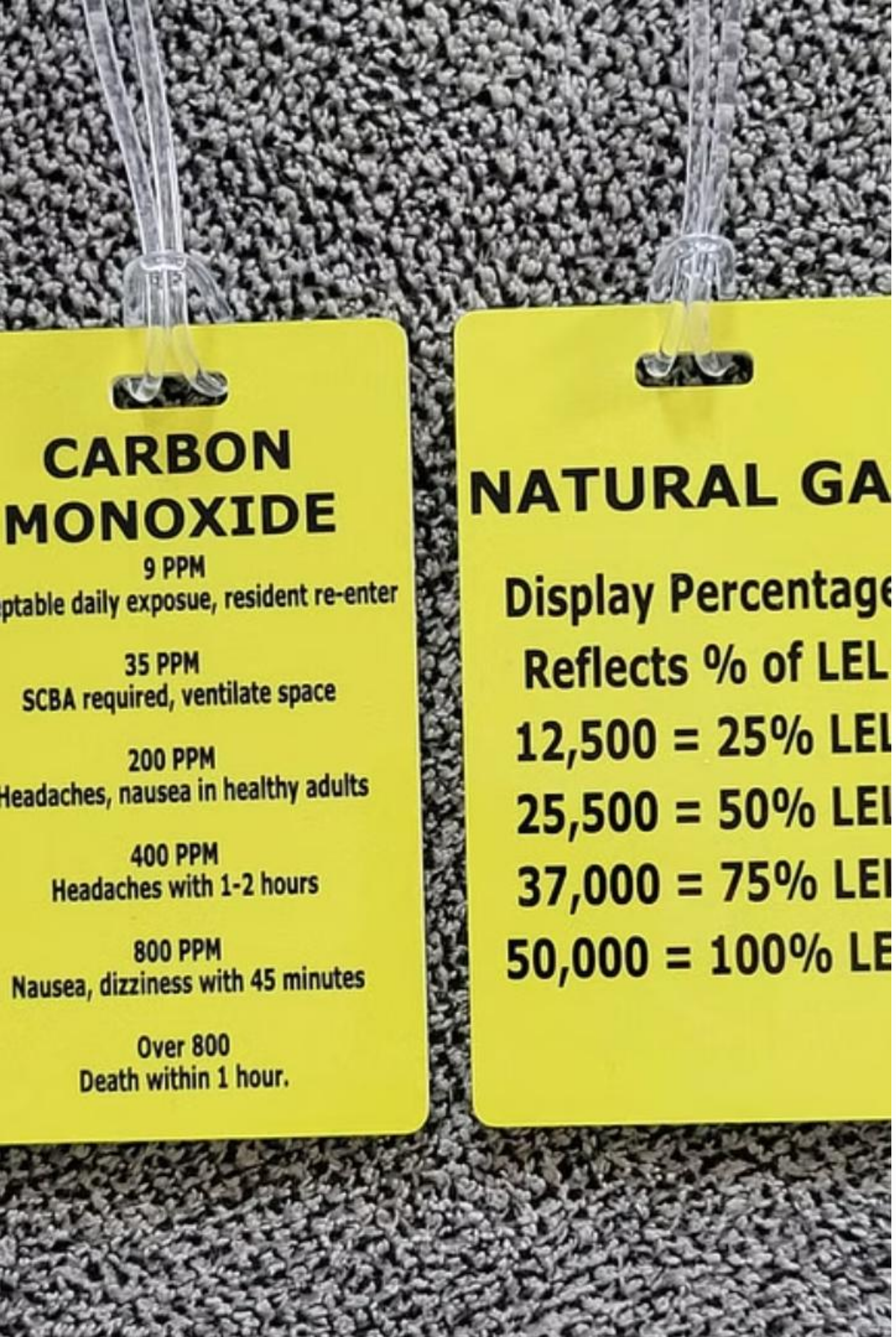
Technician Information

Fitter's name

Fitter's certificate number and classification

Warning

Statement "DO NOT REMOVE"



Sample Test Tag Layout

ADDRESS OF TEST	[Address field]
MANDATORY PRESSURE TEST	
CONTRACTOR'S NAME	[Name field]
CONTRACTOR'S PHONE #	[Phone field]
CONTRACTOR'S REGISTRATION #	[Registration field]
PRESSURE TEST INFORMATION	
DATE OF TEST	[Date field]
SYSTEM WORKING PRESSURE	[Pressure field]
TOTAL PIPE/TUBING LENGTH	[Length field]
PIPE/TUBING SIZE	[Size field]
TEST PRESSURE	[Pressure field]
TEST TIME	[Time field] MIN/HRS
GAS FITTER'S NAME	[Name field]
CERTIFICATE NUMBER & CLASSIFICATION	[Certificate field]
DO NOT REMOVE	

Test Tag Placement

Accessible Location

Attach this tag to piping, tubing or appliance in a readily accessible location

Protected Position

The tag should be protected from the environment

Visibility

Place in a location where it can be easily seen during future inspections

Importance of Proper Documentation

Legal Compliance

Proper documentation demonstrates compliance with applicable codes and regulations

- Provides evidence of proper testing
- Shows adherence to required procedures
- Meets jurisdictional requirements

Safety Record

Documentation creates a permanent record of safety verification

- Confirms system was tested properly
- Verifies no leaks were present
- Shows system was operating safely at installation

Future Reference

Test tags provide valuable information for future service technicians

- Shows original system specifications
- Provides baseline test information
- Helps with troubleshooting issues

Pressure Test Equipment Overview

Pressure Gauges

Used to measure system pressure during testing

Manometers

Used for low-pressure measurements in water column increments

Caps and Plugs

Used to seal system openings during testing

Leak Detection Solution

Soap and water mixture for locating leaks

Pressure Gauge Selection Criteria

Size Requirements

Minimum 3 in (75 mm) diameter for proper readability

Range Selection

Maximum range must exceed test pressure by at least 15% but not more than 300%

Increment Requirements

Must have appropriate increments based on system working pressure

- For 0.5-5 psig: Not greater than 1 ounce (0.5 kPa)
- For >5 psig: Not greater than 2 psig (14 kPa) or 2% of maximum reading

Calibration

Must be properly calibrated for accurate readings

Manometer Usage for Low-Pressure Testing

What is a Manometer?

A manometer is a device that measures pressure differences by comparing the height of liquid columns

For gas systems, manometers are typically used for low-pressure measurements

When to Use a Manometer

Manometers are appropriate for:

- Testing after appliance installation
- Low-pressure propane systems
- When calibration in inches of water column (in w.c.) is needed

Calibration Requirements

For post-appliance installation testing, the manometer must be calibrated in 1 in w.c. (250 Pa) increments or less

Inert Gases for Pressure Testing

Air

Commonly used for testing gas piping systems

Readily available and cost-effective

No special handling requirements

Nitrogen

Inert gas commonly used for pressure testing

Non-flammable and non-reactive

Available in compressed gas cylinders

Carbon Dioxide

Another inert gas option for pressure testing

Non-flammable and relatively safe to handle

Available in compressed gas cylinders

Safety Considerations During Testing

Personal Protective Equipment

Wear appropriate PPE during testing procedures

No Ignition Sources

Ensure no ignition sources are present during testing

Pressure Limitations

Never exceed maximum pressure ratings of system components

Component Protection

Isolate or remove components with pressure ratings below test pressure

Proper Ventilation

Ensure adequate ventilation when working with gas systems

Common Testing Mistakes to Avoid

Incorrect Gauge Selection

Using a gauge with improper range or calibration

Insufficient Test Duration

Not maintaining test pressure for the required time period

Improper Test Pressure

Using incorrect test pressure for the system type

Temperature Effects

Failing to account for temperature changes during testing

Poor Documentation

Incomplete or inaccurate test tag information

Interpreting Pressure Test Results

Successful Test

A successful pressure test shows:

- No drop in pressure during the test period
- No visible or audible leaks
- No bubbles during soap testing

Failed Test

A failed pressure test may show:

- Gradual or sudden pressure drop
- Audible hissing from leaks
- Bubbles forming during soap testing
- Meter dial movement indicating gas flow

Inconclusive Results

Inconclusive results may be due to:

- Temperature fluctuations affecting pressure
- Valve seepage masking results
- Improper test setup or equipment

Temperature Effects on Pressure Testing

Temperature Increase

Rising temperatures can cause pressure to increase, potentially masking leaks

Temperature Decrease

Falling temperatures can cause pressure to decrease, potentially indicating a false leak

Documentation

Note temperature conditions at start and end of test

Stabilization Period

Allow system to reach thermal equilibrium before starting the test

Troubleshooting Failed Pressure Tests

Identify Pressure Drop

Confirm that a pressure drop is occurring during the test period

Isolate Sections

If possible, divide the system into sections to narrow down the leak location

Apply Leak Solution

Use soap and water solution on all joints and connections

Repair and Retest

Fix identified leaks and retest the entire system

Soap Testing Techniques

Prepare Solution

Mix soap and water to create a leak detection solution

Apply Thoroughly

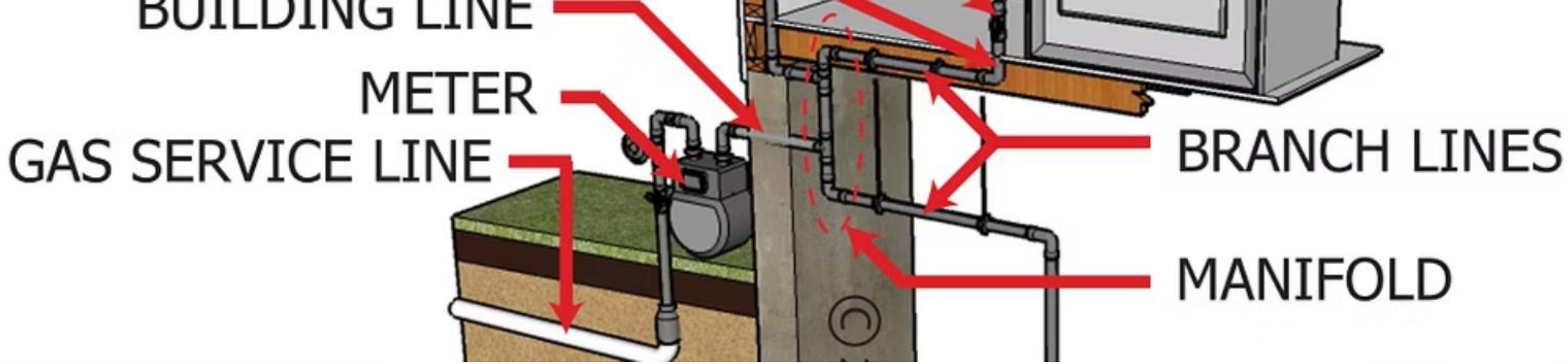
Wipe each joint or fitting in the suspect portion of the system with the solution

Observe Carefully

Watch for bubble formation, which indicates a leak at that location

Mark Leaks

Mark any locations where bubbles form for repair



Special Considerations for Concealed Piping

Test Before Concealment

Remember that you must inspect and test all piping and components to be concealed before you conceal them

Higher Test Pressure

Concealed piping may require higher test pressures as specified in codes

Longer Test Duration

Concealed piping often requires longer test durations to ensure integrity

Documentation

Thoroughly document all testing of concealed piping before walls or ceilings are closed

Testing Requirements for Different Pipe Materials

Pipe Material	Special Testing Considerations
Steel Pipe	Standard testing procedures apply
Copper Tubing	May have different pressure requirements based on size
CSST (Corrugated Stainless Steel Tubing)	Follow manufacturer's specific testing instructions
Wrapped/Factory-Coated Piping	Minimum 100 psig (700 kPa) test pressure required

Special Requirements for Wrapped Piping

1. **Higher Test Pressure**

   All wrapped and/or factory-coated piping and tubing systems (except for CSST and copper) of all sizes and lengths shall be tested at a minimum pressure of 100 psig (700 kPa)

2. **Duration Requirements**

   Test duration must follow the requirements in CSA B149.1 Table 6.3

3. **Visual Inspection**

   Carefully inspect wrapping for damage before testing

4. **Documentation**

   Note the type of wrapping or coating on the test tag

Testing Long Pipe Runs

Length Considerations

Pipe or tubing runs longer than 200 ft (60 m) have special testing requirements:

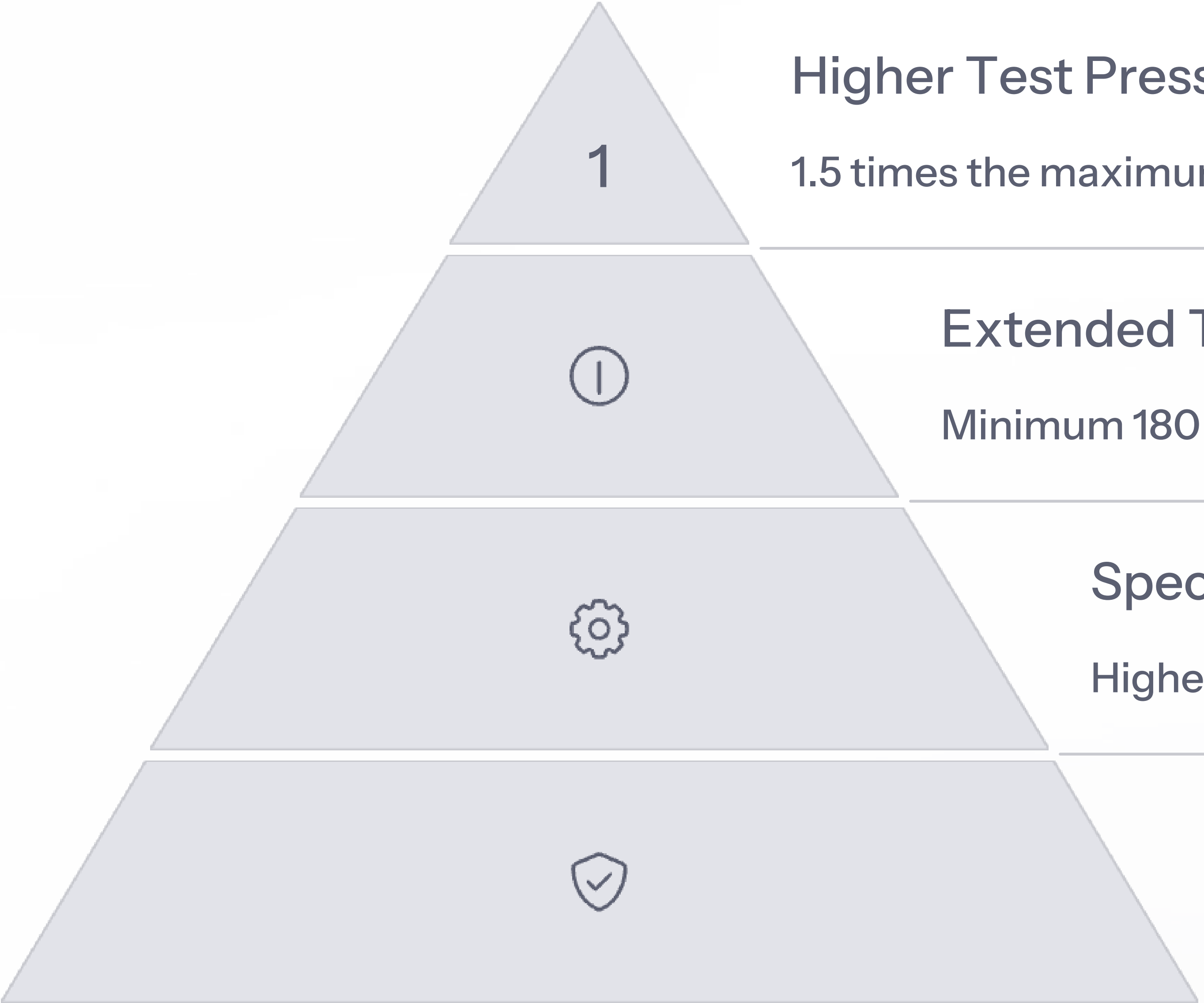
- Higher test pressures may be required
- Longer test durations are typically necessary
- More careful monitoring for pressure drops

Test Pressure Requirements

For pipe runs more than 200 ft (60 m):

- Minimum test pressure of 50 psig (340 kPa)
- Test duration of 180 minutes (3 hours)
- May require sectional testing for easier leak detection

High-Pressure System Testing



Higher Test Pressures

1.5 times the maximum operating pressure

Extended Test Duration

Minimum 180 minutes (3 hours)

Specialized Equipment

Higher-rated gauges and fittings required

Enhanced Safety Measures

Additional precautions for high-pressure testing

Propane Maximum Operating Pressure Definitions

Container Pressure

250 psi (1725 kPa) for piping and tubing operating at container pressure

Pump/Compressor Output

350 psi (2400 kPa) when connected to the outlet of a pump or compressor

Liquid Propane Lines

375 psi (2570 kPa) minimum or the hydrostatic of the relief valve in piping that can contain liquid propane, that can be isolated by valves, and that requires hydrostatic relief valves

Additional Testing Considerations

Minimum Requirements

These test pressures and test durations are minimum requirements. Circumstances can require test pressures and test durations in excess of those shown in the Table

Local Regulations

Always check local regulations which may have additional or more stringent requirements

Manufacturer Specifications

Follow any specific testing requirements from pipe or equipment manufacturers

System Complexity

More complex systems may require additional testing procedures

Testing Equipment Maintenance

Regular Calibration

Ensure pressure gauges and manometers are calibrated regularly

Pre-Test Verification

Verify equipment is functioning properly before each use

Proper Storage

Store equipment in appropriate conditions to prevent damage

Proper Cleaning

Keep equipment clean and free from debris

Record Keeping Best Practices

Test Tag Information

Ensure all test tags include:

- Complete address information
- Accurate contractor details
- Precise test specifications
- Technician certification information

Additional Documentation

Beyond the test tag, maintain:

- Detailed test logs
- System diagrams showing test points
- Photos of completed installations
- Notes about any issues encountered

Record Retention

Keep records according to:

- Local code requirements
- Company policies
- Warranty periods
- Liability considerations

Regulatory Compliance Overview

National Codes

CSA B149.1 and other national standards

Provincial/State Regulations

Regional adaptations of national codes

Local Requirements

Municipal or utility-specific regulations

Permit Requirements

Documentation needed for inspection approval

CSA B149.1 Code Structure

Code Organization

The CSA B149.1 code is organized into sections covering different aspects of gas installations

Section 6

Contains requirements for piping and tubing systems, including testing requirements

Clause 6.22

Specifically addresses testing requirements for gas piping systems

Table 6.3

Provides detailed pressure test requirements based on pipe diameter and length

Staying Current with Code Changes

Regular Training

Attend code update training sessions offered by industry associations

Subscribe to Updates

Sign up for notifications from code-making bodies about revisions

Industry Publications

Read trade magazines and newsletters that highlight code changes

Peer Networks

Participate in professional networks to discuss code interpretations

Testing Tools and Equipment Checklist

Pressure Gauges

Various ranges for different test pressures

Manometers

For low-pressure testing applications

Pressure Sources

Air pump or inert gas cylinders

Fittings and Adapters

For connecting test equipment to piping

Leak Detection Solution

Soap and water or commercial solutions

Test Tags

For documenting test results

Technician Certification Requirements

Certification Levels

Gas technicians/fitters typically have different certification levels that determine what work they can perform:

- Apprentice/trainee level
- Journeyman level
- Master level

Testing Authorization

Certification requirements for performing pressure tests:

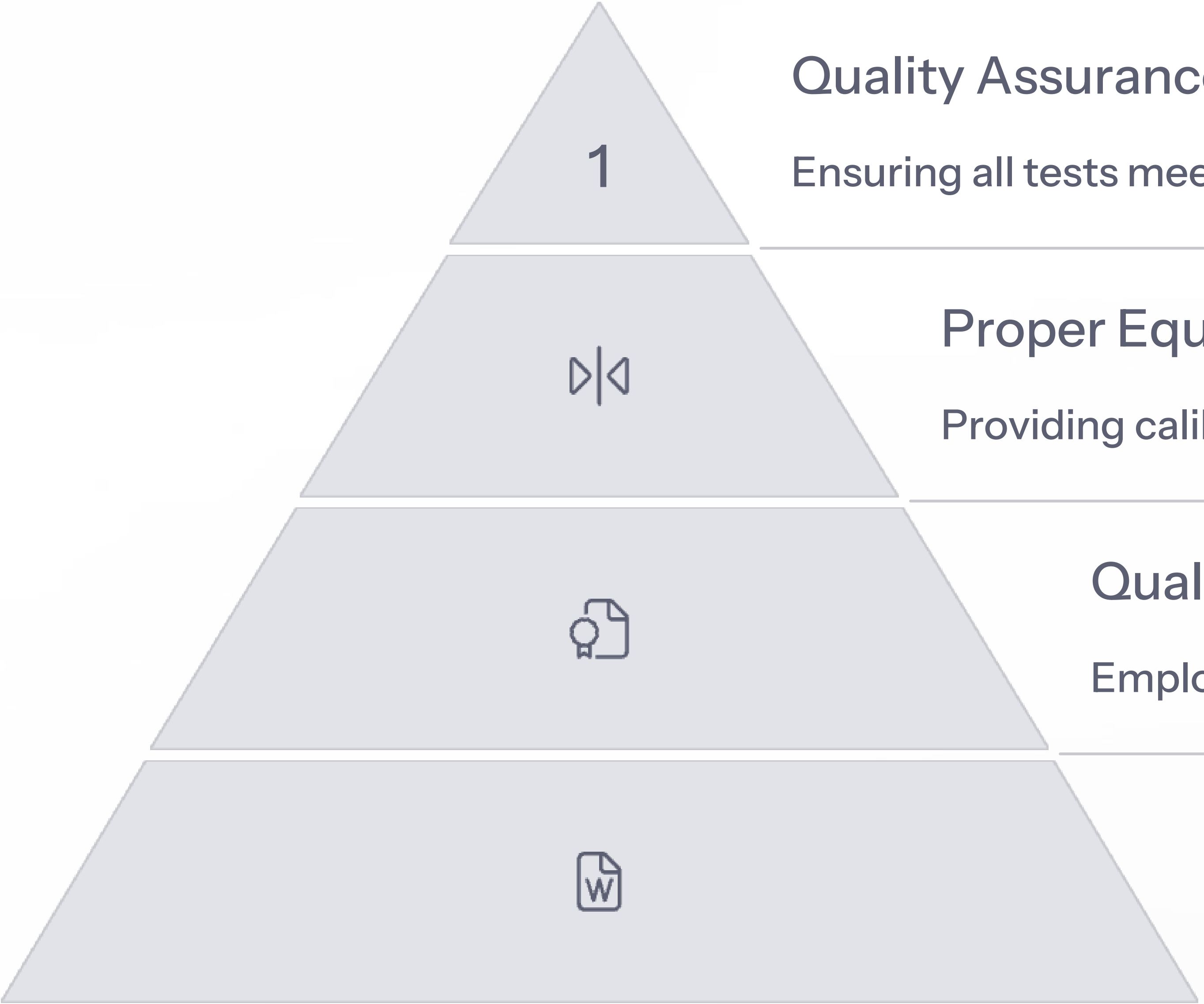
- Must have appropriate level certification
- Must understand testing procedures
- Must be familiar with applicable codes

Documentation Authority

Requirements for completing test tags:

- Must include certificate number
- Must include classification level
- Must sign off on completed tests

Contractor Responsibilities



Quality Assurance

Ensuring all tests meet code requirements

Proper Equipment

Providing calibrated testing equipment

Qualified Personnel

Employing properly certified technicians

Documentation

Maintaining complete testing records

Customer Communication

Explain Testing Process

Clearly communicate to customers what testing will be performed and why it's necessary

Scheduling Considerations

Inform customers about the time required for proper testing

Sharing Results

Provide customers with information about test results and what they mean

Documentation

Explain the importance of the test tag and why it should not be removed

Testing in Existing Buildings

System Isolation

May need to isolate sections of existing systems for testing

Occupant Notification

Inform building occupants about gas service interruptions

Older Systems

May require special considerations for older materials and components

Accessibility Challenges

Some system components may be difficult to access in existing structures

Testing After Repairs or Modifications

Repair Completion

After completing repairs or modifications to a gas system

Retest Requirements

The affected portion of the system must be retested according to code

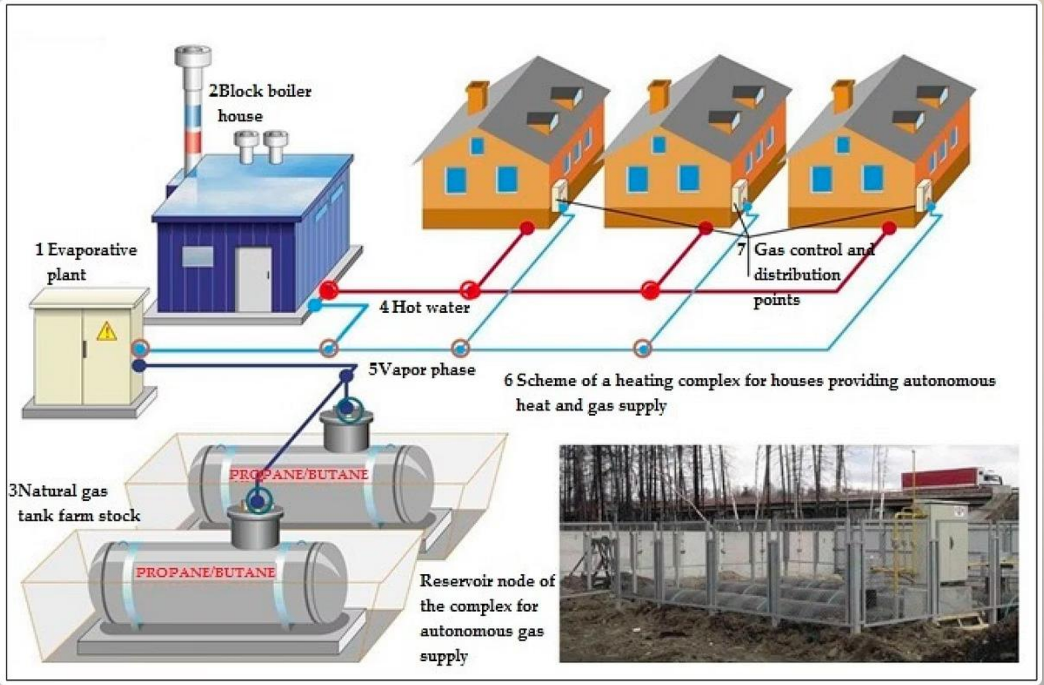
Documentation Update

A new test tag must be completed with current information

4

System Verification

Ensure the entire system is operating safely after repairs



Emergency Procedures for Leak Detection

Immediate Action

If a significant leak is detected during testing, take immediate action

Ventilation

Ensure the area is well-ventilated to prevent gas accumulation

Isolation

Shut off the gas supply to the affected section or entire system

Notification

Inform building occupants and/or gas utility if necessary

Repair

Address the leak before resuming normal operation

Summary of Testing Requirements

Visual Inspection

Inspect all components before pressure testing

Pre-Appliance Testing

Test piping system before connecting appliances

Post-Appliance Testing

Test complete system after appliance installation

Documentation

Complete test tag with all required information

CSA Unit 8

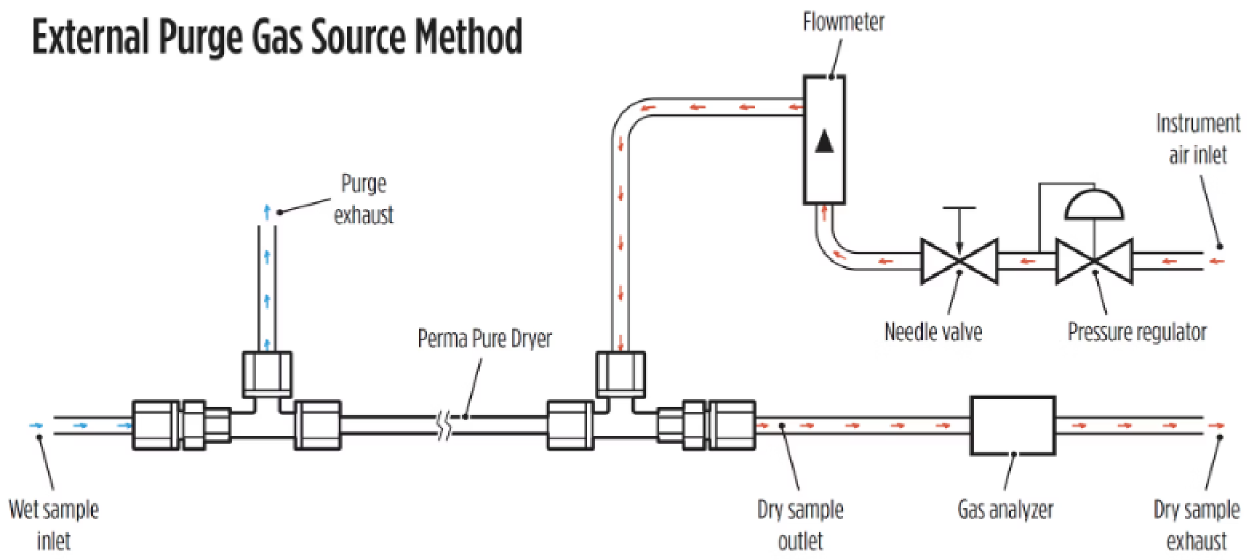
Chapter 3
Purging a Gas System: Safety and Procedures

A comprehensive guide for gas technicians and fitters on how to properly purge gas piping systems in accordance with applicable codes to prevent combustible air/gas mixtures and ensure air-free gas delivery to appliances.

Purpose and Objectives

Purpose

A gas technician/fitter must know how to properly purge a gas piping system in accordance with applicable codes to prevent a buildup of combustible air/gas mixtures and ensure that the pinng/ tubing system delivers air-free gas to the appliances.



Learning Objectives

Refer to Code Requirements

Understand and apply Code requirements related to purging gas systems

Identify Purge Points

Correctly identify appropriate locations for purge points in gas systems

Differentiate Gas Types

Describe differences in purging natural gas and propane systems

Key Terminology

Branch line

Part of a piping or tubing system that conveys gas from the main piping or tubing or header to an appliance(s)

Purge

To replace the existing fluid (gaseous or liquid) in piping, tubing, equipment, a container, or an appliance with a desired fluid

Purge burner

Burner equipped with a constant ignition source and a flame arrestor intended to burn the escaping (discharged) gas during purging operations

Specific gravity

Ratio of the density of the gas to the density of the air at a specified temperature and pressure

Purging Requirements Overview

After successfully completing pressure and leak tests, you must purge the gas system. Purging consists of forcing air out of the system with gas under pressure. It is important to begin and perform purging at the proper locations to ensure the complete system is purged.

Clause 6 of CSA B149.1 covers purging requirements and procedures.

Incorrect purging methods and shortcuts have led to numerous leaks, fires, and even explosions. It is imperative that gas technicians have louts hare four even explosion in the skills. It is imperative that gas technicians/fitters maintain safe and approved purging meth work conducted.

Purge Points and Procedures

Start at the Farthest Point

Purging should begin at the appliance farthest from the source of supply.

Purge Branch Lines

Purging of branch lines then follows one by one at a location farthest from the source on supply.

Complete Individual Lines

Furging lines includual branch line.

Clause 6.23 of CSA B149.1 lists a number of different options for purging natural gas and propane piping and tubing systems. You should review these options to ensure that you use the most suitable method for the type of installation at hand.

Incorrect purging procedures have led to gas leaks, fires, and in rare cases, explosions.

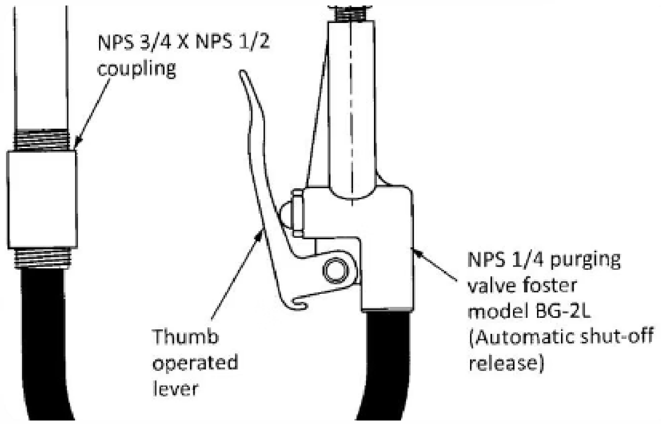
Code-Recognized Purging Techniques

Purging technique	Description
Use a hose to the outdoors	This involves a long tubing terminating outside away from air intakes and sources of ignition with a valve and a gas technician/fitter at the outside location.
Use a burner	You use a specially approved burner that connects to piping and has a propane-fired pilot light that flares off the gas/air mixture until a stable flame is established.
Use pilot tubing	On appliances equipped with a constant pilot, you can disconnect the tubing at the gas valve and purge it using the gas control valve knob. Appliances input must be less than 400,000 BTU.

Additional Purging Techniques

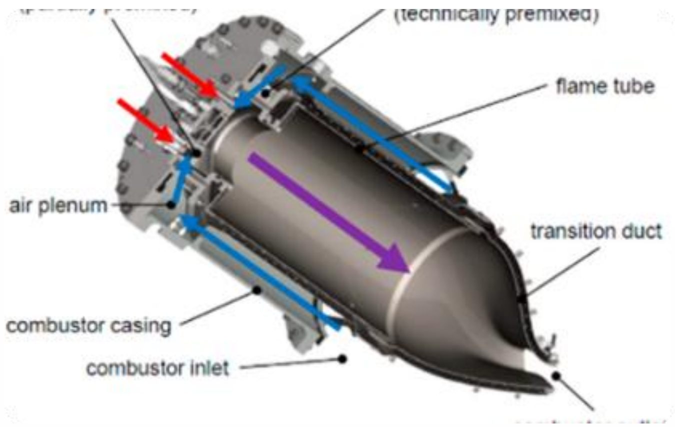
Purging technique	Description
Use a readily accessible burner	When an installation includes a gas range, you may purge the system piping at the top range burners with a match lit beside them until such time as a steady flame is established. Appliance input must be less than 400,000 BTU.
Use a purge tool	Annex H outlines the use of this approved assembly, which connects to the drip pocket and allows for purging indoors using the spring-loaded nozzle valve.

Approved Purge Assembly



Purge Assembly Components

The approved purge assembly connects to the drip pocket and allows for purging indoors using the spring-loaded nozzle valve.



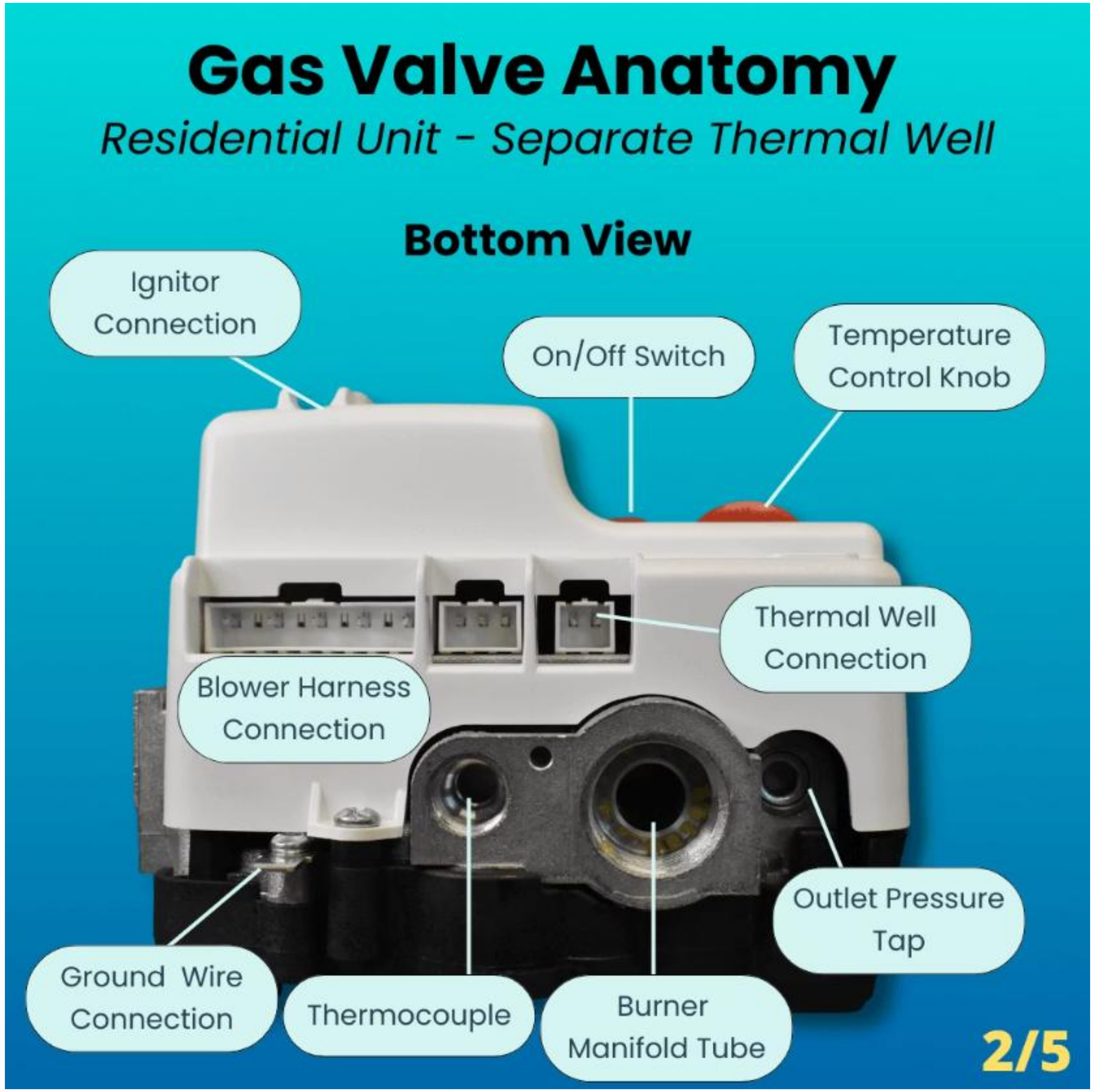
Practical Application

A gas technician using the purge assembly to safely purge a gas system according to code requirements.

Code Requirements for Purging

Clause 6.23 of CSA B149.1 titled "Purging of gas piping systems after leak testing," which also references Annex H of the Code, "Purging of piping and tubing systems where a readily accessible burner is not available or where an appliance is not equipped with a continuous pilot," lists purging requirements and procedures.

The gas technician/fitter should review and become familiar with these Code requirements.



Purging Large Diameter Piping

Identify Large Piping

CSA B149.1 outlines how you must first purge piping of 4 in or greater

Use Inert Gas First

If the test gas was air, purge with nitrogen or carbon dioxide to neutralize the interior of the piping prior to the purging procedure

Reduce Risk

This helps reduce the risk of a gas/air mixture existing inside the piping and finding a source of ignition that may flash back

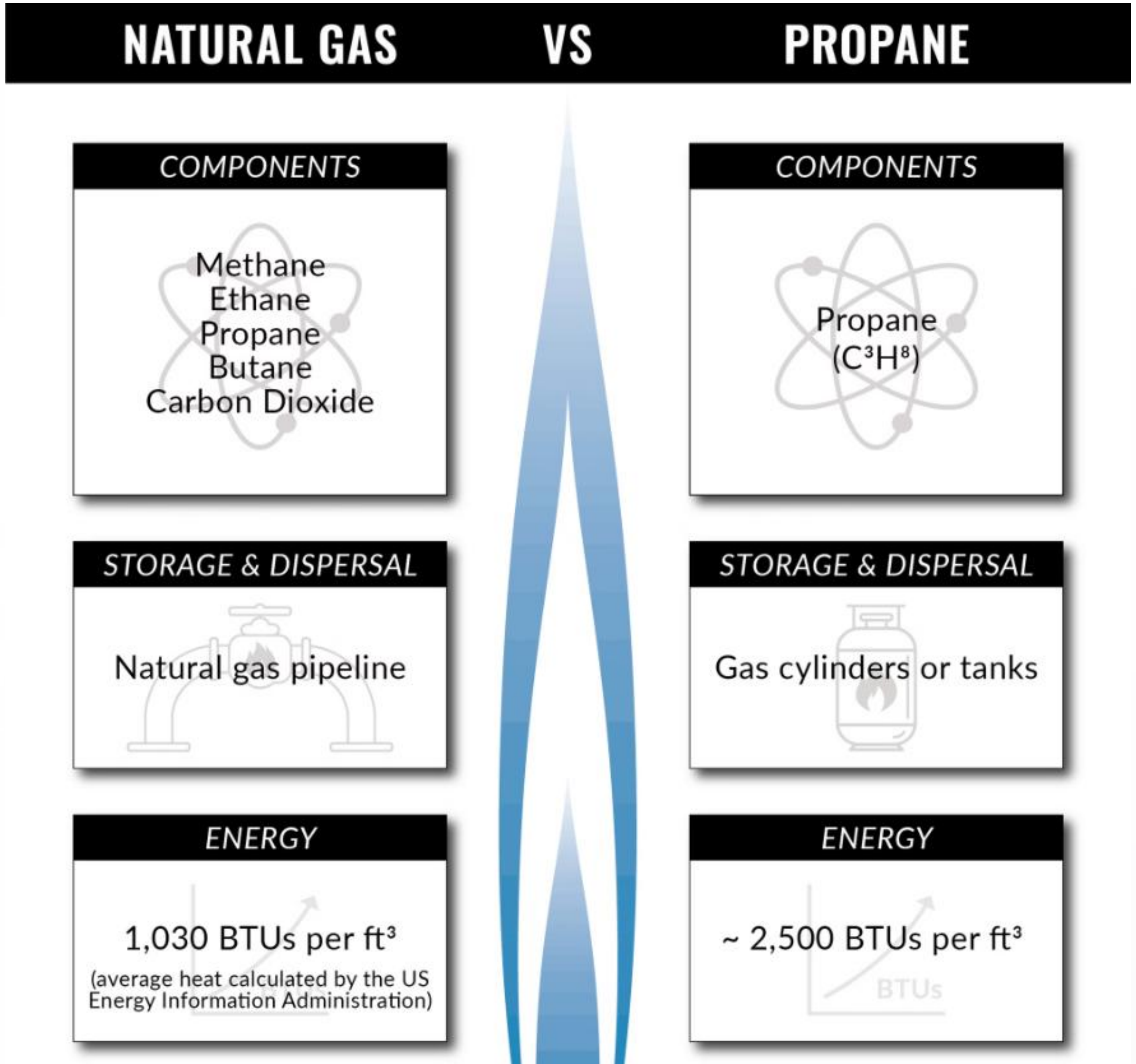
Purge Outdoors

You should always purge piping of this diameter to the outdoors in order to minimize the amount of gas buildup inside the building

Natural Gas vs. Propane: Key Differences

Main Differences

With respect to purging, the main differences to be aware of between natural gas and propane are their upper and lower explosive limits and their specific gravities.



Why These Differences Matter

These differences affect how the gases behave during purging operations and what safety precautions must be taken for each type of gas.

Understanding these differences is crucial for safe and effective purging procedures.

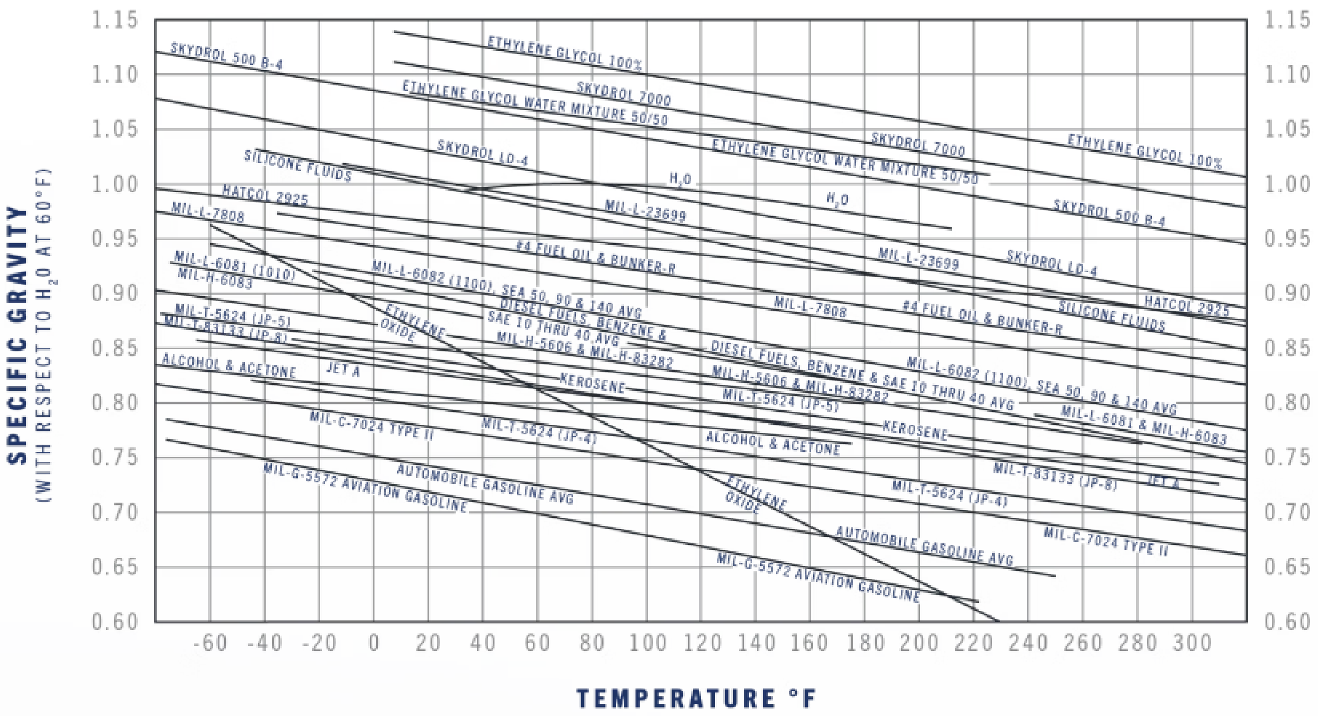
Explosive Limits of Gases

Gas	Approximate explosive limits	Explosion risk
Natural gas	Range from 4% to 15% natural gas in air	Concentrations above or below these limits lessen the risk of explosion.
Propane	Range from 2% to 10% propane in air	Narrower range than natural gas, requiring more careful purging.

Specific Gravity of Gases

Air has a specific gravity of 1.0. If a fuel's specific gravity:

- is lower than 1.0, the less dense or lighter the gas; and
- is higher than 1.0, the denser or heavier the gas.



Natural Gas Properties

Specific Gravity: 0.60

Natural gas is lighter than air (air = 1.0)

Rises in Air

Because its specific gravity is lower than that of air, natural gas is lighter than air and will rise above it in a confined space

Natural Venting

This quality of natural gas allows it to vent naturally to atmosphere when there is a path for it to do so

Propane Properties

Specific Gravity: 1.5

Propane is heavier than air (air = 1.0)

Sinks in Air

Because it is heavier than air, propane will collect in the lower areas of confined spaces

Explosion Hazard

This property of propane can create a dangerous explosion hazard if it occurs in an area where there is the possibility of the propane coming into contact with a source of ignition

Propane Purging Safety Considerations

Pools in Low Areas

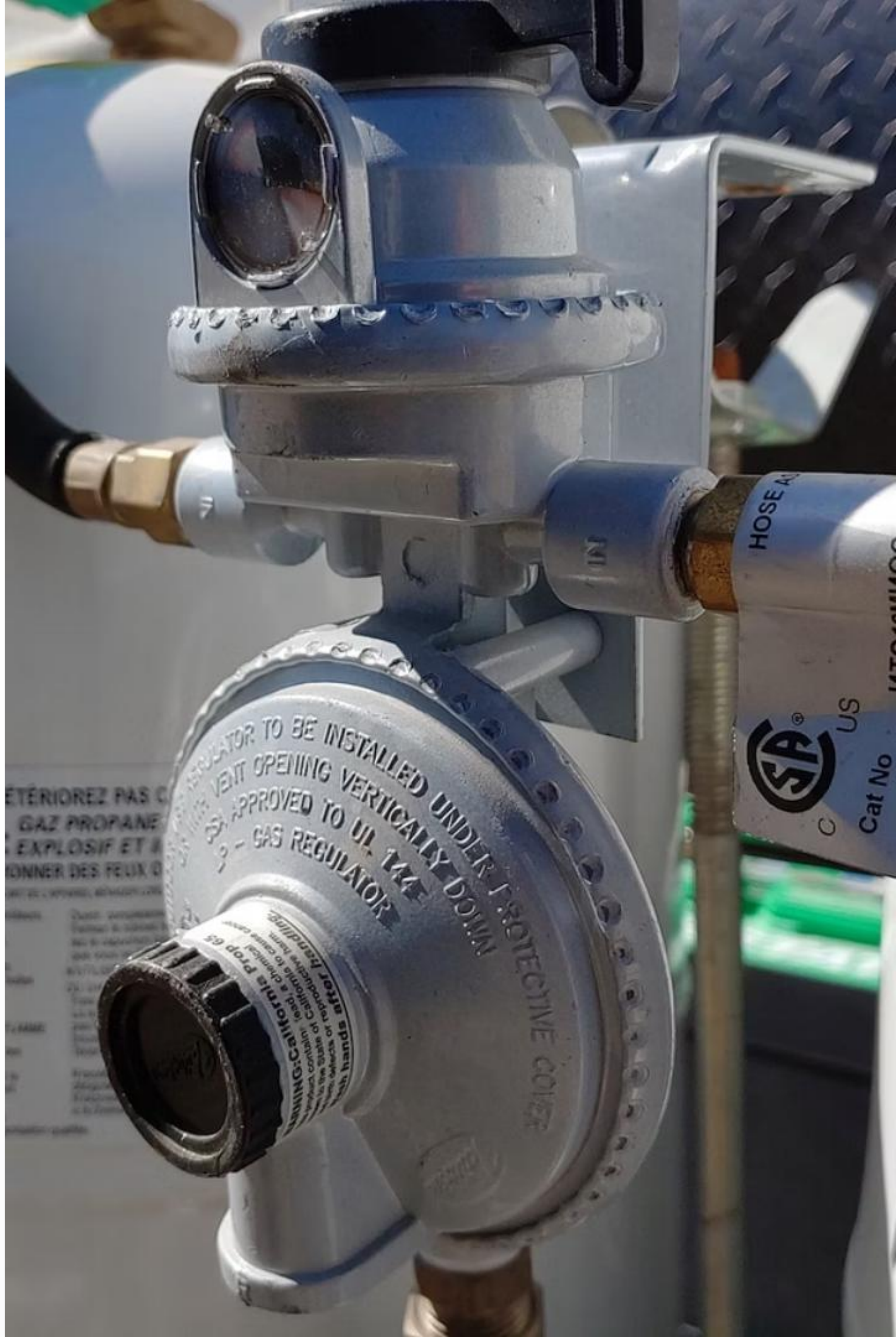
A heavier-than-air fuel, such as propane, pools and collects in low-lying areas and is more difficult to ventilate than natural gas

Flammable Mixture Risk

This creates the risk of a flammable mixture that is ready to ignite from any source of ignition

Outdoor Purging Recommended

It is always a safer procedure to utilize a purge hose to the outdoors in accordance with Code guidelines when purging propane gas piping systems



Pressure Testing Timing

Installation

Complete piping installation

Pressure Test

Perform before any appliances are installed

Final Verification

Ensure system integrity before use

Leak Test

Required after appliance installation

When during a piping installation should pressure testing be carried out? Before any appliance is installed. A leak test is required after the appliance is installed.

Pressure Gauge Requirements

2

Minimum Diameter

The minimum diameter gauge that can be used for pressure testing is 2 inches (50 mm)

100

Pressure Range

Typical pressure gauge range in kPa for residential gas systems

Inert Gases for Pressure Testing

Carbon Dioxide (CO_2)

A colorless, odorless gas that is heavier than air and non-flammable, making it safe for pressure testing gas systems.

Nitrogen (N_2)

An inert gas that comprises about 78% of Earth's atmosphere. It's non-flammable and slightly lighter than air, making it ideal for pressure testing.

What two inert gases may be used to pressure-test gas piping systems? Carbon dioxide and Nitrogen.

Post-Valve Opening Procedure

Open Gas Valve

Open the gas valve at the gas meter

Listen for Flow

Listen for the gas flow to stop

Monitor Test Dial

Monitor the gas meter test dial

What should be done immediately after opening the gas valve at the gas meter? Listen for the gas flow to stop and monitor the gas meter test dial.

Leak Detection Methods

Leak Detecting Solution

By wiping each joint in the system with a leak detecting solution (i.e., soap and water), technicians can identify leaks through the formation of bubbles at the leak point.

Meter Movement

Watching the meter for movement when all appliances are off can indicate a leak somewhere in the system.

Propane System Testing Steps

Place a pressure gauge on the system

First step in the testing process

Pressurize the system by opening the manual valves on each stage

Second step to build pressure in the system

When the system is up to pressure, close the manual valves

Third step to isolate the system

Mark the pressure gauges and observe for leakage

Fourth step to detect any pressure drops

Do a main manual shut-off valve seepage test

Final step to ensure valve integrity

Test Tag Information Requirements

Required Personal Information

Name, certification number, and classification.

Optional Information

Company name, contact details, and test date may also be included for reference.

Test Details

Test pressure, duration, and results should be documented on the tag.

Importance of Proper Purging

Safety Risks of Improper Purging

Incorrect purging methods and shortcuts have led to numerous leaks, fires, and even explosions. It is imperative that gas technicians have louts hare four even explosion in the skills.

It is imperative that gas technicians/fitters maintain safe and approved purging meth work conducted.

Consequences of improper purging can be catastrophic, resulting in property damage, injuries, or fatalities.

Purging Sequence Importance

Identify Farthest Appliance

Locate the appliance that is farthest from the gas source

Begin Purging

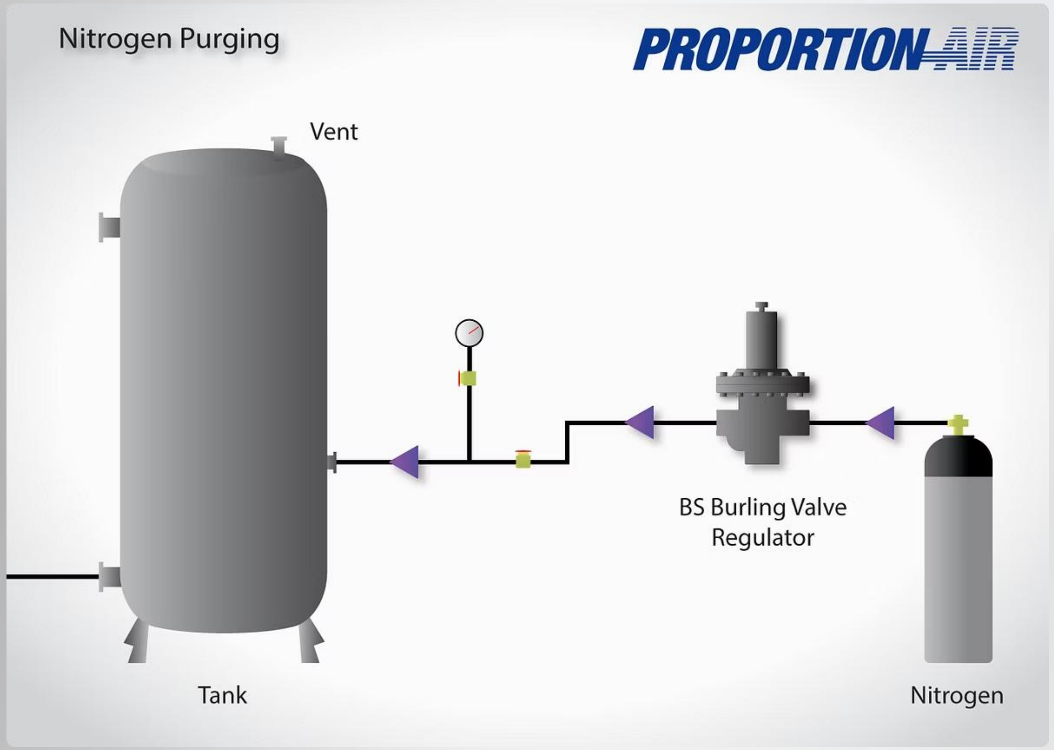
Start purging at this farthest point to ensure complete system purging

Move to Branch Lines

Purge branch lines one by one, starting with the farthest from the source

Complete Each Line

Ensure each branch line is fully purged before moving to the next



Outdoor Purging Method

Hose to Outdoors

This involves a long tubing terminating outside away from air intakes and sources of ignition with a valve and a gas technician/fitter at the outside location.

Safety Considerations

When purging outdoors, ensure the area is well-ventilated, free from ignition sources, and that the purge point is positioned to prevent gas from entering buildings through windows, doors, or air intakes.

Purge Burner Method

Specialized Equipment

You use a specially approved burner that connects to piping and has a propane-fired pilot light that flares off the gas/air mixture until a stable flame is established.

This method provides a controlled way to burn off the gas/air mixture during purging, reducing the risk of creating an explosive mixture in the surrounding area.

Pilot Tubing Purge Method

Identify Eligible Appliances

On appliances equipped with a constant pilot and input less than 400,000 BTU

Disconnect Tubing

Disconnect the tubing at the gas valve

Use Control Valve

Purge using the gas control valve knob

Range Burner Purge Method

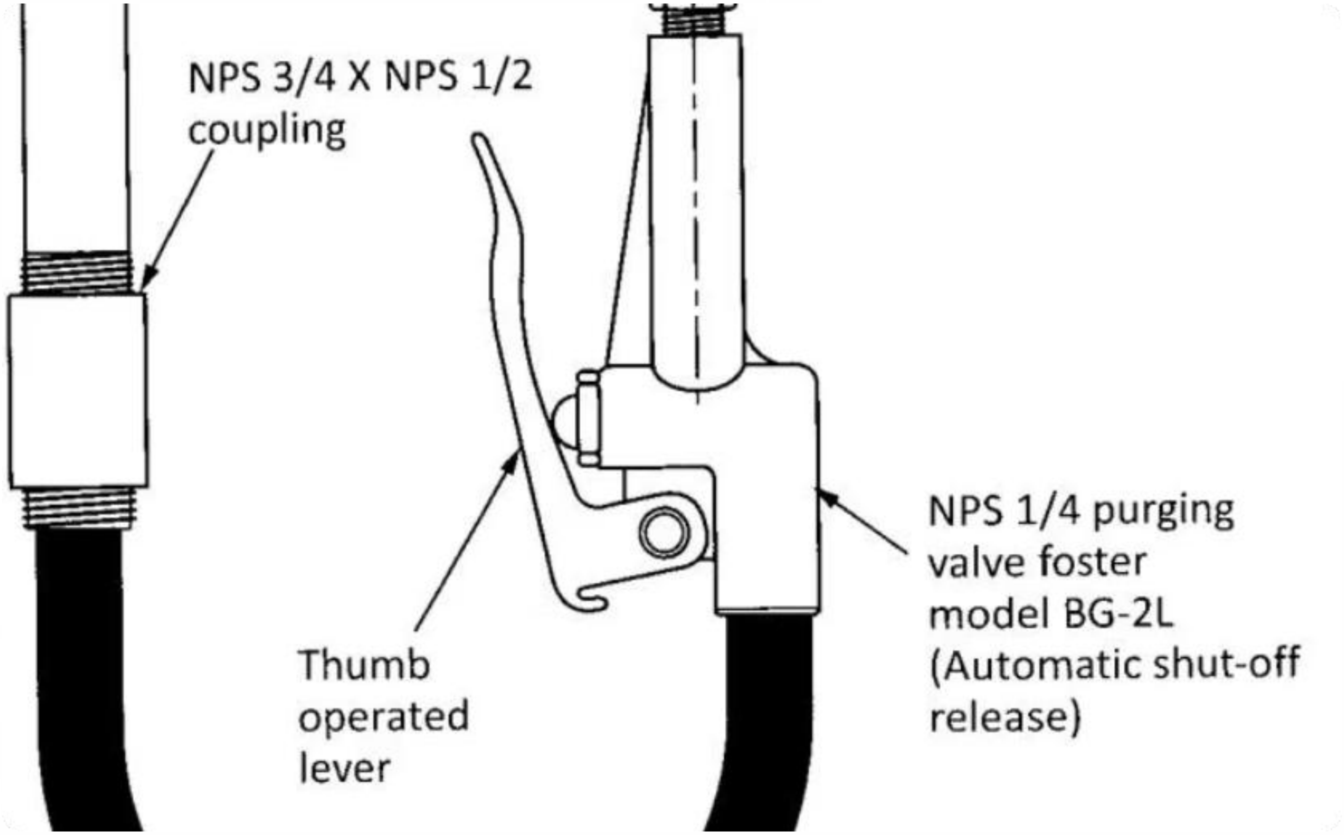
Applicable Scenarios

When an installation includes a gas range, you may purge the system piping at the top range burners with a match lit beside them until such time as a steady flame is established.

Input Limitation

Appliance input must be less than 400,000 BTU.

Purge Tool Method



Approved Assembly

Annex H outlines the use of this approved assembly, which connects to the drip pocket and allows for purging indoors using the spring-loaded nozzle valve.

Practical Application

The purge tool provides a controlled method for indoor purging when other methods are not feasible or available.

Code Reference for Purging

Clause 6.23 of CSA B149.1

"Purging of gas piping systems after leak testing"

Annex H of the Code

"Purging of piping and tubing systems where a readily accessible burner is not available or where an appliance is not equipped with a continuous pilot"

Technician Responsibility

The gas technician/fitter should review and become familiar with these Code requirements.

Large Diameter Piping Purge Process

Identify Large Piping

Piping of 4 in or greater diameter

Initial Purge with Inert Gas

If test gas was air, purge with nitrogen or carbon dioxide

Neutralize Interior

This neutralizes the interior of the piping prior to the gas purging procedure

Final Gas Purge

Complete the purging with the actual gas to be used

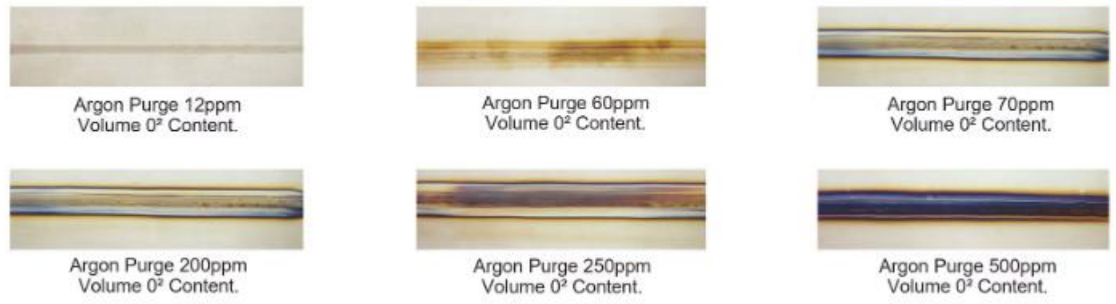
Risk Reduction in Large Pipe Purging

Flash Back Prevention

Using inert gas first helps reduce the risk of a gas/air mixture existing inside the piping and finding a source of ignition that may flash back.

Outdoor Purging Requirement

You should always purge piping of this diameter to the outdoors in order to minimize the amount of gas buildup inside the building.



Natural Gas Explosive Limits

4%	15%
Lower Explosive Limit	Upper Explosive Limit
Minimum concentration of natural gas in air that can ignite	Maximum concentration of natural gas in air that can ignite

Concentrations above or below these limits lessen the risk of explosion.

Propane Explosive Limits

2%

Lower Explosive Limit

Minimum concentration of propane in air that can ignite

10%

Upper Explosive Limit

Maximum concentration of propane in air that can ignite

Propane has a narrower explosive range than natural gas, requiring more careful purging procedures.

Understanding Specific Gravity

Natural Gas Behavior

Specific Gravity: 0.60

Because its specific gravity is lower than that of air, natural gas is lighter than air and will rise above it in a confined space.

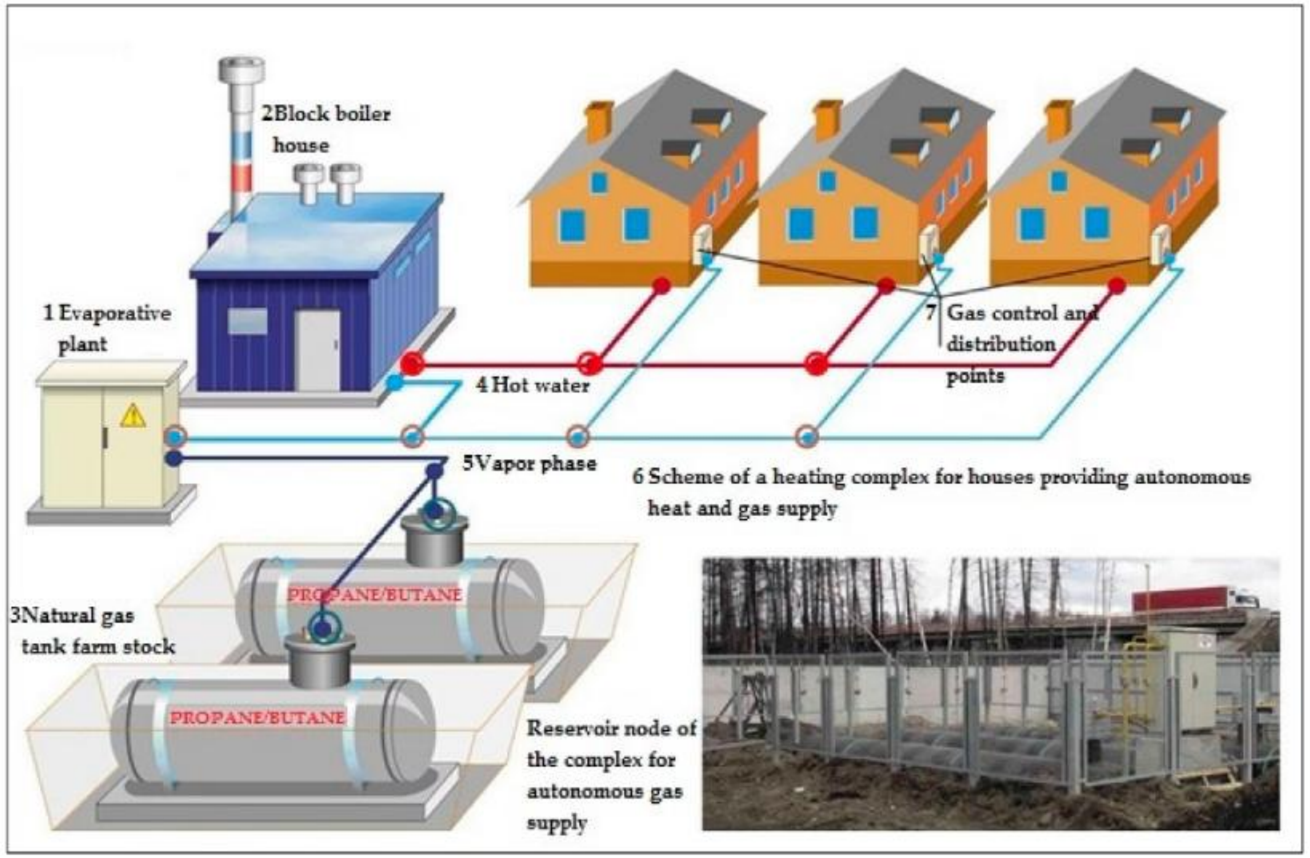
This quality of natural gas allows it to vent naturally to atmosphere when there is a path for it to do so.

Propane Behavior

Specific Gravity: 1.5

Because it is heavier than air, propane will collect in the lower areas of confined spaces.

This property of propane can create a dangerous explosion hazard if it occurs in an area where there is the possibility of the propane coming into contact with a source of ignition.



Propane Purging Safety

Pooling Behavior

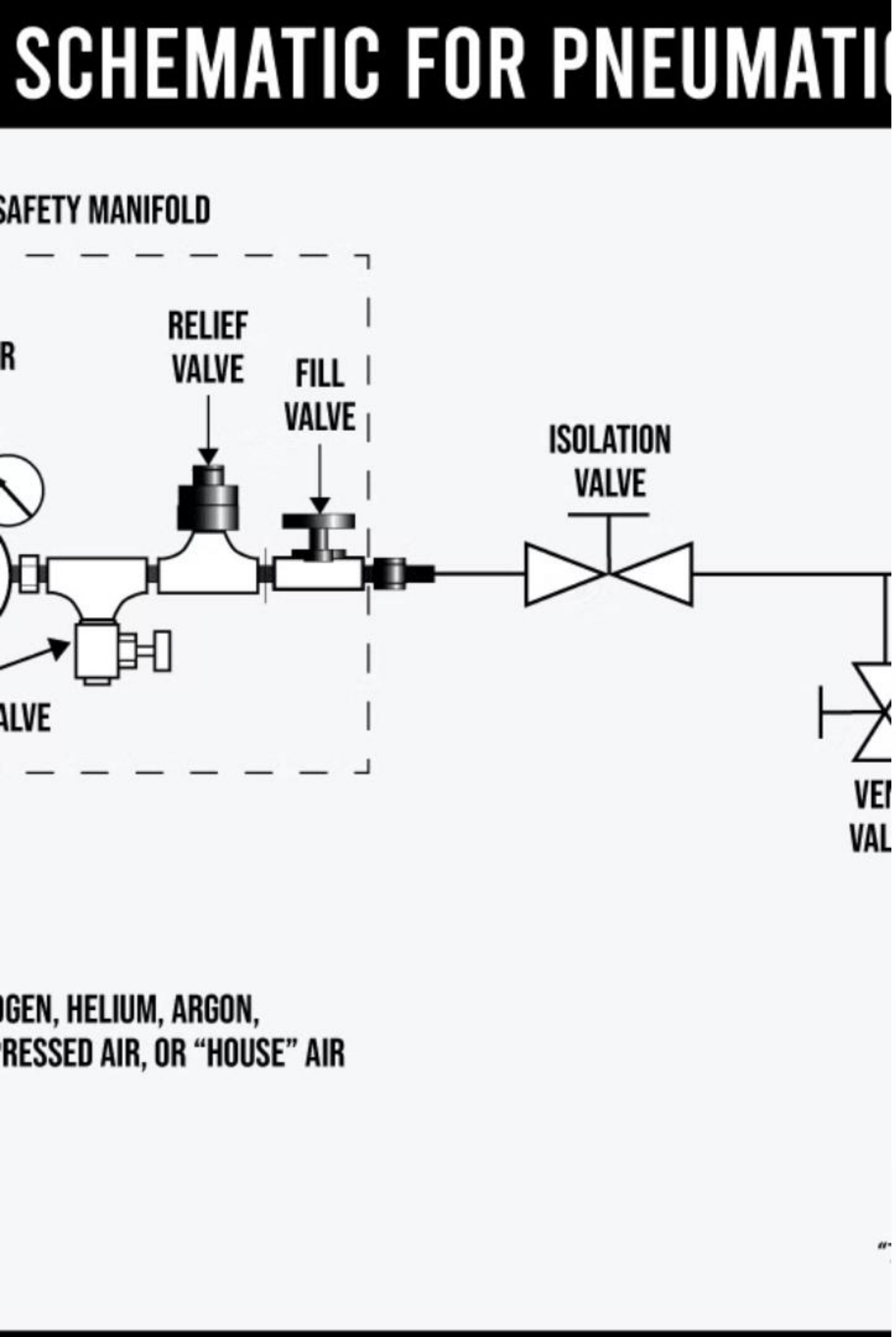
A heavier-than-air fuel, such as propane, pools and collects in low-lying areas and is more difficult to ventilate than natural gas.

Flammable Mixture Risk

This creates the risk of a flammable mixture that is ready to ignite from any source of ignition.

Outdoor Purging Recommendation

It is always a safer procedure to utilize a purge hose to the outdoors in accordance with Code guidelines when purging propane gas piping systems.



Pressure Testing Timeline

Complete Piping Installation

Install all gas piping according to code requirements

Conduct Pressure Test

Perform pressure test before any appliance is installed

Install Appliances

After successful pressure test, install gas appliances

Perform Leak Test

Conduct leak test after appliance installation

Pressure Gauge Selection

Minimum Gauge Size

The minimum diameter gauge that can be used for pressure testing is 2 inches (50 mm). This size ensures readability and accuracy during testing procedures.

Practical Application

A properly sized pressure gauge allows technicians to accurately monitor system pressure during testing, ensuring that the system maintains pressure without leaks.

Inert Gases for Testing

Carbon Dioxide

Non-flammable, heavier than air

Nitrogen

Non-flammable, slightly lighter than air

Code Compliance

Both are approved by CSA B149.1 for pressure testing

Safety Benefits

Both gases prevent potential ignition during testing

Post-Valve Opening Procedure

Listen for Gas Flow

After opening the gas valve at the meter, listen for the gas flow to stop, indicating that the system has pressurized.

Monitor Test Dial

Watch the gas meter test dial for any movement, which could indicate a leak in the system.

Avoid Immediate Ignition

Do not attempt to test fire appliances until you've confirmed the system is leak-free.

Leak Detection Methods

Apply Leak Solution

Wipe each joint with leak detecting solution

Observe for Bubbles

Watch for bubble formation indicating leaks

Repair Leaks

Fix any identified leaks and retest

Propane System Testing Sequence

1

Gauge Installation

Place a pressure gauge on the system

2

Pressurization

Pressurize by opening manual valves on each stage

3

Valve Closure

When at pressure, close the manual valves

4

Monitoring

Mark gauges and observe for leakage

The final step is to do a main manual shut-off valve seepage test.

Test Tag Information

Required Information

The gas technician/fitter must include their name, certification number, and classification on the test tag to properly document the testing procedure.

Documentation Process

Proper documentation on test tags provides a record of system testing and the responsible technician, which is important for future reference and regulatory compliance.

Purging Safety Importance

Prevent Accidents

Avoid leaks, fires, and explosions

Follow Code Requirements

Adhere to CSA B149.1 guidelines

Use Proper Techniques

Apply approved purging methods

Maintain Competence

Stay trained on current procedures

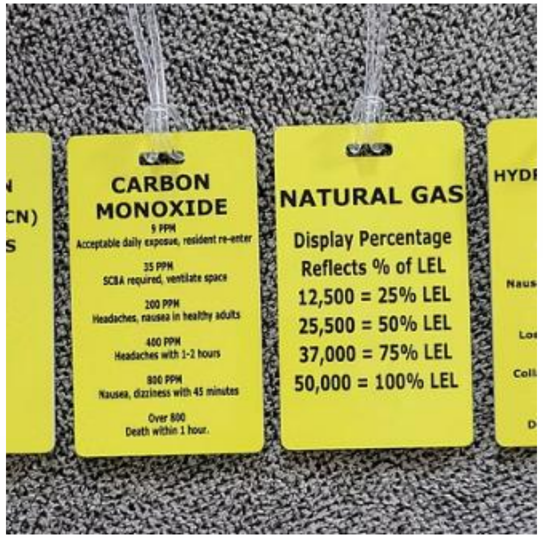
Incorrect purging methods and shortcuts have led to numerous leaks, fires, and even explosions. It is imperative that gas technicians/fitters maintain safe and approved purging methods in all work conducted.

Purging Sequence Visualization

Comparing Gas Properties

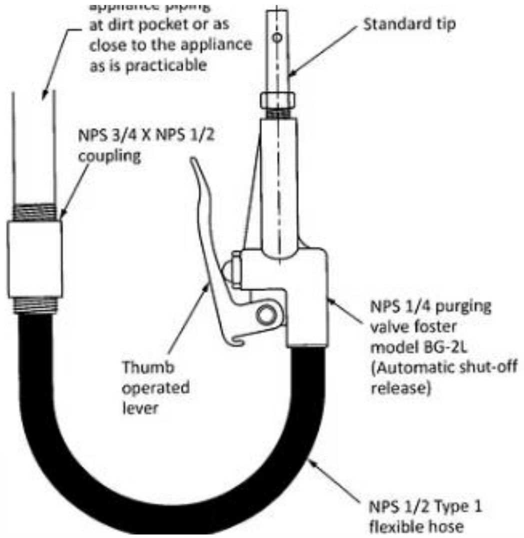
Property	Natural Gas	Propane
Specific Gravity	0.60 (lighter than air)	1.5 (heavier than air)
Lower Explosive Limit	4% in air	2% in air
Upper Explosive Limit	15% in air	10% in air
Behavior in Space	Rises	Sinks to low areas
Purging Recommendation	Various methods suitable	Outdoor purging preferred

Pressure Testing Equipment



Essential equipment for proper gas system pressure testing includes appropriately sized pressure gauges, inert gas cylinders, leak detection solutions, and documentation materials.

Purging Equipment Gallery



Various equipment options for gas system purging, each appropriate for specific situations as outlined in CSA B149.1 Clause 6.23.

Chapter Review: Key Concepts

Code Requirements

Understanding CSA B149.1 Clause 6 for purging requirements

Purge Points

Identifying proper locations starting with the farthest appliance

Gas Properties

Recognizing differences between natural gas and propane

Purging Methods

Applying appropriate techniques for different situations

Safety First: Purging Best Practices

Follow Code Requirements

Always adhere to CSA B149.1 guidelines for purging operations

Use Proper Equipment

Utilize approved purging tools and methods for the specific gas type

Consider Gas Properties

Account for specific gravity and explosive limits when purging

Document Thoroughly

Complete all required documentation including test tags

Chapter Summary

Key Takeaways

- Proper purging is essential for preventing dangerous gas/air mixtures
- Begin purging at the appliance farthest from the source of supply
- Natural gas rises while propane sinks, affecting purging procedures
- Always follow CSA B149.1 Code requirements for purging operations
- Use appropriate purging methods based on the specific installation
- Document all testing and purging procedures properly

A gas technician/fitter must know how to properly purge a gas piping system in accordance with applicable codes to prevent a buildup of combustible air/gas mixtures and ensure that the piping/tubing system delivers air-free gas to the appliances.

CSA Unit 8

Chapter 4
Protection of Piping and Tubing from Corrosion

A gas technician/fitter must know how to protect a gas piping system and its components from corrosion in accordance with applicable codes and standards. This presentation will cover the reasons for corrosion protection and describe various corrosion protection methods.

Objectives

Describe reasons for corrosion protection

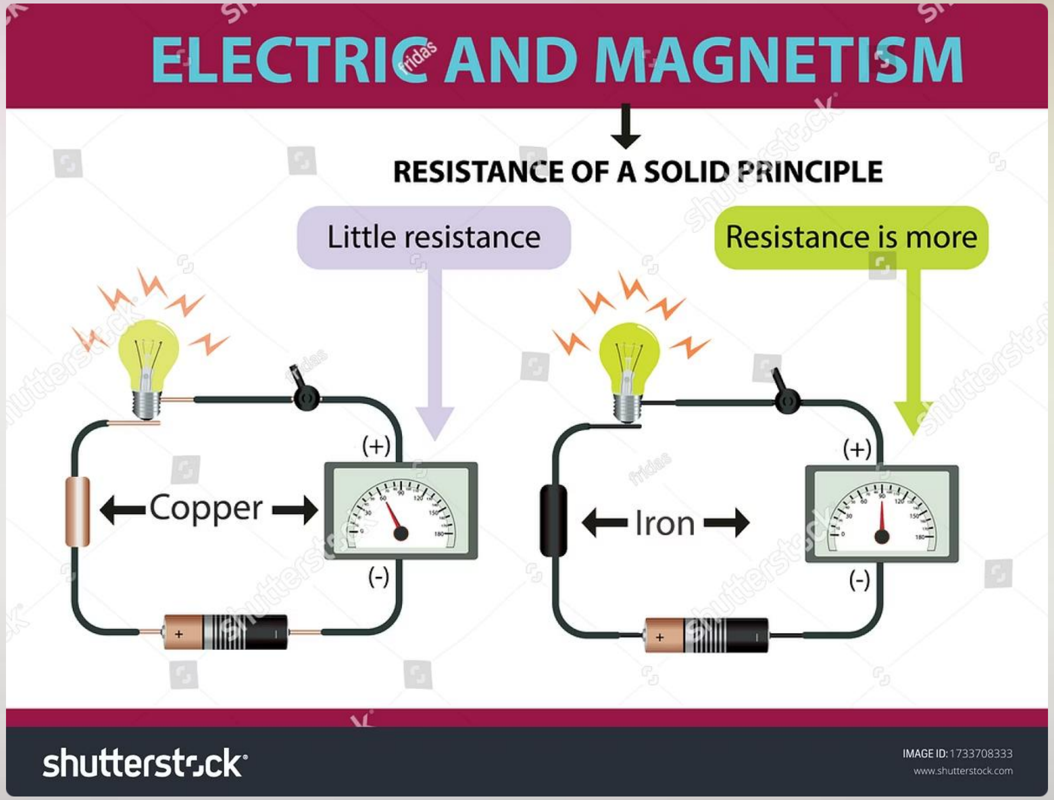
Understanding why gas piping systems need protection from corrosive elements

Describe corrosion protection methods

Learning various techniques to protect piping and tubing from corrosion

Key Terminology

Term	Definition
Anode	Electrode at which electrons leave the cell and oxidation occurs
Bonding	Connection of two or more conductive objects to one another by means of a conductor such as a wire
Cathode	Electrode at which electrons enter the cell and reduction occurs
Corrosion	Process that changes pure metals into their compound, while producing electric current



More Terminology

Term	Definition
Electrode	Electrical conductor used to make contact with a nonmetallic part of a circuit
Electrolyte	Conductor of the electric currents
Grounding	Specific form of bonding involving the connection of one or more conductive objects to the ground by means of a conductor such as a wire or rod
Resistivity	Electrolyte's resistance to electric force within a cube measuring 1 cm

Understanding Corrosion

What is Corrosion?

Corrosion is one of the ways that a pure metal can revert to a more stable compound. Some metals, when unprotected from the atmosphere, gradually corrode.

The metals used to make pipelines and piping systems are generally pure. However, you can also find metals as chemical compounds such as oxides, sulphides, and other salts.

Stability of Compounds

Many metals are more stable in their natural compound than as a pure metal. For example, iron oxide (rust) is more stable than the pure iron used in pipes. It is more stable because the atmosphere has reacted with the iron to create the compound iron oxide. As a compound, iron oxide has no further chemical reaction to atmospheric elements and is therefore stable.

Causes of Corrosion

Atmospheric and Soil Conditions

Environmental factors that can accelerate corrosion of metal pipes

Chemicals

Various chemical compounds that react with metal piping

Cement

Chemical reactions between cement and metal pipes

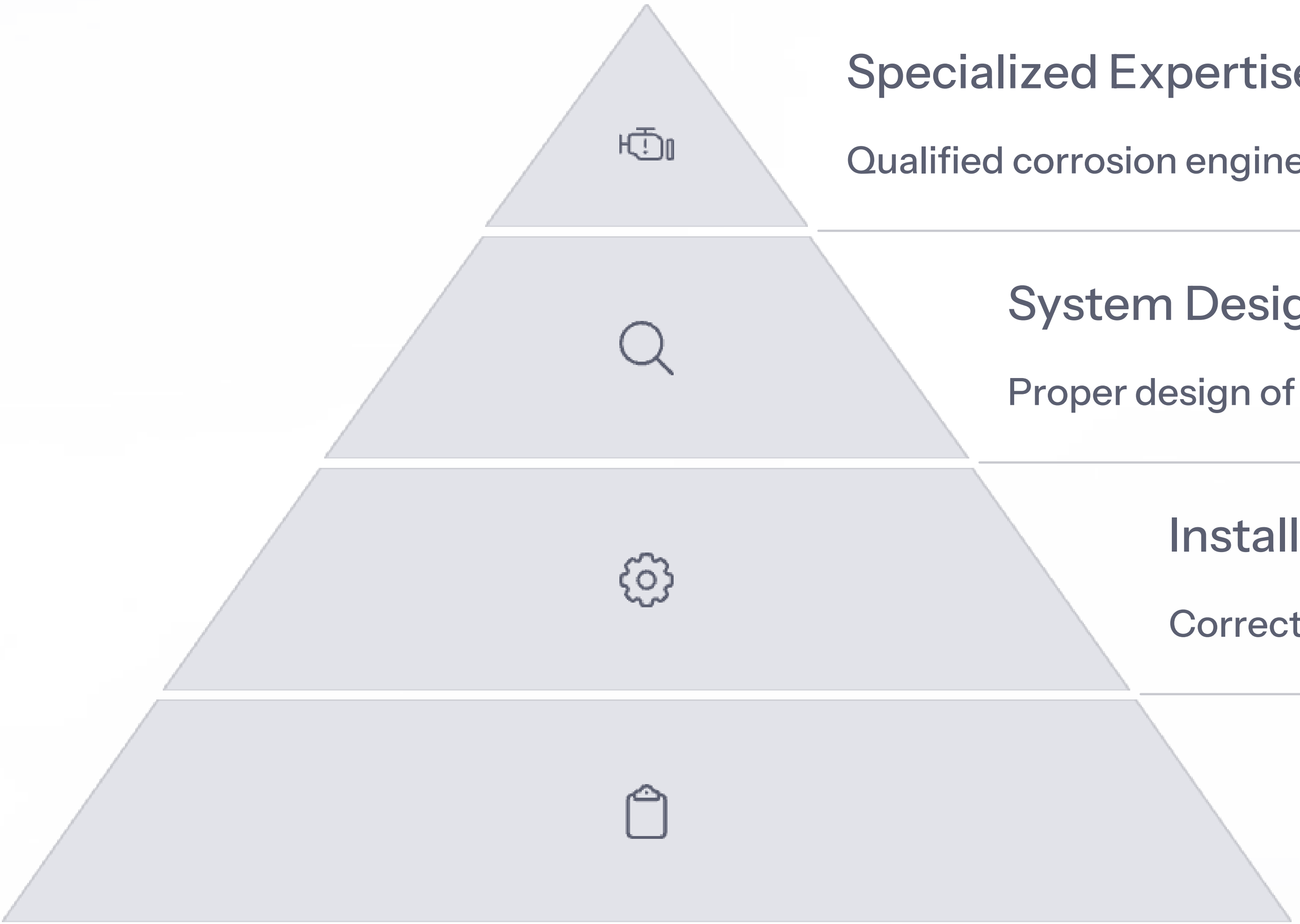
Cinders and Fly Ash

Corrosive byproducts that can damage piping systems

Electrolytic Action

Electrical current flow that causes metal deterioration

Corrosion Protection and Control



Specialized Expertise

Qualified corrosion engineers should supervise protection systems

System Design

Proper design of piping protection systems

Installation

Correct installation techniques for corrosion prevention

Testing

Verification of protection system effectiveness

Corrosion protection and control is a highly specialized area. A qualified corrosion engineer or a firm specializing in this work should always supervise the design, installation, and testing of piping protection systems. (You can obtain a current list of corrosion specialists from the local gas authority.) Nevertheless, as a gas technician/fitter, you must fully understand the corrosion process so that you can take preventive measures when internation the contribution of repairing piping that may be exposed to corrosive conditions.

The Corrosion Process

Anode

The metal surface where electrons leave and oxidation occurs

Conductive Path

The metal that allows current to flow between anode and cathode

Cathode

The metal surface where electrons enter and reduction occurs

Electrolyte

The medium (often water or soil) that conducts electric current

Corrosion is an electrochemical action that changes pure metals into their compound, while producing electric current. Corrosion cannot occur if any of these four elements is absent.

Anode and Cathode in Corrosion

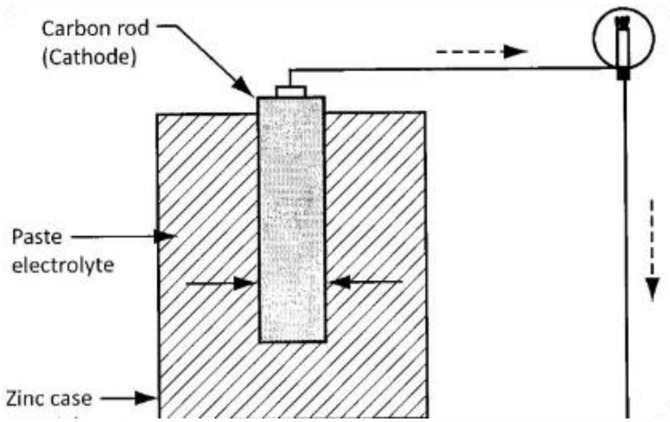
Electrical Circuit

Metal corrodes when there is a complete electrical circuit. The electrical current travels from the anode to the cathode in the electrolyte. This is conventional current the movement of positive charges you can find in a basic electrical circuit.

Figure 4-1
Four elements required for corrosion on an unprotected pipe

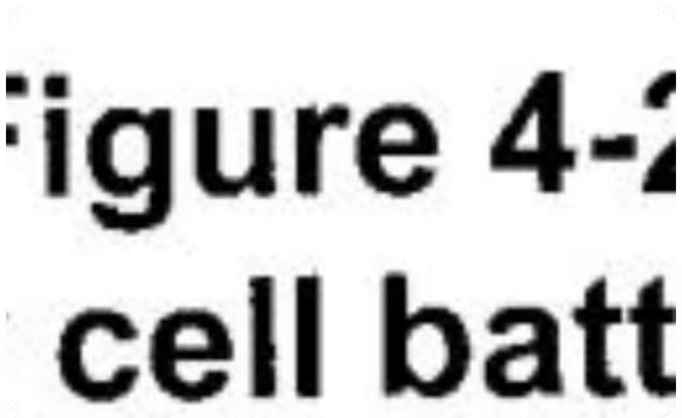
The anode and cathode are what you call electrodes. The current flows between them, causing corrosion at the anode.

Dry Cell Battery Example



Dry Cell Battery Structure

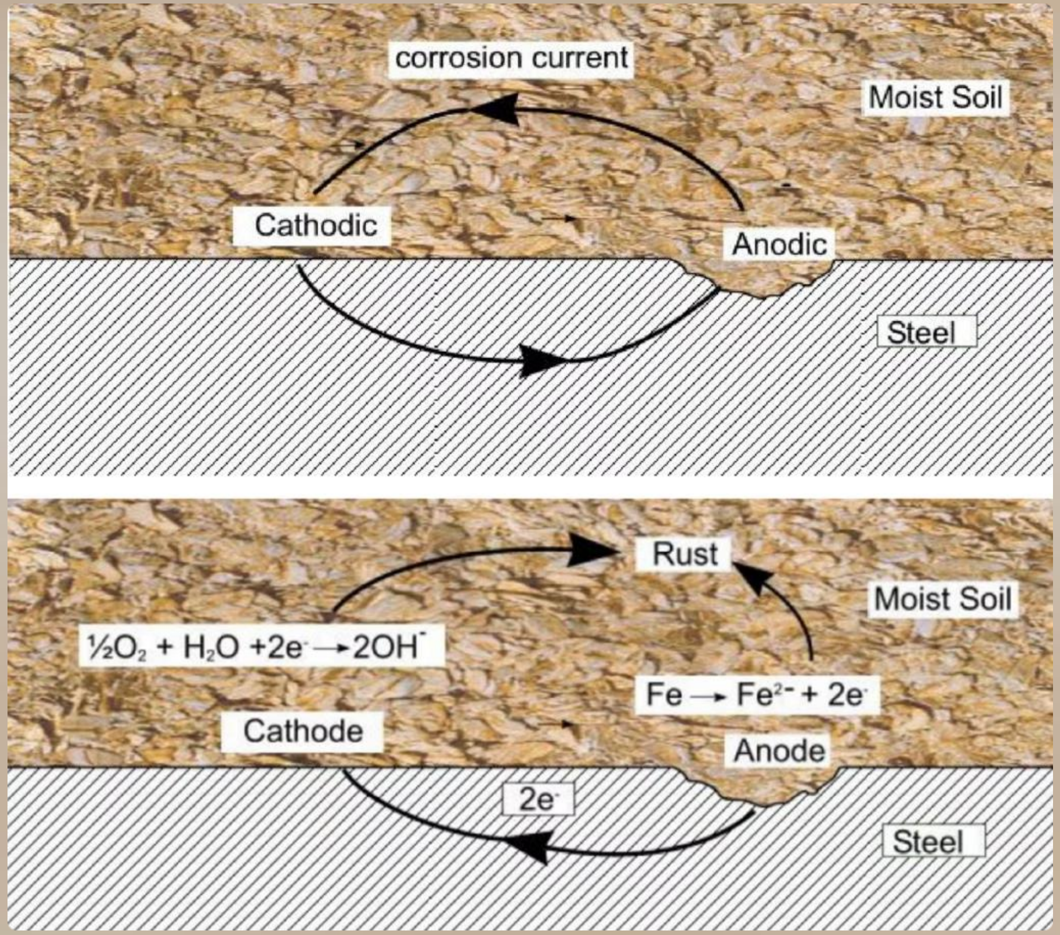
An everyday example of how we benefit from this electrochemical action is the dry cell battery. The dry cell battery produces an electric current because the zinc casing is an anode and the carbon rod is a cathode.



Current Flow

The electric current runs from the anode to the cathode, passes through the light, and goes back to the anode. This is the same principle that causes corrosion in metal pipes.

The Role of Electrolyte in Corrosion



Water as Essential Element

Dry metals, in general, do not corrode. Water is essential to the corrosion process, as it acts as the conductor of the electric currents. It is what you call the electrolyte.

Contaminants Accelerate Corrosion

Although pure water is a poor electrical conductor, traces of salts, acids, or alkalis increase its effectiveness as an electrolyte and greatly accelerate corrosion processes.

Soil as Electrolyte

Water and these contaminants are present in most soils and, with the oxygen that permeates the soil from the air above, all the corrosive agents are present.

Soil Resistivity and Corrosion

High Resistivity Soils

Dry soil and gravel have high resistance to electrical current

Low Resistivity Soils

Moist soil, loam, and clay have low resistance to electric current

Corrosion Risk

Piping buried in moist soil is more prone to corrosion

Soils have varying abilities to resist current flow and therefore have varying abilities as an electrolyte. A soil with very high resistance to electrical current is a poor electrolyte. A moist soil with low resistance to electric current is a more efficient electrolyte.

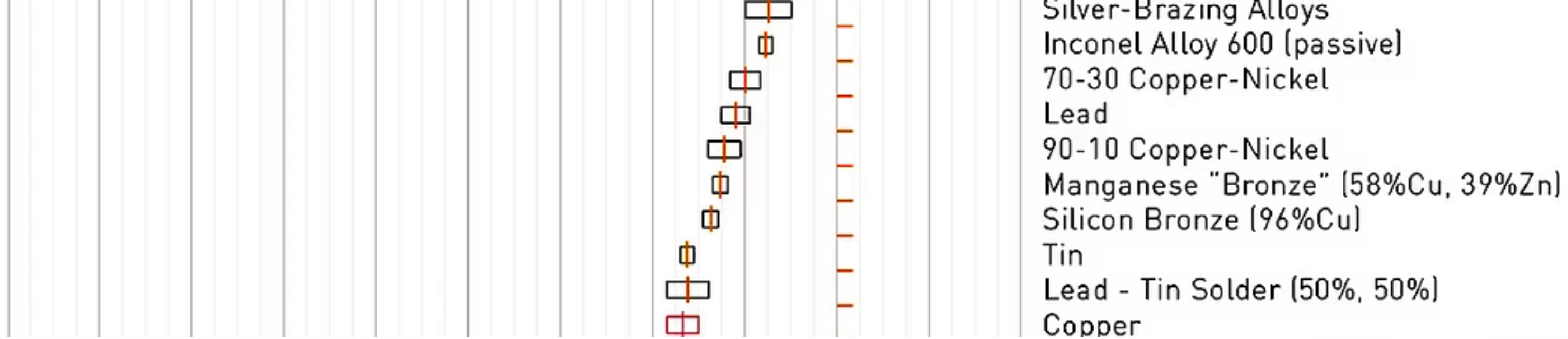
Metallic Path in Corrosion

Current Flow in Underground Pipes

In an unprotected underground pipe, the electric current flows from the anodic areas of the pipe —through the soil (the electrolyte)—to the cathodic areas. The current then returns through the pipe to complete the circuit.

Metallic Path Definition

The metallic path is the pipe length that the electrical current travels from the time it enters the cathode until it leaves the anode.



Metals with Different Potentials

Electromotive Scale

All metals have a known electrical value on an electromotive scale.

Current Flow

If two metals have different electrical potential, a current will flow between them from active metals to less active metals.

Corrosion Result

The current flows between metals of differing potential regardless of whether the metals are close together or far apart.

Types of Corrosion Based on Metal Proximity

Surface Corrosion

Surface corrosion occurs when the differing metals are close together, for example, when there is mill scale on steel piping.

Soil-Induced Corrosion

When the soil quality changes from one end of a pipeline to another, the soil's resistivity may change the metal's potential. This again creates current flow and corrosion occurs.

Soil Resistivity Measurement

Resistivity Definition

Resistivity is the soil's (electrolyte's) resistance to electric force within a cube measuring 1 cm. It is expressed in ohm/cm.

Corrosion Risk Assessment

Nearly all soils are corrosive to steel, and those below 10,000 ohms/cm are considered especially corrosive. Soils below 5,000 ohms/cm are sufficiently corrosive to cast iron or ductile iron to warrant cathodic protection.

Measurement Method

The Wenner four pin method is the technique usually used for measuring resistivity. This method involves direct driving of four pins into the ground in a straight line at specific distances apart, imposition of a current between the two outside pins, and measurement of the voltage across the two inside pins.

General Corrosion Protection Principles

Protective Coatings

Piping and tubing is covered with an approved corrosion-resistant paint or coating, when conditions require

Wall Protection

Piping and tubing is coated or wrapped where it passes through walls where it could sustain physical damage, and be subject to corrosion

Material-Specific Treatment

Different types of pipe and tubing require different treatment based on their material properties

Copper Pipe and Tubing Protection Requirements

Location	Protection Requirements
Above ground	Where it passes through concrete, cement block, or similar locations that would cause corrosive action if the copper came in direct contact with the material it passes through
Above ground	Where the copper may contact a dissimilar metal
Above ground	Where the copper may come in contact with corrosive chemicals or vapours
Underground	All underground copper tubing installations require the use of Type L or G copper having an approved protective coating. The use of Type K copper is allowed. This type does not require external protection.

Copper Protection Methods - Above Ground

Standard Installation

You may use uncoated copper pipe and tubing in above ground applications where it is not exposed to corrosive elements or physical damage.

Wall Penetration - Exterior

Coat or double wrap copper pipe and tubing that passes through exterior concrete or masonry walls with an approved protective tape, with waterproof caulking applied at the entrance and exit points.

Wall Penetration - Interior

Coat or double wrap copper pipe and tubing that passes through interior concrete or masonry walls with an approved protective tape. Caulking is not required.

Dissimilar Metals

To avoid possible electrolytic action, do not allow copper pipe and tubing to come in contact with dissimilar metals. If this is unavoidable, double wrap the copper with tape or insulation to provide galvanic protection.

Copper Protection Methods - Underground

Type K Copper

Type K copper can be used underground without external protection due to its thicker wall construction.

Type L or G Copper

Copper tubing used in underground applications must be Type K, L, or G copper. Type L or G copper must have an approved, external coating.

Mounting Considerations

Whenever possible, use only copper or plastic mounting clips to secure copper pipe and tubing to avoid dissimilar metal contact.

Steel and Iron Pipe Protection Requirements

Above Ground Requirements

- Where it passes through concrete, cement block, or similar locations that would cause corrosive action if the pipe came in direct contact with the material it passes through
- Where the pipe may contact a dissimilar metal
- Where the pipe may come in contact with corrosive chemicals or vapours

Underground Requirements

Installations require protection for steel and iron pipe by means of an approved method or combination of methods, including:

- Protective coating
- Corrosion-resistant wrapping
- Cathodic protection
- Electrical bonding
- Isolation of individual pipe sections

Steel and Iron Protection Methods - Above Ground

1. ## Corrosive Environment Protection

   Steel and iron pipe used in above-ground applications where it is exposed to corrosive elements must have an approved protective coating or corrosion-resistant wrapping.

2. ## Exterior Wall Penetration

   Coat, sleeve, or double wrap steel and iron pipe that passes through exterior concrete or masonry walls with an approved protective tape, with waterproof caulking applied at the entrance and exit points.

3. ## Interior Wall Penetration

   Coat, sleeve, or double wrap steel and iron pipe that passes through interior concrete or masonry walls with an approved protective tape. Caulking is not required.

4. ## Dissimilar Metal Contact

   To avoid possible electrolytic action, do not allow steel and iron pipe to come in contact with dissimilar metals. If this is unavoidable, double wrap the pipe with tape or insulation to provide galvanic protection.

Steel and Iron Protection Methods - Underground

Usage Limitations

Steel and iron pipe is not usually used underground, because only welded joints are acceptable and because this pipe is vulnerable to corrosion.

Required Protection

If the local inspection authority permits the use of steel and iron pipe underground, ensure that the pipe have a coating or wrap with corrosion-resistant material.

Joint Protection

Wrap all joints and risers with approved corrosion-resistant material.

Cathodic Protection

Bond a correctly sized anode to the pipe by cadwelding.

Electrical Isolation

Install a dielectric union or insulating flanges above grade at each end of the pipe run.

Plastic Pipe Installation

Underground Use Only

You may only use polyethylene pipe (plastic pipe) for underground installations.

Riser Material Requirements

Note that the material of all risers that extend above grade must be steel or copper.

Connection Requirements

Connectors must be approved transition fittings, and a tracer wire must follow the pipe for future locating.

Methods for Protecting Underground Piping

Protective Coatings

Insulate pipe from soil using materials with high electrical resistance

- Coal tar coatings
- Extruded polyethylene
- Protective tapes

Electrical Insulation

Prevent current flow between different metal components

- Dielectric fittings
- Insulated unions
- Insulated flanges

Cathodic Protection

Use sacrificial anodes or impressed current systems

- Magnesium anodes
- Zinc anodes
- Rectifier systems

Protective Coatings for Underground Piping

Coating Properties

A good coating has a high electrical resistance. It adheres tightly to the pipe and has the strength to withstand installation and handling, soil stresses, and any tendency towards cracking.

Yard applied coal tar and extruded polyethylene are the main coatings used. While most coatings allow some current to penetrate through to the steel surface, for most practical purposes, the steel is considered isolated from the soil.

Coating Limitations

In theory, this would be enough to prevent corrosion; however, it is virtually impossible to install a pipeline without some coating damage. The portions of pipe that become exposed in the soil corrode more quickly because the corrosion is concentrated in those areas.

Repairing Pipe with Protective Coating

Use Approved Materials

When repairing or adding to a pipe that has a protective coating, ensure you use approved protective coatings such as Polyken tape or heatshrink sleeves.

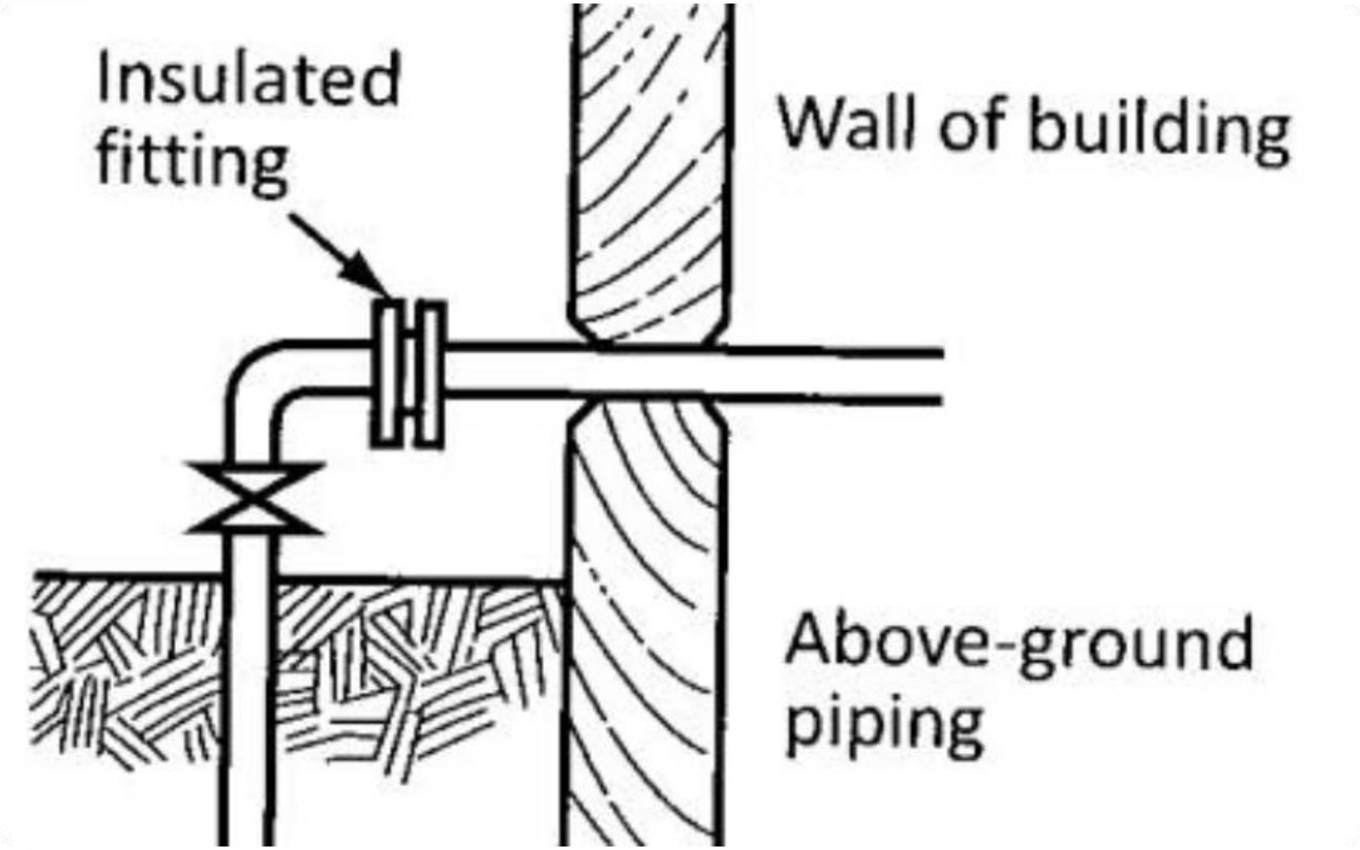
Quality Testing

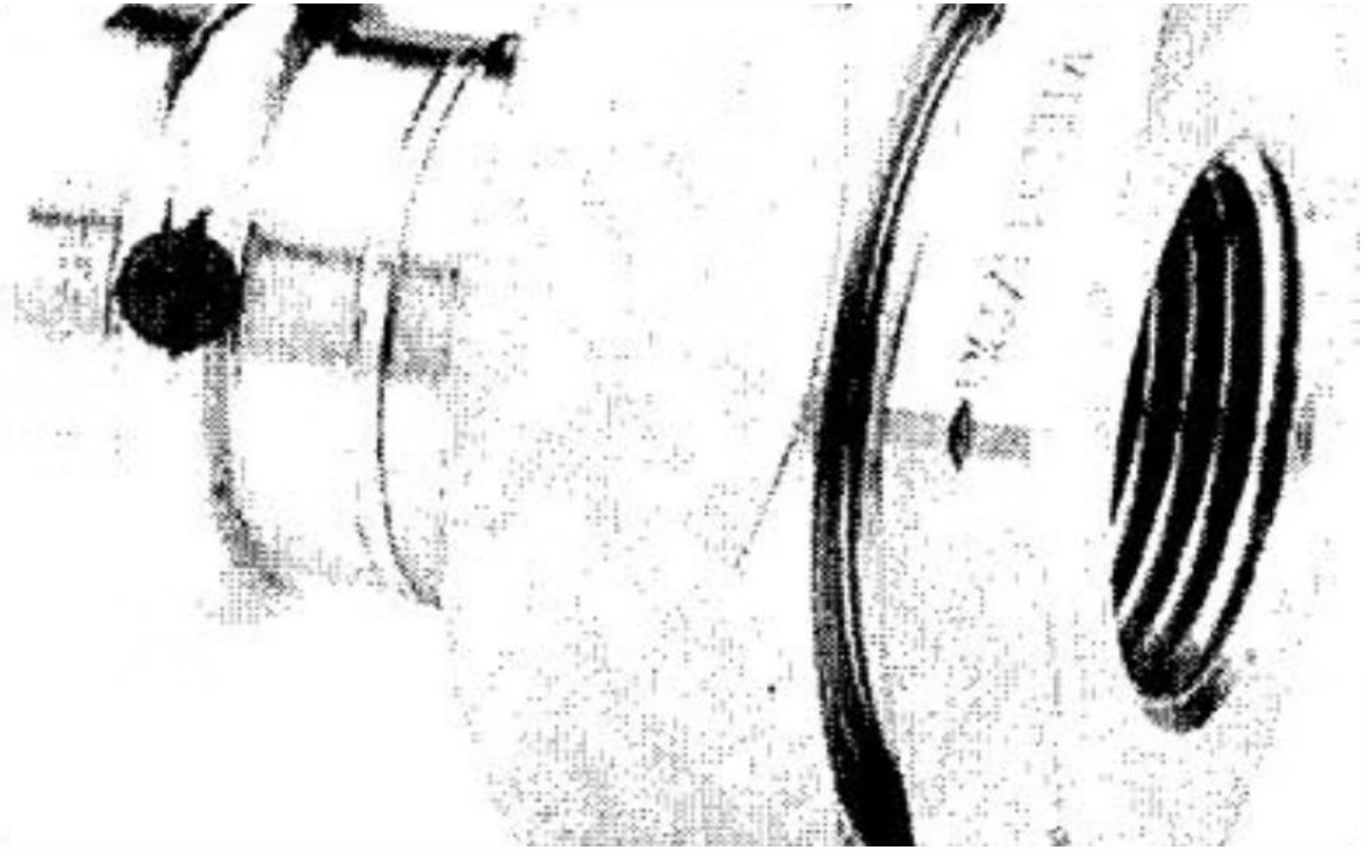
Upon repairing the pipe, check the quality of the protective coating with the Jeep Test, an Open Circuit Potential test, to find any holidays (defects) in the coating so that you can repair them before burying the piping.

Electrical Insulation

Ensure that a protected piping system is electrically insulated from other metallic structures by installing a dielectric fitting on the pipeline directly outside the building wall.

Dielectric Fittings





Dielectric Fitting Protection

Dielectric fitting protects underground pipeline from above-ground piping by preventing electrical current flow between the two systems.

Insulated Fitting

Insulated fitting to protect pipe from contact with other pipe systems. Additionally, insulated couplings separate long gas piping networks into individual electrical units. In this way, long electric current lines are inhibited, and you can accurately assess the number of anodes required for each unit.

Bonding of Piping

Code Requirements

CSA B149.1, Clause 4.7.3 requires, "All interior metal gas piping that may become energized shall be made electrically continuous and shall be bonded in accordance with the requirements of the local electrical code, or in absence of such, the Canadian Electrical Code, Part I."

CSA B149.1 forbids the use of gas piping as an electrical ground, while the Canadian Electrical Code, Part I requires bonding of continuous metal gas piping systems in a building supplied with electric power.

Bonding vs. Grounding

It is important to note that bonding and grounding are not the same. Bonding, as defined in the Canadian Electrical Code, is, "a low impedance path obtained by permanently joining all non-current-carrying metal parts to ensure electrical continuity and having the capacity to conduct safely any current likely to be imposed on it."

Grounding, as defined in Canadian Electrical Code, is, "a permanent and continuous conductive path to the earth with sufficient ampacity to carry any fault current liable to be imposed on it, and of a sufficiently low impedance to limit the voltage rise above ground and to facilitate the operation of the protective devices in the circuit."

Important Bonding Considerations

Equipotential Bonding

Code-compliant bonding of gas piping in the field will ensure the gas piping is made equipotential with the non-current-carrying conductive parts of electrical equipment.

CSST Considerations

The requirement in Rule 10-700 c) of the Canadian Electrical Code to provide equipotential bonding to a metal gas piping system is not intended to apply to metal gas tubing, i.e., CSST. Attempts to bond metal gas tubing with conventional bonding means can create a hazardous situation where the tubing can be punctured by installation of the bonding means or by arcing between improperly secured bonding faults or lightning strikes.

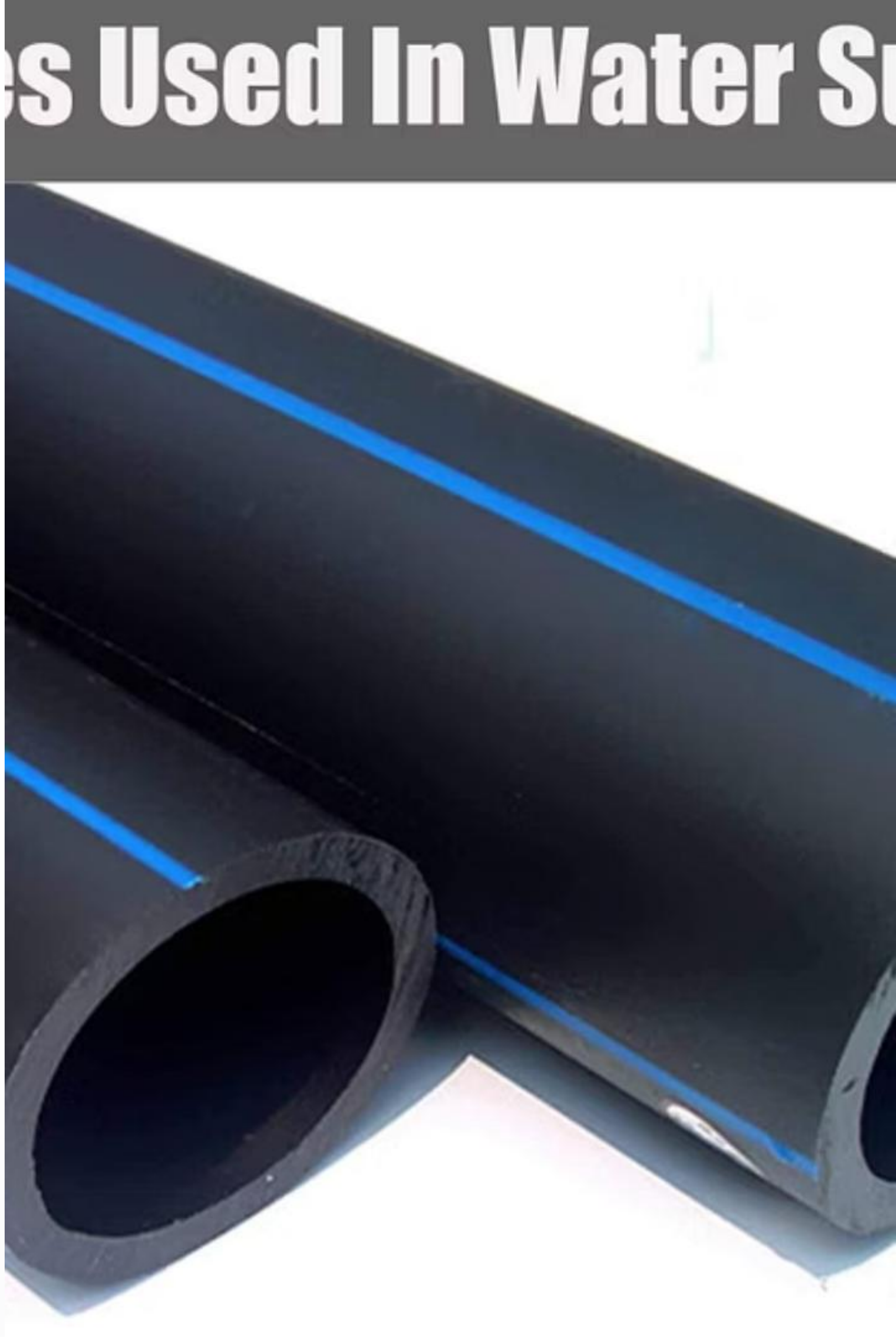
Proper Connection

The grounding conductor at a building connects to a grounding electrode, and CSA B149.1, as well as the Canadian Electrical Code, require the bonding of the gas piping to that system be installed in an approved manner. This bonding connection provides equipotentiality - the state in which conductive parts are at a substantially equal electric potential.

CSA Unit 8

Chapter 5
Piping and Tubing Used in Water Distribution

A comprehensive guide to identifying, selecting, and installing water service piping and tubing associated with gas-fired water heaters and boilers. This presentation covers different types of water distribution materials and joining methods essential for gas technicians and fitters.



Purpose and Objectives

Purpose

A gas technician/fitter must know how to identify, select, and install water service piping and tubing that is associated with gas-fired water heaters and boilers.

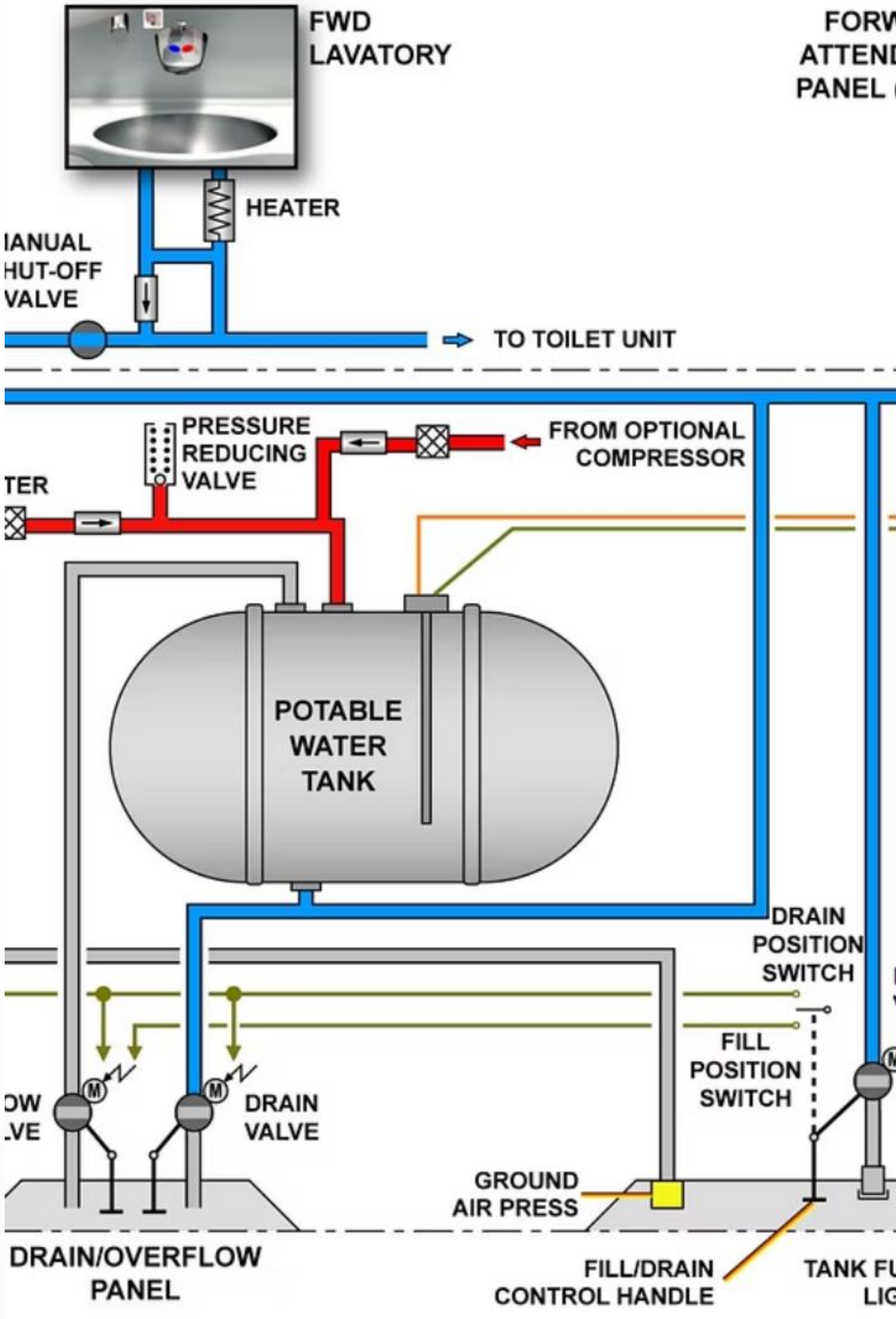
Key Terminology

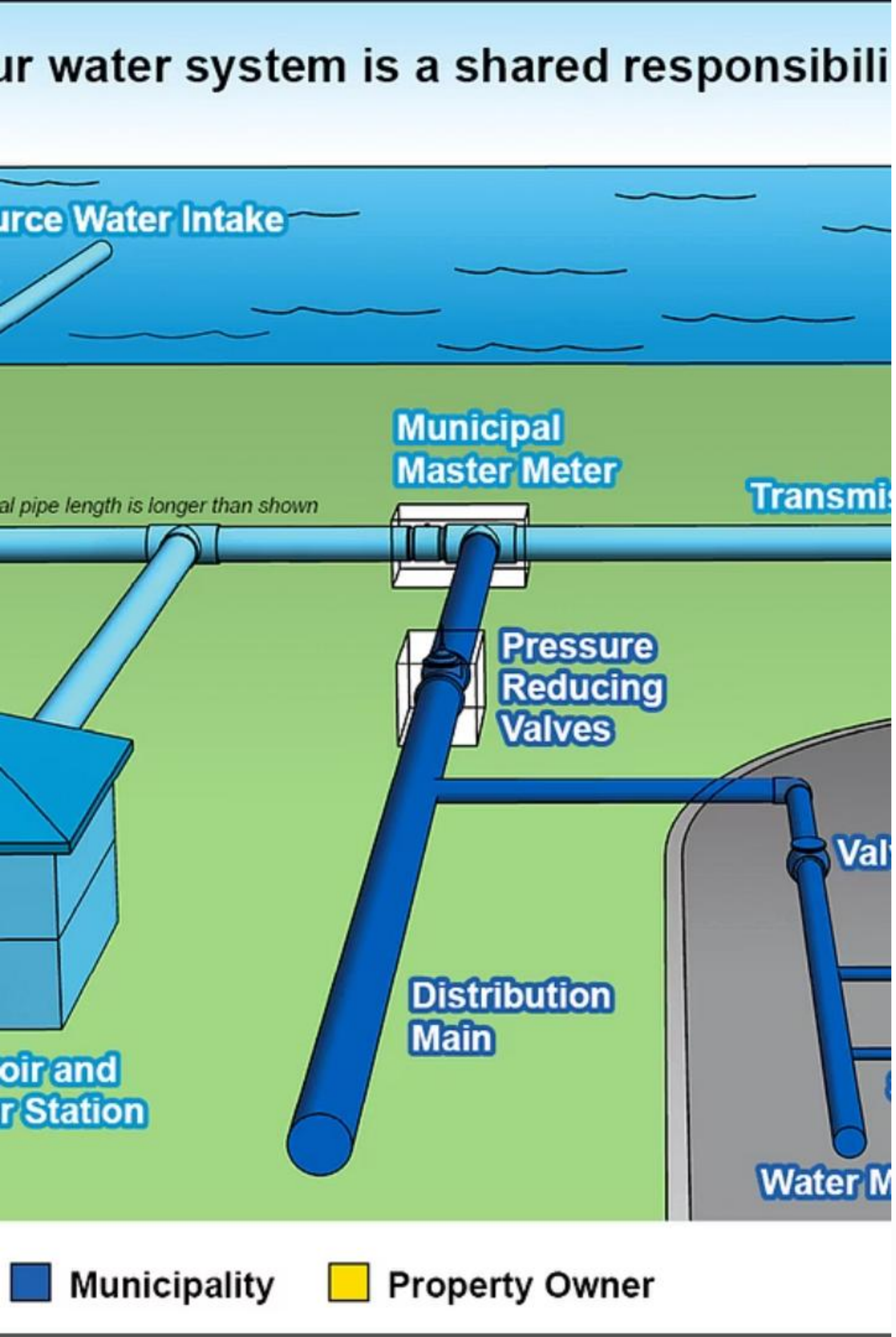
Potable

Safe to drink

Water Distribution Piping

Helps identify piping downstream of the main shut-off valve (control valve) usually at the water meter (with regard to potable water systems)





Water Distribution Overview

Part of Normal Work

The installation of waters and boilers is a normal part of a gas technician's/fitter's work

Required Knowledge

This type of installation requires knowledge of water distribution piping and tubing materials, installation methods, and the regulations governing such work

Various Options

There are various types of piping, tubing, and joints available to the gas technician/fitter for water distribution installations

Common Water Distribution Materials

Galvanized Steel

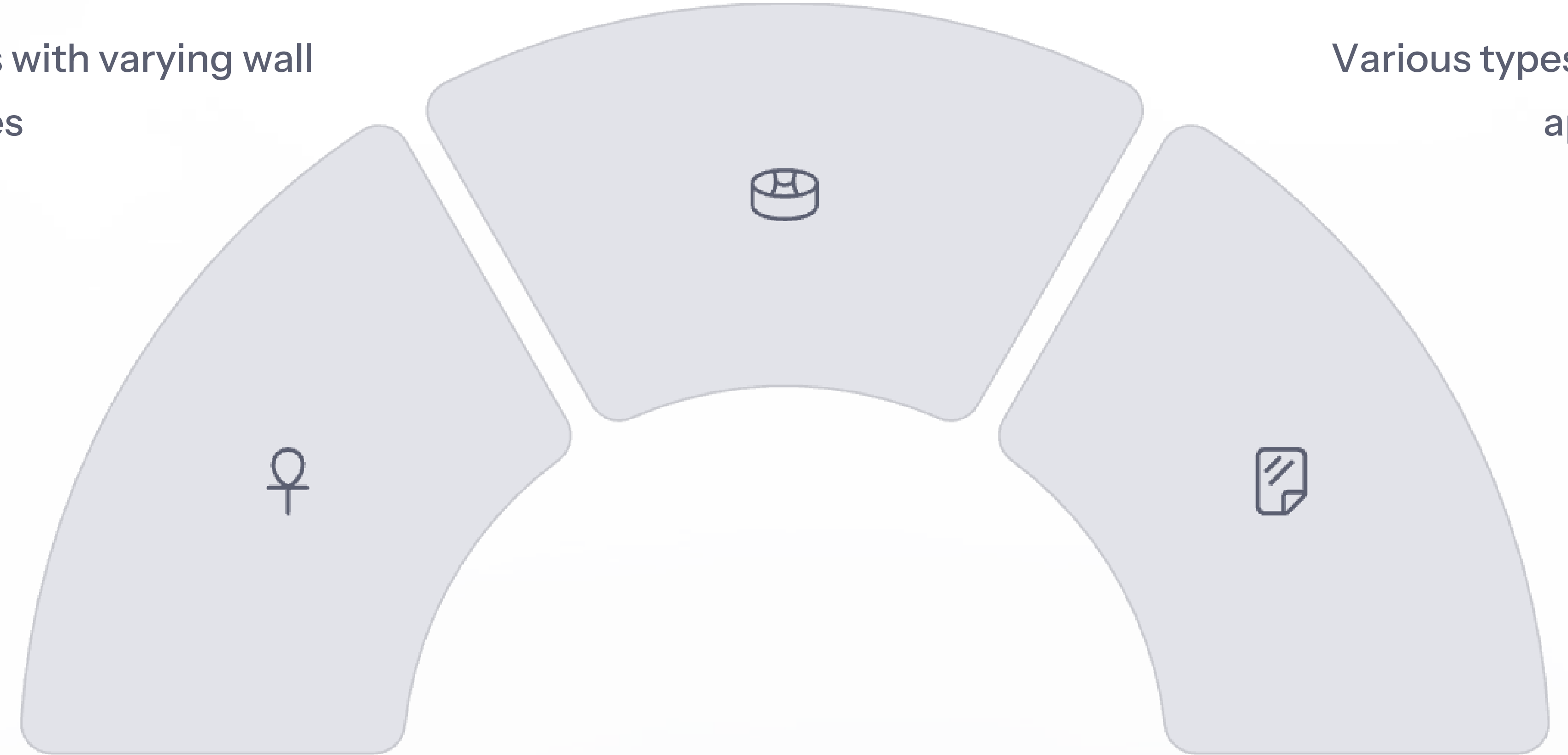
Most codes no longer permit this within potable systems

Copper

Available in different types with varying wall thicknesses

Plastic

Various types available for different applications



There are other piping materials, such as cast iron, that have approval for water distribution, but are used in situations beyond the scope of a gas technician's/fitter's normal duties.

Codes and Standards

Design Standards

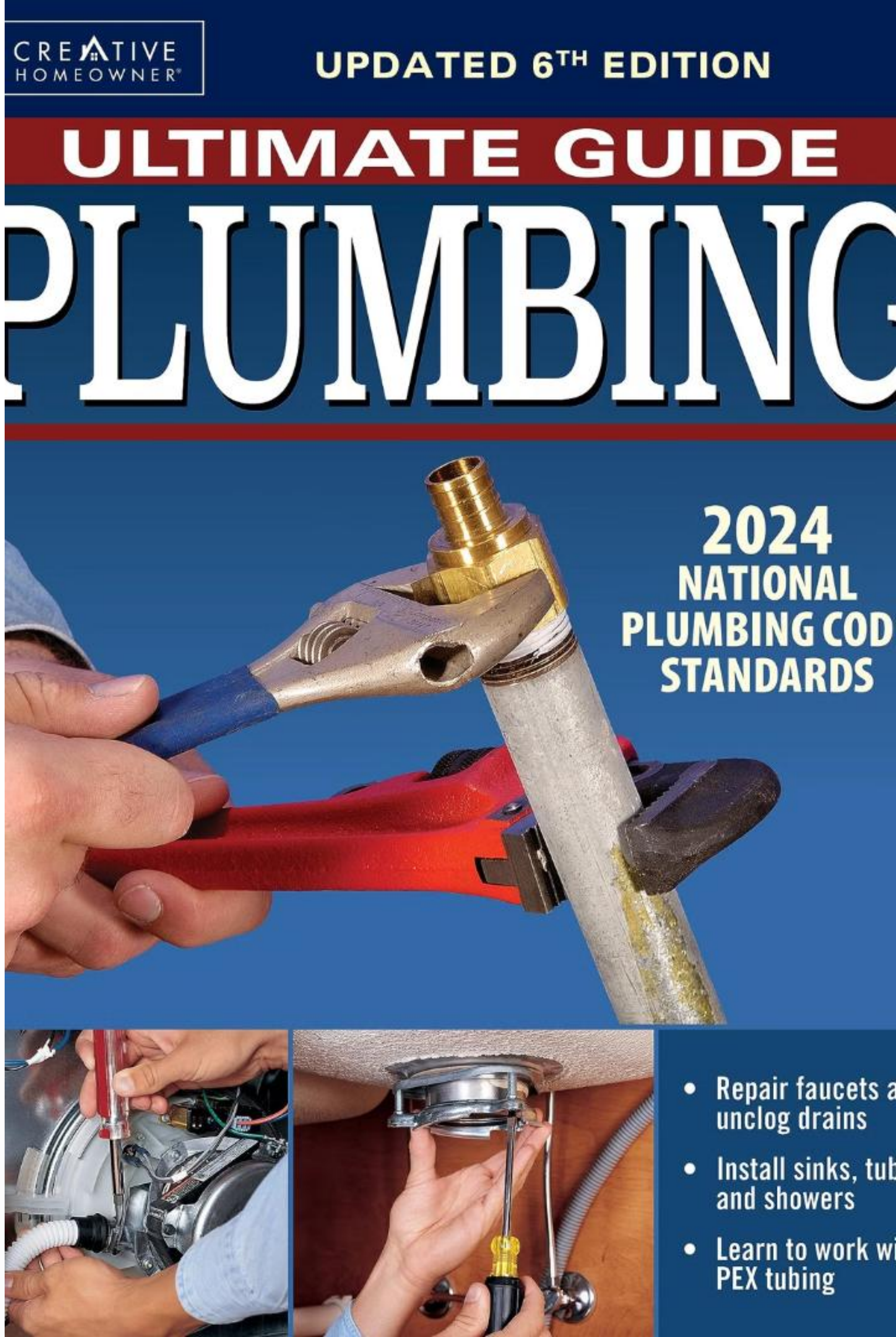
You can find design standards for water service piping in the applicable plumbing code. These standards are printed or stamped on the exterior wall of the tube or pipe.

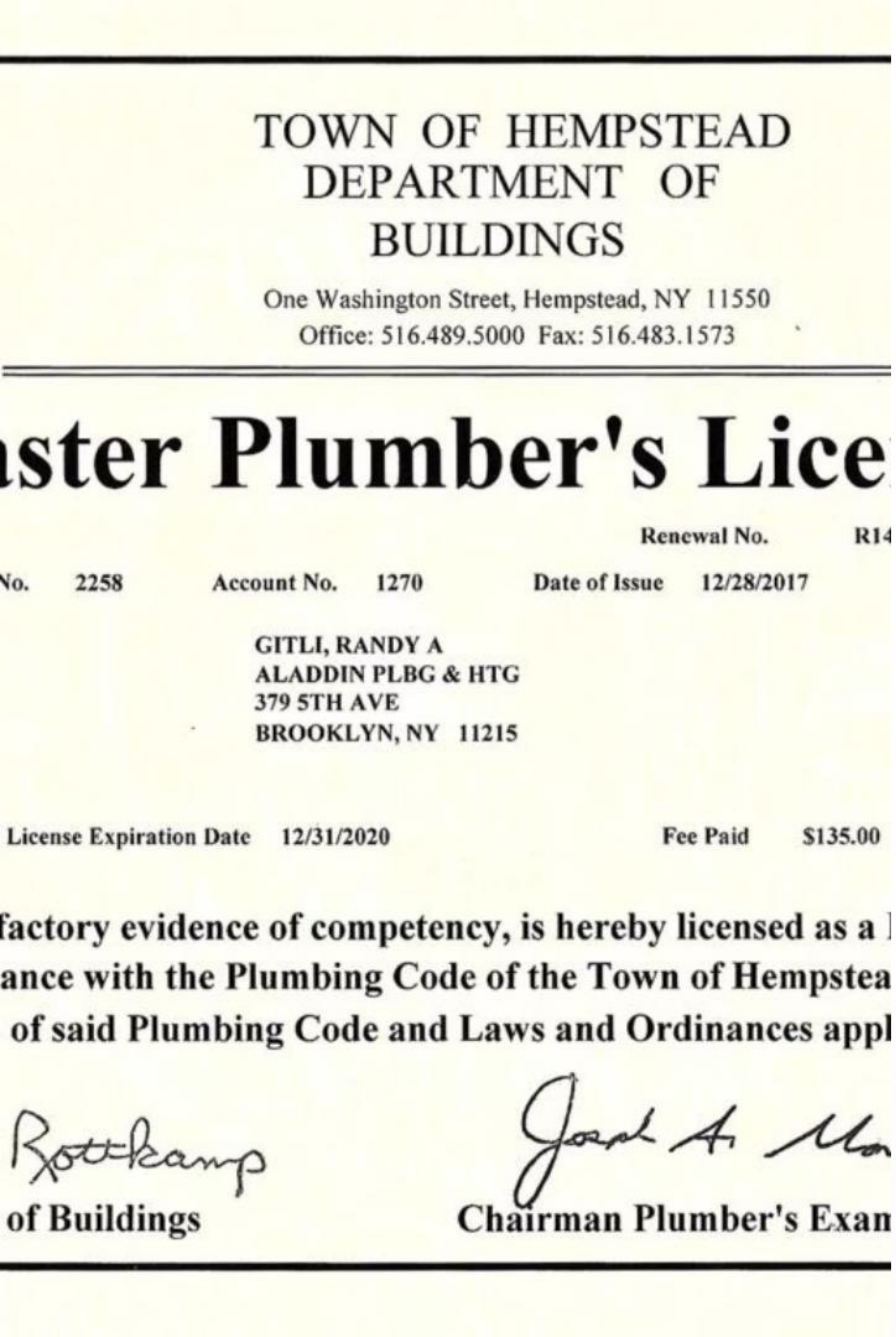
Local Codes

Consult local codes for such items as water supply shutoff, vacuum relief, temperature and/or pressure relief, and cross-connection control requirements.

Building Code Regulations

The installation of plastic piping and tubing must be in accordance with Building Code regulations concerning combustible piping and fire separations, etc.





Regulatory Requirements

Licensed Professionals

Most Provincial Regulations require a licensed Plumber or Steamfitter to perform any work beyond the immediate piping attached to a boiler or water heater

Scope Limitations

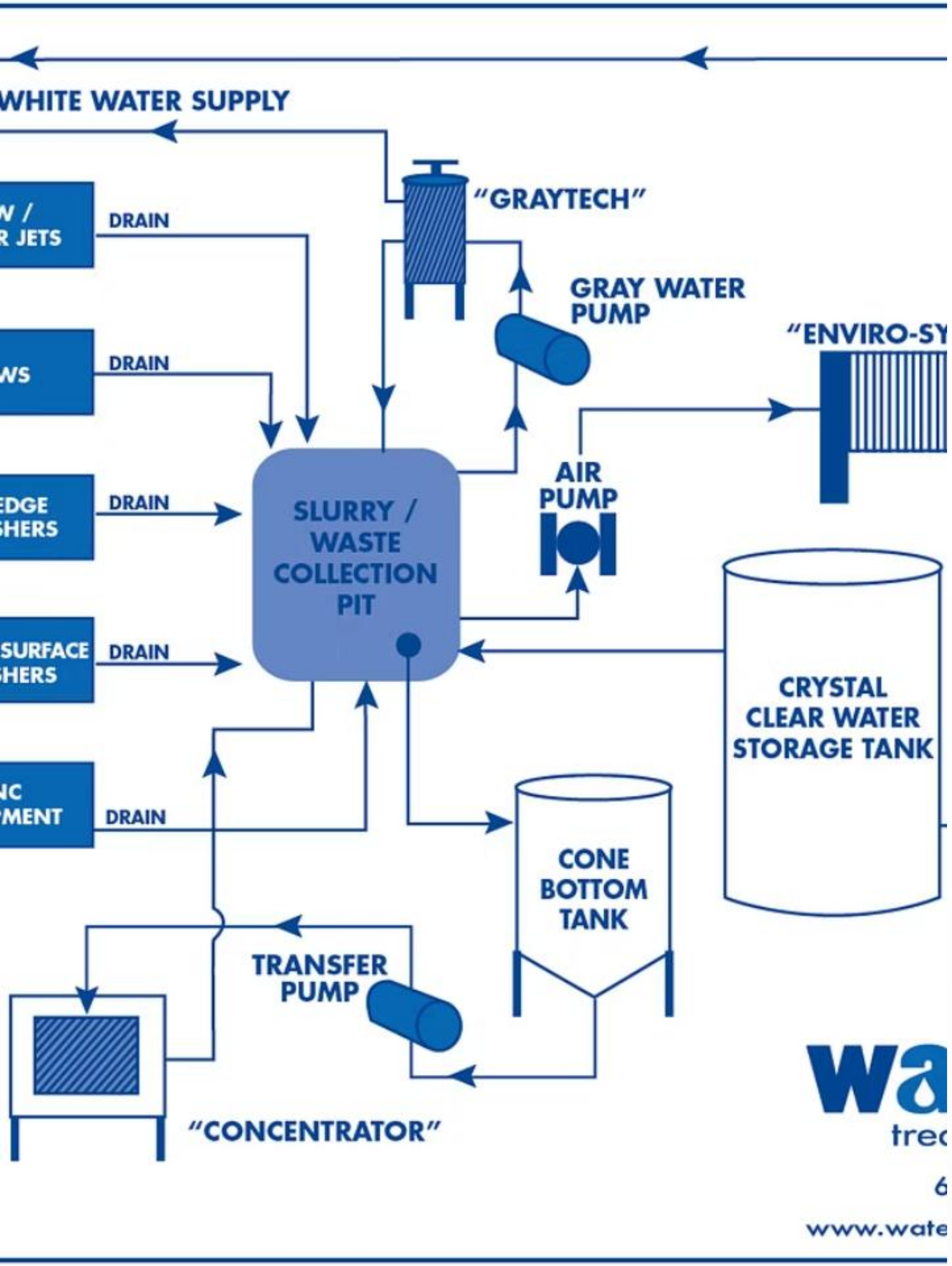
The scope of work of a gas technician/fitter does not include any work beyond that considered essential to the appliance's operation

Potential Consequences

Refusal to adhere to local regulations may cause invalidity of manufacturer warranties and insurance company coverage

Liability Concerns

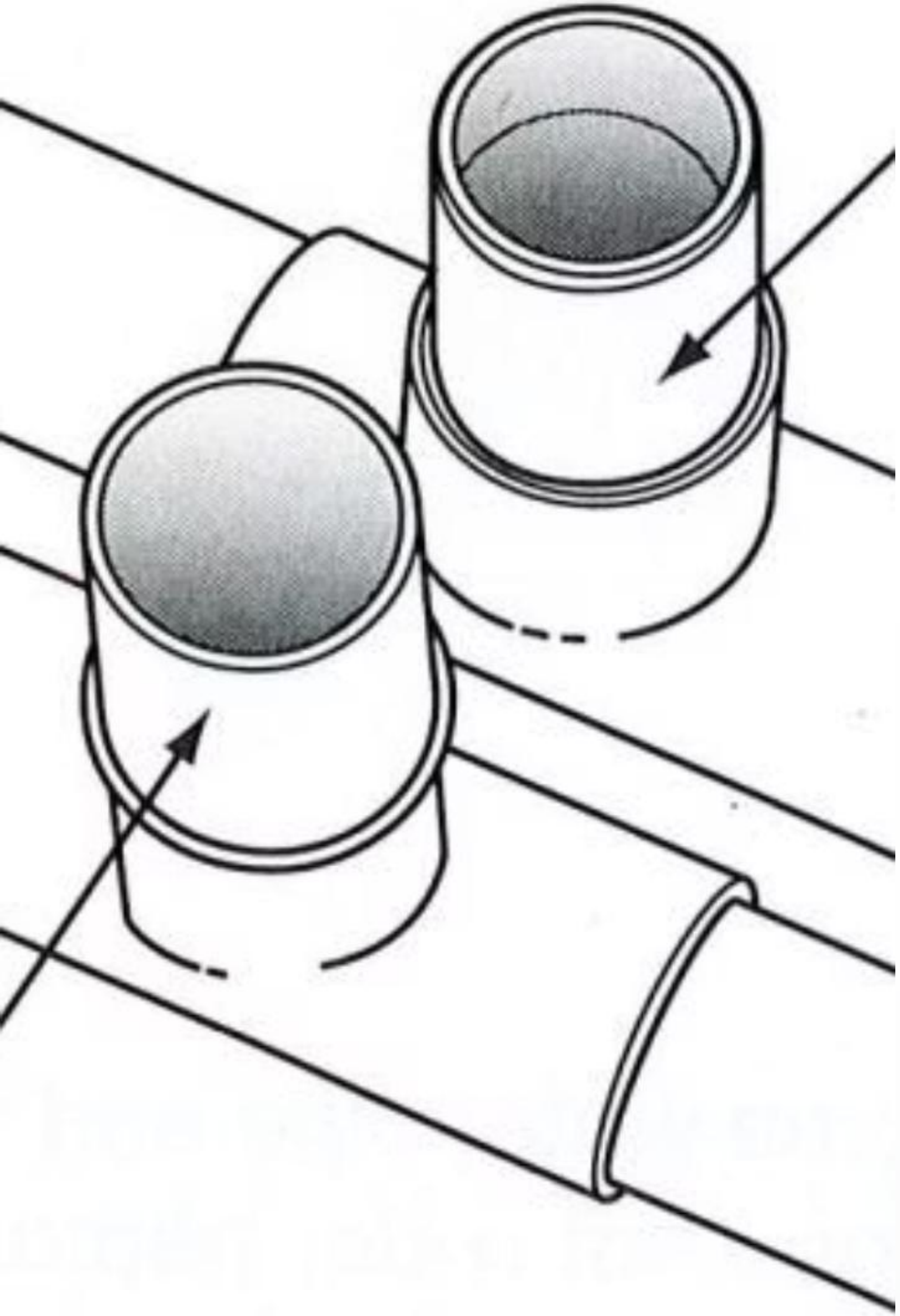
Working beyond the scope of your licensing coverage may carry liability as per your local authority having jurisdiction (AHJ)



Water Distribution Terminology

Water Distribution Piping

With regard to potable water systems, is what you use to identify piping downstream of the main shut-off valve (control valve) usually at the water meter.



Copper Tubing Types

Type	Colour Code	Available In
Type K copper	Green	Coils (soft copper), Rigid lengths (hard copper)
Type L copper	Blue	Coils (soft copper), Rigid lengths (hard copper)
Type M copper	Red	Coils (soft copper), Rigid lengths (hard copper)

You can use only the hard copper rigid lengths for water distribution piping.

Steel Pipe for Water Distribution

Galvanized Steel Pipe

You may use welded and seamless steel galvanized pipe for water supply in industrial applications or for the repair of existing galvanized pipe for water supply.

Plastic Pipe Types

Types of Plastic Pipe

Several types of plastic pipe are used for water distribution; however, some are limited to cold water applications only.

Applications

- Some plastic pipes can be used for both hot and cold water
- Others are limited to cold water applications only
- Different joining methods are required for different types

REDUCED TEE (M/F/F)

PVC Y TEE FM

REDUCED Y TEE (M/F/F)

SWEEP TEE (M/F/F)

Plastic Pipe Types and Applications

Type	Abbreviation	Distribution Permitted
Polyvinyl Chloride series 80, 100, 125, 160, 200	PVC	For cold water distribution only
Chlorinated polyvinyl chloride	CPVC	Hot and cold-water distribution
Polybutylene	Poly B	Hot and cold-water distribution
Polyethylene aluminum polyethylene	PE-AL-PE	Cold water distribution only
Cross-linked polyethylene aluminum cross-linked polyethylene	PEX-AL-PEX	Hot and cold-water distribution
Polypropylene	PP-R	Hot and cold-water distribution

Joining Methods Overview

Threaded

Used on some water pipe and fittings

Soldered

Common for joining copper tubing

Compression

Often used with copper and plastic tubing

Flared

Used on soft copper tubing

Solvent Welded

Used with some plastic pipes

Crimped

Used with plastic tubing

Cold Flared

Another method for joining pipes

Threaded Joints

Description

Threaded joints are what you use on some water pipe and fittings, as well as adapters such as those used to join the threaded outlets of a hot water to incoming copper or plastic water distribution tubing.

You should use an approved thread sealant with this type of joint.

Figure 5-2
Threaded joint

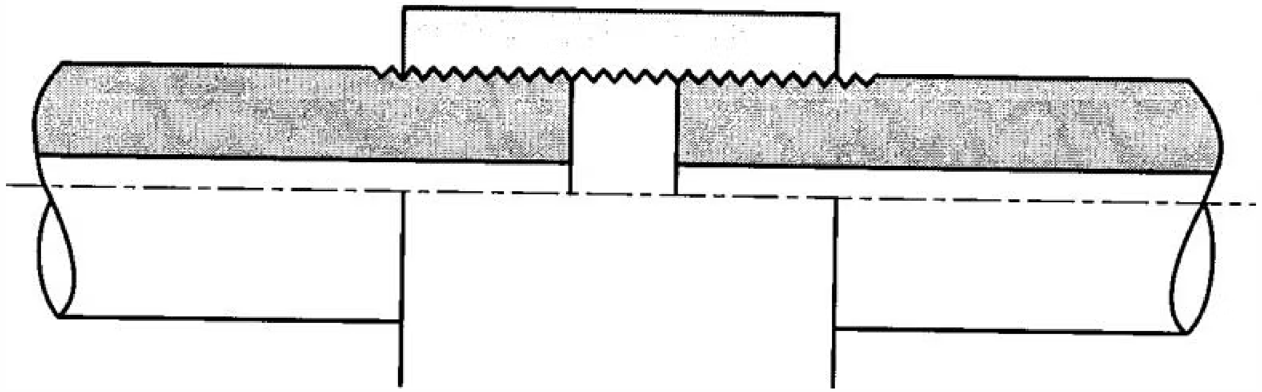
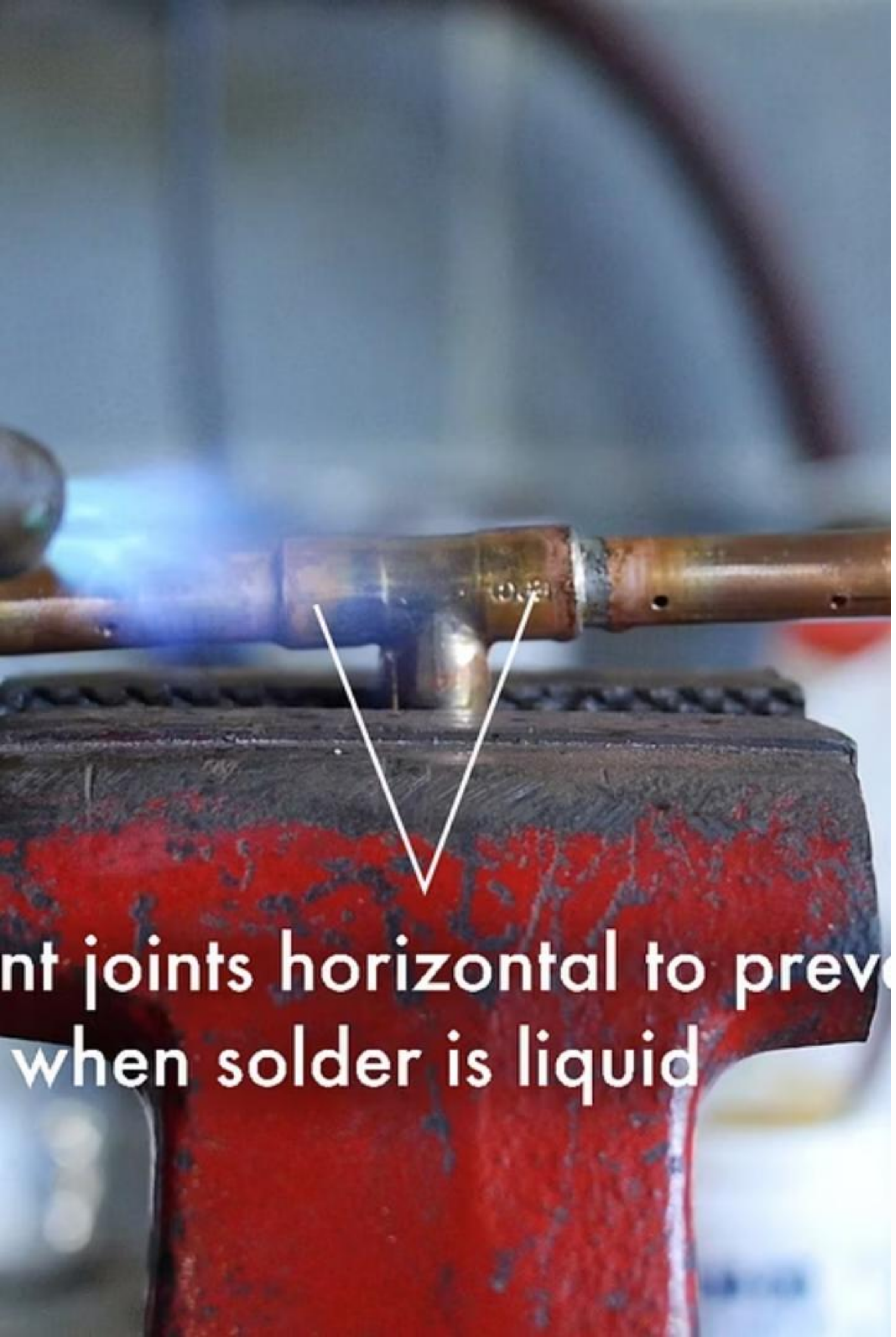


Figure 5-2 shows a typical threaded joint.



Solder Joints

Definition

Soldering can refer to the process of joining two or more pieces of metal together by means of an alloy that has a lower melting temperature than the metal being joined.

Solder Types

The many different solders available use alloys consisting of various combinations of tin, head, silver, and copper.

Soft Soldering vs. Hard Soldering

Common Practice

The joining of copper tubing using hard and soft solders is common in the plumbing and gas trades.

Key Differences

The difference between a soft-soldered joint and one that is hard-soldered (also known as silver brazing) is the melting temperature of the solder.

Hard solders have a melting temperature above 1000°F (537°C) and provide a stronger joint.

Health Considerations

With concerns related to lead exposure, plumbing products such as flux and solder now come lead-free.

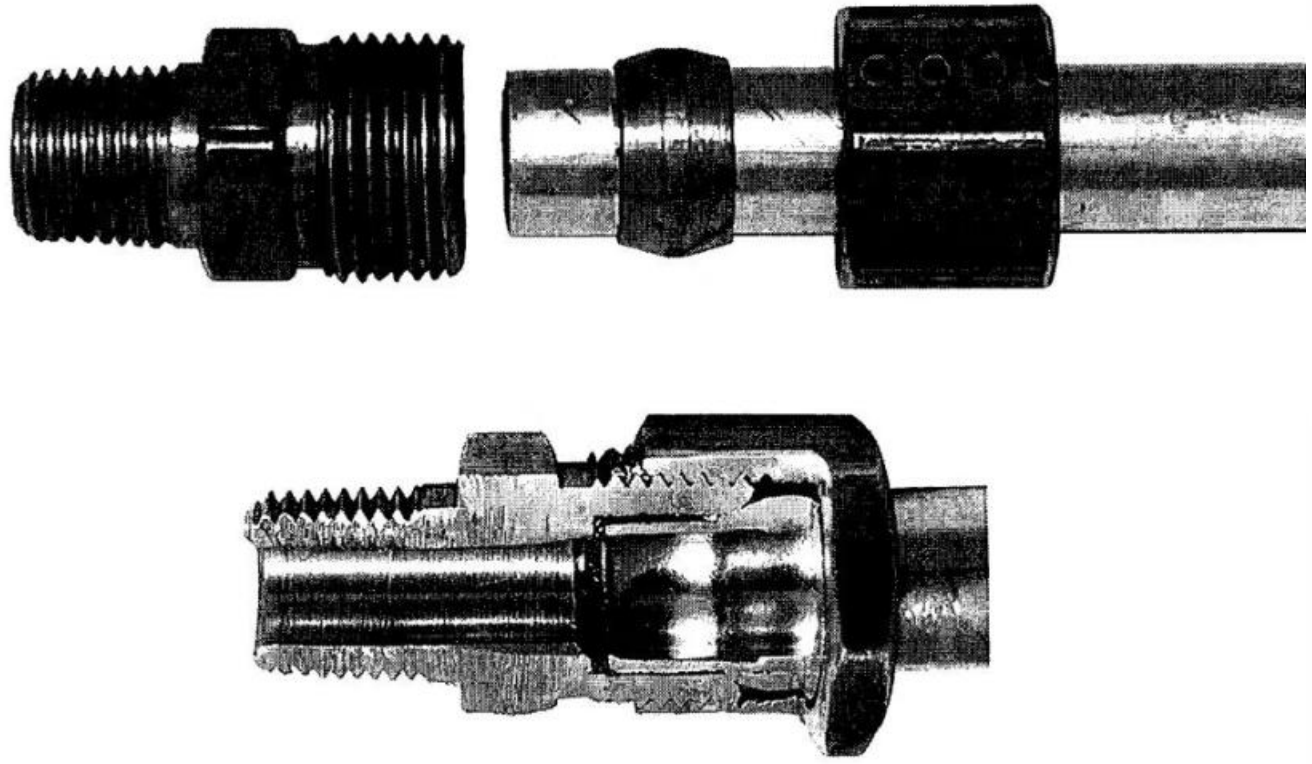
Compression Joints

Components

A compression-type fitting often joins copper and plastic tubing. A compression fitting is composed of a fitting body, a nut, and a ferrule.

You place the nut and ferrule over the tubing, then insert the tubing into the fitting body. You then tighten the external thread of the fitting body, compressing the ferrule and sealing the joint.

Figure 5-3
Compression joint fitting
Image courtesy of Terry Bell



In some cases when plastic tubing is used, place a supporting insert inside the tubing to prevent it from collapsing as it is being tightened.

Flared Joints - Part 1

Purpose

Flared joints are what you use on soft copper tubing. This type of joint requires a special tool to form the flare on the end of the tubing.

Step 1

Cut the end of the copper tubing square and smooth. You may ream the inside edge and slightly chamfer the outside edge to ensure a clean, tight joint.

Step 2

Place a flare nut and any other necessary parts of the fitting over the copper tubing in the correct orientation and slide down the tubing to leave the end clear for flaring.

Flared Joints - Part 2

Step 3

Insert the tubing into the block of the flaring tool. The block or die bar of the compression-type flaring tool shown in Figure 5-4 swings open to allow insertion of the copper tubing and, when closed and tightened by means of wing nuts, holds the tubing securely in position.

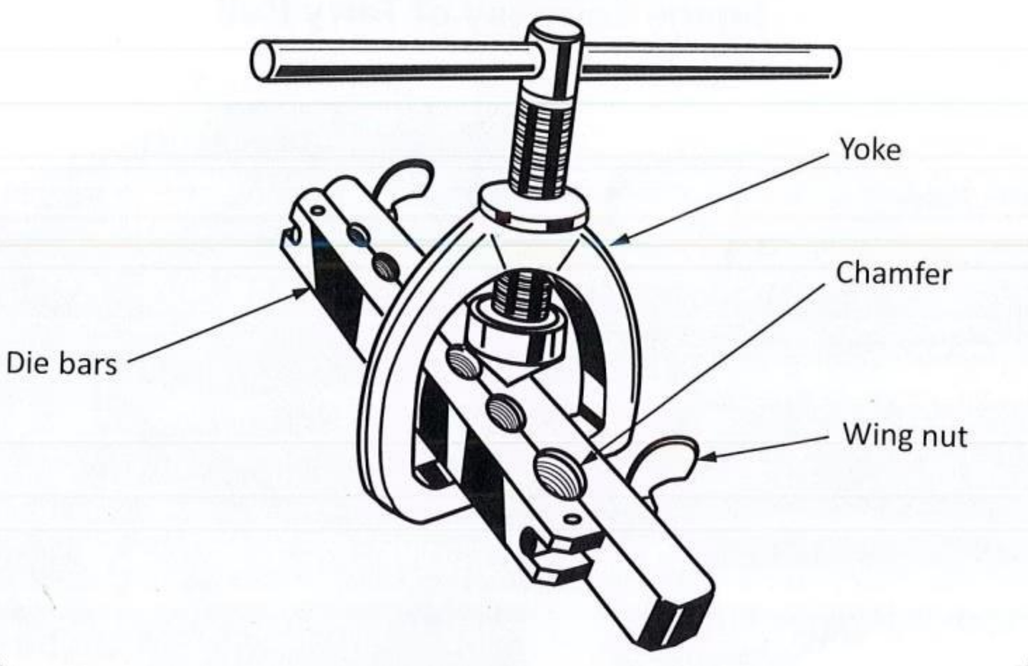
Alternative Tool

You can also use a ratchet-style flaring tool. See Figure 5-5.

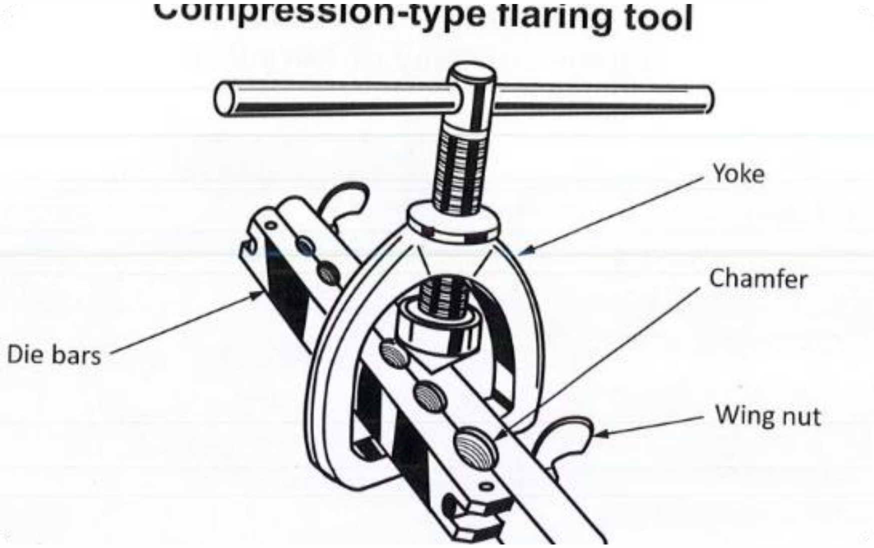
Step 4

Centre the die over the open end of the tubing and turn the handle to force the die down onto tubing to form the flare.

Figure 5-4
Compression-type flaring tool

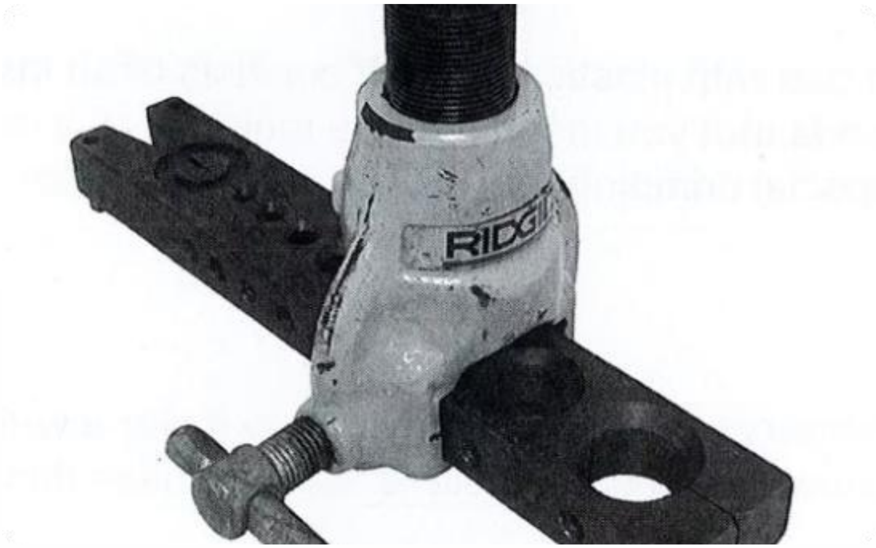


Flaring Tools



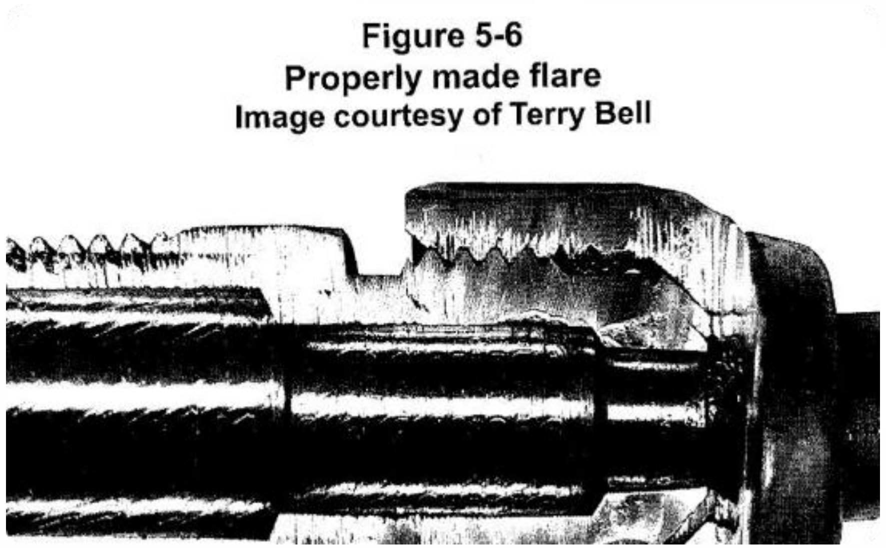
Compression-Type Flaring Tool

Traditional flaring tool with wing nuts to secure the tubing



Ratchet-Style Flaring Tool

More modern design with ratchet mechanism for easier operation



Properly Made Flare

Example of a correctly formed flare on copper tubing

Solvent-Welded Joints

Preparation

Some plastic pipes are joined by using solvent cement (glue). The piping end must be square and the pipe and socket fitting must be clean and dry.

Application

Apply the cement to both the pipe and socket, and push the pipe into the socket to complete and arrange the joint.

Compatibility

The cement must be suitable for the type of pipe being used.

Crimped Joints

Application

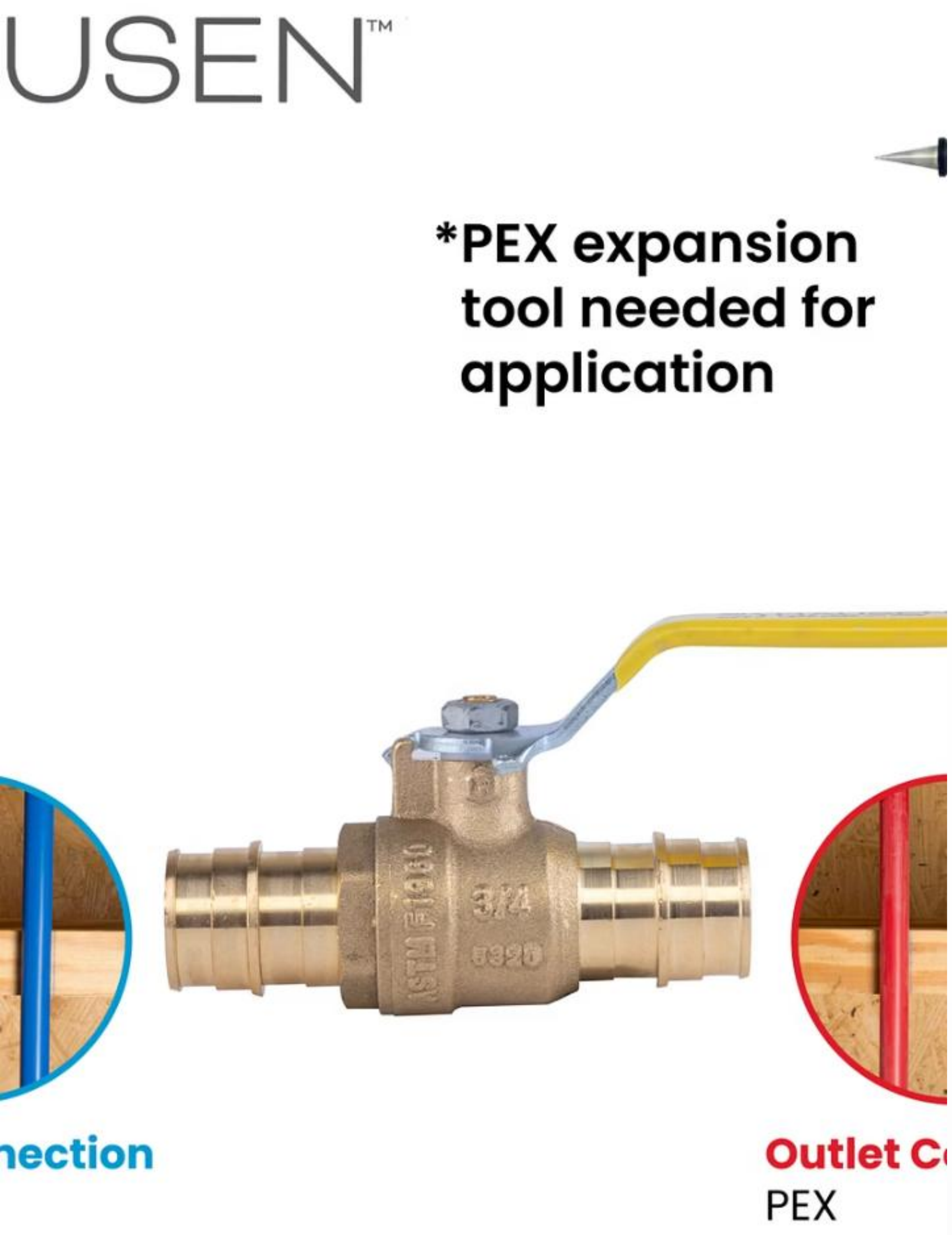
This type of joint is what you use with plastic tubing.

Components

It consists of an insert fitting with raised grooves (barb type) on the ends that you insert into the tubing, and a crimp ring that you place over the tubing.

Process

Use a special crimping tool sized for that diameter of tubing to compress the ring.



Expansion Joints - Part 1

Principle

This type of joint uses the memory effect of polyethylene to make a water-tight seal and is typically used with PEX-a, cross-linked polyethylene (Uponor uses this manufacturer and joining method).

Mechanism

The fitting is slightly larger than the original inside diameter of the tubing, so the memory effect allows the tubing to return to its original form, providing a continuous, watertight seal.

Expansion Joints - Part 2

Step 1

Cut the tubing square, and then place a polyethylene collar over the end of the tubing.

Step 2

Place a special tool in the end of the tube, and expand the tubing and collar.

Step 3

Remove the tool and insert the fitting into the tubing.

Step 4

The tubing immediately tries to return to its original diameter, in effect shrinking itself around the fitting to create a water-tight seal.

Expansion Joint Features

Extra Strength

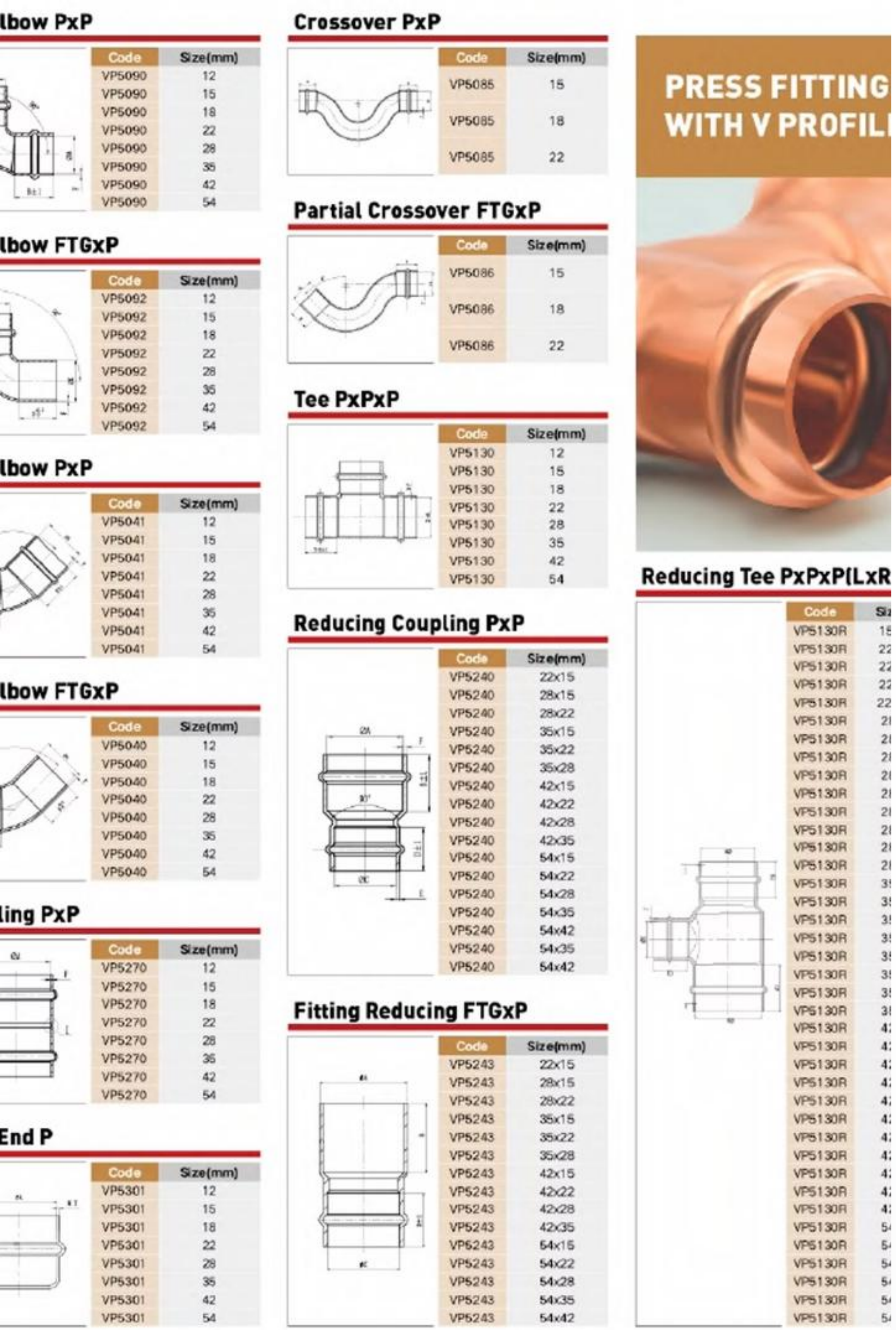
The collar provides extra strength at the joint.

Color Coding

It is also colour coded to provide identification of hot and cold-water lines.

More Information

Visit www.uponor.ca.



lbow PxP

Code	Size(mm)
VP5090	12
VP5090	15
VP5090	18
VP5090	22
VP5090	28
VP5090	35
VP5090	42
VP5090	54

lbow FTGxP

Code	Size(mm)
VP5092	12
VP5092	15
VP5092	18
VP5092	22
VP5092	28
VP5092	35
VP5092	42
VP5092	54

lbow PxP

Code	Size(mm)
VP5041	12
VP5041	15
VP5041	18
VP5041	22
VP5041	28
VP5041	35
VP5041	42
VP5041	54

lbow FTGxP

Code	Size(mm)
VP5040	12
VP5040	15
VP5040	18
VP5040	22
VP5040	28
VP5040	35
VP5040	42
VP5040	54

ling PxP

Code	Size(mm)
VP5270	12
VP5270	15
VP5270	18
VP5270	22
VP5270	28
VP5270	35
VP5270	42
VP5270	54

End P

Code	Size(mm)
VP5301	12
VP5301	15
VP5301	18
VP5301	22
VP5301	28
VP5301	35
VP5301	42
VP5301	54

Crossover PxP

Code	Size(mm)
VP5085	15
VP5085	18
VP5085	22

Partial Crossover FTGxP

Code	Size(mm)
VP5086	15
VP5086	18
VP5086	22

Tee PxPxP

Code	Size(mm)
VP5130	12
VP5130	15
VP5130	18
VP5130	22
VP5130	28
VP5130	35
VP5130	42
VP5130	54

Reducing Coupling PxP

Code	Size(mm)
VP5240	22x15
VP5240	28x15
VP5240	28x22
VP5240	35x15
VP5240	35x22
VP5240	35x28
VP5240	42x15
VP5240	42x22
VP5240	42x28
VP5240	42x35
VP5240	54x15
VP5240	54x22
VP5240	54x28
VP5240	54x35
VP5240	54x42
VP5240	54x35
VP5240	54x42

Fitting Reducing FTGxP

Code	Size(mm)
VP5243	22x15
VP5243	28x15
VP5243	28x22
VP5243	35x15
VP5243	35x22
VP5243	35x28
VP5243	42x15
VP5243	42x22
VP5243	42x28
VP5243	42x35
VP5243	54x15
VP5243	54x22
VP5243	54x28
VP5243	54x35
VP5243	54x42

Reducing Tee PxPxP(LxR

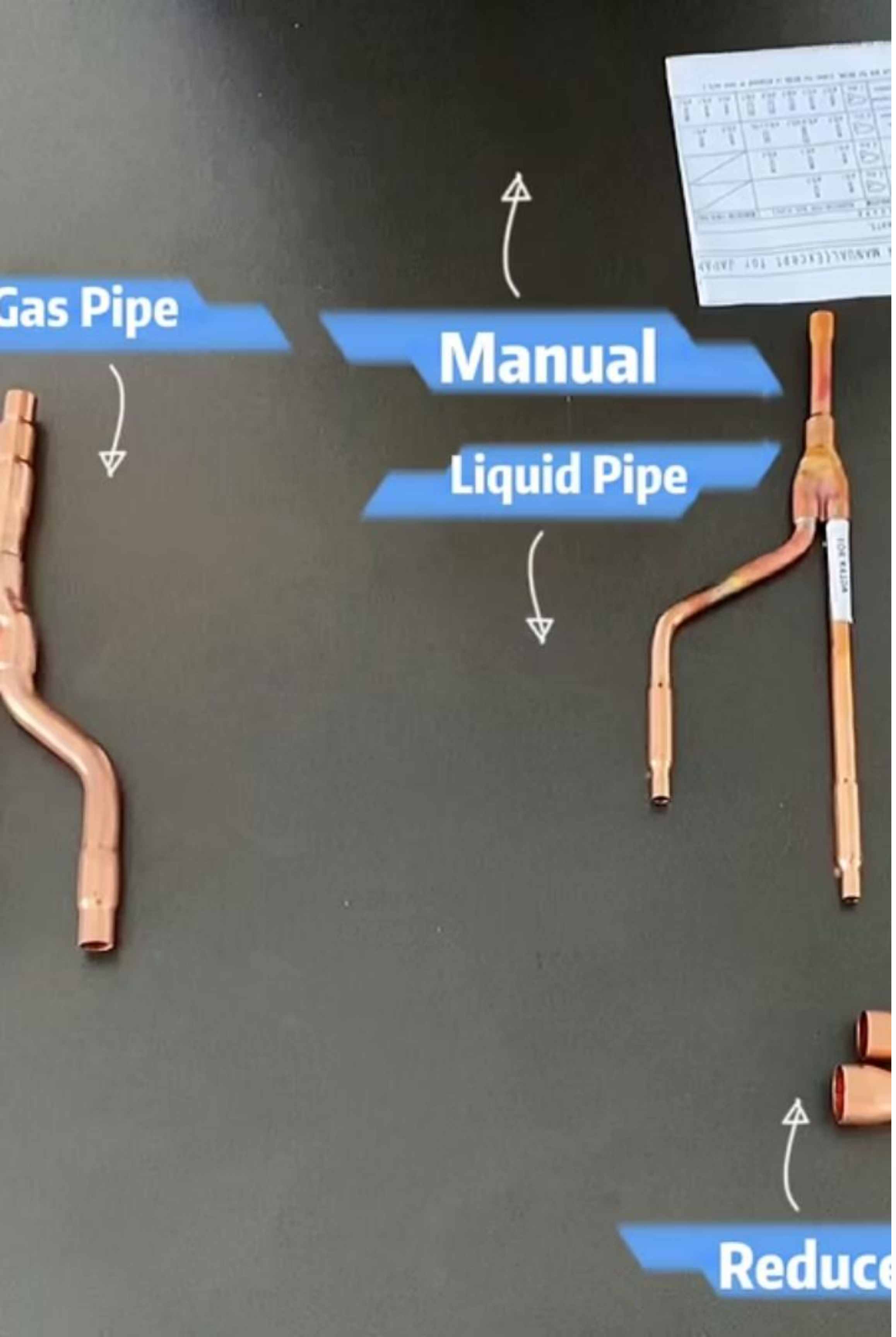
Applications and Joints Overview

Reference Table

Table 5-1 shows the common applications and joints that gas technicians/fitters use for copper and plastic pipe and tubing.

Importance

Understanding which joining methods are appropriate for each type of pipe and application is essential for proper installation.



Applications and Joints - Copper

Pipe/tube	Hot water	Cold water	Threaded	Solder	Flare	Compression
Type K copper	✓	✓		✓	✓	✓
Type L copper	✓	✓		✓	✓	✓
Type M copper	✓	✓		✓	✓	✓

Applications and Joints - Plastic

Pipe/ tube	Hot water	Cold water	Threaded	Solvent weld	Crimp	Cold flare
PVC		✓		✓		
CPVC	✓	✓		✓		
Poly B	✓	✓			✓	
PEX	✓	✓			✓	✓

Applications and Joints - Composite

Pipe/ tube	Hot water	Cold water	Threaded	Compression	Crimp	Cold flare
PE-AL-PE		✓		✓	✓	✓
PEX-AL-PEX	✓	✓		✓	✓	✓
PP-R	✓	✓				✓

Copper Tubing Installation Best Practices

Proper Measurement

Always measure twice and cut once to ensure accurate fitting

Clean Cuts

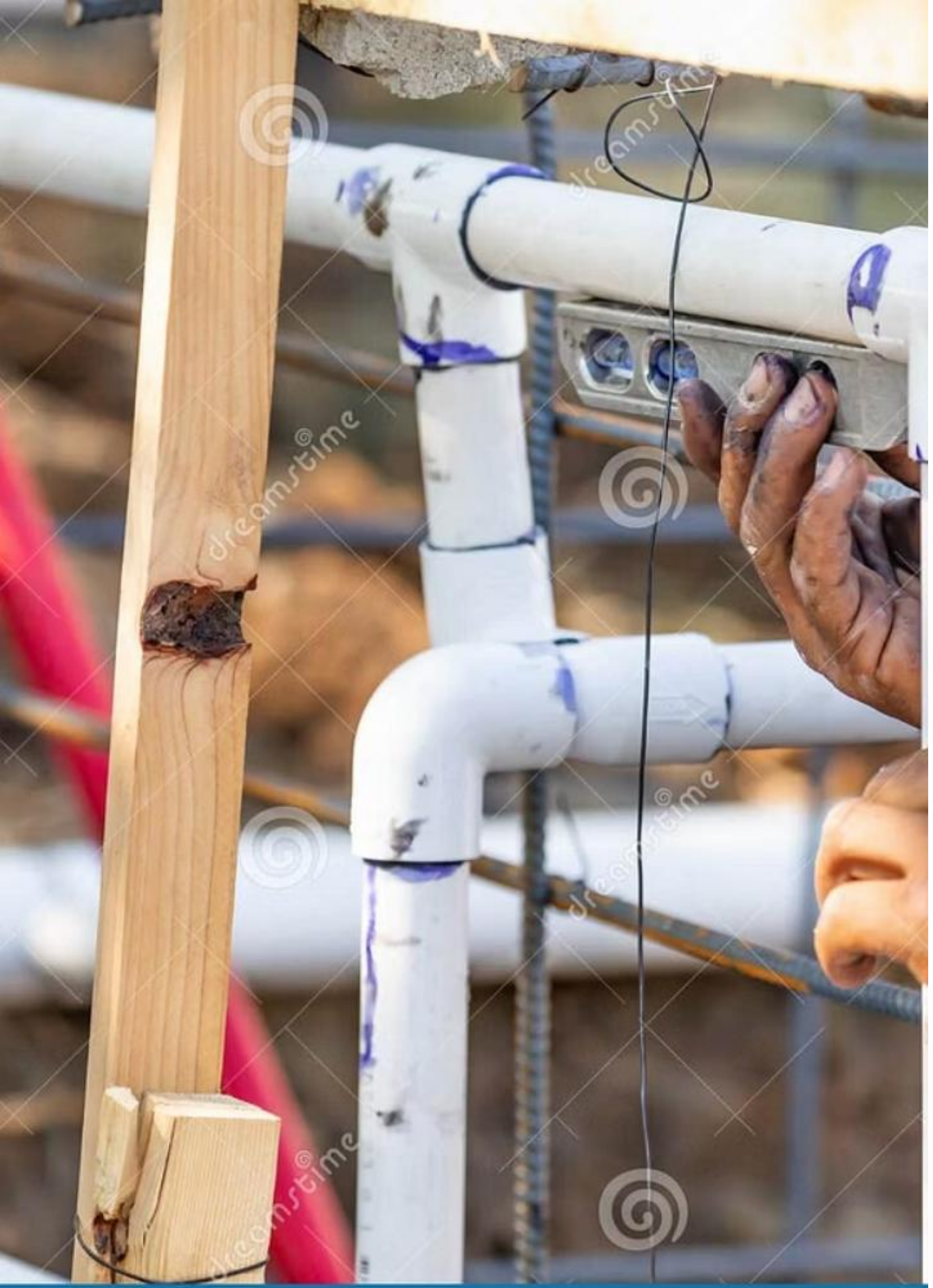
Use a proper tube cutter to ensure square, clean cuts

Deburring

Always deburr the inside of the pipe after cutting to ensure proper water flow

Clean Surfaces

Ensure all surfaces are clean before soldering or making compression connections



Plastic Pipe Installation Best Practices

Temperature Considerations

Be aware of the temperature limitations of each plastic pipe type

Proper Support

Install adequate pipe supports to prevent sagging

Expansion Allowance

Allow for thermal expansion, especially with hot water lines

UV Protection

Protect plastic pipes from UV exposure which can degrade the material

Common Installation Mistakes

Mixed Metals

Installing dissimilar metals without proper dielectric unions can lead to galvanic corrosion

Improper Support

Inadequate pipe support can lead to sagging, stress on joints, and potential leaks

Wrong Application

Using cold-water-only pipes for hot water applications can lead to failure

Poor Joints

Improperly made joints are the most common source of leaks in water distribution systems

Copper Pipe Advantages

Durability

Long service life with proper installation

Heat Resistance

Excellent for hot water applications

Biostatic Properties

Naturally inhibits bacterial growth

Recyclability

Environmentally friendly and recyclable

Plastic Pipe Advantages

Lightweight

Easier to handle and install

Corrosion Resistance

Will not corrode like metal pipes

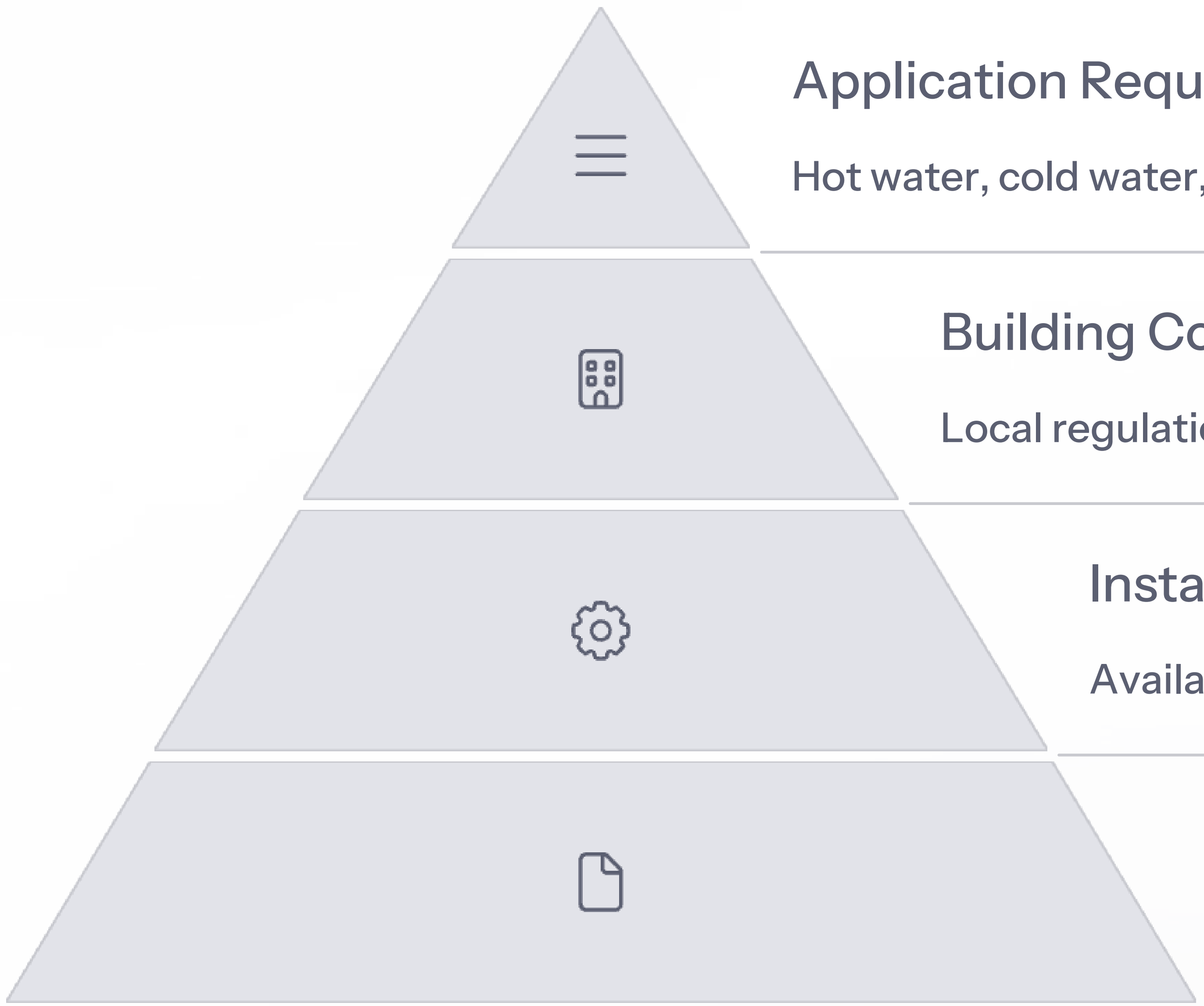
Cost-Effective

Generally less expensive than copper

Noise Reduction

Quieter water flow compared to metal pipes

Selecting the Right Pipe for the Job



Application Requirements

Hot water, cold water, or both

Building Code Compliance

Local regulations and fire code requirements

Installation Considerations

Available tools, skills, and space constraints

Budget Constraints

Material and labor costs

Water Quality Considerations

pH Level

Acidic water can corrode metal pipes over time

Mineral Content

Hard water can cause scale buildup in pipes

Water Temperature

Affects pipe material selection and longevity

Chemical Treatments

Some water treatments can affect pipe materials

Pressure Considerations

80 PSI

Maximum Residential Pressure

Typical maximum recommended water pressure for residential systems

40-60 PSI

Ideal Pressure Range

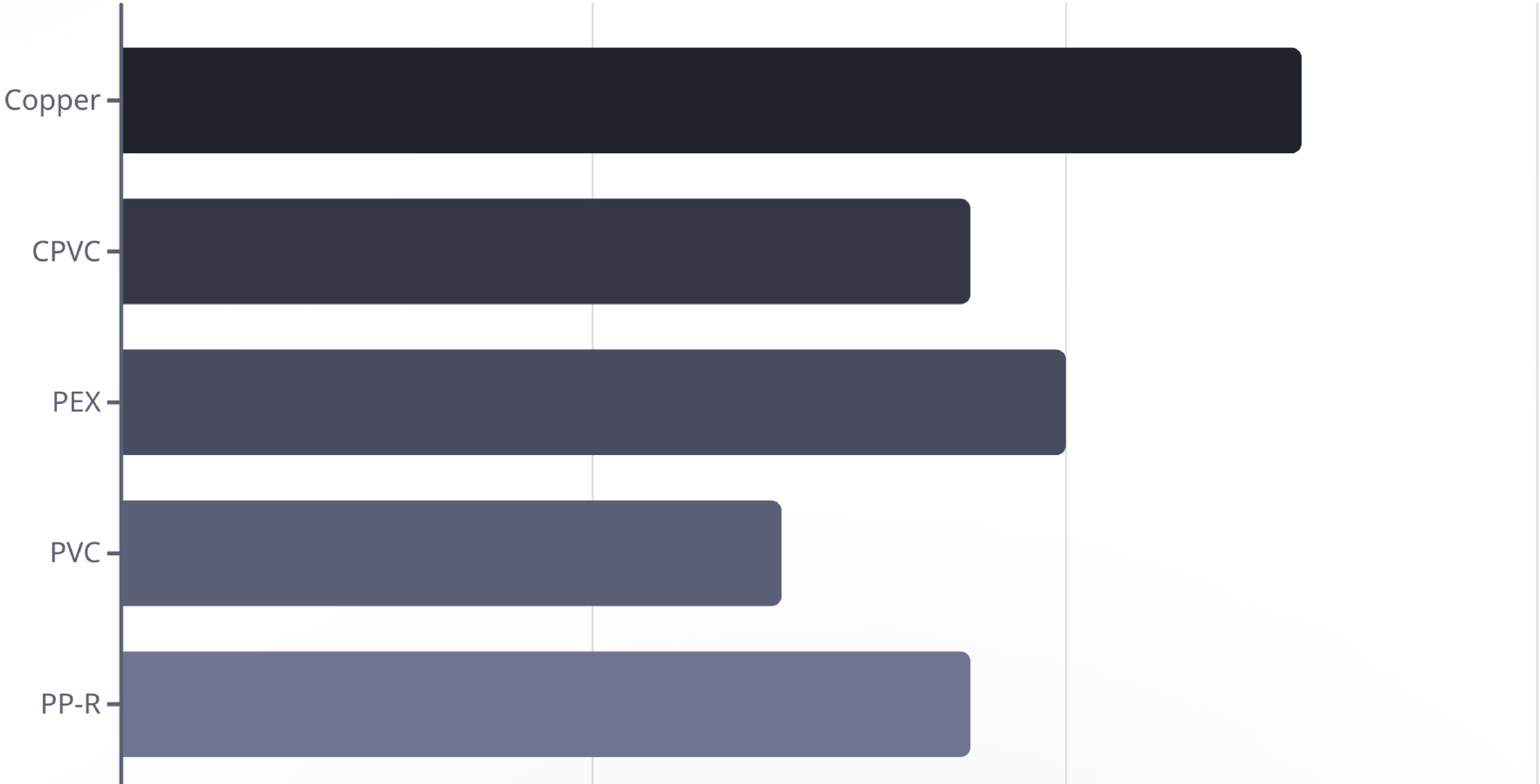
Optimal pressure range for most residential applications

125 PSI

Type L Copper Rating

Typical pressure rating for Type L copper at 180°F

Temperature Considerations



Pipe Sizing Considerations

Factors Affecting Pipe Size

- Flow rate requirements
- Pressure drop limitations
- Fixture unit demands
- Length of pipe run
- Number of fittings

Common Residential Sizes

- 3/4" main supply line
- 1/2" branch lines to fixtures
- 3/8" supply lines to individual fixtures

Always consult local plumbing codes for specific requirements in your area.

Tools for Copper Pipe Installation







Essential tools for working with copper pipe include pipe cutters, deburring tools, torches, flux, solder, wrenches, and measuring tools.

Tools for Plastic Pipe Installation

Tools for plastic pipe installation vary depending on the type of plastic and joining method, but commonly include specialized cutters, crimping tools, expansion tools, and solvent cements.

Safety Considerations

Fire Safety

When soldering, always have a fire extinguisher nearby and use heat shields to protect combustible materials

Ventilation

Ensure proper ventilation when using solvent cements or fluxes

Personal Protection

Wear appropriate gloves, eye protection, and clothing

Electrical Hazards

Be aware of electrical wiring when cutting into walls or ceilings

Testing Water Distribution Systems

Visual Inspection

Check all joints and connections for proper installation

Pressure Testing

Apply test pressure according to local code requirements (typically 1.5 times working pressure)

Leak Detection

Inspect all joints and connections for leaks

Documentation

Record test results as required by local authorities

Troubleshooting Common Issues

Leaking Joints

Check for improper soldering, loose compression fittings, or damaged threads

Low Water Pressure

Look for restrictions, undersized piping, or partially closed valves

Noisy Pipes

Check for water hammer, loose pipe supports, or excessive water velocity

Discolored Water

Investigate corrosion issues, sediment buildup, or municipal water problems

Maintenance Recommendations

Regular Inspection

Check visible pipes and connections periodically for signs of leaks or corrosion

Pressure Monitoring

Install and check pressure gauges to ensure system operates within proper range

System Flushing

Periodically flush water heaters and boilers according to manufacturer recommendations

Freeze Protection

Insulate pipes in unheated areas and drain outdoor pipes before freezing weather

Cross-Connection Control

Definition

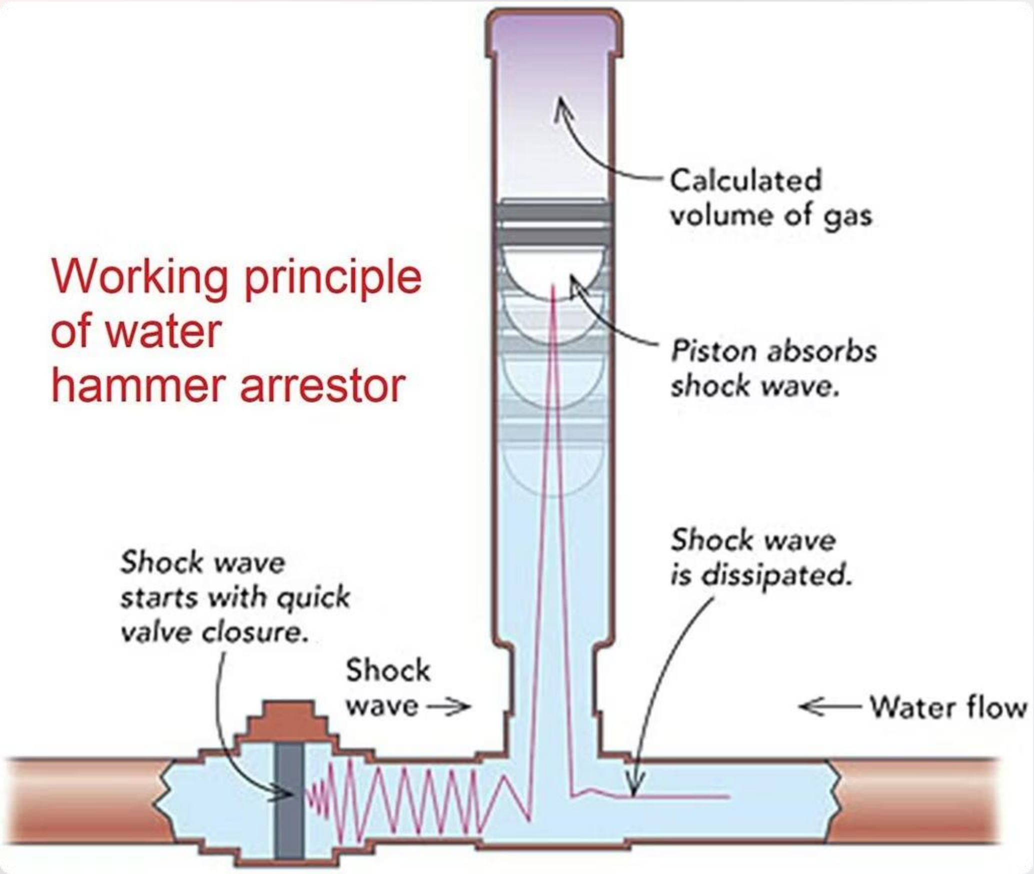
A cross-connection is any physical connection between a potable water supply and any source of contamination.

Prevention Devices

- Backflow preventers
- Vacuum breakers
- Air gaps
- Check valves

Importance

Proper cross-connection control is essential to prevent contamination of the potable water supply.



Water Hammer Prevention

What is Water Hammer?

Water hammer is the banging noise that occurs when flowing water suddenly stops or changes direction, creating a pressure wave in the pipes.

Prevention Methods

- Install water hammer arrestors
- Secure pipes properly with adequate supports
- Reduce water pressure if excessive
- Install slow-closing valves

Location Recommendations

Install water hammer arrestors near quick-closing valves, such as those on washing machines, dishwashers, and toilets.

Thermal Expansion Considerations

The Issue

When water is heated, it expands. In a closed system (with backflow prevention), this expansion can create excessive pressure.

Solutions

- Thermal expansion tanks
- Pressure relief valves
- Expansion loops in piping

Installation Location

Expansion tanks should be installed on the cold water supply line to the water heater.

Pipe Insulation

Energy Efficiency

Insulating hot water pipes reduces heat loss and saves energy

Freeze Protection

Insulation helps prevent pipes from freezing in cold areas

Condensation Prevention

Insulating cold water pipes prevents condensation and potential water damage

Noise Reduction

Insulation can help reduce water flow noise in pipes

Water Heater Connections

Copper Connections

Copper piping connected to water heaters should use dielectric unions to prevent galvanic corrosion between dissimilar metals.

PEX Connections

When using PEX tubing, ensure it's rated for the temperatures near the water heater. Some codes require metal piping for the first 18 inches from the water heater.

Safety Devices

All water heaters must have properly installed temperature and pressure relief valves with appropriate discharge piping.

Boiler Connections

Supply and Return Lines

Boiler connections typically include supply and return lines, which must be properly sized according to the boiler's specifications.

Safety Devices

Boilers require pressure relief valves, expansion tanks, and other safety devices as specified by local codes.

Zone Controls

Multi-zone systems require appropriate valves and controls to direct hot water to different areas of the building.

Future Trends in Water Distribution

Smart Water Systems

Integration of sensors and controls for leak detection and water management

Eco-Friendly Materials

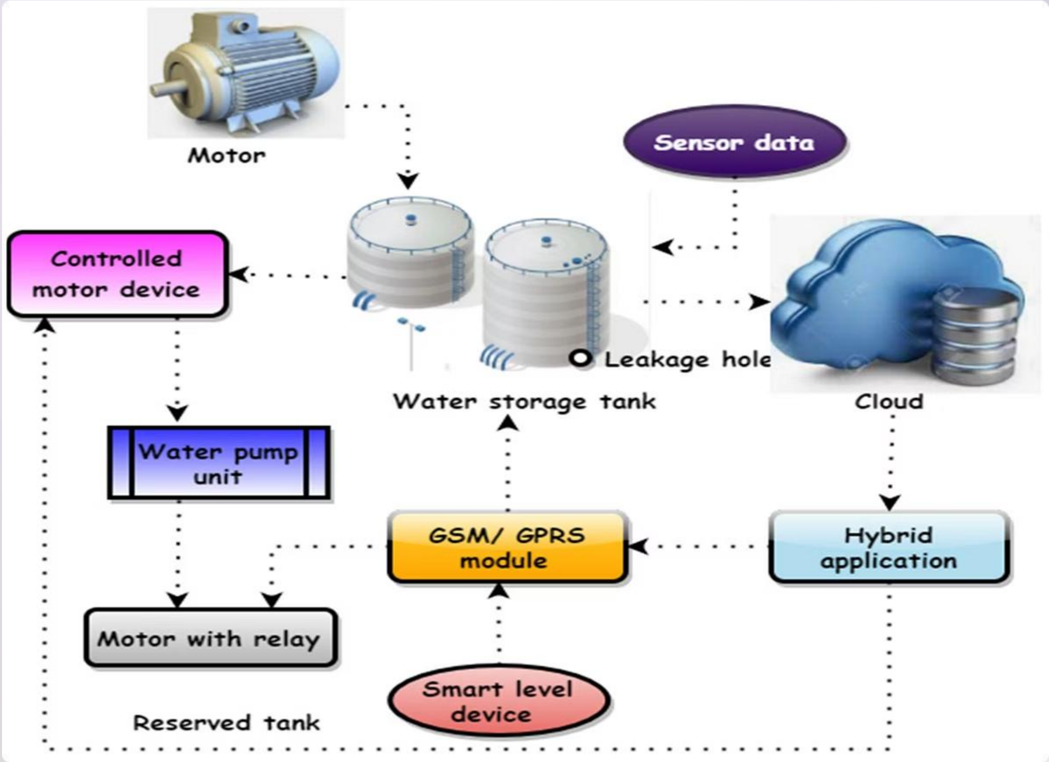
Development of more sustainable and environmentally friendly piping materials

Water Recycling

Increased implementation of greywater systems for water conservation

Energy Efficiency

Better insulation and distribution designs to reduce energy consumption



Code Compliance Checklist

Verify Local Codes

Ensure you're familiar with the specific requirements in your jurisdiction

Confirm Material Approvals

Verify that all materials are approved for their intended use

Check Support Requirements

Install proper pipe supports at required intervals

Perform Required Tests

Complete all pressure tests and inspections as required

Document Installation

Maintain records of materials, tests, and inspections

Professional Resources

Industry Associations

- American Society of Plumbing Engineers (ASPE)
- Plumbing-Heating-Cooling Contractors Association (PHCC)
- International Association of Plumbing and Mechanical Officials (IAPMO)

Code Publications

- International Plumbing Code (IPC)
- Uniform Plumbing Code (UPC)
- National Plumbing Code of Canada

Manufacturer Resources

- Installation guides
- Technical support
- Training programs

Summary

Identify Materials

Recognize different types of water distribution piping and tubing

Select Appropriate Materials

Choose the right materials for specific applications

Apply Joining Methods

Use proper techniques for connecting pipes and fittings

Ensure Code Compliance

Follow all relevant regulations and standards

Understanding water distribution piping and tubing materials, along with their appropriate joining methods, is essential for gas technicians and fitters when installing water heaters and boilers. Always consult local codes and manufacturer specifications for specific requirements in your area.

CSA Unit 8

Chapter 6
Sizing of piping and tubing systems

Overview

Purpose

The gas technician/fitter must be able to correctly measure and size gas piping systems for a variety of applications to ensure they perform safely and efficiently.

Proper sizing of gas piping systems is critical to ensure safe and efficient operation of gas appliances. This requires understanding various factors that affect pipe sizing and applying the correct calculations based on the specific application requirements.

Objectives

At the end of this Chapter, you will be able to:

Explain pipe measurement and fitting allowance

Understanding how to properly measure pipes and account for fittings

Describe sizing of low-pressure gas piping systems

Learning the methods for sizing pipes in systems with pressures below 0.5 psig

Describe sizing of 2 psig gas piping systems

Understanding the specific requirements for 2 psig systems

Describe sizing of high-pressure gas piping systems

Learning methods for sizing pipes in systems with pressures above 0.5 psig

Describe sizing of two-stage propane piping systems

Understanding the unique requirements for propane systems

Terminology

Term	Abbreviation (symbol)	Definition
Code zone	CZ	Horizontal grouping of flow values according to the longest measured run
Equivalent length	EL	For bends, fittings and valves, the comparable length of pipe needed to determine the length of equivalent run (LER). To determine this, use the appropriate capacity Tables in CSA B149.1.
Fitting allowance		Space between the centre of the fitting and the end of the pipe
Length of equivalent run	LER	Measured length of pipe added to the equivalent length of pipe
Measured length	ML	Length used in determining the size of any section of gas piping or tubing. The rows of the capacity Tables in CSA B149.1 shows the measured lengths in imperial and metric measurements.
Pressure drop		Working pressure at the meter installation downstream of the service regulator minus working pressure at the appliance
Thread engagement		Distance the pipe screws into the fitting

Factors affecting pipe sizing

Pipe sizing is an important consideration on a gas installation. Properly sized piping or tubing helps ensure that adequate supply pressure and volume of fuel is available at all appliance specifications for inlet pressure, and subsequently appliance firing rates, are achievable.

Gas piping should be large enough to meet maximum demands without undue pressure loss, i.e., a pressure drop, between the meter and the appliance.

Pressure drop is the working pressure at the meter installation downstream of the service regulator minus the working pressure at the appliance. The purpose of the pipe sizing tables is to assist you in determining the pipe size suitable for the project.

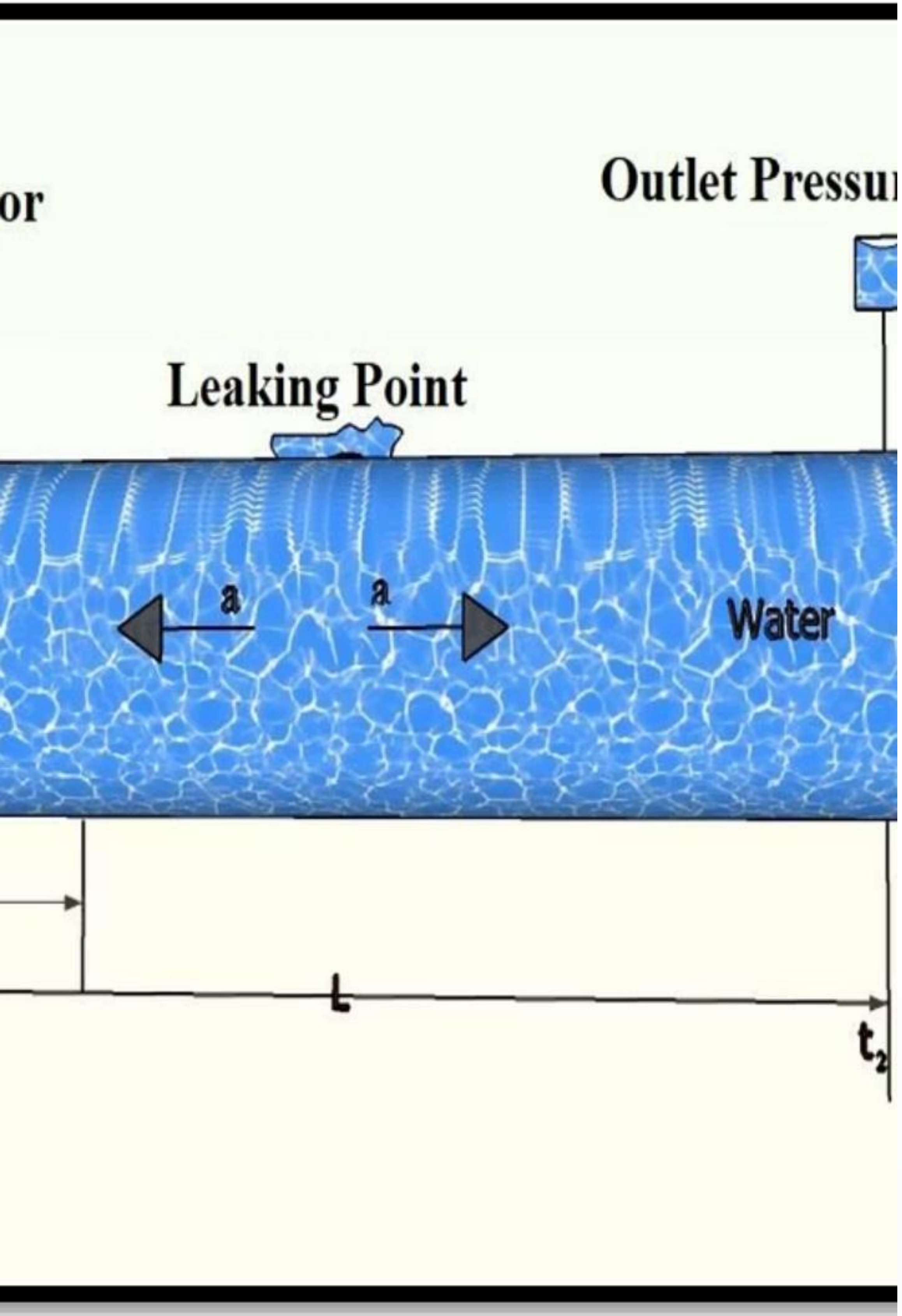
Undersized piping may lead to low gas pressure at the appliances, under-fired equipment, and poor performance. Oversized piping inflates job costs and wastes money.

Factors to Consider Before Installation

Factor	Consideration
Fuel type	Natural gas and propane have different calorific values—i.e., propane requires less fuel for the same btu rating of appliance- and different specific gravity.
Length of run	The greater the distance from the appliance to the meter, the larger the supply piping may have to be.
Allowable pressure drop	The supply pressure available will also determine pipe size.
Maximum gas consumption	You must account for the total load of all appliances firing at the same moment when sizing.
Piping configurations	The number of fittings, manifold headers, and branch lines utilized all become factors when sizing pipe.

Some piping manufacturers, such as the manufacturers of CSST products, supply their own sizing tables because the CSA B149.1 Tables do not take into account the special features and characteristics of these products. Passes in the required manufacturer training and certification would cover these piping specifics.

The steel piping tables in CSA B149.1 include plastic gas piping allowances, which can accommodate plastic as well as steel pipe.



Pipe measurement and fitting allowance

Pipe measuring methods

Generally, you use one of the following three methods to measure pipe lengths:

1. **End-to-end**

   Measuring the pipe without any fittings

2. **End-to-centre**

   Measuring from the centre of a fitting on one end to the opposite end of the pipe

3. **Centre-to-centre**

   Measuring the distance between the centres of two fittings in a line of pipe

End-to-end and End-to-centre Measurements

End-to-end

The "end-to-end" measurement is the measurement of the pipe without any fittings. See Figure 6-1.

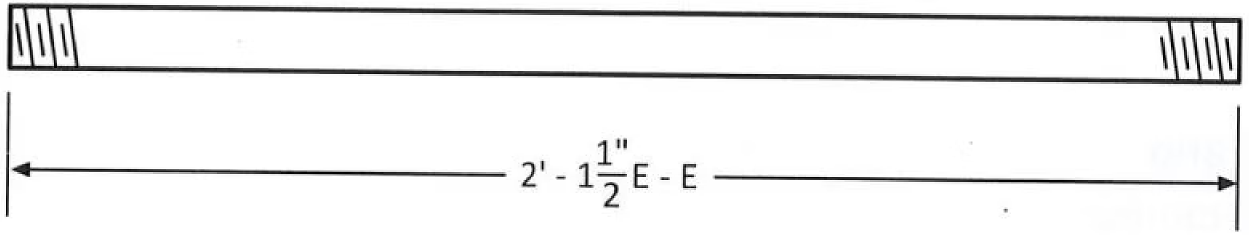


Figure 6-1 End-to-end measurement

End-to-centre

You take an "end-to-centre" measurement from the centre of a fitting screwed on one end to the opposite end of the pipe. See Figure 6-2.

Make an end-to-centre measurement by first tightening a fitting on the threaded end of a pipe. Place the end of the rule exactly in the centre of the fitting, measure along the pipe, and mark at the proper distance.

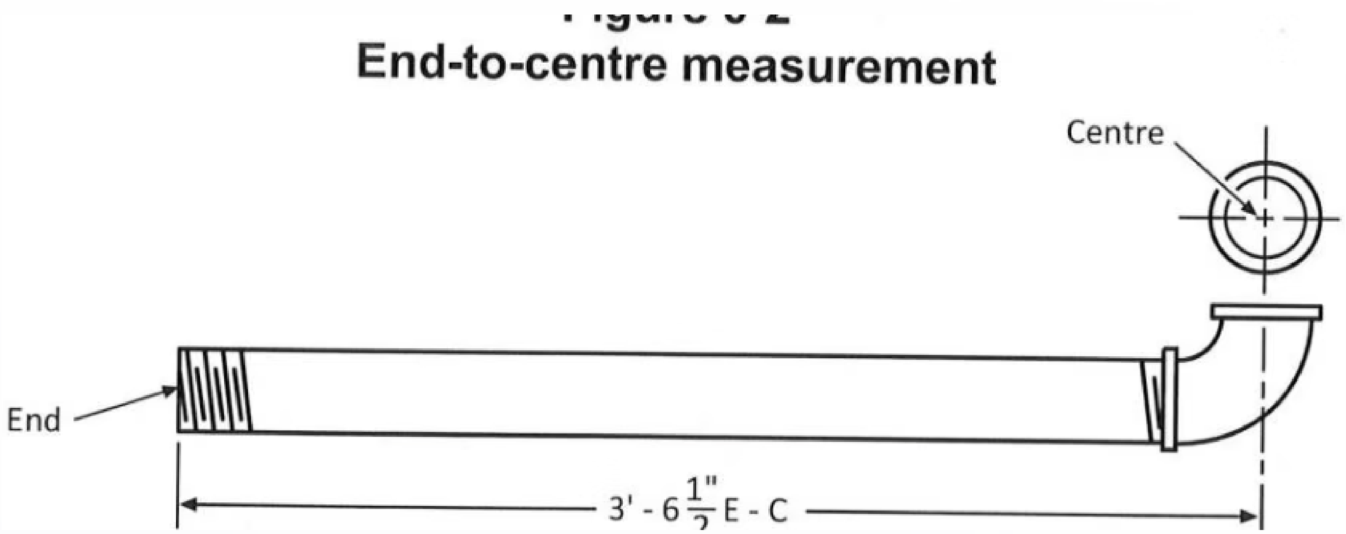


Figure 6-2

Centre-to-centre and Additional Measuring Methods

Centre-to-centre

Most pipe drawings are shown as "centre-to-centre" measurements. A centre-to-centre measurement is the distance between the centre of two fittings in a line of pipe. See Figure 6-3.

Centre-to-centre measurement

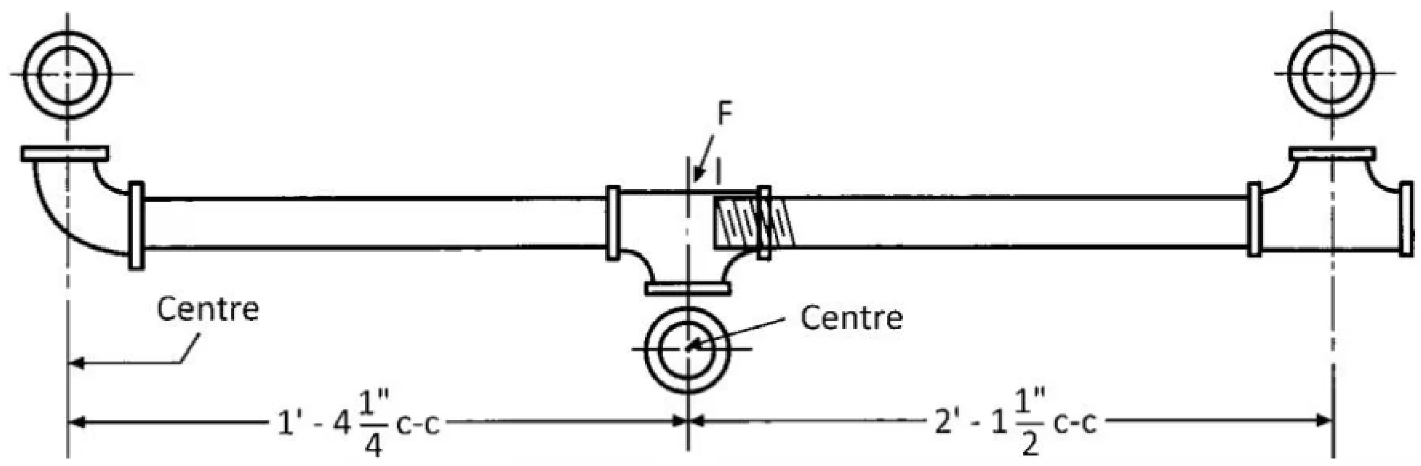


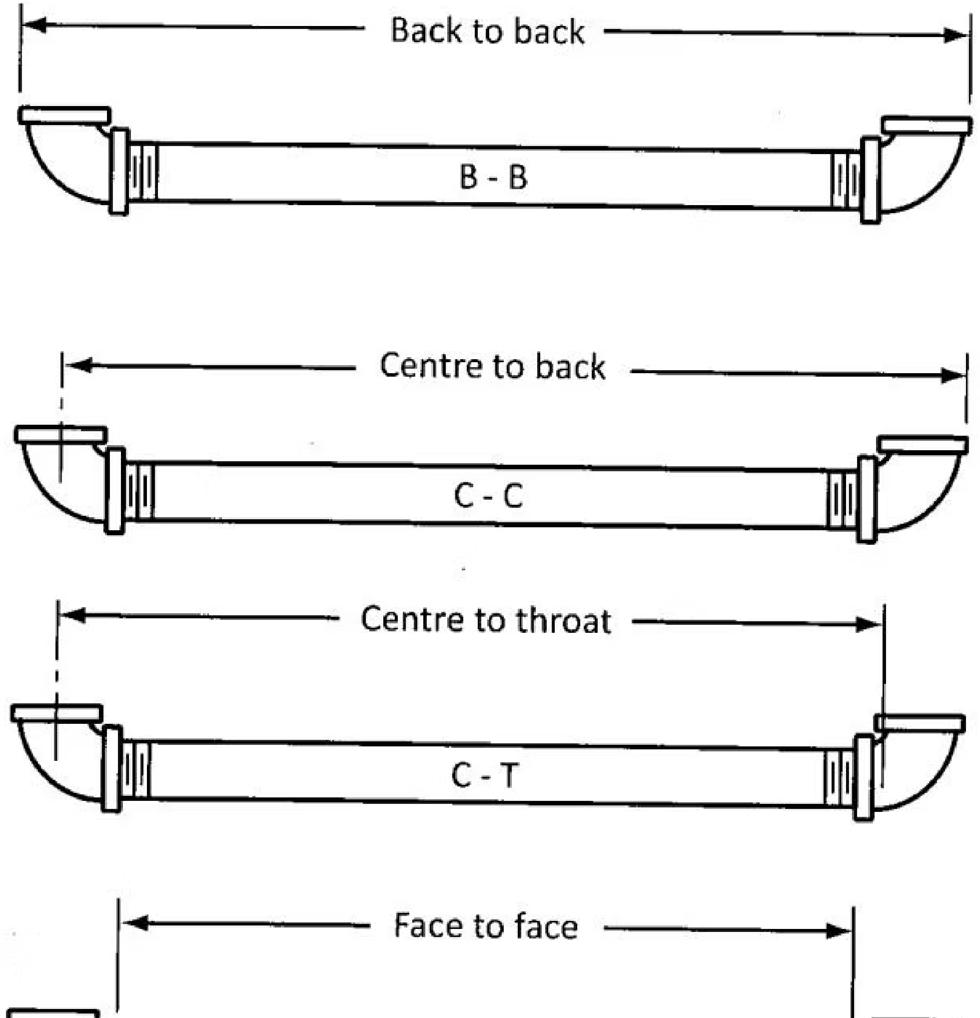
Figure 6-3

Additional measuring methods

Although not as commonly used as the preceding methods, there are additional methods of taking pipe measurements. These measurements, which you can see in Figure 6-4, are:

- back-to-back
- centre-to-back
- centre-to-throat
- overall centre-to-centre

Figure 6-4
Additional methods of measurement

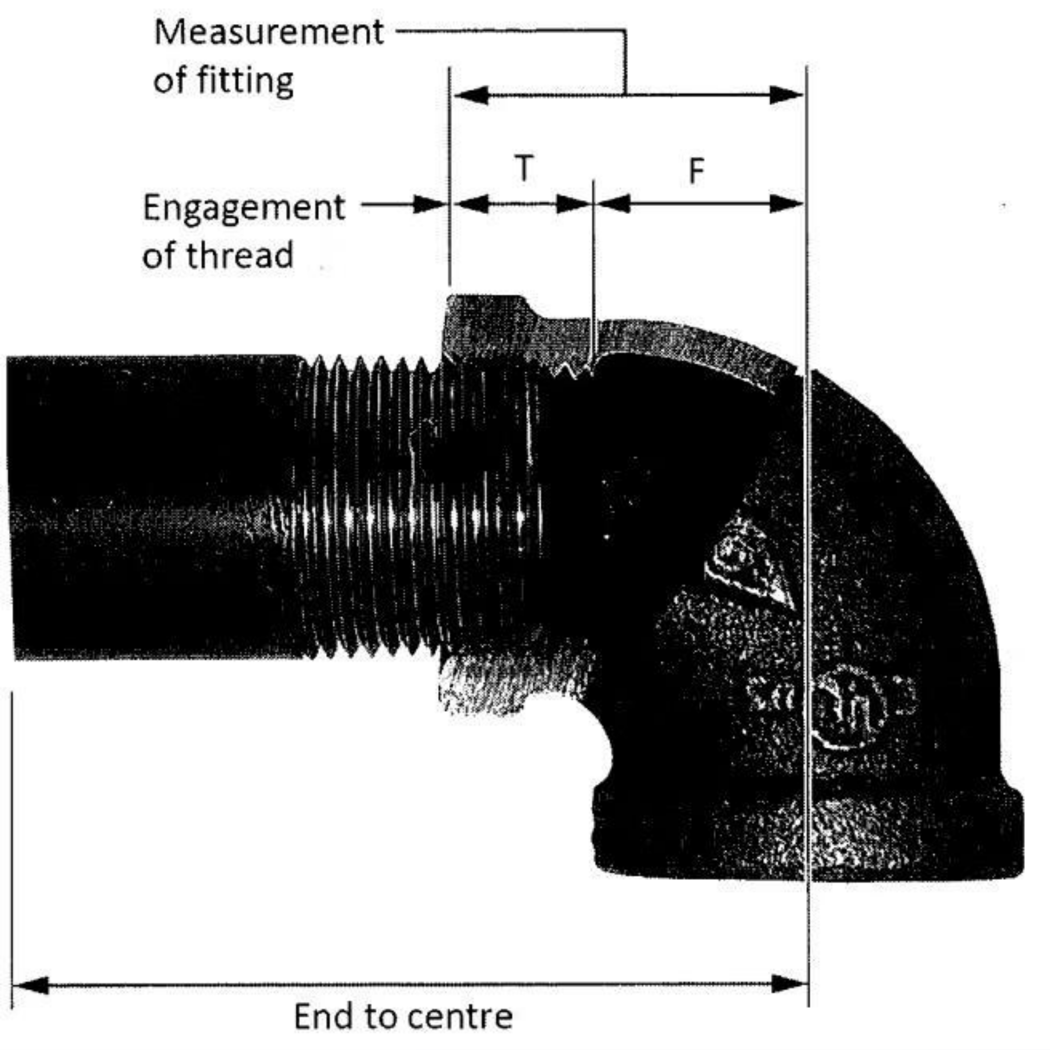


Fitting allowance

As pointed out previously, you usually make pipe measurements end-to-centre or centre-to-centre.

Using the end-to-centre measurement (see Figure 6-5), notice that the end of the pipe will not screw into the centre of the fitting. Therefore, you must make a certain allowance "F" for the fitting, and cut the pipe that much shorter.

Figure 6-5
End-to-centre measurement
Image courtesy of Terry Bell



You may measure fitting allowance on the job. Otherwise, you can find it in the manufacturer's catalogue. However, since fitting measurements are not the same for all manufacturers, it is very important that you obtain the allowance from the catalogue of the manufacturer of that fitting.

Calculating fitting allowance

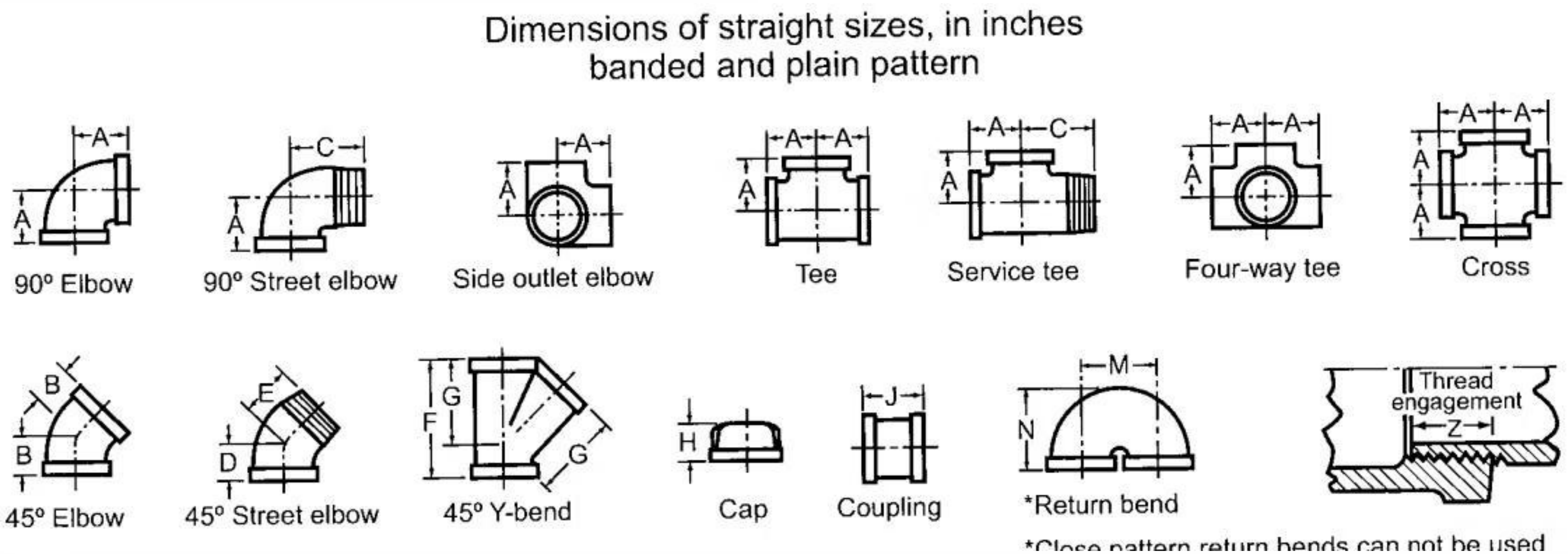
Example of Fitting Allowance Calculation

What is the fitting allowance for an NPS 3, 90°, 150-pound malleable elbow using a Crane fitting?

- "A", the centre-to-face measurement, is 3 1/8 in Table 6-1
- "T", the thread engagement, is 1 in at the bottom of Table 6-1.

Table 6-1 Dimensions of 150-pound malleable iron fittings and normal engagement between male and female threads

150-pound malleable iron crane fittings

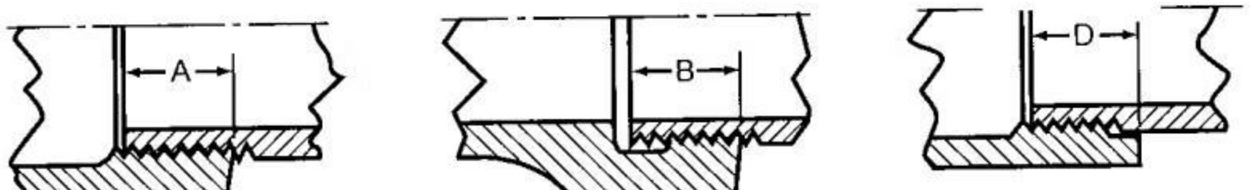


These dimensions apply to both banded and plain fittings; their centre to end dimensions are alike.

*Close pattern return bends can not be used to make up parallel coils. The centre to centre dimension is so close that the bands of adjacent bends will not clear each other.

Normal engagement

Between male and female threads



Size of pipe	D Length of pipe entering recessed railing fitting
½	½
¾	½
1	⅝

Sizing of low-pressure piping systems

Factors that influence gas flow

Type of Gas

Different gases flow at different rates due to their density

Type of Pipe

Pipe material affects internal resistance to gas flow

Length of Pipe

Longer pipes create more resistance to flow

Diameter of Pipe

Larger diameters allow greater gas flow

Number of Fittings

Each fitting adds resistance to gas flow

Pressure Drop

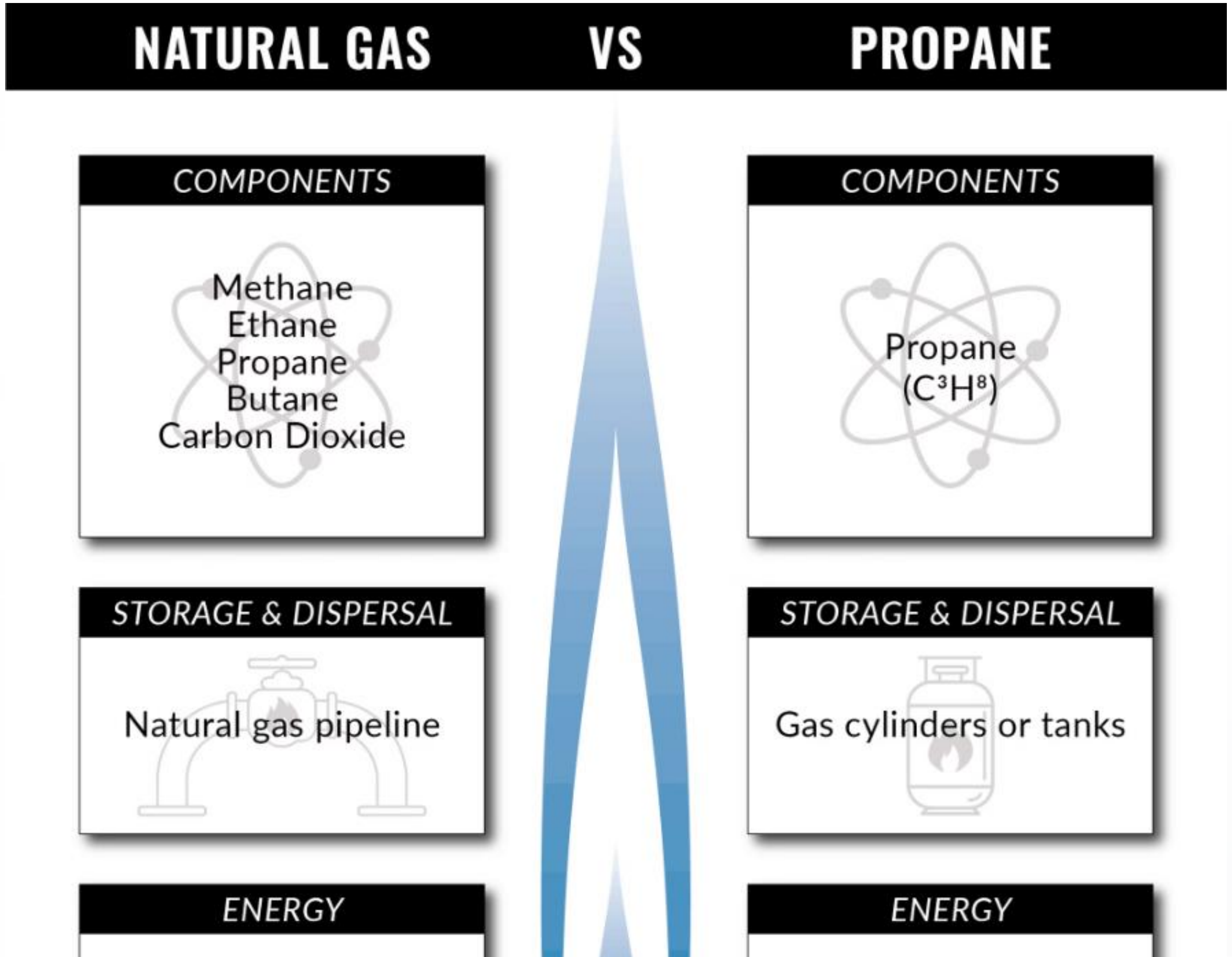
Affects the resistance through the pipe

Type of Gas and Type of Pipe

Type of gas

Before you attempt to size pipe, you should clearly understand how the following six factors affect the flow rate of gas:

- type of gas
- type of pipe
- length of pipe
- diameter of pipe
- number of fittings
- pressure drop



Propane and natural gas flow through pipe at different rates because they have different relative densities. (Relative density is the weight of a gas compared to air. Other terms to describe density are specific gravity, relative weight, and specific weight.) The relative density of propane is heavier than natural gas.

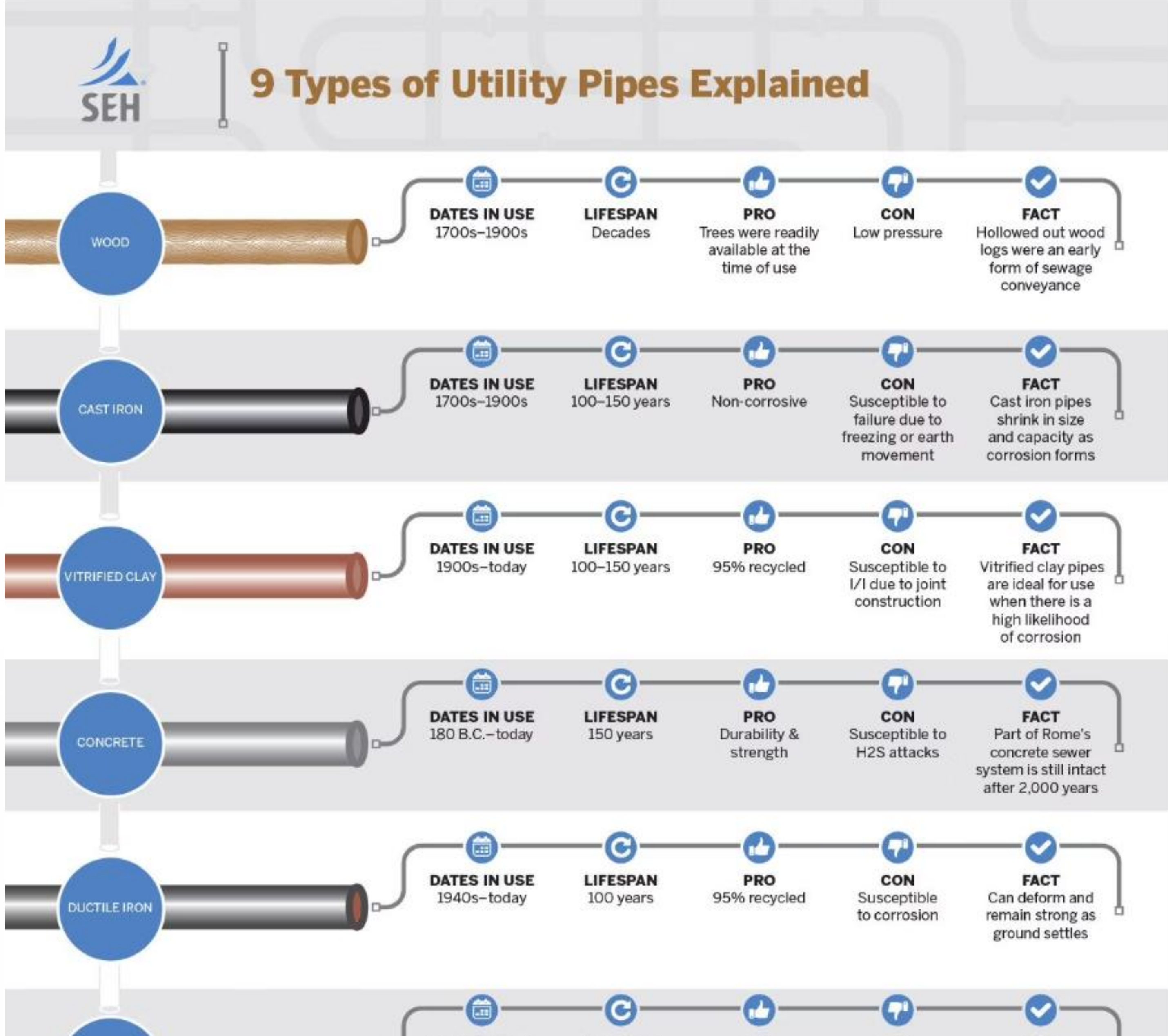
Since lighter gases flow through a pipe more easily than heavier gases, larger volumes of natural gas can flow through a pipe than propane (if both supply pressures are the same).

Type of Pipe and Length of Pipe

Type of pipe

An internal resistance forms as the gas molecules slide along the walls of the pipe. Pipes with smooth interior walls cause less resistance than pipes with rough interior walls.

For example, copper tubing offers less resistance (and therefore a higher flow rate) than an iron pipe with the same inside diameter.



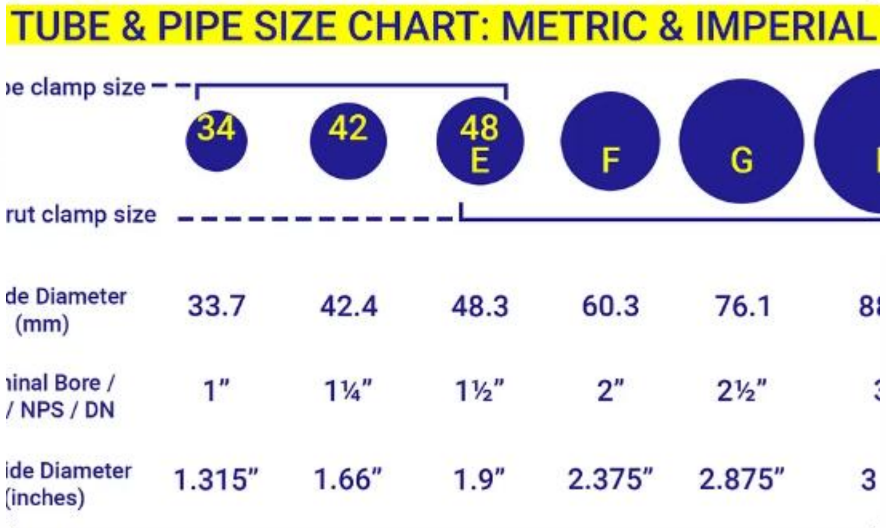
Length of pipe

The resistance factor also applies to the length of pipe: the longer the pipe, the greater the resistance.

GRAVIMETRIC FLOW UNITS							
Abs. Pres	psia			bar		kPa	mm. Hg
Flow	PPH	lb_m /s	kg/min	PPH	kg/ min	kg/ min	gm/ mi
H_2	11.6	0.00322	0.0876	168	1.27	0.0127	1.69
He	17.3	0.00479	0.131	250	1.89	0.0189	2.52
Neon	38.7	0.0108	0.293	561	4.25	0.0425	5.66
Nat. Gas	34.8	0.00966	0.263	505	3.82	0.0382	5.09
N_2	43.2	0.0120	0.326	626	4.73	0.0473	6.31
CO	43.0	0.0119	0.325	623	4.71	0.0471	6.28
Air	43.8	0.0122	0.331	636	4.81	0.0481	6.41
Ethane	42.2	0.0117	0.319	611	4.62	0.0462	6.16
O_2	46.0	0.0128	0.348	667	5.04	0.0504	6.72
Argon	54.6	0.0152	0.413	792	5.99	0.0599	7.99
CO_2	52.4	0.0145	0.396	759	5.74	0.0574	7.65
N_2O	52.7	0.0146	0.398	764	5.77	0.0577	7.70
SO_2	63.0	0.0175	0.476	914	6.91	0.0691	9.21
Freon 12	83.2	0.0231	0.629	1210	9.13	0.0913	12.2

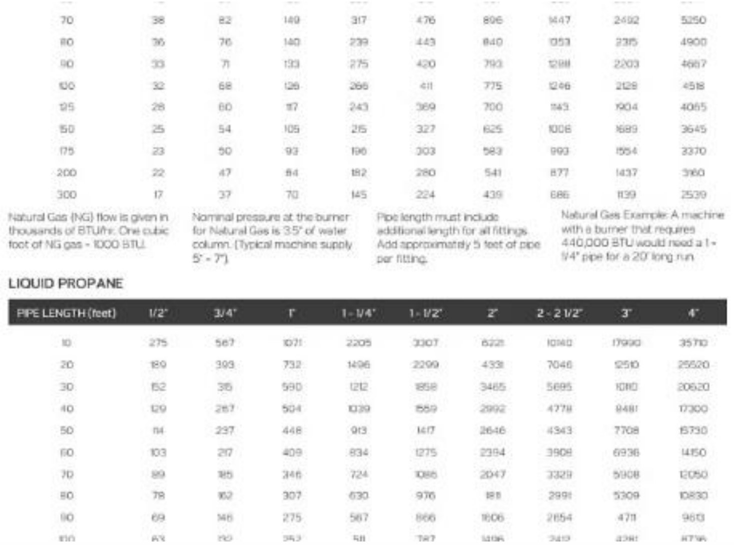
Diameter of Pipe

The larger the pipe diameter, the greater the gas flow through the system.



Pipe Diameter Comparison

Various pipe diameters showing the difference in cross-sectional area available for gas flow



70	38	82	149	317	476	896	1447	2492	5250
80	36	76	140	239	443	840	1353	2315	4900
90	33	71	133	275	420	793	1288	2203	4667
100	32	68	126	266	411	775	1246	2128	4518
125	28	60	117	243	369	700	1143	1904	4065
150	25	54	105	215	327	625	1006	1689	3645
175	23	50	93	196	303	583	993	1554	3370
200	22	47	84	182	280	541	877	1437	3160
300	17	37	70	145	224	439	686	1139	2539

Natural Gas (NG) flow is given in thousands of BTU/hr. One cubic foot of NG gas = 1000 BTU.

Nominal pressure at the burner for Natural Gas is 3.5" of water column. (Typical machine supply 5" - 7").

Pipe length must include additional length for all fittings. Add approximately 5 feet of pipe per fitting.

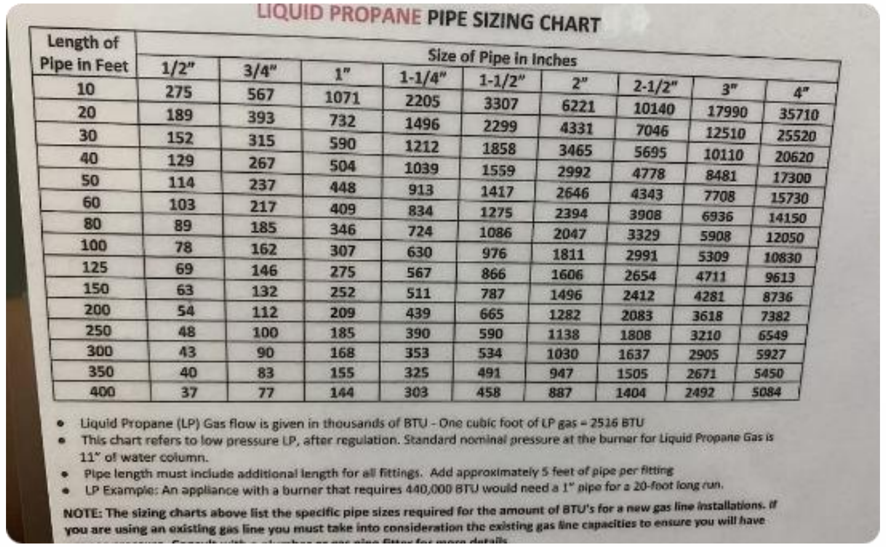
Natural Gas Example: A machine with a burner that requires 440,000 BTU would need a 1 - 1/4" pipe for a 20' long run.

LIQUID PROPANE

PIPE LENGTH (feet)	1/2"	3/4"	1"	1 - 1/4"	1 - 1/2"	2"	2 - 2 1/2"	3"	4"
10	275	567	1071	2205	3307	6221	10140	17990	35710
20	189	393	732	1496	2299	4331	7046	12510	25520
30	152	315	590	1212	1858	3465	5695	10110	20620
40	129	267	504	1039	1559	2992	4778	8481	17300
50	114	237	448	913	1417	2646	4343	7708	15730
60	103	217	409	834	1275	2394	3908	6936	14150
70	89	185	346	724	1086	2047	3329	5908	12050
80	78	162	307	630	976	1811	2991	5309	10830
90	69	146	275	567	866	1606	2654	4711	9613

Flow Rate Visualization

Illustration of how gas flow increases with larger pipe diameters



LIQUID PROPANE PIPE SIZING CHART

Length of Pipe in Feet	Size of Pipe in Inches 1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
10	275	567	1071	2205	3307	6221	10140	17990	35710
20	189	393	732	1496	2299	4331	7046	12510	25520
30	152	315	590	1212	1858	3465	5695	10110	20620
40	129	267	504	1039	1559	2992	4778	8481	17300
50	114	237	448	913	1417	2646	4343	7708	15730
60	103	217	409	834	1275	2394	3908	6936	14150
80	89	185	346	724	1086	2047	3329	5908	12050
100	78	162	307	630	976	1811	2991	5309	10830
125	69	146	275	567	866	1606	2654	4711	9613
150	63	132	252	511	787	1496	2412	4281	8736
200	54	112	209	439	665	1282	2083	3618	7382
250	48	100	185	390	590	1138	1808	3210	6549
300	43	90	168	353	534	1030	1637	2905	5927
350	40	83	155	325	491	947	1505	2671	5450
400	37	77	144	303	458	887	1404	2492	5084

- Liquid Propane (LP) Gas flow is given in thousands of BTU - One cubic foot of LP gas = 2516 BTU
- This chart refers to low pressure LP, after regulation. Standard nominal pressure at the burner for Liquid Propane Gas is 11" of water column.
- Pipe length must include additional length for all fittings. Add approximately 5 feet of pipe per fitting
- LP Example: An appliance with a burner that requires 440,000 BTU would need a 1" pipe for a 20-foot long run.

NOTE: The sizing charts above list the specific pipe sizes required for the amount of BTU's for a new gas line installations. If you are using an existing gas line you must take into consideration the existing gas line capacities to ensure you will have

Sizing Chart

Reference chart showing relationship between pipe diameter and potential gas flow capacity

Number of Fittings and Pressure Drop

Number of fittings

Each fitting on a piping system adds resistance to the gas flow. For this reason, it is important to design a system with as few fittings as possible.

If the pipe sizing table includes fittings, the figures have included a 20% allowance, which is more than enough for a normal piping system.

Pressure drop

Pressure drop is the pressure difference between the gas supply (either the gas meter or a system pressure regulator) and a gas appliance. The greater the pressure drop, the greater the resistance through a pipe.

The Natural gas and propane installation code specifies the maximum allowable pressure drop in a system, based on the system pressure.

You must design natural gas piping systems with pressures:

- less than 7 in w.c. (1.75 kPa), so the pressure drop does not exceed 0.5 in w.c. (125 Pa); and
- of 7 in w.c. to 14 in w.c. (1.75 kPa to 3.5 kPa), so the pressure drop does not exceed 1 in w.c. (250 Pa).

Design of propane piping systems of 11 in w.c. (2.7 kPa) must not allow the pressure drop to exceed 1 in w.c. (250 Pa).

Sizing low-pressure systems

The discussion of pipe sizing usually specifies low-pressure or high-pressure systems. Low-pressure systems, a topic of this Chapter, are those which contain gas pressures up to 0.5 psig (3.5 kPa).

Draw a sketch

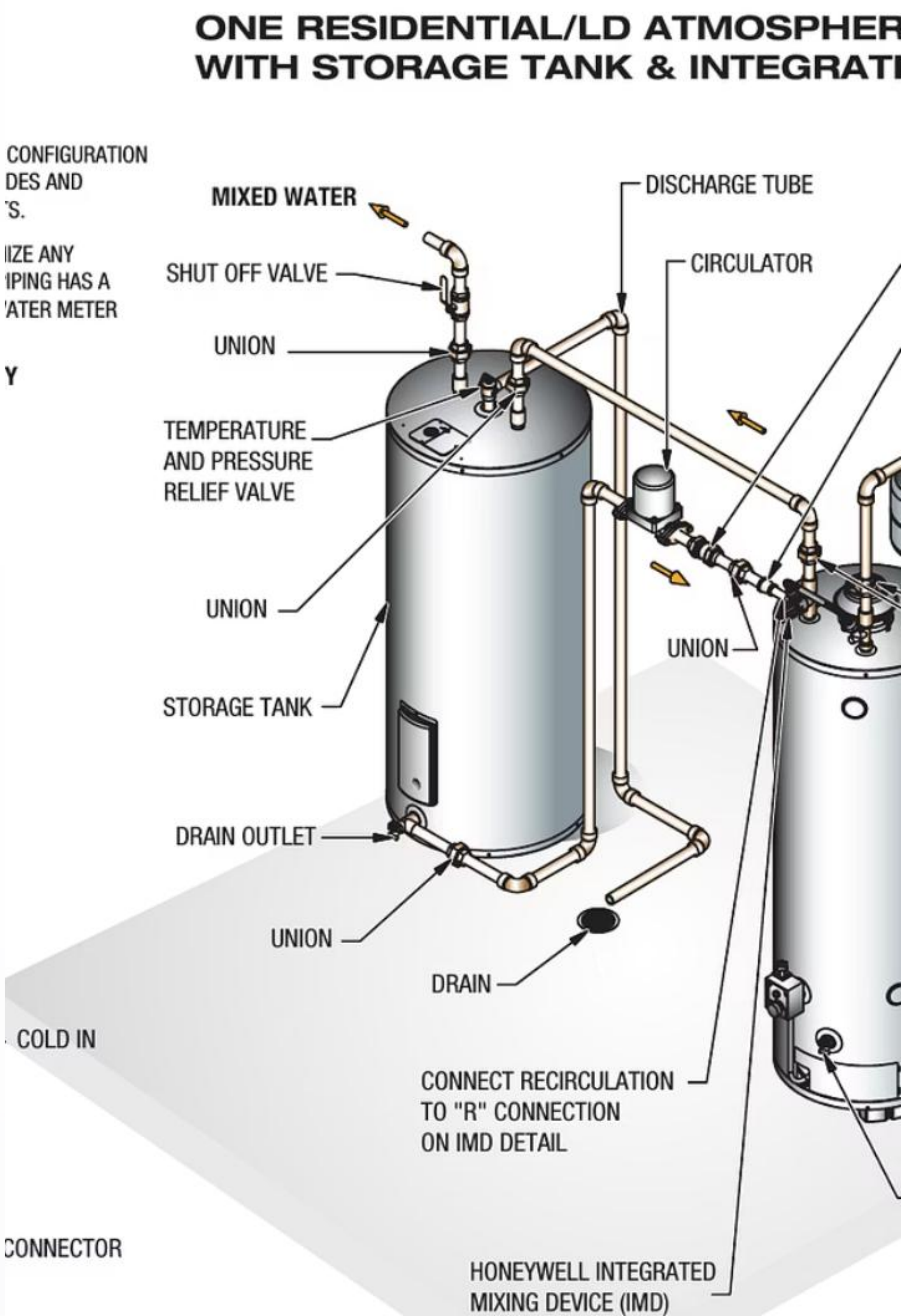
Create a detailed diagram of the entire piping system

Identify the pipe sizing table

Select the appropriate table based on system requirements

Calculate the pipe size

Determine the correct pipe dimensions for each section



Drawing a System Sketch

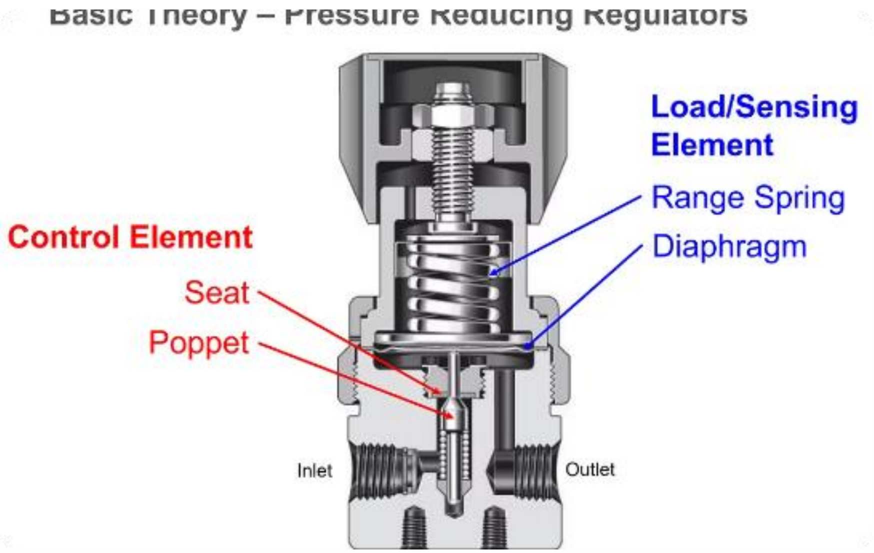
Drawing a sketch of the whole piping system allows you to identify and locate important system components. Knowing the details about these system components will ultimately guide you to choose the correct pipe sizing table.

System Components

Information	Description
Gas supply	The gas supply may be a meter that a local utility company installed for natural gas or propane. Also, supply of propane may come from a storage container.
System pressure	After carefully considering available gas pressures, you will choose the pressure that best suits the job and conforms to local codes.
Appliance location	The building design, not the gas technician/fitter, usually fixes the appliance's location.
Appliance inputs	Appliance input is the amount of heat that can be generated in the combustion chamber every hour. This therefore determines the amount of gas that the appliance requires. The manufacturer determines each appliance's input, which is then stamped on a rating plate and permanently affixed to the equipment.
Piping route	You must determine the best piping route, that is, the one that uses the least amount of pipe, fittings, and valves.

Valves and Related Equipment

Every piping system requires valves and other equipment such as regulators. You must know where to locate this equipment before sizing the piping system.



Shutoff Valves

Essential for isolating sections of the system for maintenance or emergencies

Pressure Regulators

Control and maintain consistent gas pressure throughout the system

Gas Meters

Measure gas consumption and often serve as the connection point to the utility supply

Identify the pipe sizing table

There are over 50 pipe sizing tables in CSA B149.1. Finding the correct table can be a complex undertaking unless you have the required information. Each table is identified by a sequence of pipe system criteria:

Required Information

Information	Description
Type of gas	Determine the type of gas based on availability and cost. Natural gas is usually the cheapest fuel.
Type of pipe	Determine the type of pipe you will use after considering costs of material and labour, code restrictions, and job specifications.
System pressures	Determine system pressure after considering the following: available pressures from the gas utility; code restrictions; specifications; and cost of system installations.
Maximum pressure drop	The maximum pressure drop is the maximum allowable drop in pressure across a piping system as specified by the code and the system pressure. You must thoroughly understand system pressures and allowable pressure drops before selecting a pipe sizing table.

Selecting the table

Now that you clearly understand how to identify a pipe sizing table, identify the criteria used to create the table.

Table Selection Criteria

Information	Description
Type of gas	Natural gas
Type of pipe	Iron pipe
System pressures	Less than 7 in w.c.
Pressure drop	Flow rates based on a pressure drop of 0.5 in w.c.

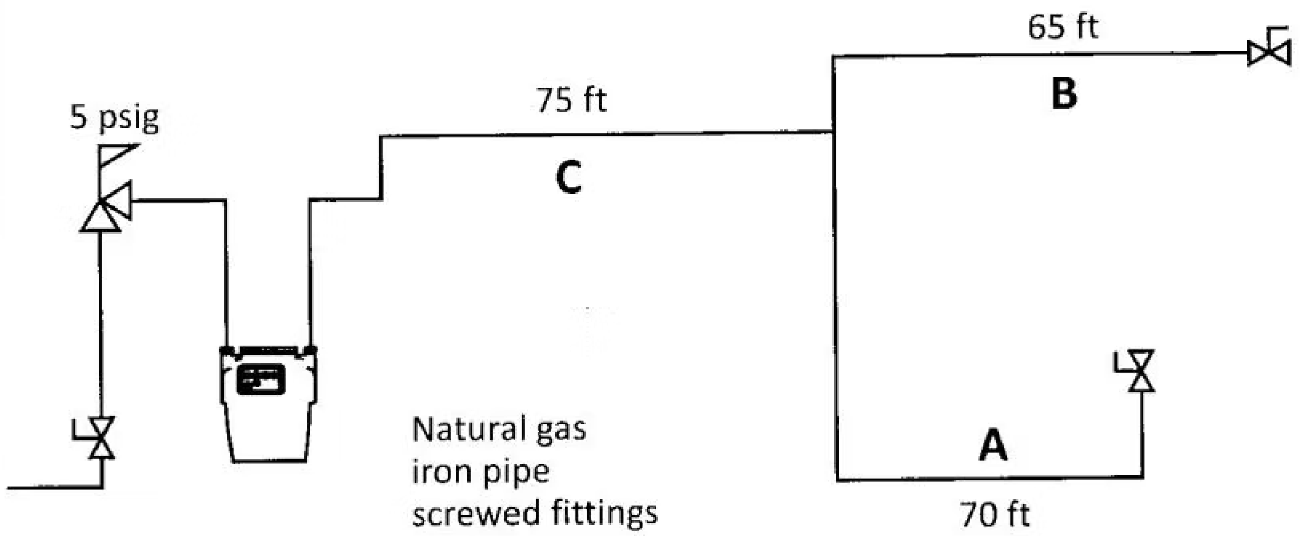
In CSA B149.1, both imperial and metric gas tables are available. The pipe sizing tables, Tables A.1 and A.2, have two parts:

- Part "a" covers imperial measurements; and
- Part "b" covers metric measurements.

Pipe Sizing Tables

Table A.1 Maximum capacity of natural gas in thousands of Btuh for Schedule 40 pipe and plastic pipe, including fittings, for pressures of less than 7 in w.c. based on a pressure drop of 0.5 in w.c.

(See Clauses 6.3.2, 6.3.5, A.2.3, A.2.4, A.2.6, and A.3.5.)



Notice that the table title includes all the necessary criteria: Schedule 40 pipe, system pressure of 1.75 kPa to 3.5 kPa and a pressure drop of 250 Pa. The volume of gas flow is expressed in metric Units (kW).

Table A.2 Maximum capacity of natural gas in thousands of Btuh for Schedule 40 pipe and plastic pipe, including fittings, for pressures of 7 in w.c. up to 14 in w.c. based on a pressure drop of 1 in w.c.

(See Clauses 6.3.2, 6.3.4, 6.3.5, A.2.3, A.2.4, A.2.6, A.3.5, E.1.2, and E.2.2.)

Once you have drawn the sketch and selected the correct table, you are ready to size the piping system. Sizing the piping system is just a matter of correctly reading the table.

Reading the table

In order to correctly read a table, you would have to identify the following information:

- piping loads
- longest measured supply run
- code zone

Key Information

Information	Description
Piping loads	This term expresses the volume of fuel that must pass through a pipe each hour. Determine this volume using the appliance load connected to that pipe. Each section of pipe has its own piping load.
Longest measured supply run	This is the distance from the point of gas supply (gas meter or system regulator) to the manifold of the furthest appliance. This measurement must be the actual length of pipe as installed. It may be expressed in feet or metres, depending on the Units of measurement in the pipe sizing table.
Code zone	The code zone (CZ) is a horizontal grouping of flow values according to the longest measured run. Choosing the code zone is based on selecting the length of pipe that is exactly the same, or larger, than the longest measured run. You may use only the flow values in the code zone to size the piping system.

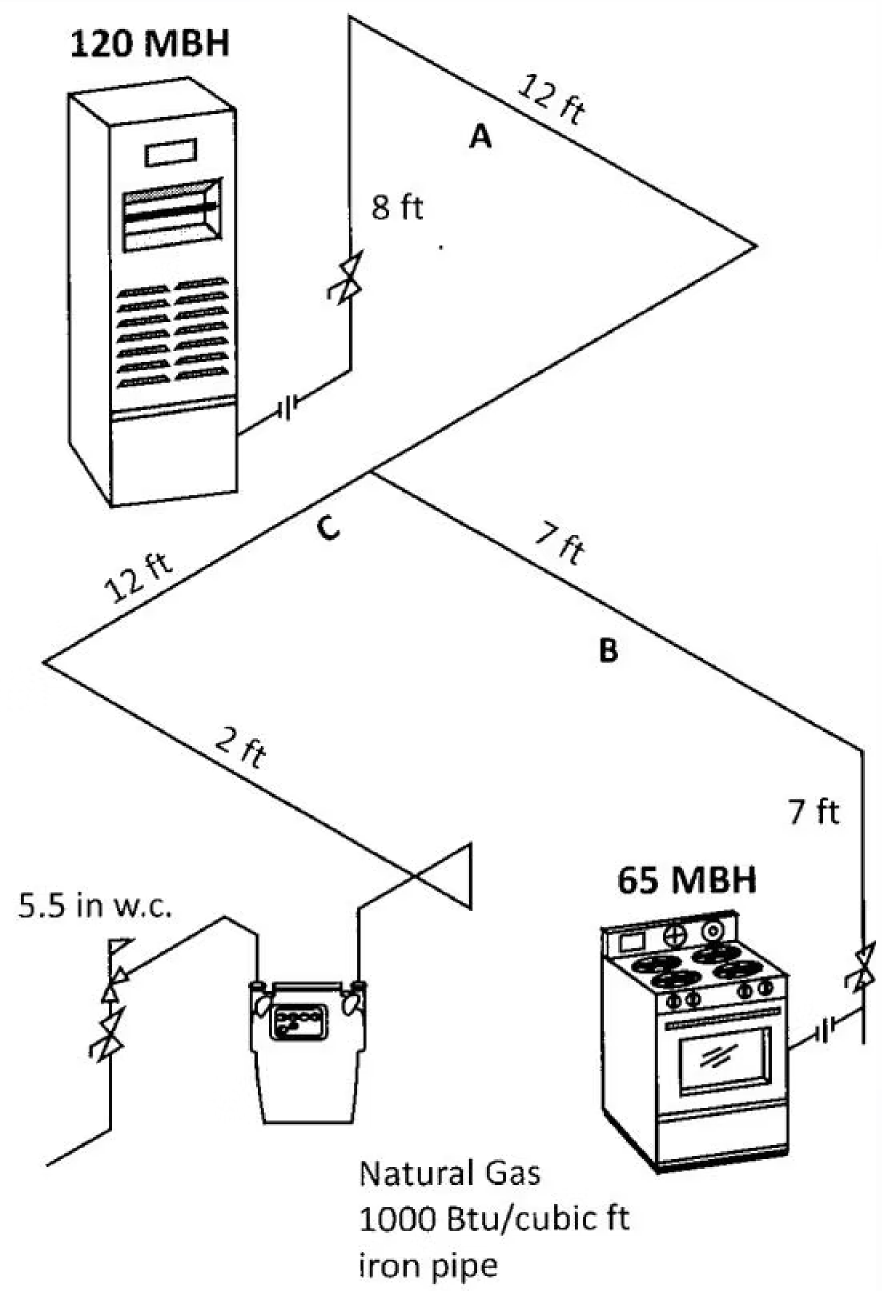
Example

Using Figure 6-7 as a guide, assume a longest measured run (LMR) of 65 ft. Identify the pipe size required to carry a flow rate of 300,000 Btu/h (expressed as 300 MBtu/h for the purpose of the table) and proceed as follows:

1. Look down the Length of Pipe column and identify the code zone (CZ) that is exactly the same or larger than the longest measured run. You will find all load values in the 70 ft code zone.
2. Move across the code zone until you find an equal or greater value than 300 MBtu/h. In this case, you locate 440 MBtu/h.
3. Move up to the top of the column and identify that a NPS 1-1/4 iron pipe size is required.

Reading the pipe sizing table

Figure 6-7 Reading the pipe sizing table



Sizing a low-pressure system steps summary

The following is a summary of the steps required to size a piping system:

1. Sketch the piping system and dimension all pipe sections.
2. Identify the gas (natural gas, propane, etc.).
3. Identify the piping material (iron pipe or copper tubing).
4. Identify the pressure system and the allowable pressure drop.
5. Select the correct pipe sizing table.
6. Calculate the gas load in Btu/h (or kW) on each section of pipe and list each load.
7. Calculate the longest measured run (LMR) in the system.
8. Locate the appropriate code zone (CZ).
9. Size each pipe in the system from the selected code zone.

Example Based on Figure 6-8

Information	Description
Type of gas	Natural gas
Type of pipe	Black iron pipe
System pressure	Less than 7 in w.c.
Allowable pressure drop	0.5 in w.c.
Table	From information in steps 1, 2, and 3, determine that Table A.1 a) in CSA B149.1 is the appropriate table.
Calculate loads	Line A = 120 MBtu/h Line B = 65 MBtu/h Line C (A + B) = 185 MBtu/h
LMR	34 ft (branch "A")
CZ	40 ft
Size each pipe	Start with the furthest appliance and pick up loads as you approach the meter. Line A = 3/4 in Line B = 1/2 in Line C = 1 in

Converting between metric and imperial measures

With the installation of new appliances and meters, you may have to mix imperial with metric values. For example, you may hook an appliance rated in Btu/h into a meter delivering its gas in m^3. Similarly, you may hook an appliance rated in kilowatts into an older type of gas meter, delivering gas in ft3.

You cannot perform pipe sizing unless all values are imperial or metric. The following conversion factors are what you use for converting between imperial and metric Units of measure.

3,412

Btu/h per kW

1 kW = 3,412 Btu/h

0.00029

kW per Btu/h

1 Btu/h = 0.00029295 kW

35.31

ft^3 per m^3

1 m^3 = 35.31 ft^3

0.028

m^3 per ft^3

1 ft^3 = 0.028317 m^3

Conversion factors for gas pressure Units:

- 1 psi = 28 in w.c. = 6.895 kPa
- 1 inHg = 2 psi = 6895 Pa

Sizing of 2 psig gas piping systems

Traditionally, the gas utility companies in Canada have offered natural gas to customers at either 7 in w.c. for low-pressure applications (domestic) or at 5 psig for high-pressure applications (industrial). Additionally, 2 psig gas pressures inside one and two family dwellings are permitted with both 1 psig and 1.5 psig pressure drops.

Before changes in the production process, natural gas had a high sulphur content and copper tubing had to have a tin-lining. Now, however, natural gas has a very low sulphur content and standard copper tubing is widely used.

You can install two psig gas piping systems using copper tubing, iron pipe, or a combination of these. Copper tubing offers some advantages over iron pipe. It is flexible and you can often install it in places where you cannot install iron pipe. Soft types of copper tubing come in long coils, reducing the number of fittings required in the system. Overall, a copper tube system can be quicker to install, allowing considerable savings.

Characteristics

Conventional vs. 2 psig Systems

In a conventional low pressure system, natural gas is supplied to the residential property at about 60 psig (see Figure 6-10). The gas flows through a service regulator at the gas meter, which reduces the pressure to 7 in w.c. The gas then flows to the appliances at the same 7 in w.c. pressure.

Notice in Figure 6-10 that the size of the pipe leaving the meter is comparatively larger than the pipe entering the appliance. The larger pipe size is required to supply enough volume to all three appliances.

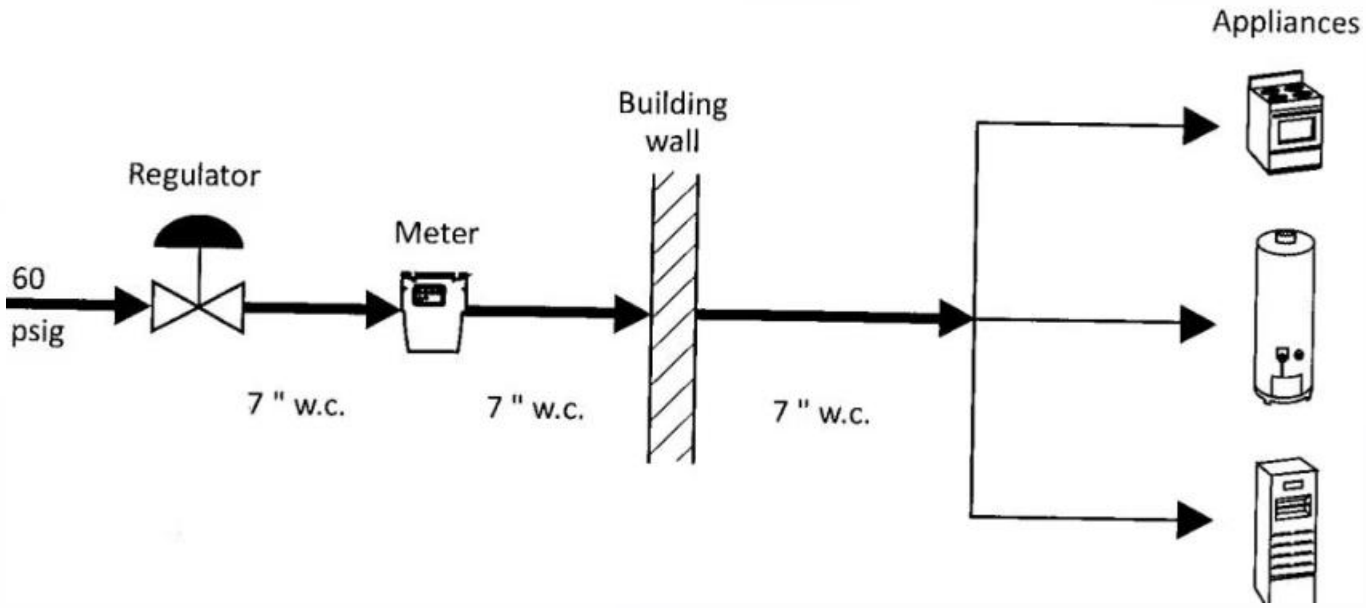


Figure 6-10 Conventional low-pressure piping system

In a 2 psig system, natural gas is also supplied to the residential property at about 60 psig (see Figure 6-11). The service regulator at the meter reduces the pressure to 2 psig instead of 7 in w.c. The second regulator reduces the gas pressure to 7 in w.c.

Notice in Figure 6-11 that a smaller-diameter piping than the conventional piping delivers the gas to the 2 psig regulators. Note also that supplying two or more appliances from a single 2 psig regulator is possible.

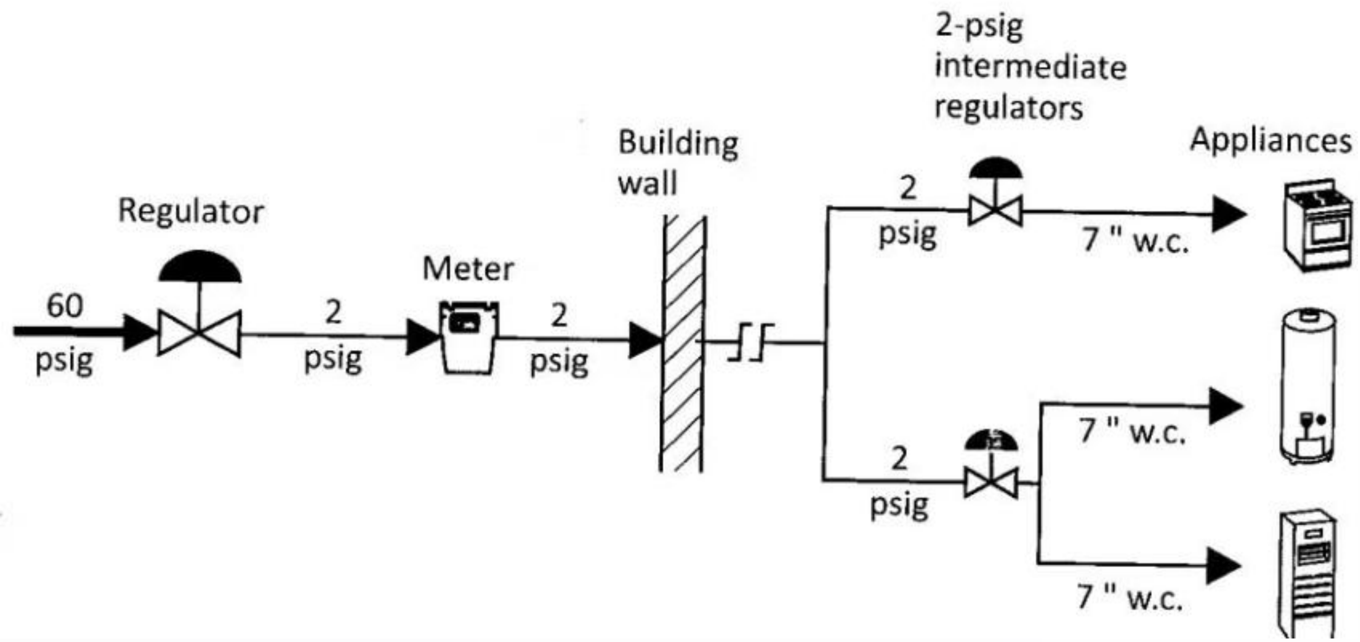


Figure 6-11 2 psig gas tubing system

2 psig regulators

Because most gas appliances require gas at low pressure, the installation of a regulator is a must to reduce the pressure. You can locate 2-psig regulators anywhere in a building, but their location should be close to the appliances, and they must be accessible.

Shut-off valves

Each regulator must have a shut off valve on the high pressure side for the regulator to be serviced.

2 psig Regulator Installation

Proper installation of a 2 psig regulator with shut-off valve on the high pressure side

Regulator with Shut-off Valve

Close-up view of a gas regulator with the required shut-off valve for servicing

System Components

Complete 2 psig gas system showing meter, regulators, and distribution piping

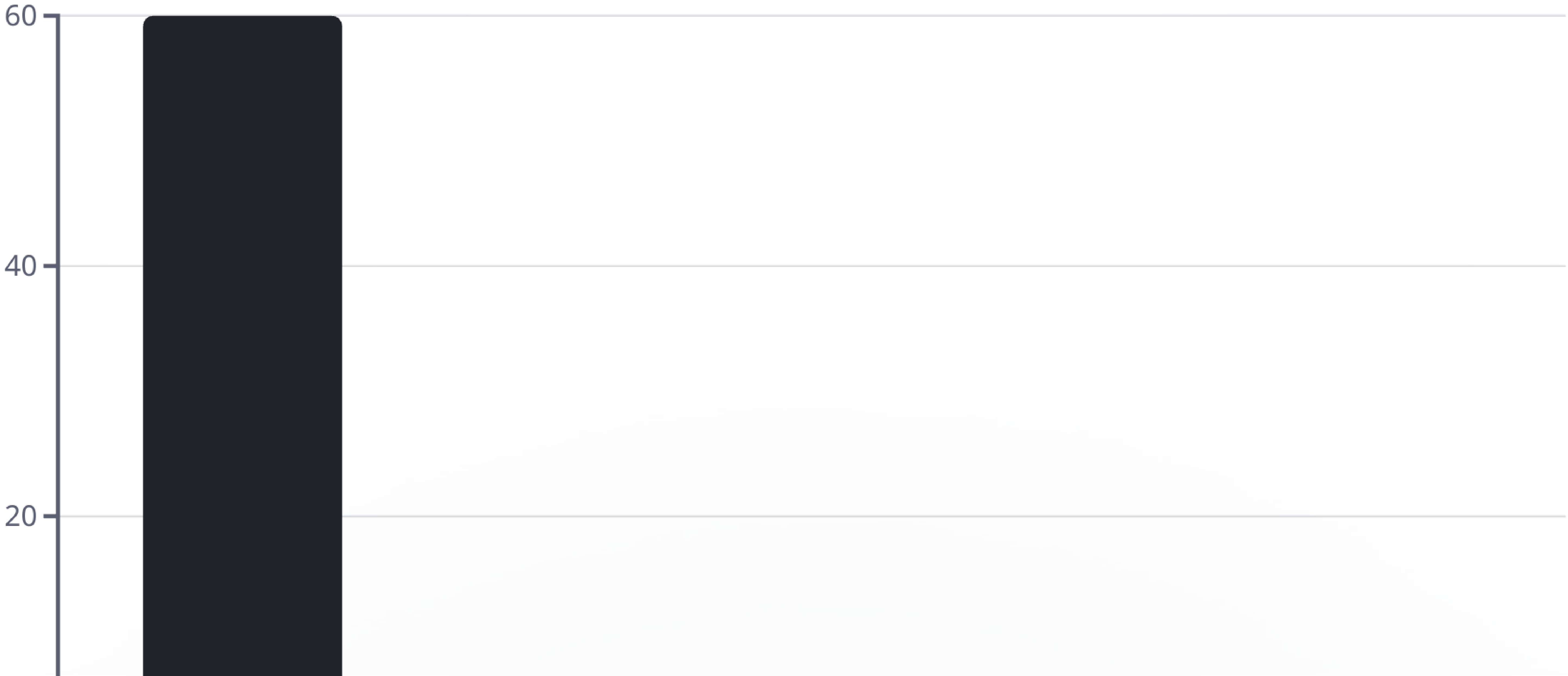
Sizing regulators

Take care when sizing regulators, particularly with respect to the inlet pressure:

Inlet pressure = system pressure - pressure drop

As CSA B149.1 tables allow for 1.5 psig pressure drop, the regulator will be sized accordingly:

0.5 psig = 2 psig - 1.5 psig



Sizing a 2 psig system

Sizing a 2 psig piping system can consist of three steps:

1. Draw a sketch.
2. Identify the 2 psig pipe sizing table.
3. Calculate the pipe size.

The sketch of the whole piping system identifies and locates important system components such as:

- gas supply
- piping route
- appliance locations
- 2 psig regulator locations

This sketch also allows you to identify the different pressure zones in the piping system:

- 2 psig pressure zone-the piping from the meter to the regulator
- low-pressure zone-the piping from the regulator to the appliances

Size each pressure zone separately

For the next two steps (identifying the table and sizing the pipe), you must size each pressure zone separately. It is advisable to first size the low-pressure zone, followed by the 2 psig zone.

You can size any low-pressure zones according to information in the Pipe measurement and fitting allowance section. Remember, you will measure the LMR for the low-pressure zone from the 2 psig regulator to the appliance.

Identify 2 psig pipe sizing tables

The sizing tables for 2 psig gas pressure also have a 20% allowance for fittings. You do not have to add an extra allowance unless the system has an unusually large number of fiittings. ("Including fittings" is found in the table title if fitting allowance is included.)

Correctly identifying the table for a 2 psig system requires the following information:

Required Information

Information	Description
Type of gas	Natural gas or propane
Type of pipe	Iron pipe or copper tubing
System pressure	2 psig
Pressure drop	1.5 psig

Calculate pipe size

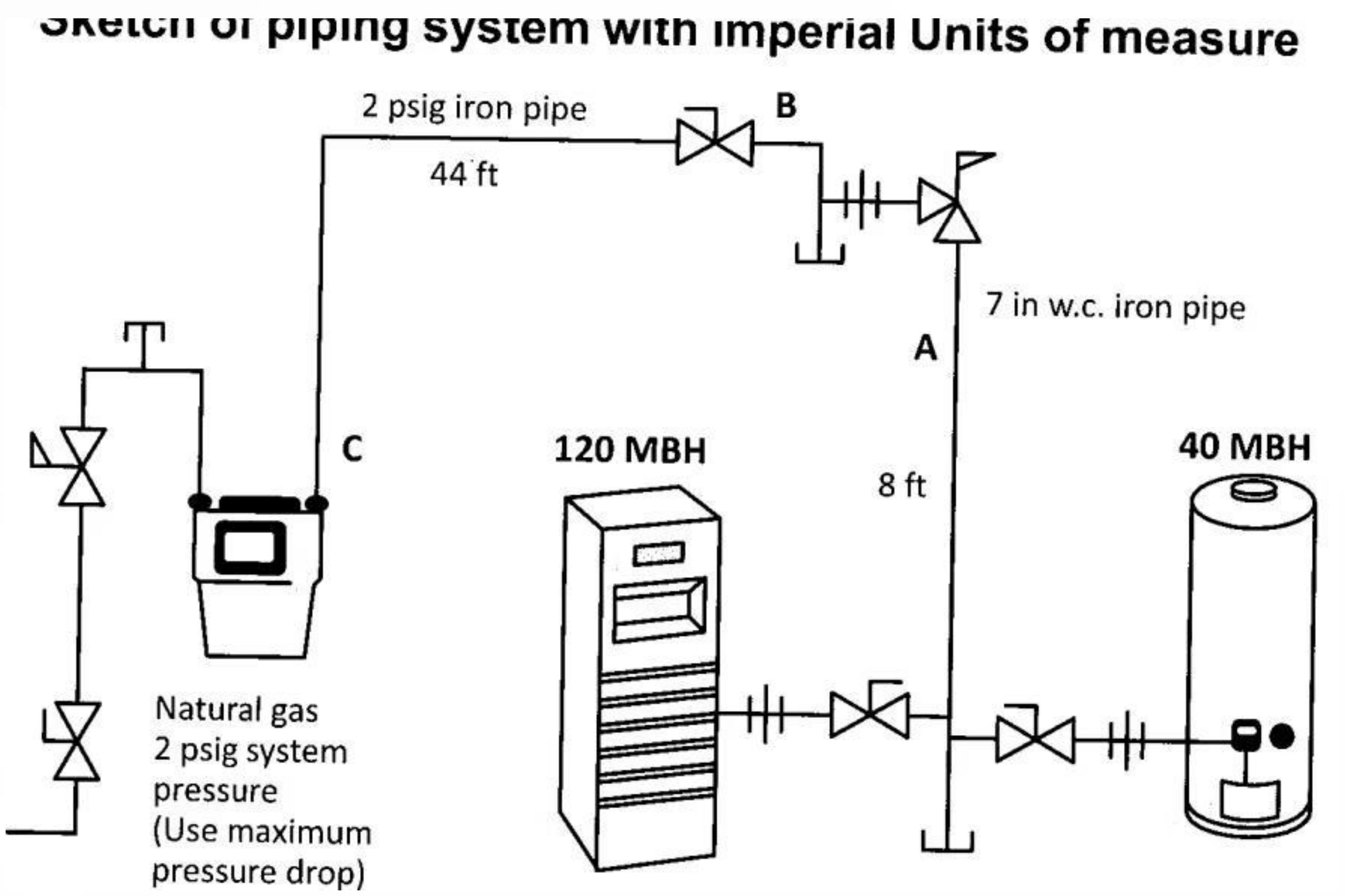
After selecting the correct pipe sizing table for the 2 psig pressure zone, follow this procedure:

Sizing Procedure

Information	Description
Type of gas	Natural gas or propane
Type of pipe	Iron pipe or copper tubing
System pressure	2 psig
Pressure drop	1.5 psig
Pipe loads	Calculate the load in MBtu/h or kW, depending on the table values.
LMR	Remember, you will measure the longest measured run of the 2 psig zone from the meter to the 2 psig regulator, not the appliance.
CZ	Size all pipes in the same code zone.

2 psig System Sizing Example

Refer to Figure 6-12 for a dimensioned sketch of the piping system for this example. Start with the furthest appliance and pick up loads as you approach the meter.



Step 1-Calculate low pressure zone

Information	Description
Type of gas	Natural gas
Type of pipe	Black iron pipe
System pressure	7 in w.c.
Allowable pressure drop	1 in w.c.
Table	Table A.2 a) in CSA B149.1 is the appropriate table.

Step 2-Calculate 2 psig zone

Information	Description
Type of gas	Natural gas
Type of pipe	Black iron pipe
System pressure	2 psig
Allowable pressure drop	1 psig
Table	Table A.3 a) in CSA B149.1 is the appropriate table

Sizing of high-pressure natural gas piping systems

High-pressure gas is any gas pressure over 1/2 psig. Two psig gas piping systems (as discussed in the Sizing of low-pressure piping systems section) are also classified as high-pressure systems, but the pipe sizing tables include fittings. This section will discuss only high-pressure pipe sizing systems for which the pipe sizing table does not allow for fittings.

CSA B149.1 specifies the maximum gas pressure allowed inside different classes of buildings. Single family dwellings are limited to a maximum of 2 psig. Because commercial and industrial buildings may have heavy flow rates and long pipe runs, it is more economical to design piping systems with small-diameter pipes. As a result of the smaller pipe size, gas pressure in industrial and commercial applications ranges from 5 to 20 psig.

Characteristics of High-Pressure Systems

In a conventional low pressure system, natural gas is supplied to the building site at about 60 psig. The gas flows through a service regulator at the gas meter that reduces the pressure either to 2 psig or to 7 in w.c. These pressures are well-suited to applications where the pressure requirements are low and the pipe runs are relatively short.

As the flow rates and the pipe length increases, it becomes more economical to design piping systems with higher gas pressures. This keeps the pipe sizes small. The most common high pressures are 5, 10, and sometimes 20 psig (34, 70, and 140 kPa).

5

psig

Common pressure for commercial applications

10

psig

Higher pressure for industrial applications

20

psig

Maximum pressure for specialized industrial uses

High-pressure regulators

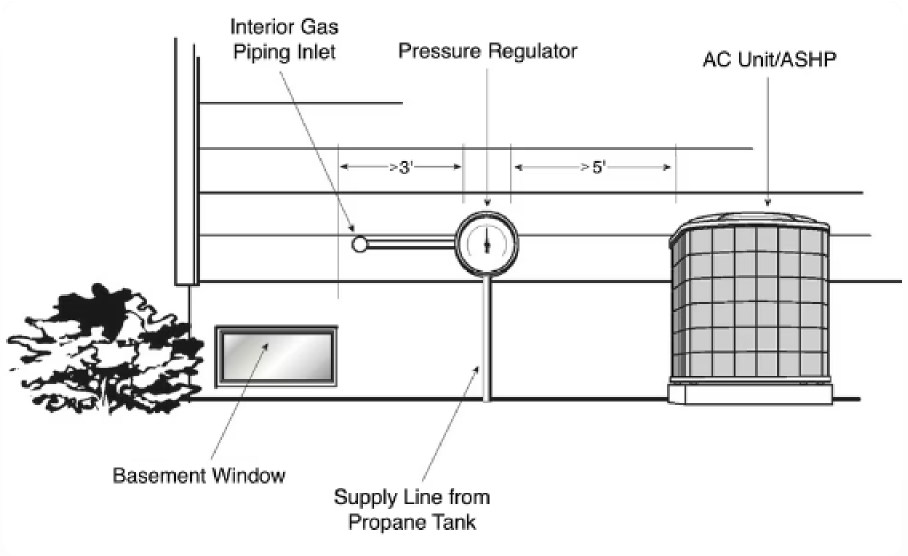
Because most appliances require gas at low pressure, a regulator is installed to reduce the pressure. You must locate the high-pressure regulators where they are accessible and make provisions to install a vent to the outdoors.

Shut-off valves

Each regulator must have a shut off valve on the high pressure side so that you can service the regulator. It is also good piping practice to have a shut-off valve on the downstream side to save time and money when servicing the regulator.

High-Pressure Regulator

Industrial high-pressure regulator with proper venting and shut-off valves



Venting Requirements

Proper venting setup for high-pressure regulators to ensure safe operation

Multiple Regulator System

Complex high-pressure system with multiple regulators for different pressure zones

Sizing regulators

Take care when sizing regulators, particularly with respect to the inlet pressure.

System pressure - Pressure drop = Inlet pressure

Since the Code tables come with large pressure drops, the regulators are sized with the following inlet pressures:

System pressure	Pressure drop	Inlet pressure
2 psig	1.5 psig	1/2 psig
5 psig	50%	2-1/2 psig
10 psig	50%	5 psig
20 psig	50%	10 psig

Sizing a high-pressure system

Sizing a high-pressure system

Sizing a high-pressure piping system can consist of three steps:

1. Draw a sketch.
2. Identify the pipe sizing table.
3. Calculate the pipe size.

Drawing a sketch of the whole piping system allows you to identify and locate important system components such as:

- gas supply
- piping route
- system regulator locations
- appliance locations

This sketch also allows you to identify the different pressure zones in the piping system:

Pressure Zones

Zone	Description
High-pressure zone	Piping from the meter to the system regulators or piping between system regulators
Low-pressure zone	Piping from the system regulators to the appliances

Size each pressure zone separately

For the next two steps (identifying the table and sizing the pipe), you must size each pressure zone separately. It is advisable to first size the low-pressure zone, followed by the high-pressure zone.

You can size all low-pressure zones according to the information in Pipe measurement and fitting allowance section. Remember, you will measure the LMR for the low-pressure zone from the system regulator to the appliance.

Identify pipe sizing table

To correctly identify the table for a high-pressure piping system, you need the following information:

Required Information

Information	Description
Type of gas	Natural gas or propane
Type of pipe	Iron pipe or copper tubing
System pressure	High pressure
Pressure drop	50%

You should now be able to identify a pipe sizing table for your specific piping project.

Calculate pipe size

Before listing the steps to sizing the high-pressure piping system, it is important to understand how fittings are allowed for in the calculations. As discussed previously, there are six factors that influence the flow rate through a pipe. One of these factors, the number of fittings, is particularly relevant to sizing high-pressure systems.

Draw system sketch

Create detailed diagram with all components

Select sizing table

Based on gas type, pipe material, and pressure

Calculate loads

Determine gas load for each pipe section

Measure pipe runs

Find longest measured run in each zone

Account for fittings

Add equivalent length for fittings and valves

Number of fittings

Fittings and valves create resistance to gas flow. Most low-pressure and 2 psig pipe sizing tables allow for this resistance by including a reasonable number of pipe fittings in the table calculations. Most high-pressure pipe sizing tables, however, do not allow for fittings. You must, therefore include fitting resistance in your calculations. The table title will indicate whether fittings are included or not.

The formula for deriving Tables A.1 to A.4 and A.8 to A.11, B.1, B.2, B.6, and B.7 contains a factor, (F = 1.2), which is used to multiply the piping or tubing length to allow for a reasonable number of fittings. Tables A.5 to A.7, A.12 to A.14, B.3 to B.5 and B.8 to B.10 do not contain a fitting allowance (F = 1), and Table A.16 or B.11 contains equivalent lengths of fittings.

How do you allow for fittings in high-pressure pipe sizing calculations? The resistance through a fitting is expressed as the equivalent length of straight pipe. In other words, each pipe fitting is equal, in resistance, to an equivalent length of straight pipe.

To make your job easier, Table A.16 in CSA B149.1 lists the equivalent length values. This table lists values for threaded or welded fittings and valves.

Notes: Keep the following points in mind when calculating the number of fittings:

- The equivalent length of pipe run includes only tees that change the direction of flow 90°. Do not include fittings that do not change the direction of flow (tees on the run, pipe couplings, unions, reducing couplings).
- Calculate reducing tees or bull-headed tees that change flow direction by the largest inlet size of the tee.
- Table A.16 does not show NPS 3.5 fittings. You will have to use a value between the NPS 3 and NPS 4 fittings.
- Where a regulator reduces the pressure on a section of pipe, calculate each section separately.

Sizing a high-pressure system steps summary

Sizing a high-pressure system is similar to sizing a low-pressure system, except for Steps 8 and 10:

1. type of gas
2. type of pipe
3. system pressure
4. pressure drop
5. pipe sizing table
6. pipe loads
7. longest measured run
8. guess code zone
9. size pipe
10. prove code zone

Special Steps for High-Pressure Systems

Information	Description
Step 8	Requires you to guess the code zone, based on the measured length of the piping run and an allowance of equivalent length for the fittings
Step 9	Sizes the pipe based on that code zone
Step 10	A check to see whether you chose the correct code zone. This is very important because since you have guessed at the code zone, you must check whether that pipe size will actually carry the gas load. You do this by checking whether the measured length added to the equivalent length exceeds the code zone length.

Example (imperial)

Referring to Figure 6-13, go through the pipe sizing procedure.

Proof length of pipe runs

To proof the length of pipe runs, add the measured length of pipe with the equivalent length of pipe to find the length of equivalent run (LER). The LER of any pipe run must not exceed the code zone used to size the piping system.

Procedure:

1. List all fittings on the run, starting with the longest measured run.
2. Look up their equivalent lengths from Table A.16.

Proof pipe A

3 -1 in screwed 90 @ 2.62 ft	7.86 ft
1 – 1 in screwed T @ 5.24 ft	5.24 ft
2 – 3/4 in screwed 90 @ 2.06 ft	4.12 ft
1 – 3/4 in valve @ 2.06 ft	2.06 ft
Equivalent length	19.28 ft

Equivalent length (EL)	19.28 ft
Measured length (ML)	145.00 ft
Length of equivalent run (LER)	164.28 ft

Proof pipe B

3 – 1 in screwed 90 @ 2.62 ft	7.86 ft
1 - 1 in screwed T @ 5.24 ft	5.24 ft
1 - 3/4 in screwed 90 @ 2.06 ft	2.06 ft
1 – 3/4 in valve @ 2.06 ft	2.06 ft
Equivalent length	17.22 ft

Equivalent length (EL)	17.22 ft
Measured length (ML)	140.00 ft
Length of equivalent run (LER)	157.22 ft

If both Pipe A and Pipe B's length of equivalent runs are less than the selected code zone, the code zone is okay. In neither case does the LER exceed the selected code zone of 175 ft. Therefore, the 175 ft code zone is okay and the pipe is sized correctly.

Note: If any LER had exceeded the chosen code zone, it would indicate the chosen code zone is too short and you would have to resize and reproof the piping on the next longest code zone.

Sizing of propane piping systems

Propane systems, like natural gas systems, may have more than one pressure zone due to the fact that the supply pressure to propane appliances is normally 11 in w.c. However, the propane supplied from a tank or cylinder, under most conditions, is much higher. (The vapour pressure in the tank is related to the temperature of the propane liquid in the tank. See the Unit 3 Properties, characteristics, and safe handling of fuel gases for temperature/pressure relationships.)

You can carry out the pressure reduction from the tank to the appliance either in a single stage or in two stages:

Propane System Types

System	Description
Single-stage system	Reduction of tank pressure immediately to 11 in w.c. with a regulator at the outlet valve
Two-stage system	Reduction of tank pressure to an intermediate pressure (usually 10 psig) in the first stage, and then to 11 in w.c. in the second stage

Sizing propane systems

Once you have determined whether it is a single- or two-stage system, you can size it using the same procedure as natural gas low-pressure sizing or high-pressure sizing. Annex B of CSA B149.1 provides the tables used for sizing propane systems.

Example of Propane System Sizing

The following example sizes a two-stage system using the high and low pressure methods previously reviewed for natural gas.

If you need to size a single-stage system, only use the low-pressure sizing method.

Refer to Figure 6-15 for a dimensioned sketch of the piping system for this example. Start with the farthest appliance and pick up loads as you approach the propane container.

Figure 6-15
Sketch of two-stage propane piping system

Propane Tank with Regulator

First stage of a two-stage propane system showing the tank and primary regulator

Second Stage Regulator

The second stage regulator reduces pressure from 10 psig to 11 in w.c.

Complete System

Full two-stage propane system with tank, regulators, and distribution piping

Step 1-Calculate low pressure zone

Low Pressure Zone Calculation

Information	Description
Type of gas	Propane
Type of pipe	Copper tubing
System pressure	11 in w.c.
Allowable pressure drop	1 in w.c.
Table	Table B.6 a) in CSA B149.1
Calculate loads	Line A = 250 MBtu/h Line B = 35 MBtu/h Line C = 285 MBtu/h
LMR	30 ft
CZ	30 ft
Size each pipe	Line A = 7/8 in Line B = 1/2 in Line C = 7/8 in

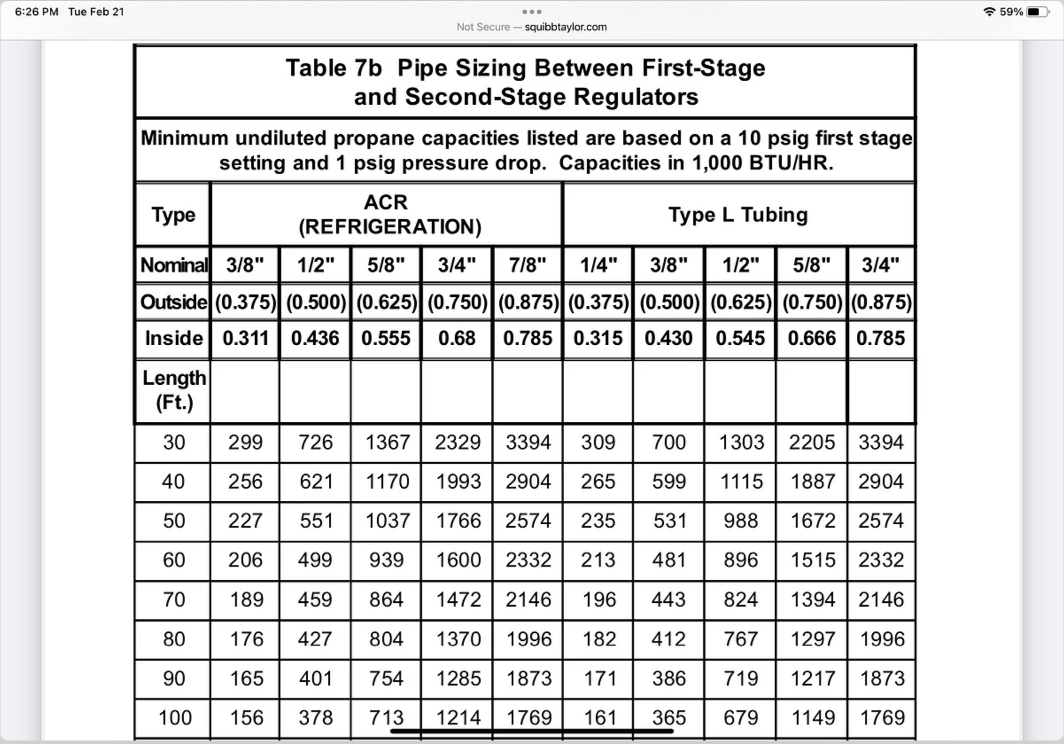


Table 7b Pipe Sizing Between First-Stage and Second-Stage Regulators

Minimum undiluted propane capacities listed are based on a 10 psig first stage setting and 1 psig pressure drop. Capacities in 1,000 BTU/HR.

Type	ACR (REFRIGERATION)					Type L Tubing				
Nominal	3/8"	1/2"	5/8"	3/4"	7/8"	1/4"	3/8"	1/2"	5/8"	3/4"
Outside	(0.375)	(0.500)	(0.625)	(0.750)	(0.875)	(0.375)	(0.500)	(0.625)	(0.750)	(0.875)
Inside	0.311	0.436	0.555	0.68	0.785	0.315	0.430	0.545	0.666	0.785
Length (Ft.)										
30	299	726	1367	2329	3394	309	700	1303	2205	3394
40	256	621	1170	1993	2904	265	599	1115	1887	2904
50	227	551	1037	1766	2574	235	531	988	1672	2574
60	206	499	939	1600	2332	213	481	896	1515	2332
70	189	459	864	1472	2146	196	443	824	1394	2146
80	176	427	804	1370	1996	182	412	767	1297	1996
90	165	401	754	1285	1873	171	386	719	1217	1873
100	156	378	713	1214	1769	161	365	679	1149	1769

Step 2-Calculate high pressure zone

High Pressure Zone Calculation

Information	Description
Type of gas	Propane
Type of pipe	Copper tubing
System pressure	10 psig
Allowable pressure drop	5 psig
Table	From Table B.9 a) in CSA B149.1
Calculate loads	Line D = 285 MBtu/h
LMR	50 ft
CZ	50 ft
Size each pipe	Line D = 3/8 in

Summary of Pipe Sizing Principles

Proper pipe sizing is critical for the safe and efficient operation of gas systems. By following the procedures outlined in this chapter, gas technicians can ensure that piping systems are correctly sized to deliver the required gas volume at the appropriate pressure to all appliances.

Remember that different systems (low-pressure, 2 psig, high-pressure, and propane) have specific sizing requirements and tables. Always consult the appropriate sections of CSA B149.1 for the correct sizing information and follow all applicable codes and regulations.