CSA Unit 10 – Advanced Piping Systems
Chapter 1
Code Requirements and Approved Joining Methods

The installation of gas piping and tubing is a basic part of a gas technician's/fitter's duties. As a student, you must be aware of the code requirements concerning approved types of piping and tubing, as well as applicable joining methods. Pipe sizes, locations, and pressures are all factors that you must consider before installing a piping or tubing system.

Created

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Learning Objectives

Describe Code Requirements

Understand the Code requirements for industrial and commercial applications

Describe Joining Methods

Learn the joining methods that may be used for gas piping and tubing systems

Apply Knowledge

Apply code requirements and joining methods in practical installation scenarios

Key Terminology

Term	Definition
Bonding	Permanent joining of metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to safely conduct any current likely to be imposed
Grounding	Intentional connection of a current-carrying conductor to ground (earth)

Understanding these terms is essential for ensuring safe gas piping installations that comply with both gas and electrical codes.

Commercial vs. Residential Code Requirements

Commercial/Industrial

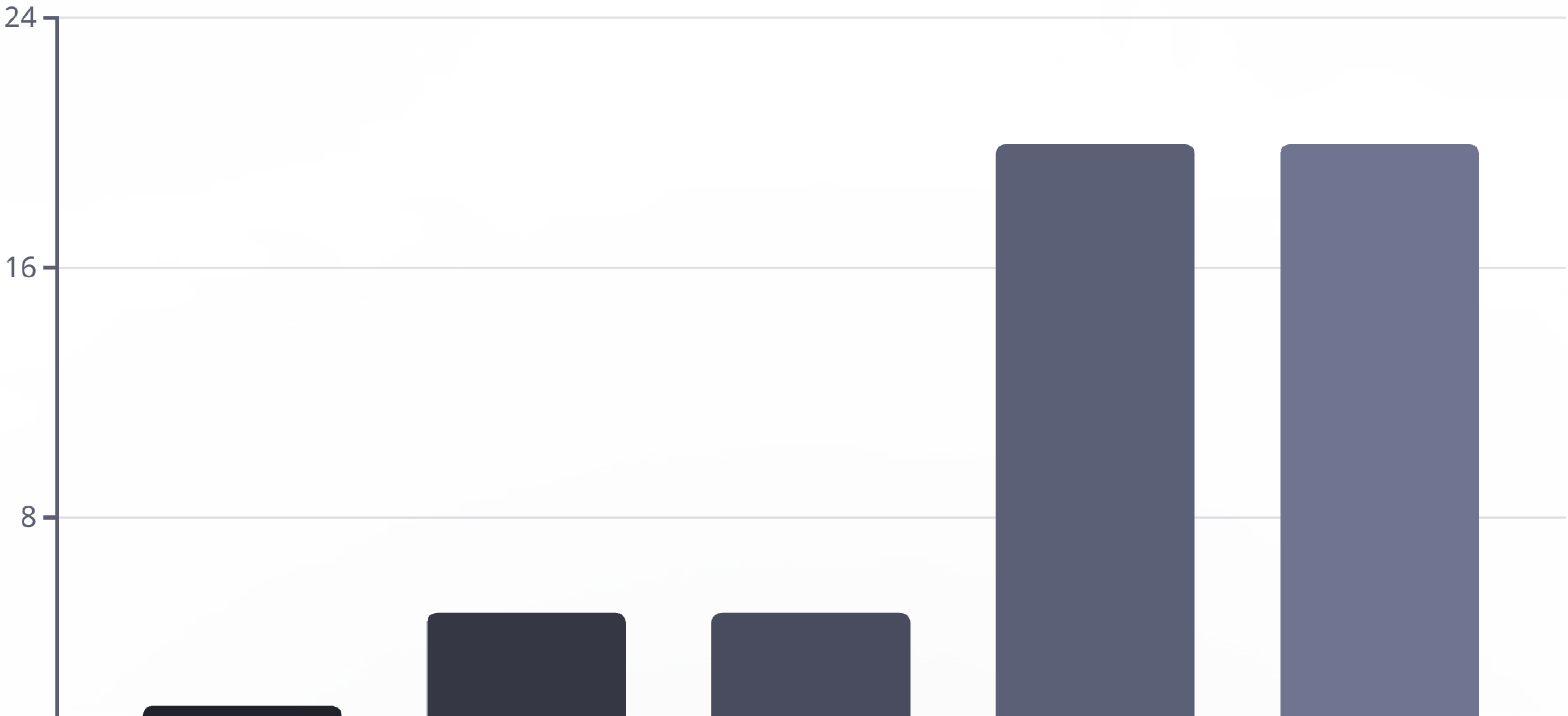
- Higher allowable pressures
- More stringent pressure testing
- Specific underground piping requirements
- Mandatory identification
- Multiple shut-off valve requirements
- Special commercial cooking appliance provisions

Residential

- Lower maximum allowable pressures
- Simpler pressure testing procedures
- Less complex underground requirements
- Fewer identification requirements
- Basic shut-off valve provisions
- Standard appliance connection methods

Allowable Pressures

CSA B149.1 specifies maximum allowable gas pressure for various building types in Clause 5.1 Delivery Pressure. Gas pressures in supply mains (natural gas) and from storage containers (propane) are generally higher than the safe operating pressures of connected appliances. As a result, you must control gas pressures to fall within an appropriate range, depending on the operating characteristics of installed appliances.



Pressure Testing Requirements

Visual Inspection

During installation of piping and tubing and before pressure testing, visually inspect piping and tubing for cuts, abrasions and other defects that may cause leaking or failure of the system when under pressure.

First Pressure Test

Performed before appliance installation. Isolate the piping system, cap all open ends, insert a pressure gauge, and pressurize with air or inert gas to the specified test pressure.

Leak Detection

If pressure drops, locate leaks using a liquid solution (soap test). Wipe each joint with leak detector solution and look for bubbles forming at the source of the leak.

Final Leak Test

Performed after appliance installation using gas supply at normal static pressure for a minimum of 10 minutes.

Pressure Test Procedure

Isolate the System

Isolate the piping system that is to be tested to ensure accurate results.

Cap Open Ends

Cap or plug all open ends to create a sealed system for testing.

Insert Pressure Gauge

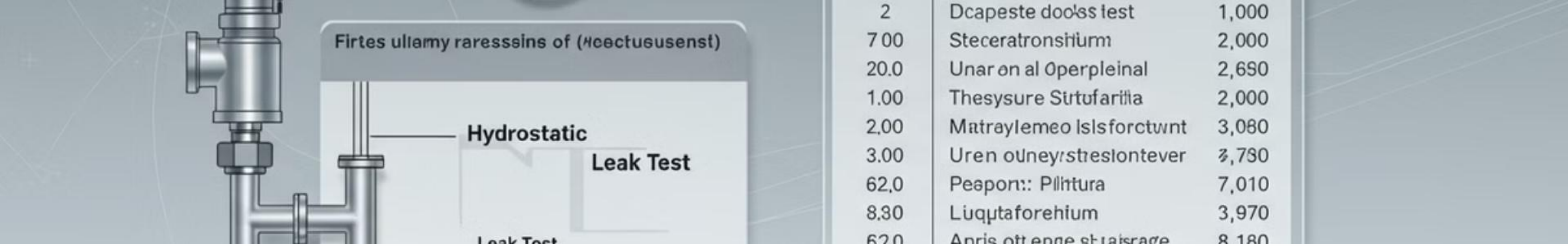
Insert a pressure gauge calibrated in 1/4 kPa (2 psig) increments or less at one end of the system.

Pressurize the System

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

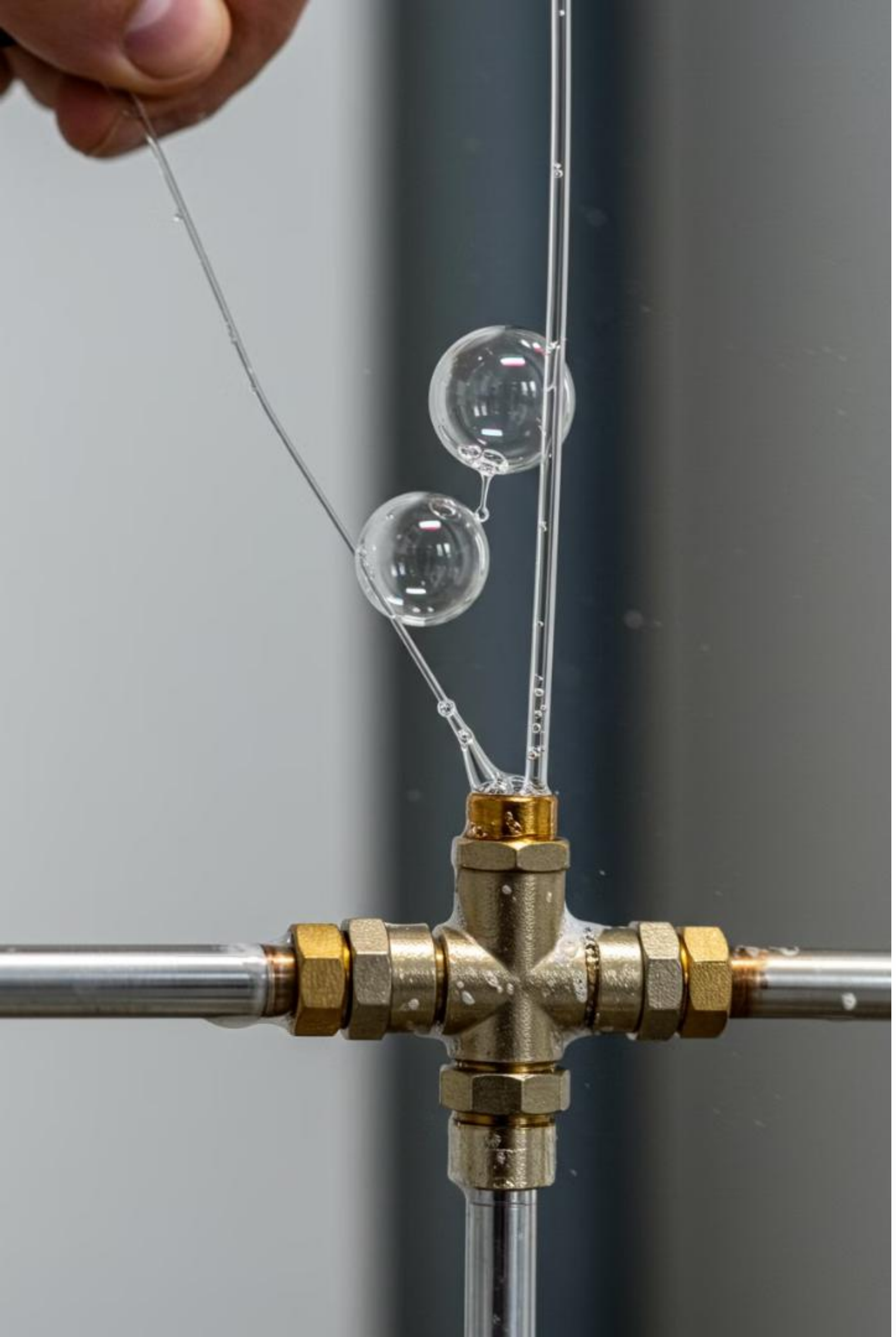
Remove Pressure Source

Remove the source of pressure and plug or cap the shut off valve.



Pressure Test Requirements Table

Working pressure, psig (kPa)	Diameter of pipe or tubing	Length of pipe or tubing ft (m)	Test pressure psig (kPa)	Test duration min
Up to and including 2 (14)	All sizes	Any length	15 (100)	15
Over 2 (14) but not over 5 (35)	All sizes	200 (60) or less	15 (100)	60
Over 2 (14) but not over 5 (35)	All sizes	More than 200 (60)	50 (340)	180
Over 5 (35) but not over 33 (230)	All sizes	Any length	50 (340)	180



Leak Detection Methods

Soap Test

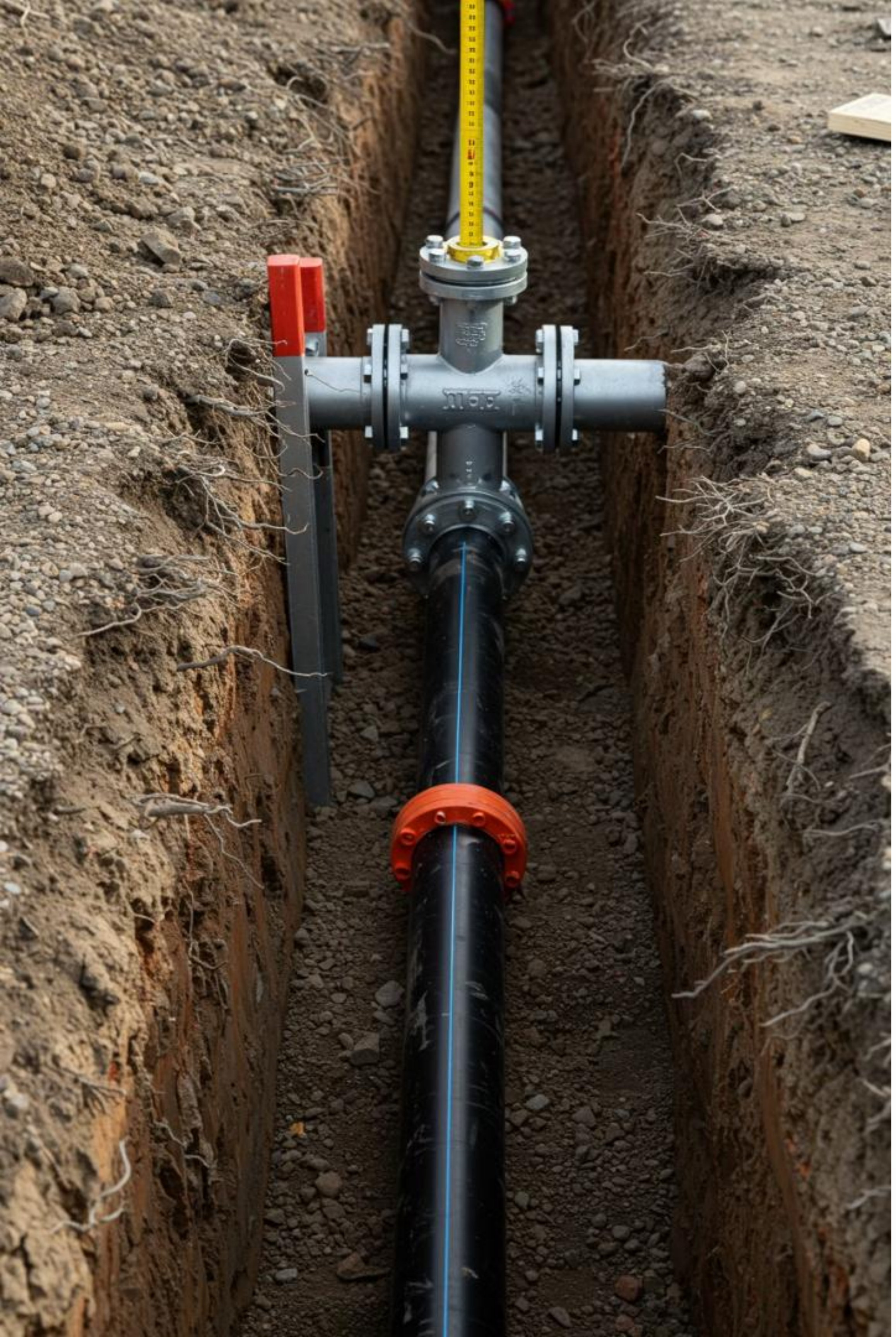
A common method for detecting leaks in gas piping systems:

1. Wipe each joint or fitting in the suspect portion of the system with leak detector solution (soap and water)
2. A leak will cause the solution to form bubbles at the source of the leak

Checking Shut-off Valve Seepage

Before performing the leak test, check the gas meter valve for seepage:

1. When the system is at static pressure, release a small amount of pressure by quickly removing, then replacing, the manometer tubing
2. This opens the service regulator and allows repressurization back to the gas meter shut-off valve
3. If pressure increases slowly to static pressure, the meter valve is seeping gas and should be serviced



Underground Piping Requirements

15 in

Minimum Depth

General minimum depth for underground piping (400 mm)

24 in

Commercial Areas

Minimum depth under commercial driveways or parking lots (610 mm)

6.15.4

Code Reference

CSA B149.1 clause specifying underground piping requirements

Additional depth of cover shall be required where the piping is located in areas where physical damage is likely to occur, such as farm operations.

Underground Piping Installation

Standard Installation

Piping entering a building shall rise above grade before entry, unless otherwise permitted by the authority having jurisdiction.

This is the preferred method as it reduces the risk of water infiltration and damage to the building foundation.

Below Grade Entry Exceptions

Watertight Seal

You must provide a watertight seal where the piping passes through an outside wall below grade

Sleeve or Protection

Piping or tubing passing through concrete or masonry walls must have a sleeve, coating, or double-wrap

Footing Restrictions

Piping may not pass under a footing or building wall because building settlement can cause crushing or rupture of the pipe

Supports for Piping

Clause 6.8.3 of CSA B149.1 states that you must install aboveground piping with individual supports of sufficient strength and quality and space it according to Table 6.2.

Pipe Size (NPS)	Maximum Spacing of Supports ft (m)
1/2 or less - horizontal	6 (2)
3/4-1 - horizontal	8 (2.5)
1-1/4-2-1/2 - horizontal	10 (3)
3-4 - horizontal	15 (5)
6 - horizontal	20 (6)
8-12 or larger - horizontal	24 (7)

Rooftop Piping Requirements

Support Requirements

Piping must have support according to the distances outlined in Table 6.2, plus support at each change of direction and at each threaded connection

Support Materials

Rooftop supports should be treated wood blocks and pipe clamps, with protection for the roof membrane

Certified Supports

Certified rooftop pipe supports are also now available on the market

Expansion Requirements

When a rooftop piping run exceeds 100 ft in length in any one direction, a piping offset (expansion loop) is required

Rooftop Piping Expansion Solutions

Expansion Loops

When a rooftop piping run exceeds 100 ft in length in any one direction, a piping offset (expansion loop) is required to allow for expansion of the piping system as it heats with sun exposure.

This can be either:

- A site-assembled piping offset (see Annex G of CSA B149.1)
- An engineered expansion joint

Both solutions allow expansion of piping to occur without damaging or breaking fittings and causing leaks. See Clause 6.25 of CSA B149.1.

Rooftop Piping Protection

Corrosion Protection

All piping exposed to atmospheres that could cause corrosion must have either painting or coating for protection.

Steel piping systems are typically installed on commercial rooftops and must have two coats of quality rust proof paint.

UV Protection

Yellow jacket PVC factory coatings should not be used as they break down and deteriorate with UV exposure and may lead to premature corrosion of the pipe.

See Clause 6.16 of CSA B149.1 for specific requirements.

Underground Piping Installation Requirements

Proper Grading

Trenches for piping must undergo proper grading to avoid any sagging in the pipes or tubes

Backfill Material

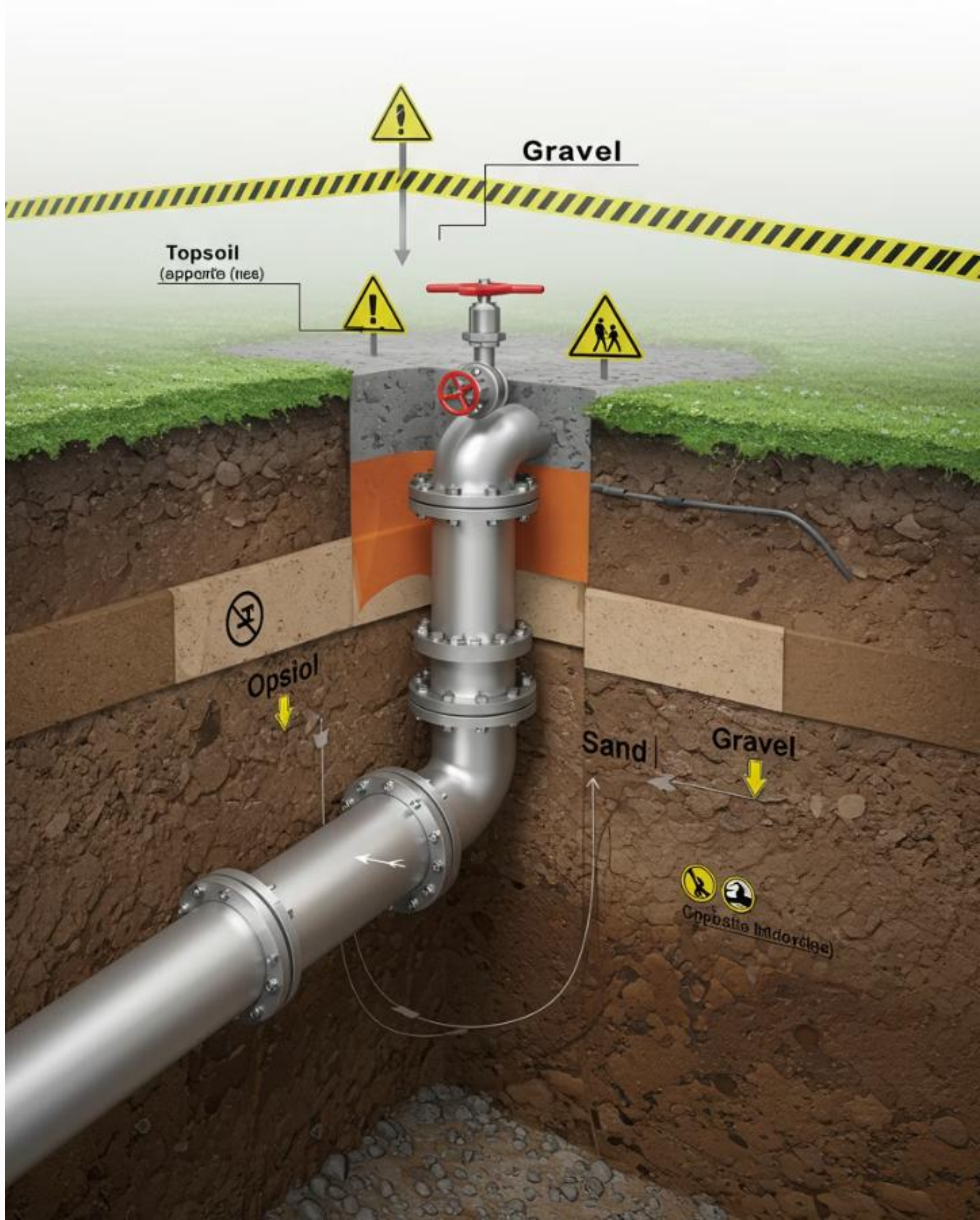
Backfill material must be free of sharp objects, large stones, or other material that may damage the piping

Tracer Wire

A tracer wire or the equivalent must accompany buried plastic piping

Venting Requirements

When paving covers the piping or extends 25 ft (8 m) or more from the building, a vent pipe inspection point must be installed



Venting Requirements for Paved Areas

Requirements

When paving covers the piping or the paving extends 25 ft (8 m) or more from the building:

- You must install a vent pipe inspection point
- You should provide a sleeve in the pavement to permit free movement of piping
- This sleeve can also serve as a vent pipe inspection point

Identification of Gas Piping

Option 1: Full Painting

The entire piping or tubing system shall be painted yellow

Option 2: Yellow Banding

The piping or tubing system shall be provided with yellow banding that has a minimum width of 1 in (25 mm)

Option 3: Labeling

The piping or tubing system shall be labeled or marked "GAS" or "PROPANE", as applicable, utilizing yellow labels or markings

When identified using banding or labels, the identification intervals shall not exceed 20 ft (6 m). For supply piping systems carrying pressures 2 psi and over, you must identify and label the supply pressure in addition to the above identification procedures.

Shut-off Valves

Clause 6.18 of the Code describes manual valve requirements for large piping installations. A manual shut-off valve shall be certified to CSA 3.11, CSA 3.16, or ANSI Z21.15/CSA 9.1, or approved for use with gas, and it shall not be subjected to either a temperature or a pressure outside of its certified rating range.

Readily Accessible

You must install a "readily accessible" manual shut-off valve for each appliance

Proper Location

In either the drop or riser as close as possible to the valve train of a commercial and industrial-type appliance

Distance Requirements

Within 50 ft of the residential appliance it serves

Shut-off Valve Locations

Between Buildings

Piping that extends between buildings must have a shut-off valve at the point of exit from the first building and one at the point of entry to the adjoining building.

This ensures that each building can be isolated in case of emergency or maintenance.

Multiple Outlet Shut-off Valves

Master Shut-off Valve

When a classroom, laboratory, or similar room or area contains multiple outlets, a clearly marked master shut-off valve in a readily accessible location within the room must be present for controlling them.

This allows for quick emergency shut-off of all gas outlets in the room from a single location.

Valve Controlling Several Systems

When a shut-off valve controls several piping systems, it shall be:

- Readily accessible for operation at all times
- Provided with an installed handle
- Installed to provide protection from damage
- Clearly marked with an enamelled metal, substantial fibre, or other permanent tag

Test Firing Valve

Location and Requirements

The test firing valve is found on commercial and industrial valve trains downstream of all safety controls and components and as close as possible to the burner of the appliance.

It must be a 1/4 turn valve with handle installed.

You may find this valve simply as a manually operated ball valve on laboratory-certified equipment and as a lubricated plug valve on field-approved equipment.

Importance

Although simple in operation, the test firing valve may be considered the most important valve on the valve train.

When in the closed position, it allows testing of safeties and flame safeguard controls without allowing gas into the combustion chamber, thereby minimizing the risk of backfire or explosion.

Any lubricated valve requires periodic greasing to ensure the valve will function when needed.

Bonding of Metal Gas Piping and Tubing

Bonding 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.

Equipotential Bonding

The Canadian Electrical Code requires equipotential bonding for the continuous metal gas piping system of a building supplied with electric power

Purpose

The objective is to establish equipotentiality, the state in which conductive parts are at a substantially equal electric potential

CSST Concerns

Special concerns exist around bonding Corrugated Stainless-Steel Tubing Systems (CSST), and manufacturers have revised bonding requirements

Bonding Requirements

Bonding Jumper Requirements

The bonding jumper shall not be smaller than:

- No. 6 AWG copper
- No. 4 AWG aluminum

Care should be taken not to have aluminum bonding conductors in contact with copper piping.

Code Requirements

Clause 4.7.3 of CSA B149.1 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."

The Canadian Electrical Code forbids the use of gas piping as an electrical ground.

Bonding vs. Grounding

Bonding

"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."

Purpose: Ensures electrical continuity between metal parts

Grounding

"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."

Purpose: Connects system to earth

The overall objective for grounding and bonding is to minimize the likelihood and severity of electric shock by establishing equipotentiality between exposed non-current-carrying conductive surfaces and nearby surfaces of the earth and to prevent damage to property during a fault.

Commercial Cooking Appliances

Clause 6.21.5 of CSA B149.1 stipulates that commercial cooking appliances certified for use with casters or otherwise subject to movement during cleaning and other large gas utilization equipment that can be moved shall be connected by a certified gas connector that is certified to either ANSI Z21.69/CSA 6.16 or ANSI Z21.101/CSA 8.5.

Certified Connectors

Movable commercial cooking appliances must be connected by a certified connector specifically designed for this application

Restraining Device

When a gas connector is used with a commercial cooking appliance installed on wheels or rollers, a noncombustible restraining device shall be provided to protect the gas connector

Clearance Requirements

A noncombustible, fixed means for maintaining a minimum 6 inch clearance between combustible materials and the sides and rear of the appliance

Approved Joining Methods Overview

This section reviews the different types of piping and tubing systems that the industry uses for gas and their associated valves and fittings and describes approved joining methods for gas piping and tubing.

Welding

Required for large piping and underground systems

Threading

Common for steel pipe connections

Flanging

Used for larger diameter connections

Compression Fittings

Approved for certain applications

Underground Piping Joining Requirements

CSA B149.1 requires the threading, flanging, and welding of joints in steel piping. However, Clause 6.15.2 specifies that underground piping systems be joined or connected by welding, approved mechanical compression fittings or press-connect fittings.

Welding Requirements

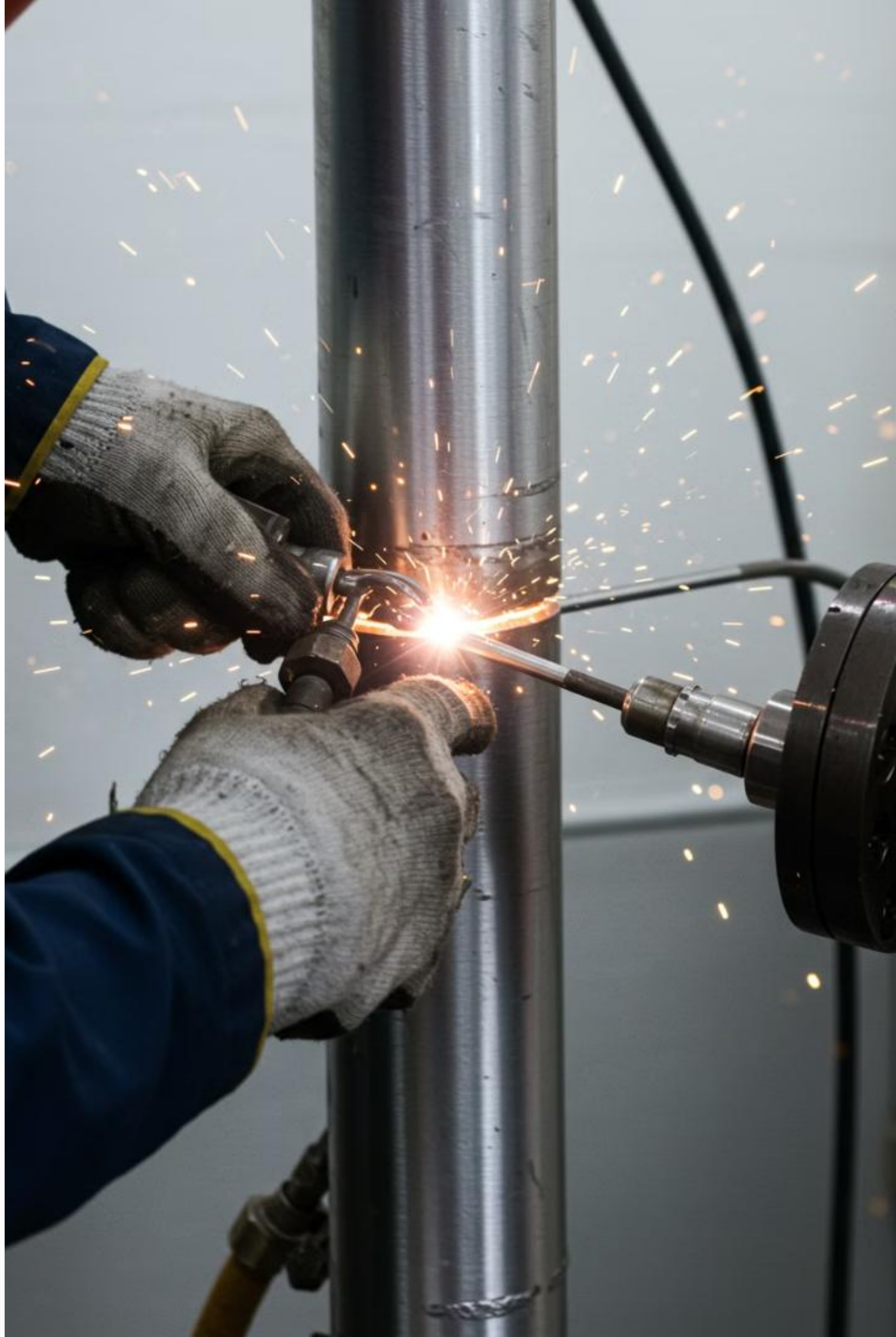
For all practical purposes, welding is the acceptable method for joining large underground piping.

The Boiler and Pressure Vessels Act governs certification requirements and procedures related to welding.

Alternative Methods

In some cases, approved mechanical compression fittings or press-connect fittings may be used for underground piping systems.

Always consult the authority having jurisdiction for specific requirements in your area.



General Requirements for Piping and Tubing

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 you must follow.

Piping Materials

Must meet specific standards and be appropriate for the application

Fittings

Must be compatible with the piping material and certified for gas use

Connections

Must use approved joining methods specific to the piping material

Pressure Ratings

All components must be rated for the intended operating pressure

Piping Materials and Fittings

Type of pipe or tubing	Type of fittings	Type of connections
Iron and galvanized iron pipe	Malleable iron	Threaded
	Steel	Welded (but not recommended for galvanized iron pipe)
	Compression	Flanged
	Mechanical	Connector with forged nut ring, flange, and bolts
Polyethylene	Hub to hub	Hot iron socket fusion
	Pipe to pipe	Butt fusion

More Piping Materials and Fittings

Type of pipe or tubing	Type of fittings	Type of connections
Polyethylene (cont.)	Saddle	Saddle fusion
	PE fittings	Compression slip lock
Copper tube	Copper to copper	Brazing over 1000°F
	Flare fittings	Single 45° flare
	Compression	Nut ball sleeve
Steel tube	Flare fittings	Single 45° flare
	Compression	Nut ball sleeve

Joints and Connections in Large-Size Piping

Size Requirements

Piping of NPS 2-1/2 and over must have welded pipe joints

Qualified Welders

An operator registered under the applicable provincial legislation must perform the welding of gas piping in accordance with a procedure

Acceptance Criteria

The acceptance criteria for any welds must be as specified in CSA Z662, Oil and gas pipeline systems

Inspection Requirements

The completed welds on the outside surface of the piping shall be visually inspected for 100% of the weld length

Gasket and Lubricant Requirements

Gasket Materials

Gasket materials must be of neoprene or a similar material that resists any action of gas.

Natural rubber is not acceptable for gas applications as it can deteriorate when exposed to gas.

Gaskets must be rated for the pressure and temperature conditions they will experience in service.

Lubricants

A lubricant used in either a valve or a control shall be of a type approved for gas use.

It shall be capable of withstanding the service conditions to which it can be subjected when used in accordance with the manufacturer's recommendations.

Special gas-approved pipe dope or thread sealant must be used on threaded connections.

Iron and Galvanized Steel Piping

Steel gas piping must conform to ASTM specification A53/A53M or A106 as described in Clause 6.2.1 of CSA B149.1. Black pipe is most commonly used for gas with pipe fittings of steel or malleable iron.

Nominal Pipe Size (NPS)

The industry uses NPS for sizing black pipe used for gas systems

Consistent Outside Diameter

For any nominal size of pipe, the outside diameter (OD) remains the same and the inside diameter (ID) changes as the wall thickness increases

Threaded Ends

Pipe is threaded on the outside only; therefore the OD must remain constant

Nominal Size

A designation used for the purpose of general identification

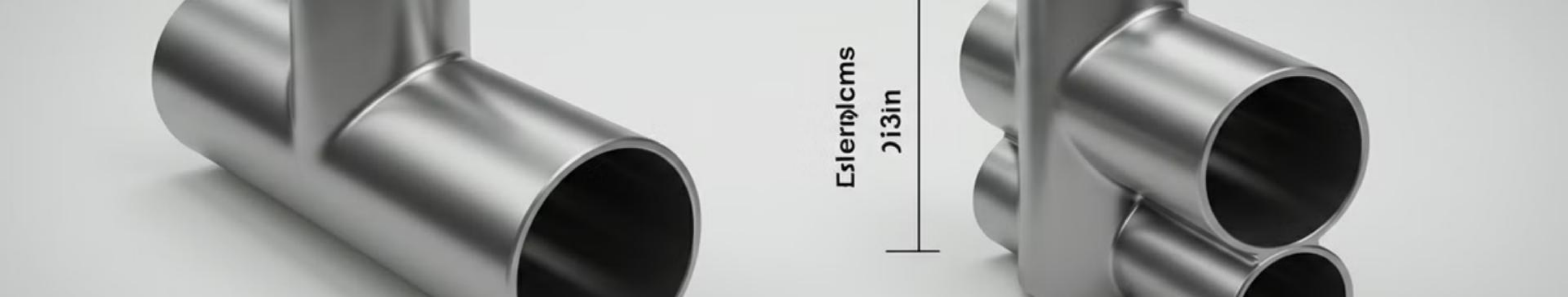
Pipe End Types

Types of Pipe Ends

You may finish the ends of gas piping and tubing in the following ways, depending on the application:

- Plain: Straight cut with no additional finishing, used for compression fittings or welding preparation
- Bevelled: Angled cut on the edge, primarily used for welded connections
- Threaded: Machine-cut threads for use with threaded fittings

The type of end finish required depends on the joining method to be used and the application requirements.



Pipe Wall Thickness

Schedule 40

The gas industry uses Schedule 40 or Schedule 80 steel pipe for gas systems. Schedule refers to the wall thickness of the pipe.

Schedule 40 pipe is standard weight and is the most commonly used for gas piping systems in normal applications.

Schedule 80

Schedule 80 is extra heavy weight pipe with thicker walls for higher pressure applications or where additional strength is required.

Schedule 40 and Schedule 80 pipe have the same outside diameter (OD), but different inside diameters (ID) due to the wall thickness difference.

Pipe Markings and Labels

You must mark and label the piping you use for gas systems as described in Clause 6.17 of CSA B149.1.

1. **Full Yellow Paint**

   The entire piping or tubing system shall be painted yellow

2. **Yellow Banding**

   The piping or tubing system shall be provided with yellow banding that has a minimum width of 1 in (25 mm)

3. **Labeling**

   The piping or tubing system shall be labeled or marked "GAS" or "PROPANE", as applicable, utilizing yellow labels or markings

When identified in accordance with options 2 or 3, the identification intervals shall not exceed 20 ft (6 m).

Pressure Test Before Appliance Installation

Isolate the System

Disconnect the system from any gas source

Cap Open Ends

Seal all open pipe ends

Install Pressure Gauge

Connect calibrated gauge to system

Pressurize System

Apply air or inert gas to required test pressure

Monitor for Required Duration

Observe for pressure drop per code requirements

Leak Test After Appliance Installation

Connect Appliances

Install all appliances to the piping system

Visual Inspection

Check for any openings in the system

Calibrated Gauge

Use gauge calibrated in 1 in w.c. (250 Pa) increments

Perform Test

Test using gas supply at normal static pressure for minimum 10 minutes

Check Connections

Apply leak detector solution to all connections

Soap Test for Leak Detection

Soap Test Procedure

The soap test is a simple but effective method for detecting gas leaks:

1. Prepare a solution of soap and water (commercial leak detector solutions are also available)
2. Apply the solution to each joint or fitting in the suspect portion of the system
3. Watch carefully for bubble formation, which indicates a leak
4. Mark any leaking joints for repair
5. After repairs, retest to confirm the leak has been fixed

This method is particularly useful for finding small leaks that might not cause a noticeable pressure drop during testing. The formation of bubbles provides a visual indication of the exact location of the leak.

Checking for Shut-off Valve Seepage

Pressurize System

Bring the system to a static pressure condition

Release Pressure

Release a small amount of the contained gas pressure by quickly removing, then replacing, the manometer or pressure gauge tubing

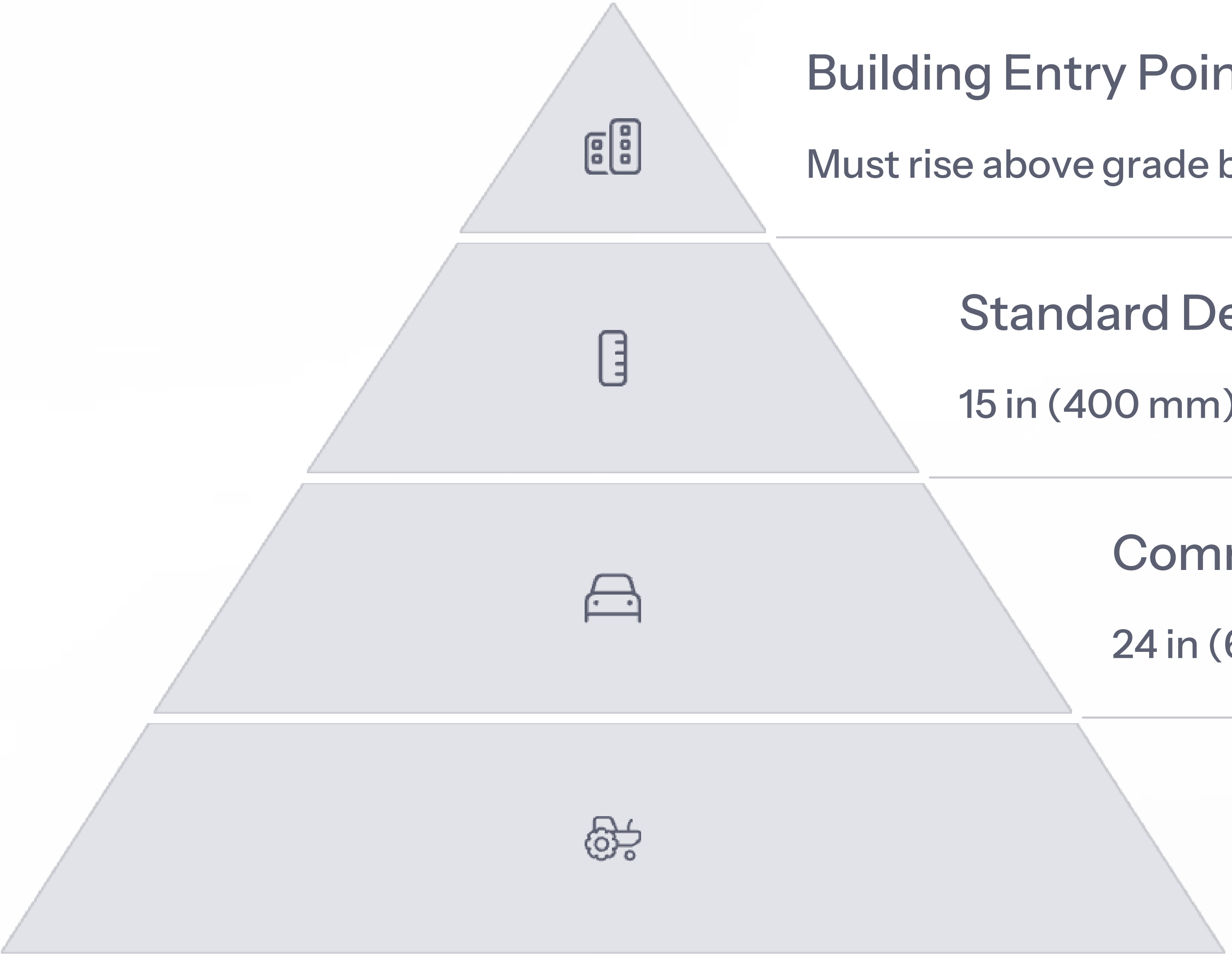
Allow Repressurization

This action opens the service regulator and allows repressurization of the system back to the gas meter shut-off valve

Observe Pressure

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

Underground Piping Depth Requirements



Building Entry Point

Must rise above grade before entry

Standard Depth

15 in (400 mm) minimum

Commercial Driveways

24 in (610 mm) minimum

Farm Operations

Additional depth required

Clause 6.15.4 of CSA B149.1 gives minimum depths for underground piping locations. Additional depth of cover shall be required where the piping is located in areas where physical damage is likely to occur, such as farm operations.

Underground Piping Entry Requirements

Standard Requirement

Piping or tubing entering a building shall rise above grade before entry, unless otherwise permitted by the authority having jurisdiction

Below Grade Entry

If below grade entry is permitted, you must provide a watertight seal where the piping passes through an outside wall below grade

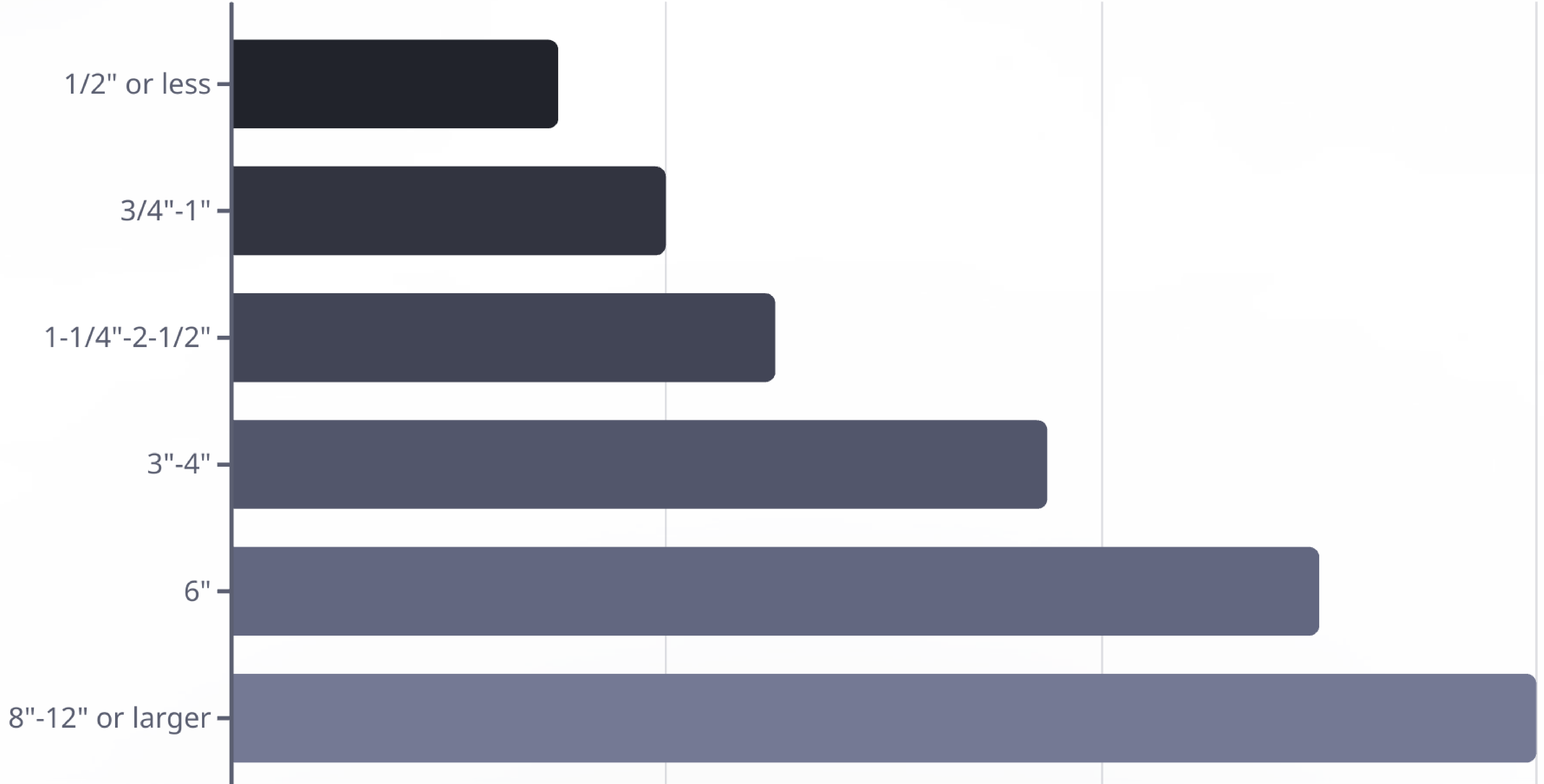
Wall Protection

Piping or tubing passing through concrete or masonry walls must have a sleeve, coating, or double-wrap

Footing Restriction

Piping may not pass under a footing or building wall because building settlement can cause crushing or rupture of the pipe

Piping Support Spacing Requirements



Rooftop Piping Support Types

Treated Wood Blocks

Traditional support method using treated wood blocks with pipe clamps. Must include protection for the roof membrane.

Certified Rooftop Supports

Commercially available certified supports designed specifically for rooftop gas piping installations.

Expansion Loops

Required when a rooftop piping run exceeds 100 ft in length in any one direction to allow for thermal expansion.

Rooftop Piping Expansion Solutions

Site-Assembled Piping Offset

A piping configuration that allows for expansion and contraction of the piping system as it heats with sun exposure.

This type of expansion loop is constructed on-site using standard pipe and fittings according to the specifications in Annex G of CSA B149.1.

The size and configuration of the offset depends on the pipe size and the expected thermal expansion.

Engineered Expansion Joint

A manufactured component specifically designed to accommodate pipe movement due to thermal expansion.

These joints are typically more compact than site-assembled offsets and may be preferred in space-constrained installations.

Must be certified for gas use and installed according to manufacturer's instructions.

Rooftop Piping Corrosion Protection

Painting Requirements

Steel piping systems installed on commercial rooftops must have two coats of quality rust proof paint.

This provides protection against atmospheric corrosion that could compromise the integrity of the piping system.

UV Protection Considerations

Yellow jacket PVC factory coatings should not be used as they break down and deteriorate with UV exposure.

This deterioration may lead to premature corrosion of the pipe and potential failure.

Code Requirements

See Clause 6.16 of CSA B149.1 for specific requirements regarding protection of piping exposed to corrosive atmospheres.

All protective coatings must be maintained to ensure continued protection throughout the life of the installation.

Underground Piping Trenching Requirements

Trench Preparation

Trenches for piping must undergo proper grading to avoid any sagging in the pipes or tubes.

The trench bottom should be smooth and free of rocks or debris that could damage the pipe.

Proper sloping may be required to ensure drainage away from the pipe.

Backfill Requirements

Backfill material must be free of sharp objects, large stones, or other material that may damage the piping.

Initial backfill around the pipe should be with fine material, carefully placed and compacted.

Final backfill can use excavated material if suitable, but must still be free of large rocks or debris.

Tracer Wire Requirements

Purpose

A tracer wire allows for future location of buried plastic piping using electronic detection equipment

Application

Required for all buried plastic piping since plastic is not detectable with standard metal detectors

Installation

The wire must be installed alongside the pipe and brought to the surface at appropriate access points

Material

Typically insulated copper wire suitable for direct burial and resistant to corrosion

Vent Pipe Inspection Points

Requirements

When paving covers the piping or the paving extends 25 ft (8 m) or more from the building:

- You must install a vent pipe inspection point
- This allows for monitoring of the underground piping space for potential gas leaks
- It also provides access for inspection and testing of the underground system

Sleeve Requirements

You should provide a sleeve in the pavement to permit free movement of piping.

This sleeve can also serve as a vent pipe inspection point.

The sleeve prevents damage to the pipe from pavement movement due to temperature changes, settling, or traffic loads.

Gas Piping Identification Options

At every care or detention occupancy, commercial, industrial, and assembly building, piping or tubing shall be identified by one of the following: the entire piping or tubing system shall be painted yellow; the piping or tubing system shall be provided with yellow banding that has a minimum width of 1 in (25 mm); or the piping or tubing system shall be labelled or marked "GAS" or "PROPANE", as applicable, utilizing yellow labels or markings.

Identification Interval Requirements

20 ft

Maximum Interval

When using banding or labels, identification intervals shall not exceed this distance (6 m)

1 in

Minimum Band Width

Yellow banding must have a minimum width of 1 inch (25 mm)

2 psi

Pressure Labeling

Supply piping systems carrying pressures 2 psi and over must identify and label the supply pressure

Proper identification of gas piping is essential for safety, allowing maintenance personnel and emergency responders to quickly identify gas lines in commercial and industrial buildings.

Manual Shut-off Valve Requirements

Certification

A manual shut-off valve shall be certified to CSA 3.11, CSA 3.16, or ANSI Z21.15/CSA 9.1, or approved for use with gas

Operating Conditions

It shall not be subjected to either a temperature or a pressure outside of its certified rating range

Accessibility

Must be "readily accessible" for operation in case of emergency

Location

In either the drop or riser as close as possible to the valve train of a commercial and industrial-type appliance

Shut-off Valve Location Options

Drop or Riser Installation

In either the drop or riser as close as possible to the valve train of a commercial and industrial-type appliance.

In either the drop or riser of a residential appliance.

Horizontal Piping Installation

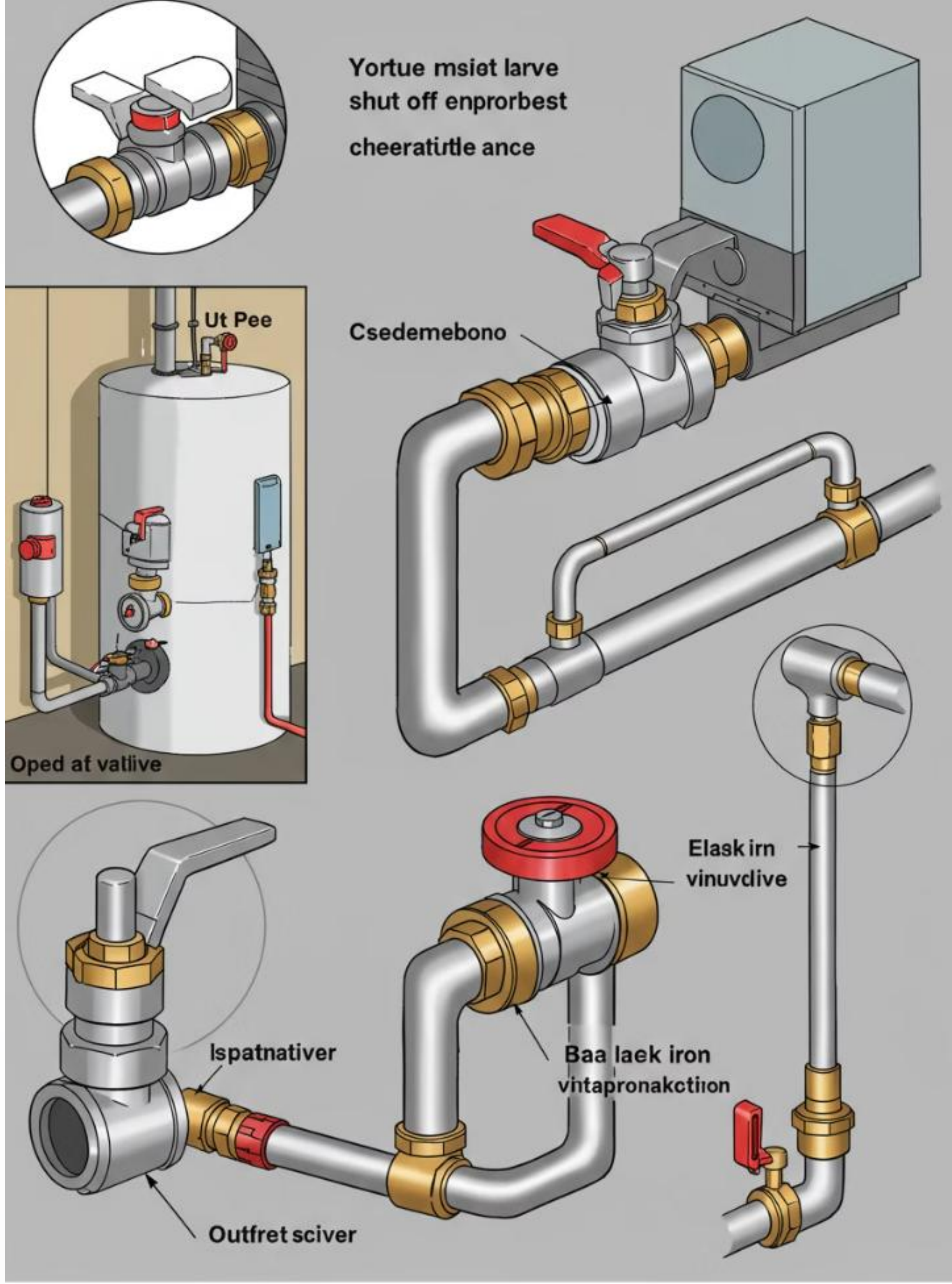
In the horizontal piping between the drop or riser and the appliance valve train.

May be the same size as the appliance connection when located within 2 ft (600 mm) of the appliance.

Distance Requirement

Within 50 ft of the residential appliance it serves.

This requirement ensures that the shut-off valve is within a reasonable distance for emergency access.



Gas Applanice Shutcff Valve
Instlbenitvalues

Multiple Outlet Control

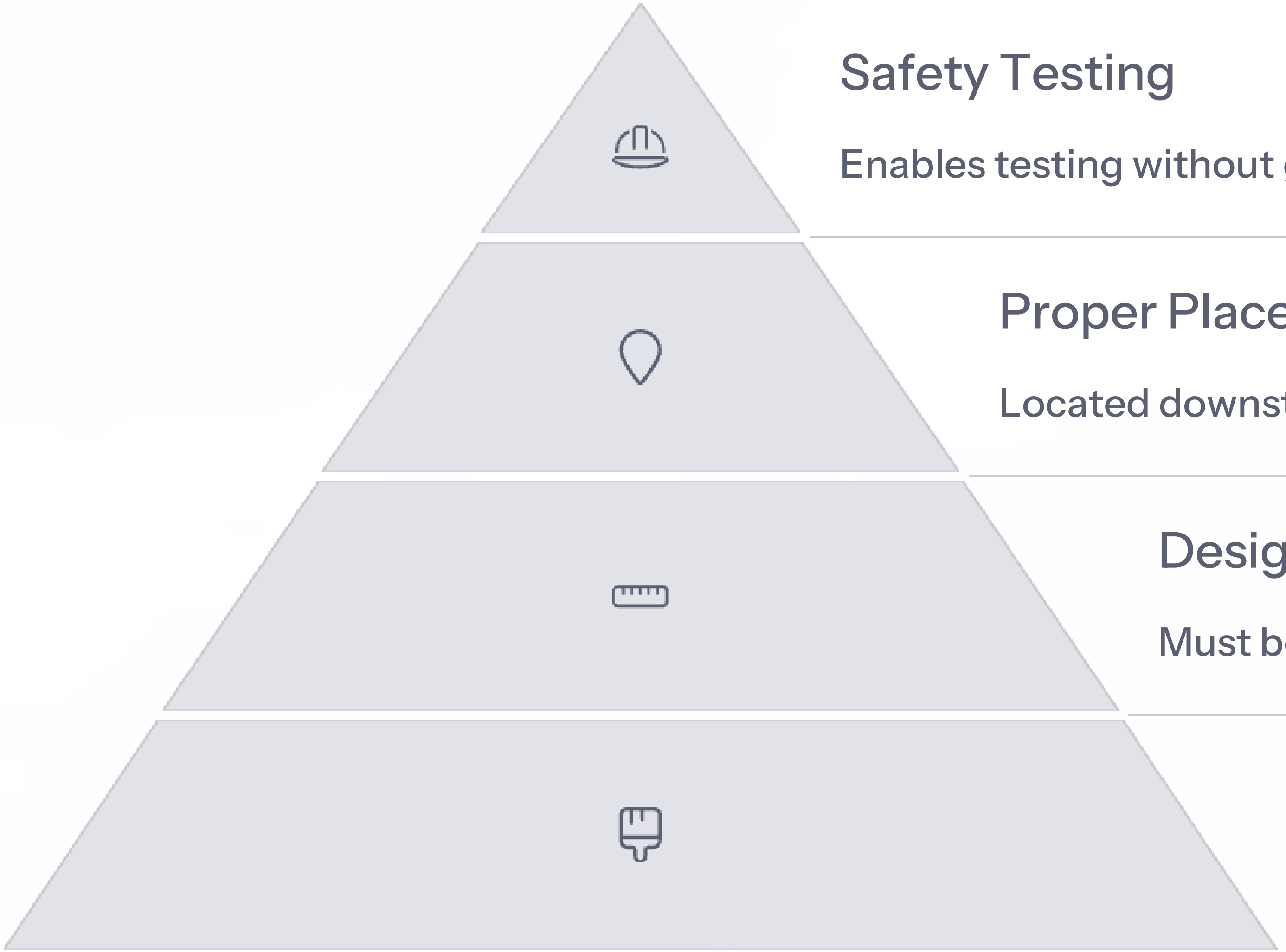
Master Shut-off Valve

When a classroom, laboratory, or similar room or area contains multiple outlets, a clearly marked master shut-off valve in a readily accessible location within the room must be present for controlling them.

This allows for quick emergency shut-off of all gas outlets in the room from a single location, enhancing safety in educational and research environments.

The master shut-off valve must be clearly identified and located where it can be quickly accessed in an emergency situation.

Test Firing Valve Function



Safety Testing

Enables testing without gas flow

Proper Placement

Located downstream of all controls

Design Requirements

Must be 1/4 turn valve with handle

Maintenance Needs

Lubricated valves require periodic greasing

Although simple in operation, the test firing valve may be considered the most important valve on the valve train. When in the closed position, it allows testing of safeties and flame safeguard controls without allowing gas into the combustion chamber, thereby minimizing the risk of backfire or explosion.

Commercial Cooking Appliance Requirements

Certified Gas Connector

Commercial cooking appliances certified for use with casters must be connected by a certified gas connector that is certified to either ANSI Z21.69/CSA 6.16 or ANSI Z21.101/CSA 8.5.

Restraining Device

When the gas connector is used with a commercial cooking appliance installed on wheels or rollers, a noncombustible restraining device shall be provided to protect the gas connector.

Clearance Requirements

A noncombustible, fixed means for maintaining a minimum 6 inch clearance between combustible materials and the sides and rear of the appliance.

Pipe and Tubing Joining Methods

Welding

Required for large piping (NPS 2-1/2 and over) and underground systems. Must be performed by certified welders according to approved procedures.

Threading

Common for steel pipe connections, especially in smaller diameters. Requires proper thread sealant approved for gas use.

Flanging

Used for larger diameter connections and where disassembly may be required. Requires proper gasket material resistant to gas.

Compression Fittings

Approved for certain applications, particularly with copper and steel tubing. Must be certified for gas use.

Fusion Methods

Used for polyethylene piping, including socket fusion, butt fusion, and saddle fusion techniques.

Summary of Code Requirements and Joining Methods

Code Knowledge

Understanding CSA B149.1 requirements for commercial and industrial applications

Material Selection

Choosing appropriate piping materials and fittings for the application

Joining Methods

Applying approved joining techniques for different piping materials

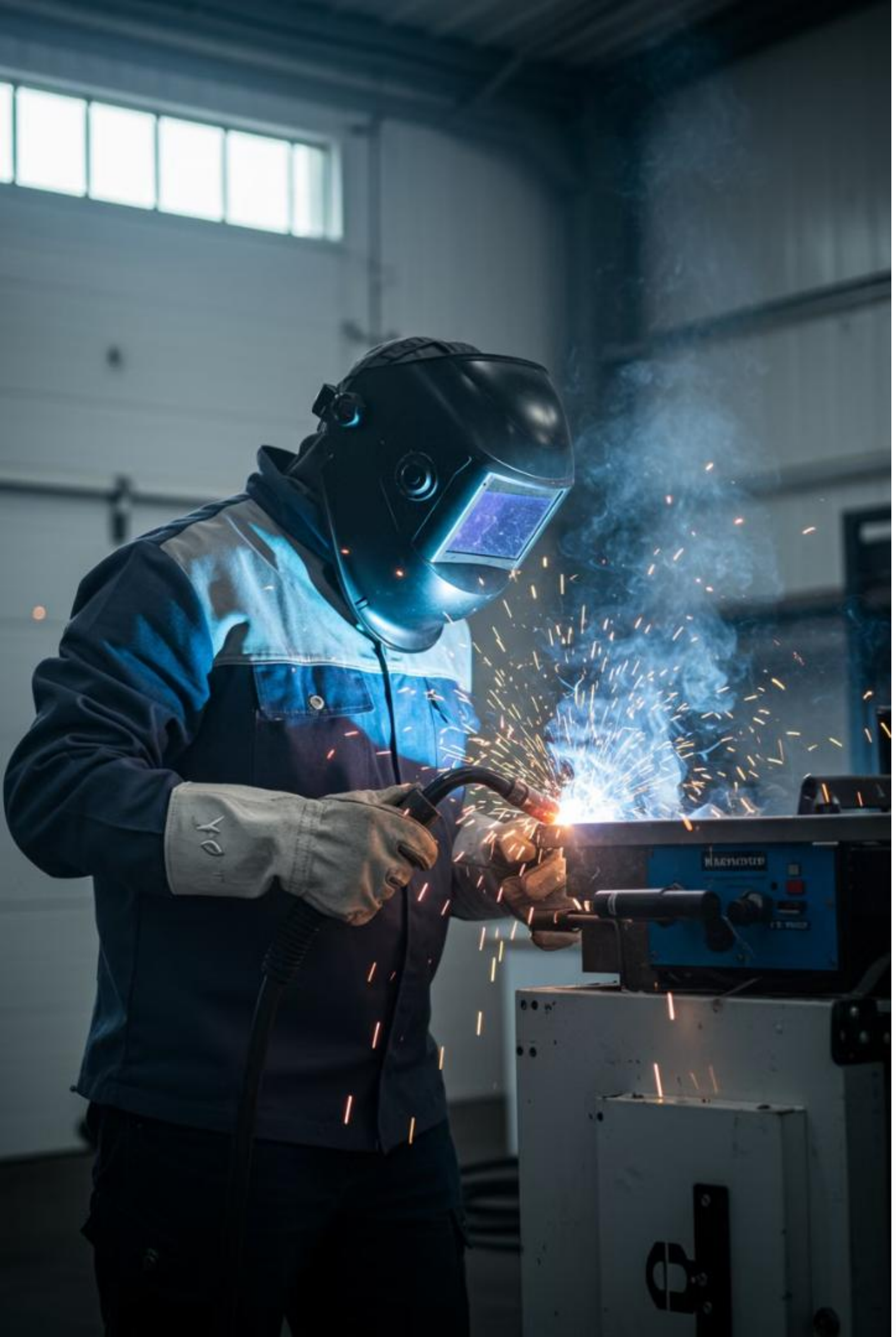
Testing Procedures

Conducting proper pressure and leak testing to ensure safety

Safety Measures

Implementing proper identification, shut-off valves, and protection

The installation of gas piping and tubing requires thorough knowledge of code requirements and approved joining methods. Gas technicians must consider pipe sizes, locations, pressures, and appropriate materials before installing any system. Proper testing, identification, and safety measures are essential for ensuring a safe and compliant installation.



CSA Unit 10 Chapter 2 Welding Safety, Certification, and Procedures

Having any type of welding certification is not a requirement for gas technicians/fitters. However, a gas technician/fitter cannot perform any type of welding without having received certification as a welder. Additionally, testing and accreditation of a certified welder is a must to perform an approved gas pipe welding procedure before obtaining legal certification to weld gas piping.

As a gas technician/fitter, you should have a thorough understanding of welding requirements and safety procedures, along with knowledge of welding-related hazards, in order to protect yourself when in the presence of welding activities.

MK by Mike Kapin

Learning Objectives

Describe Common Welding Hazards

Identify and understand the various physical, chemical, and environmental hazards associated with welding operations.

Describe Safety Precautions

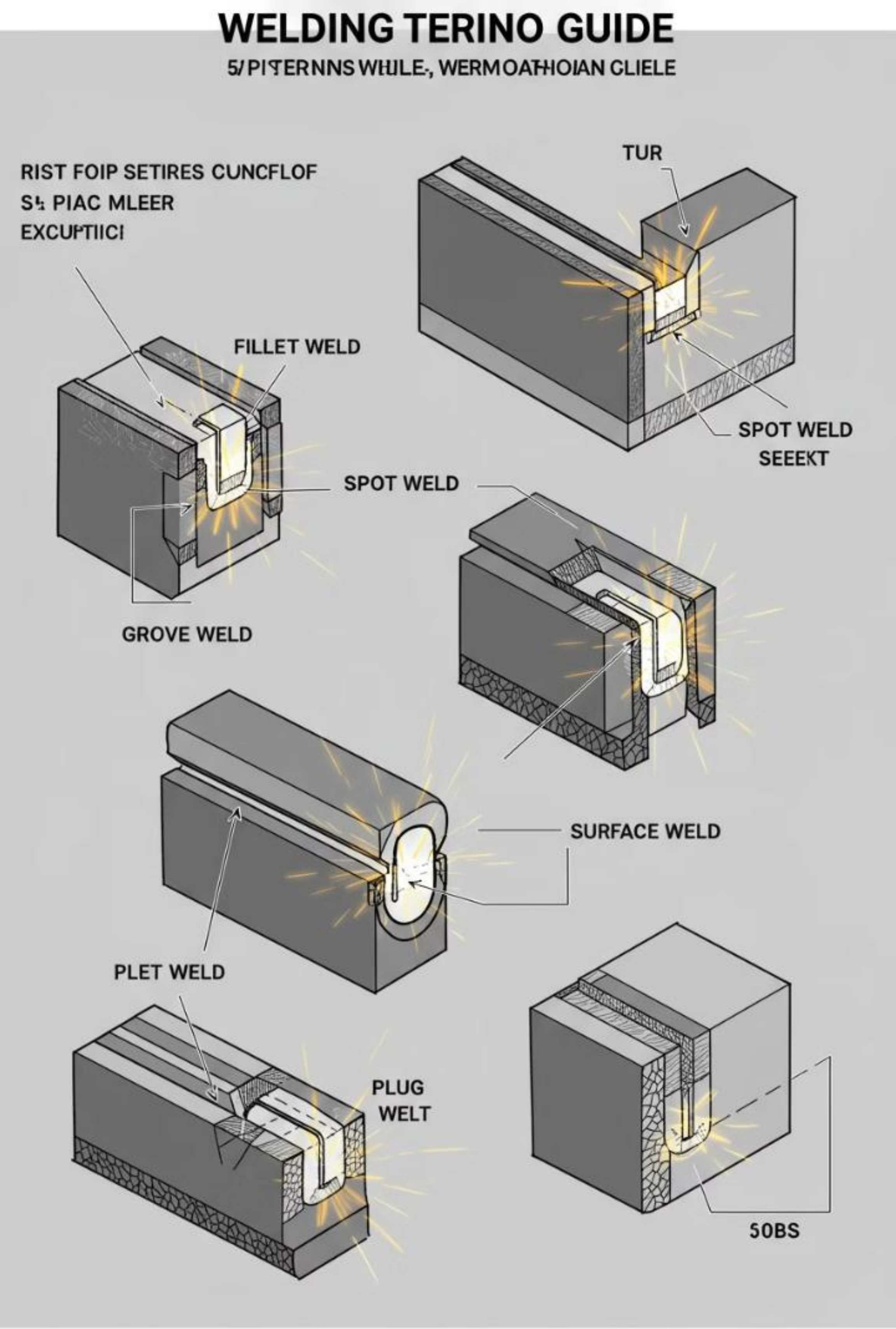
Learn the necessary safety measures and protocols to protect yourself and others during welding activities.

Describe Certification Requirements

Understand the legal and professional certification requirements for welding gas piping.

Describe Preparation for Welding

Learn the proper preparation techniques required for welding testing and operations.

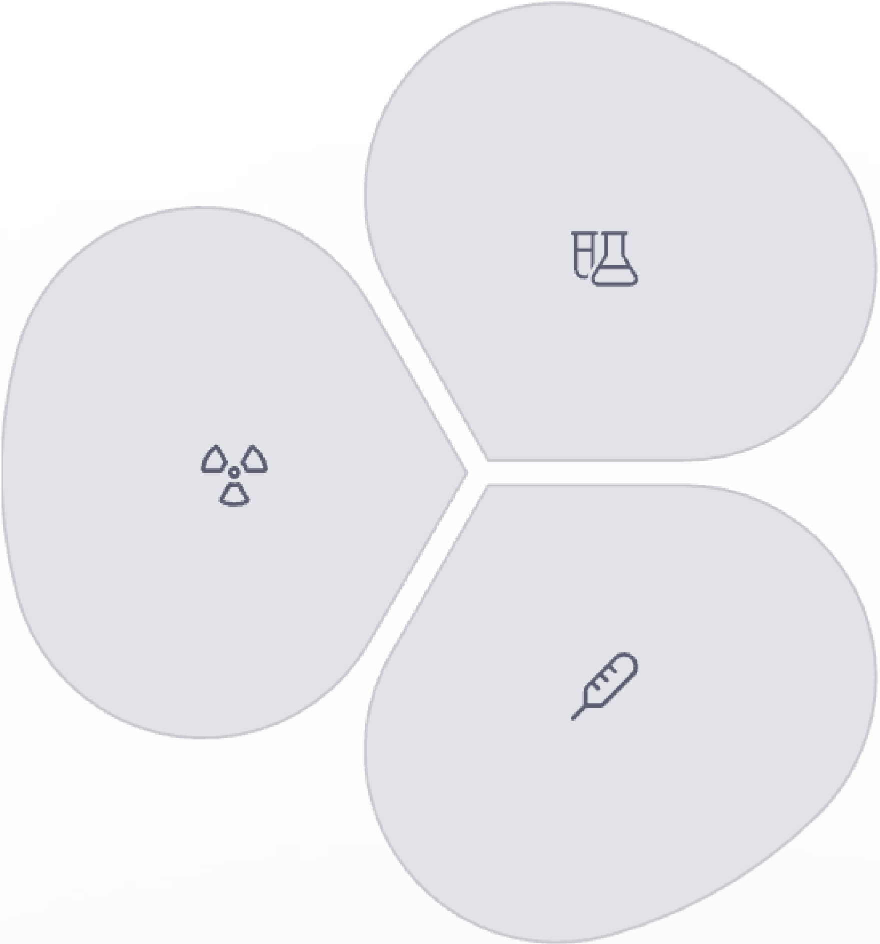


Key Terminology

Term	Abbreviation (symbol)	Definition
Boiler and Pressure Vessel Safety Branch	BPVB	
Canadian Council of Directors of Apprenticeship	CCDA	Voluntary partnership between Canada's federal, provincial and territorial governments that supports the development of skilled trades in Canada and manages the Interprovincial Standards Red Seal Program
Critical point		Point at which a material is unstable (See unstable.)
Land or root face (welding)		Part of a fusion face that is not bevelled in a welding operation
Unstable		When material is likely to break down (decompose) or undergo a physical change without much provocation or cause

Common Welding Hazards

Being a gas technician/fitter does not require you to hold a welding ticket. However, since you will be working alongside a welder for all welding operations, you must be aware of a number of hazards and safety issues related to welding.



Physical Hazards

- Various types of radiation
- Visible light
- Noise
- Electrical energy

Chemical Hazards

- Flammable and combustible products
- Welding fumes and toxic gases
- Dust

Environmental Hazards

- Extremes of temperature
- Poor ventilation
- Biological hazards

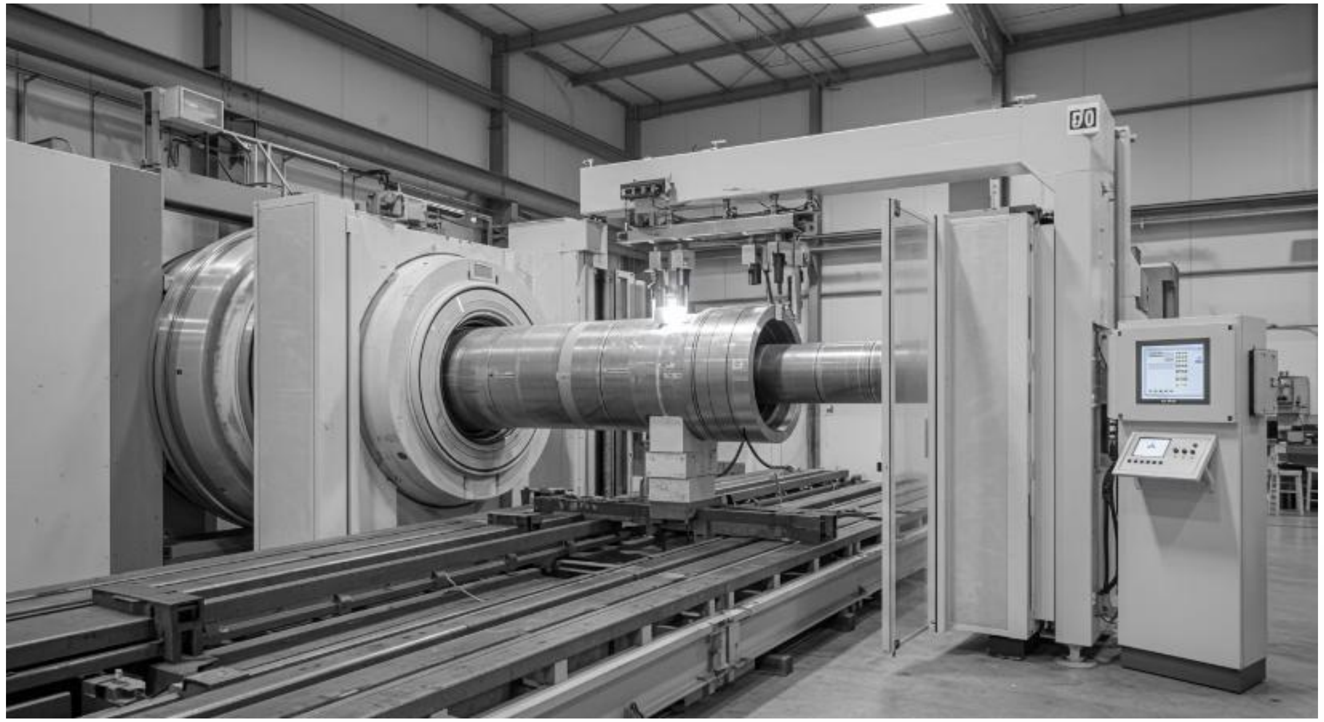
Physical Hazards: Ionizing Radiation

X-rays and Gamma Rays

X-rays and gamma rays produce ionizing radiation during the welding process. These rays are:

- Emitted from equipment for gauging the density and thickness of pipes and to check welds
- Invisible forms of ionizing radiation and can be extremely damaging to unprotected parts of the body

You must completely shield welding chambers to confine X-rays and protect the welder.



Ionizing radiation can cause serious health issues if proper shielding and protection are not used. Always follow safety protocols when working near equipment that produces X-rays or gamma rays.

Physical Hazards: Non-ionizing Radiation

Ultraviolet (UV) Radiation

Produced by the arc or from a reflection off bright objects like white clothing or shiny metal. Without adequate eye protection, you could suffer from arc flash, a burnt and blistered condition of the eyeballs.

Eyes become watery and painful in the period up to 24 hours after exposure and the condition can last up to five days. It is usually reversible, but repeated exposure can result in scar tissue and impaired vision.

Infrared and Visible Light

Prolonged exposure can cause chronic conjunctivitis and other eye ailments.

Even clear lens safety glass with side shields marked for UV protection can provide a minimum level of protection by reflecting the light.

Protection Requirements

You should wear appropriate eye protection at all times when working within the vicinity of welding to reduce the risk of eye damage and skin burn and blistering in extreme exposure to UV rays.

Physical Hazards: Fire and Flying Metal

Fire Hazards

The high temperatures involved in welding produce hot metal and sparks which can present dangers in many forms. Flying metal particles, sparks, and slag are hazardous to eyes, skin, and readily combustible clothing material.

Your clothing or elsewhere around welding or cutting operations must never carry or have plastic butane lighters. If the casing on the lighter were to come into contact with hot slag, it would melt and explode, causing damage that could be fatal.

Noise Hazards

Substantial hearing loss has been observed in welders as a result of the high noise levels from sources such as grinding, machining, polishing, hammering, and removing slag.

Proper hearing protection is essential when working in or around welding operations.

Chemical Hazards: Pure Oxygen

Combustion Danger

The combination of pure oxygen (O_2) with other materials is a potential combustion danger.

Increased Flammability

Materials that burn in air burn much more readily when exposed to O_2. Other materials that may not burn in air become combustible in O_2.

Oil and Grease Hazards

Either oil or grease, not normally thought of as highly flammable, can cause explosion when brought into contact with pure oxygen.

Cylinder Safety

Oxygen cylinders are pressurized containers. You should never attempt to repair a faulty cylinder.

Chemical Hazards: Acetylene

Properties of Acetylene

Acetylene gas (C_2H_2) used in welding work is a colourless, unstable compound. However, even very small quantities of acetylene produce a pungent odour that is quite noticeable.

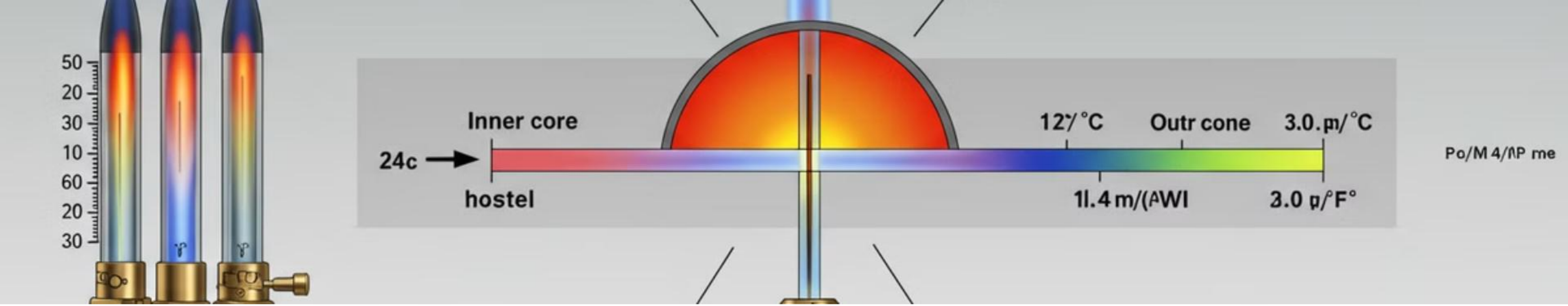
Since any mixture of oxygen and acetylene is regarded as explosive, ensure you take immediate precautions if you smell acetylene.

The term "unstable" means that the material is likely to break down (decompose) or undergo a physical change without much provocation or cause. The point at which this happens is what you call its critical point.

Critical Points and Safety

The critical point of pure acetylene is 28 psi (193 kPa) pressure at 70°F (21°C). At this point, acetylene breaks down into carbon and hydrogen and results in an explosion from the hydrogen gas.

If you increase the temperature, the pressure at which acetylene becomes critical drops. To allow for any temperature fluctuations in the work area, do not store or use free acetylene at pressures over 15 psi (103 kPa).



Acetylene Properties

Temperatures		Explosive limits	
Ignition	Burning	Lower	Upper
763 - 824°F (406 - 440°C)	4770°F (2,632°C)	2.50% acetylene 97.5% air	81% acetylene 19% air

Storage of Gas Cylinders

Secure Storage Location

You must store cylinders where no falling object, passing vehicle, or person can damage or knock them over.

Avoid Corrosive Environments

Cylinders should not come into contact with salt, corrosive chemicals, or fumes.

Secure Cylinders Upright

Whether they are full or empty, you should always secure cylinders upright to a stationary object, such as a wall or portable cart, to keep them from falling down.

Separate Full and Empty

Empty containers should be chained to one wall and full containers separated and chained to the opposite wall.

Portable Oxy-Acetylene Equipment

Portable Cart Design

A portable oxy-acetylene outfit has the acetylene and oxygen containers separately chained to a cart in an upright position.

The cylinder cart is designed to roll easily when tilted back on its wheels, yet be stable and secure when it is stationary.

This design ensures safe transport of the cylinders while maintaining proper storage orientation and security.

Other Chemical Hazards

Flammable Products

Many chemicals used in or around welding operations are highly flammable and pose significant fire risks if not properly handled and stored.

Toxic Gases and Fumes

Welding processes can produce various toxic gases and fumes that can cause respiratory issues and other health problems if inhaled.

Flammable Dust

Certain types of dust generated during welding preparation or cleaning can become flammable when suspended in air, creating explosion risks.

Environmental Hazards

Ventilation Issues

Inadequate ventilation of welding shops or confined work areas produces dangerously toxic, combustible, or inflammable conditions.

Proper ventilation is essential to remove harmful fumes and maintain safe air quality in welding environments.

Temperature Extremes

Extremes of temperature during welding can cause excessive, sometimes life-threatening, effects:

Extreme	Effect
Heat	Causes muscle cramps, dehydration, sudden collapse, and unconsciousness
Cold	Leads to fatigue, irregular breathing, lowered blood pressure, confusion, and loss of consciousness

Protective Clothing for Welding

Complete Protection

Heavy clothing fabric that sheds sparks is recommended for wear around welding operations. Leather is best, but heavy denim is adequate and more practical. Wear clothing that is in good condition, with no holes or frayed areas, and free of grease and oil that covers all exposed skin.

Hand and Arm Protection

Wear gauntlet-type gloves to protect hands and forearms from sparks, heat, and radiation. Proper gloves are essential for preventing burns and other injuries during welding operations.

Eye and Face Protection

Wear adequate eye and face protection against visible light rays, ultra-violet light rays, infrared rays, heat rays, and flying metal particles, sparks and slag. Gas technicians/fitters working with welders should wear flash goggles.

Additional Protective Equipment

Head Protection

Cover and protect head and hair by wearing a cap or other protective headgear to prevent burns from falling sparks or slag.

Foot Protection

Protect your feet with steel-toed boots to prevent injury from falling objects or hot metal.

Proper Clothing

Wear cuffless pants and make sure there are no hanging pieces of light fabric or jewelry attached to your clothing. Ensure your shirt pockets have flaps.

Respiratory Protection

In special circumstances, you may have to wear a respirator or mask to protect against harmful fumes and gases.

Fire Prevention

Follow Fire Prevention Orders

Strictly follow all fire prevention orders at the work site. The high temperatures involved in welding can quickly cause extreme danger of fire and explosion in combustible surroundings and when flammable equipment and materials are in use.

Fire Watch Requirements

There must be someone assigned—someone who is equipped with and trained in the proper use of fire extinguishers—to carry out a "fire-watch" whenever welding or oxy-fuel cutting must take place.

Monitoring Duration

The monitoring duration should not be less than 30 min after completion of any welding or cutting process, and you may determine it to be longer depending on the environment.

Oxy-Acetylene Equipment

Oxygen and Flame Temperature

The addition of oxygen to the flame increases the flame temperature and produces a smaller, more concentrated heat source. Oxygen is combined with acetylene or propane utilizing specialized burner tips that provide a hotter, more controllable flame suitable for brazing procedures on gas tubing systems.

Safety Features

Oxygen cylinders have protection from heat-caused extreme pressure by means of a fusible metal rupture disk that controls the slow escape of gas.

Oxygen is a critical component of the combustion triangle (along with fuel and ignition heat). In its concentrated form, it can lower the ignition temperature of any fuel.

Rules for Working with Oxy-Acetylene Equipment

Do

- Keep oxy-acetylene equipment away from oil or grease
- If a cylinder appears to be leaking or faulty, remove it to the outside, leave it in the open, tag it to indicate its fault, and notify the supplier
- Use the cylinder in a vertical position to prevent acetone from being drawn off
- Store cylinders in a cool area
- If your cylinder has a key-type acetylene valve, open it only 1-1/2 turns. Fully open the hand-wheel type
- Test for leaks using a soap test (never test near an open flame)

Do Not/Never

- Never use oxygen as a compressed air substitute
- Never use oxygen to start or run internal combustion engines
- Never use oxygen to blow out pipe or tubing lines
- Never use oxygen to create pressure
- Never use oxygen for ventilation
- Never use oxygen to dust off clothing or work areas
- Never oil regulators or torch parts
- Never attempt to repair a leaking or faulty cylinder yourself
- Never transfer acetylene from one cylinder to another

Oxy-Propane Equipment

Heat Properties

While propane does not burn as hot as acetylene in its inner cone, it does have a high heat value in its outer cone. So, with the right torch (injector-style), propane can make a faster and cleaner cut than acetylene and is effective for brazing.

Economic Advantages

Propane is also cheaper than acetylene and easier to transport, making it a cost-effective alternative for certain applications.

Equipment Design

Most propane tips are of a two-piece design. Most torches are designed for equal fuel and oxygen pressure and for gases, such as acetylene, which are lighter than oxygen. Propane is a heavier fuel and runs much better through a low-pressure injector torch with a wider range of pressure settings.

Certification Requirements

Legal Requirements

Welders must meet the standards set out in the provincial Boiler and Pressure Vessels Act

Qualification Standards

The welding criteria for testing and qualification is the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) for welding

Testing Procedures

Testing of welders for qualification in Canada is conducted by or through the governing provincial BPVB

Provincial Regulatory Bodies

Technical Standards & Safety Authority (TSSA)

The Boiler and Pressure Vessel Safety Branch (BPVB) in Ontario is the Technical Standards & Safety Authority (TSSA).

Alberta Boilers Safety Association (ABSA)

Alberta's equivalent to the BPVB is the Alberta Boilers Safety Association (ABSA).

Provincial Variations

Each province or territory has their own BPVB. Before performing any work requiring welded pipe, contact the provincial gas safety branch for specific certification requirements in your province.

Red Seal Program

Program Administration

Each province and territory administers the Interprovincial Standards Red Seal Program under the guidance of the Canadian Council of Directors of Apprenticeship (CCDA). Each province or territory has an appointed Director of Apprenticeship for this purpose.

Red Seal Endorsement

An Interprovincial Standards Welder Red Seal is an endorsement that a Trades Person may achieve by meeting requirements established by the provincial or territorial apprenticeship authority and writing and successfully passing the Red Seal Welder Exam (C of Q).

Though achieving this designation is a recognition of achievement of a "standard of excellence" interprovincially, you should note that the Welder Red Seal certification is a trade theory examination and does not certify a welder to weld on boiler and Pressure vessels or any piping associated with the system in question.

Welder Certification Requirements

1 Registered Welding Procedure

No welder shall have permission to weld except under a registered and approved welding procedure and said welder has received certification through performance testing to weld under the same welding procedure.

2 Certification Authority

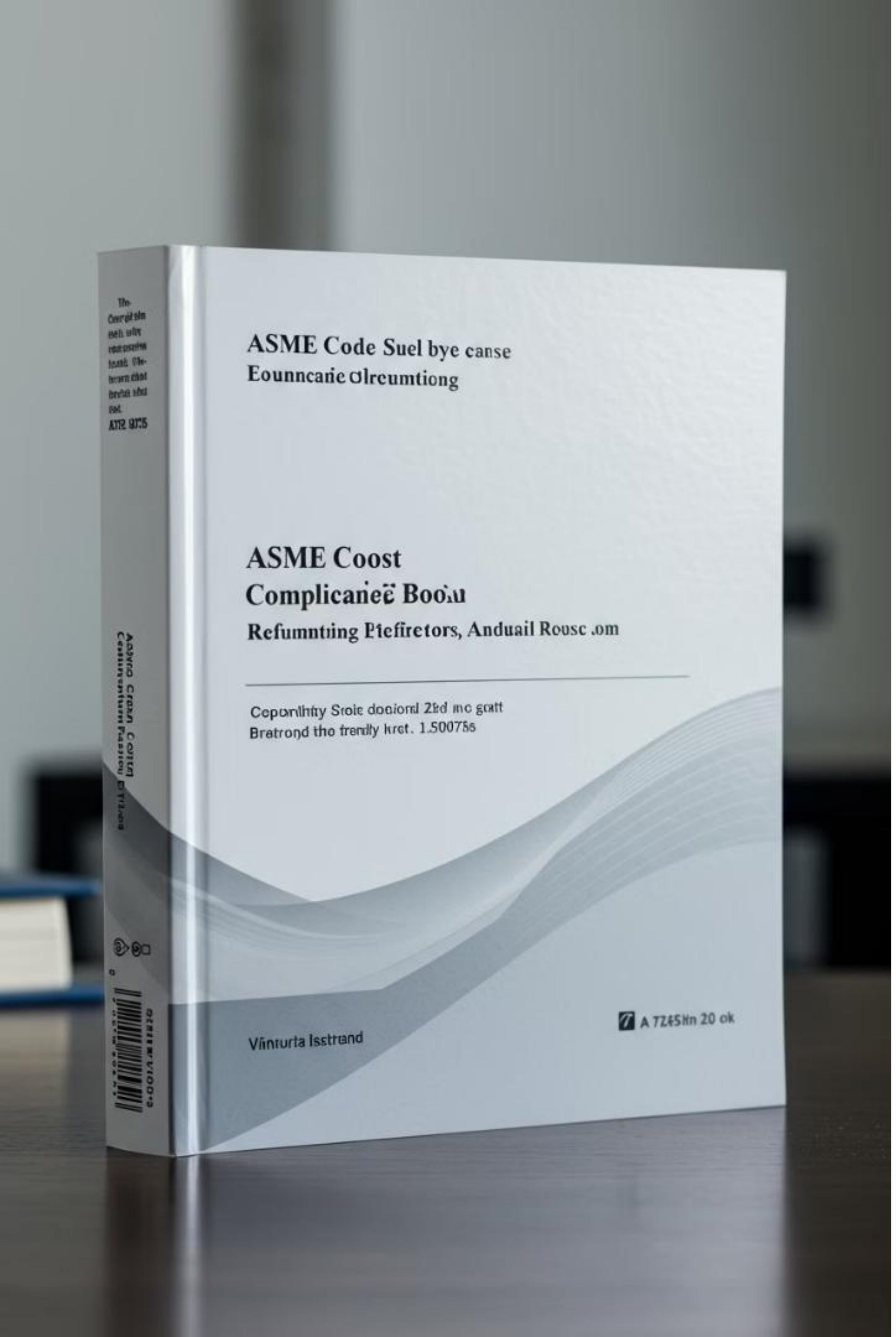
The provincial Boiler Pressure Vessel Branch has license to issue welding certifications to any welder that successfully passes a practical welding exam, with support of a registered welding procedure.

3 Documentation Requirements

The welder performance certification shall list all essential welding variables for each welding procedure tested to. The welding certification shall also identify the welding procedure owner and all pertinent welder identification for verification if required.

4 Current Certification

The welder must always be in possession of a current up to date welding performance certification to a registered welding procedure. If the welder's performance certification has expired, he/she shall not have permission to perform any welding until he/she has received recertification through a welding performance exam and is in possession of an up-to-date welding performance certification.



Code Compliance

ASME BPVC Compliance

All pressure vessel and pipe welding shall comply with an applicable welding code such as ASME BPVC or an equivalent Boiler and Pressure Vessel code.

CSA W59 Distinction

You should not confuse such with other codes/standards such as CSA W59 Welded steel construction (Metal arc welding), which has different applications and requirements.

Code Limitations

CSA W59 is not intended to apply to pressure vessels or to structures governed by special codes such as those of the American Petroleum Institute, the American Society of Mechanical Engineers, or the American Water Works Association.

Preparation for Welding

Shielded metal arc welding is the process you normally use for welding steel gas piping. However, the welding procedures for this process fall beyond the scope of this Chapter and would not be part of a gas technician's/fitter's normal duties. The layout of welded piping systems is the gas technician's/fitter's responsibility and may include such tasks as measuring, marking, cutting, joint preparation, and assembly.

Measuring

Select pipe sizes and measure lengths

Marking

Mark locations of joints and connectors

Cutting

Cut pipe to proper lengths

Joint Preparation

Prepare pipe ends for welding

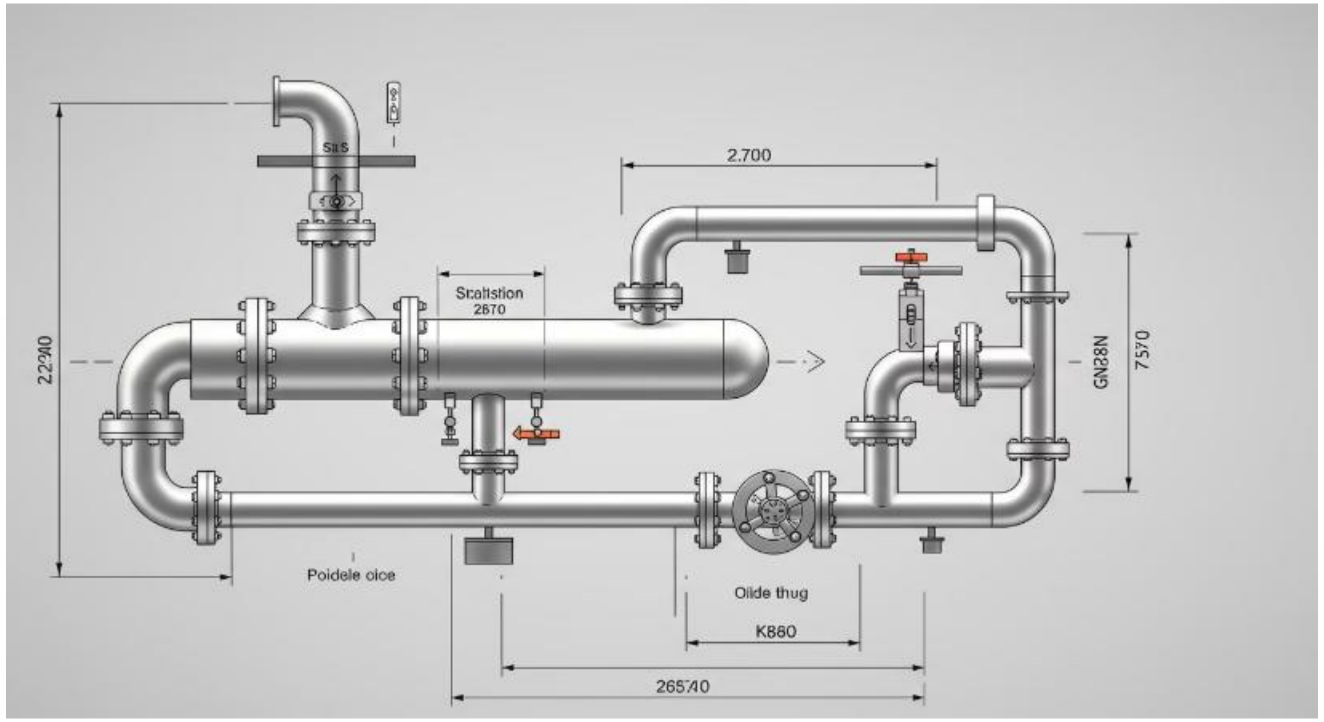
Assembly

Assemble the piping system

Measuring Pipe and Fittings

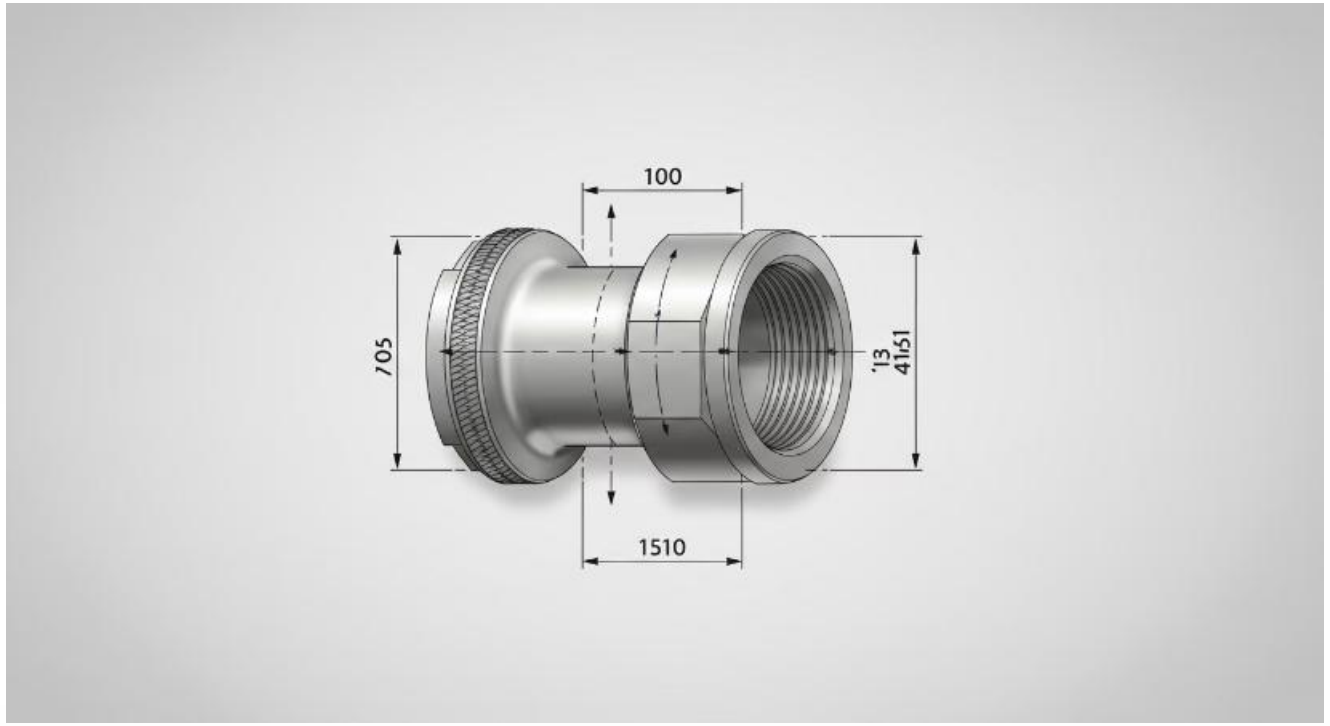
Piping Drawings

Piping drawings represent each pipe by a single line you draw along the centre of the pipe, with the meeting of lines representing the fittings. Dimension lines are what you draw parallel to the length in question, with arrows in opposite directions pointing toward the boundaries of the measurement.



A segment of a piping system with the dimensions 7-7/8 in (200 mm) end-to-centre of pipe. This does not mean that you must cut the pipe exactly 7-7/8 in long, since you must allow for fittings.

Centre Line Measurements



Centre point of a fitting. The tee makes up part of the 7-7/8 in (200 mm), while a 1/8 in (3 mm) root gap and a length of pipe will make up the rest.

Measuring Along Centre Lines

Measure pipe length along centre lines. Where two centre lines cross, place a centre point in a fitting. The dimension 7-7/8 in (200 mm) refers to the total distance between centre point A and point B.

This is what you call an end-to-centre measurement. To find the correct length to cut the pipe, you have to measure the fitting using the following procedure:

1. Measure the distance between the centre point and the point where the pipe will end.
2. Subtract this fitting allowance from the dimension shown on the drawing.
3. This dimension-minus-fitting allowance is the correct length to cut the pipe.

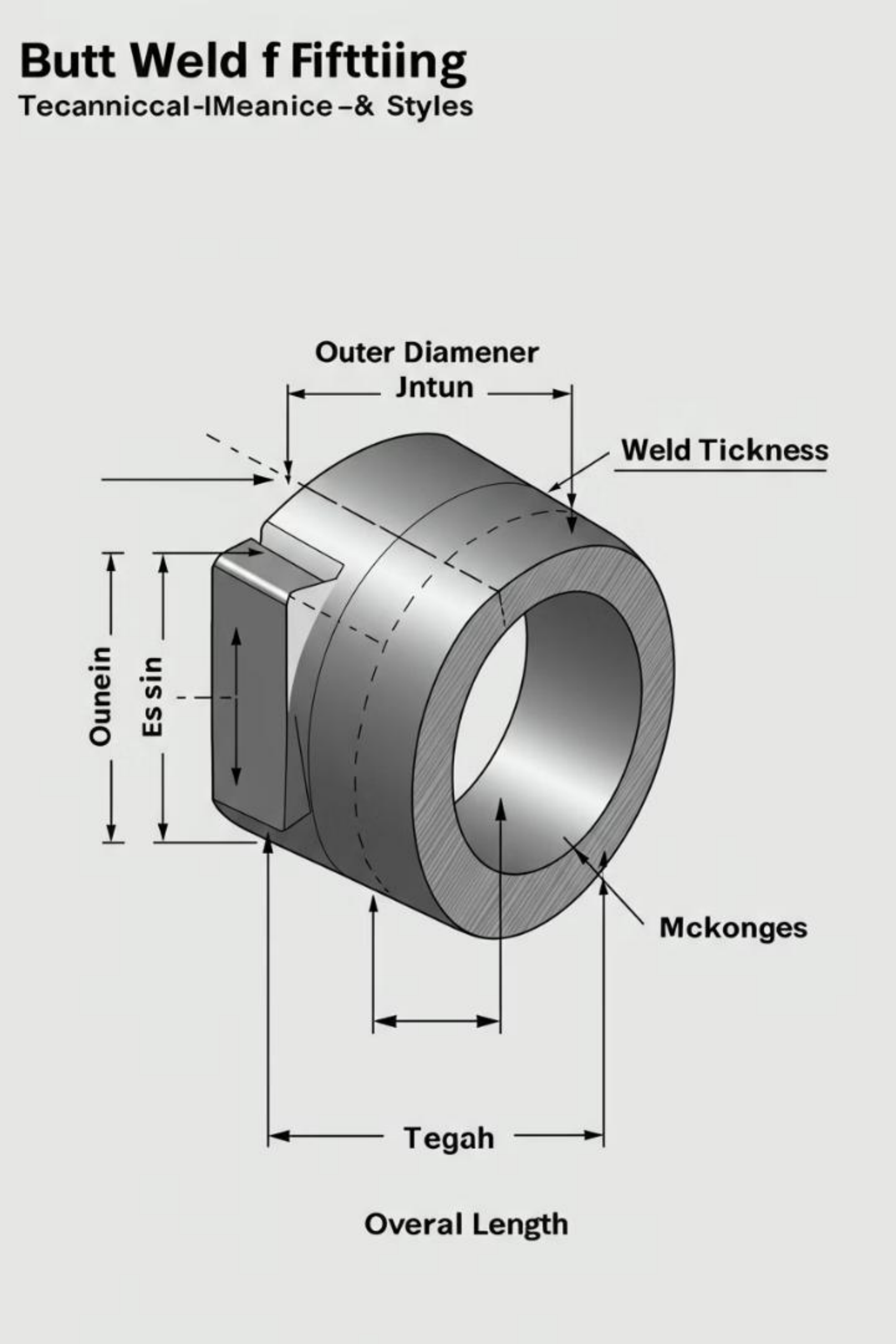
Common Weld Fittings




To calculate the fitting allowances for weld fittings, there are two options: You could make field measurements, or you could refer to a table showing various dimensions for butt weld fittings. These tables typically show Imperial Units of measurement, since these are the most widely used measurements for pipe and fitting dimensions.

Butt Weld Fitting Dimensions

Nominal pipe size (inches)	90° Long radius elbows	45° Elbows	Tees and crosses	Reducing couplings CON/ECC
	A-	B-	C.	-D-
1/2	1.50	0.62	1.00	
3/4	1.12	0.44	1.12	1.50
1	1.50	0.88	1.50	2.00
1-1/4	1.88	1.00	1.88	2.00
1-1/2	2.25	1.12	2.25	2.50



Marking the Cutting Line

Using a Wraparound

For a square cut, you may use wraparound and a piece of soapstone to accurately mark the cutting line. A wraparound is a strip of leather belting or other strong, flexible material approximately 4 in (100 mm) wide.

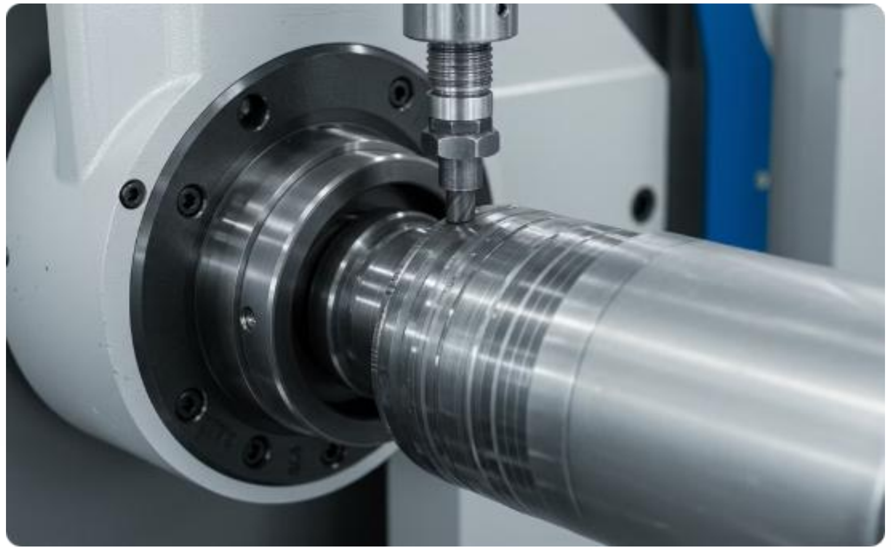
The wraparound should be long enough to go around the pipe at least 1-1/2 times. The edges must be perfectly straight.

Marking Procedure

Use the following procedure to mark a straight line around the pipe:

1. Place one edge of the wraparound against the point at which you must cut the pipe.
2. Circle the pipe with the wraparound and line up the edges accurately.
3. Use the wraparound edge as a guide to draw a line around the pipe with a piece of soapstone.

Cutting Pipe and Tubing



Pipe Cutting and Beveling Machine

Gas technicians/fitters use a variety of methods to cut pipe and tubing. On piping being prepared for welding, you must bevel the pipe end to accommodate the welding procedure. A pipe cutting and beveling machine can be used to both cut and prepare the pipe end in one operation.

Pipe Cutters

Pipe cutters are frequently used on small pipes. You may also use them on larger piping. After cutting, an angle grinder is often used to bevel the end to suit the welding requirements.

Angle Grinders

After cutting with a pipe cutter or cut-off saw, an angle grinder is used to bevel the pipe end to the proper angle for welding. This creates the necessary preparation for a strong, reliable weld joint.

Oxy-Acetylene Cutting

Cutting Large Diameter Pipe

An oxy-acetylene torch is what you often use to cut large diameter pipe. The piping is bevel cut with the torch by hand or by placing the torch in a machine that is angled to suit the bevel.

Final Preparation

The end is then further prepared with an angle grinder to ensure the proper bevel angle and smooth surface for welding.

This combination of torch cutting and grinding provides an efficient method for preparing large diameter pipe for welding operations.

Pipe and Fitting Alignment

Importance of Proper Alignment

As a gas technician/fitter, you must ensure the pipe fitting and alignment is correct before any tacking or welding of fittings, valves, or pipe to avoid weld failure and system malfunction.

Preparation Requirements

Fitting and alignment work must include preparation of pipe ends, assembling and gapping joints, alignment of pipe and fittings to other parts of the piping, and tacking.

Beveling Requirements

To prepare pressure pipe for butt welding or matching of fittings, V-bevel the ends to an angle of approximately 37-1/2°. Note that the bevel does not come to a sharp point but has a flat portion of approximately 1/16-1/8 in (1.6-3.2 mm) according to the weld procedure.

Land or Root Face

The land helps in preventing the sharp edges of the bevel from burning off during welding. Note that welded pipe fittings and pipe lengths come with standard bevelled ends that only require cleaning.

Joint Assembly

Gap and Alignment Requirements

Before tacking, it is important to assemble and gap together the pipe and fittings. The gap (or root) opening between the two ends is evenly spaced at 1/16-1/8 in (1.6-3.2 mm) according to the weld procedure.

Besides maintaining the gap between the bevelled ends, the inside and the outside surfaces of the joint must match evenly without high or low spots.

Alignment Methods

Clamps are what you often use to maintain the correct gap and high-low alignment. On smaller pipe and fitting sizes, an angle iron helps maintain proper alignment.

These alignment tools ensure that the pipe sections are properly positioned before welding begins, which is critical for creating strong, reliable welds.

Tacking Procedures

Purpose of Tack Welds

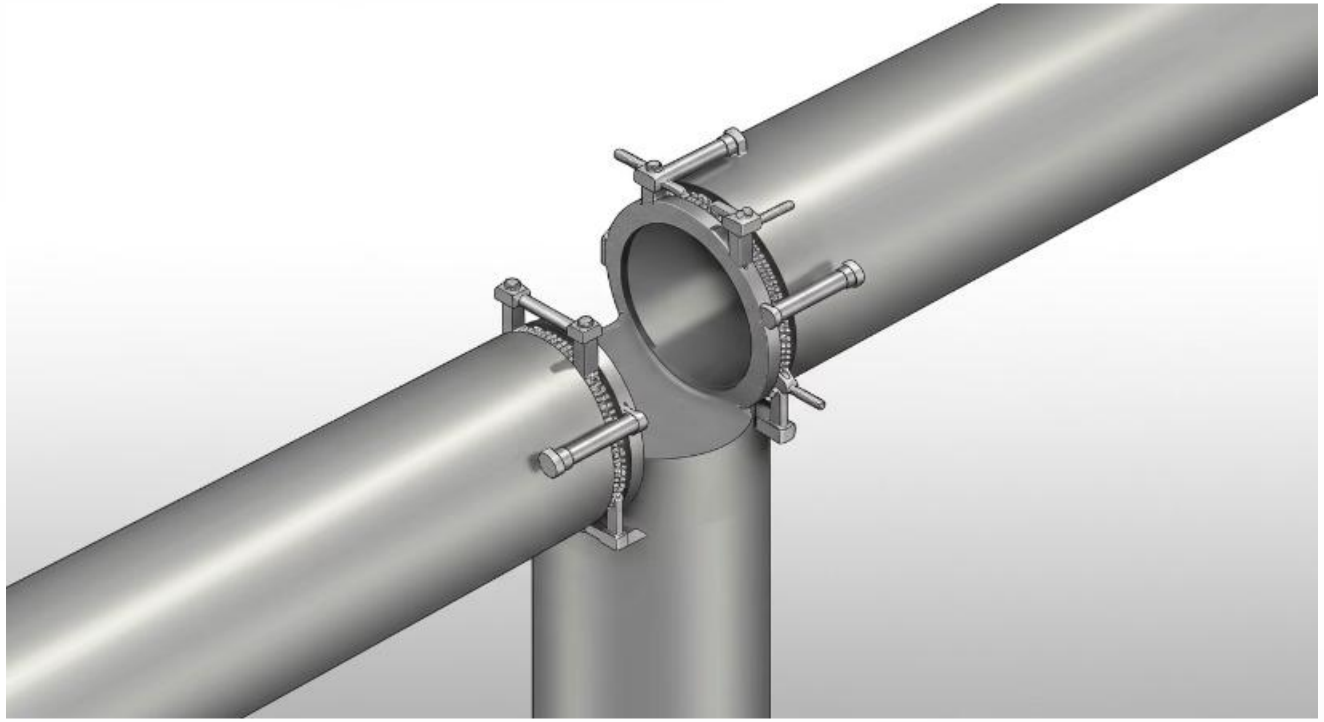
Gas technicians/fitters make tack welds in aligned and gapped pipe and fittings to hold the piping in place during complete welding operations.

A common method is to make four tack welds evenly spaced around each joint. The tack weld should be three times the thickness of the pipe wall.

Tacking Procedure

1. When you use a spacer wire, remove the wire after welding the first tack.
2. Make the second tack 180° opposite the first tack.
3. Make the third and fourth tacks at 90° angles to the first and second tacks.
4. When making the third tack, adjust the gap until the openings are equalized.

Tack Weld Positioning



Strategic Placement

If one side of the root opening is slightly wider, place the third tack weld at that point, since any shrinkage in the third tack weld, when cooling, will even out the root opening space by contracting and "pulling" together the third tack.

The fourth tack weld is at 180° from the third tack. This orientation and order of tack welds helps maintain proper alignment and gap spacing during the complete welding process.

Pressure Testing

Standard Testing Methods

You perform pressure testing of welded pipe to Code requirements using normal pressure testing methods with air or an inert gas.

Non-Destructive Testing

Other non-destructive testing that the Code may require includes radiographic testing and liquid dye testing.

Code Compliance

All testing must comply with the relevant code requirements to ensure the safety and integrity of the welded pipe system.

Radiographic Testing

X-ray Inspection

You may conduct radiographic (X-ray) testing upon a customer's request, or according to job specifications. Radiographic testing must adhere to Section 5, Article 2 of the ASME BPVC.

When the testing is complete, you must submit the radiograph to the inspector for acceptance.

Benefits of Radiographic Testing

Radiographic testing allows for non-destructive inspection of welds, revealing internal defects that might not be visible from the surface.

This method provides a permanent record of the weld quality and is particularly important for critical applications where weld integrity is essential for safety.

Liquid (Dye) Penetrant Examination

Apply Penetrant

Apply colored or fluorescent dye penetrant to the weld surface

Allow Dwell Time

Let the penetrant seep into any surface defects

Remove Excess

Clean the surface to remove excess penetrant

Apply Developer

Apply developer to draw penetrant from defects

Inspect

Examine for indications of defects

Types of Dye Penetrant Testing

Color Contrast Method

Section 5, Article 6, of the ASME BPVC sets out requirements for liquid (dye) penetrant examination of welded piping where you allow the part being tested to dry and apply a "developer". The penetrant shows through the developer if any faults are present.

The dyes in the penetrant are visible under white light (colour contrast) for easy identification of surface defects.

Fluorescent Method

Alternatively, fluorescent dyes can be used that become visible under ultraviolet light, providing enhanced detection capabilities for very small defects.

This method is particularly useful for detecting fine cracks and other small surface discontinuities that might be missed with the color contrast method.

Welding Safety Summary

Personal Protection

Always wear appropriate PPE

Fire Prevention

Maintain fire watch and proper procedures

Equipment Safety

Proper handling of gases and equipment

Environmental Controls

Ensure adequate ventilation

Certification Compliance

Follow all regulatory requirements

Certification Requirements Summary

Registered Procedure

Welding must follow an approved procedure

Performance Testing

Welder must pass practical examination

Certification

Provincial authority issues certification

Recertification

Maintain current certification status

Welding Preparation Summary

1

Measuring

Accurate pipe and fitting measurements

2

Marking

Proper marking techniques

3

Cutting

Appropriate cutting methods

4

Alignment

Precise pipe and fitting alignment

Testing and Quality Assurance

Pressure Testing

Pressure testing is performed using air or inert gas to verify the integrity of welded connections according to code requirements. This ensures that the system can safely handle its intended operating pressure.

Radiographic Testing

X-ray inspection provides a non-destructive method to examine the internal quality of welds, revealing defects that might not be visible from the surface. This testing must adhere to Section 5, Article 2 of the ASME BPVC.

Liquid Penetrant Testing

Dye penetrant examination uses colored or fluorescent dyes to detect surface defects in welds. This method is specified in Section 5, Article 6 of the ASME BPVC and provides a reliable way to identify surface discontinuities.

CSA Unit 10 – Advanced Piping Systems Chapter 3 Utility and Non-Utility Piping

A gas technician/fitter must be prepared to install various types of pipe and tubing, as well as recognize many other types. Piping can carry substances other than gas, and the type of piping is not always an indicator of what is inside. A basic understanding of how one identifies piping on drawings and on the work site is important to ensure safe and efficient installation and repairs.

MK by Mike Kapin

Course Objectives

Describe Utility Piping

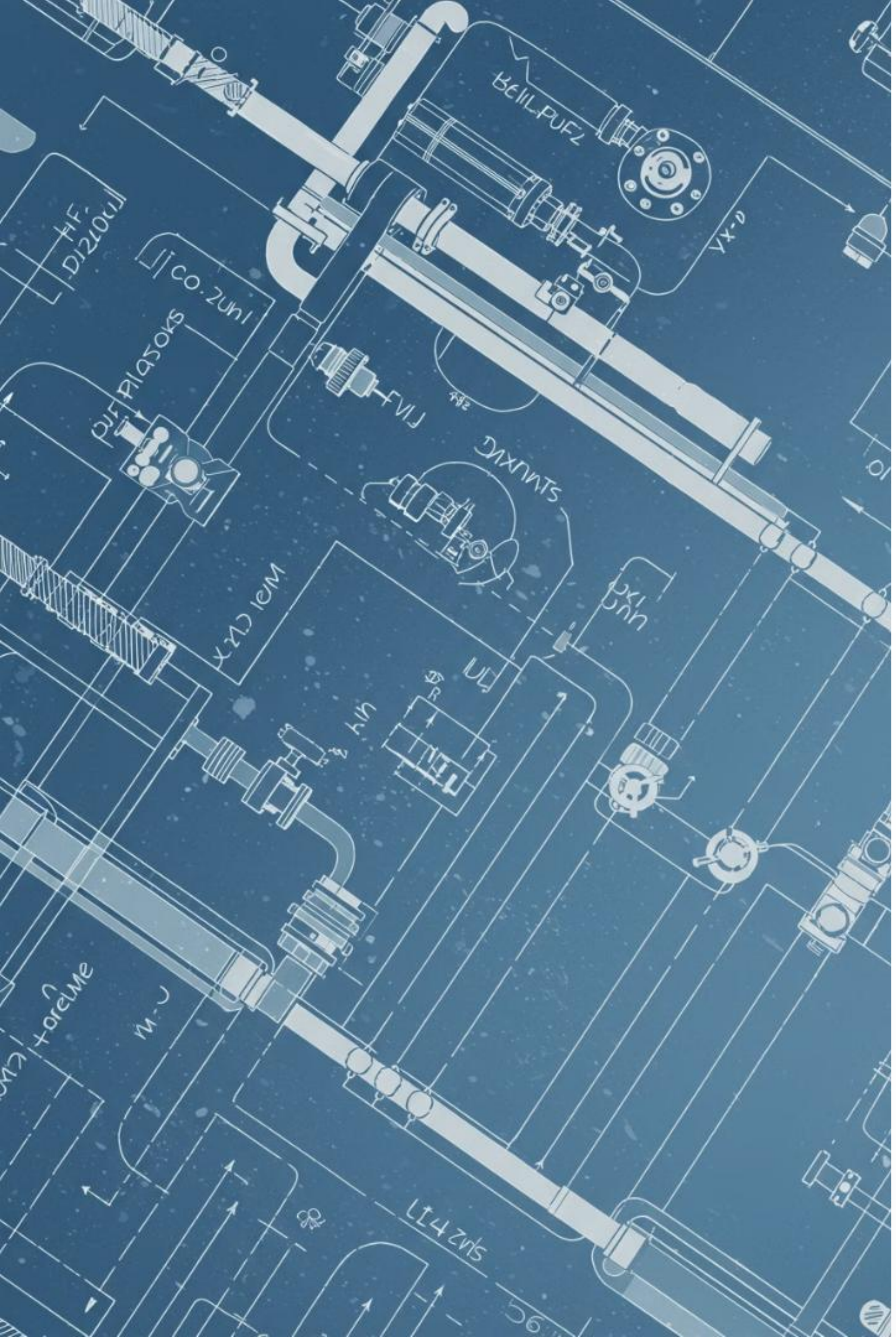
Understand the characteristics and applications of various utility piping systems

Describe Non-Utility Piping

Learn about different types of non-utility piping and their specific uses

Distinguish Gas Piping

Develop skills to identify gas piping from other types of piping systems



Key Terminology

Term	Abbreviation (symbol)	Definition
As Built Drawings		Final blueprints drawings used to locate and identify piping (include revisions to the original)

Utility Piping and Tubing

Piping and tubing in existing buildings or underground pipe lines are not always clearly identified. As a gas technician/fitter, you may have to work on or isolate an area of piping or tubing and be sure of how to determine which piping or tubing conveys what. This is not always easily done, but there are certain steps you can take to ensure that the contents of a sealed line can be clearly identified.

Underground Piping

Piping is run underground to carry a variety of things from one place to another, such as electricity, water, sewage, and gas.

The location and identification of underground piping is important whenever you perform work that might affect or come in contact with underground lines. The relevant utility blueprint all utility lines at first installation and update the plan drawings whenever there have been changes to existing systems. The utility will supply a drawing of area piping when required for digging, new construction etc.

Gas service lines normally run in a straight line from the distribution line at the street to the gas meter.

Underground gas piping will either be wrapped steel pipe or polyethylene plastic pipe.

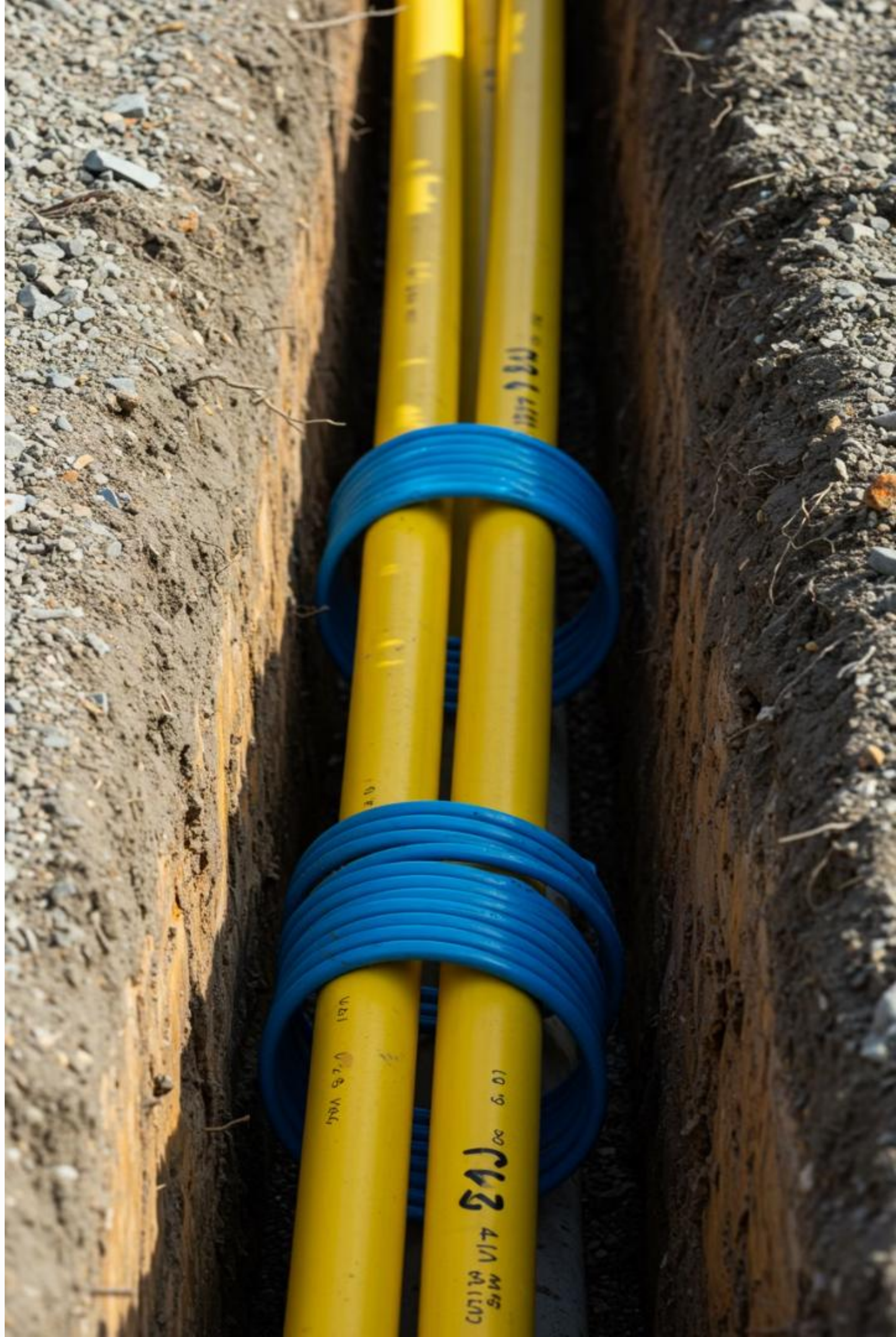
Types of Underground Gas Piping

Wrapped Steel

- Coated with polyethylene
- Coloured either blue or yellow

Polyethylene Plastic Gas Piping

- Available in various colours with the utility normally using yellow or orange ones
- When used underground a minimum 16-gauge copper wire is taped along the piping for tracing purposes using a metal pipe detector of radio signals



Underground Tubing

Underground natural gas utility piping is generally either steel or polyethylene plastic. However, copper tubing is also approved for underground use. So, while it may not be common, there will be areas of the country where you will encounter underground natural gas utility tubing.

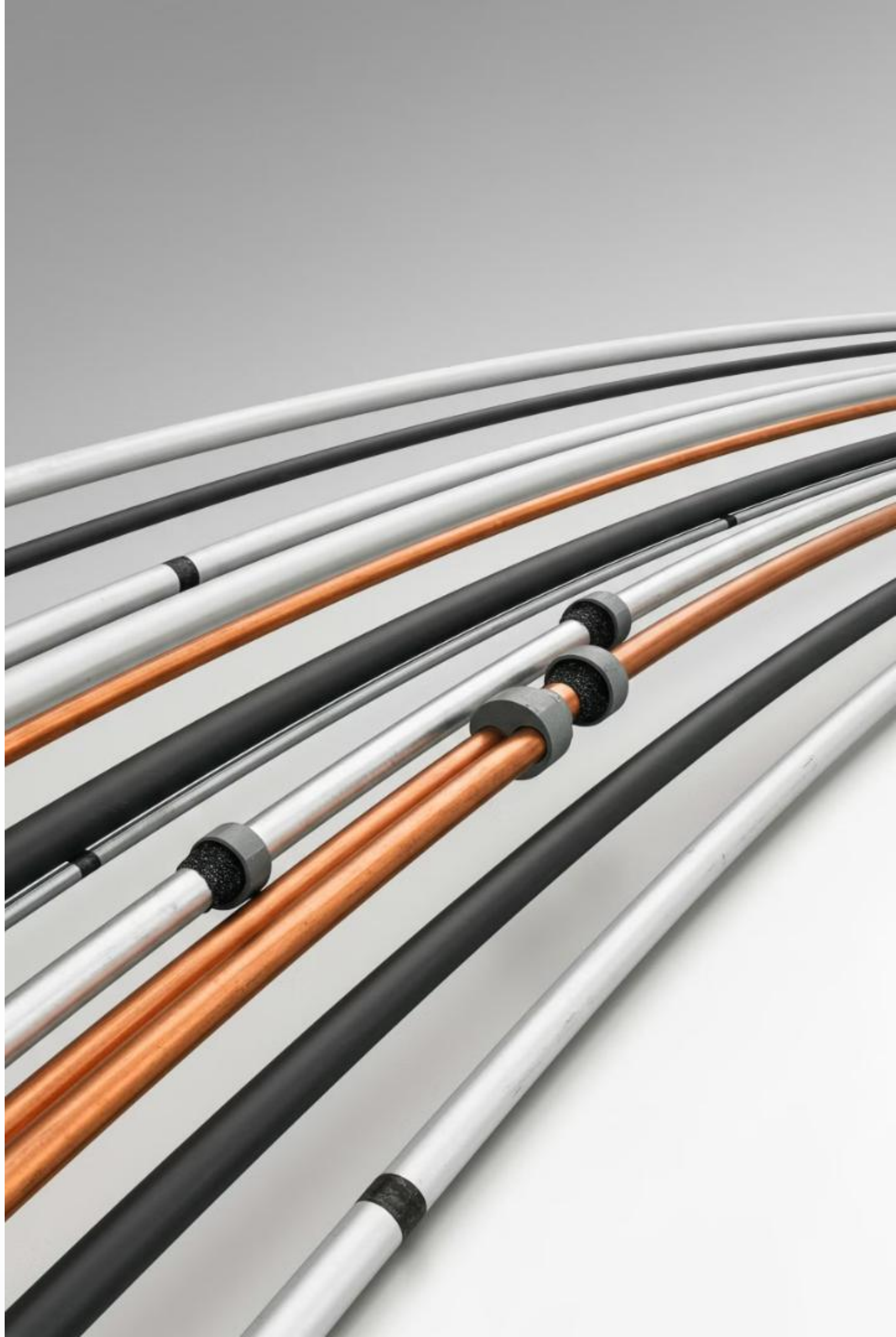
Underground gas tubing installed downstream of the natural gas meter or vapour withdrawal valve of a propane container must meet CSA B149.1 requirements:

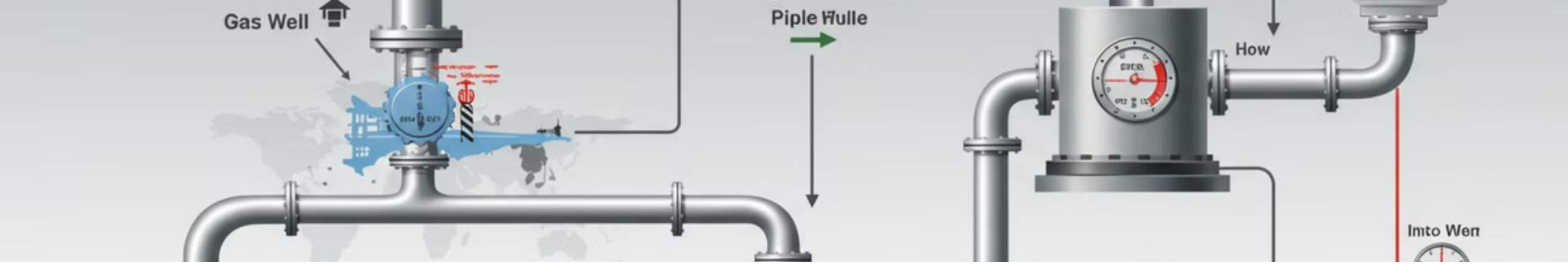
Type K Copper Tubing

The use of Type K copper tubing underground without any coating is permissible.

Types L and G Copper Tubing

Underground use requires a manufacturer-installed polyethylene or PVC coating for Types L and G copper tubing.





Upstream Requirements

1

CAN/CSA-Z662 Standards

The requirements of CAN/CSA-Z662, Oil and gas pipeline systems, govern upstream of the meter, gas utilities.

2

Different Requirements

This may involve requirements that are somewhat different from those to which you are accustomed as a gas technician/fitter.

3

Pipeline Systems

These pipeline systems are used in the servicing and transmission of gas to the meter of the end-user.

Important Safety Notice

Whenever you are dealing with underground utility piping, you must contact the utility in the area for proper locations and identification.

Call Before You Dig!

One-Call Department

Many jurisdictions have instituted a 'One-Call' department that coordinates the various underground utilities to perform the necessary location with one telephone call.

Ontario Example

An example of this organization is Ontario One Call, which you can contact at 1-800-400-2255 or www.on1call.com.

Local Jurisdiction

Check your jurisdiction for the One Call Contact Centre.

Non-Utility Piping and Tubing

Most, but not all, non-utility gas piping and tubing operate aboveground. The piping downstream of a gas utility meter is usually the responsibility of the property or building owner. In most instances, the piping runs from the meter into the building and remains in the building.

Corrugated Stainless Steel Tubing (CSST)

Corrugated stainless steel tubing (CSST) is a promising alternative to traditional threaded black-iron gas piping for residential, and industrial applications. Because it is lightweight, flexible, and needs fewer connections and fittings, it can be easier to install than traditional threaded black-iron piping. These benefits can add up to substantial labour savings for installers and cost savings for builders.

CSST consists of a continuous, flexible, stainless steel pipe with an exterior PVC yellow covering. The piping is produced in coils that are air-tested for leaks. You can most often find it in a central manifold configuration (also called parallel configuration), with "home run" lines that extend to gas appliances. Flexible gas piping is lightweight and requires fewer connections than traditional gas piping because it is easily bendable and routable around obstacles.

CSST Installation Requirements

No Direct Meter Connection

Direct connection to a meter is not permissible for CSST, same with copper tube.

Secure Building Piping

Before you can use CSST or copper, you must first secure all building piping.

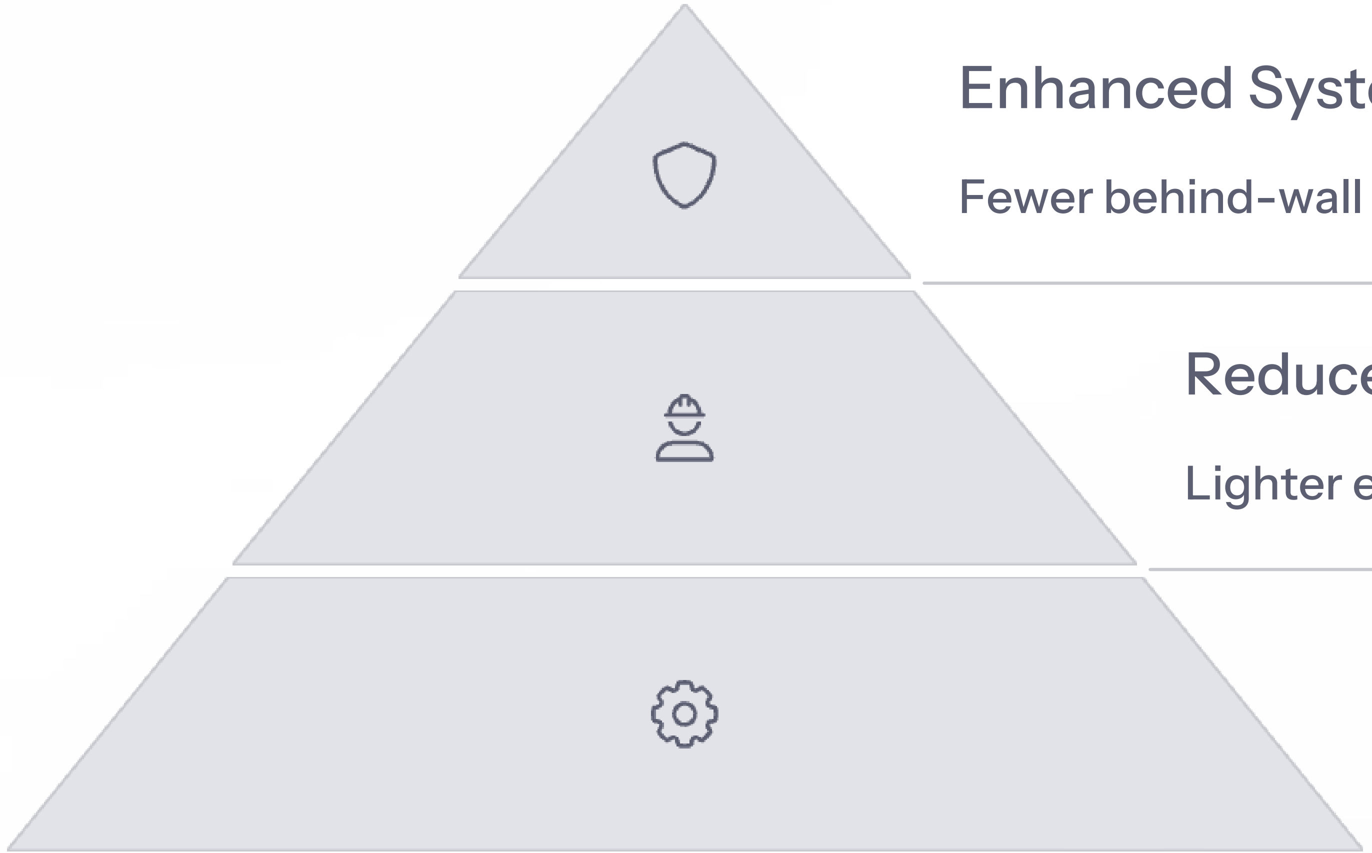
Manifold System Benefits

The multiport manifold allows for easy future expansion of the system for room additions or additional appliances.

Cost Savings

The manifold system also saves money using smaller individual pipe sizes and less fittings (no need for tee take offs), compared to the longest measured run method.

CSST Safety Benefits



Enhanced System Safety

Fewer behind-wall connections

Reduced Worker Injuries

Lighter equipment needed

Easier Installation

Flexible and bendable

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. In addition, builders and installers have noted a reduction in employee injuries by eliminating the heavy equipment and apparatus associated with traditional black iron pipe installations.

Underground Non-Utility Gas Piping

There are situations where gas piping operates underground downstream of the gas meter, for example:

Multi-Building Complexes

Complexes that have more than one building requiring gas but the gas is distributed from one central meter.

Detached Buildings

Single family dwellings with a detached building for a pool heater or other gas appliance.

Identification and Tracing

Whether you are dealing with utility or non-utility piping or tubing, it is not always clear or easy to identify at particular locations underground which are gas lines and which are not.

Know Pipe Types

Underground gas piping downstream of the gas meter is one of these three types: polyethylene coated steel pipe, polyethylene plastic pipe, or copper tubing (either coated or non-coated).

Consider Limitations

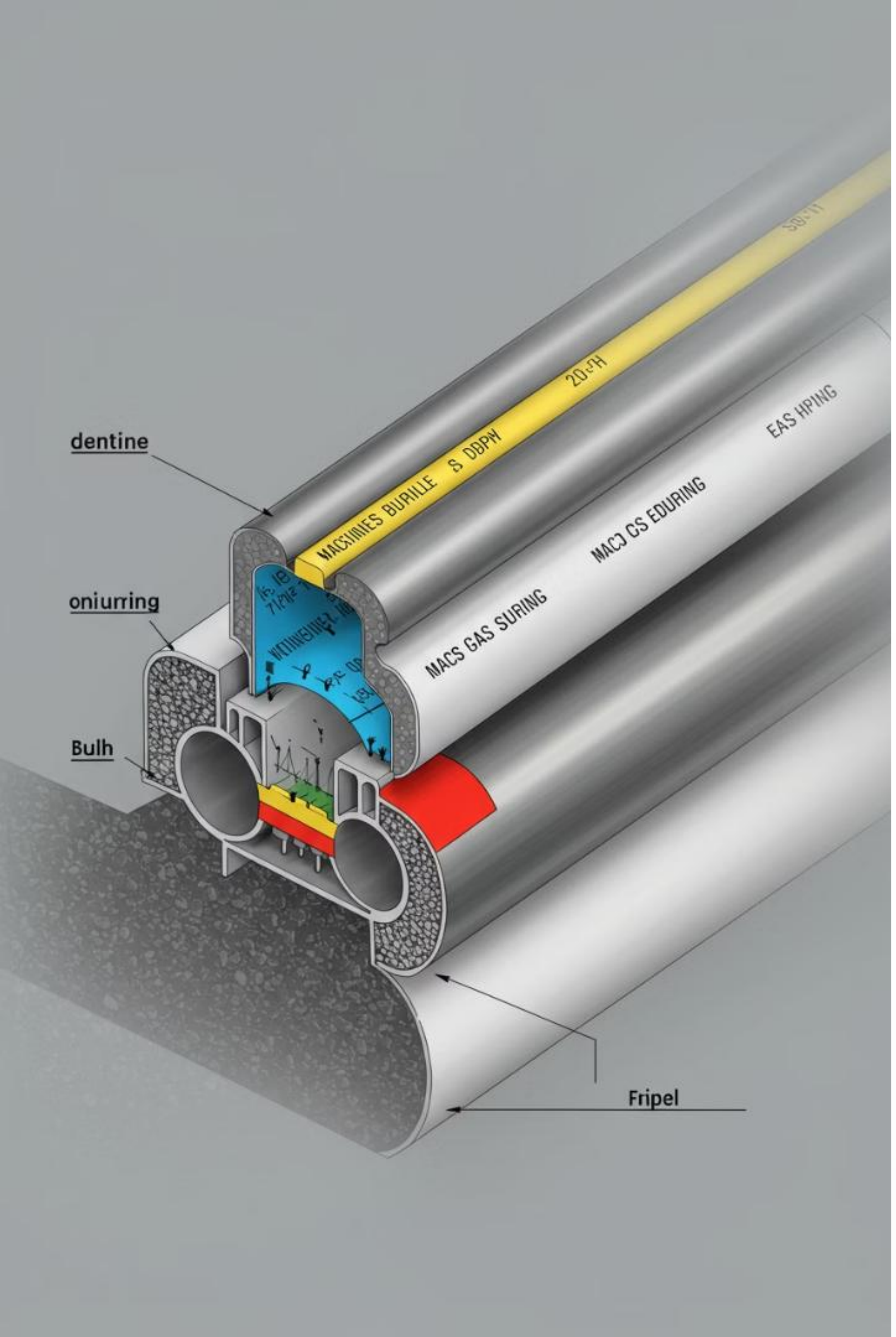
Knowing this will help you identify underground piping but will not always ensure correct identification. Water lines are also installed underground using copper and plastic.

Use Multiple Indicators

Identification of above-ground piping is easier but not always obvious. Use type of pipe, its colour coding, and marking; blueprints; and tracing.

Type of Pipe, Colour Coding, and Marking

There are separate criteria for identification of underground and above-ground gas piping and tubing.



Underground Gas Piping and Tubing Identification

Material	Description
Steel	Will have either blue or yellow plastic coating
Polyethylene pipe	May be yellow or orange Will have markings indicating it is approved for gas Tracer wire found with the piping
Copper tubing type L or G	Will have a yellow polyethylene or PVC coating
Copper tubing type K approved for use uncoated	Will have markings stamped on the side

Underground Non-Gas Piping and Tubing

Type	Description
Common water lines	Made of copper, plastic, galvanized steel, cast iron and ductile iron
Common sewer lines	Made of plastic and cast iron
Electrical and telephone conduits	Metallic and non-metallic

Above-Ground Piping Identification Requirements

The identification of gas piping inside some types of buildings and the identification of gas tubing in all types of buildings is required by Clauses 6.17.1 and 6.17.3 of CSA B149.1 as noted below:

Clause 6.17.1

At every care or detention occupancy, commercial, industrial and assembly building, piping or tubing shall be identified by one of the following:

- the entire piping or tubing system shall be painted yellow,
- the piping or tubing system shall be provided with yellow banding that has a minimum width of 1 in (25 mm); or
- the piping or tubing system shall be labelled or marked "GAS" or "PROPANE" as applicable, utilizing yellow labels or markings.

When identified in accordance with item (b) or (c), the identification intervals shall not exceed 20 ft (6 m).

Clause 6.17.3

Tubing systems for residential buildings shall be identified in accordance with Clause 6.17.1, except that identification intervals shall not exceed 6 ft (2 m) along their entire length.

Additional Identification Requirements

The above identification requirements have been in editions of CSA B149.1 for decades. The following additional requirements were added in the 2015 supplements and appear in the current Code:

Clause 6.17.2

At every care or detention occupancy, commercial, industrial, and assembly building, where the piping or tubing pressure is in excess of 14 in w.c. (3.5 kPa), both the piping or tubing and the pressure shall be identified at the following locations:

Shut-off Valves

Identification required at all shut-off valve locations

Penetrations

Identification required at wall, ceiling and floor penetrations

Other Above-Ground Piping Identification

Other above-ground piping, such as water piping, drainage piping, sprinkler lines etc. may or may not be identified by marking or colour-coding.

Sometimes water lines and heating pipes are insulated to maintain temperature or to eliminate condensation. The insulation may be colour-coded and have the tubing marked for identification and to show direction of flow.

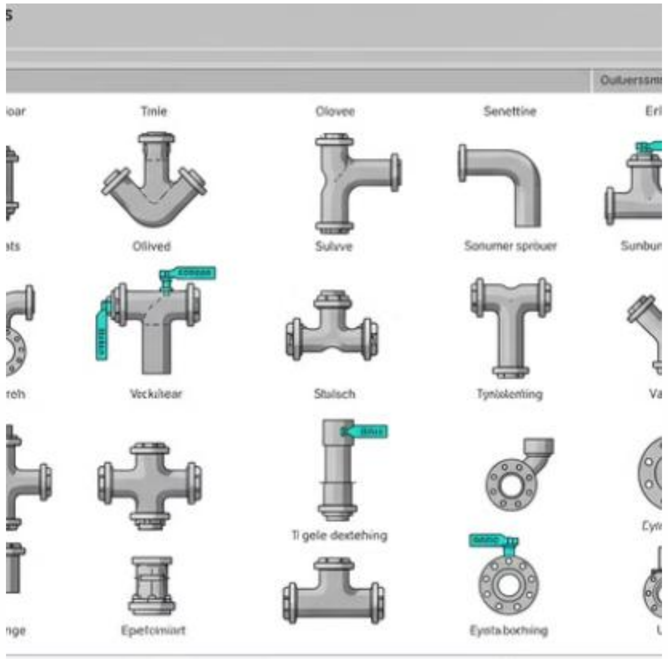
Blueprint Identification

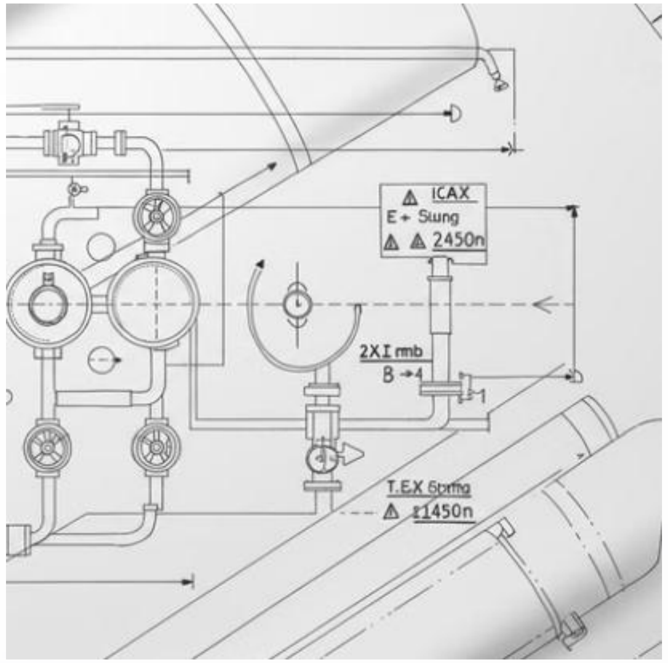
Piping in commercial and industrial establishments is generally installed according to the blueprints provided, and mechanical and plumbing drawings will show all the various piping arrangements. These drawings along with the specifications will indicate the types, sizes and location of installed piping.

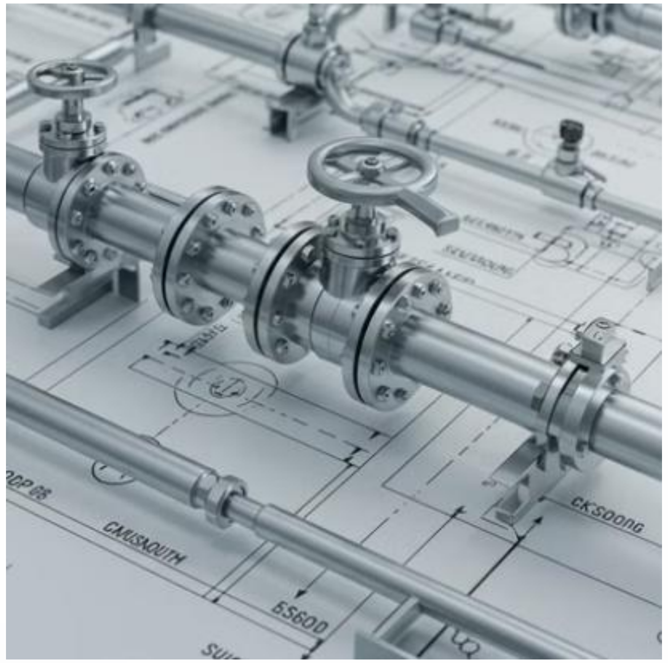
Whenever you use blueprints to locate and identify piping, use the final drawings. These are what you call "as built" drawings, meaning that the piping arrangement on the original blueprint may already have changes and the drawing may have revisions to show any changes. The drawing will indicate the system as it was built.

Piping Layout Drawings and Symbols

Chapter 4, Piping layout drawings and symbols cover blueprints and drawings in more detail.







Tracing Method

Identify the Problem

Encounter an unknown pipe that needs identification

Visual Inspection

Look for markings, color coding, or other visual indicators

Follow the Path

Trace the pipe back to its source for positive identification

In some situations, the easiest and surest way to identify what a sealed pipe is carrying is to trace it back to its source. Obviously, you will need to look at and follow the entire line to ensure proper identification. Walk the pipe back to its source!

Safety Considerations When Working with Gas Piping

Identify

Properly identify all piping before beginning work

Contact

Call utility companies before digging near underground lines

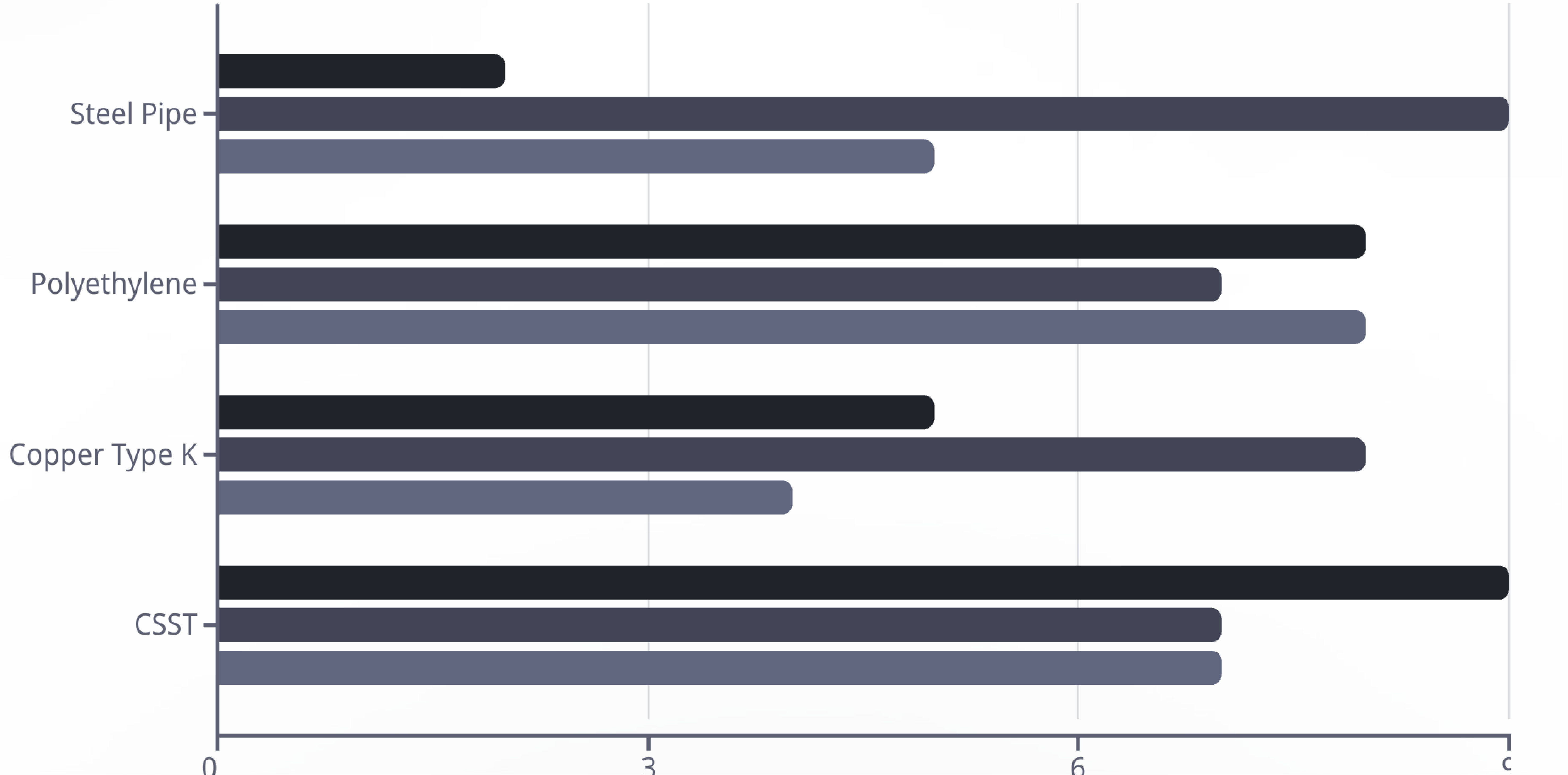
Test

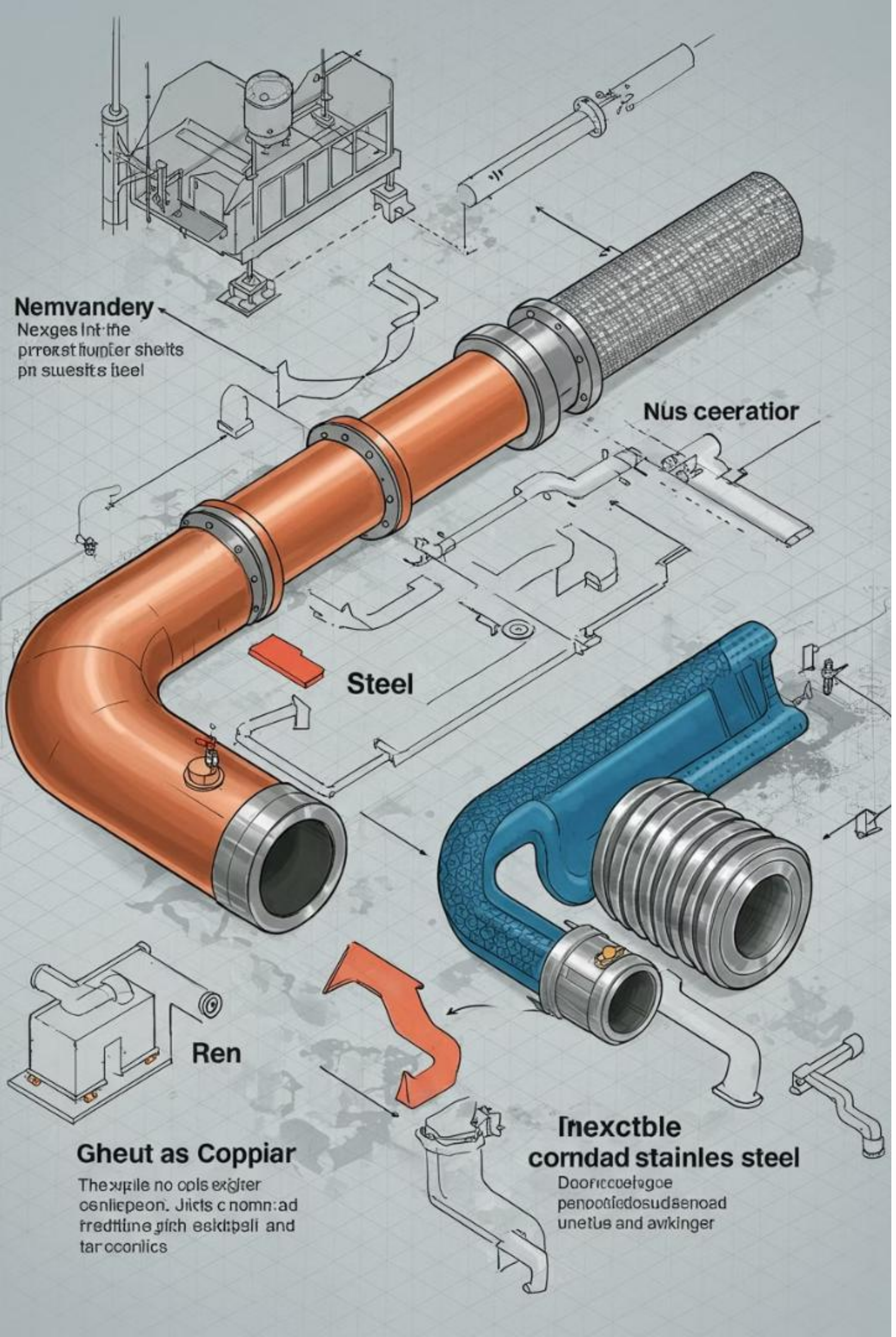
Verify work with appropriate testing methods

Prepare

Use proper tools and equipment for the specific pipe type

Comparing Underground Gas Piping Materials





Benefits of Different Gas Piping Materials

Steel Pipe

Highest durability and strength, excellent for high-pressure applications, resistant to physical damage, long service life when properly coated

Polyethylene

Highly flexible, corrosion-resistant, cost-effective installation, fewer joints needed, excellent for long runs

Copper

Corrosion-resistant, malleable for bending around obstacles, established technology with proven track record

CSST

Extremely flexible, quick installation, fewer fittings required, reduced labor costs, easy routing through buildings

Common Challenges in Gas Piping Identification

42%

Unmarked Pipes

Percentage of field issues related to inadequate pipe marking

35%

Missing Blueprints

Percentage of sites lacking proper as-built documentation

23%

Mixed Systems

Percentage of installations with multiple pipe types causing confusion

Gas technicians frequently encounter these challenges when working with existing systems. Proper identification techniques and thorough documentation can help mitigate these issues and ensure safe work practices.

Gas Piping Installation Best Practices

Plan

Create detailed layout

Prepare

Gather proper materials

Install

Follow code requirements

Test

Verify for leaks

Label

Mark according to code

Importance of Proper Documentation

As-Built Drawings

Ensure all drawings reflect the actual installation with any modifications clearly documented

Photographic Records

Take photos of installations before walls are closed, especially at critical junctions

Testing Documentation

Maintain detailed records of all pressure tests and inspections performed

Site Plans

Create accurate site plans showing the location of all underground piping with measurements

Utility vs. Non-Utility Piping Responsibilities

Utility Company

Responsible for:

- Main distribution lines
- Service lines to the meter
- Meter installation and maintenance
- Emergency response for leaks before the meter

Property Owner

Responsible for:

- All piping downstream of the meter
- Maintenance of interior gas lines
- Underground lines between buildings on property

Inspector

Responsible for:

- Code compliance verification
- Permit approvals
- Final sign-off on installations

Gas Technician

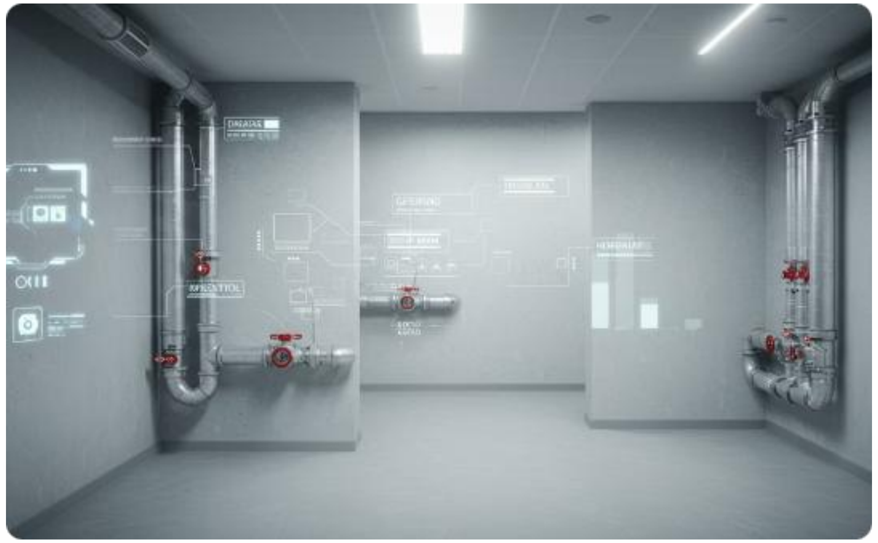
Responsible for:

- Proper installation according to code
- Testing and verification
- Documentation of work performed

Technological Advances in Pipe Identification

Electronic Pipe Locators

Modern electronic pipe locators can detect and identify underground utilities with increasing accuracy, using electromagnetic signals to trace metallic pipes or locate tracer wires installed with non-metallic pipes.



Augmented Reality

Emerging AR technologies allow technicians to visualize hidden piping systems through walls and floors by overlaying digital information from building plans onto the real environment, improving identification accuracy.

Digital Tagging

QR codes and RFID tags are increasingly being used to mark piping systems, allowing technicians to quickly access detailed information about the pipe's contents, pressure ratings, and installation date with a smartphone or scanner.

Future Trends in Gas Piping Systems

Hydrogen-Ready Piping

Development of piping systems capable of safely transporting hydrogen or hydrogen-natural gas blends as part of decarbonization efforts

Smart Piping Systems

Integration of sensors and IoT technology to monitor flow, detect leaks, and provide real-time data on system performance

Sustainable Materials

Increased use of environmentally friendly and recyclable materials in piping manufacturing

Automated Installation

Development of robotic systems for more precise and efficient pipe installation, especially in difficult-to-access areas

Summary: Key Points to Remember

Utility vs. Non-Utility

Understand the distinction between utility piping (up to the meter) and non-utility piping (after the meter) and the different responsibilities associated with each.

Identification Methods

Use multiple methods to identify piping: color coding, markings, blueprints, and tracing to source. Never rely on a single identification method.

Safety First

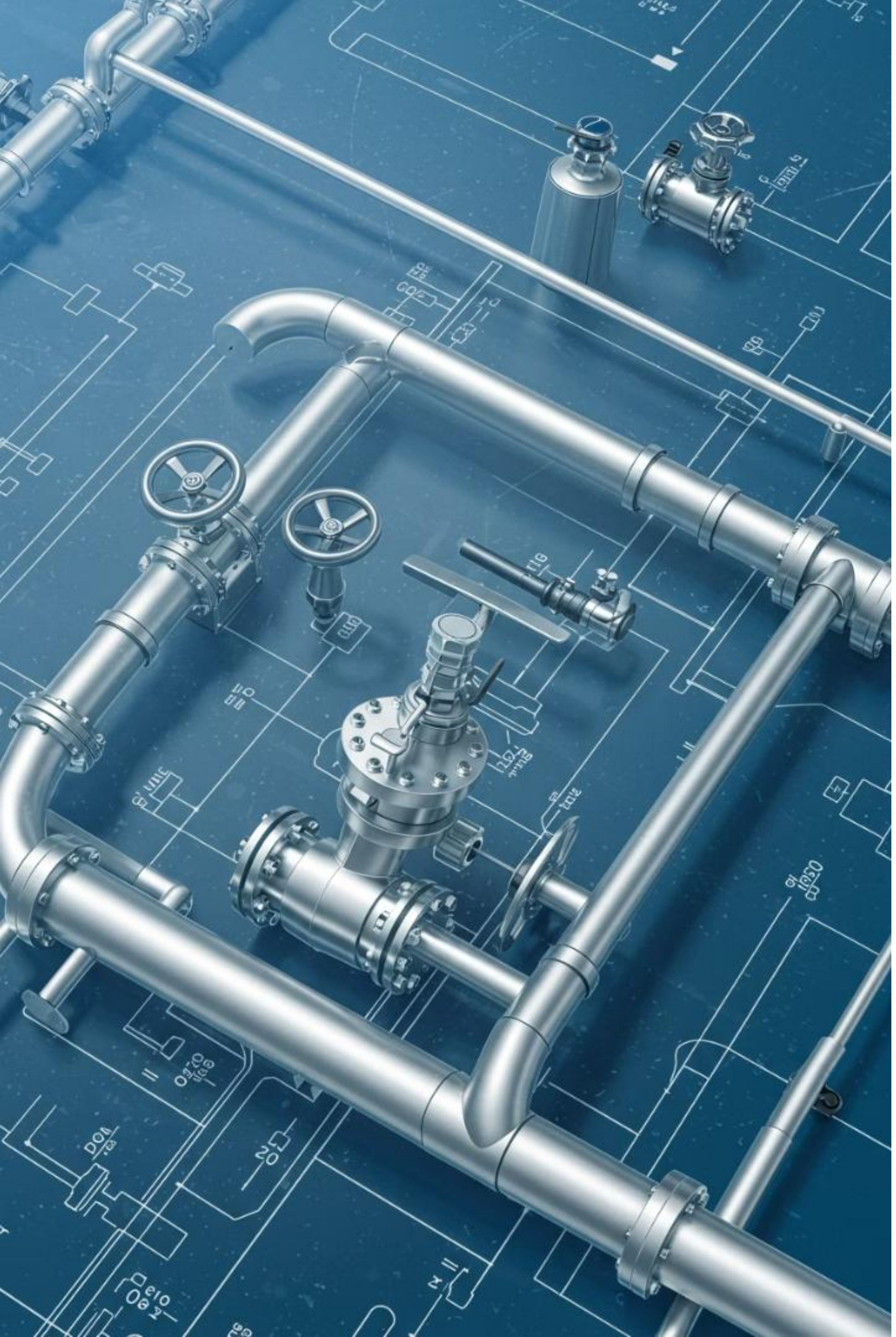
Always contact utilities before digging near underground lines. Follow the "Call Before You Dig" protocol to prevent accidents and service disruptions.

Code Compliance

Ensure all gas piping installations comply with CSA B149.1 requirements, including proper identification with yellow paint, banding, or labels at specified intervals.

Documentation

Maintain accurate as-built drawings that reflect the actual installation. These are essential for future maintenance, modifications, and troubleshooting.



CSA Unit 10 Advanced Piping Systems
Chapter 4
Piping Layout, Drawings, and Symbols

Before installing any equipment, the gas technician/fitter must have a plan that considers such aspects as how, what, where, and when. This plan can be very simple, such as one suitable for setting up a small gas barbecue, or very complex, for heating a large office building. In many cases, blueprints and specifications will contain the basic plan. Having such documents and knowing how to read and apply them will ensure that the piping layout and installation goes ahead with a minimum of problems.

MK by Mike Kapin

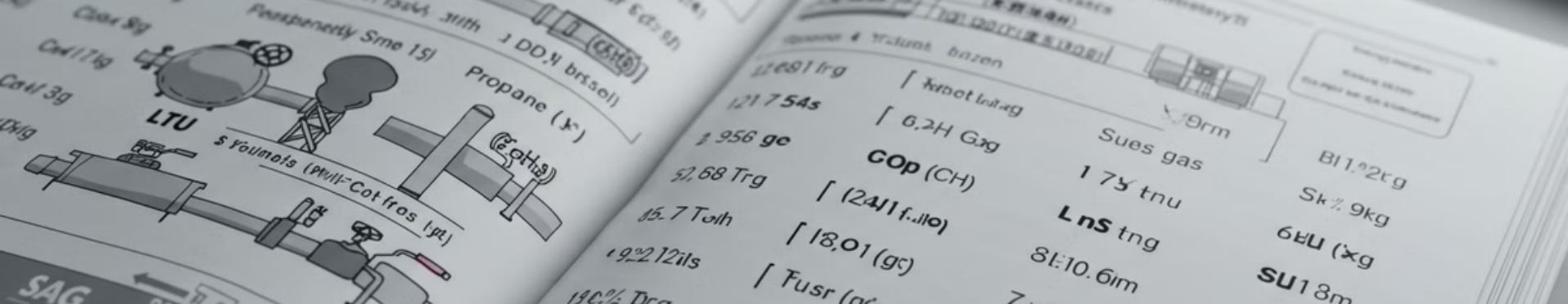
Course Objectives

Explain Blueprints and Specifications

Learn to read and interpret technical drawings and written specifications for gas installations

Describe Valves

Understand the various types of valves used in gas systems and their functions



Key Terminology

Term	Abbreviation (symbol)	Definition
Safety shut-off valve	SSOV	
Symbols		Shorthand signs used on drawings.

Blueprints and Specifications Overview

Installation Planning

The installation of gas piping is a regular part of the gas technician's/fitter's duties. How and where the piping is installed depends on the type of building, the type of piping and piping equipment, and the location of the piping.

Blueprint Function

Blueprints provide visual guidance for installation locations, equipment placement, and coordination with other building systems.

Specification Purpose

Specifications provide detailed written instructions that complement the visual information in blueprints and often take precedence in case of discrepancies.

Working with Blueprints

Small Buildings

On small buildings or installations found in single family dwellings the gas technician/fitter can work from a blueprint or set of house plans. These would not normally show water or gas piping. However, these would show the location of fixtures and equipment (such as water heaters and furnaces) for water or gas, then the installation of the piping would take place at the discretion of the gas technician/fitter.

Isometric Drawings

Many gas technicians/fitters make an isometric drawing of the planned installation that they can use as a takeoff sheet for estimating and ordering materials. This could include a drawing that they can submit for approval to the local authority if required.

Larger Installations

On larger installations the gas technician/fitter works from a complete set of blueprints. This set includes architectural, structural, electrical, and mechanical drawings, and so on, as required. You can find the gas piping and equipment on mechanical drawings, and locate and identify it on the plan drawing. There may also be detailed and isometric drawings of the layout of specific equipment and components.

Installation Considerations

Coordination with Other Trades

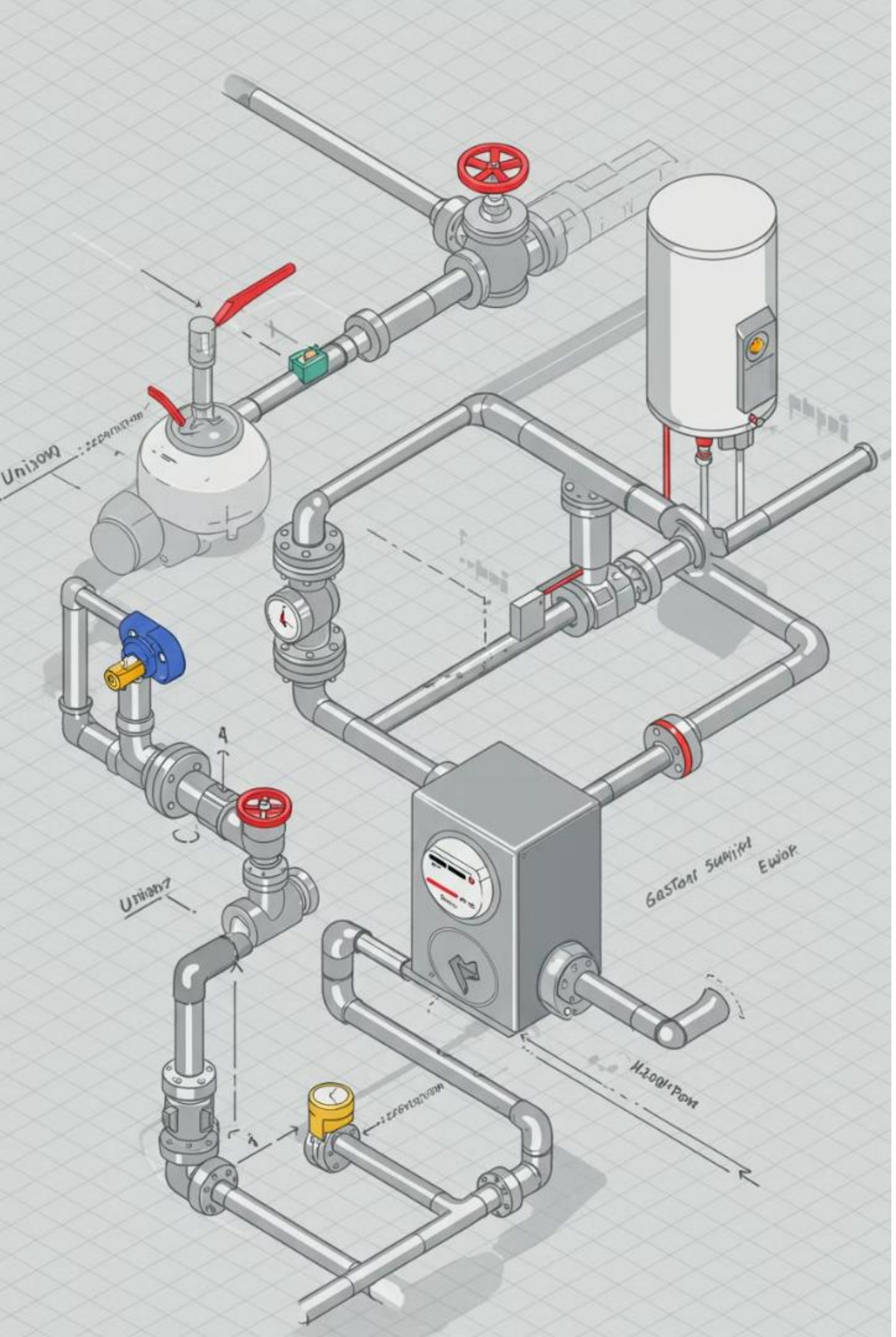
As a gas technician/fitter, you must be aware that you are only one of many trades involved in the building process. Before installing any piping, check other piping or equipment located in the same area, such as plumbing, ductwork, light fixtures, etc.

Piping Locations

You may find or place piping in ceilings, crawl spaces, pipe chases, rooftops, floors, underground or in open areas. Wherever the location, the piping must meet Code requirements as well as requirements of the building itself.

Appliance Considerations

The appliance type and venting system will always dictate where the gas technician/fitter can install an appliance. A gas supply piping system is and should be the last deciding factor of an appliance's location.



Typical Piping Diagram

Figure 4-1 shows a typical piping diagram for a building containing two gas appliances. This type of diagram provides the gas technician/fitter with a clear visual representation of how the gas piping should be routed throughout the building to supply the required appliances.

The diagram illustrates the main gas supply line, branch lines to each appliance, and the appropriate valves and fittings required for a safe and code-compliant installation. By following such diagrams, technicians can ensure proper sizing, routing, and installation of all gas piping components.

Understanding Specifications

Smaller Jobs

On smaller jobs, the specifications or "Specs" may consist simply of a list of materials written on the same page as the blueprint.

These simplified specifications still provide essential information about the materials to be used and basic installation requirements.

Large Projects

On large projects, specifications are printed in book or manual form. Often spanning several hundred pages, they cover every aspect of the job from the initial bidding process to the final payment.

These comprehensive documents ensure that all contractors and subcontractors have detailed information about materials, methods, and quality standards required for the project.

Precedence of Specifications

Contract Hierarchy

The specification is an integral part of the contract documents and is generally considered to be the most important document after the actual written agreement.

Resolving Discrepancies

If there is any disagreement between the specification and a drawing, you usually take the information in the specification to be correct. The reason for this is that, since the preparation of specifications usually comes last, they reflect final decisions.

Reporting Issues

If you find a discrepancy, you must report it to the architect and confirm the correct information in writing.

Code Compliance

Code Priority

You must follow all codes, regulations, and manufacturers' certified instructions. Where the specifications and codes or certified instructions conflict, the codes and certified instructions must prevail.

Variances

You can also apply a variance and/or field approval before the installation of an appliance.

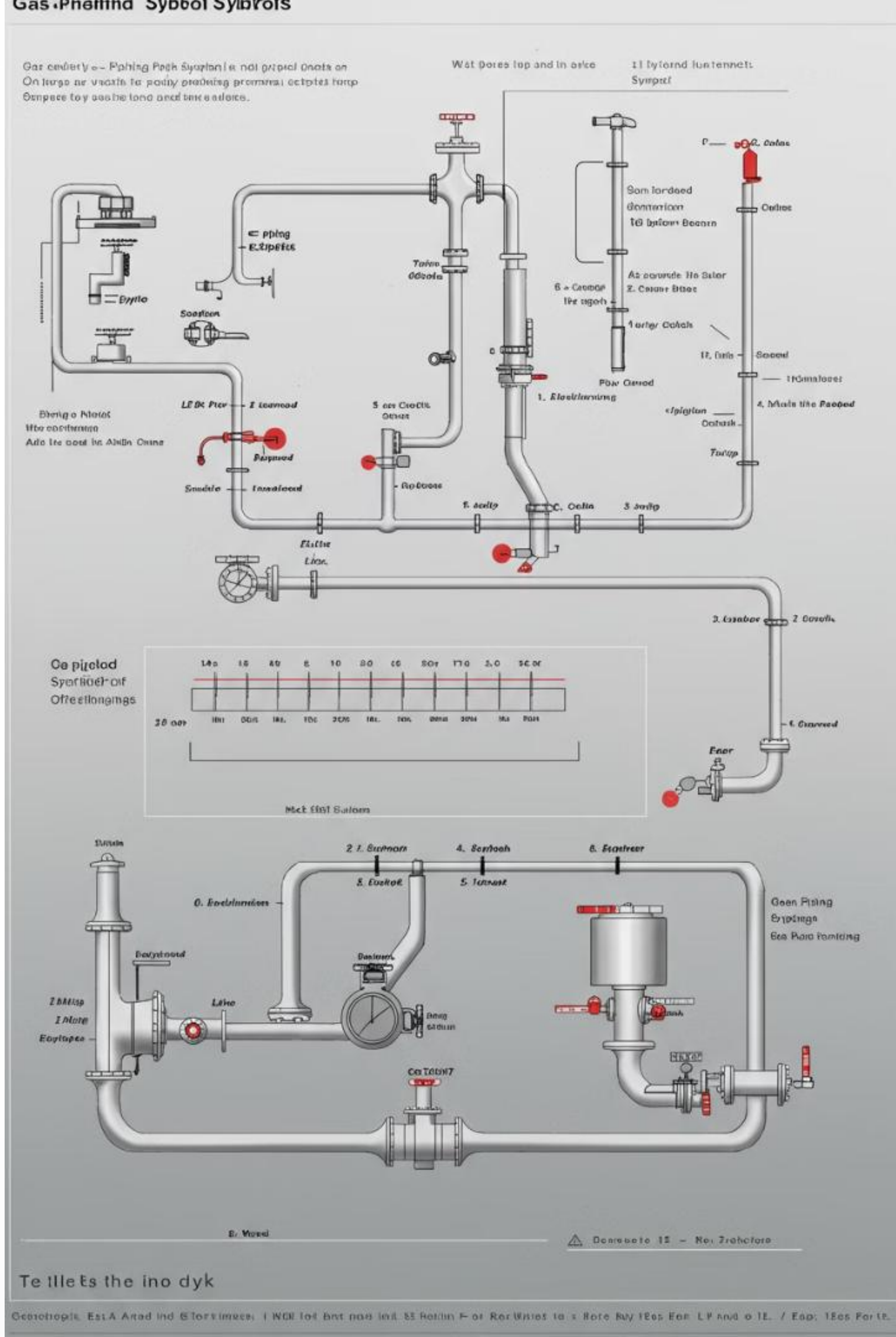
Installer Responsibility

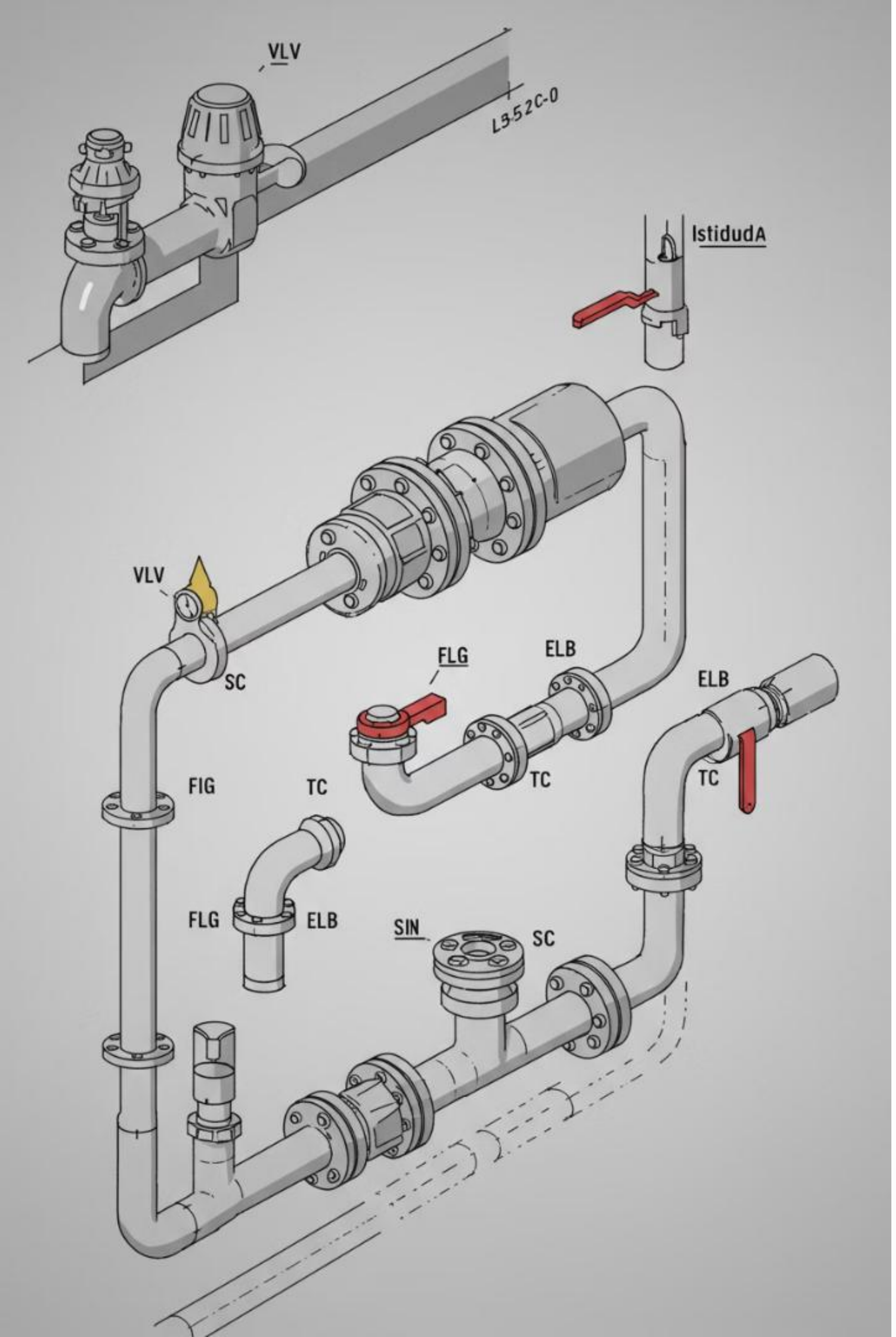
As a gas fitter, it is your responsibility to make the owner aware of any conflicting installation instructions before completing any additional work.

Interpreting Instructions and Symbols

Blueprints and specifications provide the gas technician/fitter with instructions for the installation of gas piping and equipment. To read and interpret the drawings, you must be aware of how the various pipelines are identified on the drawings, as well as the symbols for related fittings and valves.

Figure 4-2 is an example of how figures show line identification and fitting symbols. These standardized symbols allow for clear communication of complex piping systems in a visual format that can be universally understood by professionals in the field.





Understanding Symbols

International Standards

Symbols are the shorthand signs used on drawings. Most are recognizable internationally, but some countries still have different symbols.

Accredited Organizations

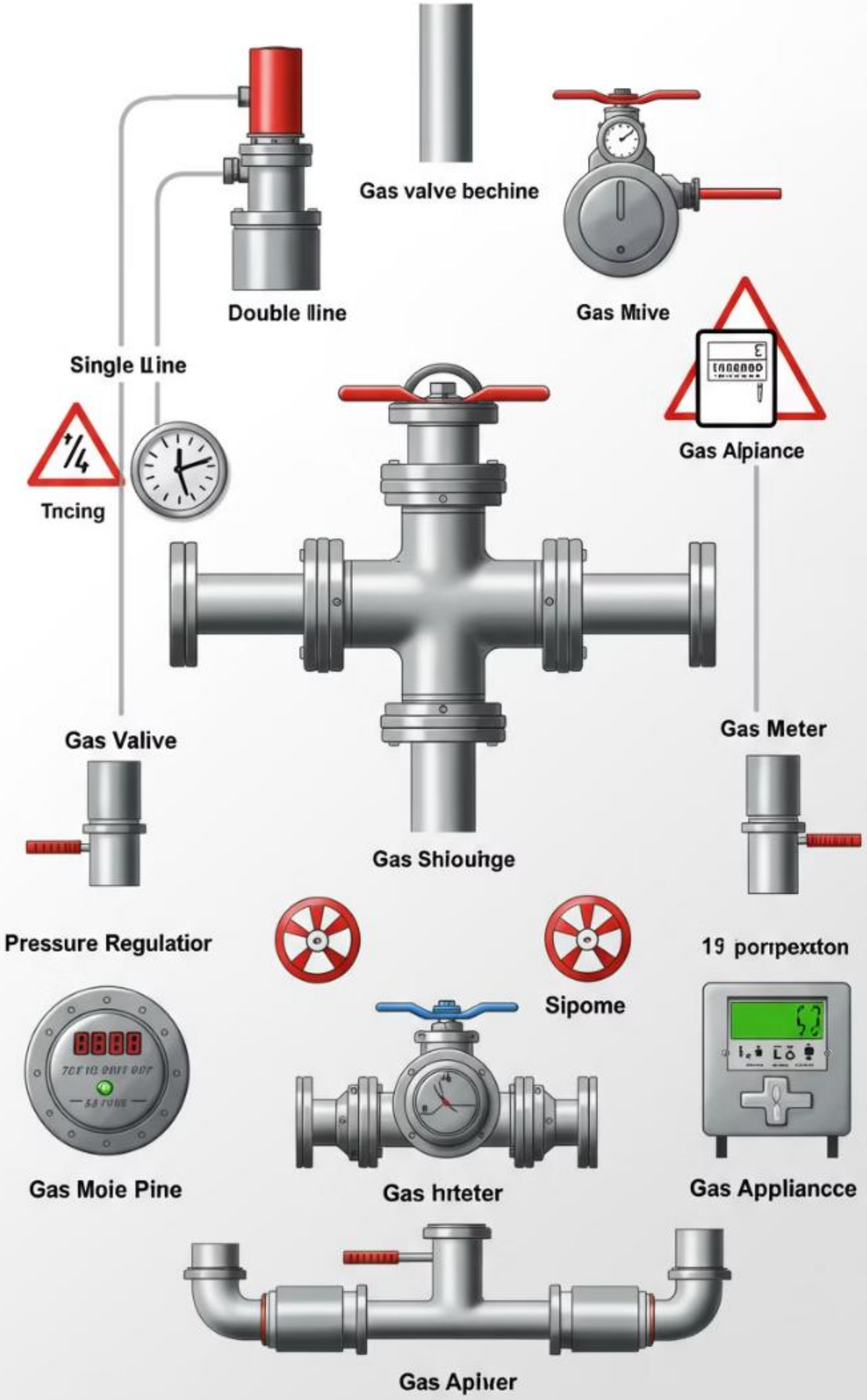
International Organization for Standardization (ISO), Canadian Standards Association (CSA), and the American National Standards Institute (ANSI) publish tables of symbols.

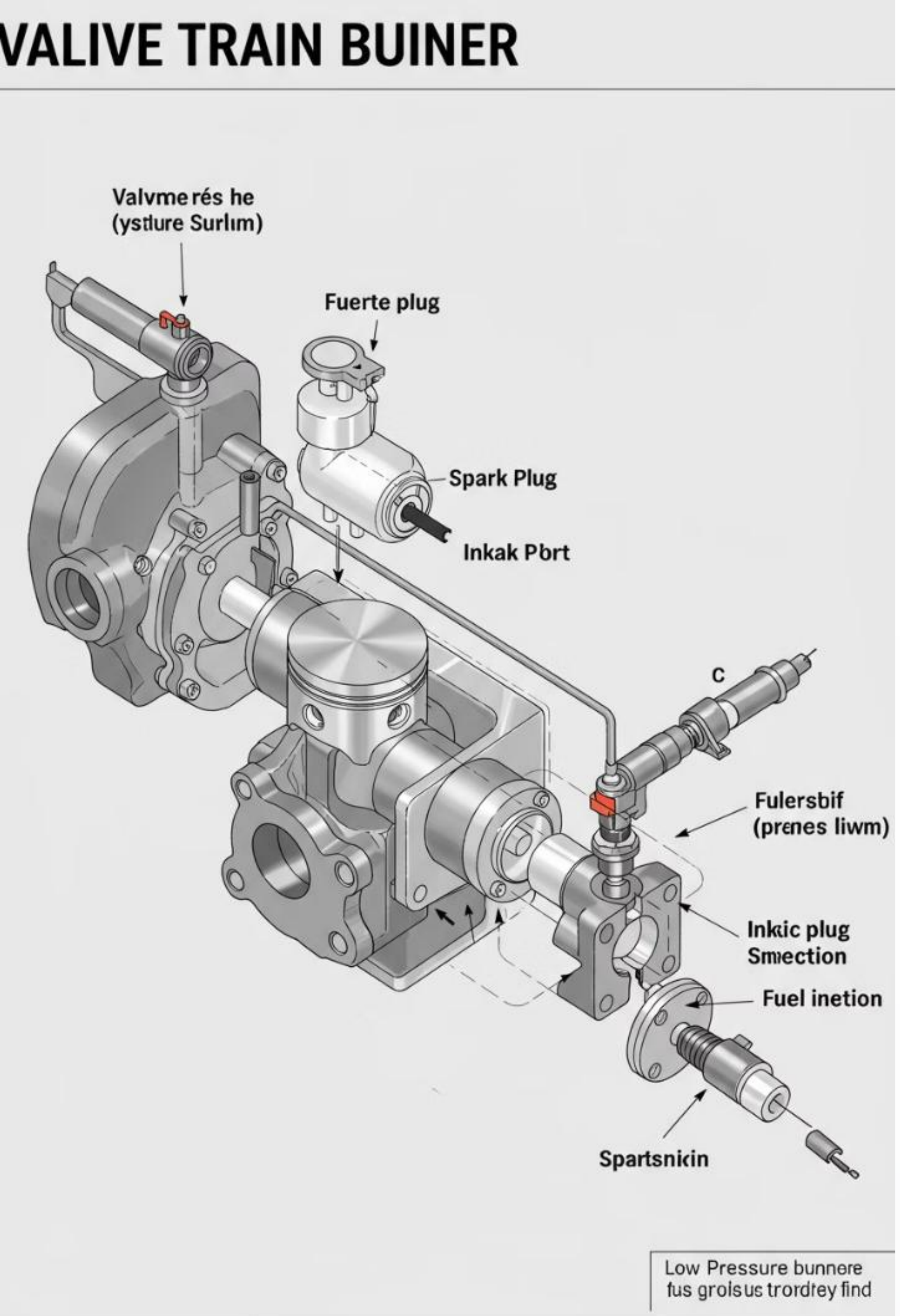
Symbol Categories

These organizations publish symbols for welding, piping, surface texture, and electrical elements, all of which you will use as a gas technician/fitter.

Common Piping Symbols

Single line				Double line		
NOOM E	116	Propl	PSILO!	ت-	·Prunt	KUpic
	HD		10			127
દ્વારા નિર્મ	1	1	I			
	oft	I	ਮਿੱਸ	100		
NYE	oc		OA			- 0)
Lines	HOH	1-	HOH			
					a (4)	
PIES						

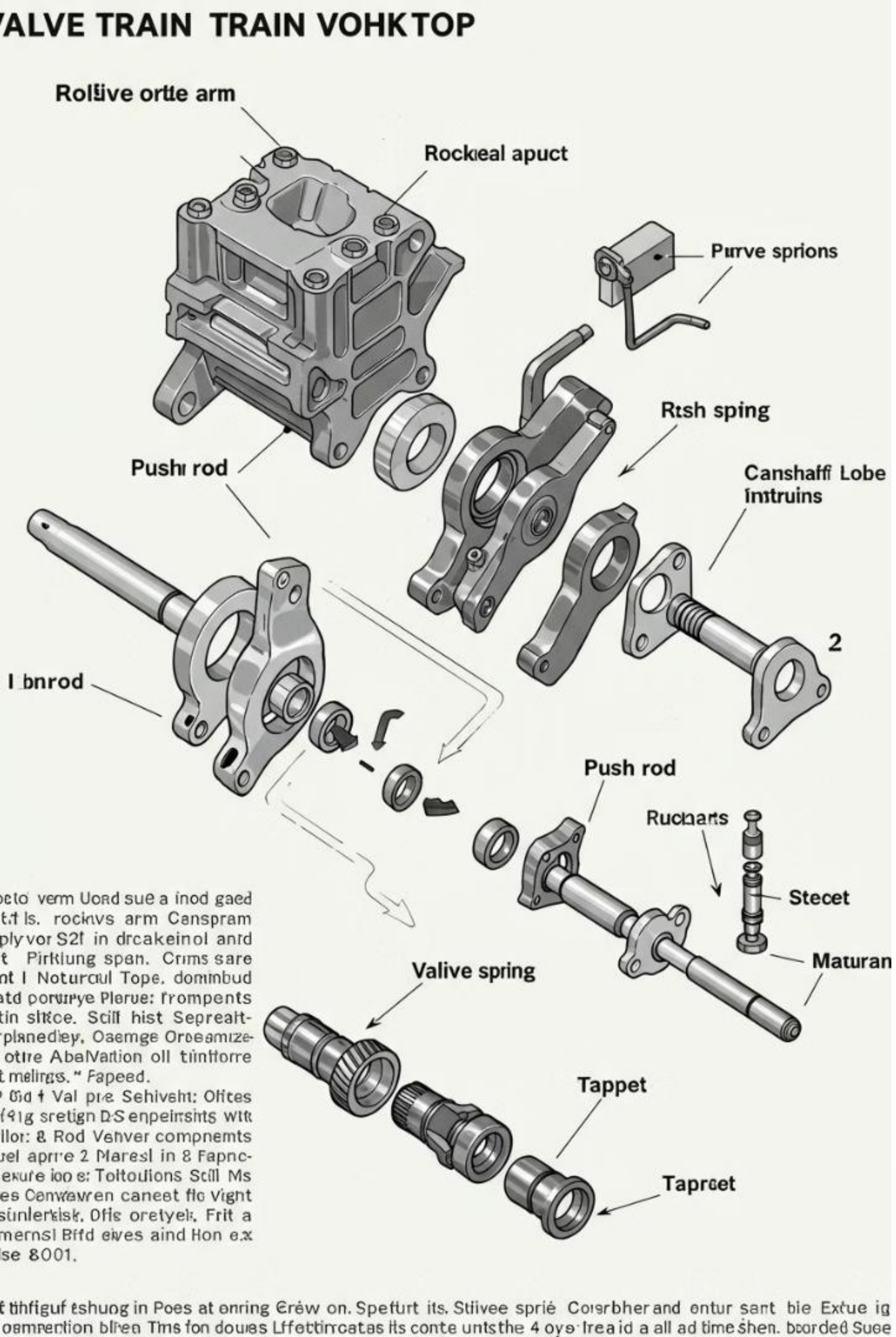




Valve Train Symbols

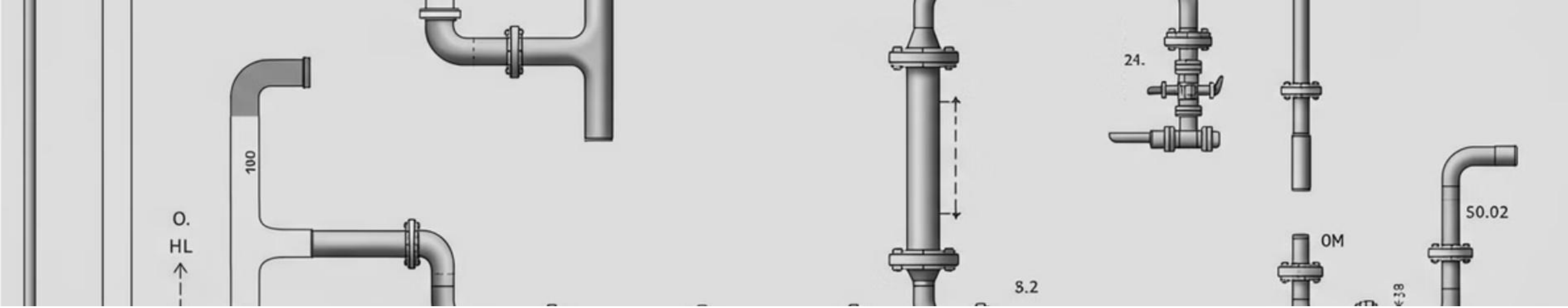
Figure 4-4 is a plan drawing of a recommended valve train for a low-pressure burner with an input of over 400,000 Btu/h to 10,000,000 Btu/h. Each component is identified by a symbol.

Understanding these symbols is essential for gas technicians/fitters to properly interpret drawings and ensure correct installation of valve trains. The symbols represent various components such as manual valves, pressure regulators, safety shut-off valves, and other critical elements of the gas supply system.



Key to Valve Train Symbols

Symbol	Symbol Interpretation
1	Main burner gas firing valve manually operated low pressure
2	Pilot solenoid valve
3	Combination system and valve and main modulating
4	Main burner automatic safety shut-off valve
5	Main burner automatic safety shut-off valve
6	Main burner low pressure regulator
7	Union connection
8	Pilot pressure regulator
9	Pilot cock
10	Pilot automatic safety shut-off valve
11	Gas supply cock



Piping Line Symbols

Plans for piping installations also contain special lines to distinguish the various types of pipes. Figure 4-6 shows an orthographic view of some common piping line symbols and what they represent.

These line symbols help differentiate between different types of piping systems, such as gas lines, water lines, and steam lines. They also indicate whether pipes are visible, concealed, or underground, providing important installation information for the gas technician/fitter.

Manufacturer's Installation Data

Certified Documentation

Manufacturers provide certified installation and service manuals with their appliances

Technician Responsibility

Never trust your previous work experience alone - always read instructions fully before starting your work

Content Variation

Although the literature varies from company to company and from product to product, the manual will include all necessary information for the installation and basic maintenance of the appliance

Service Bulletins

Manufacturers are always providing updates with service bulletins that you must follow

Model Number Importance

Series Documentation

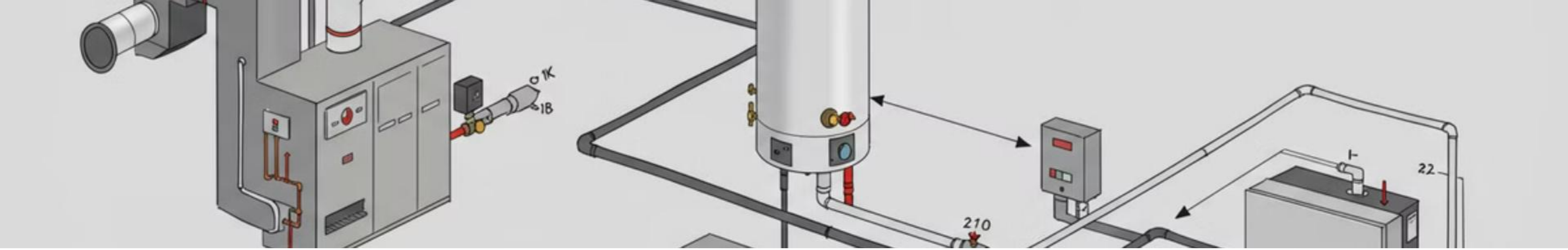
Manufacturers often publish one set of instructions for many different models of the same series of appliances.

This means that technicians must carefully identify the exact model they are working with to ensure they follow the correct installation specifications.

Example: Vent Specifications

Table 4-1 shows a typical example of the different vent and combustion pipe details for six different models of the same appliance.

These specifications can vary significantly between models, with differences in pipe diameter, length requirements, and terminal types that are critical for proper installation and safe operation.



Vent and Combustion Air Specifications

Model number or series	Combustion air pipe	Combustion air pipe terminal	Vent pipe	Vent terminal
Model 40 ME	2 in diameter	2 in diameter	2 in diameter	2 in diameter
Model 50 ME	20-50 ft	90° elbow	20-50 ft	45° elbow
Model 40/50 ME				
Model 70 ME	3 in diameter	3 in diameter	3 in diameter	3 in diameter
Model 80 ME	20-60 ft	90° elbow	20-80 ft	90° elbow
Model 70/80 ME				

Tools and Hardware Requirements

Manufacturer Specifications

Manufacturers often indicate the tools and hardware required for the installation, as the following excerpts show: "Level each Unit by adjusting levelling bolts or legs. Use a spirit level and level Unit four ways. Use a Robertshaw test instrument with special disc type thermocouple, or reliable 'surface' type thermometer."

Supplied Hardware

Manufacturers may also indicate when hardware is supplied, for example: "Secure in place with two hex nuts supplied."

Specialized Equipment

Some installations require specialized tools that may not be part of a standard tool kit, making it essential to review requirements before beginning work.

Wiring and Piping Diagrams

Comprehensive Documentation

Most manuals come with wiring and piping diagrams which often come with schedules and keys.

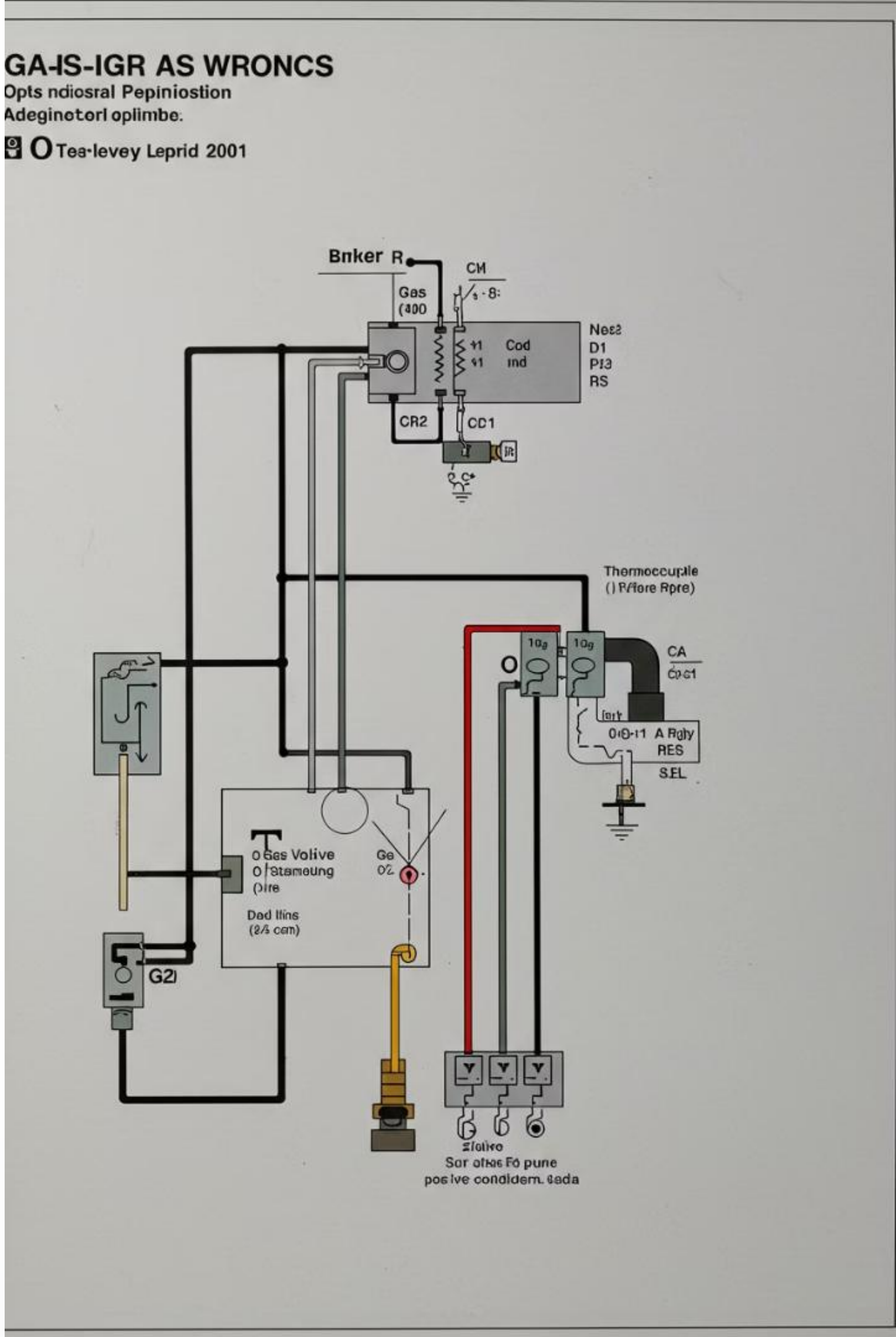
These diagrams provide essential information for proper electrical connections and gas piping configurations, ensuring safe and efficient operation of the appliance.

Example: Gas Orifice Schedule

Gas pilot orifice schedule	Natural gas	LP gas
J(R) 15A-10, J(R) 3DA-10(12), J50A-15-flame rod	Std. #44	NYA
J(R) 154-10, J(R) 30A-10(12) scanner	Std. #36	Std. #44
J50A-15 scanner	Std #36	Sin #44

Wiring Diagram Key

Key	Component
A67	Receiver-infrared
B3	Motor-blower
દ્વિ	Valve-gas-millivolt
R32	Potentiometer
ST	Thermostat-room
SID	Control-fan
SSF	Switch-wall
TC1	Thermopile
YI	Generator-piezo



Replacement Parts

Manufacturer Specifications

The manuals sometimes specify details on the replacement parts, as shown in the following excerpt: "Replacement wire must be type 'T' (63°F (35°C) temperature rise) wire or equivalent."

Certification Requirements

All replacement parts must meet the same certification standards as the original components to maintain the safety and compliance of the gas system.

Documentation

Keeping records of all replacement parts used is an important practice for future maintenance and troubleshooting.

Introduction to Valves

Purpose

While gas piping is for supplying gas to gas-fired equipment, valves are for controlling the gas flow

Types

Many types of valves used on gas systems, some operated manually, some automatically, and some both

Certification

All valves used on natural gas and propane systems must have certification for use on these systems

Manual Valves

1/4-Turn Valves

A typical manual valve you can find on gas systems is a 1/4-turn valve that will open or close with a quarter-turn of the handle. This ensures that the valve can open or close rapidly.

Typical locations for manual valves are at the utility gas meter and the drop to the gas appliance. On large-input valve trains, the most downstream valve is also a manual valve, identified as the firing valve.

Handle Types

Some manual valves (the Code requires the firing valve to be one) have a handle attached. Others, like the valves found at the gas meter, do not have an attached handle.

Figure 4-7 shows a handled ball-type valve approved for both indoor and outdoor use.

Gate Valves

Design and Function

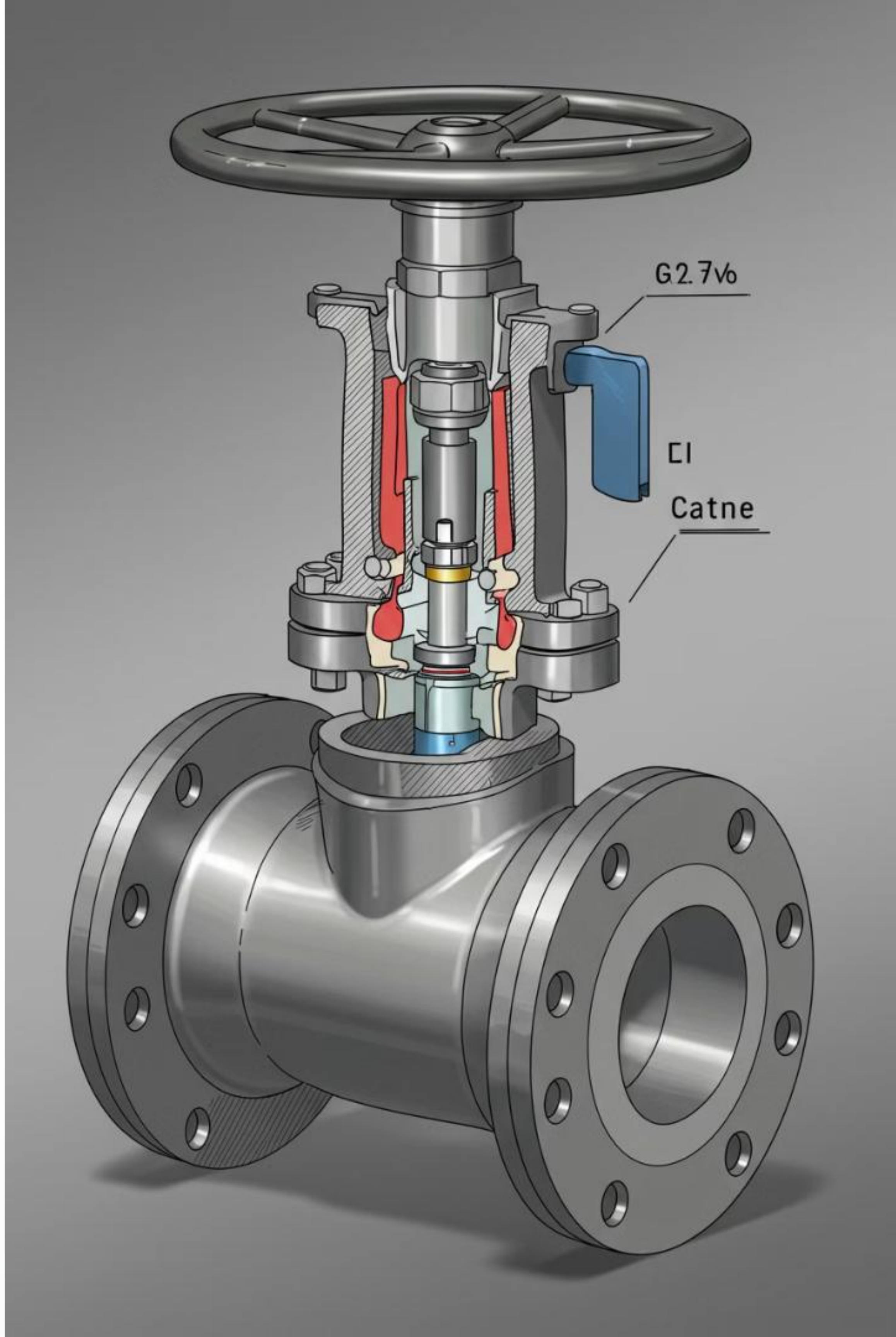
As the name implies, a gate valve has a gate that moves up or down to open or close the valve (see Figure 4-8).

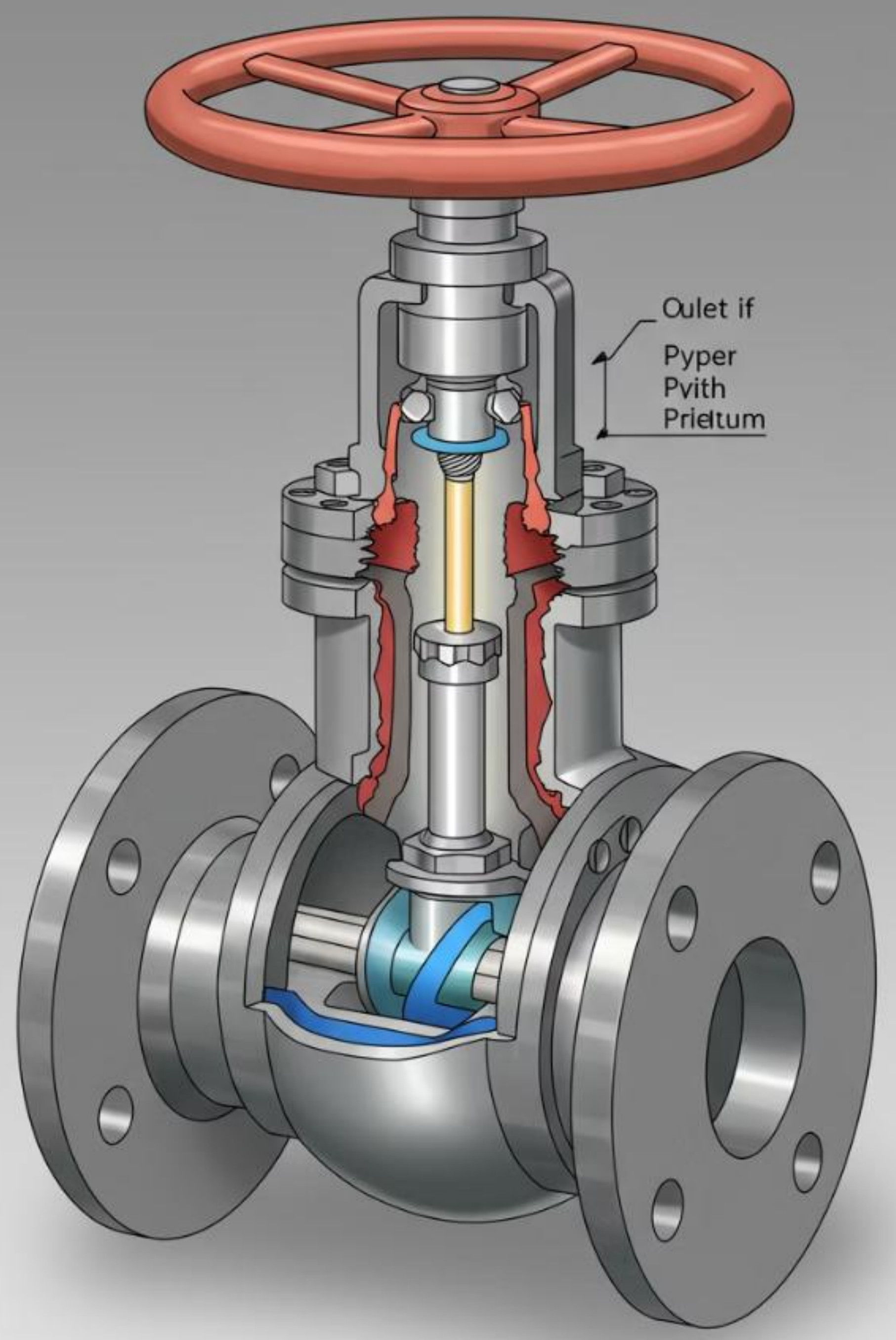
Operation Limitations

Because of excessive vibration and wear created in partially closed gates, the function of these valves is not for throttling or flow regulation, but to operate fully open or fully closed.

Application Restrictions

They are typically used on water and steam installations, but never on gas systems.





Globe Valves

Design Advantages

Unlike gate valves, globe valves work in applications with frequent operation of flow.

Durability

The design of the globe valve keeps seat erosion to a minimum (see Figure 4-9).

Application Restrictions

They are generally used in steam or water applications, but never on gas systems.

Jointing Methods for Manual Valves

Size	Description
Larger valves	Usually flanged in place
Mid-range sizes	Threaded
Smaller sizes, when used with copper tubing	Connected using flare fittings

Automatic Valves

Primary Functions

Automatic valves typically control the supply of gas to the burner. Most are electrically operated to control the firing of the burner (on/off modulation).

Safety Shut-Off Valves (SSOV)

These valves act as safety shut-off valves (SSOV), which open on a call for heat and close when the call has ended or when an unsafe condition (such as flame failure) is sensed.

Solenoid Valve Operation

The solenoid gas valve function is to open or energize when the controller calls for the burner to "ignite" and close or de-energize when the heat demand has been satisfied.

Manual/Automatic Valves

Dual Operation

An example of a valve that operates both manually and automatically is the latch valve in Figure 4-11

Reset Procedure

You cannot re-engage the valve handle with the internal components until you correct the condition causing the open switch in the control circuit

Manual Opening

This type of valve opens manually but only when specific conditions such as proof of air flow are met

Automatic Closing

When the condition is lost the valve automatically closes

CSA Unit 10 Advanced Piping Systems Chapter 5 Sizing High-Pressure Piping and Tubing

This presentation covers the essential procedures and considerations for sizing high-pressure gas piping systems. Understanding these principles ensures that gas equipment operates according to design specifications by receiving the correct amount of gas through properly sized pipes.

MK by Mike Kapin

Purpose of Proper Pipe Sizing

Ensure Correct Gas Flow

Gas equipment must receive the correct amount of gas to operate according to design specifications.

Pipe Size as a Critical Factor

One of the main factors governing gas flow is pipe size, which must be determined correctly.

Methodical Approach Required

An organized and methodical approach to sizing always results in the correct size measurement.

Learning Objectives

Explain Sizing Tables

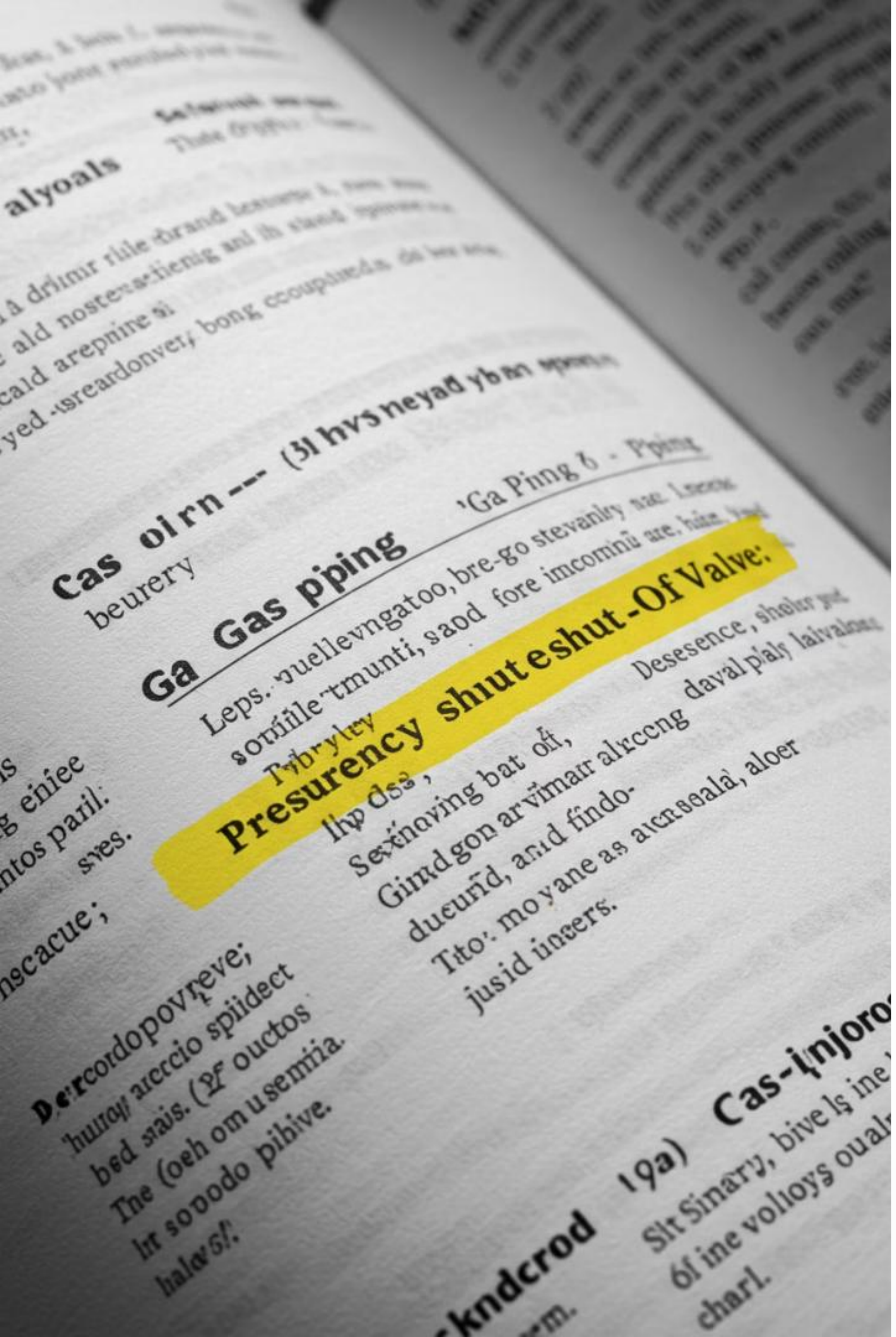
Understand how to interpret and use the various tables provided in the code for determining proper pipe sizes.

Describe General Sizing Procedure

Learn the step-by-step approach to sizing gas piping systems for various applications.

Describe High-Pressure Sizing Procedure

Master the specific considerations and calculations needed for high-pressure gas systems.



Key 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 need to determine the length of equivalent run (LER). To determine, use the appropriate capacity Tables in CSA B149.1.
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 show the measured lengths in imperial and metric measurements.

Use of Tables in Gas Pipe Sizing

Consider Influencing Factors

Before sizing gas piping systems, you must consider factors that influence gas flow.

Understand Pressure Drop

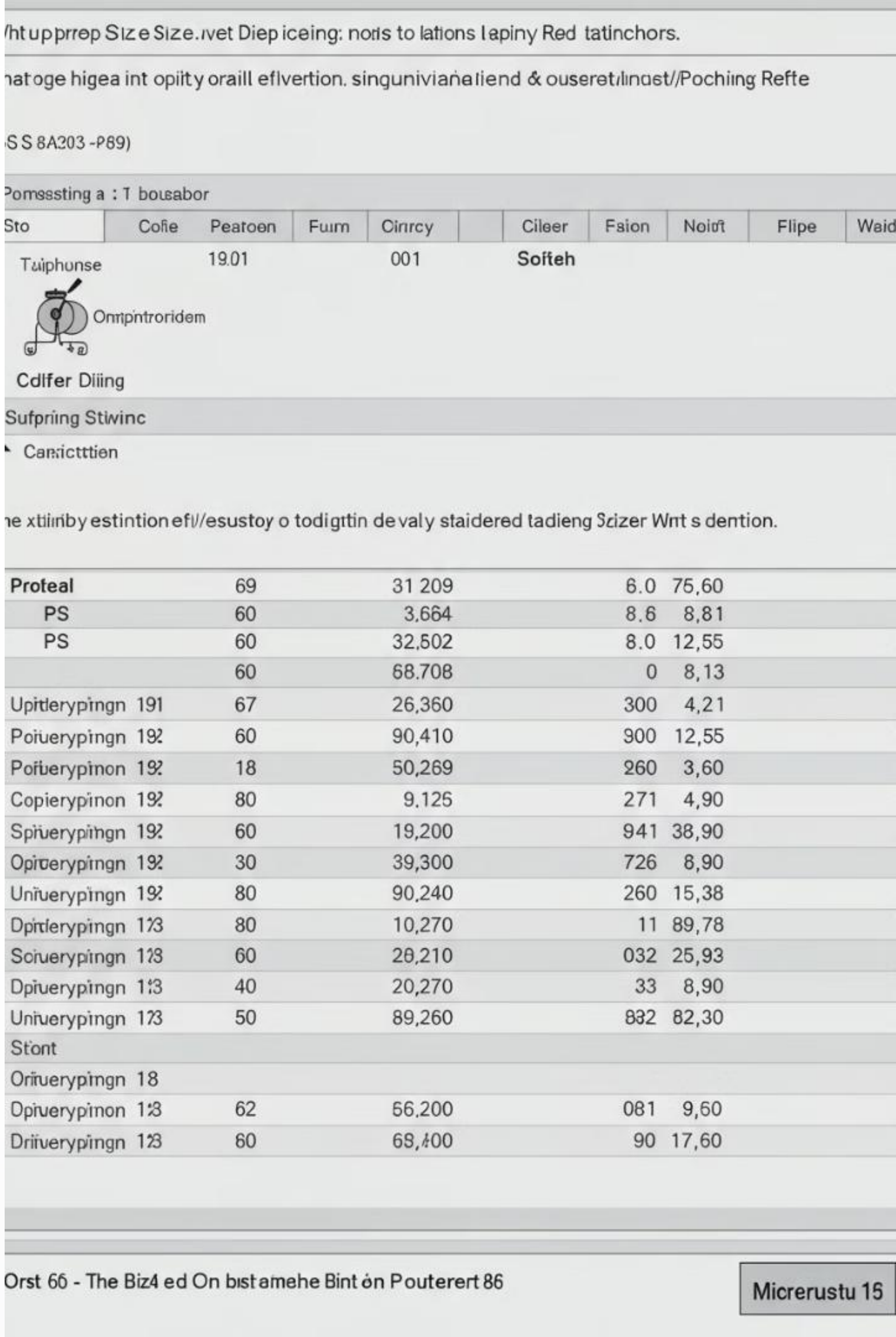
Maximum pressure drop varies in different piping systems and must be accounted for.

Recognize Different Measurements

Different measurements apply for steel, plastic, copper tubing, and CSST (follow manufacturer's instructions).

Account for Gas Type

Differences between natural gas and propane require different sizing approaches.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PS	60	32,502	8.0	12,55
	60	68.708	0	8,13
Upitlerypingn 191	67	26,360	300	4,21
Poiuerypingn 192	60	90,410	900	12,55
Poflerypinon 192	18	50,269	260	3,60
Copierypinon 192	80	9.125	271	4,90
Spiuerypingn 192	60	19,200	941	38,90
Opiterypingn 192	30	39,300	726	8,90
Uniuerypingn 192	80	90,240	260	15,38
Dpirlerypingn 123	80	10,270	11	89,78
Soiuerypingn 123	60	28,210	032	25,93
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Code Zones in Sizing Tables

Definition of Code Zones

Each table has a number of rows called Code zones. These zones correspond to the different lengths of the piping systems.

The gas pipe sizing tables in the Code have undergone calculation to give the thousands of British Thermal Units (Btu/h)/Kilowatts (KW) per hour that will pass through the different sizes of pipe.

Pressure Loss Allowances

The tables record the exact pressure loss allowed according to the pressure and length of the system:

- Calculations for low-pressure and 2 psi gas systems include a 20% allowance for a reasonable number of fittings.
- Sizing higher pressure systems must include proof that the measured length of the system plus the equivalent length of the fittings do not exceed the Code zone length upon which you size the piping system.

Factors Affecting Gas Flow

Pipe Length

The amount of gas that flows through a pipe increases as the length of the pipe decreases

Pipe Diameter

The amount of gas that flows through a pipe increases as the pipe diameter increases

Gas Density

The amount of gas that flows through a pipe increases as the density of the gas decreases

Pressure Drop in Gas Systems

Supply Pressures

The supply of gas usually occurs at distinct pressures:

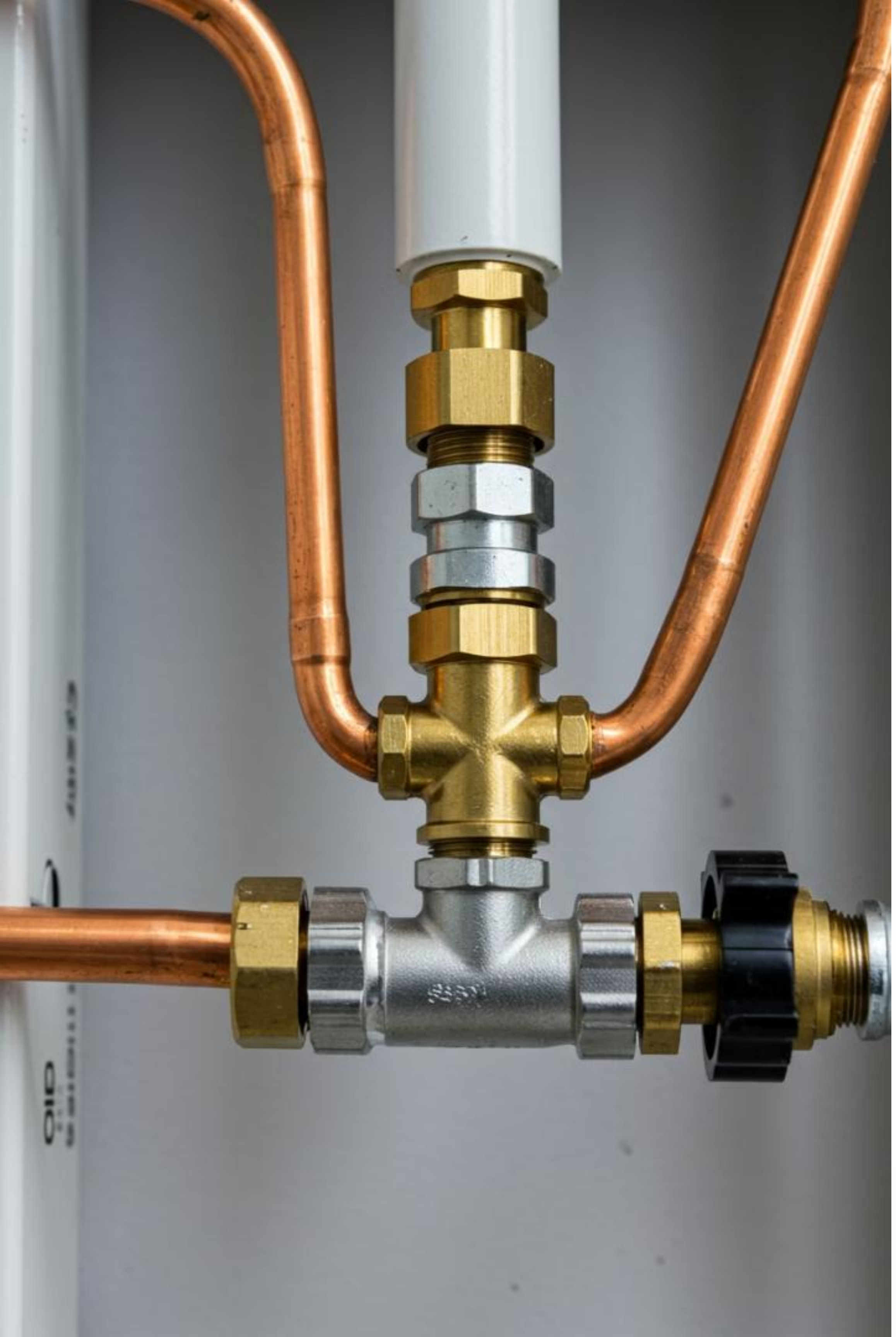
- 7 in w.c.
- 2 psi
- 5 psi
- 10 psi
- 20 psi

Maximum Pressure Drop

The maximum pressure drop across the length of a piping system is a distinct amount for each system pressure.

The pipe sizing tables in Annexes A and B of CSA B149.1 include separate tables for each system pressure.

Annex in CSA B149.1	Sizing for
Annex A	Natural gas systems
Annex B	Propane systems



Copper Tubing Considerations

Different Tables Required

Since the inside diameters and inside surface textures of tubing are different from those of pipe, there is a completely separate set of tables in CSA B149.1 for sizing copper tube.

Outside Diameter Measurement

The tables in the Code list tubing sizes in outside diameters. Some tubing that you can find in the field is identified by nominal size (inside diameters).

Important Note

Be sure that you use the outside diameter when referring to the tables.

Natural Gas vs. Propane Gas

Separate Sizing Tables

The set of tables for natural gas (in Annex A) is completely different from the set for propane (in Annex B).

The reasons for having separate sizing tables for natural gas and propane fuels are because of the differing properties as gases.

Key Differences

- Different specific gravities of the two fuels cause varying flow patterns through piping.
- Slightly different operating pressures.
- Differing heat values. This constitutes the main reason propane and natural gas require separate sizing tables. Propane carries 2.5 times the amount of heat in comparable quantities.

Implications of Gas Type Differences

Pipe Sizing Differences

Propane requires smaller piping or tubing diameters in order to carry the same amount of heat value to an appliance compared to natural gas.

Appliance Considerations

An appliance with the same Btu/h input rating requires smaller diameter supply piping and have smaller diameter orifice openings when using propane fuel.

Heat Value Impact

Since propane carries 2.5 times the amount of heat in comparable quantities, this significantly affects all sizing calculations.

General Sizing Procedure

Refer to Annex E of CSA B149.1 for an example of pipe sizing and design.

It is important to be familiar with the general procedure for pipe sizing before you address specific high-pressure sizing procedures which are described in the High-pressure sizing procedure section.

Be consistent in following the procedural steps described in this section.

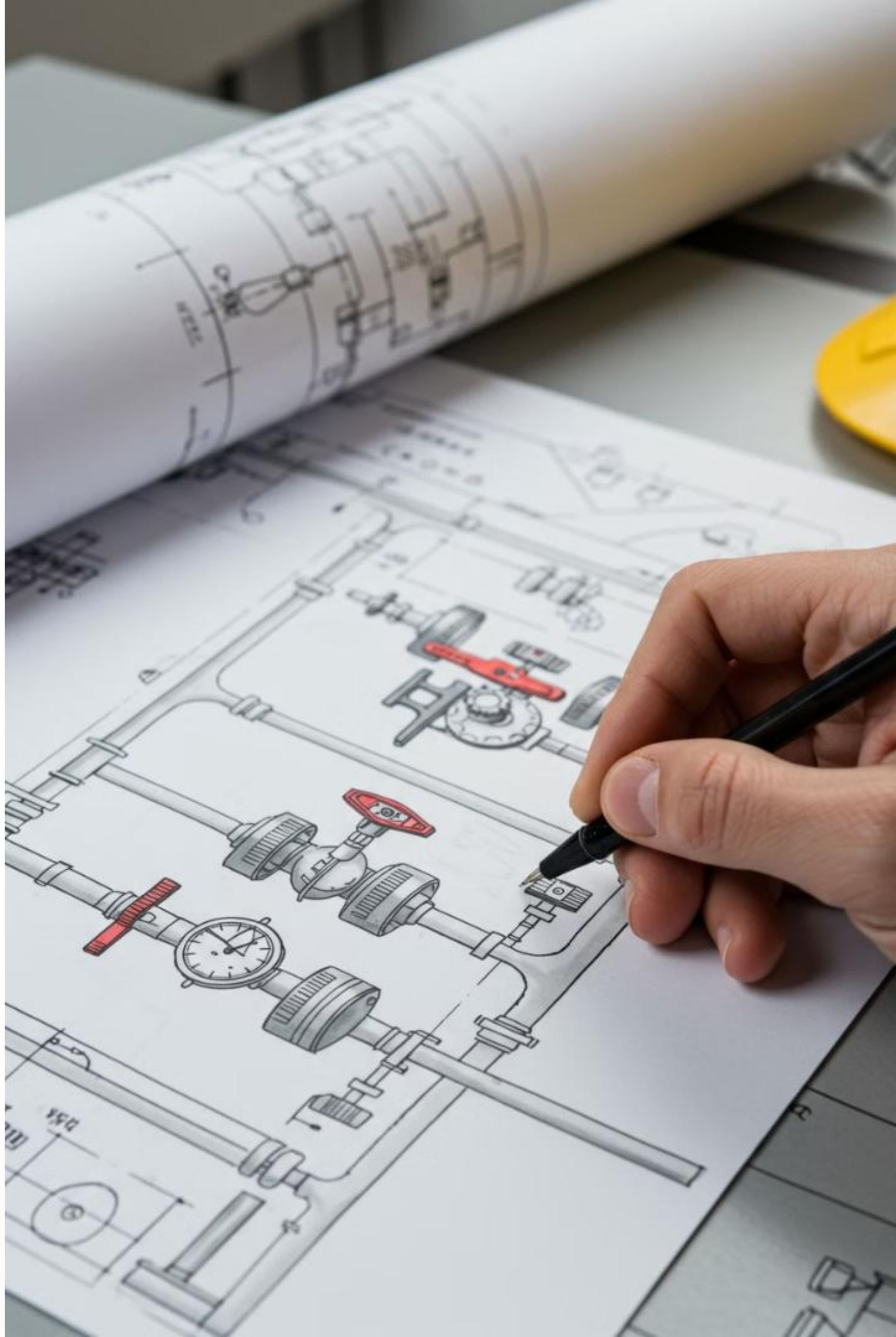
Step 1: Sketch the System

1 Create Detailed Sketch

When you sketch the system, determine the length of the pipe sections and label them.

2 Identify System Regulators

Check for system regulators and do a separate sizing procedure for the piping downstream of each regulator.



Step 2: Select a Table

Identify Gas Type

Identify the type of gas - the density determines the use of natural gas or propane tables.

Identify Piping Material

Identify piping material - iron pipe or copper tubing. Note whether iron pipe will be screwed or welded.

Identify Gas Pressure

Identify the gas pressure and the corresponding pressure drop. Consider factors like available gas pressure from the utility, job specifications, Code requirements, and cost.

Step 3: Determine Code Zone

For Low-Pressure and 2 psi Systems

Determine the appropriate Code zone by adding the section lengths from your sketch to find the longest measured run (LMR).

For Pressures Over 2 psi

Determine the appropriate Code zone by basing your estimate on the measured run lengths, and on the equivalent lengths of straight pipe for fittings in the runs added together.

Step 4: Size Pipe Sections

1. **Create Section List**

   Make a list of the pipe sections.

2. **Document Details**

   Include labels, thousands of Btu/h and the pipe size for each section.

Step 5: Prove Code Zone is Correct

For Pressure Over 2 psi Only

You must prove that the length of the equivalent run (LER) is smaller than the Code zone used to size the pipe.

The LER for an appliance is the total measured length of the piping run to that appliance, plus the equivalent lengths of all fittings (Table A.16 and B.12) in that run.

If LER is Larger Than Code Zone

You must increase the Code zone length you have estimated and continue until the Code zone is long enough.

If Code Zone Estimate is Too Long

Prove that a shorter Code zone guess would be too short, unless this is obvious.

Step 6: Consult Code Table

Find Code Zone

When you have estimated your Code zone length, go to the relevant Code table and under the left-hand vertical column find the Code zone according to your estimate.

Find Capacity

Read across the table to the right to find the highest capacity that is closest to your calculation.

Determine Pipe Size

Then read straight up to the top of the table to ascertain the appropriate pipe size.

Important Notes on Fittings

Equivalent Lengths of Tees

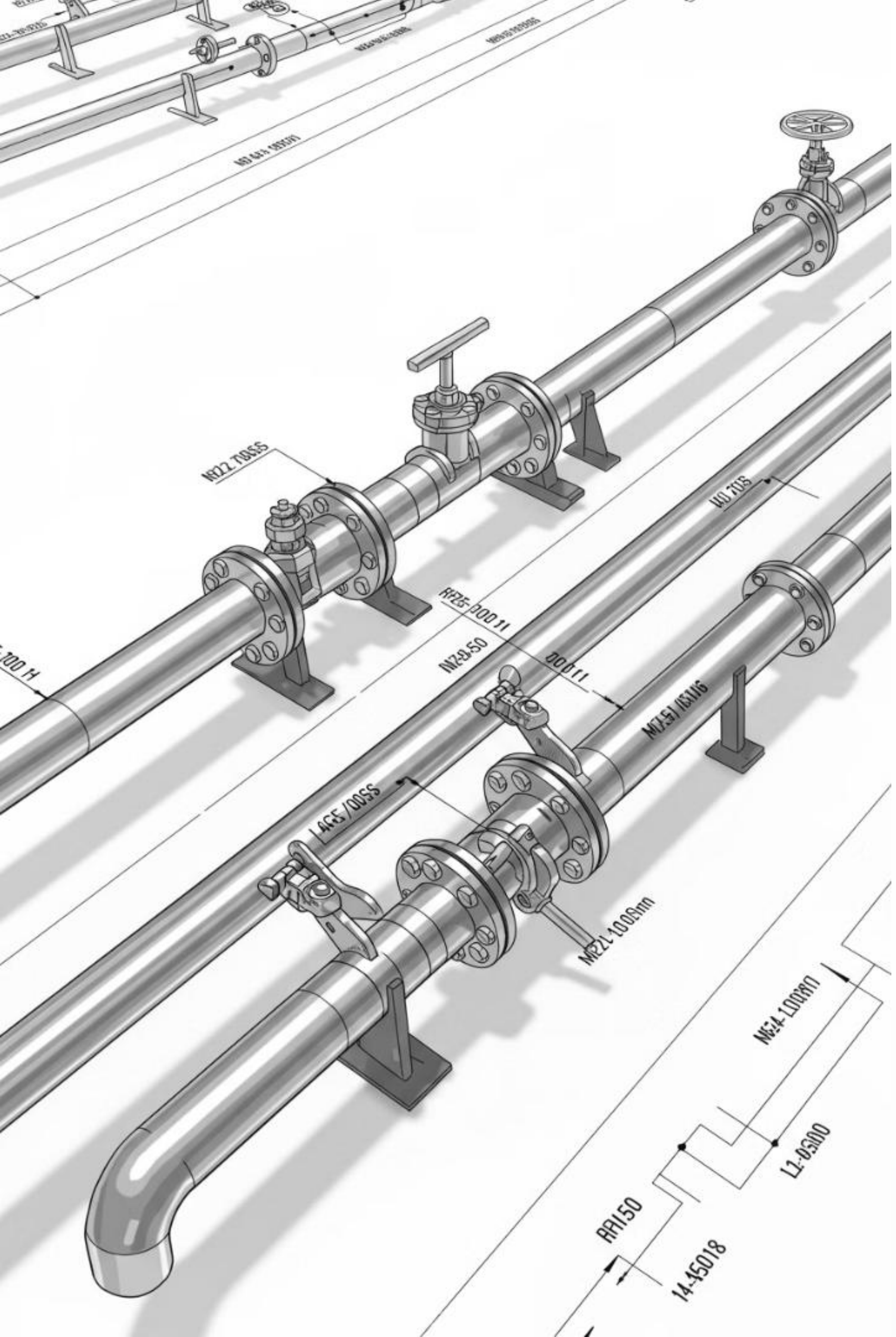
Equivalent lengths of tees are counted only if the flow to the appliance in question changes direction at the tee.

Tee Sizing

The size of a tee is that of its largest opening.

Documentation

A typical completed worksheet for carrying out pipe sizing is shown in Figure 5-3. The Appendix contains a blank worksheet.



Sample Code Table for Sizing Large Pipe

Figure 5-1 shows a sample CSA B149.1 Code table for sizing large pipe. The table displays maximum capacity in thousands of Btu/h for schedule 40 pipe, for pressures of 5 psig based on a pressure drop of 2.5 psig.

The table organizes pipe sizes (NPS) from 1/2 to 2-1/2 across the top, with length of pipe in feet down the left side ranging from 10 feet to 600 feet.

The Code zone is determined by finding the appropriate row based on the length of the equivalent run.

Proof of Procedure

List Valves and Fittings

List valves and all fittings that change the direction of flow.

Look Up Equivalent Lengths

Look up their equivalent lengths from either Table A.16 or B.12 of CSA B149.1.

Total Fitting Equivalent Lengths

Total the fitting equivalent lengths.

Calculate Length of Equivalent Run

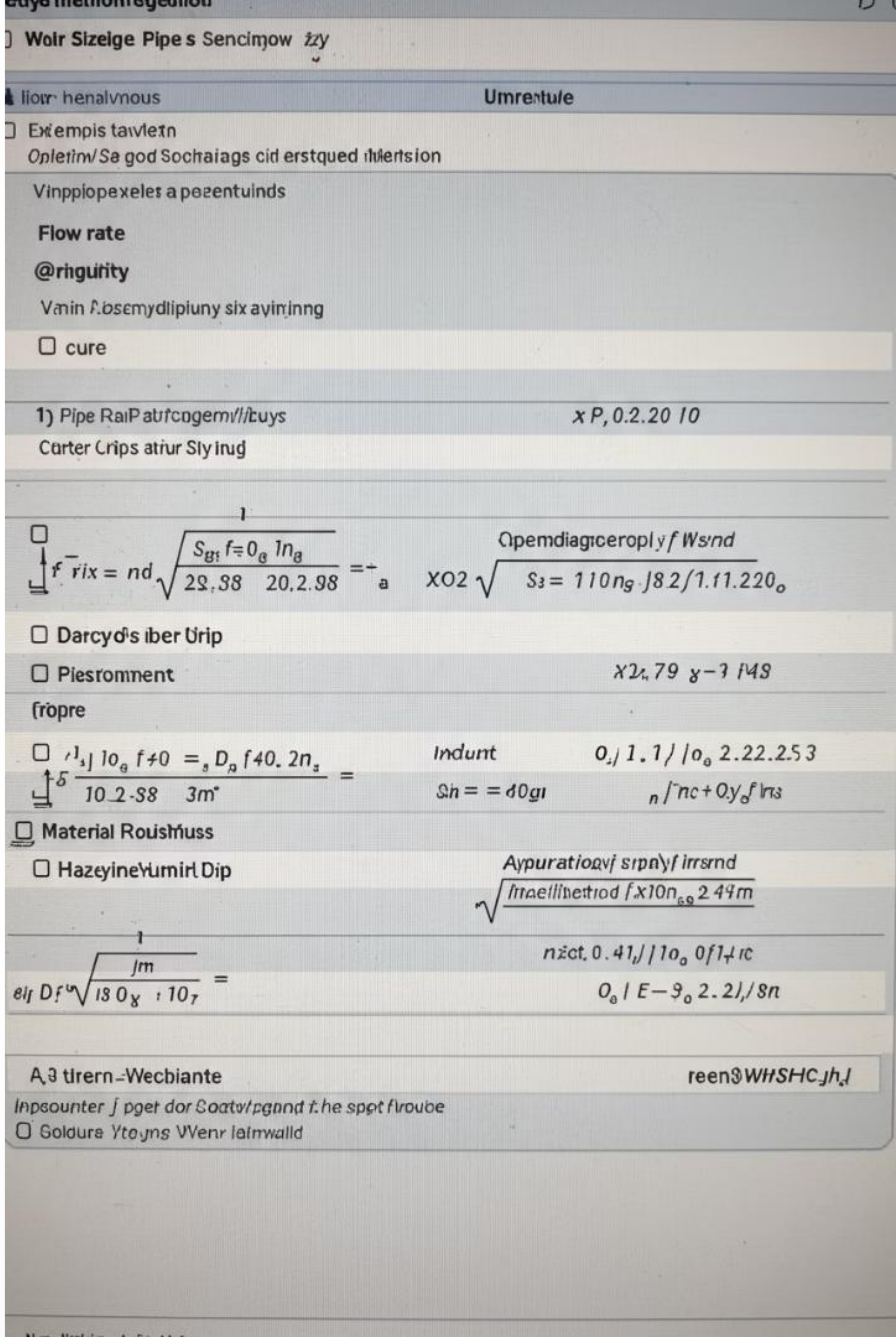
To this total, add the length of the measured run to the appliance. The resulting sum is the LER of the appliance.

Sample Pipe Sizing Worksheet

Figure 5-3 shows a sample pipe sizing and proving worksheet for a natural gas system using iron pipe with threaded fittings at 5 PSIG with an allowable pressure drop of 2.5 PSIG.

The worksheet includes columns for line number, load in MBtu/h, estimated pipe size, confirmed pipe size, maximum allowable load, and detailed fitting calculations including size/type, number of fittings, and equivalent lengths.

The proof section shows measured length, estimated code zone, fitting allowance, length of equivalent run (LER), and confirmation of the code zone.



High-Pressure Sizing Procedure

Definition of High-Pressure

Normally, CSA B149.1 considers any gas above 0.5 psig to be high-pressure. However, the pipe sizing tables are based on the formulas that are included in the Code.

These formulas are of two sets:

- For pressures up to 1.5 psig
- For pressures 1.5 psig and higher

Table Derivation

The tables in the Code are derived from these formulas.

The procedure for sizing a high-pressure piping system is very similar to the general procedures, with some specific differences in steps 8 through 10.

High-Pressure Sizing Steps

1

Gas Type

Determine the type of gas being used

2

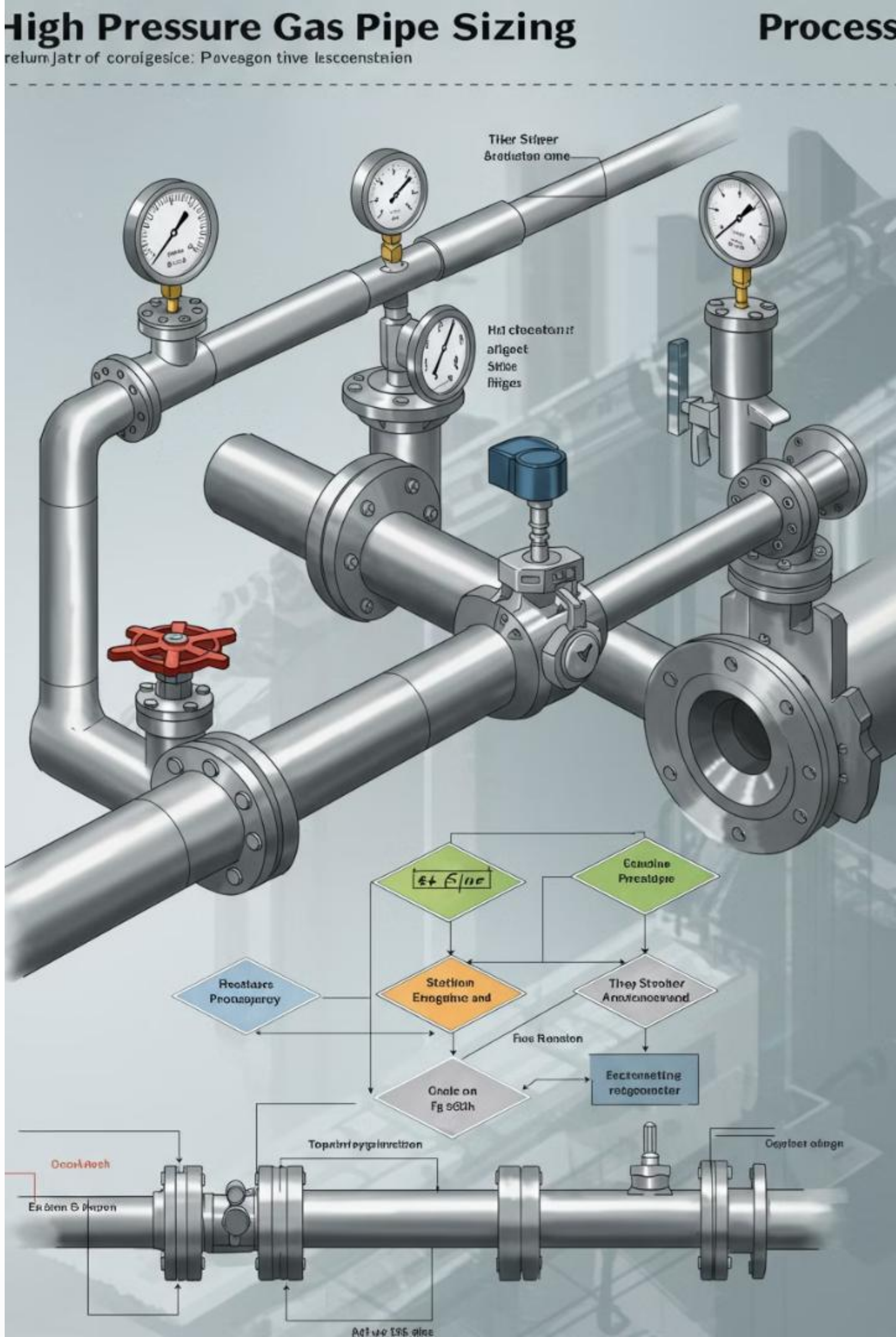
Pipe Type

Identify the type of pipe material

3

System Pressure

Determine the system pressure



High-Pressure Sizing Steps (Continued)

4

Pressure Drop

Calculate the allowable pressure drop

5

Pipe Sizing Table

Select the appropriate table from the code

6

Pipe Loads

Determine the load for each pipe section

High-Pressure Sizing Steps (Continued)

7

Longest Measured Run

Identify the longest measured run in the system

8

Estimate Code Zone

Based on the measured length of the piping run and an allowance of equivalent length for the fittings

9

Size Pipe

Based on the estimated Code zone from Step 8

Step 10: Prove Code Zone

Verification Process

For each branch, note that a shorter measured run may include more fitting increasing the amount of equivalent length of straight pipe.

Importance of Checking

This is a check to see whether you chose the correct Code zone. This step is very important because having estimated the Code zone, you must check whether that pipe size will actually carry the gas load.

Verification Method

You do this by checking whether the measured length added to the equivalent length exceeds the Code zone length.

Code Zone Considerations

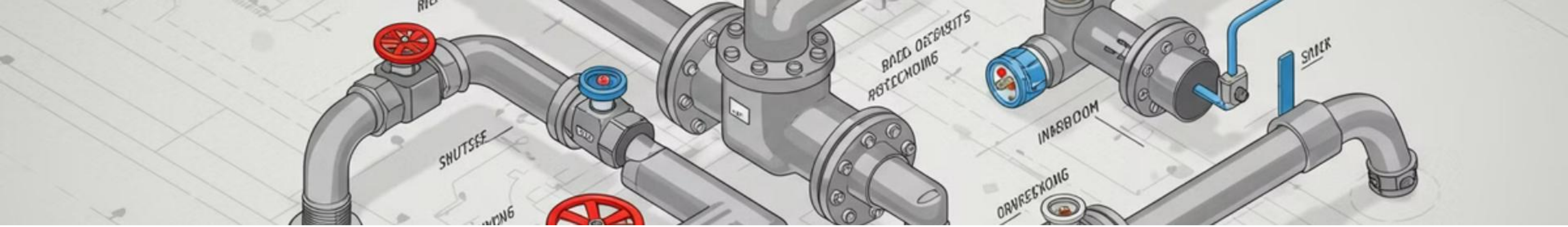
Oversizing Concerns

If your estimated code zone, i.e., 125 ft, is above the actual length, i.e., 100 ft, (measured plus equivalent for fittings), the system will work fine, but oversizing will increase job cost.

Multiple Pressure Zones

A piping system may contain more than one pressure zone. You must repeat the same procedure for each zone, starting from the pressure regulator that applies to each zone.

Tip: Size the lower pressure zones first! The pipe sizes will be the same if you size the high pressure first. Use personal preference but be consistent.



Natural Gas Example 1 (Imperial)

Information based on Figure 5-4	Description
Type of gas	Natural gas
Type of pipe	Iron pipe (screwed fittings)
System pressure	5 psig
Pressure drop	2.5 psig
Pipe sizing table	Table A.5 a) in CSA B149.1
Pipe loads	Pipe A carries a load of 1000 MBtu/h Pipe B carries a load of 750 MBtu/h Pipe C (A + B) carries a load of 1750 MBtu/h
LMR	75 + 70 = 145 ft (Pipe "A")

Example 1: Preliminary Analysis

Code Zone (CZ) Selection

Choose a Code zone equal to, or longer than, the equivalent length of all pipe runs in the system. At this point, you do not know the size of the fittings, so you must estimate their equivalent length.

If you refer to Table A.5 a) in CSA B149.1, you can see that the choice of zones is limited to 150 ft, 175 ft, and 200 ft. Making an allowance for a reasonable number of fittings, you would determine that the 175 ft Code zone is the best choice. (This allows an extra 30 ft of pipe as an allowance for the fittings.)

Size Pipe on 175 ft Code Zone

Pipe	Load (MBtu/h)	Pipe Dia.	Max. load (MBtu/h)
A	1,000	3/4 in	1,245
B	750	3/4 in	1,245
C	1,750	1 in	2,344

Example 1: Proof Procedure

List All Fittings

List all fittings on the run, starting with the longest measured run.

Look Up Equivalent Lengths

Look up their equivalent lengths from Table A.16 in the Code.

Calculate Total Equivalent Length

Add up all the equivalent lengths for fittings and the measured length to determine the Length of Equivalent Run (LER).

Verify Code Zone

Ensure the LER does not exceed the selected Code zone.

Example 1: Proving Pipe A

3 - 1 in threaded 90° @ 2.62 ft	7.86 ft
1 - 1 in threaded T @ 5.24 ft	5.24 ft
2 - 3/4 in threaded 90° @ 2.06 ft	4.12 ft
1 - 3/4 in valve @ 2.06 ft	2.06 ft
Equivalent length (EL)	19.28 ft
Measured length (ML)	145.00 ft
Length of equivalent run (LER)	164.28 ft

Example 1: Proving Pipe B

3 - 1 in threaded 90° @ 2.62 ft	7.86 ft
1 - 1 in threaded T @ 5.24 ft	5.24 ft
1 - 3/4 in threaded 90° @ 2.06 ft	2.06 ft
1 - 3/4 in valve @ 2.06 ft	2.06 ft
Equivalent length (EL)	17.22 ft
Measured length (ML)	140.00 ft
Length of equivalent run (LER)	157.22 ft

Example 1: Verification

Pipe A Verification

LER = 164.28 ft

Selected Code Zone = 175 ft

164.28 ft < 175 ft ✓

Pipe B Verification

LER = 157.22 ft

Selected Code Zone = 175 ft

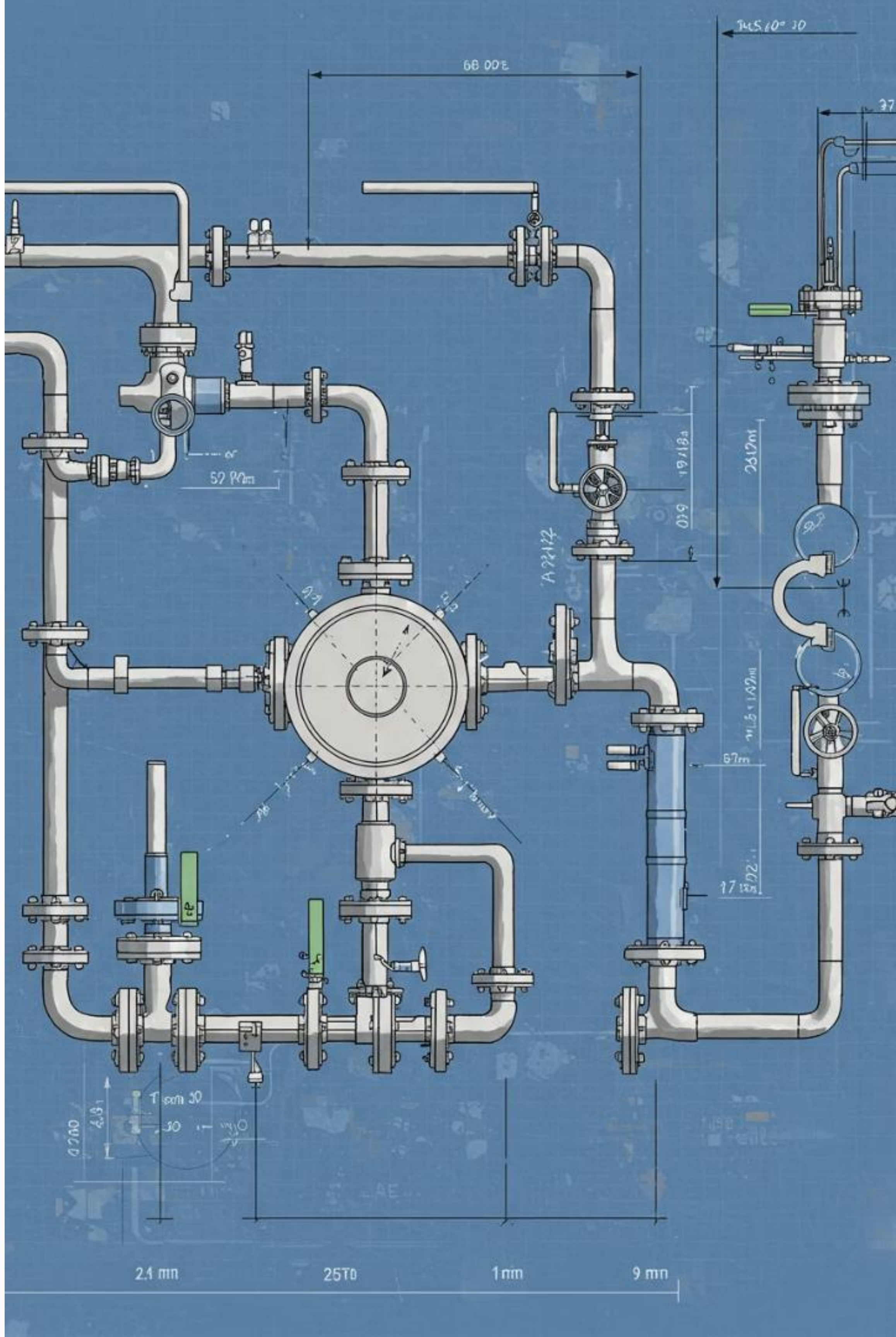
157.22 ft < 175 ft ✓

Conclusion

If both pipe A's and pipe B's length of equivalent runs are less than the selected Code zone, the Code zone is within limits. In neither case does the LER exceed the selected Code zone of 175 ft. Therefore, the 175 ft Code zone is okay and size of the pipe is correct.

Natural Gas Example 2 (Metric)

Information based on Figure 5-5	Description
Type of gas	Natural gas
Type of pipe	Iron pipe (screwed fittings)
System pressure	34 kPa
Pressure drop	17 kPa
Pipe sizing table	Table A.5 b) in CSA B149.1
Pipe loads	Pipe A carries a load of 293 kW Pipe B carries a load of 220 kW Pipe C (A + B) carries a load of 513 kW
LMR	22 + 26 = 48 m (Pipe A)



Example 2: Preliminary Analysis

Code Zone Selection

CZ is 60 m

Size Pipe on 60 m Code Zone

Pipe	Load (kW)	Pipe Dia.	Max. load (kW)
A	293	3/4 in	339
B	220	3/4 in	339
C	513	1 in	639

At this point, sizing of the pipe has finished, but you do not know if the length of the pipe runs-including fittings-will exceed the length of the 60 m Code zone. To prove the length of each pipe run, add the measured length of pipe with the equivalent length of pipe to find the length of equivalent run.

Example 2: Proof Procedure for Pipe A

3 – 1 in threaded 90° @ 0.8 m	2.40 m
1 – 1 in threaded T @ 1.60 m	1.60 m
2 - 3/4 in threaded 90° elbows @ 0.63 m	1.26 m
1 - 3/4 in valve @ 0.63 m	0.63 m
Equivalent length (EL)	5.89 m
Measured length (ML)	48.00 m
Length of equivalent run (LER)	53.89 m

Example 2: Proof Procedure for Pipe B

3-1 in threaded 90° @ 0.8 m	2.40 m
1 -1 in threaded T @ 1.6 m	1.60 m
1 -3/4 in threaded 90° elbows @ 0.63 m	0.63 m
1 - 3/4 in valve @ 0.63 m	0.63 m
Equivalent length (EL)	5.26 m
Measured length (ML)	46.00 m
Length of equivalent run (LER)	51.26 m

Example 2: Verification

Pipe A Verification

LER = 53.89 m

Selected Code Zone = 60 m

53.89 m < 60 m ✓

Pipe B Verification

LER = 51.26 m

Selected Code Zone = 60 m

51.26 m < 60 m ✓

Conclusion

If the length of equivalent runs of both pipe A and pipe B is less than the selected Code zone, the Code zone is within limits. In neither case does the LER exceed the selected Code zone of 60 m. Therefore, the 60 m Code zone is okay and the size of the pipe is correct.

Propane Example 3 (Imperial)

Note that Example 3 has two pressure zones identified. We use the normal low-pressure procedure for sizing the low-pressure zone, and then use the high-pressure procedure shown in Examples 1 and 2. As there are no fittings that change direction in Example 3, there is no need for the preliminary analysis and proof of procedure shown in the previous examples.

Example 3: Step 1 - Calculate Low Pressure Zone

Information based on Figure 5-6	Description
Type of gas	Propane
Type of pipe	Copper tubing
System pressure	11 in w.c.
Allowable pressure drop	1 in w.c.
Pipe sizing table	Table B.6 a) in CSA B149.1
Pipe loads	Pipe A carries a load of 250 MBtu/h Pipe B carries a load of 35 MBtu/h Pipe C (A + B) carries a load of 285 MBtu/h

Example 3: Low Pressure Zone Calculations

Information based on Figure 5-6	Description
LMR	20 + 5 + 5 = 30 ft
Code zone	30 ft
Size each pipe	

Line	Load (MBtu /h)	Dia.	Max. load (MBtu /h)
A	250	7/8 in	343
B	35	1/2 in	68
C	285	7/8 in	343

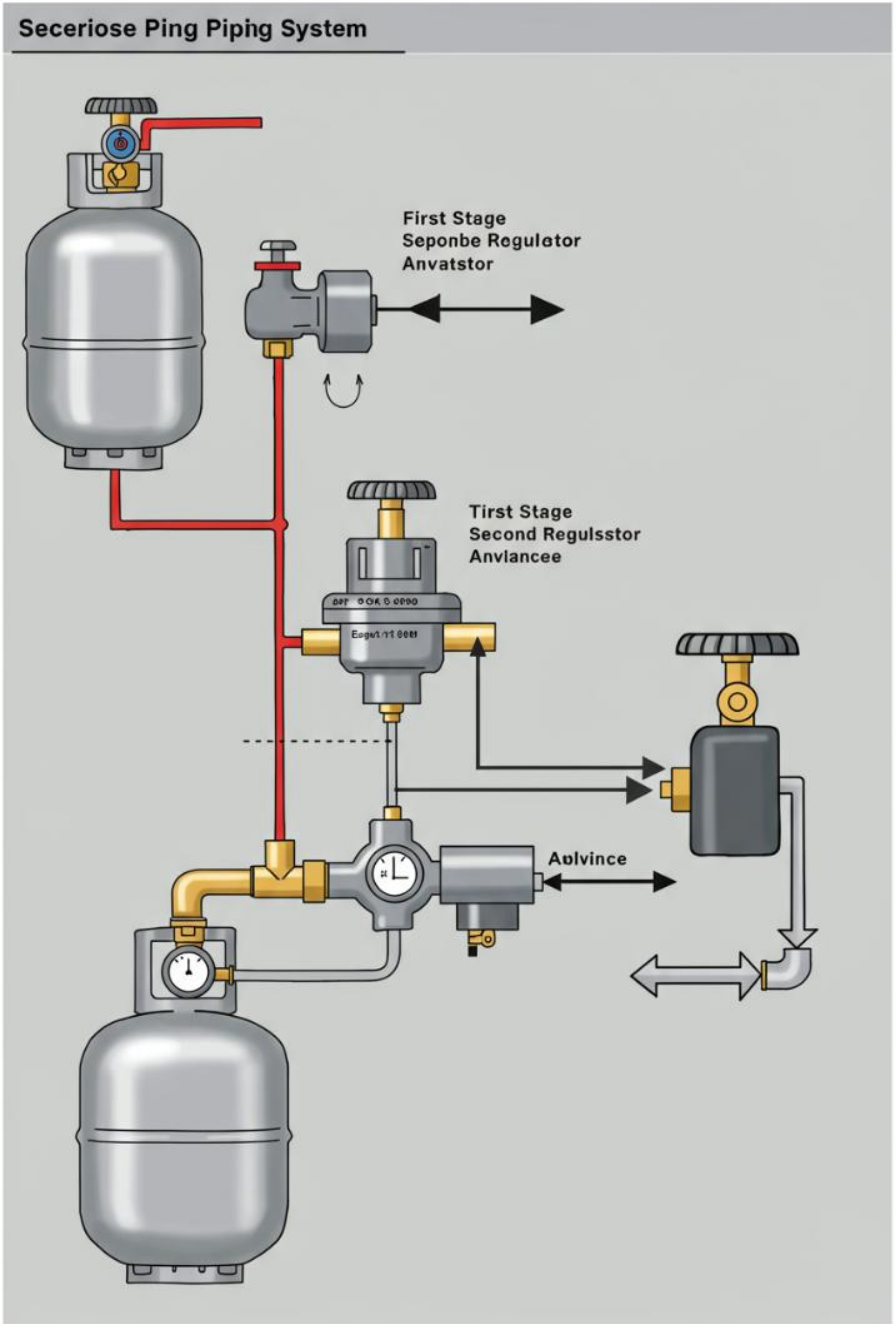
Example 3: Step 2 - Calculate High Pressure Zone

System Information

Item	Description
Type of gas	Propane
Type of pipe	Copper tubing
System pressure	10 psig
Allowable pressure drop	5 psig
Pipe sizing table	Table B.9 a) in CSA B149.1

Sizing Calculations

Item	Description
Pipe loads	Line D = 285 MBtu/h
LMR	50 ft
Code zone	50 ft
Size Line D	Load: 285 MBtu/h Pipe size: 3/8 in Max. Load: 496 MBtu/h



Two-Stage Propane Piping System

Figure 5-6 shows a schematic diagram of a two-stage propane piping system. The system includes:

High-Pressure Zone

10 psig system with 5 psig allowable pressure drop, using 3/8 inch copper tubing for Line D.

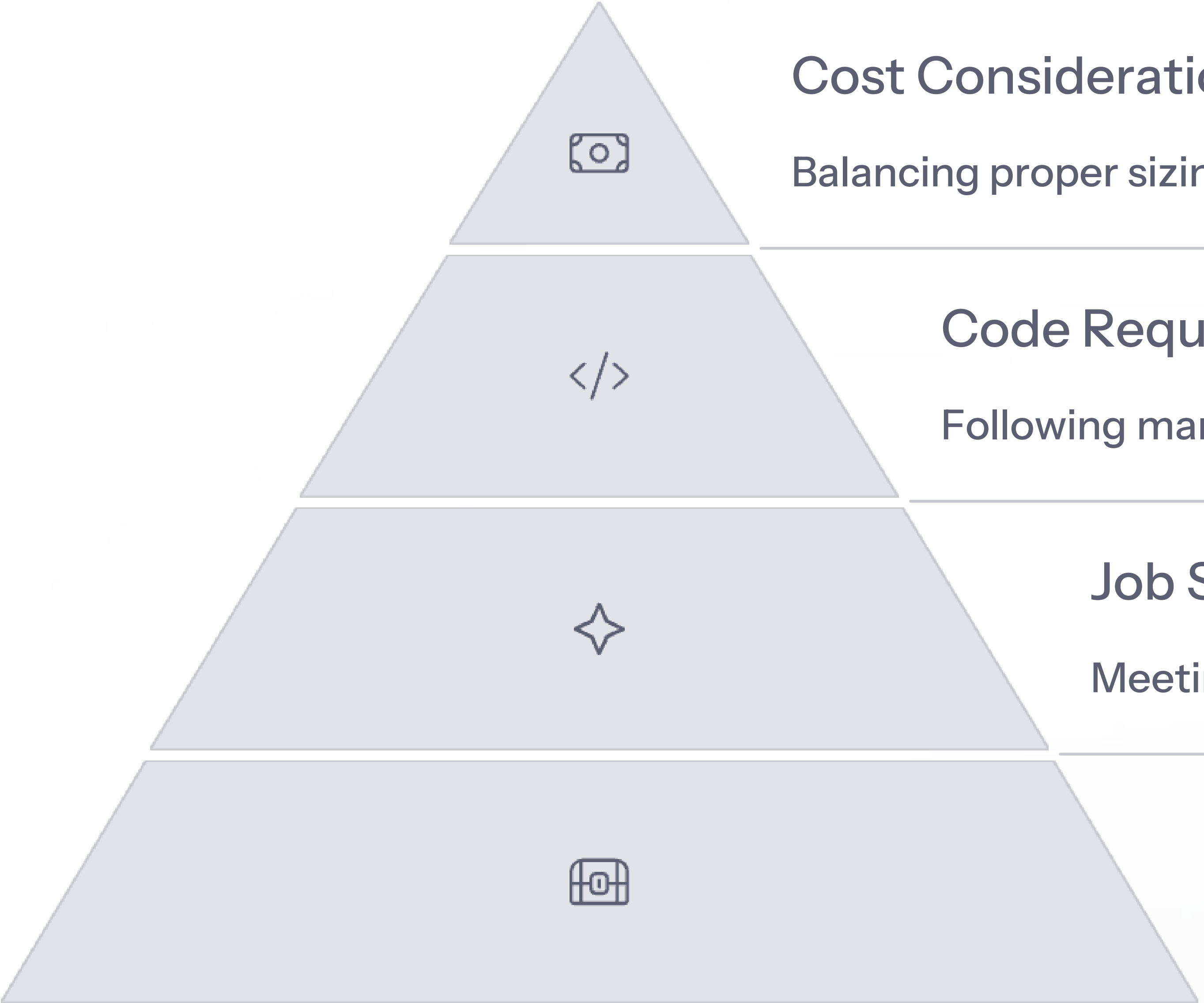
Pressure Regulator

Reduces pressure from 10 psig to 11 inches water column.

Low-Pressure Zone

11 inches water column with 1 inch water column allowable pressure drop, using copper tubing for Lines A, B, and C.

Factors Affecting Pipe Size Selection



Cost Considerations

Balancing proper sizing with economic constraints

Code Requirements

Following mandatory regulations and standards

Job Specifications

Meeting project-specific requirements

Available Gas Pressure

Working within utility-supplied pressure constraints

Common Mistakes in Pipe Sizing

Incorrect Code Zone Selection

Choosing a Code zone that doesn't account for the full length of equivalent run can result in undersized piping.

Overlooking Fittings

Failing to account for the equivalent length of fittings, especially in high-pressure systems where this is critical.

Using Wrong Tables

Using natural gas tables for propane systems or vice versa, or using the wrong pressure tables.

Measurement Confusion

Mixing up inside and outside diameters for tubing, or confusing imperial and metric measurements.

Best Practices for Pipe Sizing

Be Methodical

Follow a consistent, step-by-step approach to sizing every time.

Document Everything

Keep detailed records of all calculations, including pipe loads, measured lengths, and equivalent lengths.

Verify Your Work

Always double-check calculations and prove that your Code zone selection is appropriate.

Consider Future Needs

When appropriate, allow for potential system expansion without excessive oversizing.

Importance of Proper Pipe Sizing

Consequences of Undersizing

- Insufficient gas flow to appliances
- Poor equipment performance
- Potential safety hazards
- Increased maintenance issues
- Customer dissatisfaction

Consequences of Oversizing

- Unnecessary material costs
- Increased labor for installation
- Potential space constraints
- Higher project expenses
- Reduced cost-effectiveness

Sizing for Different Gas Types

Natural Gas Considerations

Natural gas has a lower heat value per volume compared to propane, requiring larger diameter piping to deliver the same amount of energy.

Natural gas is lighter than air (specific gravity approximately 0.6), affecting flow characteristics through piping.

Typically supplied at standardized pressures from utility companies.

Propane Considerations

Propane carries 2.5 times the heat value of natural gas in comparable quantities, allowing for smaller diameter piping.

Propane is heavier than air (specific gravity approximately 1.5), creating different flow patterns.

Often supplied from on-site storage tanks with pressure regulators to achieve desired system pressures.

Sizing for Different Piping Materials

Iron Pipe

- Available in schedule 40 and schedule 80
- Can be connected with threaded or welded fittings
- Different sizing tables for threaded vs. welded connections
- Durable and widely used in commercial applications
- Sized by nominal pipe size (NPS)

Copper Tubing

- Typically used in residential and light commercial applications
- Different inside diameter and surface texture from iron pipe
- Requires separate sizing tables in the code
- Listed in tables by outside diameter (OD)
- Sometimes identified in the field by nominal size (inside diameter)

Sizing for Different Pressure Systems

Low Pressure (< 0.5 psig)

Typically 7 inches water column for natural gas

Medium Pressure (0.5 - 5 psig)

Common in commercial and industrial applications

High Pressure (> 5 psig)

Used for long runs and high-demand systems

Each pressure range requires different sizing tables and has different allowable pressure drops. Higher pressure systems can use smaller diameter piping for the same gas load but require more rigorous verification of equivalent lengths.

Multi-Stage Pressure Systems

High Pressure Zone

Smaller diameter piping for long runs

Pressure Regulator

Reduces pressure to next stage

3

Medium Pressure Zone

Intermediate distribution

4

Pressure Regulator

Reduces to appliance pressure

5

Low Pressure Zone

Final distribution to appliances

Equivalent Length Calculations

Purpose of Equivalent Length

Fittings and valves create resistance to gas flow similar to straight pipe. The equivalent length concept allows us to convert this resistance into an equivalent length of straight pipe for sizing purposes.

Calculation Process

For each fitting or valve:

1. Identify the type and size of fitting
2. Look up the equivalent length in Table A.16 (natural gas) or B.12 (propane)
3. Add up all equivalent lengths
4. Add this total to the measured length of pipe
5. The result is the Length of Equivalent Run (LER)

Tee Fitting Considerations

Direction of Flow

Equivalent lengths of tees are counted only if the flow to the appliance in question changes direction at the tee.

Sizing Rule

The size of a tee is that of its largest opening.

Flow Patterns

Gas flowing straight through a tee experiences less resistance than gas changing direction through the branch.

Resistance Factors

The equivalent length accounts for the additional resistance created when gas changes direction.

Worksheet Documentation

Worksheet Components

- System information (gas type, pipe type, pressure)
- Line numbers and loads
- Estimated and confirmed pipe sizes
- Maximum allowable loads
- Fitting calculations (size, type, quantity)
- Equivalent length calculations
- Proof calculations for each run

Benefits of Documentation

- Provides a record of sizing decisions
- Allows for verification by inspectors
- Helps troubleshoot issues
- Serves as reference for future modifications
- Demonstrates code compliance
- Facilitates knowledge transfer

Code Table Navigation

Select Appropriate Table

Based on gas type, pipe material, and system pressure.

Find Code Zone Row

Locate the row corresponding to your estimated Code zone length.

Read Across for Capacity

Move horizontally to find the capacity value closest to but not less than your required load.

Read Up for Pipe Size

From that capacity value, move vertically to the top of the table to find the required pipe size.

Practical Application Tips

Start with a Clear Sketch

A detailed, labeled sketch of the system is essential for accurate sizing.

Be Conservative in Estimates

When estimating Code zones, it's better to slightly overestimate than underestimate.

Always Verify

Never skip the verification step to prove your Code zone selection is appropriate.

Document Everything

Keep detailed records of all calculations and decisions for future reference.

Sizing for System Modifications

Adding Appliances

When adding new appliances to an existing system:

1. Calculate the total new load
2. Verify existing pipe sizes can handle the increased load
3. Size new branch lines appropriately
4. Consider pressure drop across the entire system
5. Document all changes and calculations

Extending Systems

When extending an existing system:

1. Determine the new longest measured run
2. Recalculate the appropriate Code zone
3. Verify existing pipe sizes remain adequate
4. Size new sections based on the updated calculations
5. Consider using a higher pressure zone with regulators for long extensions

Summary of Sizing Procedure

Sketch System

Create detailed diagram with measurements

Select Table

Based on gas type, pipe material, and pressure

Determine Code Zone

Based on longest measured run

Size Pipe Sections

Calculate required diameter for each section

Verify Code Zone

Prove LER doesn't exceed Code zone length

Key Takeaways

Methodical Approach

An organized and methodical approach to sizing always results in the correct size measurement.

Verification is Critical

Always verify that your pipe sizing will deliver the required gas flow by proving the Code zone is appropriate.

Different Systems, Different Methods

Natural gas and propane systems require different sizing tables, as do different pipe materials and pressure ranges.

Documentation Matters

Thorough documentation of all sizing calculations provides a record for verification and future reference.

CSA Unit 10 Advanced Piping Systems Chapter 6 Purging Operations on Large Piping Systems

The methods for purging large diameter piping are somewhat different from those for purging small diameter piping. This is due to the large air gas volumes involved, as well as the greater chance of pipe wall rupture if there is an ignition and explosion. The gas technician/fitter must be aware that the use of inert gases to purge large lines removes the possibility of accidental ignition and explosion.

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Purpose of Purging Operations

Purpose

The methods for purging large diameter piping are somewhat different from those for purging small diameter piping. This is due to the large air gas volumes involved, as well as the greater chance of pipe wall rupture if there is an ignition and explosion.

The gas technician/fitter must be aware that the use of inert gases to purge large lines removes the possibility of accidental ignition and explosion.

Learning Objectives

Describe the Code requirements

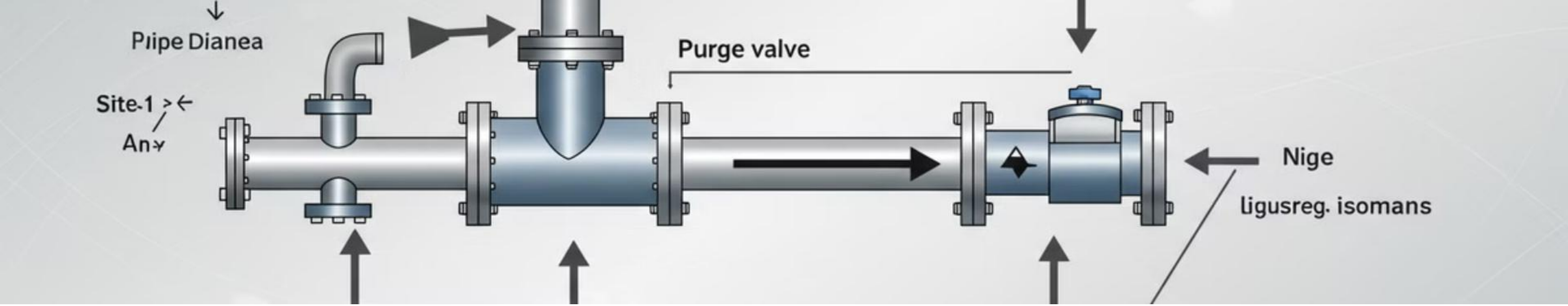
Understanding the specific regulations that govern purging operations

Explain the safety reasons for purging

Recognizing the importance of proper purging procedures for safety

Describe the types of purging

Identifying and understanding different purging methodologies



Key Terminology

Term	Abbreviation (symbol)	Definition
Nominal Pipe Size	NPS	
Purge		To replace the existing fluid (gaseous or liquid) in piping, tubing, equipment, a container, or an appliance with a desired fluid

Industry Reasons for Purging

Safe Introduction of Fuel Gas

To safely introduce fuel gas into a pipeline

Safe Removal of Fuel Gas

To safely remove fuel gas from a pipeline for the purposes of abandonment and repair

Code Concerns for Purging

Purging After Leak Testing

Concerned with purging of piping and tubing systems and hose after leak testing

Gas Mixtures for Specific Purposes

Refer to gas mixtures to be used for purging other than for leak testing: i.e., "for the purpose of repair, alteration, or abandonment"

CSA B149.1 Recommendations

Large Diameter Piping Requirements

If the piping is NPS 4 or larger, and testing involves the use of air, you must first purge it with carbon dioxide, nitrogen, or a mixture of these, and then purge it with gas in accordance with Clause 6.23.4.

Competent Person Requirement

The person doing the purging must be a competent person and in direct control of the purging gas supply during the purging operation by means of a valve having an attached operating handle within 5 ft of the purge point.

Piping Size Requirements

The piping for the gas being purged must either be of a size or be reduced to a size not larger than NPS 1/2 for piping up to NPS 4.

Engineering Practices

If the piping exceeds NPS 4, purging pipe must follow engineering practices.

Safety Importance in Purging

Explosion Risk

Mixing air and fuel gas poses a very real risk of a serious explosion

Personal Responsibility

Gas technicians/fitters must follow proper purging procedures

Code Compliance

Code regulations require correct purging to prevent accidental explosions

Fire and Explosion Risks Outside Pipe

Combustible Mixture

If you mix natural gas and air in a ratio that falls between 4% and 15%, you produce a combustible mixture.

Avoid Confined Spaces

It is important that you do not purge into any confined space, such as a room where the potential for fire and explosion exist.

Safe Approach

Generally, the safest approach is to use a purge hose to the outdoors, with a gas technician/fitter at each end operating manual valves to ensure that the purge is safely evacuating away from sources of ignition and air inlets to the building.

Purging Safety Prohibitions

Do Not Purge Through Burner System

Do not purge a new gas line through the burner system into a combustion chamber.

Do Not Allow Uncontrolled Gas Escape

Do not crack the piping union or drip leg open and allow an uncontrolled escape of gas.

Special Caution with Propane

Propane Properties

You need to take extreme caution when purging propane gas, as it is heavier than air and collects in buildings, low lying areas, and drains.

Ventilation Challenges

This makes the area difficult to ventilate after purging. Use a gas detector to ensure the ventilation of propane.

Fire and Explosion Risks Inside Pipe

Large Diameter Risk

Explosion inside the pipe is a serious hazard, especially when the diameter of the pipe is 4 in or greater

Pipe Wall Failure

The pipe walls are not strong enough to contain the pressure increase as the gas-air mix burns inside

Catastrophic Result

The pipe bursts, causing serious damage

Internal Ignition Sources

Internal Sparks

Sources of ignition exist inside the pipe

High Velocity

Even with little gas flow, gas moves at very high velocities

Ignition Conditions

Fuel, oxygen, and heat are all present in an inadequately purged pipe

Debris Movement

Iron filings, stones, and other debris inside the pipe are swept along

Categories of Purging

Small Diameter Pipes

Pipes below Nominal Pipe Size 4 (NPS 4)

Review the description of pipes less than NPS 4 in Unit 8 Introduction to piping and tubing systems.

Large Diameter Pipes

Pipes at or above Nominal Pipe Size 4 (NPS 4)

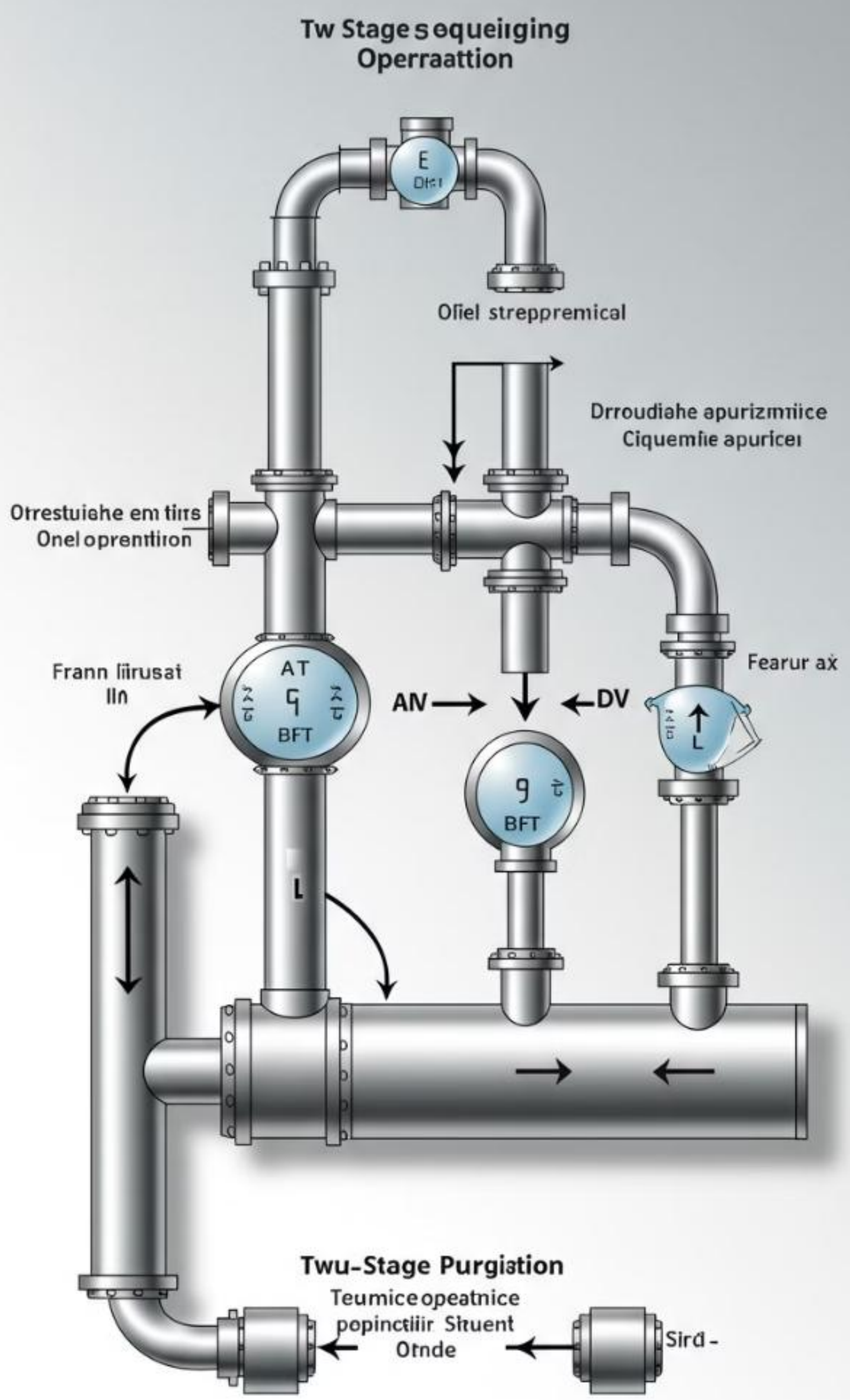
For larger pipes, you can use these two types of purging:

- Two separate purges in succession
- Slug purging

Two Purges in Succession

For larger pipes, introducing fuel gas into a pipe requires two separate purges in succession, while removing fuel gas from a piping system only requires the completion of one purge operation.

Purge	Description
Introduce fuel gas	1) Purge air with inert gas on new installations or after repairs or alterations.
	2) Purge inert gas with fuel gas. This will prevent the formation of gas-air mixtures.
Remove fuel gas	1) Purge fuel gas with inert gas before you repair or abandon an existing large system.



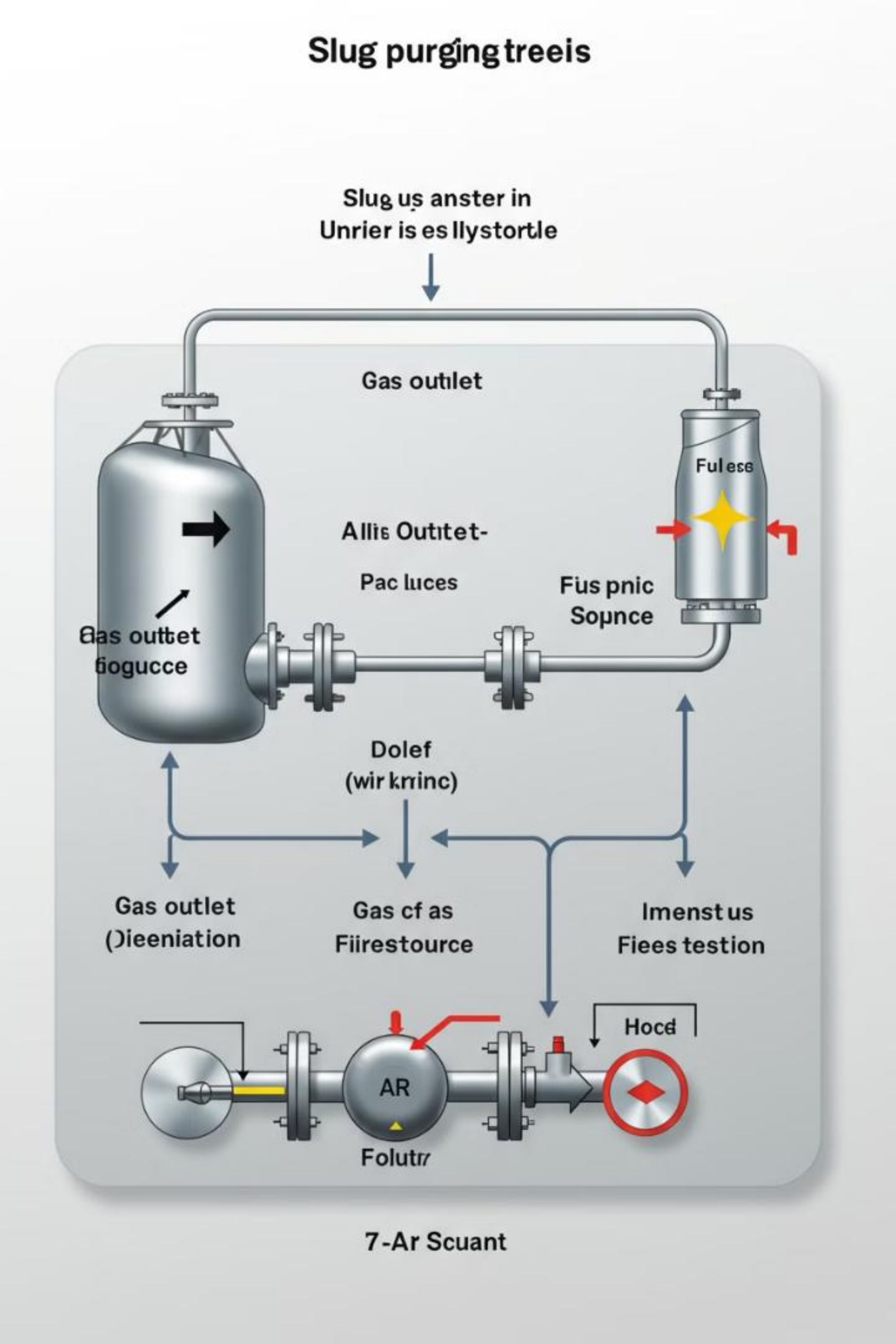
Slug Purging Overview

Definition

For very long, large pipes (such as those installed by the gas supply company), instead of performing two successive purges, you might slug-purge to flush out all the contents of the pipe.

Benefit

Slug purging reduces the amount of inert gas you would otherwise have to use.



Slug Purging Process

Inject Inert Gas

Inject a mass of inert gas, called a slug, into the pipe

Flush with Fuel Gas

Flush the slug gas with the fuel gas

Complete Purge

The slug acts as a barrier between air and gas

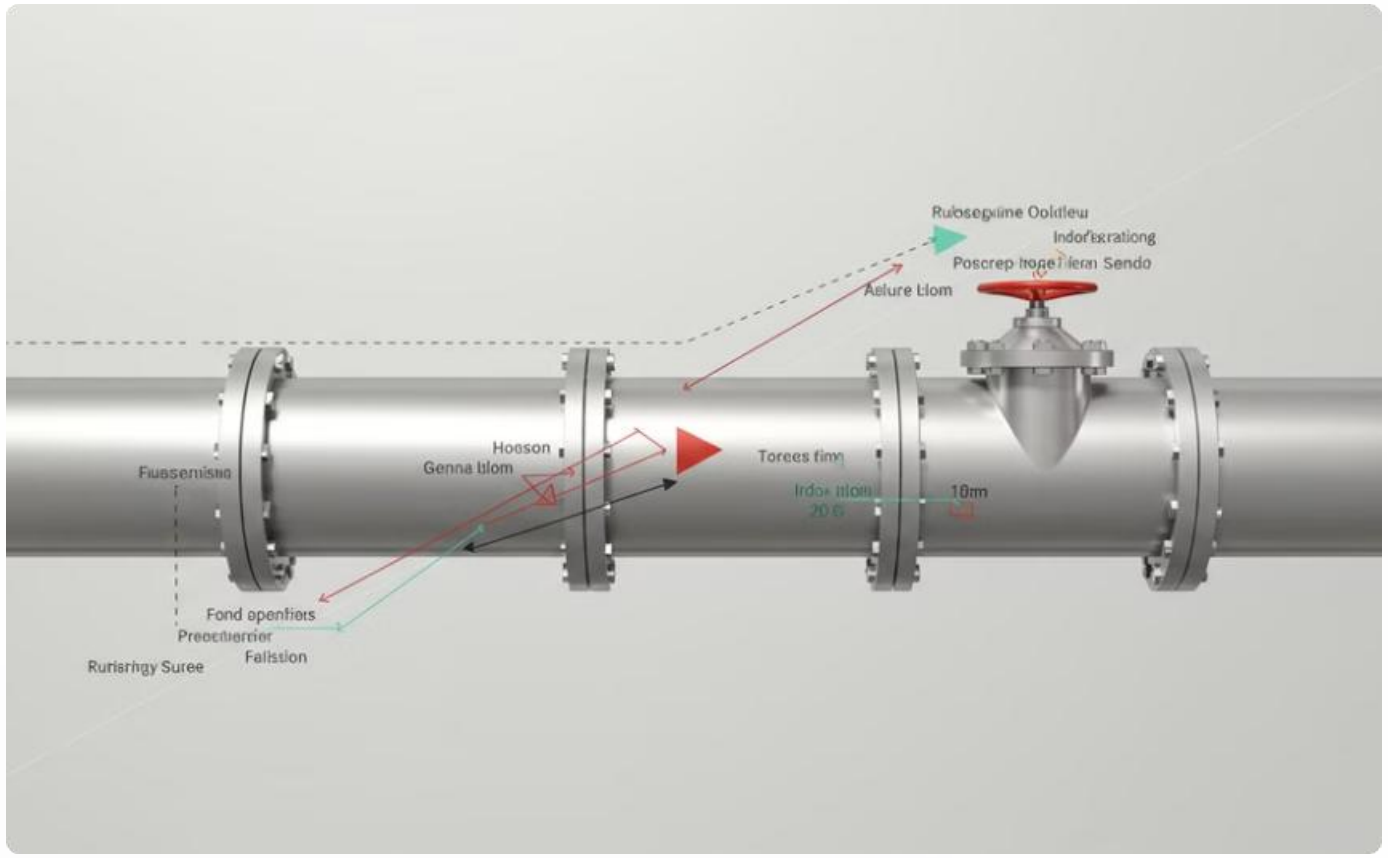
Slug Purging Example

A common example of the use of slug purging is the safe removal of air from a large-diameter piping system.

Rather than completely purging the line with nitrogen, it is more economical to insert a large slug of nitrogen into the piping first and then turn on the fuel gas to force the nitrogen and air through the purge point. The nitrogen acts as a divider between the air and gas to prevent them from mixing.

Nitrogen Slug Injection

Inserting a large volume of nitrogen as a barrier between air and fuel gas



Fuel Gas Introduction

Fuel gas pushing the nitrogen slug and air through the purge point

Slug Purging Best Practices

Maintain Proper Velocity

Maintain normal purge velocity (200 ft/min in large piping) so that the pipe is scrubbed as the gas moves and prevents the gases from intermingling as they move.

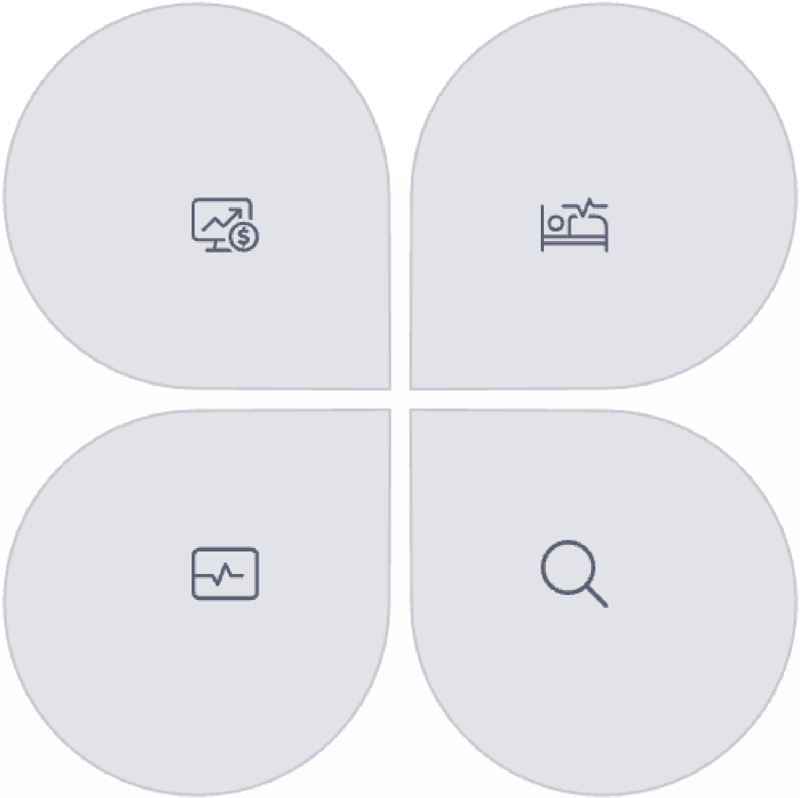
Ensure Adequate Volume

The slug must have enough volume to prevent the formation of fuel gas-air mixture. The volume of the slug takes into account the diameter and length of the piping system (which you can see in piping tables).

Consider Slug Length

Since the slug is slowly destroyed over distance and time and since longer piping systems require longer purge times, you must be sure that the slug of inert gas is long enough to compensate.

Safety Considerations Summary



Competent Personnel

Only trained technicians should perform purging operations

Proper Procedures

Follow all code requirements and engineering practices

Continuous Monitoring

Maintain control of the purging operation at all times

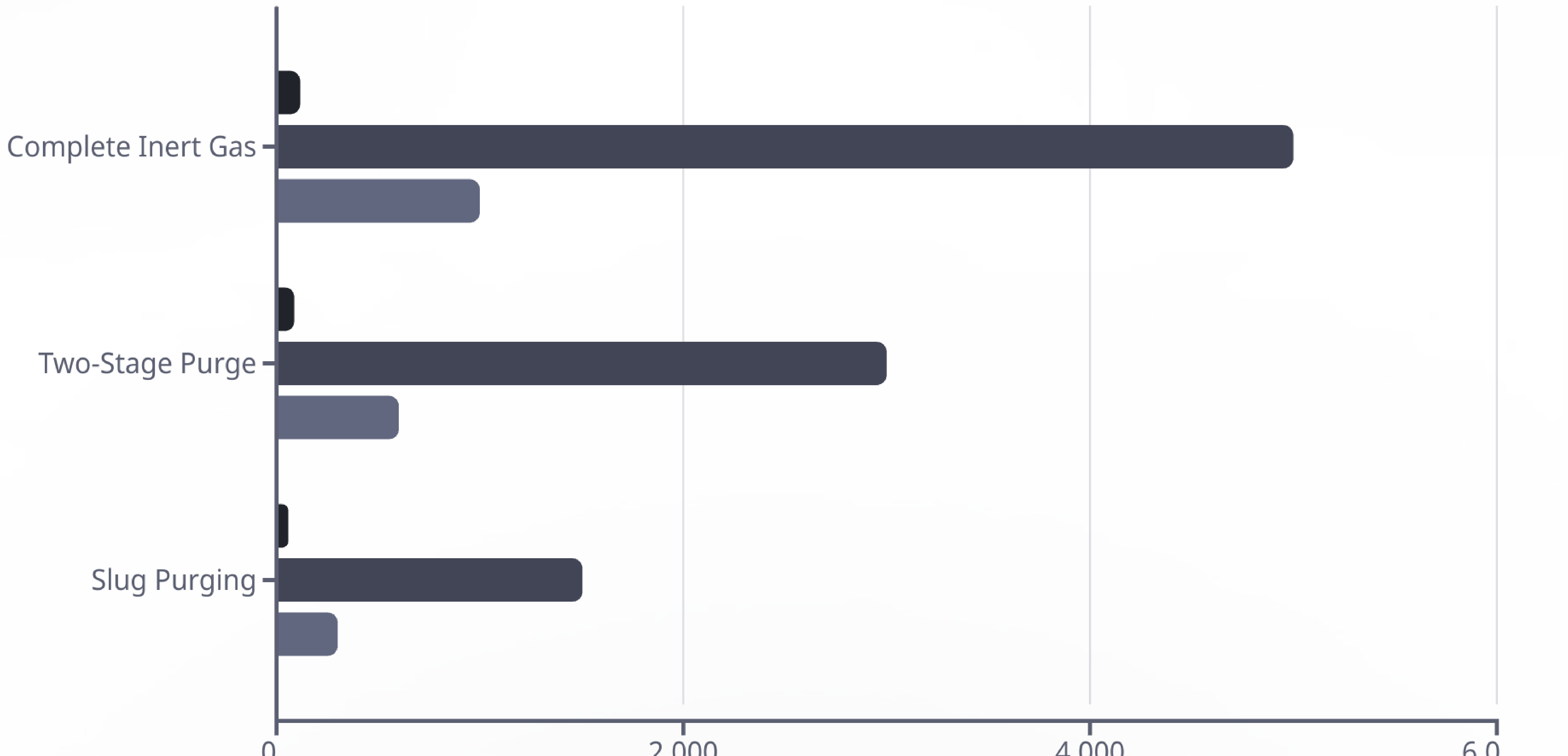
Appropriate Equipment

Use the right tools and materials for the job

Purging Equipment Requirements

Proper equipment is essential for safe and effective purging operations. This includes inert gas supplies, appropriate hoses and valves, gas detection equipment, and manual control systems that allow technicians to maintain direct control of the purging process.

Comparing Purging Methods



Purging Documentation Requirements

Pre-Purge Checklist

- Verify pipe size and material
- Confirm purging method selection
- Check availability of required gases
- Ensure proper valve configuration
- Verify safety equipment is in place

During Purge Documentation

- Record start and end times
- Document gas flow rates
- Note pressure readings
- Record gas detector readings
- Document any issues encountered

Post-Purge Verification

- Confirm complete purge with gas detector
- Document final system state
- Record total gas volumes used
- Obtain necessary signatures
- File documentation according to code

Training Requirements for Purging Operations

40

Training Hours

Minimum hours of specialized training required for large diameter purging operations

5

Years Experience

Recommended minimum experience for lead technicians on complex purging operations

100%

Safety Compliance

Required adherence to safety protocols and code requirements

Key Takeaways on Purging Operations

Safety is Paramount

Mixing air and fuel gas poses a very real risk of a serious explosion. Gas technicians/fitters who are ignorant of or refuse to follow proper purging procedures create highly dangerous conditions.

Follow Code Requirements

CSA B149.1 contains specific recommendations for large diameter piping. If the piping exceeds NPS 4, purging pipe must follow engineering practices.

Choose Appropriate Methods

For larger pipes, you can use two separate purges in succession or slug purging depending on the specific situation and pipe characteristics.

Ensure Competent Personnel

The person doing the purging must be a competent person and in direct control of the purging gas supply during the purging operation.

CSA Unit 10 Advanced Piping Systems
Chapter 7
Rigging Safety

A good workplace safety philosophy to adopt is one of zero accidents and zero incidents. Preparing and moving heavy equipment and materials can result in serious accidents and injury if not properly planned and executed. Performing rigging work operations safely is one of the cornerstones of a workplace safety program.

Construction crew trainers typically provide trainees with a Riggers Handbook or a Rigging Card to reinforce appropriate and safe rigging, lifting, and hoisting procedures. These handbooks and cards summarize basic safe rigging practices and provide sling tables and shackle charts. Hardhat stickers with sling capacities can also provide similar information.

MK **by Mike Kapin**

Occupational Health Safety and Safety Regulations

Provincial and Territorial Regulations

Provincial or territorial Occupational Health and Safety (OH&S) acts and regulations define requirements for safe rigging work practices in Canada.

Regulatory Documentation

These documents have various subparts, each addressing an aspect of hoisting and lifting work operations. The subparts that apply to rigging work operations are available through the Canadian Centre for Occupational Health and Safety (CCOHS) or online at http://www.ccohs.ca.

Accessing Regulations

See Unit 1 Safety > Chapter 2. Government acts and regulations > Occupational Health and Safety acts and regulations for a list of the acts and regulations specific to workplace safety by province and territory.

Personal Protective and Life Saving Equipment

Working at Heights

The execution of rigging work operations often require individuals to work in elevated locations that can lead to accidental falls.

Minimum Requirements

OH&S establishes minimum requirements for the use of fall protection devices including belts, lifelines, lanyards, and safety nets. These requirements are designed to prevent serious injuries that could result from a fall.

Training Requirements

Local and regional requirements may specify a fall arrest certificate of training prior to using any fall protection equipment. Check for OH&S requirements in your province or territory.

Task and Job-Site Requirements

Planning

In order to ensure the safety of workers and the equipment involved, thoroughly plan any operation involving the use of a crane to lift items before you carry them out.

Equipment Selection

This Chapter details requirements for planning and performing an incidental lift using an overhead crane and commonly available rigging components, such as slings, shackles, eye bolts, and turnbuckles.

Job Site Considerations

Job site considerations include the handling, setting, and assembly of materials and equipment. Each operation presents its own peculiar problems as no two jobs are alike.

Execution

With proper planning and execution, you can perform each job free of bodily harm to the employee and without damage to the equipment.

Purpose of Rigging and Hoisting

This Chapter outlines basic practices and basic hazards in rigging and hoisting, explains the safeguards necessary to control or eliminate these hazards, and spells out other essential safety requirements to sling and rig loads in a safe manner according to CAN/CSA-Z150, Safety code on mobile cranes standard, ANSI, and ASME requirements.

Information Usage

Use the information in conjunction with the applicable regulations for contractors, supervisors, operators, riggers, and others delivering or receiving instruction in the basics of safe rigging and hoisting.

Important Note

The information is this Chapter is for awareness only. Completion of the information does not certify you as a licensed rigger or crane operator. Refer to current certification requirements.

Learning Objectives

Identify Rigging Safety Requirements

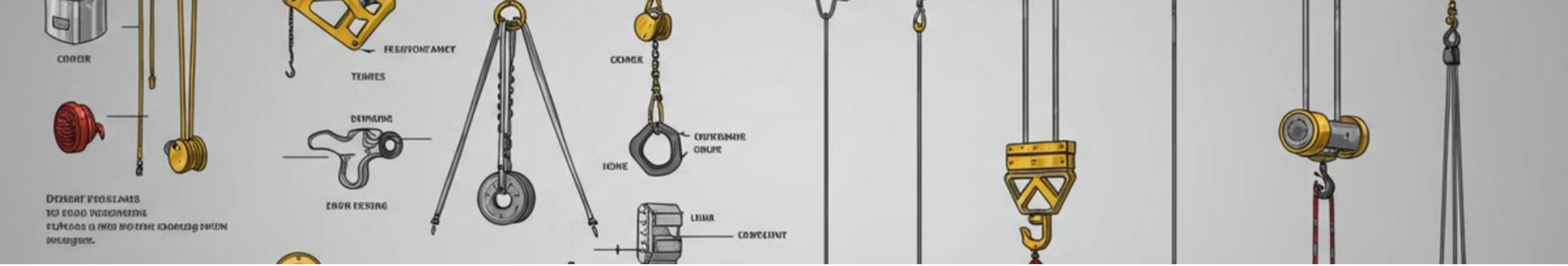
At the end of this Chapter, you will be able to identify rigging safety, tasks, and job-site requirements.

Select and Inspect Equipment

You will be able to identify, select and inspect rigging equipment.

Move Loads Safely

You will be able to explain how to safely move a load with the proper preparation, material and equipment.



Key Terminology

Term	Abbreviation (symbol)	Definition
Load center of gravity		Load's balance point or center of weight
Shackles		Primary devices for attaching slings to equipment lifting lugs
Sling angle factor		Multiplier used to determine the required sling size when angle formed between sling and load is less than 90°

See more terms in the Rigging safety > Definitions section.

Importance of Rigging Safety

Zero Accidents Philosophy

A good workplace safety philosophy to adopt is one of zero accidents and zero incidents.

Training Resources

Construction crew trainers typically provide trainees with a Riggers Handbook or a Rigging Card to reinforce appropriate and safe procedures.

Proper Planning

Preparing and moving heavy equipment and materials can result in serious accidents and injury if not properly planned.

Safe Execution

Performing rigging work operations safely is one of the cornerstones of a workplace safety program.

Regulatory Compliance

Provincial and Territorial Regulations

Provincial or territorial Occupational Health and Safety (OH&S) acts and regulations define requirements for safe rigging work practices in Canada.

These documents have various subparts, each addressing an aspect of hoisting and lifting work operations. The subparts that apply to rigging work operations are available through the Canadian Centre for Occupational Health and Safety (CCOHS) or online at http://www.ccohs.ca.

Accessing Regulations

See Unit 1 Safety > Chapter 2. Government acts and regulations > Occupational Health and Safety acts and regulations for a list of the acts and regulations specific to workplace safety by province and territory.

It's essential for all rigging personnel to be familiar with the specific regulations that apply to their jurisdiction, as requirements may vary between provinces and territories.

Fall Protection Requirements

Safety Belts

OH&S establishes minimum requirements for the use of fall protection devices including belts for preventing falls from heights.

Lifelines

Properly installed lifelines provide a continuous point of attachment for workers at heights.

Lanyards

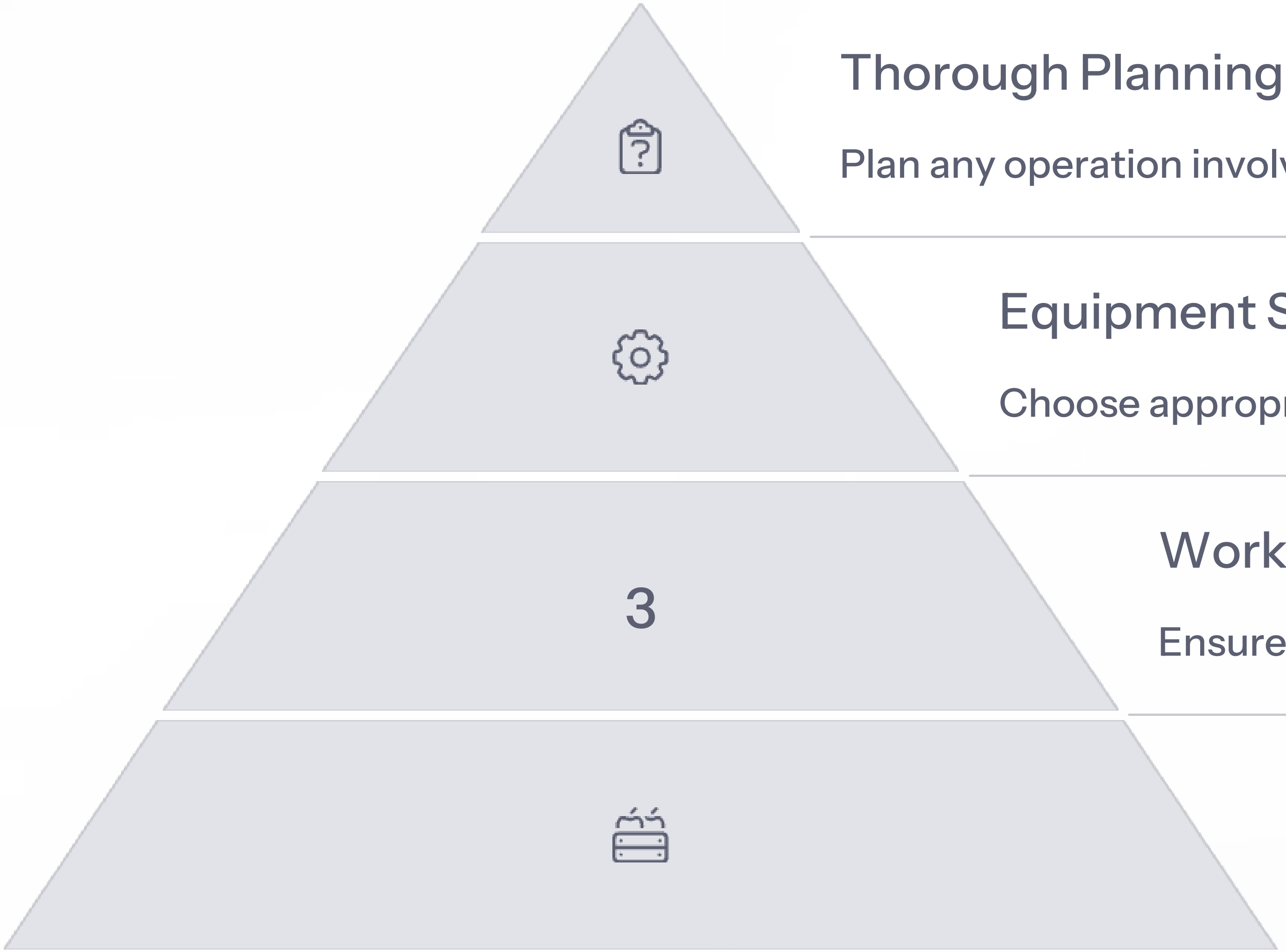
Lanyards connect the worker's harness to the lifeline or anchor point, limiting fall distance.

Safety Nets

Safety nets can be installed to catch workers in case of a fall when other fall protection is impractical.

Local and regional requirements may specify a fall arrest certificate of training prior to using any fall protection equipment. Check for OH&S requirements in your province or territory.

Planning Rigging Operations



Thorough Planning

Plan any operation involving cranes before execution

Equipment Selection

Choose appropriate rigging components for the task

Worker Safety

Ensure safety of all personnel involved

Equipment Protection

Prevent damage to equipment and materials

In order to ensure the safety of workers and the equipment involved, thoroughly plan any operation involving the use of a crane to lift items before you carry them out. This Chapter details requirements for planning and performing an incidental lift using an overhead crane and commonly available rigging components, such as slings, shackles, eye bolts, and turnbuckles.

Job Site Considerations

Material Handling

Job site considerations include the handling, setting, and assembly of materials and equipment.

Unique Challenges

Each operation presents its own peculiar problems as no two jobs are alike.

Proper Planning

With proper planning and execution, you can perform each job free of bodily harm to the employee and without damage to the equipment.

Attention to Detail

The person authorized and qualified to do rigging must always pay close attention to details. One distraction, careless moment, miscalculation, or action can result in serious injury or death and possible equipment/property damage.

Rigging Personnel Requirements

Qualified Personnel

You should never perform proper rigging, which requires following all current safety requirements/procedures and using appropriate type/size of equipment, if you are inexperienced. If you don't know how to do it properly, then don't attempt it.

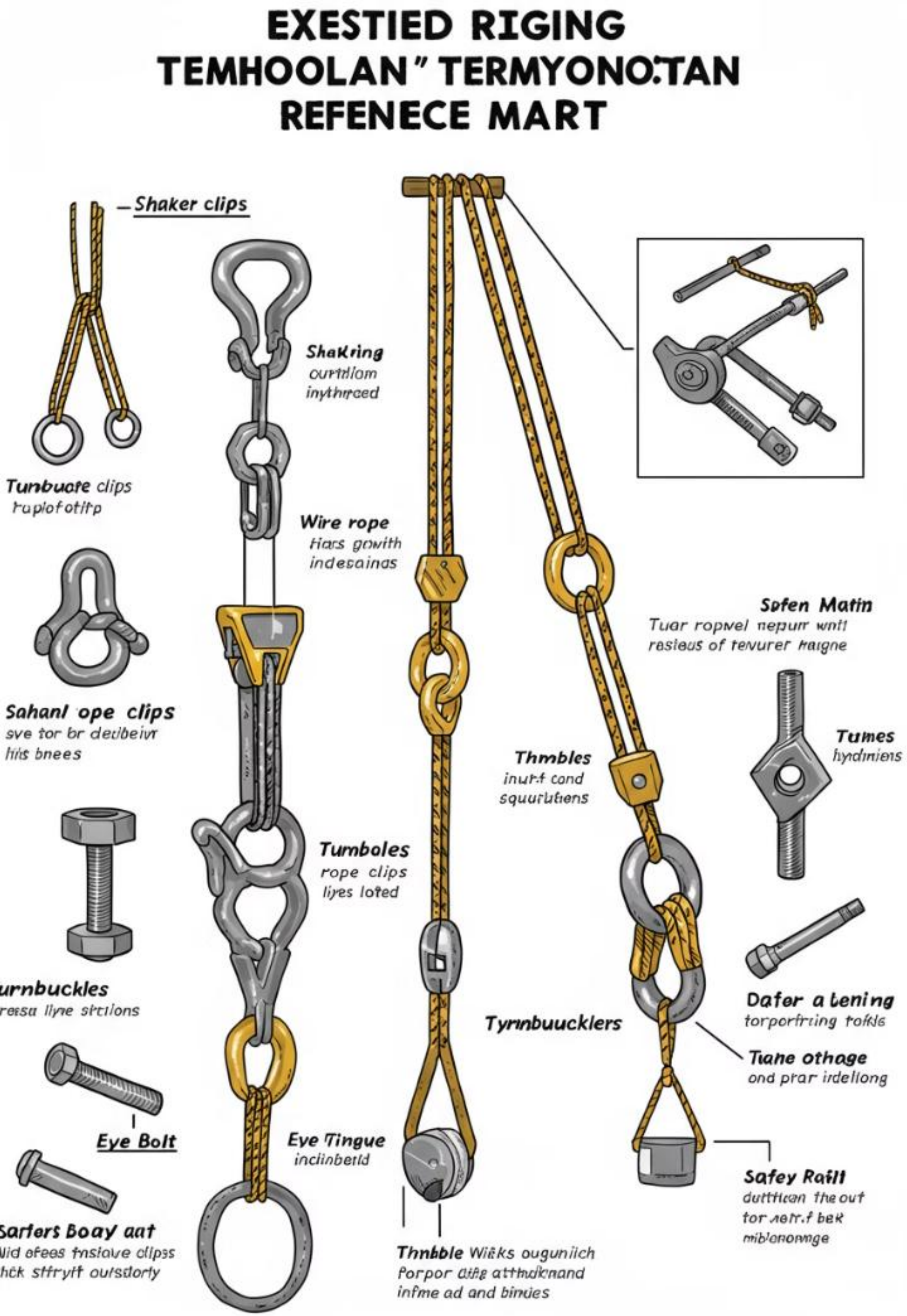
Challenging Conditions

Usually, persons performing rigging tasks already have the two following strikes against them when they start:

- Unfavourable job conditions
- Job schedule to meet

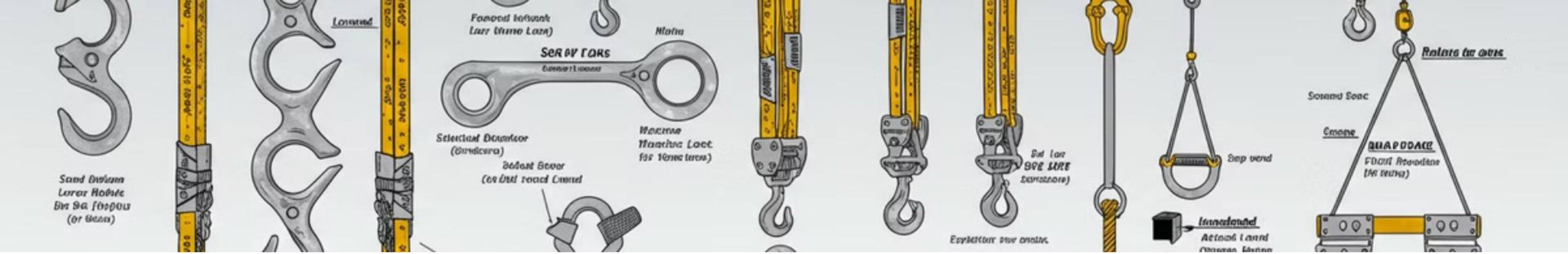
Certification Requirements

The information in this Chapter is for awareness only. Completion of the information does not certify you as a licensed rigger or crane operator. Refer to current certification requirements.



Key Definitions in Rigging

Term	Definition
Asymmetrical load	Object with an off-center center of gravity due to the object's irregular shape and/or composition.
Critical lifts	Require confirmation of engineering or merit additional engineering input because of an item's or location's size, weight, close-tolerance installation, or high susceptibility to damage.
Person-in-charge	Person appointed by the responsible manager or designee to direct critical or pre-engineered lifts. He/She must be present during the entire lifting operation.
Pre-engineered lifts	Repetitive lifts that meet the definition of a critical lift. May use tooling, fixtures, sketches, analyses, and written procedures.



More Key Definitions

Term	Definition
Safe working load (SWL)	The same as the WLL in most cases. The exceptions are where the conditions of use require a reduction to a lower safe working load. Examples would be severe environmental conditions such as very low temperatures, inaccuracy of weight, and likelihood of shock loading.
Symmetrical load	Object that, because of its uniform shape and composition, has its center of gravity located exactly in its middle.
Working load limit (WLL)	Maximum load that an item of lifting equipment is designed to raise, lower, or suspend.

Classifying Lifts

Lift Assessment

A lift assessment to determine the lift's category must take place before planning a lift

Three Categories

There are normally three lift categories: incidental/ordinary lift, pre-engineered lift, and critical lift

Manager Determination

The responsible manager or designee determines the type of lift by conducting a lift assessment

Lift Categories and Requirements

If the lift is a/an	Then
Incidental or ordinary lift	The manager/designee must select, inspect, and connect appropriate equipment prior to the lift.
Pre-engineered lift	The manager/designee must meet additional criteria prior to operation.
Critical lift	The manager/designee must use worksite engineering riggers or an approved contractor.

Incidental/Ordinary Lift Requirements

Planning and Approval

Following the planning and approval of a lift, you must select, inspect, and connect correctly the appropriate rigging equipment-including slings, spreader beams, shackles, turnbuckles, and the crane itself-prior to beginning the lift.

Pre-Lift Checklist

Check and confirm the following items before selecting rigging components:

- Weight of lift
- Lift points
- Center of gravity
- Crane capacity
- Speed, height, width, and length of lift
- Wind, temperature, and visibility

Additional Considerations

Also check:

- Crane and load foundation ratings
- Sharp corners and angles on load
- Sling angles
- Load angle factor
- Travel route clearance
- Floor loading capacity
- Work zone safety

Pre-engineered Lift Requirements

Documentation Requirements

You must complete and submit a Pre-engineered Lift Plan to the Safety Committee before performing any work.

The Lift Plan consists of as many drawings, specifications, and procedures as necessary to assess all important load factors and site factors relating to the lift.

Additional Information

For further details, consult the company's Pre-engineered Lift Procedure.

Pre-engineered lifts are repetitive lifts that meet the definition of a critical lift. If the Safety Committee determines that through the use of tooling, fixtures, sketches, analyses, and written procedures, the possibility of dropping, upset, or collision is reduced to an acceptable level, the lift may have designation as a pre-engineered lift.

Calculating Weight of Load - Step 1

Measure the Object

Measure the object to get dimensions (length, width, and height) to determine volume.

Calculate Volume

Use the appropriate formula based on the shape of the object:

- Rectangle/square: Volume = length × width × height
- Hollow cylinder: Volume = 3.14 × length × wall thickness × (diameter - wall thickness)
- Complex shape: Break into smaller parts or use enclosing rectangle

Special Considerations

For concrete reinforcing rod, calculate as a cylinder. For pipe, calculations require actual measurements of diameter and wall thickness for accuracy.

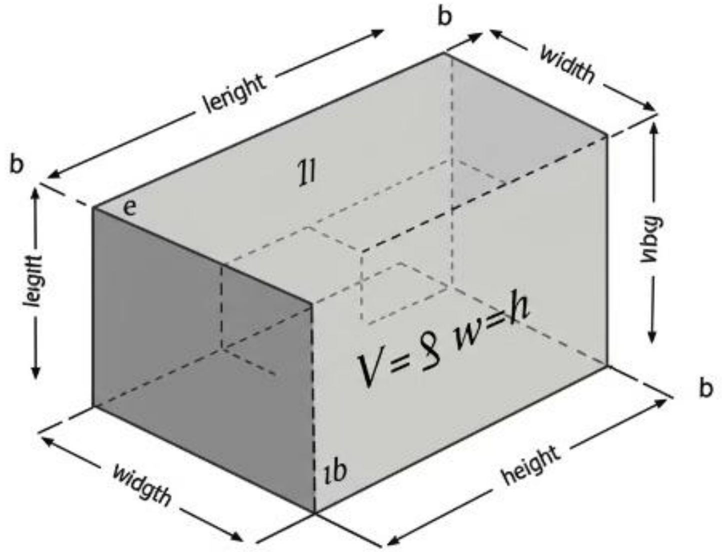
Rectangle Three-dimensional Example

Rectangular Volume Calculation

For a rectangular object, the volume is calculated using the formula:

Volume = length × width × height

This simple formula allows you to determine the volume of any rectangular or square object by multiplying its three dimensions together.



The diagram shows a rectangular prism with its three dimensions clearly labeled. To find the volume, multiply the length by the width by the height.

Determining Object's Material - Step 2

Material Identification

Look up the weight per unit volume for the material of the object.

Different materials have different densities, which affects the overall weight of the object. Identifying the correct material is crucial for accurate weight calculations.

Material	Pounds per cubic foot (lb/ft^3)
Aluminum	165
Concrete	150
Copper	560
Lead	710
Paper	60
Steel	490
Water	65
Wood, pine	40

Determining Weight of Object - Step 3

Apply the Formula

Multiply the weight per unit volume by the calculated volume to get the calculated weight of the object.

Example Calculation

For a concrete block measuring 8 ft × 4 ft × 6 ft:

Volume = 8 ft × 4 ft × 6 ft = 192 ft^3

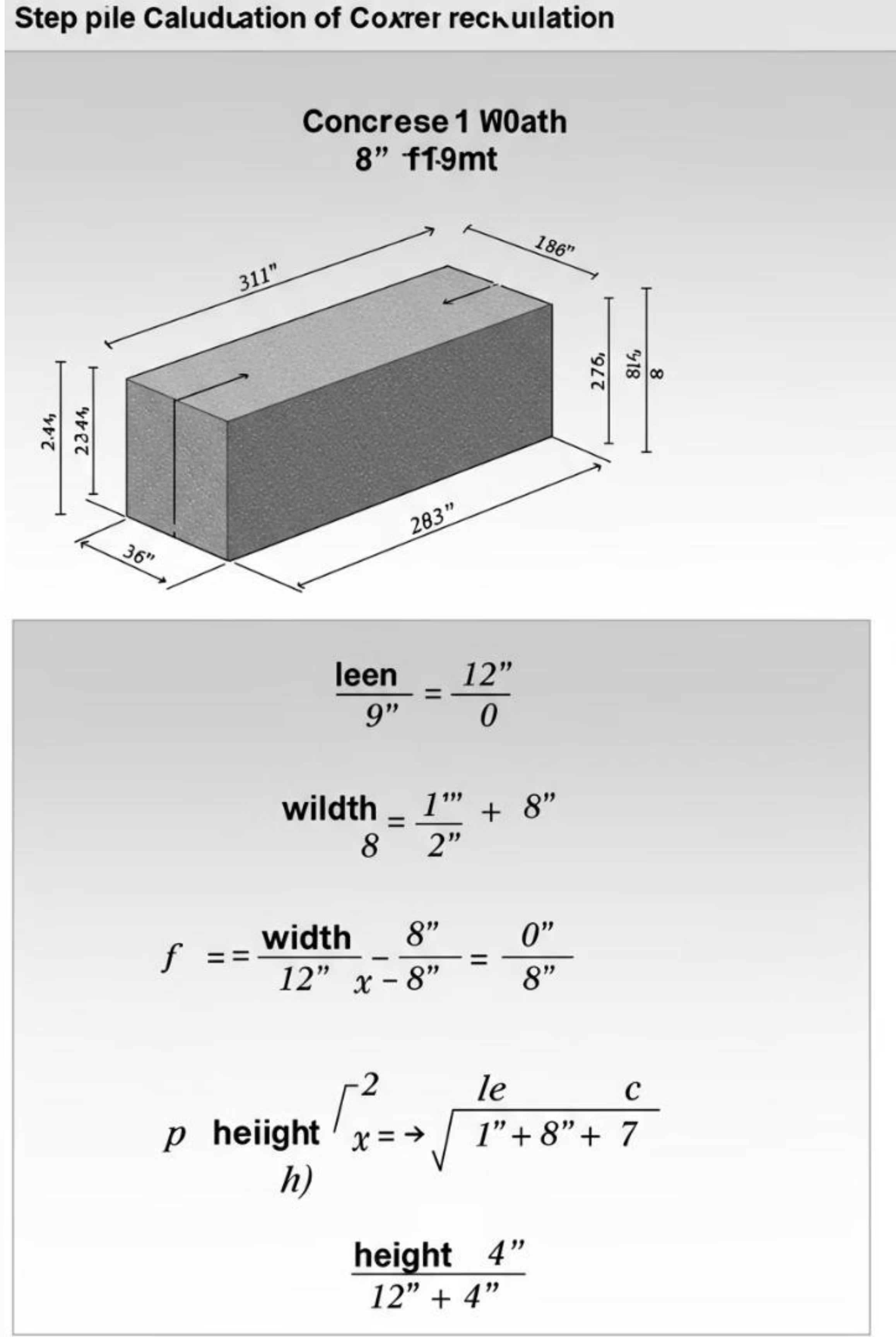
Weight = 192 ft^3 × 150 lb/ft^3 = 28,800 lbs

Verification

Always verify your calculations and consider adding a safety factor when planning rigging operations.

Rectangular Shape Calculation Example

Step	Description
Step 1-Calculate weight of load	Dimensions of object: · 8 ft long × 4 ft wide × 6 ft high 4 ft W 6 ft H 8ft L Volume of a rectangle is its length times its width times its height: L × W × H = V · 8 ft × 4 ft × 6 ft = 192 ft^3
Step 2-Determine object's material	Concrete block: · Concrete weighs 150 lbs/ft^3 (see Table 7-1).
Step 3-Determine weight of object	The load will weigh approximately: · 192 ft^3 × 150 lbs/ft^3 = 28,800 lbs (block weight).



Complex Shape Calculation Example

Step	Description
Step 1-Calculate weight of load	Dimensions of object: Complex shape 9 ft H 3 ft W 4 ft H 2 ft L 2 ft L Volume of a rectangle is its length times its width times its height. Cut the object into rectangles, and then calculate the weight of each section, as shown below: · L×W×H=V · Left section Vleft = 2 ft × 3 ft × 4 ft = 24 ft^3 · Right section Vright = 2 ft × 3 ft × 9 ft = 54 ft^3 · Total volume Vtotal= 24 + 54 = 78 ft^3
Step 2- Determine object's material	Concrete widget. · Concrete weighs 150 lbs/ft^3 (see Table 7-1),
Step 3-Determine weight of object	The load will weigh approximately: · 78 ft^3 × 150 lbs/ft^3 = 11,700 lbs (block weight)

Wire Rope Slings

Main Component

One of the main components of any rigging arrangement is the sling or "choker". Slings come in a number of shapes, sizes, capacities, and types.

Main Types

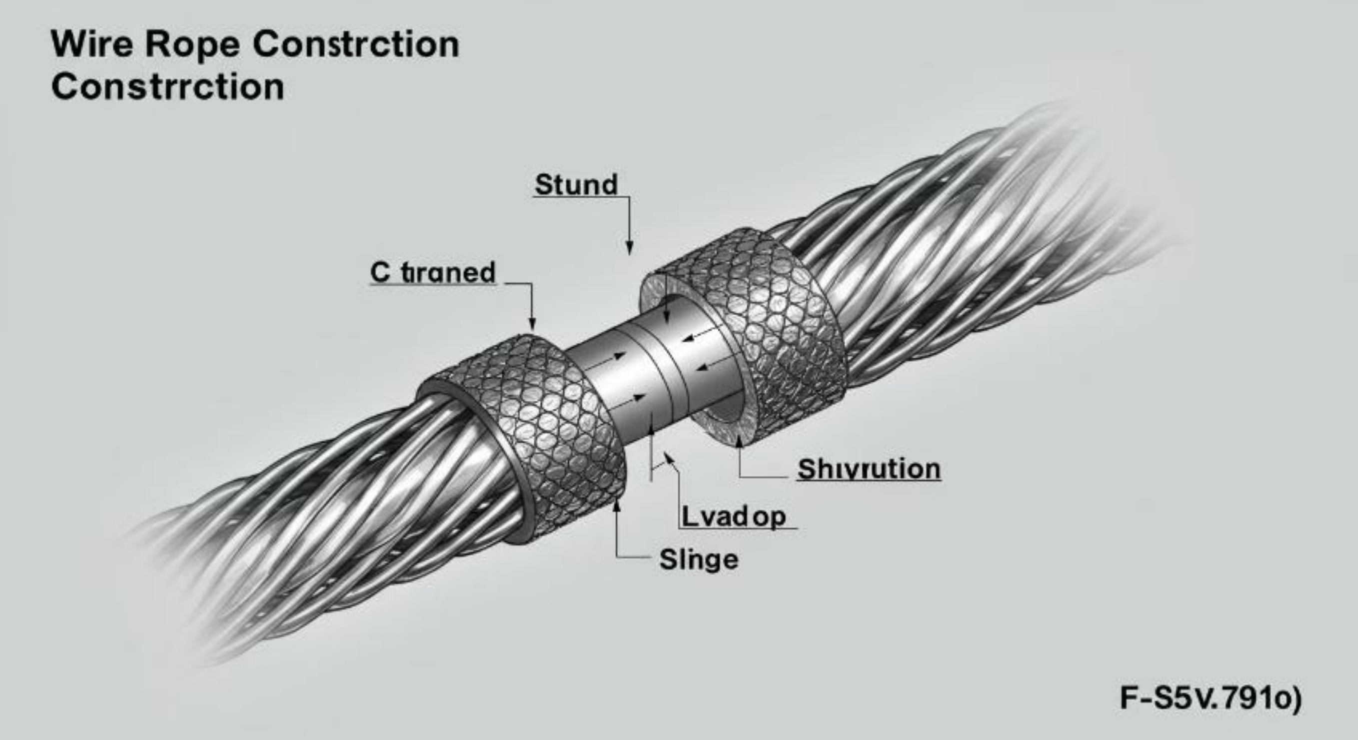
- Wire rope
- Nylon
- Polyester round
- Chain
- Wire mesh

Wire rope used in rigging is typically 6 × 19 (6 strands and 19 wires per strand) or 6 × 37 (6 strands and 37 wires per strand) class.

Safe Working Load

All slings (regardless of type) must have a legible tag stating, among other things, it's safe working load (SWL) when in a straight pull. The SWL does not account for how to use the sling, whether in a choke or basket hitch or on an angle.

You could de-rate the sling as much as 30% when it is placed in a choker configuration, while a true basket hitch (where both legs are vertical) will have twice the rated capacity.



Wire Rope Sling Pre-use Inspection

Inspection Frequency

Inspect daily before use and frequently during use.

Remove From Service When

- Ten randomly distributed broken wires are in one rope lay, or five broken wires are in one strand in one rope lay
- More than one broken wire are at an end connection
- Reduction in rope diameter (1/3 or more of the original wire diameter)
- Severe localized wear, abrasion, or scraping

Additional Removal Conditions

- Kinking, crushing, under-stranding, bird-caging, core protrusion
- Evidence of heat damage
- End attachments that are cracked, deformed or worn
- Hooks or latches deformed or damaged
- Corrosion of the rope or end attachments

Required Markings

Each wire rope sling must have marking that shows the name or trademark of manufacturer, the rated load capacity for the types of hitches and the angle upon which it is based, and its diameter or size.

Wire Rope Sling Configurations

Single Leg Bridle or Sling

A single leg bridle or sling-the most common type of sling-has a loop at each end and optional thimbles, links, or hooks.

This sling is sometimes referred to as choker. The term "choker" can be confusing because you can use the sling in a vertical hitch, basket hitch, or choker hitch. You can use other types of slings in a choker hitch.

Multiple Leg Bridle

The multiple leg bridle consists of two or more legs attached to a link for convenient handling and assembly.

Endless Sling

You may mechanically splice or lay up endless slings endlessly in a helical manner to form a loop of six parts and a core. The latter is also correctly called a grommet. Use caution when using an endless sling in basket hitches because if the center of gravity of the load is high, the sling can rend over the hook. This sling is what you most often use in a doubled choker or anchor hitch.

Wire Rope Sling Body Construction

Single-Part Sling

A single-part sling is the most common sling construction. It consists of a single leg sling made from a length of wire rope or a grommet sling made from a continuous length of strand to form an endless rope.

This is:

- The stiffest type of sling construction
- The most abrasion resistant

This construction, in form of a grommet, is what you call strand-laid.

Multi-Part Cable-Laid Sling

A cable-laid sling is composed of six individual wire ropes laid helically around a wire rope core. It is much more flexible and less abrasion resistant than the single-part sling.

Grommet slings are available in this configuration.

Braided Sling

A braided sling may be machine- or hand-braided using four, six, or eight parts of wire rope.

This is the most flexible and most expensive construction.

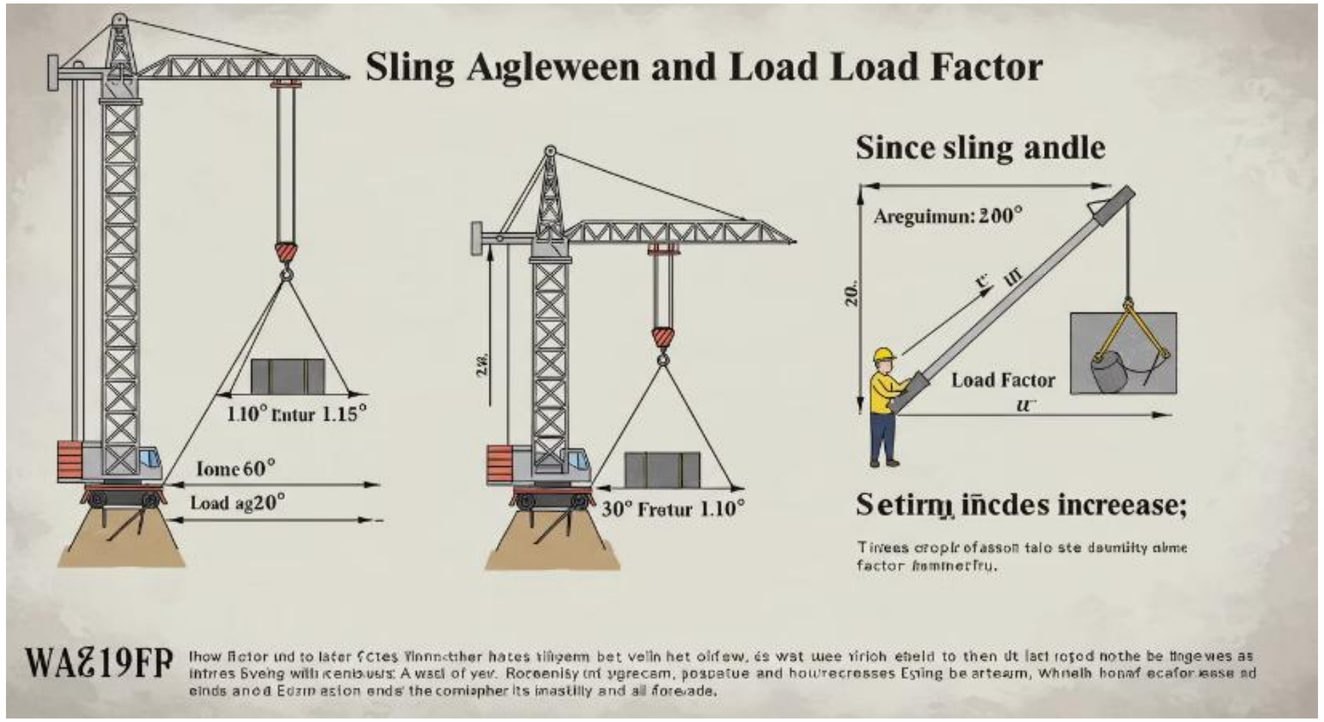
Sling Angle Factor

Definition and Usage

The sling angle factor is a multiplier used to determine the required sling size when angle formed between sling and load is less than 90°:

- Estimate angle to nearest 5°
- Avoid rigging loads where angle is less than 45°

As the angle between the sling and the horizontal decreases, the force on each sling increases, requiring a stronger sling to safely lift the same load.



The diagram illustrates how the sling angle affects the load on each sling. As the angle decreases, the load factor increases, putting more stress on the rigging equipment.

D/d Ratio in Wire Rope Slings

Definition

When a basket hitch uses a wire rope sling, the diameter of the load where the sling contacts the load can reduce sling capacity. The method for determining the loss of strength or efficiency is what you refer to as the D/d Ratio, where:

- "D" refers to the diameter of the object being lifted
- "d" refers to the diameter of the wire rope sling

Example

For example, when you use a 1 in wire rope sling to lift an object with a 25 in diameter, the D/d Ratio is 25-to-1 (25/1).

Alternatively, the "D" can refer to the cross-sectional diameter of the eye, hook, or other object being used to hoist the load. In both cases, the effective strength of the sling results.

A smaller D/d ratio can significantly reduce the strength of the sling due to the sharp bend in the wire rope.

Synthetic Slings

Advantages

Because of their relative softness, width, and flexibility, synthetic webbing slings have fewer tendencies to mar or scratch finely machined, highly polished or painted surfaces and crush fragile objects.

Adaptability

Synthetic slings tend to mould themselves to the shape of the load.

Material Benefits

- Do not rust
- Do not stain ornamental precast concrete or stone
- Are non-sparking
- Can be used safely in explosive atmospheres

Usage Warning

Do not use web slings at an angle placing more load on one edge than the other.

Synthetic Web Sling Inspection

Inspection Frequency

Inspect slings daily before use and frequently during use.

Remove From Service When

- Knots, snags, holes, tears, or cuts
- Extensive abrasive wear
- Melting or charring of any part of the sling surface
- Visible red yarns or threads indicating excessive wear
- Broken or worn stitches

Additional Removal Conditions

- Chemical damage including acid or caustic burns, brittle or stiff areas, and discoloration
- Corrosive discoloration or other damage to fittings
- Missing, illegible, or incomplete sling identification

Identification Requirements

Synthetic web slings must have tag(s) marked with specific information on the manufacturer and sling usage.

Endless and Eye-and-Eye Synthetic Web Sling Inspection

Inspection Frequency

Inspect slings daily before use and frequently during use.

Chemical Damage

Remove slings from service when chemical damage including acid or caustic burns, brittle or stiff areas, and discoloration of any kind is present.

Heat Damage

Remove slings from service when melting, charring, or weld spatter on any part of the sling is detected.

Physical Damage

Remove slings from service when holes, tears, cuts, snags, broken or worn stitching, or any abrasion in the sling cover that exposes the core yarns is found.

Other Conditions

Also remove slings for knots in the sling, general abrasive wear, stretching, cracking, pitting, distortion, or any other damage to the sling.

Chain Lifting Slings

Performance in Harsh Environments

Chain lifting slings provide excellent performance in harsh environments.

When using a chain for overhead lifting, an alloy grade, either grade 80 or 100, is recommended. Both are manufactured from special analysis alloy steel and engineered for a superior combination of strength and durability.

Applications

Other grade chain and components can be appropriate for specific applications with unusual requirements.

Chain lifting slings provide excellent flexibility and resistance to high temperatures.

Hooks

Construction and Rating

Most hooks are:

- Constructed from forged alloy steel
- Stamped with their rated safe working load (SWL)

Note that:

- The SWL applies only when the load is applied to the saddle of the hook
- When the hook is eccentrically loaded, you must reduce the hook capacity SWL
- All hoisting hooks must have safety catches

Inspection

During inspection of hooks, look for cracks, severe corrosion, twisting of hook body, and opening of the throat.

Hook Types

Common hook types include:

- Clevis sling hook
- Eye sling hook

Hook Pre-use Inspection

Inspection Frequency

Inspect hooks daily before use and frequently during use.

Identification

Remove hooks from service when missing or unreadable manufacturer identification.

Physical Damage

Remove hooks from service when cracks, nicks, or gouges are present.

Heat Damage

Remove hooks from service when damage from heat is detected.

Unauthorized Repairs

Remove hooks from service when unauthorized repairs are found.

Latch Function

Remove hooks from service when improper operation and locking of self-locking hooks is observed.

For added safety, equip hooks with a latch or close off/secure the throat opening with a mouse. Note that the function of the latch or mouse is not to support the load.

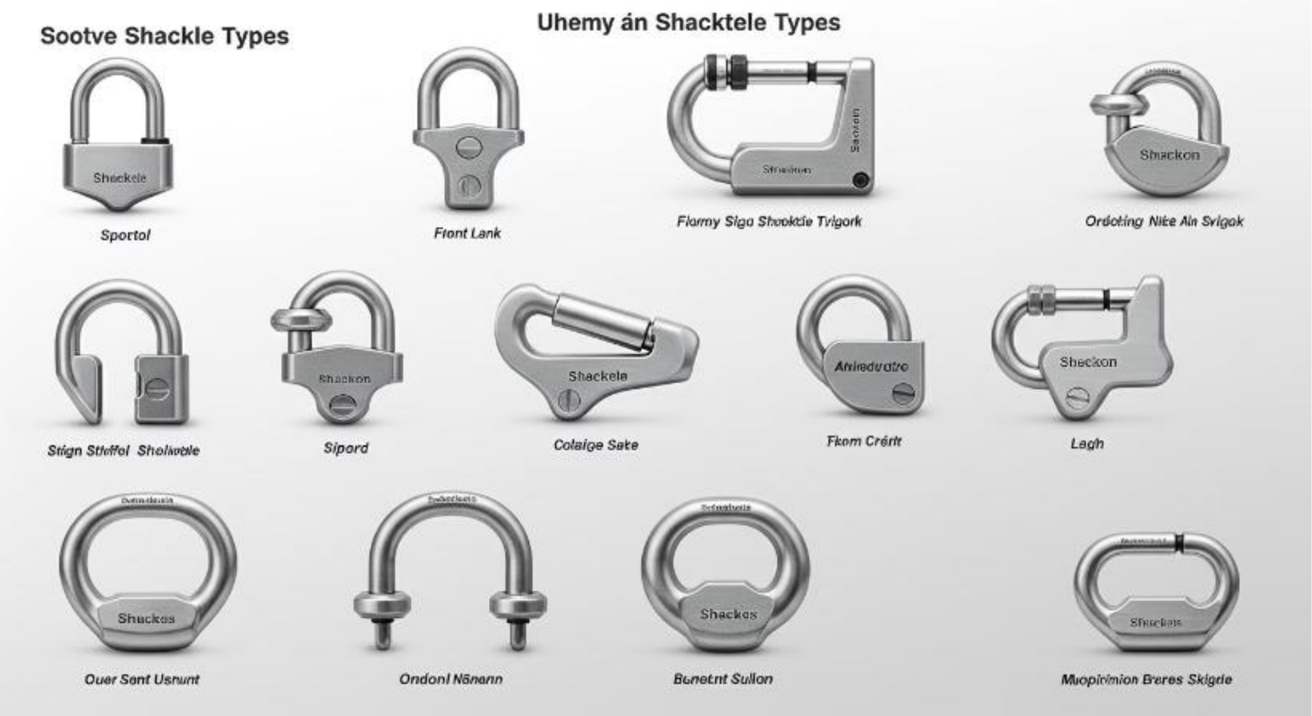
Shackles

Primary Function

Shackles are the primary devices for attaching slings to equipment lifting lugs.

There are many specialized shackle designs, including:

- Wide body screw pin shackle
- Screw pin D-shackle
- Wide body bolt type shackle



The image shows different types of shackles commonly used in rigging operations. Each type has specific applications and load capacities.

Shackle Pre-use Inspection

Inspection Frequency

Inspect shackles daily before use and frequently during use.

Required Markings

Each shackle body must have forged, cast, or die-stamped markings by the manufacturer showing:

- Name or trademark of the manufacturer
- Rated load/capacity (WLL or SWL)
- Size

This information must not be missing and must be legible.

Remove From Service When

- Indications of heat damage, including weld spatter or arc strikes
- Excessive pitting or corrosion
- 10% reduction of the original or catalogue dimension at any point around the body or pin
- Body spread including bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components
- Excessive nicks or gouges
- Incomplete pin engagement, shoulder of pin not flush with shackle body
- Excessive thread damage
- Evidence of unauthorized welding

Note: The rated capacity of shackles only applies when they are symmetrically loaded and the included angle between two sling legs is a maximum of 120°. You must reduce shackle capacity when the angle is greater than 120°.

Load Attachment Devices

Lift Lugs

Lift lugs constitute a broad category of load attachment devices.

They are generally custom engineered and fabricated and include anything from welded plates with shackle holes to loops of rebar embedded in concrete.

Eyebolts

Eye bolts are typically prefabricated devices that bolt or screw into bolt holes in the lifting equipment.

They usually have light capacity and limited sideload capacity. The user must closely inspect the manufacturer's instructions to assure safe usage of these devices.

Swivel Eyes

Swivel eyes are prefabricated devices similar to eyebolts but with the ability to rotate.

This rotation capability helps prevent twisting of the sling during lifting operations.

Swivel Hoist Rings

Advantages

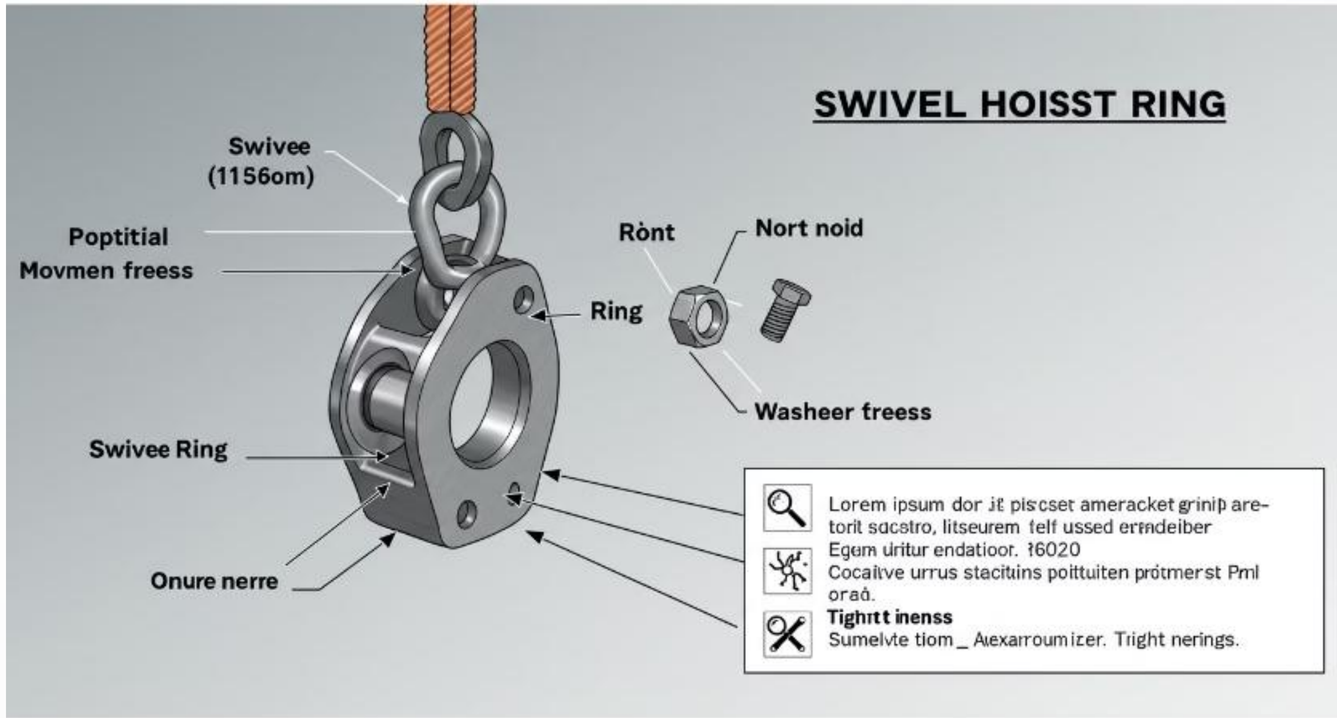
Swivel hoist rings provide 360-degree rotation and 180-degree pivot action, making them ideal for lifting loads that may shift or need to be rotated during lifting.

They are designed to eliminate the side loading of eyebolts, providing greater safety and versatility in lifting operations.

Inspection

On eye bolts and hoist swivel rings, inspect for signs of elongation, cracks, bent pins, and other forms of damage before each use.

Proper inspection is critical as these components are often used as primary attachment points for lifting operations.



Eyebolt Inspection and Markings

Required Markings

All eye bolts must have forged, cast, or die-stamped marking with the:

- Name or trademark of the manufacturer
- Size or capacity
- Grade (alloy eye bolts only)

This information must not be missing and must be legible.

Inspection Frequency

Inspect eye bolts daily before use and frequently during use.

Remove From Service When

- Nicks, gouges, bent or distorted eye or shank
- Noticeable wear (10% reduction of original/catalogue dimension at any point)
- Worn, corroded and/or distorted threads
- Indications of heat damage including weld spatter or arc strikes

Modifications

Any alteration or repair to eye bolts, such as grinding, welding, notching, stamping, etc., is not permissible.

Receiving Holes

Clean and inspect tapped receiving holes for thread wear and deterioration.

Eyebolt Installation and Applications

Proper Positioning

Always position shoulder eye bolts to take the load in the plane of the eye. An eye bolt that is "turned to the side" will have less capacity and may experience damage and failure when you lift a load.

Loading Angle

Do not load shoulder eye bolts at angles below 30° unless the manufacturer approves doing so.

Non-Shoulder Eyebolts

You can only use non-shoulder eye bolts for vertical loads. When loaded at angles, a non-shoulder eye bolt will bend or break.

Tightening

Tighten eye bolts securely, and torque it to spec if the manufacturer requires doing so. For angular lifts, the shoulder must be flush, making full contact with the load. Otherwise, only vertical lifts are permissible.

Note: Do not lift or pull loads with slings reefed from one eye bolt to another. This will change the angle of loading on the eye bolts and create added tension.

Hoist Rings

Torque Values

Tightening torque values shown are based upon threads being clean, dry, and free of lubrication.

Use long bolts with soft metal (i.e., aluminum) work pieces. While you may use them with ferrous metal (i.e., steel and iron) work pieces, short bolts function only for use with these work pieces.

Installation Steps

Follow the steps below and the manufacturer's instructions when installing hoist rings:

- Retention nuts, when used, must have full thread engagement. For the rated capacity to apply, use SAE 8 standard hex or equivalent.
- Never use spacers between the bushing flange and the mounting surface.
- Contact must be flush and in full contact with the hoist ring bushing mating surface.
- Drilled and tapped hole must be 90° to the load surface.
- Using a torque wrench, install hoist ring to the manufacturer-recommended and -provided torque value.
- Drilled holes must have correct diameter. Depth must be threaded shank length plus one-half the threaded shank diameter.

Turnbuckles

Purpose

You can use turnbuckles to level and distribute the load among the sling.

When you intend to use turnbuckles in hoisting and rigging applications, ensure that they are made from alloy steel or the equivalent and not welded.

Note that you must only use turnbuckles in a straight or in-line pull only.

Types of Turnbuckles

Common types include:

- Eye-eye turnbuckle
- Jaw-eye turnbuckle
- Jaw-jaw turnbuckle

Spreader Beams and Lifting Beams

Variety and Design

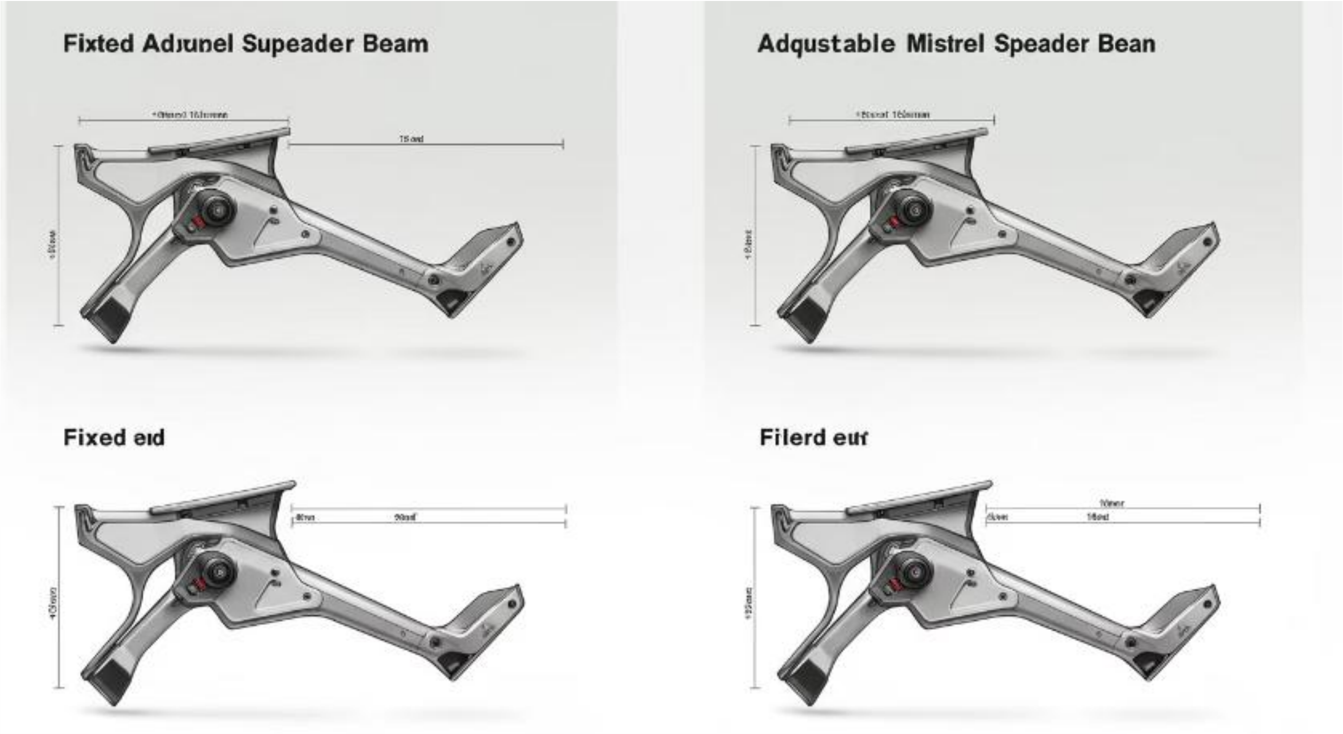
A wide variety of spreader beams come in many different design configurations.

Normally, spreader beams and lifting beams are below-the-hook lifting devices that lift loads with single or multiple attachment points. They act as a crosspiece for spacing the hooks or chains that hold loads such as bundles, rolls, cylinders, and machinery.

Types and Designs

Other types and designs of spreader beams and lifting beams include:

- Low headroom designs
- Multiple and adjustable hook locations
- Special capacities and lengths



Using Rope in Rigging Applications

Applications

You can use rope for:

- Hand hoisting of objects to elevated positions
- Tag lines

Other acceptable uses require:

- Knowledge of knots
- Knowledge of rope strength
- Fibre or synthetic rope strength

Calculating Safe Working Load

This is the rule of thumb for calculating safe working load in pounds:

1. Change rope diameter into 8th of an inch
2. Square the numerator of the fraction
3. Multiply the result by:
   - N = 20 for manila
   - N = 60 for nylon and polyester
4. Example: 3/4 in manila rope
   - Convert to 8th: 3/4 = 6/8
   - Square the numerator: $6^2 = 36$
   - Multiply the result by N: 36 × 20 = 720 lbs

Rope Strength Reductions

Safe Working Load Application

Calculated safe working load applies to straight length of new rope.

Knots and Hitches

Additional reductions are required for knots, age, and condition. Knots, bends, and hitches reduce the working strength of a rope:

- 50% (knot)
- 50% (bend)
- 75% (hitch)

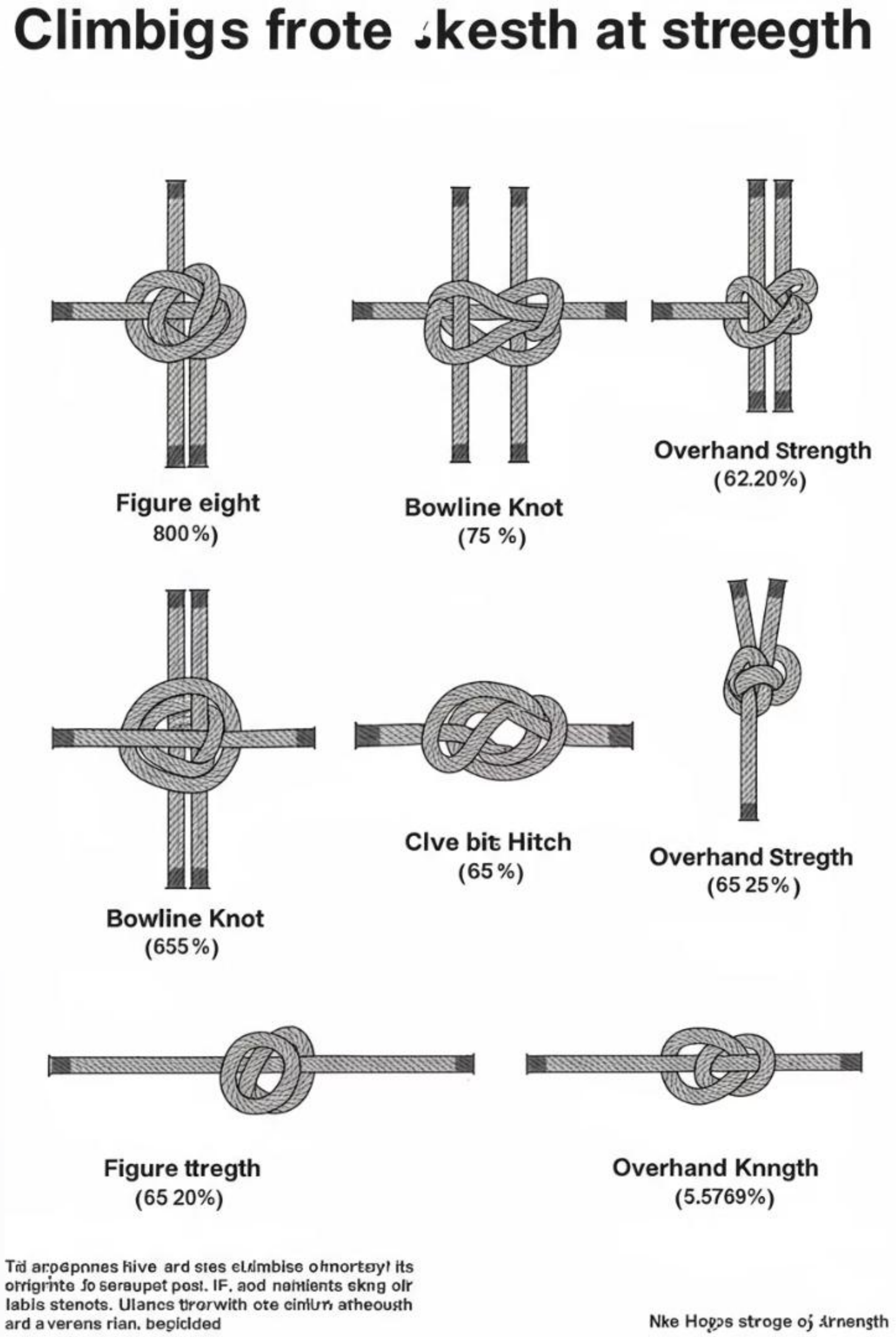
Age Effects

Age affects manila rope, so safe working load decreases 1% per year.

Removal Conditions

Remove all rope from service if any of the following conditions are present:

- Abnormal wear
- Powder or grit between strands
- Broken or cut fibres
- Variations in size or roundness
- Discoloration or rotting



Tag and Hoisting Lines

Regulatory Requirements

Occupational Health and Safety Code 2009, Section 70 Tag and hoisting lines Subsections 70(1) and 70(2) states that tag lines, usually made of nylon rope or other nonconductive material:

- Help riggers control the motion of a suspended load
- Allow riggers to stand a safe distance away from the load
- Provide some protection from electrocution as nylon rope is a poor conductor of electricity

Load Control

A load can move or swing dangerously if the crane boom moves rapidly or a gust of wind catches the load. To do so, they must be of sufficient length to allow control of the load and must be used in a manner that ensures the rigger holding the line will not be struck by the load.

Alternative Approaches

As an alternative to tag lines, an employer may consider options for securing the load to the crane or controlling equipment.

Center of Gravity and Tag Line Safety

Center of Gravity

To reduce the likelihood of a suspended load swinging or moving uncontrollably, position the hoisting line over the load's center of gravity. The load's "center of gravity" is the load's balance point or center of weight.

The location of a load's center of gravity depends on the load's shape and how its weight is distributed (i.e., heavier at one end than the other, or distributed evenly).

Tag Line Safety Considerations

Usually, tag lines improve the level of safety for riggers. You should not use them if there is a chance that the danger to workers would increase. This could include a risk of:

- Contact with live electrical conductors
- Entanglement in moving machinery
- Getting caught on moving mobile equipment

As an alternative to tag lines, an employer may consider options for securing the load to the crane or controlling equipment.

Lifting with Hand-Operated Chain Hoists

Versatility and Applications

Lever chain hoists (or come along), which are an indispensable tool for lifting and rigging, are available in many lifting capacities-from 100 lb up through 5 tonnes and beyond.

You can use lever hoist, also referred to as ratchet lever hoist, in vertical and horizontal applications. They are compact, light, and very easy to rig into position. Since they come with top and bottom hooks, you can rig them to just about anything imaginable.

Mechanical Advantage

These manually operated hoisting devices enable one person to lift heavy loads (multiple tonnes) by using a series of reduction gears to provide a mechanical advantage and, thereby, reduce the amount of effort (muscle energy) you need to lift a load.

Operation Guidance

Hoisting guidance operation of a hand operated chain hoist involves more than pulling the hand chain.

The use of these hoists is subject to certain hazards that cannot be met by mechanical means but only by the exercise of intelligence, care, common sense, and experience in anticipating the motions that will occur as a result of operating the hoists.

Chain Hoist Pre-use Inspection

Designated Inspector

A designated person must conduct pre-use inspections and determine whether conditions found constitute a hazard and a more detailed inspection is necessary.

Documentation

Frequent inspections do not require records.

Inspection Frequency

Remember that you must inspect daily before use and frequently during use.

Identification

The hoist must have a marking with the manufacturer's name, model, serial number, and rated load capacity attached on a plate or label, or cast, forged, or stamped on the hoist or load block.

Chain Hoist Warnings and Labels

Label Requirements

Hoists or blocks have labels displaying warnings and operating procedures. Labels must comply with ANSI Z535.4 Product safety signs and labels.

Warning Against

- Lifting more than rated load capacity
- Operating hoist with twisted, kinked or damaged chain
- Operating damaged or malfunctioning hoist

Additional Warnings

- Lifting people or lifting loads over people
- Operating hoist other than with human power
- Removing or obscuring labels

Chain Hoist Pre-use Inspection Checklist

1. **Operating Mechanism**

   Inspect operating mechanism for proper operation, proper adjustment and unusual sounds.

2. **Braking System**

   Check hoist braking system for proper operation.

3. **Hook and Latches**

   Inspect hook and latches, if used, for compliance with ASME B30.10 Hooks: Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings.

4. **Load Chain**

   Check hoist load chain, reefing, and hoist rope for compliance with manufacturer's recommendation.

Pre-Hoist Operations

Operator Training

The operator must be trained.

Adjustments and Repairs

The operator must not make adjustments or repairs unless qualified.

Reporting Issues

The operator must report substandard conditions.

Tagged Equipment

The operator must not operate a hoist that is tagged out-of-service.

Welding Precautions

The operator must not use the chain or rope as a welding ground and must not allow welding electrodes to contact the hoist.

Manual Operation

The operator must operate only manually (hand power) by one operator.

Hoist Operations Safety Requirements

Rope and Chain Management

Hoist rope or chain must not wrap around a load. Before load movement, the operator must be sure chains are not kinked or twisted around each other.

Proper Seating

Operation of the hoist must not take place unless rope or chain is seated properly on the drum, sheaves, or sprockets.

Load Positioning

Operation of the hoist must not take place unless centred over the load, except if it has authorization from a qualified person.

Load Capacity

The operator must not pick up a load in excess of the rated load bearing capacity on the hoist or load block, except during authorized tests or pre-engineered lifts.

Additional Hoist Operation Requirements

Overload Device

The operator must not use a hoist overload limiting device to measure the maximum load to be lifted.

Brake Testing

Each time a load approaching load capacity is handled, the operator must check hoist brake action by lifting the load just clear of supports and continuing only after verifying the brake system is operating properly.

Lowering Limits

Unless a lower limit device is provided, the operator must not lower the load below the point where less than two wraps of rope remain on the anchorage of the hoist drum.

Safety Precautions

Always follow manufacturer's guidelines and safety procedures when operating hoisting equipment.

Handling Symmetrical Loads

Equipment Inspection

Check that all crane systems are up-to-date and in proper working condition prior to crane operation, including annual inspection tags, controls, hooks, ropes, and brakes.

Route Planning

Check the travel route to ensure there is sufficient clearance for the load and check the destination area for adequate clearance and floor strength.

Rigging Attachment

Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan. Equalize loading on multiple leg slings and maintain a balanced load.

Test Lift

Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt. If the load tilts, lower immediately and reposition rigging components.

Completing the Symmetrical Load Lift

Notification

After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility's notification system (sounding an alarm, etc.).

Execution

Proceed by lifting the load slowly and moving the load slowly to its destination. Keep load as low to ground as possible. Use attendants to walk with the load, if needed, to keep it from impacting surrounding objects.

Placement

Lower the load slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.

Completion

Detach the rigging, and secure the equipment.

Handling Asymmetrical Loads

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Center of Gravity Identification

Determine and identify the location of the load's center of gravity.

Rigging Attachment

Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan. If the only available attachment points are below the center of gravity, stabilize the load using taglines.

Load Balancing

Equalize loading on multiple leg slings and maintain a balanced load. Protect rigging equipment and the load from sharp surfaces and damage.

Test Lift

Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt. If the load tilts, lower immediately and reposition rigging components to prevent the load from listing.

Completion

After the load is balanced correctly, warn everyone, proceed with the lift keeping the load as low as possible, lower carefully, and detach rigging.