Module 10

Piping and Tubing Systems for Industrial and Commercial Applications

The requirements for gas installations vary between requirements for single family dwellings and for commercial and industrial applications. This learning module details four areas where significant requirements for the installation, operation and testing of large piping and tubing systems should be understood by the gas technician.

At the end of this module you will be able to:

- Describe Code requirements and approved joining methods
- Describe welding safety, certification and procedures
- Identify utility and non-utility piping and tubing
- Explain piping layout, drawings and symbols
- Size high pressure piping and tubing systems
- Explain purging operations on large piping systems

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Module 10

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Unit 1 Code requirements and approved joining methods

Purpose

The installation of gas piping and tubing is a basic part of a gas technician's duties. The student 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 must be considered before a piping or tubing system is installed.

Learning objectives

1. Describe the Code requirements for industrial and commercial applications.

2. Describe the joining methods that may be used.

Topics

Code requirements for industrial and commercial piping applications

As a gas technician you must familiarize yourself with how Canadian Gas Code requirements for piping in commercial and industrial applications differ from requirements governing single-family dwellings. Note the following areas of significant difference between residential and commercial buildings and the applicable Code sections relating to the following:

- allowable pressures
- pressure testing requirements
- underground piping requirements
- identification
- shut-off valves
- commercial cooking appliances.

Review also Module 8 of the Gas Technician 3 training.

Allowable pressures

The most significant of the Gas Code variations is contained in Clause 5.1 Gas System Pressure. Gas pressures in supply mains (natural gas) and from storage containers (propane) are generally higher than the safe operating pressures of connected appliances. So gas pressures must be controlled to fall within an appropriate range, depending on the operating characteristics of installed appliances.

Table 5.1 from the B149.1 Code shows the maximum allowable gas pressures in buildings for natural gas and propane. Gas pressure regulators are the only practical means of meeting these requirements in most installations.

Table 5.1
Pressure inside buildings
(See Clause 5.1.1.)

	Maximum pressure, psig (kPa)	
Type of building	**Other than central boiler or mechanical room**	**Central boiler or mechanical room**
One- and two-family dwellings and row housing	2 (14)	-
Hotels and motels	5 (35)	20 (140)
Residential, other than one- and two-family dwellings and row housing	5 (35)	20 (140)
	5 (35)	20 (140)
Care or detention and assembly buildings	5 (35)	20 (140)
Commercial buildings	20 (140)	20 (140)*†
Industrial buildings	66 (450) Natural gas 20 (140) Propane	66 (450) Natural gas 20 (140) Propane
Central heating plants	-	66 (450) Natural gas 20 (140) Propane
Building under construction using propane (construction heater application)	25 (175) Propane	25 (175) Propane

**20 psig (140 kPa) may be used in boiler or mechanical rooms located on the roof of commercial buildings for propane.*
†66 psig (450 kPa) may be used in boiler or mechanical rooms located on the roof of commercial buildings for natural gas.

Pressure testing requirements

After a gas piping system has been installed, it must be pressure tested in accordance with the requirements of the applicable codes and regulations. All piping and components that will be concealed must be inspected and tested before being concealed. Testing should be performed at two specific times:

- First pressure test: before any appliances are installed
- Second pressure test: after appliances are installed.

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.

Remember that all piping and components that will be concealed must be inspected and tested before being concealed.

First pressure test: before appliances installed

The first system test is performed after the piping system is installed and before any appliances are connected to it. Refer to the Code for this test. Any components of the system that have a pressure rating below the test pressure must be isolated or removed from the system before testing to prevent them from being damaged.

Procedure

1. Isolate the piping system that is to be tested.
2. Cap or plug all open ends.
3. Insert a pressure gauge at one end of the system
4. Pressurize the system with air or inert gas (nitrogen or carbon dioxide) to the specified test pressure. Refer to Figure 1-1.
   (Table 1-2 shows the pressure test requirements for gas piping and tubing systems.)

The pressure is measured with a pressure gauge calibrated in 14 kPa (2 psig) increments or less, or 2% of the full-scale reading of the gauge, whichever is greater.

Note that the Code requires that the pressure and duration of the test be in accordance with Table 6.3 (see next page).

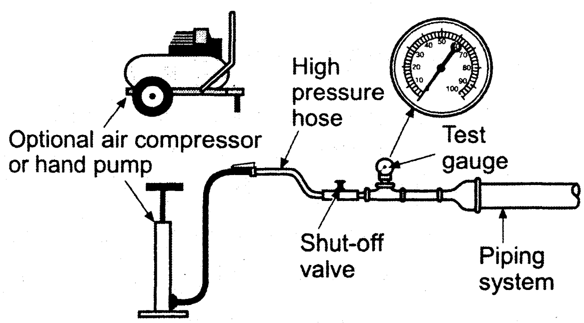


Figure 1-1 Pressure test before appliance installation

Table 6.3
Pressure test requirements
(See Clauses 6.22.1 and 6.22.2.)

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	200 (60) or less	15 (100)	15
Up to and including 2 (14)	All sizes	More than 200 (60)	15 (100)	60
Over 2 (14) but not more than 33 (230)	All sizes	200 (60) or less	50 (340)	60
Over 2 (14) but not more than 33 (230)	All sizes	More than 200 (60)	50 (340)	180
Over 33 (230)*	All sizes	All lengths	1.5 times the maximum operating pressure	180
All welded pipe	All sizes	All lengths	The greater of 50 psig (340 kPa) or 1.5 times the maximum operating pressure	180

**Propane maximum operating pressure is defined as*
(a) 250 psi (1725 kPa) for piping and tubing operating at container pressure;
(b) 350 psi (2400 kPa) when connected to the outlet of a pump or compressor; or
(c) 375 psi (2570 kPa) minimum or the setting of the hydrostatic relief valve in piping that can contain liquid propane, that can be isolated by valves, and that requires hydrostatic relief valves as specified in Clause 5.4.1 of this Standard or Clause 5.6.1 of CAN/CSA-B149.2.

Notes :

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

(2) All wrapped and/or factory-coated piping systems of all sizes and lengths shall be tested at a minimum pressure of 100 psig (700 kPa) in accordance with the time duration in the Table.

Leak detection

If a leak is indicated by a drop in pressure in the system, you will need to locate the source of the leak with either a liquid solution or leak detection device. Typically, a "soap test" is conducted (Figure 1-2).

- Each joint or fitting in the suspect portion of the system is wiped with the leak detector solution (soap and water).
- A leak will cause the solution to form bubbles at the source of the leak.

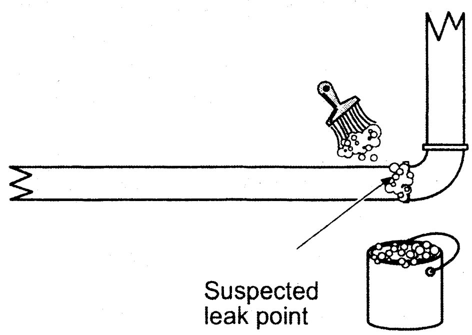


Figure 1-2 Soap test

Checking for shut-off valve seepage

A gas meter valve may sometimes seep gas if its sealing grease becomes dry and hardened. If the valve passes gas in this way, the system test will not be accurate and results will be invalid. For this reason, *before the second pressure test is performed*, the gas meter valve should be checked for seepage using the following procedure.

1. When the system is brought to a static pressure condition, release a small amount of the contained gas pressure by quickly removing then replacing the manometer or pressure gauge tubing.
2. This action opens the service regulator and allows the system to be tested back to the gas meter shutoff valve.
3. If the gas pressure increases slowly to static pressure, the meter valve is seeping gas and should be serviced before testing proceeds.

Second pressure test: after appliances installed

After appliances are installed, the system should be checked visually to ensure there are no openings in the system from which gas could escape. The manometer or pressure gauge used for this test must be calibrated in one inch w.c. (250 Pa) increments or less. Since the procedures for both natural gas and propane are covered in detail in Module 8, please refer to that module for more detailed information.

Underground piping

Clause 6.15 of the Gas Code identifies requirements for installing underground piping systems.

Installation depths and location

Clause 6.15.4 gives minimum depths for underground piping locations:

- 15 inches (400 mm) generally
- 24 inches (600 mm) under a commercial driveway or parking lot, except when the piping or tubing rises above ground at the point of supply to either a building or an outdoor appliance.

Figure 1-3 shows minimum depths and location of rise prior to piping entering the building.

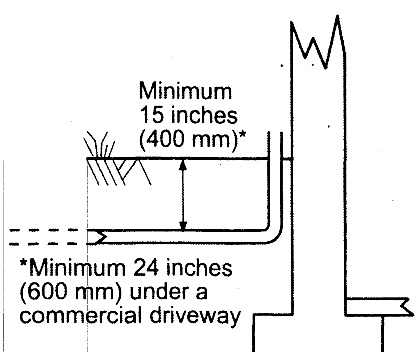


Figure 1-3 Required piping depths for underground piping

An exception to the above minimum depths is where physical damage may occur to piping from commercial operations (such as farming). In this case, underground piping will require additional depth of cover, appropriate to the operation involved.

Note also Clause 6.15.8: "Piping entering a building shall rise above grade before entry, unless otherwise permitted by the authority having jurisdiction."

In such exceptions (Figure 1-4):

- a watertight seal must be provided where the piping passes through an outside wall below grade
- piping or tubing passing through concrete or masonry walls must be sleeved, coated or double-wrapped (if one layer is wrapped in one direction, say clockwise, the second layer is wrapped in the opposite direction, counterclockwise)

- piping may *not* pass under a footing or building wall because of building settlement which can cause crushing or rupture of the pipe.

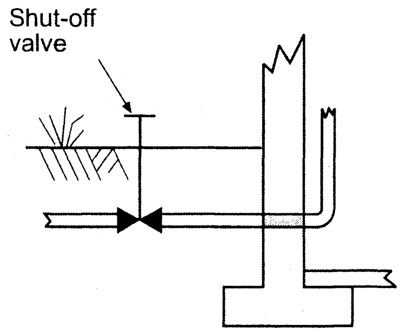


Figure 1-4 Underground piping entering building below grade

Supports for piping

Clause 6.8.3 of the Code states that above-ground piping must be installed with individual supports of sufficient strength and quality (Figure 1-5), and be spaced according to Table 6.2 of the CSA B149.1 Code.

Table 6.2
Spacing of supports for piping
(See Clauses 6.8.3 and 6.26.1.)

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)
5 – 8 — horizontal	20 (6)
10 or larger — horizontal	25 (8)
All sizes — vertical	Every floor but not more than 125% of horizontal
Tubing – all sizes – vertical and horizontal	6 (2)

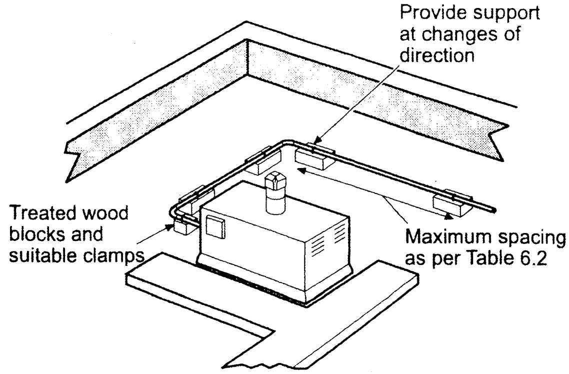


Figure 1-5 Supports for piping

Other installation requirements

Note the following additional requirements for underground piping:

- Trenches for piping must be properly graded to avoid any sagging in the pipes or tubes.
- Back fill material must be free of sharp object, large stones or other material that may damage the piping.

Buried plastic piping must be accompanied by a tracer wire or equivalent.

Figure 1-6 shows requirements for venting when the piping or tubing is covered with paving, or the paving extends 25 ft (8 m) or more from the building:

- A vent pipe inspection point must be installed.
- A sleeve in the pavement should be provided to permit free movement of piping. This sleeve can also serve as a vent pipe inspection point.

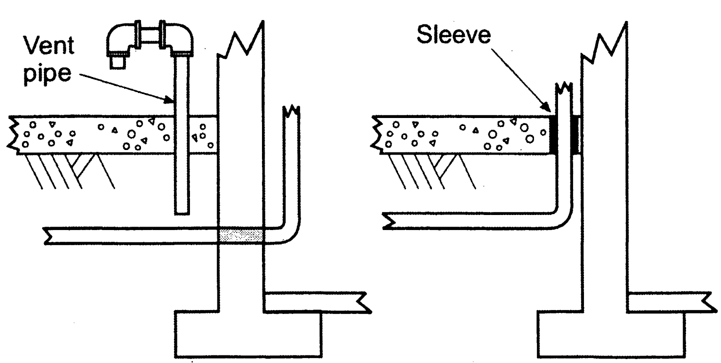


Figure 1-6 Venting of underground piping under pavement

Identification of gas piping

In all industrial and commercial buildings, gas piping must be clearly distinguished from other types of pipes and tubes. The Code in Clause 6.17 provides three options for identifying gas pipes:

- painting the entire gas piping system yellow (this is an international ruling)
- providing the piping with yellow bands at no more than 20 ft (6 m) intervals
- marking or labelling the piping system with the words "GAS" or "PROPANE" in yellow labels or markings at 20 ft (6 m) intervals.

Clause 6.17.4 requires that piping entering a building having more than one gas meter must be clearly identified, showing the number of the room, apartment or area of the building each meter serves.

Shut-off valves

Clause 6.18 of the Code describes manual valve requirements for large piping installations:

- to enable servicing
- to provide large buildings that have multiple gas outlets with a clearly identified shut-off valve in an accessible location.

In large installations the shut-off valve must be ball, eccentric or lubricated plug type, with piping larger than NPS 1 and tubing 1 inch (25.4 mm) outside diameter or larger.

Location of valves

A "readily accessible" manual shut-off valve for each appliance must be installed:

- in either the drop or riser as close as possible to the valve train of a commercial and industrial type appliance
- in the horizontal piping between the drop or riser and the appliance valve train and may be the same size as the appliance connection when located within 2 ft (60 cm) of the appliance.

These requirements may be waived when a "readily accessible single manual shut-off valve is installed for commercial cooking appliances manifolded in line" (Clause 6.18.3).

Piping that extends between two buildings must have a shut-off valve at the point of exit from the first buildings and one at the point of entry to the adjoining building (Figure 1-7).

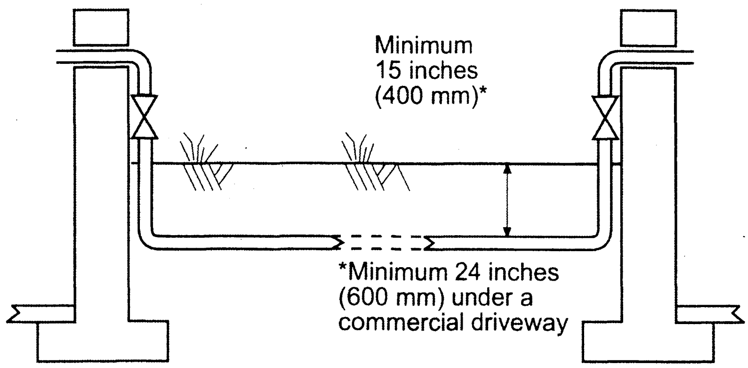


Figure 1-7 Location of shut-off valves when piping extends between two buildings

When multiple outlets are installed in a classroom, laboratory or similar room or area, they must be controlled by a clearly marked master shut-off valve in a readily accessible location within the room.

Shut-off valve controlling several piping systems

Clause 6.18.5 requires that shut-off valves that control more than one piping system be:

- readily accessible for operation at all times
- provided with an installed handle
- provide protection from damage
- clearly marked with an enameled metal, substantial fibre or other permanent tag, for easy identification of the piping system.

Commercial cooking appliances

The Gas Codes stipulate that *commercial cooking appliances certified for use with casters or otherwise subject to movement for cleaning, and other large gas utilization equipment that may be moved, shall be connected by a certified connector complying to Standard CAN/CSA-6.16, "Connectors for Movable Gas Appliances."*

When a metal connector is used with a commercial cooking appliance installed on wheels or rollers, a noncombustible restraining device shall be provided to protect the connector, and the installation shall be in accordance with Clause 7.31.4.

Refer to Figure 1-8.

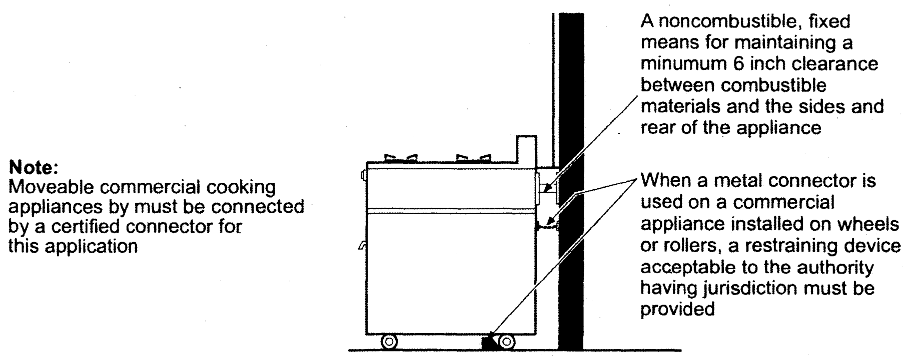


Figure 1-8 Commercial cooking appliance installation

TOPIC 2

Approved joining methods

The information in this topic reviews the different types of piping and tubing systems used for gas, associated valves and fittings, and describes approved joining methods for gas piping and tubing.

The Gas Code requires that joints in steel piping be threaded, flanged or welded. However Clause 6.15.2 specifies that underground piping systems be joined or connected by welding or approved mechanical compression fittings. This means that for the large underground piping described in this learning unit, for all practical purposes welding is the acceptable method. The *Boilers and Pressure Vessels Act*, certification requirements and procedures related to welding are dealt with in more detail in Unit 2.

General requirements of piping, tubing and connectors

Section 6 of the Gas Code details requirements for piping material and fittings. It also outlines the proper connecting methods and the many piping practices you must follow.

Piping material and fittings

Table 1-4, on the following page, lists the types of pipe and tubing, the fittings used with them, and the approved methods for making connections. For a good general review of this material, look through the table and review the articles in the Code pertaining to each.

Table 1-1 Pipe or tubing, fittings and their connections

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 & bolts
Polyethylene	hub to hub	hot iron socket fusion
	pipe to pipe	butt fusion
	saddle	saddle fusion
	slip-on	compression slip-lock
Copper tube	copper to copper	brazing over 1000°F
	flared	single 45° flare
	compression	not ball sleeve
Steel tube	flared	single 45° flare
	compression	not ball sleeve

Joints and connections in large-size piping

The following requirements in Clause 6.9 of the Gas Code apply to joints and connections in large-size piping (NPS 2 1/2 and over).

- Piping of NPS 2 1/2 and over must have welded pipe joints.
- Welding of gas piping must be performed in accordance with a procedure and by an operator registered under the applicable Provincial or Territorial legislation.
- The acceptance criteria for any welds shall be as specified in CSA Standard Z662, *Oil and Gas Pipeline Systems.*
- Gasket materials are required to be of neoprene or a similar material that resists any action of gas. Natural rubber is not acceptable.
- Lubricants used in valves or controls have to be approved for gas use and able to withstand the service conditions to which they may be subjected (when used in accordance with the manufacturer's recommendations).

Iron and galvanized steel piping

Steel gas piping must conform to ASTM specification A53 or A106 as described in *Natural Gas Installation Code*, Clause 6.2.1.
Black pipe is most commonly used for gas with pipe fittings of steel or malleable iron.

Pipe sizes

Black pipe used for gas systems is sized by the Nominal Pipe Size (NPS). For any nominal size of pipe, the outside diameter (OD) remains the same and the inside diameter (ID) changes as the wall thickness increases. Nominal size is a designation used for the purpose of general identification. Pipe is threaded on the outside only, therefore, the OD must remain constant.

Types of ends

The ends of gas piping and tubing may be finished in the following ways, depending on the application:

- plain
- bevelled
- threaded.

Wall thickness

Steel pipe used for gas systems is Schedule 40 or Schedule 80. *Schedule* refers to the wall thickness of the pipe. Schedule 40 pipe is standard and Schedule 80 is extra heavy. Schedule 40 and Schedule 80 pipe have the same outside diameter (OD).

Markings and labels

Piping used for gas systems must be marked and labeled as described in *Natural Gas Installation Code*, Clause 6.17.

Other types of piping and tubing

Refer to Module 8 of the Gas Technician 3 training material which describes Canadian installation codes and regulations covering the use of copper, stainless steel, aluminum and polyethylene piping and tubing.

Assignment 1

When you have completed the following questions, ask your instructor for the Answer Key.

1. State a Code practice during installation of piping and tubing that will ensure the system stays leak-free for years to come.

2. Describe the first pressure test of the system, before appliances are connected.

3. When and where would you perform a soap test?

4. What must be done to piping or tubing passing through concrete?

5. May a sleeve installed in pavement to allow free movement of the pipe also serve as a vent pipe inspection point?

6. List three methods of identifying gas piping inside a commercial or industrial building.

   a)

   b)

   c)

7. How would you recognize a manual shut-off valve as being approved for installation in a natural gas or propane system?

8. How must multiple outlets that are installed in a laboratory (school or other), be protected from leaking gas into the area accidentally?

9. Joints in steel piping used in gas systems shall be:

10. List all approved gasket material for gas systems and why natural rubber is *not* approved.

Unit 2 Welding safety, certification and procedures

Purpose

A gas technician is not required to hold any type of welding certification, however a thorough knowledge of the requirements for welded gas piping is important. This, along with an understanding of welding procedures and welding related hazards, is vital to a safe and secure installation.

Learning objectives

1. Describe some of the common welding hazards.
2. Describe the safety preacuations that need to be taken.
3. Describe the certification requirements.
4. Describe the preparation that is required for welding testing.

Topics

TOPIC 1

Common hazards

As a gas technician you are not required 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.

Major welding hazards to welders, or gas technicians working in their vicinity, may be divided into three general categories:

Physical :
- various types of radiation
- visible light
- noise
- electrical energy

Chemical
- flammable and combustible products
- welding fumes and toxic gases
- dust

Environmental
- extremes of temperature
- poor ventilation
- biological hazards

Physical hazards

Ionizing radiation

X-rays and gamma rays produce ionizing radiation during the welding process. These rays are emitted from equipment used to gauge the density and thickness of pipes and to check welds. They are invisible forms of ionizing radiation and can be extremely damaging to unprotected parts of the body. Welding chambers must be completely shielded to confine x-rays and protect the welder.

Non-ionizing radiation

Ultraviolet, infrared and visible light radiation are also produced by certain welding processes. Ultra-violet radiation is produced from the arc or from a reflection off bright objects like white clothing or shiny metal. If eyes are not adequately protected, it produces *arc eye*, 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.

- Ultraviolet rays may also cause skin burn and blistering in extreme cases.
- Infrared and visible light radiation can cause eye damage and, after prolonged exposure, chronic conjunctivitis.

Fire, flying hot metal sparks, etc.

The high temperatures involved in welding produce hot metal and sparks which can quickly cause fire, particularly when working in combustible surroundings. For a time after work has been carried out around combustible materials, there can be a risk of fire. Stay around for at least 30 minutes after welding in such environments, and keep fire extinguishers at hand.

Flying metal particles, sparks and slag are hazardous to eyes, skin and readily combustible clothing material.

Plastic butane lighters should never be carried in your clothing or elsewhere around welding operations or welders. 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

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 slag removal.

Chemical hazards

Pure oxygen

The combination of pure oxygen (O_2), when combined with other materials, is a potential combustion danger. Materials that burn in air burn much more readily when exposed to O_2. Other materials which may not burn in air become combustible in O_2. Either oil or grease, not normally thought of as highly flammable, can cause explosion when brought into contact with pure oxygen.

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

Acetylene

Acetylene gas ($C_2 H_2$) used in welding work is a colourless unstable compound. However, even very small quantities of acetylene produce a pungent odour which 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 called its *critical point.*

The critical point of *free acetylene* (acetylene which is the only occupant of the volume) 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 the temperature is increased, the pressure at which acetylene becomes critical is lowered. To allow for any temperature fluctuations in the work area, free acetylene is not stored or used at pressures over 15 psi (103 kPa).

Other physical properties of acetylene are:

Temperatures:		Explosive Limits:	
Ignition	Burning	Lower	Upper
763-824°F (406-440°C)	4770°F (2632°C)	2.50% Acetylene 97.5% Air	81% Acetylene 19% Air

Storage of cylinders

Cylinders must be stored where they will not be knocked over or damaged by falling objects, passing vehicles, or persons. They should not come into contact with salt, corrosive chemicals or fumes. Whether they are full or empty, cylinders should always be secured upright to a stationary object, such as a wall or portable cart to keep them from falling down. Figure 2-1 shows safe storage conditions for acetylene containers. Empty containers are chained to one wall and full containers are separated and chained to the opposite wall.

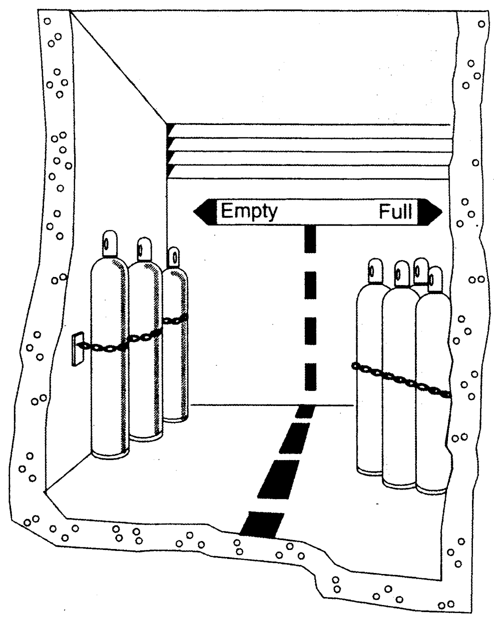


Figure 2-1 Storage of full and empty cylinders

Figure 2-2 shows a portable oxy-acetylene outfit where the acetylene and oxygen containers are 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.

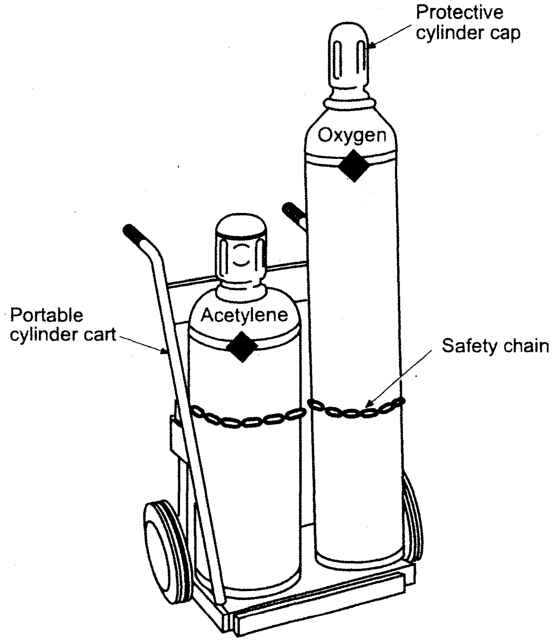


Figure 2-2 Portable storage unit

Other chemical hazards

Other chemical hazards to be aware of include risks of fire from flammable/combustible products, toxic gases and fumes, and dust which may become flammable.

Environmental hazards

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

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

- Extreme heat causes muscle cramps, dehydration, sudden collapse and unconsciousness.
- Extreme cold leads to fatigue, irregular breathing, lowered blood pressure, confusion and loss of consciousness.

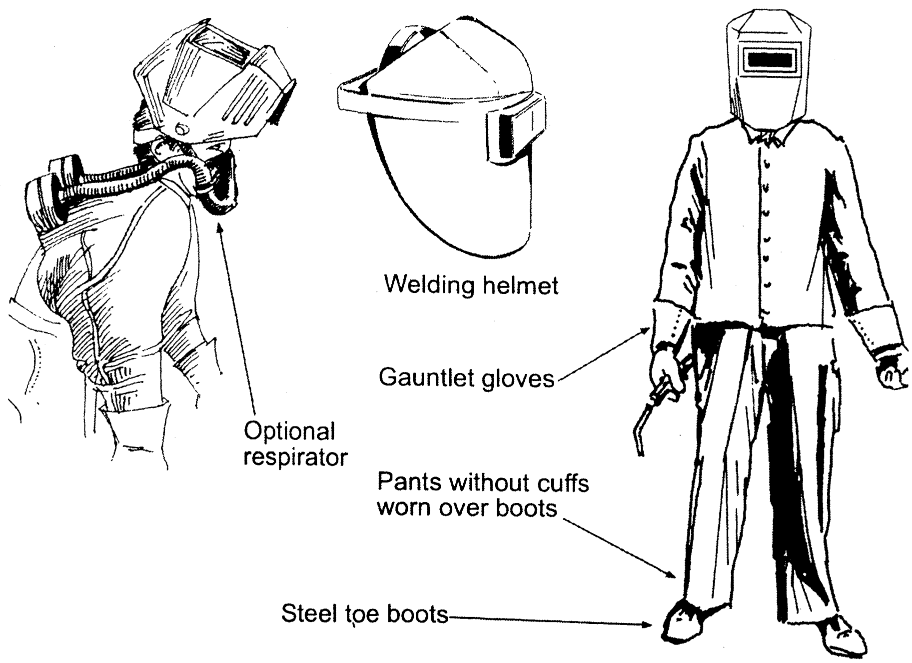


Figure 2-3 Protective clothing for welding operations

Safety precautions

Proper safety precautions to be observed wherever welding work is being carried out include: appropriate protective clothing, radiation protection, fire prevention, appropriate oxy-acetylene safety measures, and working in a well-ventilated environment.

Protective clothing

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 free of grease and oil and that covers all exposed skin. Refer to Figure 2-3 opposite.

- 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 working with welders should wear flash goggles.
  In special circumstances you may have to wear a respirator or mask.
- Wear gauntlet type gloves.
- Cover and protect head and hair by wearing a cap or other protective headgear.
- Protect your feet with steel-toed boots.
- Wear cuffless pants and make sure there are no tears, frays or hanging pieces of light fabric or jewelry attached to your clothing. Ensure your shirt pockets have flaps.

Fire prevention

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. (See the following section for specific precautions when working with oxy-acetylene equipment.)

Keep fire extinguishers close to hand and ready for use. Stay around areas where welding has been carried out for 30 minutes after the work has been completed.

Oxy-acetylene equipment

Oxygen cylinders are protected from extreme pressure caused by heat by means of a fusible metal rupture disk that controls the slow escape of gas. Figure 2-4 shows the components on an oxy-acetylene outfit, including its safety features.

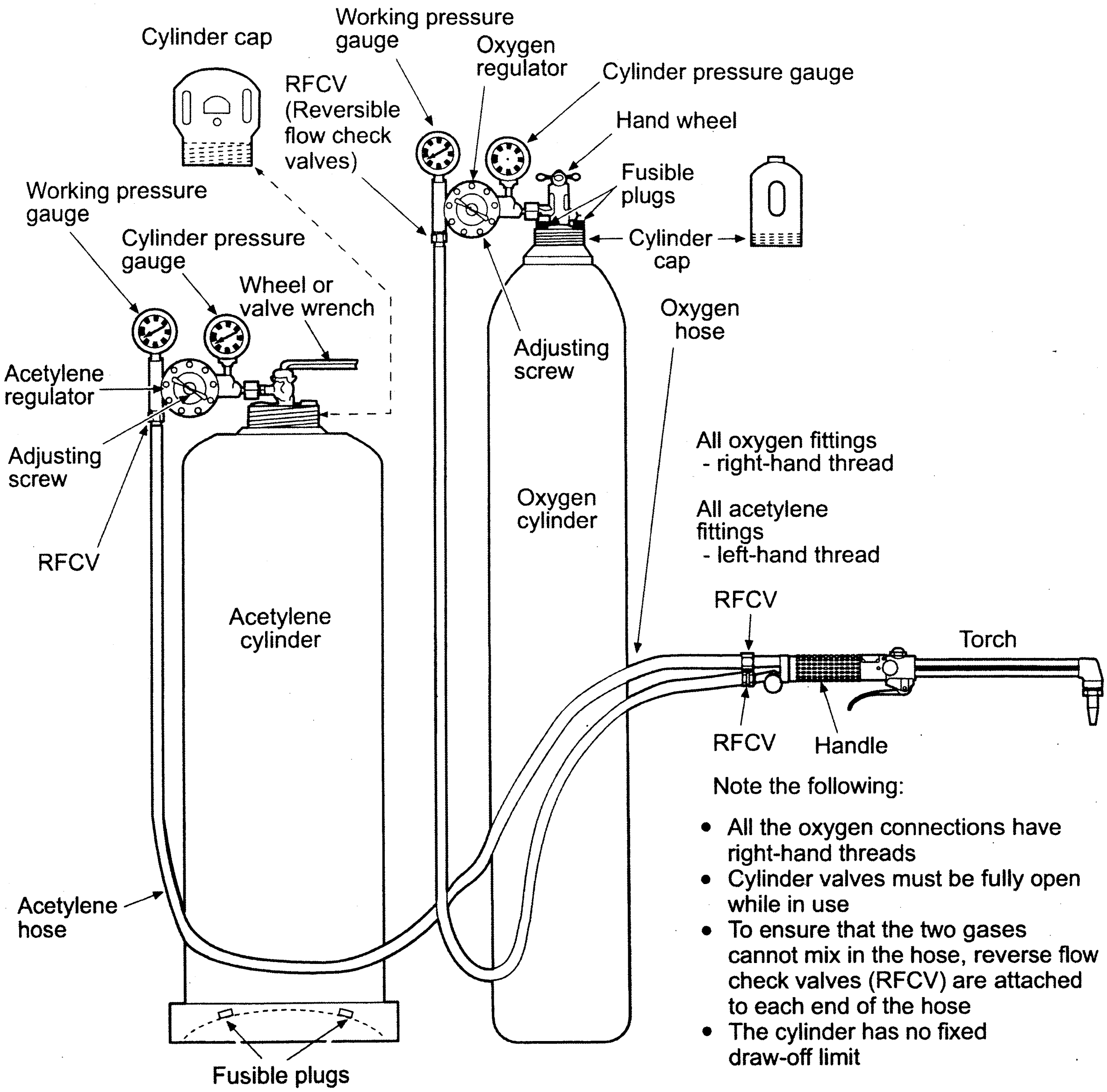


Figure 2-4 Components of an oxy-acetylene outfit

Rules for working with oxy-acetylene equipment

Follow these rules when working with oxygen and acetylene.

- Never use oxygen:
  - as a compressed air substitute
  - to start or run internal combustion engines
  - to blow out pipe or tubing lines
  - to create pressure
  - for ventilation
  - to dust off clothing or work areas.
- Keep oxy-acetylene equipment away from oil or grease. Never oil regulators or torch parts.
- If a cylinder appears to be leaking or faulty, it must be removed to the outside, left in the open, tagged to indicate its fault, and the supplier notified. *Never attempt to repair it yourself.*
- Acetylene cylinders are required by Codes to have at least one fusible plug on each end of the cylinder. The plug, with a melting point of 212°F (100°C) is designed to melt out in case of fire. This allows for a slow, controlled escape of gas and avoidance of explosion. Note the following rules for acetylene cylinders:
  - To prevent acetone from being drawn off, use the cylinder in a vertical position.
  - Store cylinders in a cool area.
  - Never transfer acetylene from one cylinder to another.
  - Do not attempt to interchange equipment from one gas type to another.
  - If your cylinder has a key-type acetylene valve, open it only 1 1/2 turns. The hand-wheel type should be opened fully.
- If you smell acetylene, immediately extinguish all open flames and ventilate the room or work area, *before you turn on a light switch if possible*.
- Test for leaks using a soap test (*never test near an open flame*).
- Welding shops are required to have a minimum of four air changes per hour. Ensure that good ventilation is provided at all times around welding operations.

Topic 3

Certification requirements

Welders are required to meet the standards set out in provincial *Boilers and Pressure Vessels Acts*. Testing of welders for qualification in Canada is conducted by or through the governing provincial Boiler and Pressure Vessel Safety Branch (BPVB). The BPVB may issue a red seal of approval for interprovincial certification of welders. Before performing any work requiring welded pipe, contact the provincial gas safety branch for specific certification requirements in your province.

The following general rules relate to qualification:

- No welding operator shall weld except under an approved procedure.
- The chief inspector shall issue an identification card to every welding operator who passes a qualification test.
- Every identification card shall indicate the employer for whom the welding operator is qualified to weld or that he or she is self-employed or that he or she desires to be employed and the class or position of welding that he or she is qualified to do.
- A welding operator may be required at any time to pass such further qualification tests as the chief inspector may require, at which time his or her identification card shall be cancelled, and, on passing such further tests, a new identification card shall be issued to him or her.
- In this section, "employer" includes a trade association of persons or companies whose business includes welding.

TOPIC 4

Preparation for welding

Shielded metal arc welding is the process normally used for welding steel gas piping. However, the welding procedures used for this process fall beyond the scope of this learning unit, and would not be part of a gas technician's normal duties. The layout of welded piping systems *is* the gas technician's responsibility and may include such tasks as measuring, marking, cutting, joint preparation and assembly. The following sections give an overview of typical layout procedures.

Measuring pipe and fittings

Before any welding operation is started, the gas technician selects pipe sizes and related fittings and connectors, measures pipe lengths and marks locations of joints and connectors.

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

Figure 2-5 shows a segment of a piping system with the dimensions 7 7/8 inches (200 mm) end-to-centre of pipe. This does not mean that the pipe must be cut exactly 7 7/8 inches long, since you must allow for fittings.

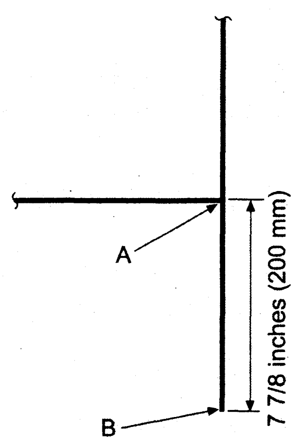


Figure 2-5 Piping drawing showing a segment of a piping system

Pipe length is measured along centre lines. Where two centre lines cross, a centre point (Figure 2-6) is located in a fitting. In Figure 2-5, the dimension 7 7/8 inches (200 mm) refers to the total distance between centre point A and point B.

This is known as an end-to-centre measurement. The tee in Figure 2-6 will make up part of the 7 7/8 inches (200 mm); a 1/8 inch (3 mm) root gap and a length of pipe will make up the rest.

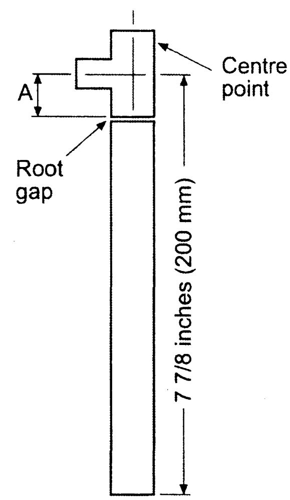


Figure 2-6 Centre point of a fitting

To find the correct length to cut the pipe, you have to measure the fitting. Measure the distance between the centre point and the point where the pipe will end. Subtract this fitting allowance from the dimension shown on the drawing. This dimension-minus-fitting allowance is the correct length to cut the pipe.

As shown in Figure 2-6, length A is deducted from the overall end-to-centre measurement to arrive at the length of pipe needed.

Common weld fittings

Examples of common butt weld fittings are shown in Figure 2-7. To calculate the fitting allowances for weld fittings, you have two options:

1. You could make field measurements.
2. You would refer to a table such as Table 2-1 which shows various dimensions for butt weld fittings similar to those illustrated in Figure 2-7. Table 2-1 is shown in Imperial units of measurement, since these are the most widely used measurements for pipe and fitting dimensions.

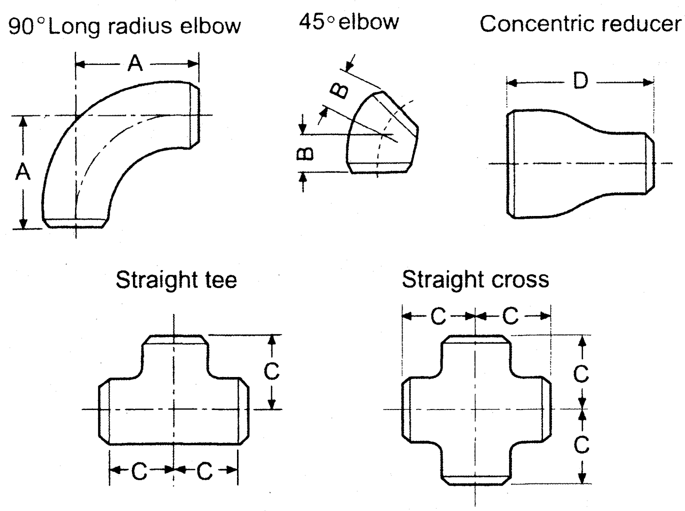


Figure 2-7 Common weld fittings and dimensions

Table 2-1 Sample table of dimensions for butt weld fittings

Nominal pipe size (inches)	90° long radius elbows --------A--------	45° elbows --------B--------	Tees and crosses --------C--------	Reducing couplings CON/ECC --------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
2	3.00	1.38	2.50	3.00
2 1/2	3.75	1.75	3.00	3.50
3	4.50	2.00	3.38	3.50
3 1/2	5.25	2.25	3.75	4.00
4	6.00	2.50	4.12	4.00
5	7.50	3.12	4.88	5.00
6	9.00	3.75	5.62	5.50
8	12.00	5.00	7.00	6.00
10	15.00	6.25	8.50	7.00
12	18.00	7.50	10.00	8.00

Marking the cutting line

For a square cut, the cutting line may be accurately marked using a *wraparound* and a piece of soapstone. A wraparound is a strip of leather belting or other strong, flexible material approximately 4 inches (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.

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

1. Place one edge of the wraparound against the point at which the pipe is to be cut.
2. Circle the pipe with the wraparound and line up the edges accurately as shown in Figure 2-8.
3. Use the wraparound edge as a guide to draw a line around the pipe with a piece of soapstone.

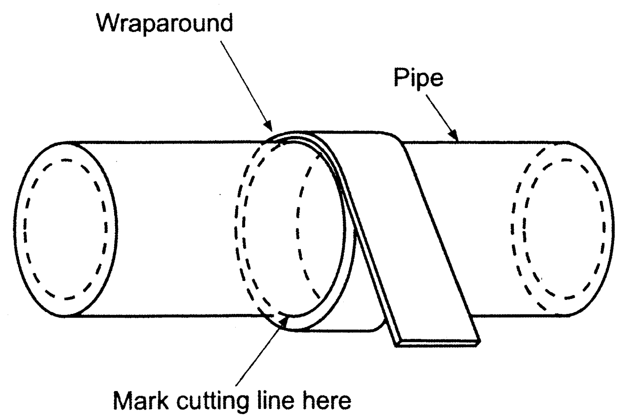


Figure 2-8 Using a wraparound to mark cutting line

Cutting pipe and tubing

Gas technicians use a variety of methods to cut pipe and tubing. Pipe cutters are frequently used on small pipes and may also be used on larger piping. On piping being prepared for welding, the pipe end must be bevelled to accommodate the welding procedure. This is generally done in one of the following ways:

- A pipe cutting and bevelling machine is used (Figure 2-9).
- The end can be cut using a pipe cutter or cut-off saw, then beveled to suit, using a side grinder (Figure 2-10).

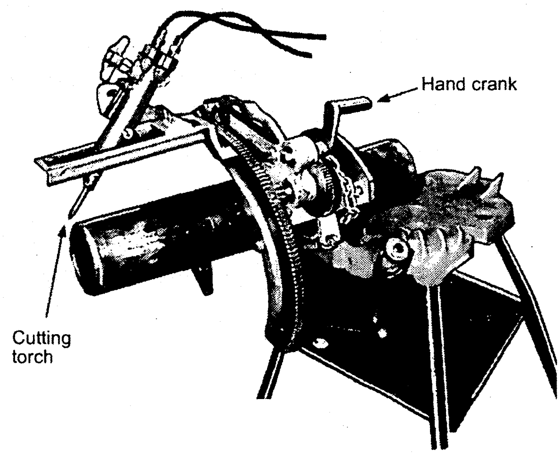


Figure 2-9 Pipe cutting and bevelling machine

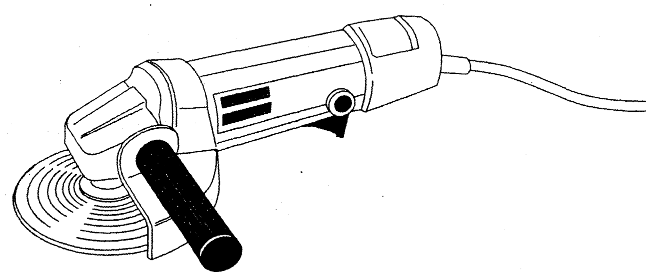


Figure 2-10 Angle side grinder

An oxy-acetylene torch is often used 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. The end is then further prepared with a side grinder.

Pipe and fitting alignment

To avoid weld failure and system malfunction, the gas technician must ensure the pipe fitting and alignment is correct before any tacking or welding of fittings, valves or pipe. 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
- tacking.

To prepare pressure pipe for butt welding or matching of fittings, you V-bevel the ends to an angle of approximately 37 1/2 degrees. Note that the bevel does not come to a sharp point, but has a flat portion of approximately 1/16–1/8 inch (1.6–3.2 mm). This is called a *land* or *root* face.

The land helps in preventing the sharp edges of the bevel from burning off during welding (Figure 2-11). Note that welded pipe fittings and pipe lengths come supplied with standard bevelled ends which only require cleaning.

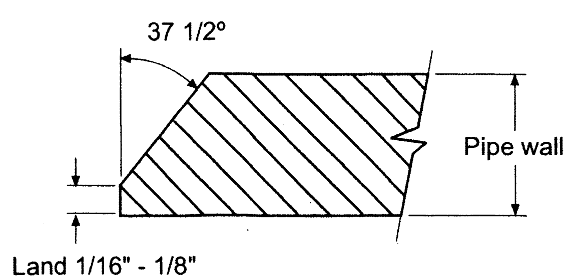


Figure 2-11 Bevel preparation

Joint assembly

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 inch (1.6–3.2 mm). 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.

Clamps are often used to maintain the correct gap and high-low alignment. On smaller pipe and fitting sizes, proper alignment is maintained using an angle iron. Figure 2-12 shows three methods of maintaining pipe and fitting alignment.

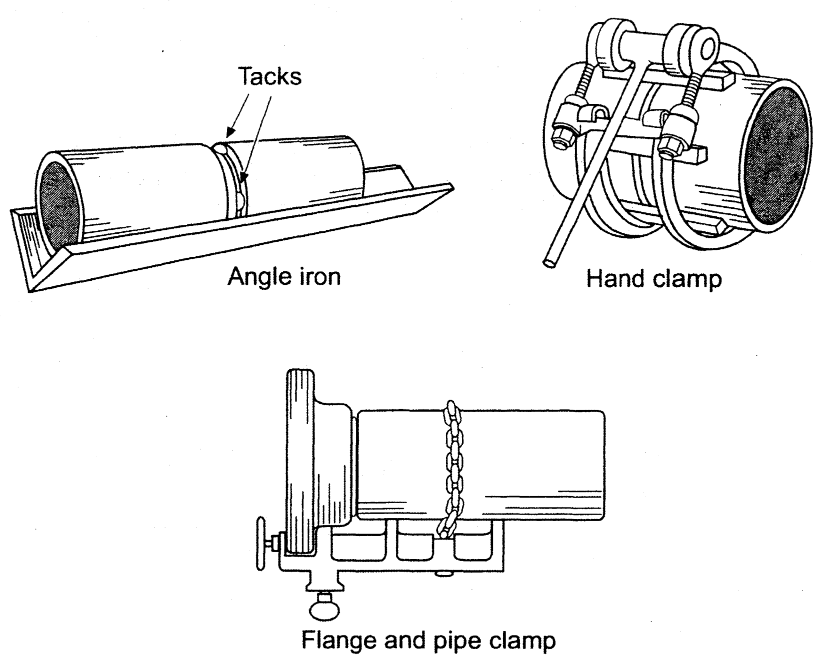


Figure 2-12 Joint alignment methods

Tacking

Tack welds are made 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.

Sometimes a spacer wire is used, in which case the wire must be removed after the first tack is welded. Make the second tack 180 degrees opposite the first tack. The third and fourth tacks are made at 90 degree angles to the first and second tacks.

When making the third tack, adjust the gap until the openings are equalized. 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 will even out the root opening space.

The fourth tack weld is at 180 degrees from the third tack. Figure 2-13 shows the orientation and order in which the tacks should be made along the circumference of the pipe.

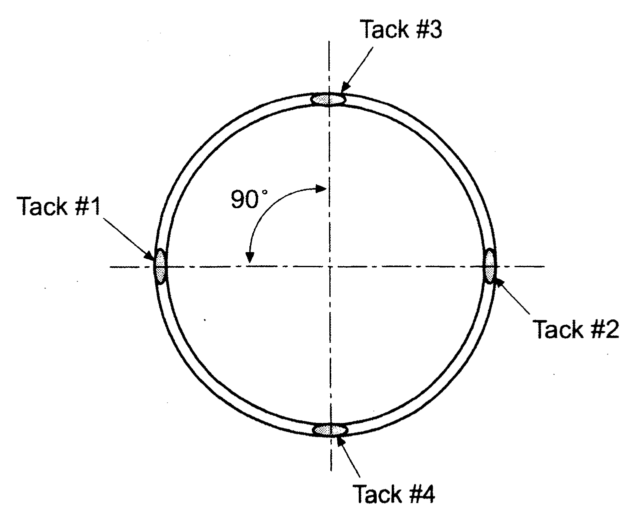


Figure 2-13 Four tack welds

TOPIC 5

Testing

Pressure testing of welded pipe to Code requirements is carried out using normal pressure testing methods with air or an inert gas. Other non-destructive testing that may be required includes radiographic testing and liquid dye testing.

Radiographic testing

Radiographic (X-ray) testing may be conducted upon a customer's request, or according to job specifications. Radiographic testing must adhere to Section 5, Article 2 of the American Society of Mechanical Engineers (ASME) Boilers and Pressure Vessels Code. When the testing is completed, the radiograph must be submitted to the inspector for acceptance.

Liquid (dye) penetrant examination

Section 5, Article 6, of the Boilers and Pressure Vessels Code sets out requirements for liquid (dye) penetrant examination of welded piping. The part being tested is allowed to dry and a "developer" is applied. The penetrant shows through the developer if any faults are present.

The dyes in the penetrant are visible under white light (colour contrast), or under ultra-violet light.

Assignment 2

When you have completed the following questions, ask your instructor for the Answer Key.

1. The three general categories of major welding hazards to workers in the vicinity of welding operations are:

   a)

   b)

   c)

2. State the adverse health effects from exposure to welding X-ray equipment.

3. List the adverse effects from ultraviolet radiation produced by arc welding.

4. After welding is completed in an area where combustible material is present, how long should a "fire watch" be maintained?

5. List the types of personal protective equipment that must be worn when working with or around a welder.

6. List two important safety precautions to be observed when working with an oxygen cylinder.

7. Is acetylene a very stable gas that is easily compressed to high pressures?

8. What should be done if welding is taking place in a confined area?

9. What type of gloves should be worn around welding operations?

10. Should oxygen and acetylene regulators be oiled regularly?

11. How many air changes per hour are required in a welding shop?

12. With what are oxygen and acetylene cylinders fitted to minimize the possibility of explosion in case of fire?

13. To what angle should pipe be bevelled if it is to be welded?

14. When the pipe and fittings are set up for welding, how wide is the root gap?

Unit 3 Utility and non-utility piping

Purpose

A gas technician 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 piping is identified on drawings, and on the worksite, is important to ensure installation and repairs are done safely and efficiently.

Learning objectives

1. Describe utility piping.
2. Describe non-utility piping.
3. Distinguish gas piping from other types of piping.

Topics

TOPIC 1

Utility piping and tubing

Piping and tubing in existing buildings or underground pipe lines are not always clearly identified. As a gas technician, 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 work is being done that might affect or come in contact with underground lines. All utility lines are blueprinted by the relevant utility when first installed and the plan drawings are updated whenever there have been changes to existing systems. The utility will supply a drawing of area piping whenever it is 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 be either wrapped steel pipe or polyethylene plastic pipe.

- Wrapped steel is coated with polyethylene and coloured either blue or yellow.
- Polyethylene plastic gas piping is available in various colours: yellow or orange is normally used by the utility.

When polyethylene plastic pipe is used underground, a minimum 16-gauge copper wire is taped along the piping for tracing purposes using a metal detector or radio signals.

Underground tubing

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

Normally, gas tubing that is installed underground must meet the Gas Code requirements. This means that the tubing will be either type K copper or type L or G polyethylene or PVC coated. However, gas utilities are governed by the requirements of the CSA Z662 *Oil and Gas Pipeline Systems* standard. This may involve requirements that are somewhat different to those to which you are accustomed as a gas technician.

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

TOPIC 2

Non-utility piping and tubing

Most, but not all, non-utility gas piping and tubing is run above ground. 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.

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

- complexes that have more than one building requiring gas but the gas is distributed from one central meter.
- single family dwellings that have 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.

Underground gas piping downstream of the gas meter will be one of three types: polyethylene coated steel pipe, polyethylene plastic pipe, or copper tubing, either coated or non-coated. 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. Identification of above-ground piping is easier but not always obvious.

The following are the typical indicators of the contents of sealed lines.

- type of pipe and its colour coding and marking
- blueprints
- 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

- Steel will have either blue or yellow plastic coating.
- Polyethylene pipe may be yellow or orange; pipe will have markings indicating it is approved for gas, and a tracer wire should be 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 piping and tubing, other than gas

- Common water lines are copper, plastic, galvanized steel, cast iron, and ductile iron.
- Common sewer lines are plastic and cast iron.
- Electrical and telephone conduits are metallic and non metallic.

Above-ground piping and tubing

Gas lines above ground will be either steel or copper, identified by yellow paint, yellow banding, or labelling (natural gas copper tubing). The B149.1 Gas Code specifies the colour coding of piping and tubing as follows:

a) the entire piping or tubing system shall be painted yellow;

b) the piping or tubing system shall be provided yellow banding; or

c) the piping or tubing system shall be labelled or marked "gas" or "propane" utilizing yellow labels or markings respectively.When identified in accordance with (b) or (c), the identification shall be no more than 20 feet (6 m) intervals. However, tubing installed in a residential occupancy shall be identified at no more than 6 ft (2 m) intervals.

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 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 blueprints are used to locate and identify piping, the *final* drawings must be used. These are called "As Built" drawings meaning that the piping arrangement on the original blueprint may have been changed and the drawing revised to show any changes. The drawing will indicate the system, *as it was built.*

Blueprints and drawings are covered in more detail in Unit 4.

Tracing

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.

Assignment 3

When you have completed the following questions, ask your instructor for the Answer Key.

1. What size is the tracer wire (a) on underground gas piping? (b) What material is it made of?

   a)

   b)

2. Who is responsible for piping downstream of the meter?

3. Coatings on underground steel pipe are made of (a) what material; and (b) in which colours?

   a)

   b)

4. What are two methods to identify above-ground gas piping?

   a)

   b)

5. The final drawings on a job are called:

6. The surest way to identify contents of a sealed pipe is to:

Unit 4 Piping layout, drawings and symbols

Purpose

Before installing any equipment, the gas technician must have a plan. The plan must take into consideration things like *how*, *what*, *where* and *when*. The plan can be very simple, such as setting up a small gas barbecue, or very complex, such as for heating a large office building. In many cases the basic plan will be supplied through blueprints and specifications. Documents such as these, and a knowledge of how to read and apply them, will ensure that the piping layout and installation goes ahead with a minimum of problems.

Learning objectives

1. Explain blueprints and specifications.
2. Describe valves.

Topics

TOPIC 1

Blueprints and specifications

The installation of gas piping is a regular part of the gas technician'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. Answering these questions begins with blueprints and specifications.

Blueprints

On small buildings or installations found in single family dwellings, the gas technician can work from a blueprint or set of house plans. These would *not* normally show water or gas piping. However, the location of fixtures and equipment (such as water heaters and furnaces) for water or gas *would* be shown. Then the piping would be installed, at the discretion of the gas technician. The technician does this in accordance with all applicable codes and bylaws.

Many gas technicians make an isometric drawing of the planned installation which can be used as a takeoff sheet for estimating and ordering of materials. This could include a drawing that can be submitted for approval to the local authority, if required.

On larger installations, the technician works from a complete set of blueprints. This set includes architectural, structural, electrical and mechanical drawings and so on, as required. The gas piping and equipment is found on mechanical drawings, and located and identified on the plan drawing. There may also be detailed and isometric drawings of the layout of specific equipment and components.

The piping shown on the plan is normally a rough location of where piping is to be installed, but there are many factors to be considered before you can begin installation. As a gas technician, 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, duct work, light fixtures, etc., since all installations must be coordinated with the other trades. It is vital to problem-free installation that you have a full set of prints showing both the structure and all the requirements of other trades.

Piping may be located 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. Figure 4-1 shows a typical piping diagram for a building containing two gas appliances.

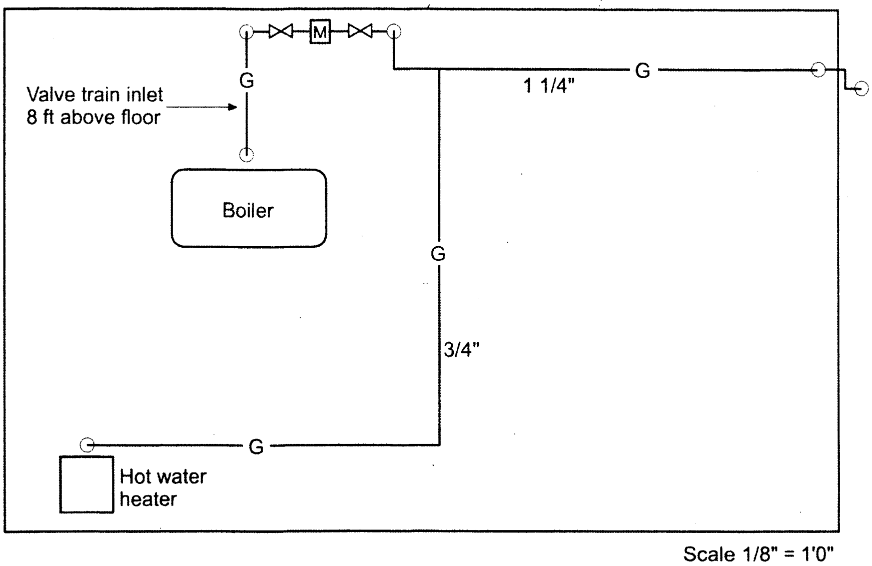


Figure 4-1 Piping drawing of a building containing two gas appliances

Specifications

A specification normally accompanies the construction prints, and can vary considerably in length depending on the size and complexity of the project.

- On smaller jobs, the specifications—or "specs"—may consist simply of a list of materials written on the same page as the drawings.
- On large projects, the 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.

Precedence of specifications

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. For example, if there is any disagreement between the specification and a drawing, the information in the specification is usually taken to be correct. The reason for this is that, since the specifications are usually prepared last, they reflect final decisions. Written instructions also carry more weight in a court of law. However, if a discrepancy is found, it should be reported to the architect and the correct information confirmed in writing.

Interpreting instructions and symbols

Blueprints and specifications provide the gas technician with instructions for the installation of gas piping and equipment. To read and interpret the drawings, you must be aware of how the various pipe lines 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.

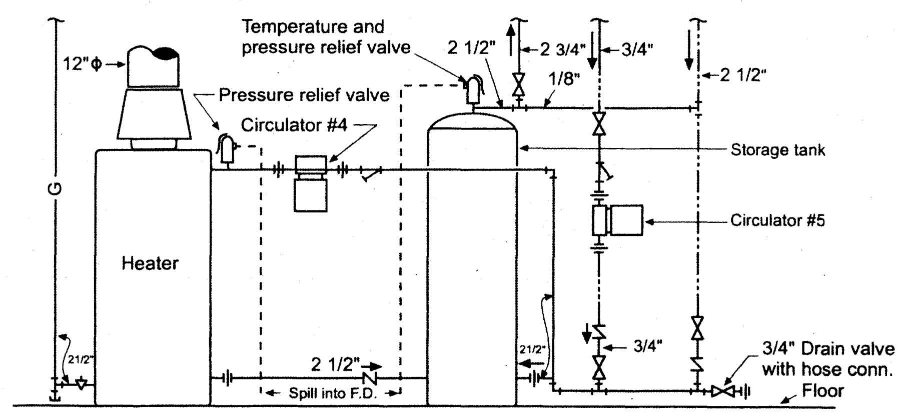


Figure 4-2 Sample pipe fitting drawing

Symbols

Symbols are the shorthand signs used on drawings. Most are recognizable internationally, but some countries still have different symbols. Accredited organizations are the International Standards Organization (ISO), Canadian Standards Association (CSA) and the American National Standards Institute (ANSI). These three organizations publish tables of symbols for welding, piping, surface texture, and electrical elements, all of which you will use as a gas technician.

The Canadian Gas Association lists all of the symbols you will use as a gas technician in the *Industry Glossary* to its *Natural Gas Manual*. Figure 4-3 shows the most common piping symbols.

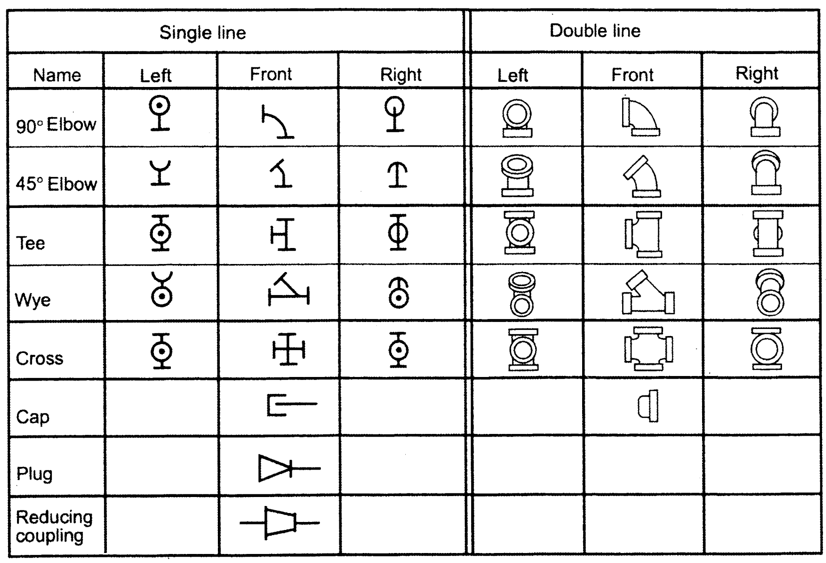


Figure 4-3 Common piping symbols

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. The key to these symbols is shown in Figure 4-5.

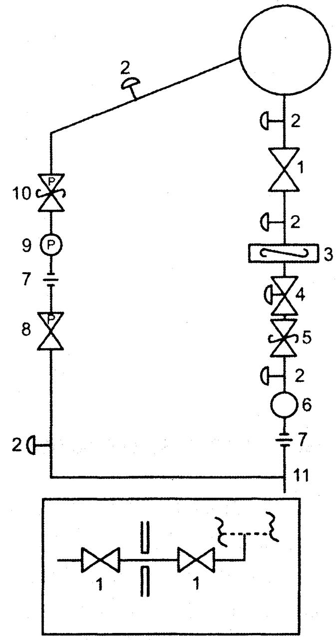


Figure 4-4 Drawing of a valve train showing symbols for various components

Symbol Interpretation	*Symbols*	Symbol Interpretation	Symbols
Main burner test firing valve manually operated low pressure	1	Union connection main burner control manifold	7
Pressure test point	2	Pilot shut-off manually operated	8
Gas input flow ratio valve automatic if modulating	3	Pilot pressure regulator low pressure	9
Main burner automatic, slow-opening input control and fast shut-off valve	4	Pilot automatic control and safety shut-off valve	10
Main burner automatic, safety shut-off valve	5	Pilot supply take-off	11
Main burner gas pressure regulator (low pressure)	6	System regulator	

Figure 4-5 Key to symbols used in Figure 4-4

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.

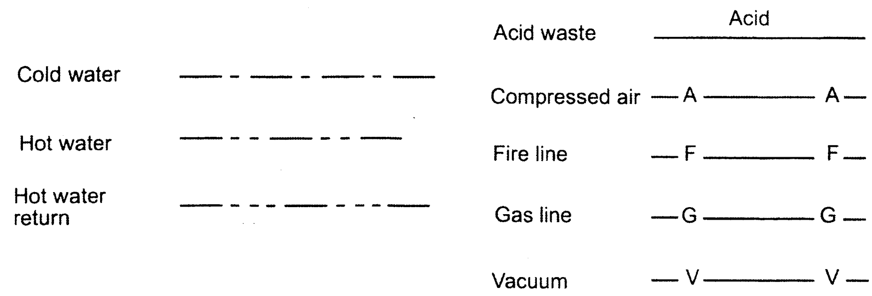


Figure 4-6 Various piping line symbols

Manufacturers' installation data

Manufacturers provide certified installation and service manuals with their appliances. Although the literature varies from company to company, and from product to product, all necessary information for the installation and basic maintenance of the appliance will be included in the manual. It is up to you to find it!

The following excerpts from manufacturer's manuals will show you the various ways installation information can be presented. Again, it is up to you to *read the complete manual* and study the charts and diagrams before you start so that you can begin to locate the tools, hardware, wiring, and piping needed for a trouble-free installation.

Model number

Manufacturers often publish one set of instructions for many different models of the same series of appliances. Table 4-1 shows a typical example of the different vent and combustion pipe details for six different models of the same appliance.

Table 4-1 Example of air and venting information for various models

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

Tools and hardware

Manufacturers will often indicate the tools and hardware required for the installation as shown by the following excerpts:

> *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.*

They may also indicate when hardware is supplied, for example:

> *Secure in place with two hex nuts supplied.*

Wiring and piping

Most manuals come with wiring and piping diagrams which are often accompanied by schedules (Table 4-2) and keys (Table 4-3).

Table 4-2 Example of gas orifice schedule

Gas pilot orifice schedule	Natural gas	LP gas
J(R) 15A-10, J(R) 30A-10(12), J50A-15-flame rod	Std. #44	N/A
J(R) 15A-10, J(R) 30A-10(12) Scanner	Std. #36	Std. #44
J50A-15 Scanner	Std. #36	Std. #44

Table 4-3 Example of wiring diagram key

Description	
Key	**Component**
A67	Receiver–infrared
B3	Motor–blower
GV1	Valve–gas-millivolt
R32	Potentiometer
S1	Thermostat–room
S10	Control–fan
S66	Switch–wall
TC1	Thermopile
Y1	Generator–piezo

Replacement parts

The manuals sometimes specify details on the replacement parts, as shown in the following excerpt:

> *Replacement wire must be type "T" (63°F or 35°C temperature rise) wire or equivalent.*

TOPIC 2

Valves

Gas piping is installed to supply gas to gas-fired equipment and the gas flow is controlled by valves. Of the many types of valves used on gas systems, some are operated manually, some automatically, and some are both manual and automatic. As a gas technician, you must be able to recognize valves as symbols on drawings and to physically identify them on a piping system. All valves used on natural gas and propane systems must be certified.

Since valves are discussed in detail elsewhere in the learning materials, this topic confines itself to identifying the various types of manual and automatic valves, for gas and some for water or steam systems.

Manual

A typical manual valve found on gas systems is a *1/4-turn* valve which will open or close with a quarter-turn of the handle. This ensures that the valve can be opened or closed 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.

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 is a handled ball-type valve approved for both indoor or outdoor use.

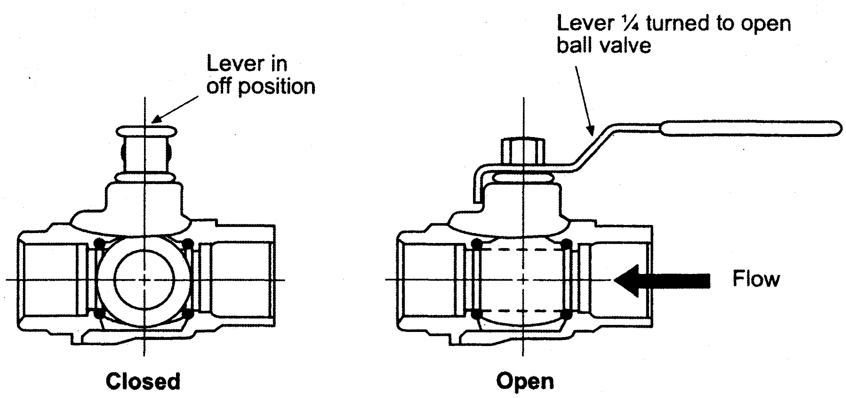


Figure 4-7 Cross-section of a manual ball-type valve

Some valves are designed to be lubricated, and can maintain lubricant between the bearing surfaces. The lapped bearing surfaces are lubricated and the lubricant level maintained without having to remove the valve. The construction of such valves also allows for the lubricant to be reservoired and distributed evenly over the entire lapped bearing surfaces of the valve when the plug is rotated.

Gate valves

As the name implies, a gate valve has a gate that moves up or down to open or close the valve (Figure 4-8). Because of excessive vibration and wear created in partially closed gates, these valves are not intended for throttling or flow regulation, but are designed to operate fully open or fully closed. They are typically used on water and steam installations, *never on gas systems*.

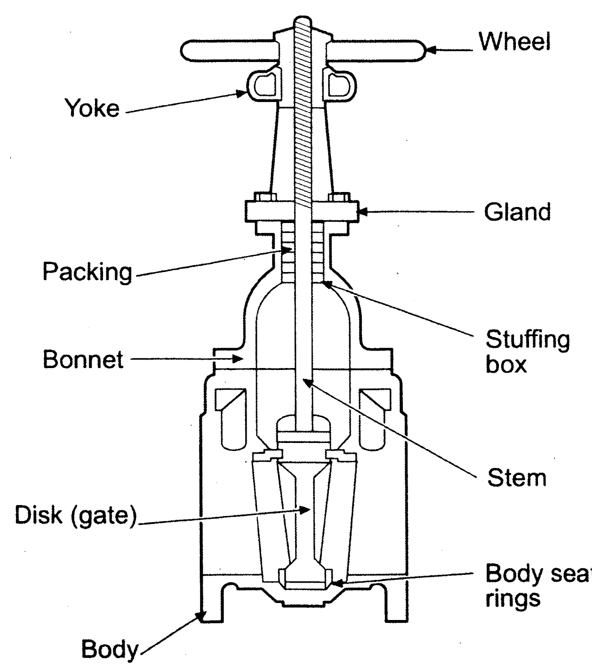


Figure 4-8 Gate valve

Globe valves

Unlike gate valves, globe valves are used in applications with frequent operation or throttling of flow. The design of the globe valve keeps seat erosion to a minimum (Figure 4-9). They are generally used in steam or water applications, *never on gas systems*.

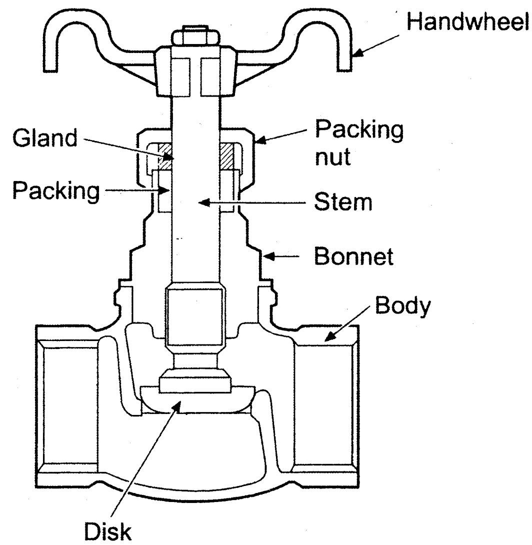


Figure 4-9 Globe valve

Jointing methods for manual valves

Manual gas valves are incorporated into the piping system in different ways. In most cases, the size of the valve dictates the jointing method used. The larger valves are usually flanged in place; the mid-range sizes are threaded; and the smaller sizes, when used with copper tubing, are connected using flare fittings.

Automatic

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)
- 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

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. Refer to Figure 4-10.

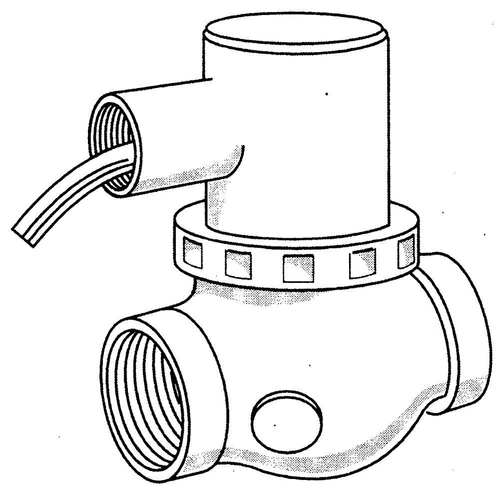


Figure 4-10 Solenoid valve

Manual/ Automatic

An example of a valve that operates both manually and automatically is the latch valve shown in Figure 4-11. This type of valve is opened manually, but only when specific conditions such as proof of air flow are met. When the condition is lost, the valve automatically closes.

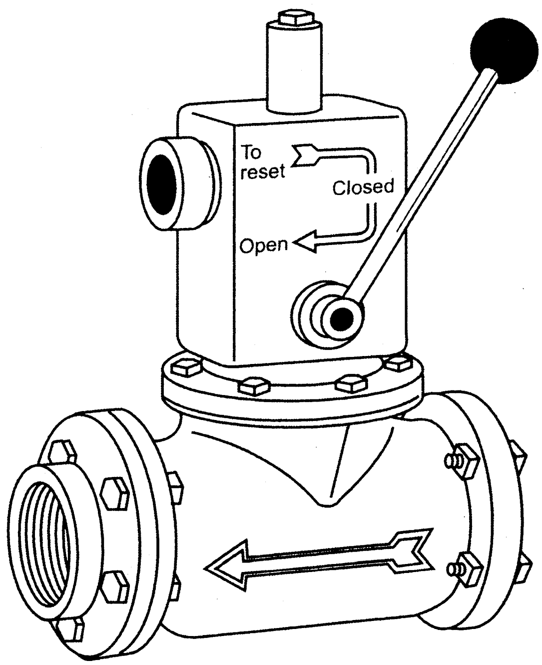


Figure 4-11 Manually opened, automatically closing latch valve

Manual reset shut-off valves shut off the supply of gas to the combustion system when any interlocking limit device in the control circuit opens. If the power unit in the shut-off valve is de-energized, the valve closes and the handle disengages from the internal components to prevent the valve from re-opening. The valve handle cannot be re-engaged with the internal components until the condition causing the open switch in the control circuit is corrected.

Assignment 4

When you have completed the following questions, ask your instructor for the Answer Key.

1. If there is a discrepancy between the specifications and the drawings:
   a) which one is taken to be correct? b) State the reasons for your answer.

   a)

   b)

2. The manufacturer's installation and service manual is supplied with every appliance. How much of it should you read?

3. Do the installation and service manuals supplied by the manufacturer always specify details of replacement parts?

4. The two ways that manual valves are joined to the gas piping systems are:

   a)

   b)

5. What two functions do automatic valves perform?

   a)

   b)

6. Describe the function of a solenoid valve.

Unit 5 Size high-pressure piping and tubing

Purpose

To ensure that gas equipment will operate to design specifications, it must receive the correct amount of gas. One of the main factors governing gas flow is pipe size. The gas technician must be aware of the procedure used to determine the correct pipe size. An organized and methodical approach to sizing will result in the correct size being determined.

Learning objectives

1. Explain the use of sizing tables.
2. Describe the general sizing procedure.
3. Describe the high-pressure sizing procedure.

Topics

TOPIC 1

Use of tables

This topic describes how factors that influence gas flow must be taken into account before you can start to size gas piping systems using Code tables. The factors include:

- maximum pressure drop in different piping systems
- different measurements for copper tubing
- differences between natural gas and propane.

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 been calculated to give the thousands of British Thermal Units per hour that will pass through the different sizes of pipe. 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 the piping system was sized.

Pressure drop

The amount of gas that flows through a pipe increases:

- as the pipe diameter increases
- as the pressure drop across the length of the pipe increases
- as the length of the pipe decreases
- as the density of the gas decreases.

Gas is usually only supplied at distinct pressures (7 inch w.c., 2 psi, 5 psi, 10 psi and 20 psi). The maximum pressure drop across the length of a piping system is a distinct amount for each system pressure.

As a result, the pipe sizing tables in Annex A and Annex B of the B149.1 Code include separate tables for each system pressure.

Copper tube

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 the Code for sizing copper tube.

Note that the tables in the Codebook list tubing sizes *in outside diameters*. Some tubing found in the field is identified by nominal size (*inside diameters*). Therefore, be sure that the outside diameter is used when referring to the tables.

Natural gas vs. propane gas

The set of tables for natural gas (Annex A) are completely different from the set for propane (Annex B), because of the difference in the densities of the two gases (0.6 for natural gas and 1.52 for propane).

General sizing procedure

It is important to be familiar with the general procedure for pipe sizing before you address specific high-pressure sizing procedures (described in Topic 3). Be consistent in following the procedural steps described in this topic.

Procedural steps

1. *Sketch the system*

When you sketch the system, determine the length of the pipe sections and label them. Check for system regulators and do a separate sizing procedure for the piping downstream of each regulator.

2. *Select a table*

To select the correct pipe sizing table you must:

a) Identify the type of gas—the density determines the use of natural gas or propane tables.

b) Identify piping material—iron pipe or copper tubing. Note whether iron pipe will be screwed or welded.

c) Identify the gas pressure and the corresponding pressure drop. Consider the following factors:

- available gas pressure from the utility
- job specifications
- Code requirements
- cost

3. *Determine Code zone*

Determine the appropriate Code zone:

a) For low-pressure and 2 psi systems: These are found by adding the section lengths from your sketch to find the longest measured run (LMR).

b) For pressures over 2 psi: Your estimate is based on the measured run lengths, and on the equivalent lengths of fittings in the runs.

4. *Size pipe sections*

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

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 the LER is larger than the Code zone, you must increase the Code zone length you have estimated in 3 b) above, and continue until the Code zone is long enough. If your Code zone estimate is too long on the first try, prove that a shorter Code zone guess would be too short, unless this is obvious.

6. *Consult Code table*

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

Read across the table to the right to find the highest capacity that is closest to your calculation. Then read straight up to the top of the table to ascertain the appropriate pipe size. (Refer to Figure 5-1 which reproduces a sample Natural Gas Code table with the columns and lines highlighted.)

Equivalent lengths of tees are counted only if the flow to the appliance in question makes a turn at the tee.

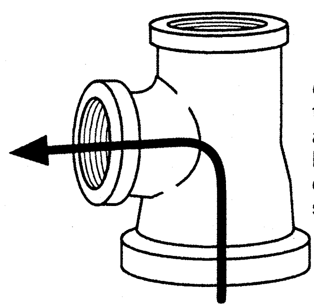
The size of a tee is that of its largest opening. Refer to Figure 5-2.

Figure 5-3 shows a typical *completed* worksheet for carrying out pipe sizing. A blank worksheet is contained in the Appendix to this unit.

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

	Length of pipe (feet)	Pipe size (NPS) 1/2	3/4	1	1 1/4	1 1/2	2	2 1/2
	10	2 800	5 855	11 029	22 643	33 926	65 338	104 139
	20	1 924	4 024	7 580	15 562	23 317	44 907	71 574
	30	1 545	3 231	6 087	12 497	18 725	36 062	57 476
	40	1 323	2 766	5 210	10 696	16 026	30 864	49 192
	50	1 172	2 451	4 617	9 480	14 203	27 354	43 598
	60	1 062	2 221	4 184	8 589	12 869	24 785	39 503
	70	977	2 043	3 849	7 902	11 840	22 802	36 342
	80	909	1 901	3 581	7 351	11 014	21 213	33 810
	90	853	1 783	3 360	6 897	10 334	19 903	31 722
	100	806	1 685	3 173	6 515	9 762	18 800	29 965
	125	714	1 493	2 183	5 774	8 652	16 662	26 557
175 ft	150	647	1 353	2 548	5 232	7 839	15 097	24 063
Code zone	175	595	1 245	2 344	4 813	7 212	13 889	22 138
	200	554	1 158	2 181	4 478	6 709	12 921	20 595
	250	491	1 026	1 933	3 969	5 946	11 452	18 253
	300	445	930	1 751	3 596	5 388	10 376	16 538
	350	409	855	1 611	3 308	4 957	9 546	15 215
	400	381	796	1 499	3 078	4 611	8 881	14 155
	450	357	747	1 406	2 888	4 327	8 333	13 281
	500	337	705	1 329	2 728	4 087	7 871	12 545
	550	320	670	1 262	2 591	3 881	7 475	11 915
	600	306	639	1 204	2 471	3 703	7 132	11 367

Figure 5-1 Sample Code table for sizing large pipe



If a tee changes the direction of flow in the line being calculated an equivalent length must be added. The largest opening of the tee is the size used.

Figure 5-2 Tee-fitting

Proof of procedure

To prove the procedure for any appliance run, you must

1. List valves and all fittings that change the direction of flow.
2. Look up their equivalent lengths from either Table A.16 or B.12 of the B149.1 Code.
3. Total the fitting equivalent lengths.
4. To this total, add the length of the measured run to the particular appliance. The resulting sum is the LER of the appliance.

Piping System EXAMPLE 1

Type of Gas NATURAL GAS

System Pressure 5 PSIG

Table A.5 (a)

Type of Pipe IRON PIPE THREADED

Allowable Pressure Drop 2.5 PSIG

Line Number	Load MBtu/h kW	Estimated Pipe Size	Confirmed Pipe Size	Max. Load Allowable
A	1000	3/4"	3/4"	1245
B	750	3/4"	3/4"	1245
C	1750	1"	1"	2344

Fittings Line #	Thread Fitting Size/Type	Weld # of Fittings	Ft Equiv. Length	M Total
A-C	1" 90°	3	2.62	7.86
	1" T	1	5.24	5.24
	3/4 90°	2	2.06	4.12
	3/4 VLV.	1	2.06	2.06
				19.28
B-C	1" 90°	3	2.62	7.86
	1" T	1	5.24	5.24
	3/4 90°	1	2.06	2.06
	3/4 VLV.	1	2.06	2.06
				17.22

	Line #	Measured Length	Estimated CZ	Fitting Allowance from Above	Length Equivalent Run (LER)	Longest (LER)	Confirm CZ
Proof	A-C	145	175	19.28	164.28	164.28	175
Proof	B-C	140	175	17.22	157.22		
Proof							

Figure 5-3 Sample pipe sizing and proving work sheet

TOPIC 3

High-pressure sizing procedure

Normally, the Gas Code considers any gas above 0.5 psig to be high-pressure. However, the pipe-sizing tables are based on the formulas which are included in the Codebooks. Two sets of formulas are used:

- for pressures up to 1.5 psig
- for pressures 1.5 psig and higher.

The tables in the Codebook are derived from these formulas.

Summary of procedure

The procedure for sizing a high-pressure piping system is very similar to the general procedures, as summarized in the following list of calculations to be made, except as shown for Steps 8 through 10:

1. Type of gas
2. Type of pipe
3. System pressure
4. Pressure drop
5. Pipe sizing table
6. Pipe loads
7. Longest measured run
8. 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.
10. Prove Code zone.
    (This is a check to see whether you chose the correct Code zone. It is very important because, since you have estimated the Code zone, you must check whether that pipe size will actually carry the gas load. You do this by checking whether the measured length added to the equivalent length exceeds the Code zone length.)

Systems containing more than one-stage

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.

Size the lower pressure zones first!

The following examples are shown for natural gas and propane.

Natural Gas Example 1 (Imperial)

Referring to Figure 5-4 on the following page, go through the following pipe sizing procedure.

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 the B149.1 Code
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")

**Note: 1 MBtu/h = 1000 Btu/h*

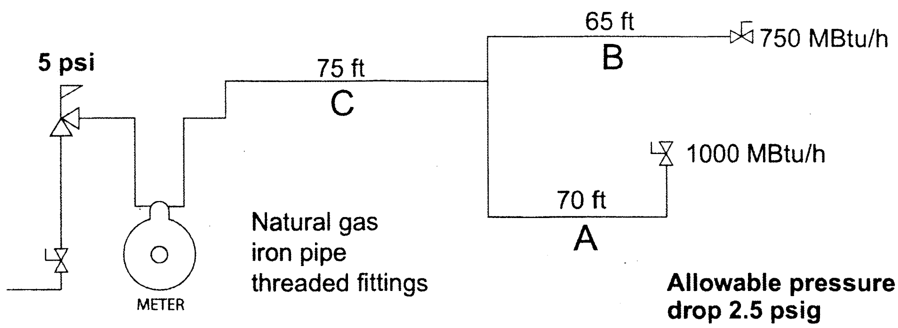


Figure 5-4 Schematic diagram for sizing high-pressure gas piping system (Imperial measurements)

1. Preliminary analysis (estimating)

Code zone (CZ)

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 the Code, 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, 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)	Dia.	Max. load (MBtu/h)
A	1000	3/4 inch	1245
B	750	3/4 inch	1245
C	1750	1 inch	2344

Prove length of pipe runs

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

2. Proof procedure

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

Prove Pipe A

3 — 1 inch threaded 90° @ 2.62 ft		7.86 ft
1 — 1 inch threaded T @ 5.24 ft		5.24 ft
2 — 3/4 inch threaded 90° @ 2.06 ft		4.12 ft
1 — 3/4 inch valve @ 2.06 ft		2.06 ft
	Equivalent length	19.28 ft

Equivalent Length (EL)	19.28 ft
Measured Length (ML)	145.00 ft
Length of Equivalent Run (LER)	164.28 ft

Prove Pipe B

3 — 1 inch threaded 90° @ 2.62 ft		7.86 ft
1 — 1 inch threaded T @ 5.24 ft		5.24 ft
1 — 3/4 inch threaded 90° @ 2.06 ft		2.06 ft
1 — 3/4 inch valve @ 2.06 ft		2.06 ft
	Equivalent Length	17.22 ft

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

If both pipe A and pipe B's length of equivalent runs are *less* than the selected Code zone, the Code zone is 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 the pipe is sized correctly.

Note:

If any LER had *exceeded the chosen Code zone, it would indicate the chosen Code zone is too short and the piping would have to be resized, re-analyzed and re-proved on the next longest Code zone.*

Natural Gas Example 2 (metric)

Referring to Figure 5-5, go through the pipe sizing procedure.

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 the *B149.1 Code*
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)

1. Preliminary analysis (estimating)

Code zone (CZ) CZ chosen is 60 m

Size pipe On 60 m Code zone:

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

Prove length of pipe runs

At this point, the pipe has been sized 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.

Starting with the longest measured run, list all fittings on that run. Look up their equivalent lengths from Table A.16(b) in the *B149.1 Code*.

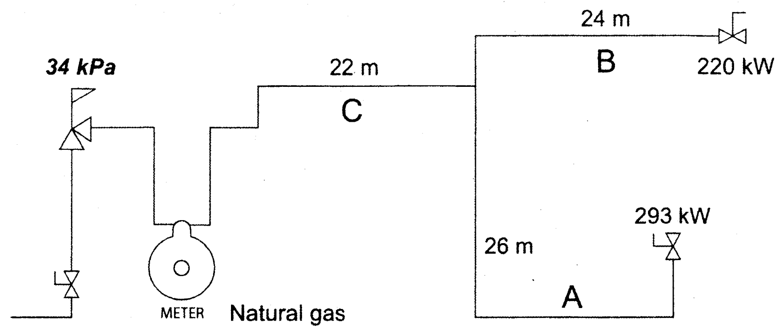


Figure 5-5 Schematic diagram for sizing high-pressure gas piping system (metric measurements)

2. Proof procedure

Prove Pipe A

3 — 1 inch threaded 90° @ 0.8 m		2.40 m
1 — 1 inch threaded 'T' @ 1.60 m		1.60 m
2 — 3/4 inch threaded 90° elbows @ 0.63 m		1.26 m
1 — 3/4 inch valve @ 0.63 m		0.63 m
Equivalent length		5.89 m
Equivalent Length (EL)	5.89 m	
Measured Length (ML)	48.00 m	
Length of Equivalent Run (LER)	53.89 m	

Prove Pipe B

3 — 1 inch threaded 90° @ 0.8 m		2.40 m
1 — 1 inch threaded 'T' @ 1.6 m		1.60 m
1 — 3/4 inch threaded 90° elbows @ 0.63 m		0.63 m
1 — 3/4 inch valve @ 0.63 m		0.63 m
Equivalent length		5.26 m
Equivalent Length (EL)	5.26 m	
Measured Length (ML)	46.00 m	
Length of Equivalent Run (LER)	51.26 m	

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 60 m. Therefore, the 60 m Code zone is okay and the pipe is sized correctly.

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.

Referring to Figure 5-6, go through the following procedure:

Step 1—Calculate low pressure zone

Type of gas	Propane
Type of pipe	Copper tubing
System pressure	11 inch w.c.
Allowable pressure drop	1 inch w.c.
Pipe sizing table	Table B.1(a) in the *B149.1 Code*
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
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 inch	343
B	35	1/2 inch	68
C	285	7/8 inch	343

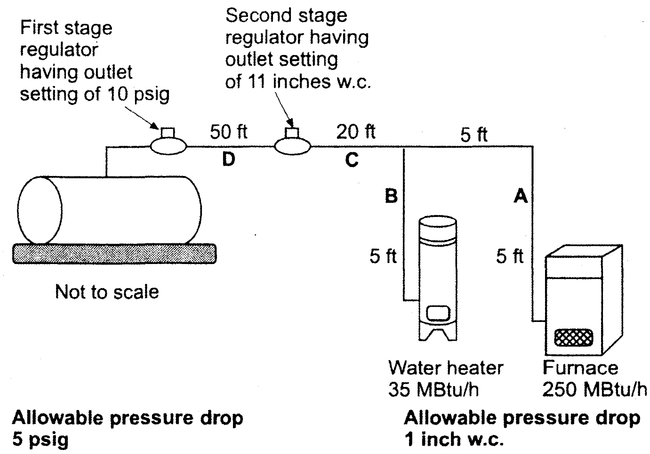


Figure 5-6 Schematic diagram of a two-stage propane piping system

Step 2—Calculate high pressure zone

Type of gas	Propane
Type of pipe	Copper tubing
System pressure	10 psig
Allowable pressure drop	5 psig
Pipe sizing table	Table B.4(a) in the *B149.1 Code*
Pipe loads	Line D = 285 MBtu/h
LMR	50 ft
Code zone	50 ft
Size Line D	Load: 285 MBtu/h 3/8 inch
	Max. Load: 496 MBtu/h

Now complete Assignments 5-1—5-6.

Assignment 5-1

When you have completed the following questions and the exercises that follow, ask your instructor for the Answer Keys.

1. Why are there different sizing tables in the Code for (a) copper tubing and (b) steel pipe?

   a)

   b)

2. State the five procedural steps when pipe sizing.

Assignment 5-2

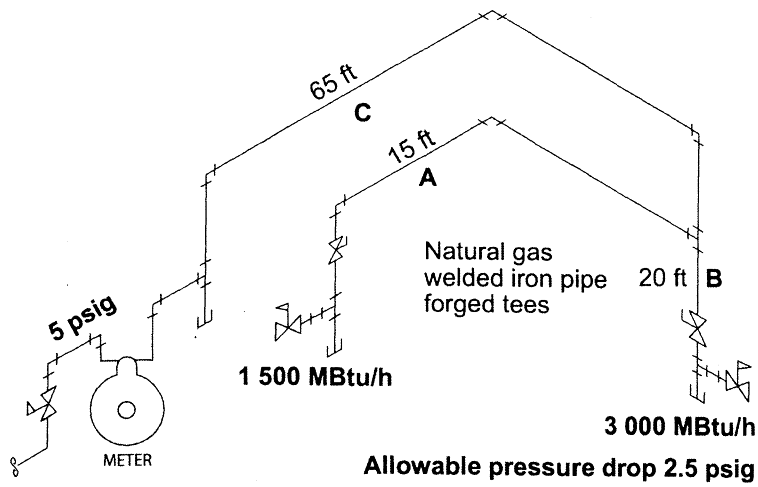


Figure 5-A2

Assignment 5-2

Size the drawing in Figure 5-A2 (opposite) and show your calculations here.

Assignment 5-3

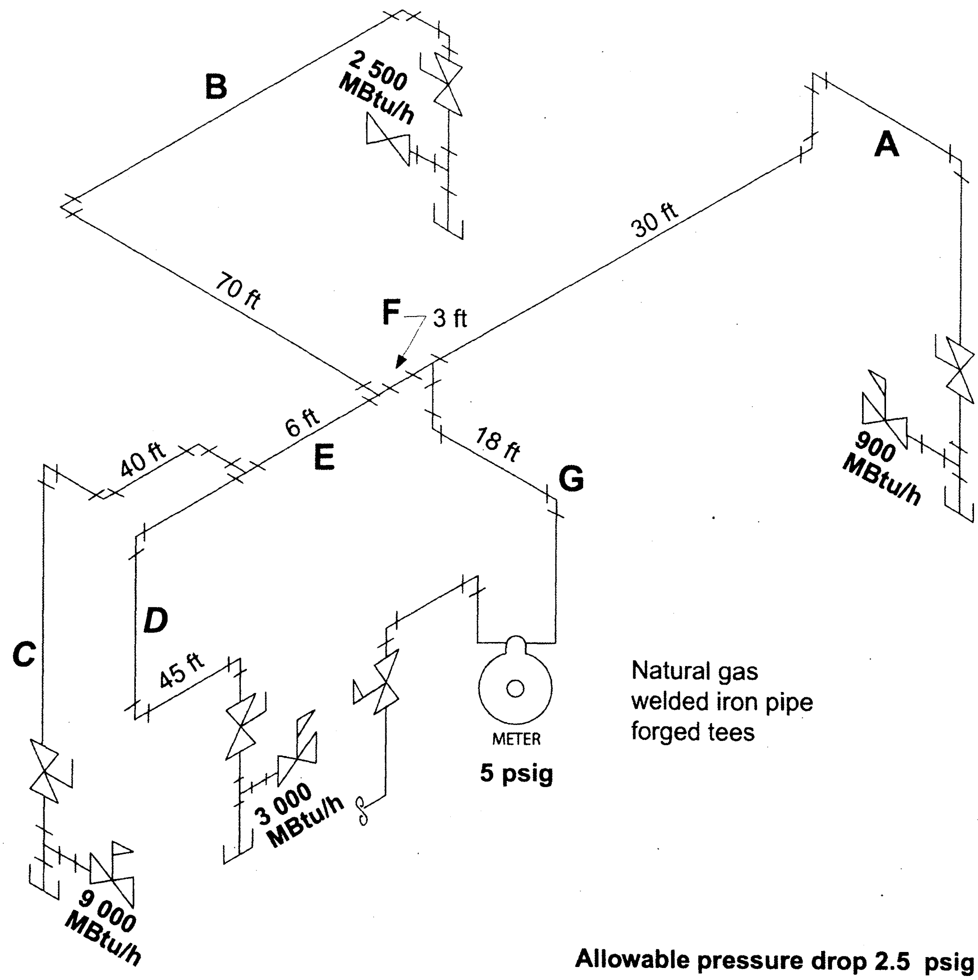


Figure 5-A3

Assignment 5-3

Size the drawing in Figure 5-A3 (opposite) and show your calculations here.

Assignment 5-4

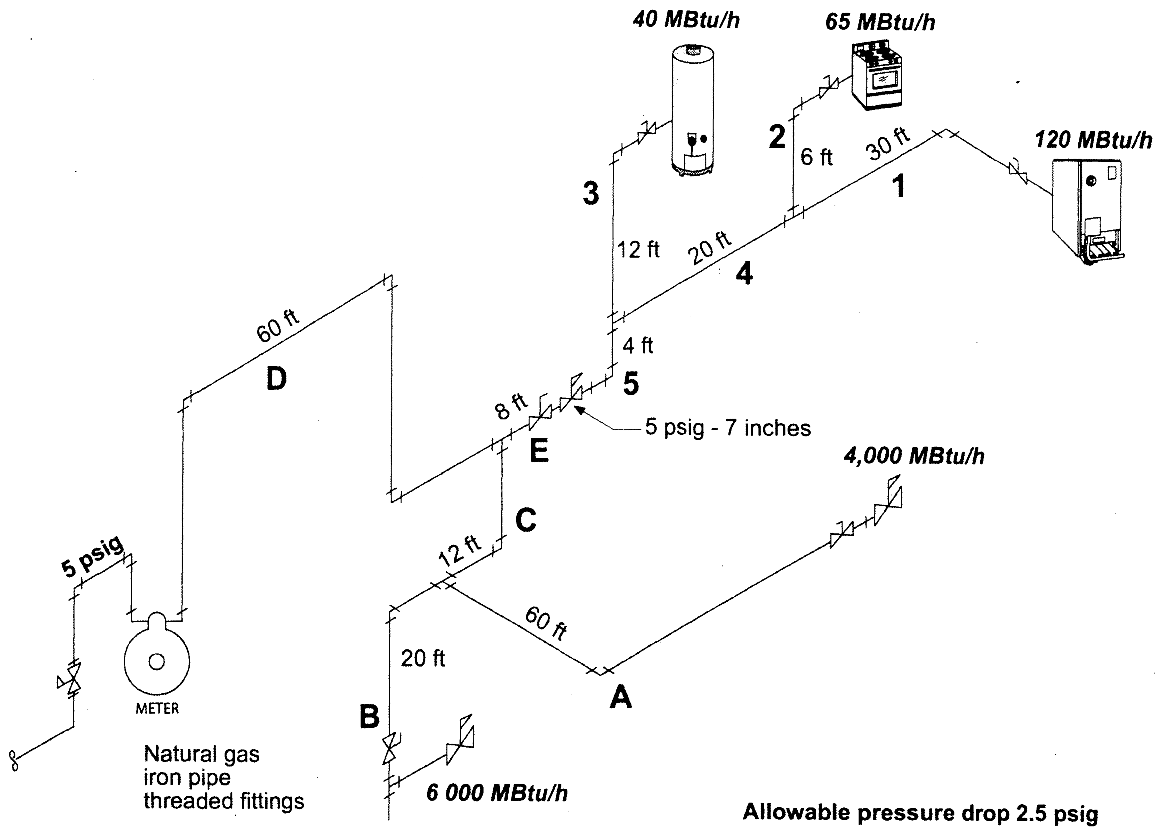
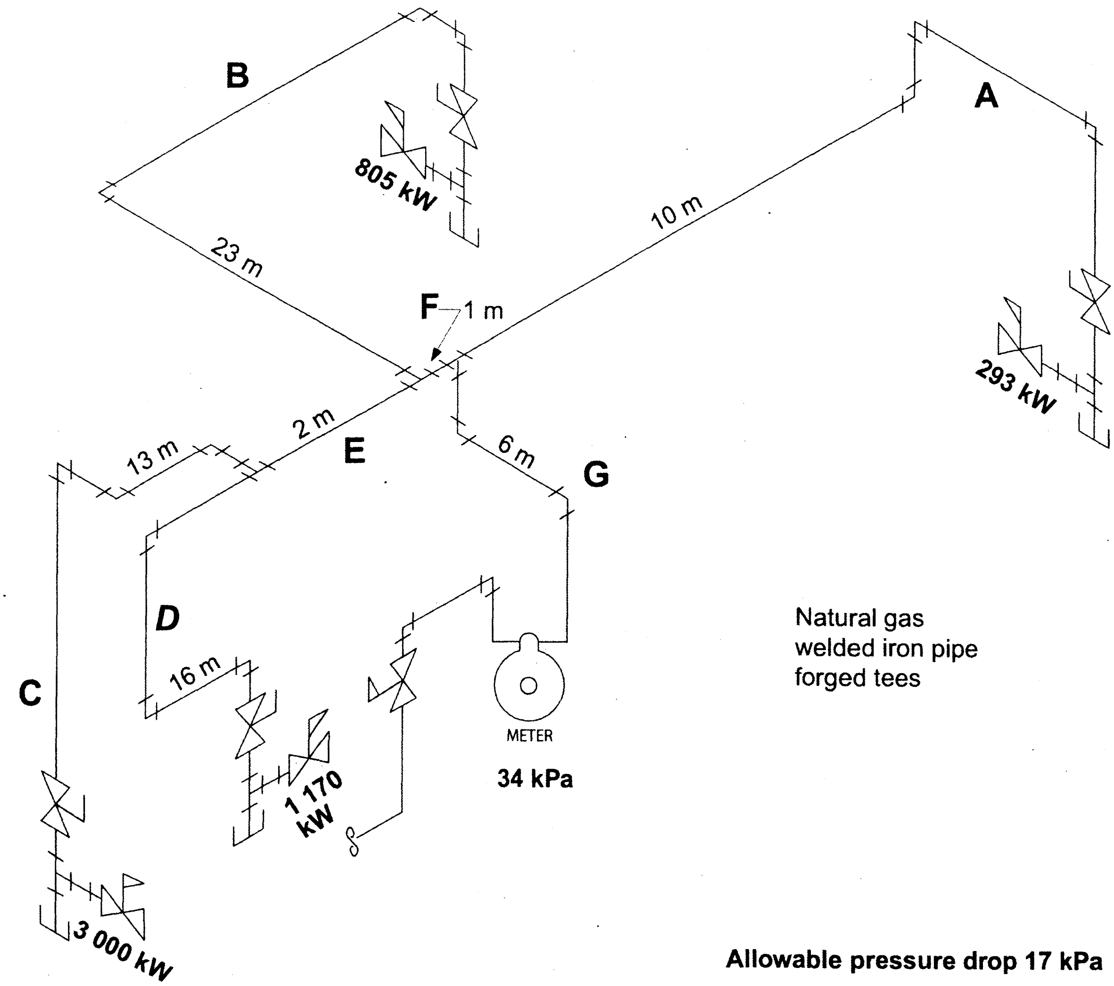


Figure 5-A4

Assignment 5-4

Size the drawing in Figure 5-A4 (opposite) and show your calculations here.

Assignment 5-5



Natural gas
welded iron pipe
forged tees

Allowable pressure drop 17 kPa

Figure 5-A5

Assignment 5-5

Size the drawing in Figure 5-A5 (opposite) and show your calculations here.

Assignment 5-6

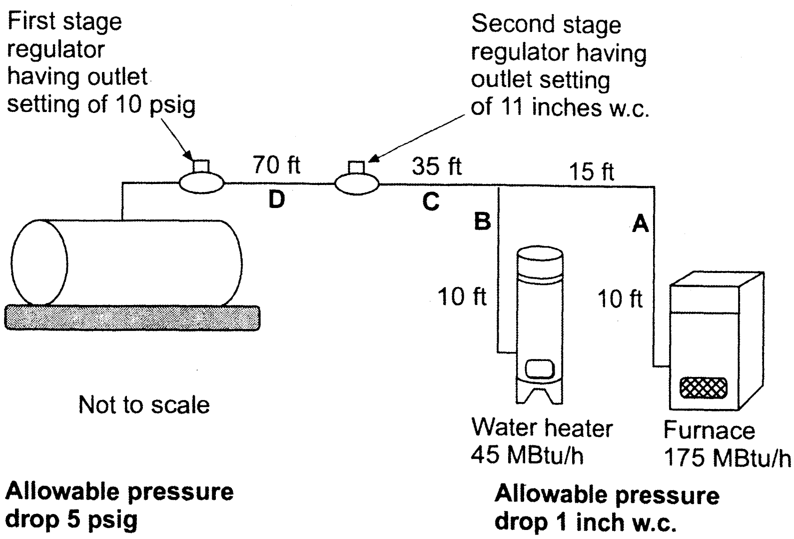


Figure 5-A6

Assignment 5-6

Size the drawing in Figure 5-A6 (opposite) and show your calculations here.

APPENDIX A TO UNIT 5

Pipe sizing and proving work sheet

The attached work sheet is described in Topic 2 of this unit.

Piping System ______________________

Type of Gas ______________________ Type of Pipe ______________________

System Pressure ______________________ Allowable Pressure Drop ______________________

Table ____________________

Line Number	Load MBtu/h kW	Estimated Pipe Size	Confirmed Pipe Size	Max. Load Allowable

Fittings Thread ✓ Weld ___ Ft ___ Mtr ___				
Line #	Fitting Size/Type	# of Fittings	Equiv. length	Total

	Line #	Measured Length	Estimated CZ	Fitting Allowance from above	Length Equivalent Run (LER)	Longest (LER)	Confirm CZ
Proof							
Proof							
Proof							

Unit 6 Purging operations on large piping systems

Purpose

The methods used to purge large diameter piping are somewhat different to those used to purge 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 must be aware that the use of inert gases to purge large lines removes the posibility of accidental ignition and explosion.

Learning objectives

1. Describe the Code requirements.
2. Explain the safety reasons for purging.
3. Describe the types of purging.

Topics

TOPIC 1

Review Code requirements

Purging is carried out in the gas industry for two reasons:

- to safely introduce fuel gas into a pipeline
- to safely remove fuel gas from a pipeline for the purposes of abandonment and repair.

The Codes are concerned with purging:

- of piping and tubing systems and hose after leak testing.
- and refer to gas mixtures to be used for purging other than for leak testing: i.e. "for the purpose of repair, alteration, or abandonment."

The CSA B149.1 Code contains specific recommendations for large piping:

- If the piping is NPS 4 or larger, and air has been used for testing, it must be first purged with carbon dioxide, nitrogen or a mixture of these, and then purged with gas in accordance with Clause 6.23.7.
- The person doing the purging shall be in direct control of the purging gas supply during the purging operation by means of a valve having an attached operating handle.
- The piping for the gas being purged shall either be of a size or be reduced to a size not larger than NPS 1/2 for piping up to NPS 4.

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

Topic 2

Safety reasons for purging

Whenever air and fuel gas are mixed together, there is a very real risk of a serious explosion. Gas technicians who are ignorant of, or refuse to follow proper purging procedures create highly dangerous conditions. Code regulations require that you purge correctly to prevent the accidental explosion of a gas–air mixture outside and inside the pipe.

Fire and explosion outside pipe

If you mix natural gas and air in a ratio that falls between 4% and 15%, you produce a combustible mixture. It is therefore important that you not purge into any confined space, such as a room where the potential for fire and explosion exist.

Do not:

- *purge a new gas line through the burner system into a combustion chamber*
- *crack the piping union open and allow an uncontrolled escape of gas.*

Fire and explosion inside pipe

Explosion inside the pipe is a serious hazard, especially when the diameter of the pipe is 4 inches or greater. The larger pipe walls are not strong enough to contain the pressure increase as the gas–air mix burns inside, and the pipe bursts, causing serious damage.

Remember that there are sources of ignition inside the pipe. Even with a very little pressure drop, gas moves at very high velocities. At high velocities, iron filings, stones, and other debris inside the pipe are swept along and create sparks. In the case of an inadequately purged pipe, this causes any volume of combustible mixture inside the pipe to burn, since the three conditions necessary for ignition—fuel, oxygen and heat—are all present.

TOPIC 3

Types of purging

Purging may be divided into two broad categories, based on whether the pipes fall above or below Nominal Pipe Size 4 (NPS 4). Note the difference between them and ensure you follow the category for all large-size piping.

Review the description of purging of pipes less than NPS 4 in Module 8.

For larger pipes, two types of purging can be used:

- two separate purges in succession
- slug purging.

Two purges in succession

For larger pipes, introducing or removing fuel gas into a pipe requires two separate purges *in succession*

- *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*
  Purge fuel gas with inert gas before you repair or abandon an existing large system.

Slug purging

For very long, large pipes (such as those installed by the gas supply company), instead of doing two successive purges, you might *slug-purge* to flush out all the contents of the pipe. Slug purging reduces the amount of inert gas you would otherwise have to use.

To slug-purge large pipes:

1. Inject a mass of inert gas, called a *slug*, into the pipe.
2. Flush the slug gas with the fuel gas.

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. Observe the following practices:

- 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.
- 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 (found in piping tables).
- 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.

Assignment 6

When you have completed the following questions, ask your instructor for the Answer Key.

1. With what would you purge a pipe sized 4 inches or over, if it has been tested with air?

2. What can occur when purging is not carried out correctly?

3. Is it acceptable to purge a new gas line through the burner system into a combustion chamber?

4. Why is it important to purge the air out of larger diameter pipes with an inert gas prior to the fuel gas being introduced into the pipe?

5. What is an alternative to completely purging long, large pipes with nitrogen?

6. What is normal purge velocity for large pipes?

Module 12

Controls

Gas-fired appliances are designed, built and installed for various processes. The supply of gas and the disbursement of the energy produced must be done safely and efficiently. This is accomplished with the use of controls and control systems. The types, concepts, and operations for these controls are numerous: from manual to automatic, electrical to mechanical as well as solid state. This module gives an overview of how gas systems are controlled and how various components are used to start, stop, and sequence the operation in such a way as to ensure the equipment is working correctly.

At the end of this module you will be able to:

- Describe the fundamentals of controls
- Describe and troubleshoot control circuits
- Service and troubleshoot controls
- Describe and select motors

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