16) Correctly complete the following sentence with the appropriate word provided:
    In a "cutting" operation with an electric saw, _____ lubricants are used to reduce friction between the cutting blade and the material being cut.
    a)   Anti-welding
    b)   Abrasive
    c)   Purple
    d)   Gray

17) Low- and high-velocity cartridges are distinguished by their cases. What type of case do low-velocity cartridges have?
    a)   Nickel
    b)   Aluminum
    c)   Plastic
    d)   Brass

18) Low- and high-velocity cartridges are rated weakest to strongest according to a colour code. What colour is the strongest colour-code?
    a)   Purple
    b)   Grey
    c)   Brown
    d)   Red

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# 4. Measuring tools

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# Overview

# Purpose

The installation of piping systems and gas equipment involves measurement. This Chapter provides descriptions and formulas for some of the basic Units of measurement and describes the most commonly used measuring instruments and tools.

# Objectives

At the end of this Chapter you will be able to:
• describe Units of measurement and dimensions;
• describe requirements for selecting measuring tools;
• identify types of measuring tools; and
• describe the use of measuring tools.

## Terminology

| Term | Abbreviation (symbol) | Definition |
|---|---|---|
| Area | A | The extent or measurement of a surface. |
| Circumference | C | The enclosing boundary of a curved geometric figure, especially a circle. |
| Cubic foot | $ft^3$ | The volume of a cube with sides of one foot (0.3048 m) in length. |
| Cubic meter | $m^3$ | The volume of a cube with edges one meter in length. |
| Diameter | D | A straight line passing from side to side through the center of a body or figure, especially a circle or sphere. |
| Height | H | The measurement from base to top or (of a standing person) from head to foot. |
| Length | L | The measurement or extent of something from end to end. |
| Pi | $\pi$ | The ratio of a circle's circumference to its diameter, commonly approximated as 3.1416. |
| Radius | R | A straight line from the center to the circumference of a circle or sphere. |
| Square feet | $ft^2$ | The area of a square whose sides measure exactly one foot. |
| Square meters | $m^2$ | The area of a square whose sides measure exactly one meter. |
| Volume | V | The amount of space that a substance or object occupies, or that is enclosed within a container, especially when great. |
| Width | W | The measurement or extent of something from side to side. |

# Measurement of dimensions

Gas technicians/fitters usually measure the dimensions of solid objects with simple tools and methods. Some use more specialized tools.

# Measurements involving straight lines

## Length, width, and height

Length (L), width (W), and height (H) are measured in straight lines from one point to another, as shown in Figure 4-1, usually with a ruler or measuring tape.

They are expressed in imperial Units such as inches and feet, or metric Units such as millimeters and meters.

**Figure 4-1**
**Rectangular cube showing length, width, height, and area**
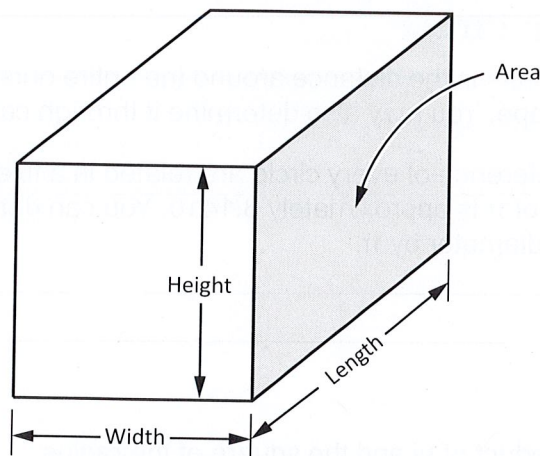


## Area

Area (A) of a rectangle is the product of its length and width. It is expressed in *square* Units such as square feet (ft²) or square meters (m²).

$$A = L \times W$$

## Volume

Volume (V) of a cube is the product of its length, width, and height. It is expressed in cubic Units such as cubic feet (ft³) or cubic meters (m³).
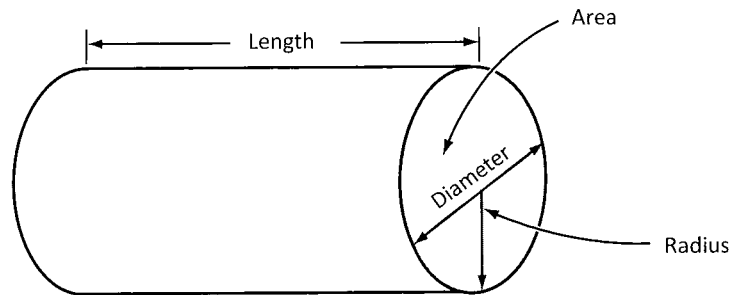
$$V = L \times W \times H$$

# Measurements involving circles

## Diameter of a circle

The diameter (D), measured like any other straight length, is the distance across the circle at its widest point. A diameter (D) divides the circle in half. Half of it is called the radius (R). See Figure 4-2.

**Figure 4-2**
**Cylinder showing length, diameter, and circular area**



## Circumference of a circle

The circumference (C) of a circle is the distance around the entire outside edge. In some cases, you can measure it using a tape. You may also determine it through calculation.

The diameter (D) and circumference of every circle are related in a fixed ratio known as *pi* (the Greek symbol π). The value of π is approximately 3.1416. You can determine the circumference of a circle by multiplying the diameter by π.

$$C = \pi \times D = 2 \times \pi \times R$$

## Area of a circle

The area of a circle is the product of pi and the square of the radius.

$$A = \pi \times R^2$$

Because the radius is half the diameter, the area is also equal to the product of 0.7854 and the square of the diameter.

$$(3.1416 \div 4 = 0.7854)$$
$$A = 0.7854 \times D^2$$

## Volume of a cylinder

The volume (V) of a cylinder (such as pipe) is the product of the area (A) of the circle and the cylinder's length (L) (or height).

$$V = A \times L = 0.7854 \times D^2 \times L$$

# Requirements for selecting measuring tools

## Selecting the right tool

The tool to select depends on the following:
- the type of measurement required;
- rough size of the dimension you are measuring;
- required precision of the measurement; and
- accuracy of available tools.

The application of the measurement—it may be for:
- measuring components and equipment;
- aligning components and equipment; or
- checking sizes of components and equipment.

## Storage and maintenance

To maintain accuracy and reliability of measuring tools, do the following:
- Handle tools with care.
- Keep tools clean as you work.
- Use tools only for the job for which they are designed.
- Put a thin coating of oil on moving parts.
- Store them in a clean, dry environment.

Before using any measuring tool, check that it has been maintained properly to give accurate measurements.

# Types of measuring tools

Many of the tools used in the gas industry are quite familiar. They include:
- hinged and jointed folding rules;
- spring-loaded tapes;
- squares; and
- straight edges.

Gas technicians/fitters occasionally use drill gauges, feeler gauges, micrometers, calipers, and other instruments.

## Spring-loaded tapes

Long flexible steel tapes are wound inside a carrying case. Their lengths range from 50 ft to 200 ft (15 m to 60 m). Longer metric tapes have markings every 2 mm. Longer imperial tapes have markings every 1/8 in. They have a crank handle to retract the tape. A hook at the zero end can extend to brace against the measured object for external measurements. Alternatively, it can fold to hook over a nail.

## Pocket tapes

The pocket-type or spring-loaded tape is the measuring device that gas technicians/fitters use most often. It is easy to carry, accurate, and long enough for most purposes. Metric tapes have markings every millimeter. Imperial tapes have markings every 1/16 in or 1/32 in.

You can use it for internal and external measurements. A hook at the zero end of the tape braces the tape for external measurements. The width of the case is marked, so that you can deduct it from internal measurements.

Available tape widths are 1/2 in, 3/4 in, and 1 in (12 mm, 19 mm, and 25 mm). Wide tapes are more rigid when extended. Narrow blades are easier to carry.

## Folding rules

There are two basic types of folding rules: hinged and spring-jointed. Both may be made of plastic, metal or wood. Metric rules have markings every millimeter. Imperial rules have markings every 1/16 in or 1/32 in.

They fold to 6 in or 8 in (150 mm to 200 mm), so that you can easily carry them. When extended, folding rules are rigid and can span distances without sagging. This gives greater accuracy than a steel tape on long spans.
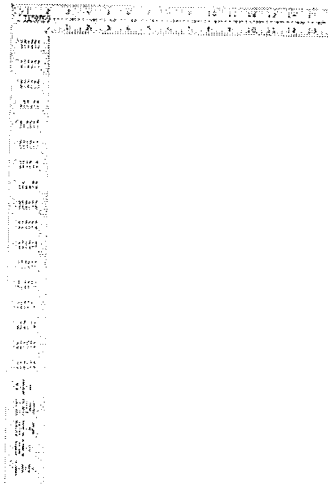
## Squares and straight edges

Gas technicians/fitters use straight edges and squares for:
- marking straight layout lines and some basic angles such as 90° and 45°;
- laying out supports, brackets, and welded pipe.; and
- squaring up pipe and other equipment.

### Squares

The most common square is a right angle (Figure 4-3) made up of a 2 ft (600 mm) long straight edge and a 16 in (400 mm) straight edge. Gas technicians/fitters most often use it to lay out and fabricate welded pipe and fittings.

**Figure 4-3**
**Framing square**
**Image courtesy of DeWalt**



## Try squares

Try squares have a single straight edge connected to a handle. Their blade lengths are usually only 6 in to 10 in (150 mm to 250 mm), so gas technicians/fitters use them on smaller work pieces. The handle may be at 90° to the straight edge or 45°. The 45°-angle ones are called try and miter squares.

## Combination squares

The combination square (Figure 4-4) has an adjustable head that can be fixed anywhere along its length. The steel rule is 12 in (300 mm) long. The head has one edge at 90° to the blade and another at 45°. You may use it for:

- marking 90° and 45° angles;
- as a depth gauge;
- as a marker gauge; and
- marking a line parallel to the edge of a work piece at a set distance.
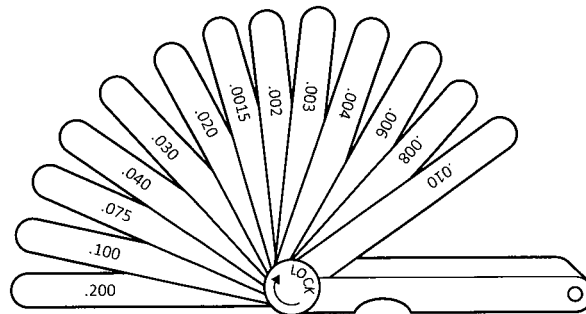
**Figure 4-4**
**Combination square**
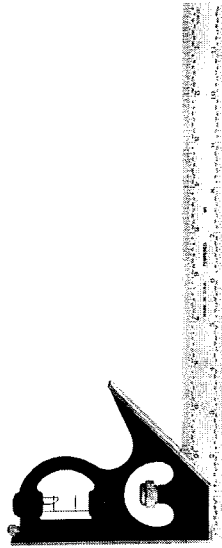


# Gauges and drills

## Feeler gauges

Gas technicians/fitters use feeler gauges (Figure 4-5) to determine the amount of clearance between parts, such as the spark plug gaps on spark igniters.
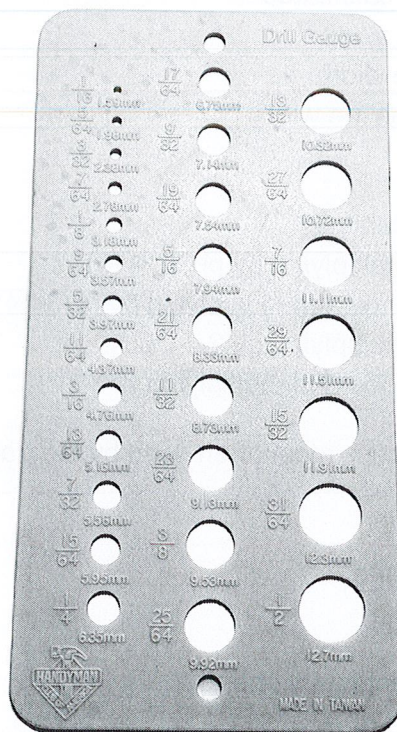
**Figure 4-5**
**Set of feeler gauges**



## Drill gauges

A drill gauge (Figure 4-6) helps measure the diameter of drill bits. It is available in metric, letter, and fractional sizes.
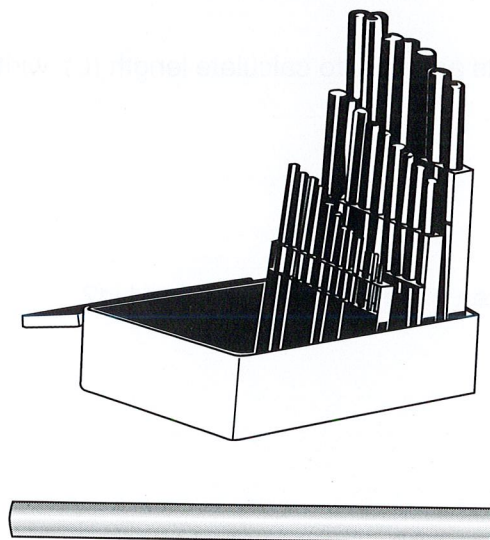
**Figure 4-6**
**Drill gauge**
**Image courtesy of Terry Bell**



## Drill bit blanks

A drill bit blank (Figure 4-7) measures the size of a small hole. Typically, gas technicians/fitters use it to measure the size of a gas orifice.

**Figure 4-7**
**Drill bit blank**

# Assignment Questions – Chapter 4

1) How is the area of a rectangle calculated?
   a) Adding the length of the 4 sides
   b) Adding the length plus the width
   c) Multiplying the length times the width
   d) Using pi R2

2) How is the area of a circle calculated?
   a) Squaring the radius and multiplying by pi (3.1416)
   b) Measuring the circumference and multiplying by pi (3.1416)
   c) Squaring the radius and multiplying by 2
   d) Measuring the circumference and multiplying 2

3) Which type of measuring device is most often used by the gas technician/fitter?
   a) Spirit level
   b) Stopwatch
   c) Pocket or spring-loaded tape
   d) Surveyor (Long tape)

4) Which type of square has an adjustable head?
   a) Crescent square
   b) Combination square
   c) Open end square
   d) Try square

5) What is a drill gauge used for?
   a) Identifying the type of material the drill bit is used for
   b) Measuring screw size
   c) Measuring drill size

6) What type of measurements are used to calculate length (L), width (W), and height (H)?
   a) Straight-line
   b) Square
   c) Area
   d) Circumference

7) What type of Units is the area of a rectangle expressed in?
   a) Cubic
   b) Imperial
   c) Metric
   d) Square