

- 8) What type of transformer consists of a single coil that serves as both the primary and secondary windings?
- AC transformer
 - DC transformer
 - Autotransformer

7. Electrical measuring instruments

Overview

Purpose

The gas technician/fitter requires knowledge of electrical measuring instruments. It is important to understand how to safely use and interpret instrument readings to effectively troubleshoot the types of electrical equipment and circuits in the gas industry.

Objectives

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

- identify and select common electrical measuring instruments;
- describe how to use electrical measuring instruments; and
- read electrical measuring instruments.

Terminology

Term	Abbreviation (symbol)	Definition
Digital multimeter	DMM	Digital electronic measuring instrument that combines several functions in one Unit
Volt-ohm-milliammeter	VOM	Electronic measuring instrument that combines several functions in one Unit

Common electrical measuring instruments

The three most common electrical measuring instruments are:

Instrument	Used to Measure
Voltmeter	Voltage
Ammeter	Current
Ohmmeter	Resistance and continuity

Multimeters

The functions of each individual instrument can be combined into a single versatile instrument called *multimeter*. Multimeters are more commonly used in the field and are often known by other names such as volt-ohm-milliammeter (VOM) and digital multimeter (DMM). A multimeter saves having to purchase numerous individual meters.

Features of analogue and digital multimeters

Electrical measuring instruments have traditionally been analogue. Analogue meters consist of a needle-type pointer that moves across a fixed scale. Modern instruments display digitally, using liquid-crystal or light-emitting diodes (LED). Digital instruments are not necessarily more accurate than analogue instruments, but they are often easier to read. Digital instruments will retain their accuracy regardless of how you position them, while analogue instruments are somewhat delicate and requires placement on a horizontal surface to retain their accuracy.

Digital multimeters can vary greatly in their operation and functions. Most multimeters can measure both alternating current (ac) and direct current (dc), whereas some voltmeters and ammeters can measure only one type of current. Always refer to the instrument's operating instruction booklet before using it to confirm its safe and proper use.

If you can understand how to use a voltmeter, an ammeter, and an ohmmeter, then it becomes very easy to understand how to use a multimeter.

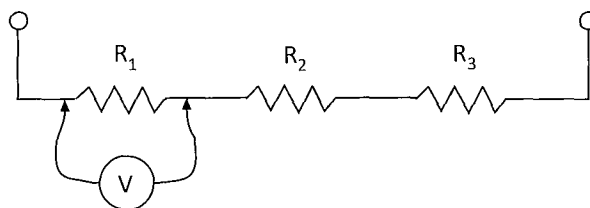
Measuring voltage, current, and resistance

Measuring voltage

In order to measure voltage, you must connect a voltmeter across the two points in the circuit where the voltage appears (see Figure 7-1) or, in other words, in parallel with the part of the circuit under test.

Figure 7-1

To measure voltage across resistance R_1 , voltmeter is connected in parallel with R_1



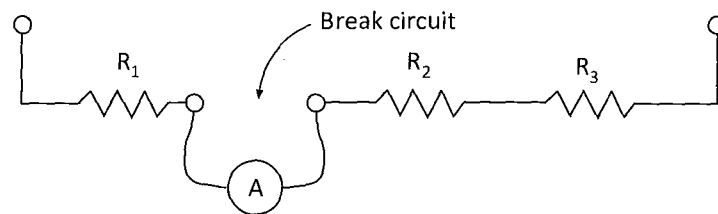
It is very important that the addition of the voltmeter into a circuit has very little effect on the conditions normally existing in the circuit. A voltmeter, therefore, must have a very high internal resistance, so that operating the instrument will draw very little current from that circuit. For maximum accuracy, a voltmeter's internal resistance should be many times higher than any resistance encountered in the circuit under test. Analogue voltmeters have internal resistances in the thousands of ohms, while digital instruments often have internal resistances in the millions of ohms.

Measuring current

In order to measure current, break down the circuit at the point where you will measure the current and insert the ammeter (see Figure 7-2). In other words, you must connect an ammeter in series with the circuit under test. (In order to avoid danger, before breaking any circuit to insert an ammeter, it is first necessary to switch the circuit off.)

Figure 7-2

To measure current through a circuit, break circuit and insert ammeter in series



It is very important to note that the insertion of the ammeter is designed to have very little effect on the normal current flowing in the circuit. The internal resistance of the ammeter is therefore very low, normally a fraction of an ohm. Due to the ammeter's low internal resistance, you must avoid connecting it across a load under test or the supply voltage itself. This would cause high current to flow through the ammeter, seriously damaging the instrument and possibly harming the operator. Some ammeters come with a fuse or circuit-breaker for protecting the instrument. Should this happen, however, you should never assume that this is adequate protection.

Measuring resistance

Ohm's law tells us that, with a fixed value of voltage across a circuit, the value of current flowing depends upon the resistance of that circuit:

- The higher the resistance, the lower the current flow.
- The lower the resistance, the higher the current flow.

In other words, the value of the current flowing through a circuit is a guide to the resistance of that circuit. This is the principle of operation of the ohmmeter.

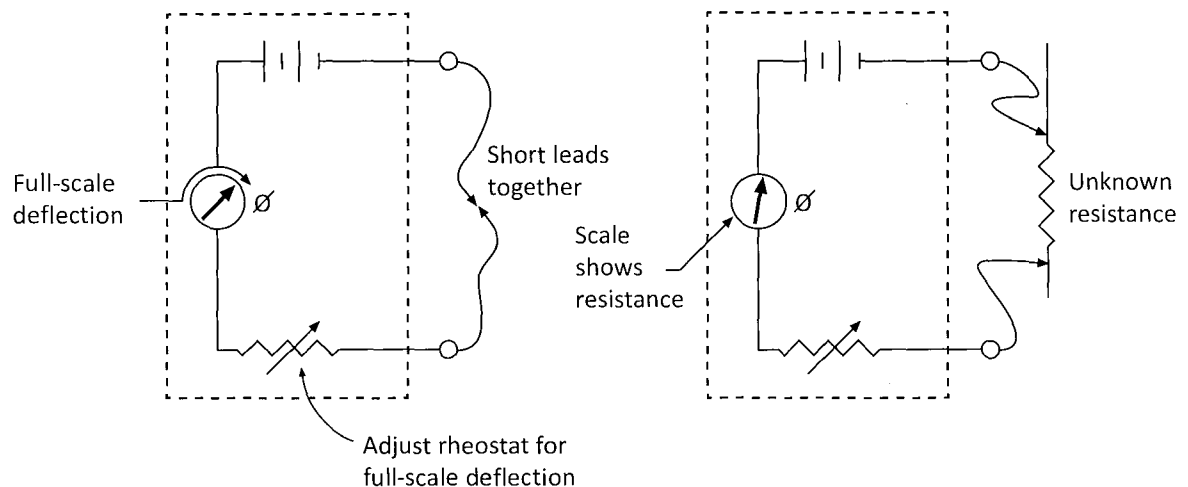
The ohmmeter is an instrument similar to an ammeter connected in series with a rheostat (variable resistor) and a battery (see Figure 7-3). A case with a scale, terminals, and the variable resistor's control-knob visible contains these components. The ohmmeter works in the following manner:

- 1) The test-leads are connected to the instrument's terminals and are first short-circuited together.

- 2) Adjustment of rheostat occurs until the instrument registers *full-scale deflection*—this corresponds to zero ohms.
- 3) Now, the test-leads are connected to the circuit or component under test.

The resulting current through the ohmmeter will be lower than it was before, because of the added resistance, and the instrument's pointer will register somewhat less than full-scale deflection. Rather than calibrating the scale in amperes, which is what the instrument is really reading, the manufacturer has calibrated it directly in ohms.

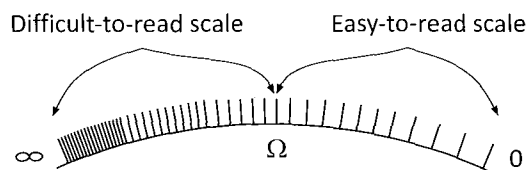
Figure 7-3
Schematic of ohmmeter operation



Analogue ohmmeter scale

Unlike the voltmeter and the ammeter, the most noticeable thing about an analogue ohmmeter's scale is that you read it from right to left. Furthermore, it is *non-linear*. This means that the graduations that represent the higher values of resistance (to the left side of the scale) are very close together, while those representing lower values (to the right side of the scale) have wider spacings. See Figure 7-4.

Figure 7-4
Non-linear, analogue ohmmeter scale



Zero ohms adjustment

Using the built-in rheostat to adjust for full-scale deflection is what you call *zero ohms adjustment*. You must perform it before using the ohmmeter to measure resistance. This compensates for any variation in the voltage of the instrument's battery. If you cannot achieve zero ohms adjustment, it means the battery is too weak and needs replacement.

Ohmmeter operating precautions:

Do...	Do not/never...
<ul style="list-style-type: none"> Always be aware of inadvertently measuring the resistance of other components that are connected in parallel with the component under test. You may have to physically remove the component from the circuit before performing the test. Technicians/fitters very often use ohmmeters to check for continuity—to confirm, for example, that a circuit, or component, is not open-circuited. When checking continuity, the actual resistance of the circuit or component is unimportant—a simple deflection of the pointer confirms continuity. Always switch an ohmmeter off when measurements are completed. If you fail to do this, and the test-leads are accidentally left shorted together, then the instrument's battery will very quickly discharge. 	<ul style="list-style-type: none"> Just like the ammeter, an ohmmeter must never be connected across a live load or the supply voltage itself. This would cause high current to flow through the ammeter, seriously damaging the instrument and possibly harming the operator!

Variable range instruments

In order to extend their versatility, most electrical measuring instruments have several ranges. For example, you may adjust a voltmeter to read: 0 to 5 V, 0 to 10 V, 0 to 25 V, and 0 to 100 V.

Scale selection

An analogue voltmeter may have four separate scales or only one scale (say, 0 to 5 V), in which case you must multiply its reading by factors of $\times 2$, $\times 5$, or $\times 20$, according to the selected range. The method for selecting the range on such an instrument varies from manufacturer to manufacturer, with the most common being a rotary knob that aligns with ranges engraved onto the case. Modern digital instruments often select the appropriate range automatically.

Range selection

If you are unsure of the value of voltage or current that you are about to measure, always start with the highest range and work down until you achieve the greatest readable deflection of the pointer. Despite this, you should always estimate the likely value of voltage or current before performing the test, just in case it is beyond even the highest range of the instrument.

For maximum accuracy with analogue instruments, always select the range that gives the greatest readable deflection because all instruments are calibrated to give maximum accuracy at full-scale deflection. For example, suppose a 100 V voltmeter is manufactured to an accuracy of

$\pm 5\%$. This accuracy applies to the instrument's full-scale deflection. In other words, it is accurate to ± 5 V at its 100 V reading. So, when it indicates 100 V, the actual voltage could be anywhere between 95 V and 105 V. However, when the same instrument indicates, say, only 10 V, it is still accurate to ± 5 V, so the actual voltage could range from 5 V to 15 V!

In the case of an ohmmeter, you must adjust the instrument for zero ohms:

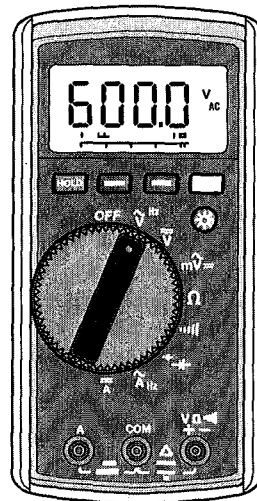
- each time its range is changed; and
- before you use it to take a measurement.

Using electrical measuring instruments

Digital multimeter (DMM)

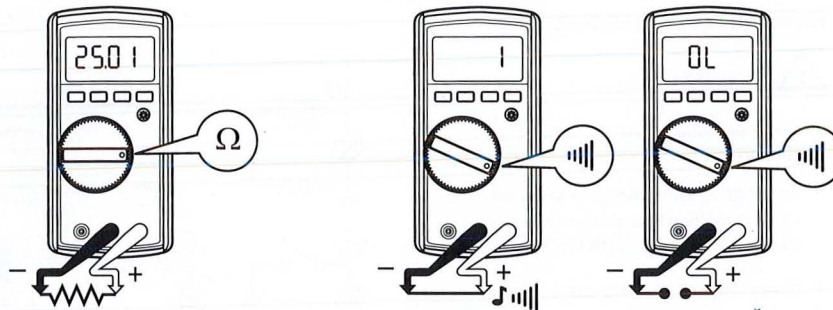
As discussed in Unit 2 *Fasteners, Tools and Testing Instruments* > Chapter 6. *Electrical Testing Instruments*, a digital multimeter has all the functions of an analogue multimeter plus advanced features. The primary difference to the technician/fitter is the way the user reads the data. DMMs have extended features depending on the make and model.

Figure 7-5
Field service technician's multimeter

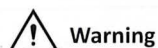


The following illustrations from a user's manual give typical examples of taking measurements with a common digital multimeter. See Figures 7-6 to 7-9.

Figure 7-6
Example: Measuring resistance and testing for continuity



Measuring resistance



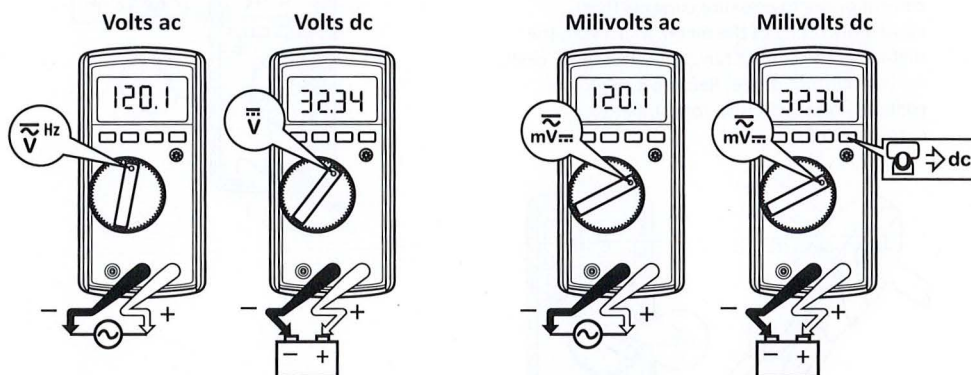
Warning

To avoid electric shock, injury, or damage to the meter, disconnect circuit power and discharge all high-voltage capacitors before testing resistance, continuity, diodes, or capacitance.

Testing for continuity

Note: The continuity function works best as a fast, convenient method to check for opens and shorts. For maximum accuracy in making resistance measurements, use the meter's resistance (Ω) function.

Figure 7-7
Example: Measuring ac and dc voltage—Using auto volts selection and measuring ac and dc volts millivolts



Measuring ac and dc voltage — Using auto volts selection

With the function switch in the AUTO-V position, the meter automatically selects a dc or ac voltage measurement based on the input applied between the V or + and COM jacks.

This function also sets the meter's input impedance to approximately $3k\Omega$ to reduce the possibility of false readings due to ghost voltages.

Measuring ac and dc millivolts

With the function switch in the mV position, the meter measures ac plus dc millivolts. Press \square to switch the meter to dc millivolts.

Figure 7-8
Example: Measuring ac or dc current

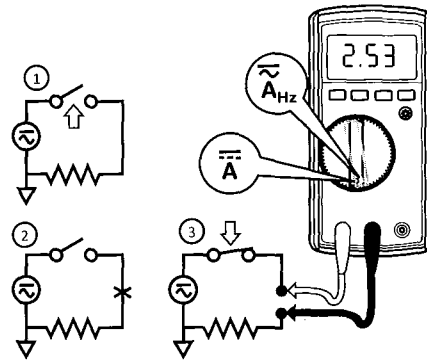
Measuring ac or dc current



Warning

To avoid personal injury or damage to the meter:

- Never attempt to make an in-circuit current measurement when the open-circuit potential to earth is >600V.
- Check the meter's fuse before testing.
- Use the proper terminals, switch position, and range for your measurement.
- Never place the probes in parallel with a circuit or component when the leads are plugged into the A (amps) terminals.

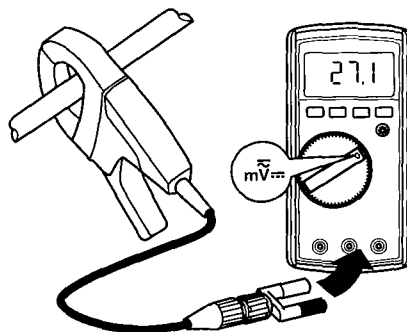


Turn circuit power off, break the circuit, insert the meter in series with the circuit, and then turn circuit power on.

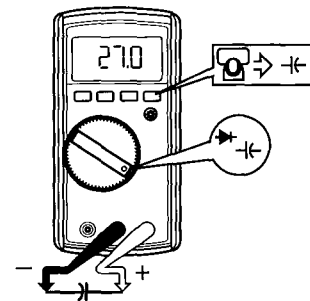
Figure 7-9
Example: Measuring current above 10 amps and measuring capacitance

Measuring current above 10 amps

The millivolt and voltage function of the meter can be used with an optional mV/A output current probe to measure currents that exceed the rating of the meter. Make sure the meter has the correct function selected, ac or dc, for your current probe. Refer to a catalog or contact a representative for compatible current clamps.



Measuring capacitance



Assignment Questions – Chapter 7

- 1) What type of electrical meter is used for measuring resistance and continuity?
 - a) Ammeter
 - b) Ohmmeter
 - c) Voltmeter