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Using the Right Instrument for the Job

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Measurement	Range	Resolution	Accuracy ± ([% of reading] + [counts])
DC millivolts	600.0 mV	0.1 mV	0.5 % + 2
DC volts	6.000 V	0.001 V	0.5 % + 2
	60.00 V	0.01 V	
	600.0 V	0.1 V	
Auto volts	600.0 V	0.1 V	2.0 % + 3 (dc, 45 Hz to 500 Hz) 4.0 % + 3 (500 Hz to 1 kHz)
AC millivolts[1] true-rms	600.0 mV	0.1 mV	1.0 % + 3 (dc, 45 Hz to 500 Hz) 2.0 % + 3 (500 Hz to 1 kHz)
AC volts[1] true-rms	6.000 V	0.001 V	1.0 % + 3 (45 Hz to 500 Hz) 2.0 % + 3 (500 Hz to 1 kHz)
	60.00 V	0.01 V	
	600.0 V	0.1 V	
Continuity	600 Ω	1 Ω	Beeper on < 20 off > 250 ; detects opens or shorts of 500 µs or longer.
Ohms	600.0 Ω	0.1 Ω	0.9 % + 2
	6.000 kΩ	0.001 kΩ	0.9 % + 1
	60.00 kΩ	0.01 kΩ	
	600.0 kΩ	0.1 kΩ	
	6.000 MΩ	0.001 MΩ	
	40.00 MΩ	0.01 MΩ	5 % + 2
Diode test	2.000 V	0.001 V	0.9 % + 2
Capacitance	1000 nF	1 nF	1.9 % + 2
	10.00 µF	0.01 µF	
	100.0 µF	0.1 µF	
	9999 µF	1 µF	
	100 µF to 1000 µF		1.9 % + 2
	> 1000 µF		5 % + 20
Lo-Z capacitance	1 nF to 500 µF		10 % + 2 typical
AC amps true-rms (45 Hz to 500 Hz)	6.000 A	0.001 A	1.5 % + 3
	10.00 A	0.01 A	
	20 A overload for 30 seconds max.		
DC amps	6.000 A	0.001 A	1.0 % + 3
	10.00 A	0.01 A	
	20 A overload for 30 seconds max.		
Hz (V or A input)[2]	99.99 Hz	0.01 Hz	0.1 % + 2
	999.9 Hz	0.1 Hz	
	9.999 kHz	0.001 kHz	
	50.00 kHz	0.01 kHz	

Notes:

[1] All ac voltage ranges are specified from 1 % to 100 % of range. Because inputs below 1 % of range are not specified, it is normal for this and other true-rms meters to display non-zero readings when the test leads are disconnected from a circuit or are shorted together. For volts, crest factor of ≤ 3 at 4000 counts, decreasing linearly to 1.5 at full scale. AC volts is ac coupled and ac mV is dc coupled.

[2] Frequency is ac coupled, 5 Hz to 50 kHz for ac voltage. Frequency is dc coupled, 45 Hz to 5 kHz for ac current.

It’s in your hands

One of the most frustrating aspects of trying to get a job done is to not have the right tool. How many times have you needed a Philips screwdriver and all you could find was a flat-head? Gages are the same way. Although in the case of using your instruments you may have one that measures the parameter you need measured, it still may not be the right tool for the job. Gages come in all different ranges, accuracies and sizes, and you have to ask yourself a series of questions before you can choose the proper one.

The processes you monitor or the parameters you measure will probably have some sort of limits they must fall between. If the processes fall outside of those limits, then some action must be taken and in some cases, it’s a severe enough action that might affect an entire facility. For example, let’s say you work at a nuclear reactor and you are monitoring the temperature of the water that cools the fusion process. Should the high limit be breached and the temperature of the water start rising considerably, that’s a pretty severe situation which would necessitate the entire facility being evacuated. So in the case of monitoring the water temperature of the nuclear reactor, what is a good choice to measure temperature? The selection lies in answering three basic questions: What range do you need, what resolution do you need, and how accurate do you need it?

Range, Accuracy, Resolution

Range is defined as the span that an instrument can measure. For instance, most people know the range of a typical school ruler is 12”, or 1 foot. A thermometer that reads from 0 to 100°C has a range of 100°, while a thermometer that reads from 50 to 100°C has a range of 50°. Always make sure what you are measuring falls inside the range of the instrument. This is significant for two reasons: 1) You won't be able to measure what you intend on measuring if the value falls outside the range of the instrument 2) You could damage or over-range your instrument if you measure a value too high outside the range. Both cases are undesirable, and the second can be very costly. Whenever in doubt of the value you are measuring, always choose an instrument that you believe will not be over-ranged.

Accuracy is defined by how "good" an instrument is, or the "quality" of the value obtained. In other words, how close are you to the true value of what you're measuring. It should not be confused with "precision", which refers to how consistently a measurement can be repeated. You can have a horribly accurate yet precise measurement. That just means you make the same bad measurement over and over. If you are monitoring air temperature outside and your process says that the limits you must stay between are ±5°C, then a simple mercury thermometer with an accuracy of ±1°C may be well suited for the task. However, in the case of the nuclear reactor water, you might have a process limit of ±0.08°C, in which case you must use something much more accurate like an SPRT. In Metrology, you will hear people talk in terms of how much better one instrument is than another in terms of accuracies and uncertainties. The standard ratio for what is being used to measure something to whatever it is you are measuring is 4:1. This means the instrument or standard you are using should be 4 times better than the process or instrument you are measuring. Some apply this ratio to the accuracies of the instruments involved or instrument and process involved. Others use the 4:1 ratio to qualify the uncertainty of the measurement to the accuracy of the instrument. The accuracy ratio is referred to as a TAR (Test Accuracy Ratio), while the uncertainty ratio is referred to as a TUR (Test Uncertainty Ratio). Both are useful in determining what instrument to use in a process.

Resolution is a description of how many digits you can see an instrument count. 'Digits' doesn't imply digital-only displays, as they can be analog counts as well. A lot of cars still have needle speedometers which are a good example of an analog resolution. Typically the speedometer will have a tick mark indication of speed every 5 mph. This means it has a resolution of 5 mph. A 0-60 psi dial pressure gage with a needle indicator generally has a tick indication of pressure every 1 psi. That means it has a resolution of 1 psi. In the digital realm, resolution refers to how many digits past the decimal point you can see a number. For instance, a Fluke 8508 displays 8 digits of resolution past the decimal point for some parameters. This means one can see 0.XXXXXXXX on the display. A Fluke 87 will read to 0.XXX for some parameters. So depending on your process limits or instrument limits, the resolution becomes a key factor in determining what instrument to use. And remember, just because an instrument has a high resolution doesn't necessarily mean it is accurate. These two things are separate.

All three attributes should be considered when using the right instrument for the job. Knowing your measurement process needs will ensure you make useful measurements!