"ELECTRONIC CALIBRATORS"

Associated techniques, uses, traceability, and problems.

Roger Thomas
Ametek Mansfield & Green Division
305 Taylor St.
PO Box 294
Orrick, MO 64077

INTRODUCTION:

Pressure calibration is as important today as it has been for a very long time, but the way calibration is done and the equipment used to do it has changed drastically.

In the past it was a standard practice to use a primary standard for pressure calibration. That standard was normally a dead weight tester or a manometer. Today with more accurate secondary standards available there is a larger choice in what can be used for pressure calibration. What is used normally will depend on the requirements that have to be met and the equipment that is available.

This paper discusses issues that should be taken into consideration when choosing a pressure calibrator from the many that are available today.

ACCURACY:

Overall accuracy of any device is made up of several factors. Any of these factors can cause the device to deviate from the value that is being sought. The factors that would normally effect accuracy in a pressure calibrator are hysteresis, repeatability, linearity, temperature, and gravity. Change in any of these factors can cause a change in the accuracy of the equipment used for calibration. Some types of pressure calibration equipment are affected more than other and some types of equipment take these factors in consideration when accuracy is defined.

There is no set standard for specifying accuracy. Some specifications base accuracy on one factor only, and some will use a combination of these factors, while others omit certain elements completely.

A percent of full scale and a percent of indicated reading are the two most common ways to present accuracy. A more recent way of indicating accuracy and one used by several digital calibrators is a combination of both. It is very important to understand the differences between these for a significant error can be overlooked if these are not understood.

Accuracy based on a percent of full scale is always a fixed value and will have the best accuracy at the top range limit. Consequently the nearer to zero the worse the accuracy becomes based on percent.

Accuracy expressed as a percent of indicated reading will have pressure values that chance through the range of measurement, but the percent of accuracy will remain constant. This means that the accuracy in percent is the same from the bottom to the top of the range of the instrument.

Generally a percent of indicated reading accuracy is preferred because it will indicate a better overall accuracy over the full scale of an instrument. There are however, other considerations that should be looked at when choosing a digital pressure calibrator.

RESOLUTION:

Resolution is a function of the number of digits on a digital display and can be defined as the smallest change of the input that can be seen by the device.

The total number of digits before or after a decimal point are usually used to state the resolution of an instrument. Most are called out as 3.5, 4.5 or 5 digit resolution. When indicating one half of one digit this refers to the digit to the far left of the display being represented as no larger than a 1. A 3.5 digit display will indicate the highest value of 199.9 while a 4.5 digit display can indicate a value of 1999.9 and a 5 digit display will show a value of 99999.

It is important to understand that you must be able to see enough digits on a display in order to verify accuracy. A devise with a 100 PSI full scale range and an accuracy of +/- 0.05% of full scale accuracy must be capable of indicating down to 0.05 PSI (100PSI X 0.05/100). Therefore it would require at least a resolution of 4.5 digits to be able to see and read this accuracy. The same example with an accuracy of 0.05% of indicated reading

would need an indication of 5 digits in order to prove accuracy. For example, at 9 PSI in order to prove 0.05% indicated reading accuracy you would need to be able to see 9.0045 PSI. To do this would require a 5 digit indication.

Another issue that should be covered is a fixed point or floating point display. The number of digits to the right of the decimal point are constant on a fixed point display. With a floating point display, the number of digits to the right of the decimal point varies with the size of the reading. It can be one, two, three, four, or five depending on the number of digits on the display and the reading required. Referring to the example above based on 0.05% of indicated reading, the accuracy would be impossible to resolve if the decimal place had been fixed at two or three digits. It has to be able to indicate the full range 100.00 PSI but also show the possible error at .0045 below 9 PSI. Thus the need for at least a 5 full digit display with a floating decimal point. There can be resolution with out accuracy, but there cannot be accuracy without proper resolution.

TRACEABILITY:

Tractability is important. Without traceability there is no proof that the pressure calibration equipment is as accurate as stated.

Traceability is the ability to refer individual measurement results through an unbroken chain of calibrations to a common source. The most common source used in the United States is the National Institute of Standards and Technology (NIST).
To insure an audit trail is traceable calibration results should include

- The assigned desired value
- The stated uncertainty
- Identification of the standard used in the calibration
- A statement of the environmental conditions where the calibration took place.

Traceability does not necessarily imply accuracy. It is a common misunderstanding that if something is traceable it is also highly accurate. Digital pressure calibrators can be traceable to NIST and still not be accurate enough for today's calibration needs.

SITE EFFECTS:

Temperature affects all measuring devices. This includes primary pressure standards and secondary pressure standards. This includes digital pressure calibrators.

Some accuracy statements will indicate the effect of temperature on the overall accuracy of the instrument. If the units is going to be used in areas where temperature can vary it is important to include the affects of temperature in the overall measurement accuracy.

Some devices are temperature compensated over a working range. This means that the change in ambient temperature is taken into consideration during the calibration of the unit and the affects of temperature on the measured reading are either done away with or are minimal.

Either way it is important to understand that temperature does affect the measured reading on a digital pressure calibrator and it has to be noted and taken into consideration when looking at overall accuracy of a unit.

All pressure calibrators should be allowed to stabilize at the temperature they are going to be used. Even devices that are temperature compensated will have a zero shift due to changes in temperature. All digital pressure calibrators must be allowed to "warm up" to ambient temperature before they can be correctly used.

Gravity Effect

Gravity has a major affect on primary pressure standards. Most dead weight testers are calibrated for either international mean gravity or U.S. mean gravity. This refers to the force that is being exerted on the weights on deadweight testers. If local gravity is not taken into consideration when looking at the output of a deadweight tester the accuracy of the tester can be affected.

Digital pressure calibrators, because there are no weights involved, require no compensation for gravity.

Vibration

Vibration does not affect digital pressure calibrators.

Vibration is a factor that has to be taken into consideration when using a primary standard. Primary standards need to be level and placed on a stable surface to function properly.

Intrinsic Safety

Intrinsic safety is very important when choosing a digital pressure calibrator. When using these units in today's work environment it is important to know if intrinsic safety is required.

Locations where volatile material are handle, stored, or processed are know as hazardous locations. The National Electric Code (NEC) defines hazardous locations in terms of Class, Division and Group. The four primary agencies that test and certify equipment for use in hazardous location in North America are Underwriter's Laboratories (UL), Factory Mutual (FM), Canadian Standards Association(CSA), and Electrical Testing Laboratories (ETL).

It is important to understand what if any hazardous certifications digital calibrators have before being used in these locations.

Electromagnetic Interference (EMI)

Electromagnetic interference is one side effect of using electronic device in close relationships to one another. These type of devices both emit and are susceptible to EMI. If the amount of emission from one electronic devise to another causes one to malfunction, this is referred to as EMI. Most EMI problems are limited to radio communications interference and is referred to as radio frequency interference (RFI).

If not properly shielded, EMI and RFI can be a major problem with digital pressure calibrators. By properly shielding for EMI and RFI, this problem can be eliminated by the manufactures of digital pressure calibrators.

REPRODUCABILITY:

This term is often confused with repeatability, but there is a clear difference

The ability of a device to consistantly produce the same output given the same input is repeatability.

Reproducability is the ability of different operators to product the same output with the device, given the same input. Reproducability is influenced by the amount of "skill" involved in taking a measurement.

Reproducability is generally easier in digital pressure calibrators than it is in primary pressure calibrators.

CONCLUSION:

There are several factors to take into consideration when choosing a pressure calibrator. The topics discussed in this paper are only some that should be considered when choosing a pressure standard. It is up to the individual company, user, and the standards that have to be met as to what type of calibrator to chose and use.