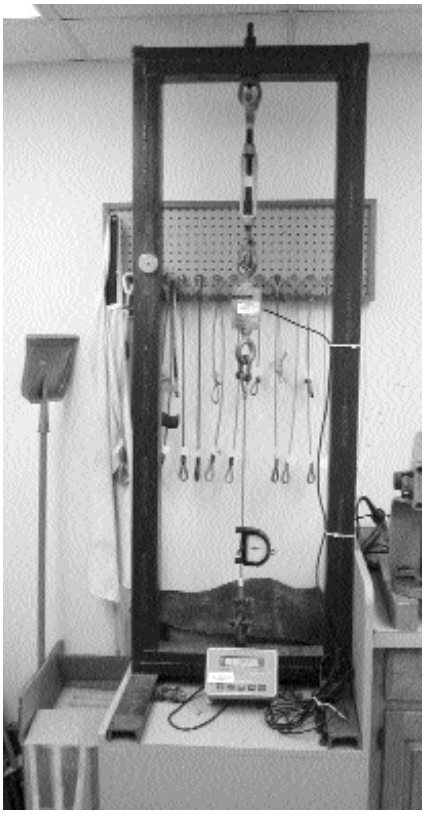
CALIBRATION BLUES

BY BRAD PRIMM

The annual calibration bill for the typical avionics shop can make anyone blue. Not only do we calibrate the precision test equipment required to do bench repairs and in-field adjustments of avionics, but also the crimping tools required for installations and wiring repairs, tensiometers used for autopilot cable checks, and gauges used for pressure testing. In addition, some of the rack mounted test panels and perhaps even some of the bench harnessing and break-out boxes may require calibration.



Device used for tension meter calibrations

What are the basics of calibration and why do we need to do it? What can be done to control these costs?

In order to answer these questions, we must delve into the world of metrology and calibration. Metrology is the science of weights and measures. It also encompasses a system of weights and measures.

The reason we calibrate is to ensure accuracy and what is accuracy? For the purposes of metrology, it is the conformity to fact or exactness. What is calibration? The act of calibration of a measurement device is to measure, adjust and compare the measurement device results to a standard. What is measurement? Measurement is defined as the act of measuring or being measured.

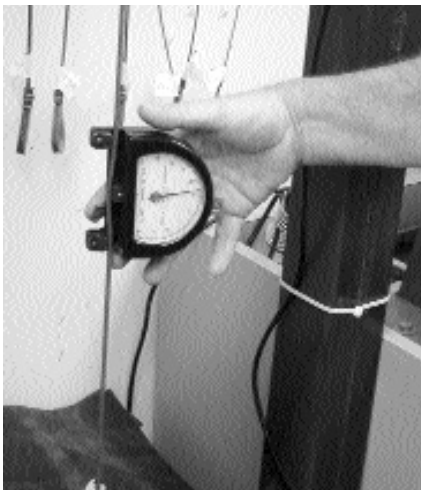
What do we measure to? The International System of Units, SI, is a coherent system of metric units defined by international consensus. These units define the standards we use. There are seven SI base units and they are the meter (length), kilogram (mass), second (time), ampere (electric current), kelvin (temperature), mole (amount of substance), and candela (luminous intensity).

What are standards? Primary standards are defined as standards to which comparisons can be made that are designated or recognized as having the highest metrological qualities or precision in their field.

What is precision? Precision is the quality of being exact or precise. Primary Laboratories are metrology laboratories that maintain an SI unit or units through the use of primary standards and are capable of carrying out calibrations with reference to precise primary standards.

Other basic terms to know are; resolution, which is the amount of detail

Measuring the calibration of a torque wrench using two standards



Calibrating a cable tensiometer

that can be measured; tolerance, which is the allowable variation from a particular standard; traceability, which is the ability to trace a calibration back to a primary standard; and uncertainty, which is the estimated amount that a measured or calculated result may be off from the true result.

So why calibrate? It is amazing how much calibration affects our lives. The next time you are at the gas pump, look for the certificate of calibration. In my locale, it is a sticker with the smiling face of the county auditor. When you set your watch, you are actually calibrating it to a higher standard (hopefully). The scale at the grocery will have a sticker as well. Measured mile markers on the interstates are used to check the calibration of your speedometer.

In our industry, the test equipment we use undergoes mechanical stress, changes in temperature and the natural process of aging. All of these factors contribute to drift. We control the menace of drift with the process of calibration.

In researching this article, I visited a local calibration lab and looked at several different calibrations. The shop I visited calibrates a variety of items related to aviation and general industry. Many of you probably think I am about to bore you with the description of a Fluke Voltage Standard used to calibrate a digital multimeter, but fear not! How about the calibration of a cable tensiometer? What about a torque wrench calibration?

The bench used to calibrate cable tensiometers is located in a temperature and humidity controlled environment. The setup employs a rack device to apply controlled amounts of tension to short cable samples. The tension is measured by an electronic transducer in-line with the cable itself. The tensiometer is then tested in the same manner in which we use it in the field by actually taking readings with it on the cable sample.

Digital Pressure Standard

One caveat though. When using a tensiometer such as this to measure the cable tension of steel cable, it is necessary to take three measurements in different positions on the cable and average them together, a procedure commonly missed in the field. This is necessary because the strands of the steel cable create an uneven surface with peaks and valleys.

The calibration bench used for torque wrenches is also located in the controlled environment and during the demonstration, an analog standard as well as an electronic standard were used to check the torque wrench. See the picture for the set-up. Dual standards ensure the reliability of the measurement. Here is a caution about torque wrenches and tools in general: IF YOU DROP IT, RECHECK IT. During normal use, torque wrenches and any gage in general, should only be exercised to two-thirds of the full-scale value.

Other common tools we use that require calibration checks are crimping tools. The frequency of calibration for crimpers depends upon the frequency of use. At the cal shop I visited, they perform the calibrations on these tools by actually crimping the pins for which the tool was designed and performing a pull test on the wire. In addition, they inspect the crimp for evenness, quality and height.

Many crimpers come with a go/no-go gauge. The gauge will have two machined ends. One end should fit through the closed jaws of the tool and the other end should not. Depending upon your FAA inspector, this may be good enough to satisfy the calibration check requirement of the tool. In a production environment, the go/no-go gauge should be used at the start of every shift and whenever the tool is dropped to verify continued quality of crimps. Some may consider the go/no-go gau ge as a tool for confidence checks which are a form of self-checking between regular, more exacting calibrations.

The typical avionics shop has numerous test panels that employ analog meters. These meters should be calibrated on an annual basis. At my shop, we calibrate these meters ourselves in order to control costs. We use our 4-1/2 digit Fluke as a secondary standard when doing these calibrations. The Fluke meter we use is only considered a secondary standard right after a good traceable calibration and before it is put into service in any other capacity. This ensures a high level of confidence in the results.

When sending out equipment for calibration, we are required by the FAA to get Certificates of Calibration with traceability to primary standards. When you receive a piece of avionics from a vendor, you always examine the paperwork for completeness and accuracy. But what do you look for when you receive a piece of test equipment from calibration?

The Certificate of Calibration should contain the following elements

Continued on page 59

CALIBRATION BLUES

Continued from page 57

as a minimum. There should be a unique tracking or certificate number on the paperwork. This will allow trace back to the specific records for the calibration. The equipment calibrated should be clearly identified with the correct part number and serial number. The testing date and test conditions should be specified. The confidence level of the testing should be stated. A performance summary should state whether the equipment was found in-cal or out-of-cal and whether any adjustments were required. The final state of the equipment after calibration should also be indicated. Details of the traceable standards should be supplied. This commonly means listing the test equipment used by model and serial number, including a statement that the standards used in the calibration are traceable back to primary standards. Measured values should be provided especially for non-conforming tests.

The performance summary should be examined to determine if the equipment was found in an out-of-tolerance condition. If so, you need to ask several questions. Was the equipment used while it was out-of-tolerance? Did the out-of-tolerance condition cause any problems during use? Will a recall of work be necessary? Unfortunately, some cal shops will adjust as they calibrate. This may influence the measurements downstream of the adjustment, which will make the measured values less reflective of "as-found" readings. This makes the question, "Will a recall of the work be necessary?" much harder to answer.

When the performance summary indicates that a piece of equipment holds its calibration, you can petition your local FAA avionics inspector to extend the cal interval beyond the normal calibration interval. In my shop, I save all of the calibration certificates for just this purpose. Our calibration records book contains clear page protectors and I stuff the certificates in the protector so they are readily available for review by the FAA.

In many ways the typical avionics shop "calibrates" aircraft systems. During pitot-static and altimeter tests, we are comparing (calibrating) the ship's instruments to known standards. As we move toward domestic RVSM, the standards we use must be upgraded to exceed the accuracy of the aircraft instruments. Even in the non-RVSM world, you must know the limitations of your equipment. For instance, is it proper to use a standard master altimeter to calibrate a servo counter-drum altimeter in a jet?

The rule of thumb for metrology is that the calibration standard should be at least four times the accuracy of the unit being calibrated. The answer to the above question is probably no. It may be allowed by your local FAA, but is not a good practice. The standard analog master altimeter has numerous sources of error including hysteresis and after-effect. Digital altimeter standards do not suffer from these limitations and will deliver reliable test results time after time.

I wish I had more time to devote to this subject and I realize that we have barely scratched the surface. The parting thought I want to leave you with is that you must treat your calibrated test equipment with great care. You must teach all users of the equipment to handle it carefully and be mindful of their part in the unbroken chain of traceability back to primary standards. There is a corollary to the phrase "If you drop it, recheck it." That corollary is, "IF YOU TAKE CARE OF YOUR CALIBRATED TOOLS, YOUR CALIBRATED TOOLS WILL TAKE CARE OF YOU." ❑

Special thanks goes to Harry Harris of Cleveland Instrument Corp.