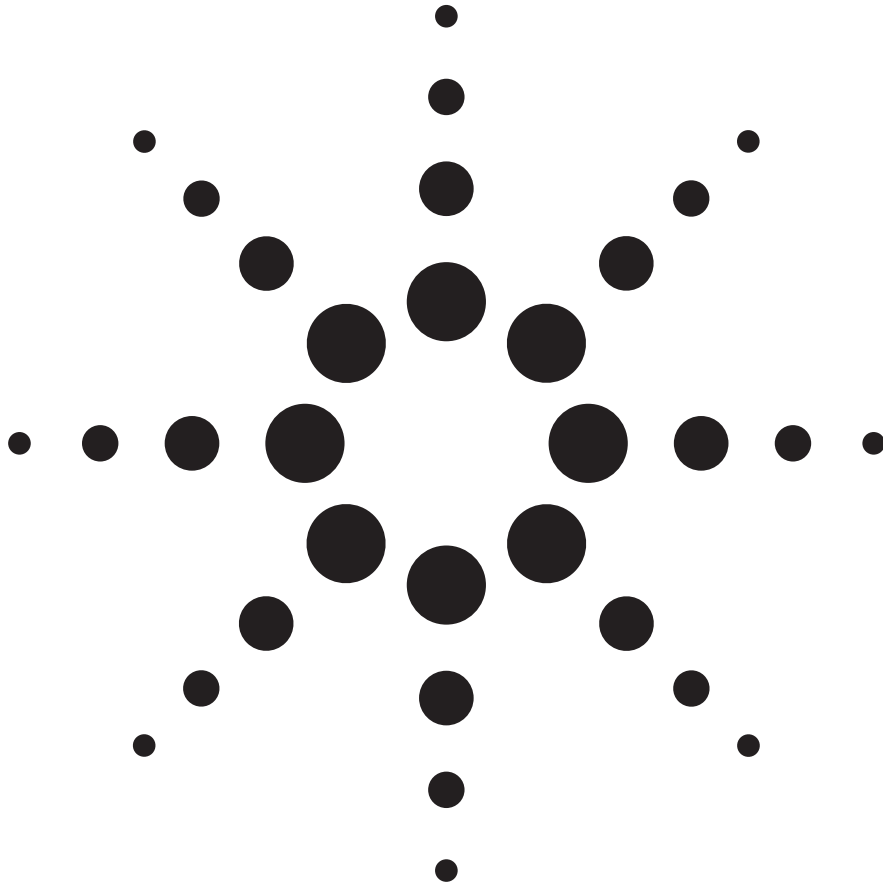


Remove all doubt

Your instrument restored to like new condition.

Minimizing Risk In Instrument Calibration

Application Note



Agilent Technologies

Minimizing Risk In Instrument Calibration

Calibration is essentially risk management. How do you lower your risk of measurements that are potentially inaccurate over the lifetime of your valuable test and measurement equipment? Regular calibration, of course, is essential. But what type of calibration, and from what vendor? This paper looks at managing risk with calibration suppliers by investigating the key areas of any calibration service:

Low measurement uncertainty

Extent of testing

Adjustments and repairs

Automated test equipment

Calibration lab procedures (ISO 17025)

Measurement reports

Calibration "extras"

Low Measurement Uncertainty

Evaluating measurement uncertainty (MU) is the only accepted way to determine how good your measurements are. In general, the smaller the uncertainty, the more credible the result. The same applies to measurements made when your instrument is calibrated. Labs that consistently have lower MU generally will produce more trusted calibrations.

One way you can determine the quality of a calibration lab is by comparing best measurement capability given in the Scope (or Schedule) of Accreditation. You can find this information by visiting the websites of national accreditation bodies. Here you will find MU data for different labs. The quality of a particular measurement may be assessed by its MU value.

The following MU data on common measurements was obtained from the accreditation body in the United Kingdom. It is shown as an example, but is also indicative of the kinds of variations that might be seen in other parts of the world. This is also a good sampling of measurements for a simple comparison, since more complex measurements are often a combination of these basic ones, and the differences between vendors typically become even more pronounced with more complex measurements.

Chart 1: Measurement uncertainty for a 10 V DC measurement

Source: United Kingdom Accreditation Service (UKAS) Web site, <http://www.ukas.com/> on February 3, 2006. Note logarithmic scale.

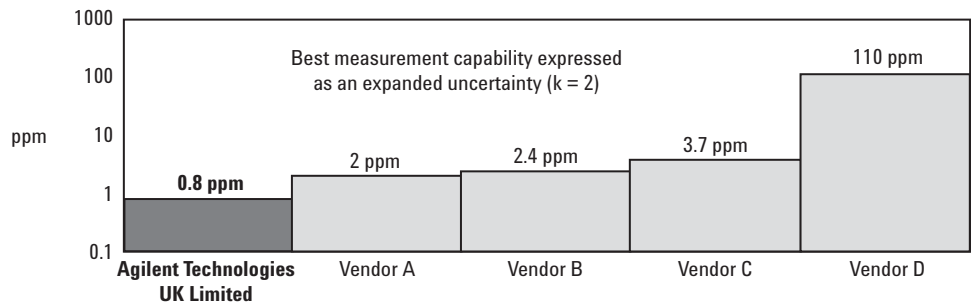


Chart 2: Measurement uncertainty for a 1 kV DC measurement

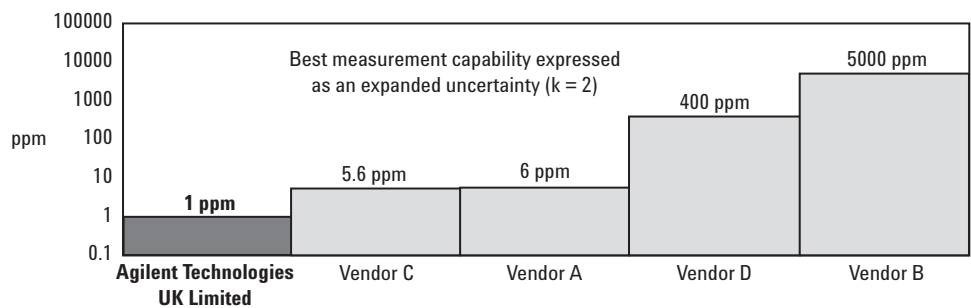
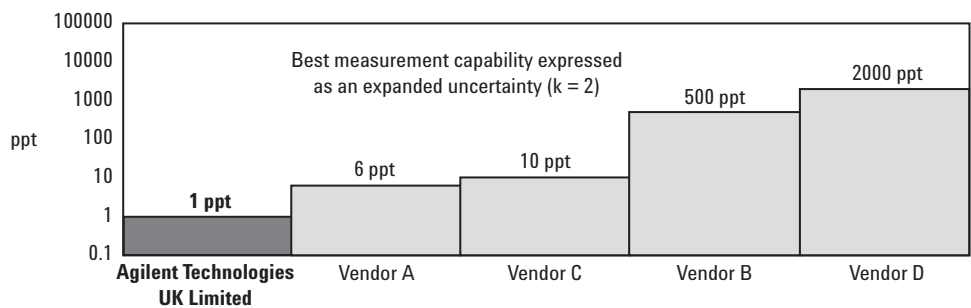


Chart 3: Measurement uncertainty for 10 MHz frequency measurement



Note: To find your local accrediting body's website, go to the Agilent Metrology Forum page, http://metrologyforum.tm.agilent.com/ww_accredited.shtml, and find the link to your country.

As a rule, most accrediting bodies will show that Agilent calibration services will provide the lowest MU available for an Agilent instrument. And evaluating MU is the only accepted way to determine how good the measurements are from a particular lab. Getting the highest accuracy is the first way to remove doubt.

The Extent of Testing

The next area to examine is the extent of the testing, specifically how many parameters are tested (breadth of testing) and how many data points are collected for each parameter (depth of testing). The greater the depth and breadth of testing, the more thorough the calibration, and the more confident you can be of the results. When Agilent develops a new instrument, we determine the parameters that should be evaluated and the number of test points for each parameter required for a full manufacturer calibration. This is the level of calibration we, as the manufacturer, recommend to ensure your instrument is fully within specification. Third party calibrators frequently do less than a full manufacturer calibration. For example, let's compare Agilent and a typical third party calibration service with a spectrum analyzer.

Services comparison: Typical spectrum analyzer calibration

	Agilent Calibration	Typical third party calibration
Reference output accuracy	✓	✓
Calibration amplitude accuracy	✓	✓
Resolution BW accuracy	✓	
Resolution BW selectivity	✓	
IF gain uncertainty	✓	
Scale fidelity	✓	✓
Input attenuator switching uncertainty	✓	
Residual FM	✓	
Resolution BM switching & IF alignment	✓	
Frequency readout	✓	✓
Marker count accuracy	✓	
Frequency span accuracy	✓	✓
Frequency response	✓	✓
Noise sidebands	✓	
Image and multiple responses	✓	
Sweep time accuracy >= 30ms	✓	
Sweep time accuracy < 30ms	✓	
1st LO output amplitude	✓	
Displayed average noise level	✓	
Residual responses	✓	
Other functional tests	✓	
Number of measured points:	412	Typically 40 – 80

As you can see, not only does Agilent Calibration measure all the parameters required for a complete calibration (versus very limited parameter coverage by the third party), but it also collects 412 vs. 40 – 80 data points. Agilent Calibration provides confidence that the instrument is completely healthy in terms of accuracy, and that it is likely to maintain that accuracy and reliability in the future. Furthermore, this calibration certifies that all supporting functionality in the instrument is working properly, just like the testing that is done in final production.

Full Adjustment and Repair Capability

Invariably, some instruments sent in for calibration are out of specification and require adjustment. A full manufacturer calibration also includes adjustments to the instrument, if needed. While many third party vendors are able to make calibration measurements, they are often not able to make adjustments. Those that are not able to usually end up sending the equipment to the manufacturer for adjustment. To save time and money, it makes sense to send the equipment to a vendor that can perform the adjustments when they do the calibration, instead of sending it somewhere else. Full adjustments are a standard part of Agilent's calibration procedures.

If Agilent finds that the equipment cannot be calibrated without being repaired, we can repair it on the spot. The resulting delay to the customer is very small. Many third parties do not have full repair capability. With a typical third party, the instrument would need to go to the manufacturer for repair. The customer ends up paying with a longer turnaround time.

Automated Test Equipment and Procedures

Automated test equipment and procedures provide speed and reliability in the calibration process. All Agilent instruments are tested using factory-written procedures. Only Agilent holds the intellectual property for the calibration and measurement uncertainty formulas written into these procedures. The combination of the best uncertainties and access to original design engineering make it easier for Agilent to test the instrument in the most meaningful way.

Automation of the test procedures enables the complete suite of tests to be run quickly. Agilent also has superior knowledge of the instruments, which they designed. In contrast, the drive to cut costs with many third party suppliers leads to less automation and less equipment. This in turn means a reduced suite of tests, which increases risk for the customer in the reliability of their calibrations. Risk is further increased because manual procedures are also more prone to errors.

ISO Process Compliance/Accreditation

Agilent quality systems are certified to ISO 9001:2000 standards worldwide. The customer gets the same quality of service regardless of what Agilent service center they send it to.

Audits are performed both by skilled internal auditors and external experts from accreditation bodies. In addition, Agilent conducts measurement assurance programs to compare the results between labs. Therefore, the confidence in measurements is very high in all regions.

ISO 17025 (ISO/IEC 17025:2005) is the global standard for the technical competence of calibration and test laboratories. The ISO 17025 process has both technical and management aspects. First, it requires labs to demonstrate that they are generating technically valid results considering equipment, procedures, and personnel. Second, labs need to show that they operate a quality system, which covers their processes, documentation, and management.

To claim status as an ISO 17025 process-compliant laboratory, an internal audit program is required. To be an ISO 17025 accredited laboratory, the calibration supplier must be independently assessed through an external review. All of the 46 Agilent labs are using ISO 17025 compliant processes, and many are accredited for ISO 17025.

Australia Melbourne*	France Paris*	Korea Seoul*	Thailand Bangkok
Brazil Manaus Sao Paulo	Finland Helsinki	Malaysia Kuala Lumpur*	United Kingdom Winnersh*
Canada Calgary Montreal	Germany Boeblingen*	Mexico Mexico City Reynosa	United States Irvine, CA Roseville, CA* Santa Rosa, CA* Loveland, CO* Arlington Heights, IL
China Beijing* Shanghai Shenzhen	India Bangalore*	Netherlands Amsterdam*	Spain Richardson, TX Bethlehem, PA
Denmark Copenhagen*	Israel Tel Aviv*	Singapore *	Taiwan Andover, MA Durham, NC
	Italy Milan*	Spain Madrid*	
	Japan Tokyo* Osaka	Taiwan Chung-Li*	

Figure 2: Agilent labs using ISO 17025 compliant processes (*Accredited laboratories. Check scope of accreditation at accrediting body website.)

Agilent invests to obtain state-of-the-art instrumentation for low measurement uncertainties, while adhering to the most rigorous ISO 17025 procedures for lab management.

ANSI/NCSL Z540 compliance is also available for most instrument models to fulfill the quality needs of U.S. aerospace and defense customers.

Measurement Reports

ISO 9000:2000 compliance requires both pre and post adjustment measurement reports to satisfy traceability requirements. If the instrument is outside specifications, another calibration supplier may charge up to 50% more to get the pre-adjustment report. Agilent includes it in the price with all calibration services.

Agilent's measurement reports have the following advantages over the typical third party supplier:

- **Comprehensive reports:** Reports are comprehensive and reflect the full manufacturer calibration. A typical third party will produce a report only a fraction of the size, which implies tests may have been omitted.
- **Pre and post data reports fulfill quality standard requirements:** These reports provide equipment status – “as received” and “as shipped” – which allow customers to estimate the impact of out-of-tolerance equipment on their production. The information provided will identify which points were out-of-tolerance, and the precise value of that deviation.
- **Calibration certificate designed to facilitate audit purposes:** The calibration certificate contains all the necessary data to answer questions ranked of high importance to customers in facilitating their work, including information on standard compliance, traceability, environmental conditions, etc.

Calibration “Extras”

Agilent performs other procedures when an instrument is in for calibration that other labs might consider as extras, or may not be qualified to perform. Addition of these procedures ensures that your equipment performs “like new” when you receive it.

- **Safety check:** Agilent does a full safety check. For example, the unit is thoroughly checked for electrical shorts.
- **Firmware updates:** Firmware updates are made, if required.
- **Repairs:** Simple repairs like replacement of burned-out fuses and broken knobs are performed at no charge.
- **The unit is thoroughly cleaned.**
- **Service advisories:** If a service advisory is out on the unit, Agilent performs it.

Removing Doubt

By taking each one of these areas into account, you will be able to manage your risk to an acceptable level. Managing risk in calibration is about reducing the probability of inaccurate measurements. To reduce risk,

- Look for low measurement uncertainty resulting in TAR of 4:1 or better for high quality calibrations.
- Require complete test suites recommended by the manufacturer including all parameters and test points.
- Choose a vendor that can perform full adjustments and repairs, if needed.
- Select calibration labs that have invested in automated systems and follow proven procedures.
- Choose labs using ISO 17025 compliant processes while performing extra procedures designed to maintain the overall capability of your instruments.

Agilent provides all these benefits. Choose Agilent for your next calibration.



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Agilent Technologies' Test and Measurement Support, Services, and Assistance

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you receive your new Agilent equipment, we can help verify that it works properly and help with initial product operation.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and onsite education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

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