Warning: Calibration isn't enough

How to identify measurement problems

By Dr. Jacqueline Graham

Most organizations have a system to calibrate measurement equipment routinely. It is seen as fundamental to good business in any organisation that uses physical equipment to measure its product or service. Generally, measurement equipment is uniquely identified and calibrated at regular frequencies against nationally recognized standards. Compliant organizations maintain appropriate records to demonstrate conformity to ISO 9001 and other standards.

Calibration is a time consuming activity. However, most organizations correctly view the task as fundamental to the business. How can they possibly get accurate results unless their equipment is correctly calibrated? This is absolutely the case. But does a calibrated measurement system necessarily produce accurate results?

Even the most conscientious company with the best possible measurement system can run into issues when it comes to day-to-day assessment of its products. Just because the measurement system is calibrated does not mean that the results are going to be accurate! Other potential causes of variation exist, which are often more significant than an out-of-calibration piece of equipment; the main one is the operator or tester. Does every tester in the organization complete the measurement in exactly the same way? Do apparent minor differences in testers' work procedures matter?

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The learning curve

Calibrating a piece of equipment is like getting a car serviced so it is in prime condition for use. The best serviced car does not guarantee that the driver will operate it well and safely arrive at a destination point. So, does it follow that calibrated equipment will result in accurate results? Of course not.

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When we begin to learn to drive, we know we need special training and guidance. This same learning curve applies to a measurement system. Most organizations have systems in place to train new personnel to use measurement systems. But how can you tell when enough training has been given? How can you be sure an employee is ready to complete tests solo?

When learning to drive, the new driver is tested, then let loose on the road. Yet we know from looking at road statistics that these same drivers that have just passed their tests are more likely to be in car accidents. Many countries identify new drivers on the road by making them display a sign indicating their inexperience. Then other road users know to be careful and treat them in a similar way as a learner. Do we take the same care over a new tester? Or, once they have been defined as competent, do we throw them into the working environment and hope for the best?

As we drive along the roads, it is easy to pick up the student drivers. Of course, they are well identified and often their driving style gives them away. But are they the only poor drivers on the road? Absolutely not! There are many drivers on the road who show poor driving technique. Whether driving in the US, Europe, or Asia, poor drivers are everywhere.

Frequently the worst drivers are not the learner drivers, but experienced drivers who were either poorly trained in the first place or have developed bad habits over time. These drivers have developed their own techniques when it comes to lane control, steering, and maintaining the distance to the vehicle in front. The lessons of how to drive the vehicle correctly are long gone.

How to find the hidden problems

Is this the same in your organization in terms of measurement? Have testers developed poor techniques over time? Have testers developed their 'own' ways of doing things? Just as poor driving can lead to fatal consequences, poor measurement can lead to incorrect assessment of your product or service, resulting in customer complaints and frustration when trying to determine where things went wrong.

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Figure 1 displays some production data in a conventional Shewhart control chart.[1]

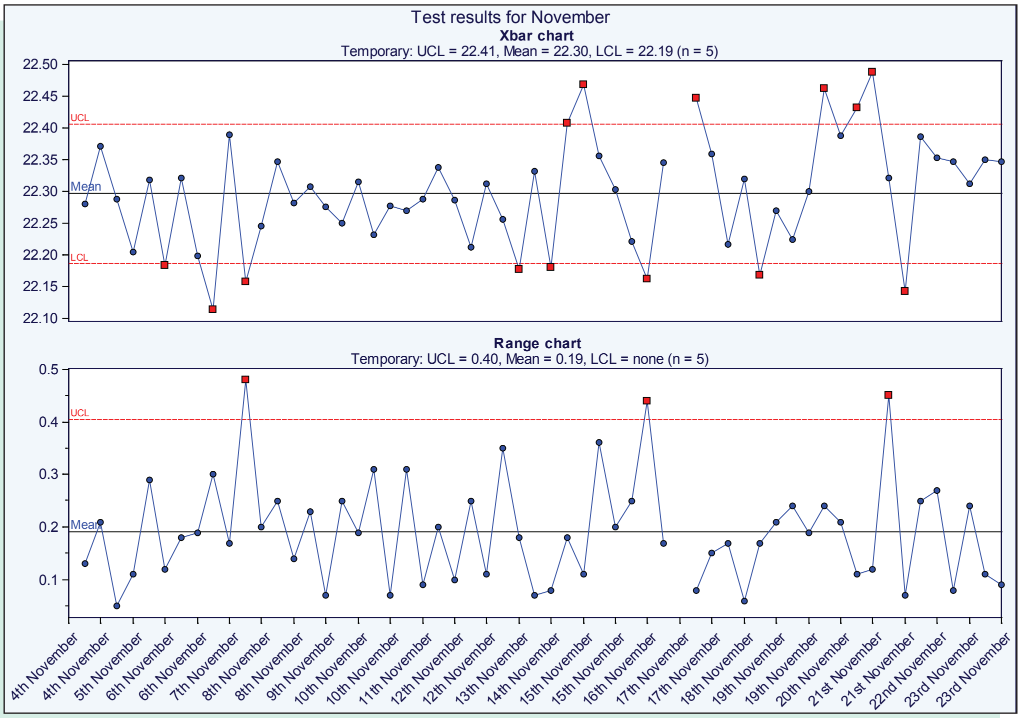

Figure 1 – Control chart of test results.

The control chart shows step changes and periods of poor control in the process. But is this a production issue? Or could it be related to who completed the test?

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How do we find out? How do we identify significant differences among the testers? The answer is relatively simple; use a control chart, but instead of plotting the data over time, plot it by tester, as in figure 2.

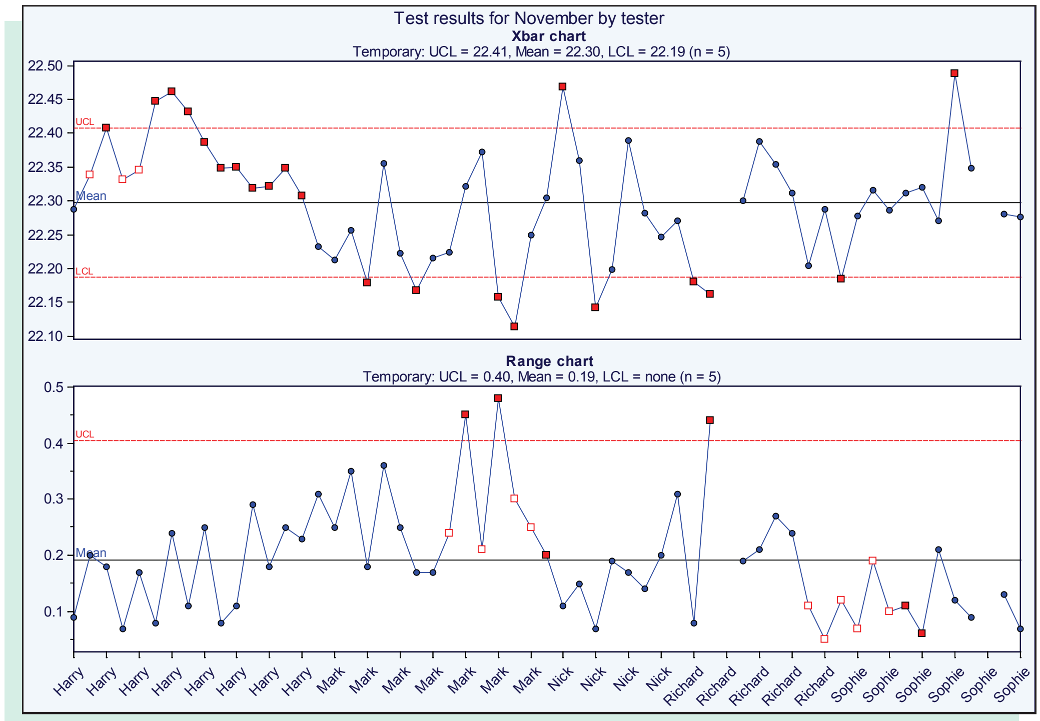

Figure 2 – Control chart of test results sorted by tester.

From figure 2, it is apparent that differences in testers exist. To emphasize this further, we calculate control limits for each tester, shown in figure 3.

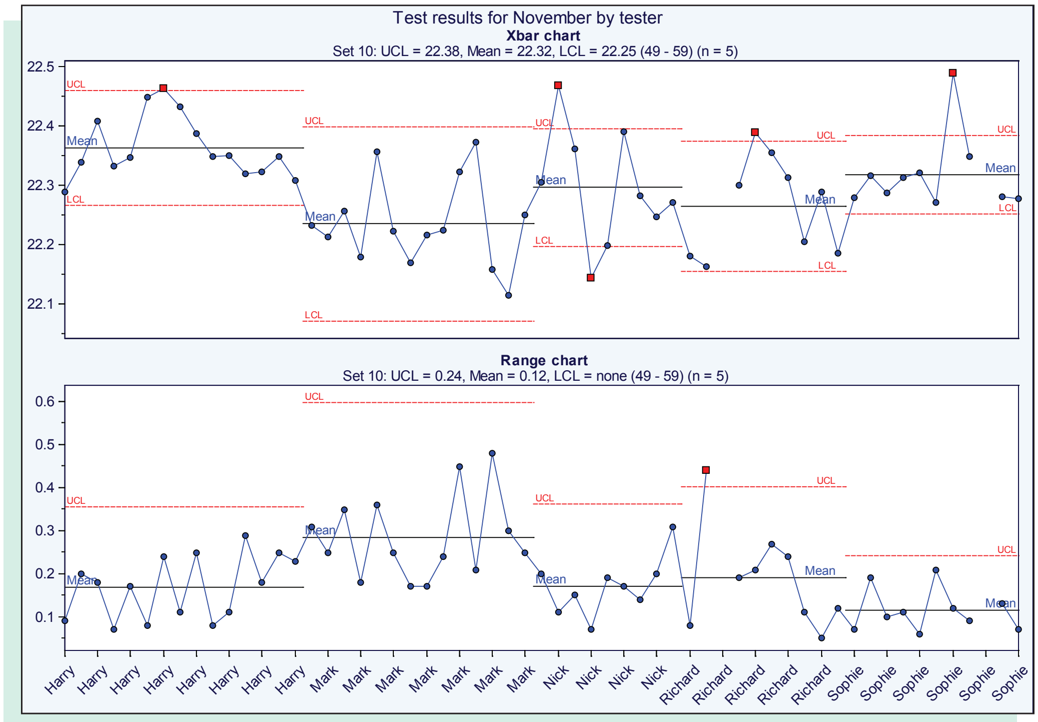

Figure 3 – Control chart of test results sorted by tester, with individual tester control limits.

This chart shows substantial differences among testers. For example, Harry's results show a high bias and Mark's results are much more variable. This simple technique demonstrates whether a measurement issue is present or not. It is evident in this case that an issue exists.

So, how can we be more proactive and answer questions such as:

- How do we know when a new tester is proficient and ready to make assessments alone?
- How do we know if the new tester is maintaining his or her testing ability?
- How do we know if an experienced tester is still doing a good job?

The answer is a measurement systems analysis study focusing on testers. When conducted correctly, this study will reveal the answers to all these questions and more. It will show whether or not bias issues are present, and reveal if some operators are more variable than others.

What is an MSA study?

A measurement systems analysis (MSA) study is a type of experimental design. It consists of a series of measurements made of the same product, using the same equipment, by different testers. In the previous example, the results clearly showed the measurement issues.

A number of MSA techniques can be used. A bias or ANOM chart is one way to review results. Figure 4 shows such a chart for the example.

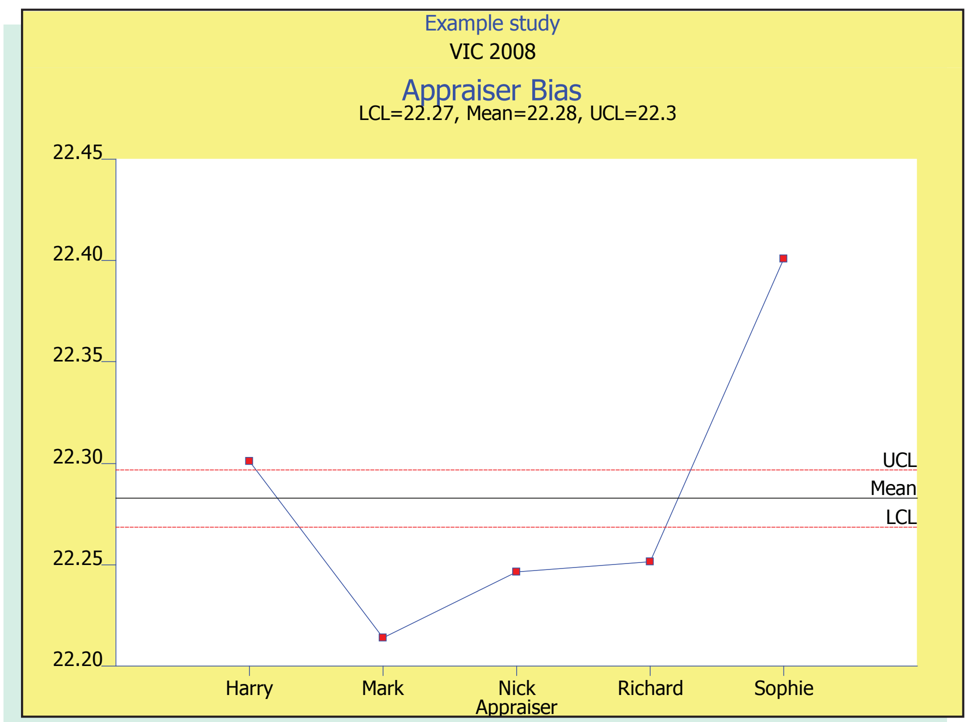

Figure 4 – Bias (ANOM) chart.

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Figure 4 shows the average of all the test results for each operator. Control limits operate in a similar way to those in an average chart. If no bias issues existed, all operator averages would be within the limits. It is clear to see that this is far from the case. Harry has a high bias, as seen in the production data; Sophie's bias is much worse in the assessment. Mark appears to have a low bias. Nick and Richard have produced similar results.

An inconsistency chart assesses the variation in the measurements of the operators. Figure 5 shows the chart for the example data.

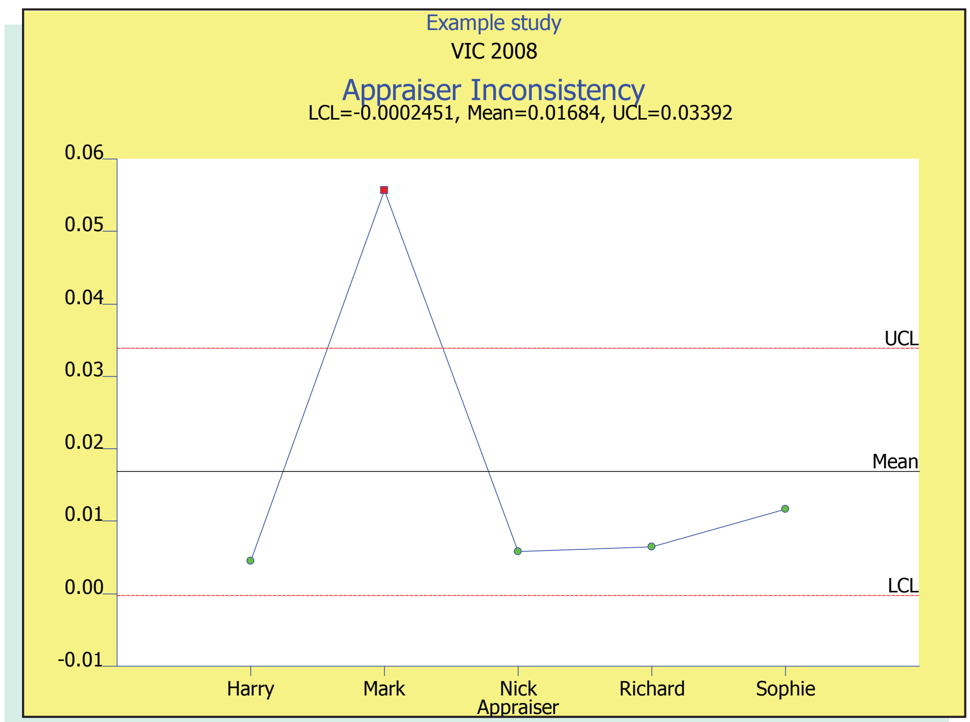

Figure 5 – Inconsistency chart.

An inconsistency chart compares the results from the study and indicates the average variation for each operator. Again, control limits similar to those found on a normal range control chart are applied. Figure 5 clearly shows that Mark is much more inconsistent than the other testers. Measurement systems analysis provides further techniques if necessary, but these two simple charts show us what we need to know. We have confirmed a serious measurement issue.

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Wouldn't it have been better to find this issue before testing production results? Shouldn't new testers be assessed before they begin to measure production data? Completing regular measurement studies is an essential part of any production system and equally as important as calibrating equipment.

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Where to go from here?

So how do you get started with measurement systems analysis? First, learn how to conduct measurement studies and how to interpret them. Find a public course or seek an experienced consultant who can work with you directly. Make sure the course instructor or consultant has significant experience working with manufacturers to conduct measurement studies. Many breeds of quality consultants exist, but rare is the measurement systems analysis expert. Many consultants claim to have the skills necessary to help you adequately analyze your measurement system, but few truly specialize in it. When you seek an outside expert, be sure to ask a few key questions:

When you seek an outside expert, be sure to ask a few key questions:

1. **Who are your clients?** The answer won't necessarily reveal the caliber of the consultant, but may provide insight if the clients are respected.
2. **How long have you been helping customers perform measurement systems analysis?** Make sure the consultant can back up the claims with examples of people you can call to verify the work.
3. **What are your credentials?** This is important. A good consultant will have learned from the best.
4. **Are you the person who will be performing the consultation?** Some firms will subcontract or delegate to junior folks. Make sure the person you interview is the person you get when you hire.

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Then, once you understand the methodology, choose a software solution to do the number crunching for you. Reputable software will not only save you an enormous amount of time, it will also ensure that your studies are error free. Choose a package that will guide you through a study with a wizard for foolproof results.

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References
1. Graham J and Cleary M, *Practical Tools for Continuous Improvement*, PQ Systems.

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Jacqueline Graham, PhD, is former managing director of PQ Systems in Australia and co-author with Michael J. Cleary, PhD, of *Practical Tools for Continuous Improvement*. She holds a doctorate in statistics and quality management from the University of Salford, England. For nearly ten years, Graham was an aide to W. Edwards Deming. She worked in General Motors as the company pioneered supplier quality assurance in its UK and European operations in the 1980s. She has a wide variety of clients in many industries and is a fellow of the Australian Institute of Company Directors and Australian Organization for Quality.