CALIBRATION & CALIBRATION CURVES

DEFINITION:

Calibration is the process of evaluating and adjusting the precision and accuracy of measurement equipment. Proper calibration of an instrument allows people to have a safe working environment and produce valid data for future reference.

OR

Calibration is the comparison of measurement values delivered by a device under test with those of a calibration standard of known accuracy. Such a standard could be another measurement device of known accuracy, a device generating the quantity to be measured such as a voltage, a sound tone, or a physical artifact, such as a meter ruler.

The outcome of the comparison can result in one of the following:

- No significant error being noted on the device under test.
- A significant error being noted but no adjustment made.
- An adjustment made to correct the error to an acceptable level.

"calibration" means just the act of comparison and does not include any subsequent adjustment.

The calibration standard is normally traceable to a national standard held by a national metrological body.

TYPES OF CALIBRATION

1. Traceable calibration certificate.
2. UKAS calibration certificate.

1. TRACEABLE CALIBRATION CERTIFICATE

Traceable calibration involves referencing your instruments against pre-calibrated devices so that a degree of error can be calculated. At ATP we reference your equipment against our own in-house instrumentation that has all been calibrated to UKAS standards. This is known as second generation calibration and ensures that your instruments are accurate to within the standards claimed +/- the possible deviation of our own instruments.

The main advantage of traceable calibration is that there is more flexibility in the testing and adjustment. This means that where possible, any instrument that produces readings that are outside of the claimed specification are adjusted back into alignment and re-tested. At least that's how we do it at ATP! This ensures that the instrument you send in is returned with guaranteed accuracy at the points indicated. This produces a certificate that meets national standards.

2. UKAS CALIBRATION CERTIFICATE

A UKAS calibration is performed by a laboratory that has gained UKAS Accreditation. This means that the calibration laboratory has fulfilled the requirement of ISO/IEC 17025 and meets the technical competence requirements and management system requirements that are necessary to provide technically valid test results and calibrations. The management system requirements of ISO/IEC 17025 ensure that the laboratory meets the principles of ISO 9001

In short, a UKAS calibration certificate is an accredited certificate that is produced to international standards and is a legal document that can stand up in court. The downside to this level of calibration is that the instruments will not be adjusted if they fail to meet standards. Meaning they must be adjusted and re-sent for calibration. This can become a costly procedure if your instruments routinely fall out of specification.

THE IMPORTANCE OF CALIBRATION

- The importance of calibration is not just to check that the instrument's displayed values are within specification, but also to help you understand the inaccuracy of the displayed values at specific points of measurement.
- When you're calibrating an instrument, it is best practice to calibrate at points of measurement critical to the instrument's application. For instance, it's a legal requirement for food caterers and retailers to ensure hot-held food is kept at 63°C or above to avoid cultivating harmful bacteria, therefore it would be advisable to calibrate a thermometer at 63°C, or as close as possible.
- A calibration certificate proves that an instrument has been checked and verified against these critical points of measurement, and will list any errors the instrument has, giving you confidence to demonstrate to an auditor or customer that your instrument reading is within the specified accuracy, and is fit for your desired application.
- The certificate will be available for most instruments that are used in a professional environment where traceable accuracy is required. In a professional environment, it's standard procedure to calibrate an instrument upon its purchase, and on an annual re-calibration basis, but if your instrument application demands a shorter period between calibrations, it's often best practice to set-up an 'automatic re-call' procedure with a qualified laboratory technician.

- This way you'll always be reminded when your instrument is due to be calibrated, and the instrument's accuracy won't be compromised without your prior knowledge.
- If you're using an instrument that hasn't been calibrated, it has to be considered that your measurement may be seen as unreliable and incompliant to national or international standards in a professional environment.

PURPOSE OF INSTRUMENT CALIBRATION

- Calibration refers to the act of evaluating and adjusting the precision and accuracy of measurement equipment. Instrument calibration is intended to eliminate or reduce bias in an instrument's readings over a range for all continuous values.
- Precision is the degree to which repeated measurements under unchanged conditions show the same result
- Accuracy is the degree of closeness of measurements of a quantity to its actual true value.
- For this purpose, reference standards with known values for selected points covering the range of interest are measured with the instrument in question. Then a functional relationship is established between the values of the standards and the corresponding measurements.
- There are two basic situations

1. Instruments which require correction for bias:

- The instrument reads in the same units as the reference standards.
- The purpose of the calibration is to identify and eliminate any bias in the instrument relative to the defined unit of measurement.

- For example, optical imaging systems that measure the width of lines on semiconductors read in micrometers, the unit of interest. Nonetheless, these instruments must be calibrated to values of reference standards if line width measurements across the industry are to agree with each other.

2. Instruments whose measurements act as surrogates for other measurements:

- The instrument reads in different units than the reference standards. The purpose of the calibration is to convert the instrument readings to the units of interest.
- An example is densitometer measurements that act as surrogates for measurements of radiation dosage. For this purpose, reference standards are irradiated at several dosage levels and then measured by radiometry.
- The same reference standards are measured by densitometer.
- The calibrated results of future densitometer readings on medical devices are the basis for deciding if the devices have been sterilized at the proper radiation level.

Why Are Calibrations Necessary?

- There are technical and legal reasons why calibration is performed.
- Four main reasons for having an instrument calibrated are:

1. To establish and demonstrate metrological traceability.
2. To ensure readings from the instrument are consistent with other measurements.
3. To determine the accuracy of the instrument readings.
4. To establish the reliability of the instrument.

- To guarantee interchangeability of parts, it is fundamental to establish traceability of measurements to national standards by means of calibration.
- In particular, suppliers and customers producing and assembling parts with other components must ensure valid measurement results and need to measure parts with the same measure.
- When necessary to ensure valid results, measuring equipment shall be calibrated, or verified, or both, at specified intervals, or prior to use, against measurements standards traceable to international or national measurements standards.

CALIBRATION CURVE

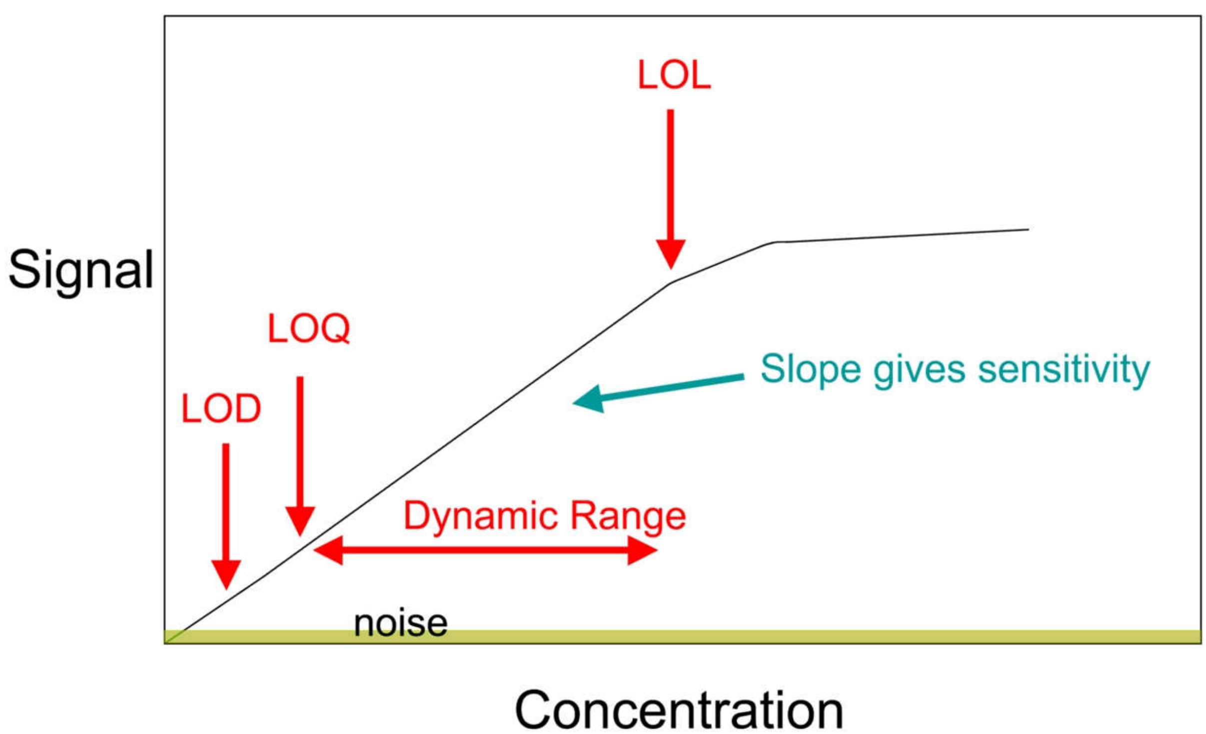

Fig: A calibration curve plot showing limit of detection (LOD), limit of quantification (LOQ), dynamic range, and limit of linearity (LOL).

- A calibration curve, also known as a standard curve.
- A general method for determining the concentration of a substance in an unknown sample by comparing the unknown to a set of standard samples of known concentration.
- A calibration curve is one approach to the problem of instrument calibration other standard approaches may mix the standard into the unknown giving an internal standard.
- The calibration curve is a plot of how the instrumental response, the so-called analytical signal, changes with the concentration of the analytic (the substance to be measured).
- Analyzing each of these standards using the chosen technique will produce a series of measurements. For most analyses a plot of instrument response vs. Concentration will show a linear relationship
- . The operator can measure the response of the unknown and, using the calibration curve, can interpolate to find the concentration of analytic.

ERROR IN CALIBRATION CURVE RESULT

- As expected the concentration of the unknown will have some error which can be calculated from the formula below.
- This formula assumes that a linear relationship is observed for all the standards.

$$s_x = \frac{s_y}{|m|}\sqrt{\frac{1}{n} + \frac{1}{k} + \frac{(y_{unk} - \bar{y})^2}{m^2 \sum (x_i - \bar{x})^2}}$$

- $s_y = \sqrt{\frac{\sum (y_i - mx_i - b)^2}{n-2}}$, is the standard deviation in the residuals
- m is the slope of the line
- b is the y-intercept of the line
- n is the number of standards
- k is the number of replicate unknowns
- $y_{unknown}$ is the measurement of the unknown
- $\bar{y}$ is the average measurement of the standards
- x_i are the concentrations of the standards
- $\bar{x}$ is the average concentration of the standards

- It is important to note that the error in the concentration will be minimal if the signal from the unknown lies in the middle of the signals of all the standards.

GENERAL USES

- In more general use, a calibration curve is a curve or table for a measuring instrument which measures some parameter indirectly, giving values for the desired quantity as a function of values of sensor output.
- For example, A calibration curve can be made for a particular pressure transducer to determine applied pressure from transducer output (a voltage).
- Such a curve is typically used when an instrument uses a sensor whose calibration varies from one sample to another, or changes

with time or use if sensor output is consistent the instrument would be marked directly in terms of the measured unit.

- The data the concentrations of the analytic and the instrument response for each standard can be fit to a straight line, using linear regression analysis.
- Many different variables can be used as the analytical signal. The detector converts the light produced by the sample into a voltage, which increases with intensity of light. The amount of light measured is the analytical signal.
- Most analytical techniques use a calibration curve. There are a number of advantages to this approach.
- First the calibration curve provides a reliable way to calculate the uncertainty of the concentration calculated from the calibration curve (using the statistics of the least squares line fit to the data).
- Second the calibration curve provides data on an empirical relationship. The mechanism for the instrument's response to the analytic may be predicted or understood according to some theoretical model, but most such models have limited value for real samples.
- The chief disadvantages are
- That the standards require a supply of the analytic material preferably of high purity and in known concentration.
- That the standards and the unknown are in the same matrix. Some analytes e.g. Particular proteins are extremely difficult to obtain pure in sufficient quantity.

- Other analytes are often in complex matrices. E.g. Heavy metals in pond water.
- In this case, the matrix may interfere with or attenuate the signal of the analytic.
- Therefor a comparison between the standards (which contain no interfering compounds) and the unknown is not possible. The method of standard addition is a way to handle such a situation.

INTERPRETATION AND CONSTRUCTION

1. Interpretation means the art of finding out the true sense of an enactment by giving the words their natural and ordinary meaning whereas construction means drawing conclusion in the base of the true spirit of the enactment.
2. Interpretation take place when we look for the original meaning of the constitution. All other forms of the construction analysis engage in construction.
3. Interpretation the meaning of the constitution is clear (by any broadly accepted theory of constructional interpretation). Constructional takes place when the meaning of the constitution is contested.
4. Original its engage in interpretation even when they focus on original intentions, expectations or method. All other forms of constructional analysis engage in construction.
5. Courts may only interpretation the constitution. Elected officials are free to construe the constitution.
6. To find out the real meaning of any legislation is the main function of interpretation. On the other hand, construction is applying to find out the general and simple meaning of a statute.

7. Interpretation is the activity of identifying the semantic meaning of a particular use of language in context. Construction is the activity or applying that meaning to particular factual circumstances.
8. By interpretation we find at the way of analysis of any statute by construction we try to conclude it.
9. Interpretation is the linguistics meaning in context (or communicative context) of a legal text. Construction is the activity of determining the legal effect (or legal context) of a legal text.
10. Interpretation resolve ambiguity but construction creates subsidiary rules to resolve that vagueness.
11. Interpretation is just a broad word for how someone construes a statute or the constitution method where the words of the law are vigorously followed.