Understanding Instrument Specifications

Specification can be presented in different ways; they may be a single figure, a 2-term expression, or even a 3-term expression.

The 3 terms normally used by manufacturers to specify instruments performance are

- **Full Scale (or range)**
- **Reading**
- **Floor (or zero)**

For example, 0.1% of **full scale** + 0.02% of **reading** + 1 **digit**

Note: In many cases ppm is used instead of %, and the floor term many be expressed in absolute units, for example milliohms, or in a number of digits or counts.

To accurately specify performance over a range of values it is necessary to use at least 2 terms, most usually a % of reading plus a floor, or zero value.
The percentage of reading allows for increasing error as the reading increase, at zero reading this term is zero. The 'Floor' or zero term allows for error when the instrument is reading/output zero.

The calculation and addition of these two terms allow and instruments accuracy to be specified, and calculated at any point from zero to full scale, and includes the effects of zero offsets, gain errors and linearity.

It is usual for specifications to be arithmetical added together, to give a 100% confidence level.

Key Terms

Full Scale (F.S) : The maximum value that may be read/output on a range.
Reading : The value being read/output as used to calculate the accuracy.
Floor (zero) : The error at zero reading/output
Digits (counts) : The last or lowest digit on the display. Often used to specify the floor term on a DMM, for example on a display of 1.000V the lowest digit would be 1mV
ppm : Parts per million, works as %, 0.01% = 100ppm

Calibration : Assigning a numerical value to a measurement
Adjustment : Changing the value of a setting

Stability : The change over a period of time, normally 24 hours,
` of the reading/output of an instrument with all factors is remaining the same. For example an instrument output is measured at one point, it is then left on continuously outputting this value for 24 hours in the same environment, 24 hours later the instrument is measured again, the stability is the change from the first reading to the last.

Please note stability and accuracy are quite different, accuracy, even 24hour accuracy relative to calibration standards, covers a range, e.g. 0 to full scale and includes the effects of all errors, linearity etc at any point on that range, where stability is only the change at one point over the 24hours.

Accuracy relative to calibration standards.

When an instrument is adjusted it is adjusted to read correct against a reference or standard, for example when you set the time on your watch it is set to the time from another clock.
If the clock used as a reference is 1 minute fast, so will your watch be. This error is not due to your watch, but the adjustment of it.

This is the same with any instrument, so it is necessary for the manufacture to separate the errors due to the adjustment and that of the instrument.
Transmille give several sets of specifications, the ‘Accuracy relative to calibration standards’ – the performance of the instrument itself over different time periods, and also the Total accuracy specifications when calibrated by Transmille, - this specification combines the adjustment uncertainty from Transmille UKAS calibration laboratory along with the instruments specifications to give an ‘out of the box’ accuracy.

The reason it is important to know the ‘Relative to calibration standards’ specifications is it may not be possible to use the manufacture to re calibrate the instrument. In this case the user needs to know the performance of the instrument ‘by itself’ without the manufactures calibration uncertainties.

Accuracy and Uncertainty.

Whenever a measurement is made there is always an uncertainty, the uncertainty can be due to many contributions, one of which may be the accuracy of the instruments being used. For example, a watch manufacture may specify the watch accuracy of 20 seconds a year (this is of course accuracy to calibration standards).

When you set the watch the time from the reference clock may also have an error in its time due to many contribution, so this reference clock may have an unknown error, this is your ‘imported’ uncertainty. It is not important if this imported uncertainty is larger than the 1 year accuracy of the watch.

The time displayed on your watch has an unknown, or uncertainty made up of several contributions, imported uncertainty, the year accuracy, the resolution and several other terms, so you can know the time plus or minus an uncertainty.

In every day life the words **accuracy**, and **calibration** frequently are misused where the words **uncertainty** and **adjustment** should be used.