



PRESSURE SOLUTIONS

C102: Test Uncertainty Ratio (VL)

Briefly, Test Uncertainty Ratio (TUR) is an important characteristic of a calibration system, being the ratio of the allowable uncertainty in the instrument under test (UUT), to the total uncertainty of the reference.

ISO guidelines suggest a TUR of between 3 and 10.

What is the significance of this?

The average calibration technician (not a metrologist) will assume that the reference he is using is true, and only looks at the deviations he sees from "true". If he is calibrating a 1% pressure gauge of 600 kPa range, he knows that as long as the gauge is within 6 kPa of the reference, it is acceptable.

In fact, it requires a very high TUR to make it acceptable, because the uncertainty of the reference has to be taken into account.

Combining Uncertainties:

This can be done arithmetically (conservative) or statistically. The statistical Root Sum Square method is more liberal and more common. In this procedure, all uncertainties are squared, summed, and the square root of the sum is taken.

This method gives most weight to the large uncertainties, and in any realistic calibration system, the allowable deviation in the UUT should be the most significant of the various uncertainties.

Common sense tells us that the calibration reference should be more accurate than the unit under test. The TUR quantifies this.

Let's consider the example above, and assume that we are using a 0,25% FS 600 kPa test gauge as our reference. The uncertainty of the reference is thus 0,25% of 600 or 1,5 kPa. The allowable error in the UUT is 6 kPa. If we combine these, the total uncertainty in the UUT becomes $\sqrt{6^2 + 1,5^2} = 6,2$. There may be a temperature error as well, typically 0,3% per 10°C, so if we are running at 25°C instead of the standard 20°C, there could be errors of 0,15% or 0,9 kPa in both instruments, so the total uncertainty is now $\sqrt{6^2 + 1,5^2 + 0,9^2} = 6,25$. We are already 5% over the limit!

Lets re-look at this using a Jofra APC 1 500 kPa with an uncertainty of 0,04% of reading + 0,01% of range, temperature compensated. The total uncertainty is 0,39 kPa and the TUR is 15. The total uncertainty becomes

$\sqrt{6^2 + 0,39^2 + 0,9^2} = 6,1$ and if we were in a temperature controlled room it would be $\sqrt{6^2 + 0,39^2} = 6,01$.

What we are seeing is that if the TUR is high enough, the calibrator uncertainties do not add much to the total uncertainty, and we can approximate the total uncertainty to the observed deviation from the reference.

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Lets look at a 4 – 20 mA 600 kPa pressure transmitter in a similar application, using an Agilent 34401A DMM as the current reference, and the Jofra APC as the pressure reference. The current uncertainty is 0,075% of 20 mA = 600 kPa = 0,45 kPa. The allowable deviation is 1,5 kPa. The TUR on the DMM is 3,3 and on the APC 3,8.

The total uncertainty is now $\sqrt{(1,5^2 + 0,39^2 + 0,45^2)} = 1,6$ kPa.

We can do a bit of reverse calculation here and calculate what U should be to maintain the total uncertainty allowed, where U is the UUT error. $\sqrt{(U^2 + 0,39^2 + 0,45^2)} = 1,5$. So $U^2 + 0,39^2 + 0,45^2 = 1,5^2$ or $U^2 = 1,5^2 - 0,39^2 - 0,45^2 = 1,377$ kPa or 91% of allowable uncertainty.

A good rule of thumb is that while maintaining a TUR of 3, as long as the largest observed deviation is within 90% of that allowed, the calibration is valid.

When a TUR of 3 is not available, a detailed uncertainty budget should be generated, and a maximum allowable deviation calculated.

If the TUR is 1, this means that the reference by itself is providing the total allowable uncertainty, so neither the UUT nor the environment is allowed to contribute any uncertainty at all. Everything must be perfect!

This makes the point that no instrument can be better than the reference against which it is calibrated.

Next question: How many reps selling calibration equipment understand the above?

Next Question: How many purchasers of calibrators understand the above?

Last Question: How many purchasers of calibration equipment are happy with their purchase?

Makes you think, doesn't it.