Metrology Concepts

What does less than 4:1 TUR (Test Uncertainty Ration) Mean?

Frequently Asked Questions:

1. Q: What is the difference between TAR and TUR?
   A: TAR (Test Accuracy Ratio) and TUR (Test Uncertainty Ratio) are both test ratios that are intended to indicate whether or not the calibration process was good enough to be able to make a statement of compliance about your test instrument. TAR is the ratio of your instrument's accuracy against the accuracy of the standard that is used to report the error of your instrument. TUR is the ratio of your instrument's accuracy against the laboratory's measurement uncertainty. Uncertainty estimates are required under ISO-17025 accreditation practices in order for a lab to become accredited. TUR is, therefore, a more correct ratio indicator of the calibration process.

2. Q: Does TUR make my instrument OOT when TAR would not have?
   A: No, TAR vs. TUR has no effect on whether or not an instrument is In-Tolerance or OOT. The only thing that changes is that the indeterminate zone* is wider when using TUR since the lab is considering all factors that affect the measurement process (which often includes the accuracy of the lab's standards, the uncertainty of the calibration for those standards, environmental factors, etc.). Simply put, TAR does not consider all of the facts; TUR does. Therefore TAR is an outdated measure and should no longer be used. TUR is a more truthful statement of the bias that is present in any laboratory's measuring process and the effect it has on the quality of the reported calibration results.

3. Q: My quality policy regarding calibration says that all calibrations must meet a 4:1 TAR. Transcat reported measurements that are < 4:1 TUR on a particular measurement for my instrument. What should I do with this information?
   A: Calibration laboratories that are accredited under ISO-17025 are required to work and report in terms of the uncertainty of their measurement process (TUR) rather than simply using the accuracy of their lab standard (TAR). This paradigm shift in the way that cal labs look at how they affect traceable measurement implies that there are two things that you should do as a participant in this traceability chain:

      a. Short Term: Since TUR is a more realistic and conservative number than TAR, taking action as if this was reported as TAR will keep your quality system in check.
      b. Long Term: Make changes to your quality policy to update it so that it follows current good Metrology practices (cGMetP) that rely upon uncertainty (TUR) rather than accuracy (TAR).

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4. Q: `What should I know if my calibration cert contains a statement that reads, “This unit was calibrated with a TUR of less than 4:1. See supplemental report.”?

SUPPLEMENTAL REPORT FOR 1-Z026S-2-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Description	Setpoint	Accuracy	Low Limit	High Limit	As Found / As Left	OOT	Uncertainty (k=2, ±)	TUR
	-80.000 mV	±(0.005% Rdg + 0.006 mV)	-80.012	-79.988	-80.002 mV			
	-60.000 mV	±(0.005% Rdg + 0.006 mV)	-60.011	-59.989	-60.001 mV			
	-40.000 mV	±(0.005% Rdg + 0.006 mV)	-40.009	-39.991	-40.002 mV			
	-20.000 mV	±(0.005% Rdg + 0.006 mV)	-20.008	-19.992	-20.002 mV			
	0.000 mV	±(0.005% Rdg + 0.006 mV)	-0.006	0.006	-0.002 mV			
	20.000 mV	±(0.005% Rdg + 0.006 mV)	19.992	20.008	19.998 mV			
	40.000 mV	±(0.005% Rdg + 0.006 mV)	39.991	40.009	39.997 mV			
	60.000 mV	±(0.005% Rdg + 0.006 mV)	59.989	60.011	59.998 mV			
	80.000 mV	±(0.005% Rdg + 0.006 mV)	79.988	80.012	79.997 mV			
	99.000 mV	±(0.005% Rdg + 0.006 mV)	98.986	99.014	98.997 mV			
Temperature Measure Sim.								
Type K (ITS90)	-5.150 mV	±(0.6 °C)	-220.6	-219.4	-219.9 °C			
	0.000 mV	±(0.5 °C)	-0.2	0.2	0.0 °C		1.000e-1 °C	2.0 : 1
Units Conversion	0.000 mV	±(0.4 °F)	31.6	32.4	32.0 °F		1.800e-1 °F	2.2 : 1
	4.096 mV	±(0.2 °C)	99.8	100.2	100.0 °C		1.000e-1 °C	2.0 : 1
	20.644 mV	±(0.2 °C)	499.8	500.2	500.0 °C		1.000e-1 °C	2.0 : 1
	41.276 mV	±(0.2 °C)	999.8	1000.2	1000.1 °C		1.000e-1 °C	2.0 : 1
	54.819 mV	±(0.3 °C)	1369.7	1370.3	1370.1 °C		1.000e-1 °C	3.0 : 1
Type J (ITS90)	0.000 mV	±(0.1 °C)	-0.1	0.1	0.0 °C		1.000e-1 °C	1.0 : 1
Type T (ITS90)	0.000 mV	±(0.1 °C)	-0.1	0.1	0.0 °C		1.000e-1 °C	1.0 : 1
Type E (ITS90)	0.000 mV	±(0.1 °C)	-0.1	0.1	0.0 °C		1.000e-1 °C	1.0 : 1

Figure 1: Supplemental Calibration Report indicating measurements with <4:1 TUR

A: In unavoidable situations that cause a TUR that is less than 4:1, a calibration laboratory should report their measurement uncertainty for the measurement. Using the uncertainty, the allowed tolerance of your instrument, and your instrument’s reported reading, you can determine whether or not the reading lies within the indeterminate zone* (see other side of this attachment for more details):

a. If it does not lie within the indeterminate or OOT zone, then you can rest assured that the lower TUR had no effect on the process in which your test instrument was used to make qualifying measurements.
b. If it does reside within the indeterminate or OOT zone, then you should treat the measurement as if it were reported OOT and perform an evaluation on the processes in which the instrument was used.

The calibration that Transcat performed on your instrument followed ISO-17025 accredited practices. Within this calibration, there may have been one or more measurements that resulted in a Test Uncertainty Ratio (TUR) of less than 4:1. TUR is the ratio between your instrument's allowed tolerance and the calibrating lab's measurement uncertainty. While Transcat attempts to maintain a TUR of 4:1 or better for each measurement made on your instrument, there are times when this is simply not feasible. This may leave you with the question, "Does a TUR that is less than 4:1 have an impact on my quality system?" This paper should help to make that decision easier for you to answer; or at least will get you on your way to a better understanding of what this means.

Following the requirements of ISO-17025, Transcat calibration technicians calculated the uncertainty of each measurement that was taken on your instrument and then determined the TUR for each reading. The uncertainty reported by a calibration laboratory represents the variation that occurs within that lab's controlled measurement process. This uncertainty includes multiple components: the estimated drift of the lab standard over its calibration interval, the uncertainty of the calibration performed on the lab standard when it was calibrated and environmental effects, among other things. These values may change within an expected range over time, but usually much less than your instrument changes over time. The exact amount of drift in these values is determined each time the lab standard is re-calibrated.

Even though a 4:1 TUR (or better) is considered ideal, the most important point to consider is that, even at 4:1 or 10:1, there is an "indeterminate zone" that still may have an effect on your quality decision for In-Tolerance vs. Out-Of-Tolerance situations. This "indeterminate zone" is the area where the actual reading, plus/minus the uncertainty, may cause the statement of compliance to be misleading. If any of your instrument's readings lie within this zone, you should understand how Transcat handles this and you should make a decision rule in your quality system outlining what to do in this scenario.

The greater the TUR, the smaller the indeterminate zone. Likewise, the smaller the TUR, the larger the zone. Sometimes small TURs cannot be avoided, either because of the limits of technology or because of the cost to achieve better TURs. This means that sooner or later you'll run into this indeterminate decision situation. If your instrument's reading lies within this zone or beyond, you need to make a decision on whether or not the value of the instrument (as it had been used over its past calibration cycle) adversely affected the product or process in which it was used to make qualifying measurements.

Transcat's decision rules are as follows:

1. Regardless of the uncertainty, we will report compliance based on the actual reading.
2. Whenever the reading lies within the indeterminate zone or is out of tolerance, we will adjust the instrument (when possible) to return its value as close to nominal as is possible
3. We will include the uncertainty of the measurement and the calculated TUR for any reading in which the TUR is less than 4:1
4. For any reading in which the TUR is less than or equal to 1:1, we require our customer's approval to proceed

We follow this set of decision rules because the vast majority of our customers rely upon a statement of compliance to tell them when it is time to perform an impact evaluation wherever the instrument had been used over its last calibration interval. Transcat will make a statement of compliance (In-Tol or OOT) for measurements where the TUR is less than 4:1, but only to the point that we reach a 1:1 TUR. When the TUR reaches or drops below a 1:1 ratio, there is simply insufficient evidence for us to clearly state whether or not your instrument meets its tolerance limits. Therefore we do not include a statement of compliance when any reading must be performed at a TUR less than or equal to 1:1.

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Better by every measure

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