Ultrasonic Contact Impedance (UCI) accuracy, measurement deviation and repeatability explained

Many producers talk about the UCI accuracy and how accurate the probes are, but this creates even greater confusion among the users when it comes to the technique itself.

1. The Misconception: “Probe accuracy”

Many users ask about "probe accuracy," but this term is misleading. It implies that the technology itself is the only variable. In reality, Ultrasonic Contact Impedance (UCI) testing is heavily influenced by how the user handles the probe.

Therefore, standards like **DIN 50159, GB/T 34205** and **ASTM A1038** do not use the term "accuracy." Instead, they evaluate performance using two specific metrics:

- Measurement deviation
- Repeatability

2. Key definitions.

a) Measurement deviation definition:

$$E = \frac{\bar{H} - H}{H} \cdot 100\%$$

(E – measurement deviation, $\bar{H}$ – Average value of n measurements, H – reference value i.e. test block)

In Plain English: If the block says 800 HV and your average is 830 HV, your deviation is +3.75 %.

b) Repeatability definition (also denoted as coefficient of variation):

Defined in **DIN 50159 & GB/T**, describes the relative difference between the highest and the lowest hardness value with respect to the average:

$$r = \frac{H_{max} - H_{min}}{\bar{H}} \cdot 100\%$$

(r-repeatability, H_{min} and H_{max} – the lowest and the highest hardness values respectively, $\bar{H}$- average value)

In Plain English: If you measure the same spot 5 times, are the numbers close together?

3. User daily verification requirements.

As an end-user, your daily responsibility is to check **Measurement Deviation. You must verify that the device reads the test block correctly within the tolerances defined by DIN 50159.**

Scale / Range	Instrument verification criteria: Max. measurement deviation (E) in % DIN 50159, ASTM A1038, and GB/T 34205							
	DIN & GB/T	ASTM	DIN & GB/T	ASTM	DIN & GB/T	ASTM	DIN & GB/T	ASTM
	< 250 HV		250 - < 500 HV		500 – < 800 HV		>800 HV	
HV 0.1	6	6	6	7	8	8	9	9
HV 0.3	6	6	7	7	8	8	9	9
HV 0.8	5	6	5	7	6	8	7	9
HV 1	5	5	5	5	6	7	7	7
HV 5	5	5	5	5	5	7	5	7
HV 10	5	5	5	5	5	7	5	7

Table 1: User Daily Verification Requirements.
The summary of maximum tolerable errors for measurement deviation from DIN 50157-1, ASTM A1038 and GB/T 34205.

4. Laboratory calibration requirements: Why repeatability is not checked in the daily verification (table above).

When your device is sent to a certified lab (e.g., annually), it must pass **stricter tests**.

Repeatability is primarily a **mandatory check for calibration laboratories**, not for daily field use. Users in the field often cannot achieve laboratory-level stability due to environmental factors. While you should aim for consistent results, strict pass/fail repeatability limits are enforced during annual calibration, not daily checks. *Note: ASTM A1038 focuses primarily on deviation (E) and does not strictly mandate a repeatability (R) limit for calibration, whereas DIN 50159 & GB/T 34205 do.*

Scale / Range	Max. measurement deviation (E) in % DIN 50159, ASTM A1038, and GB/T 34205								Repeatability (R) / %			
	DIN & GB/T	ASTM	DIN & GB/T	ASTM	DIN & GB/T	ASTM	DIN & GB/T	ASTM	DIN & GB/T	ASTM	DIN & GB/T	ASTM
	<250 HV		250 - <500 HV		500 – < 800 HV		>800 HV		≤ 250 HV		> 250 HV	
HV 0.1	5	6	6	7	7	8	8	9	8	Not required	6	Not required
HV 0.3	5	6	6	7	7	8	8	9	8		6	
HV 0.8	4	6	4	7	5	8	6	9	8		6	
HV 1	4	5	4	5	5	7	6	7	8		8	
HV 5	4	5	4	5	4	7	4	7	5		5	
HV 10	4	5	4	5	4	7	4	7	5		5	

Table 2: Laboratory calibration requirements
Maximum tolerable errors for measurement deviation and repeatability from DIN 50157-2, ASTM A1038 and GB/T 34205.

5. Are probes compliant to DIN50159 & GB/T 34205 compliant also to ASTM A1038?

Yes. The requirements for DIN and GB/T UCI standards are stricter, and account for repeatability. The probes must not only be more accurate on certain levels but also repeatable.