Metrology

Granite Plates: Accuracy and Calibration of Critical Reference Surfaces

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This technical bulletin addresses the accuracy and calibration of granite surface plates. The technical basis for this document is the American national standard (ANSI standard) entitled ASME B89.3.7-2013, Granite Surface Plates. This technical bulletin summarizes key technical issues; however, the ASME standard should be consulted for further information.

Surface plates are made of various types of granite – they are massive, stiff, and hard. The top work surface is lapped flat and smooth to provide a critical reference surface for many types of dimensional measurements. The quality of surface plates had been standardized for decades through the Federal Specification GGG-P-463c. That document was made inactive in 2013 when the ASME B89.3.7 standard was published. Much of the content of GGG-P-463c, including the standardized grades and tolerance values, was left unchanged and moved into the new standard.

Accuracy Specifications

The focus of this technical bulletin is the surface plate flatness, which is the most important metrological characteristic of surface plates and is subject to routine calibration over time. In accordance to the ASME B89.3.7 standard, there are two separate flatness characteristics that are important – the overall flatness, which covers the entire work surface, and the local variation in flatness, which is also called the repeat reading. The local variation in flatness applies to a smaller area of the surface plate and will therefore always have a smaller flatness tolerance than the overall flatness. For both characteristics, the same definition of flatness applies – it is the distance between two parallel planes that contain all the points on the surface of the plate. In practice, flatness is assessed by measuring points across the surface and determining the distance, or range, from the highest peak to the lowest value.

ASME B89.3.7 defines standardized tolerance grades for surface plates. The highest accuracy plates are called Grade AA, and they are often found in calibration laboratories. Grade B plates are the lowest accuracy plates, and they might be found on shop floors. The middle grade plates, Grade A, are often used in inspection areas. Surface plates are typically manufactured in common sizes and in accordance to the standardized grades. Customers can order the size and quality of the plate needed. The table below lists the tolerance values for the overall flatness and the local variation in flatness for the three

different grades as defined in the ASME B89.3.7 standard.

Calibration and Verification

In practice, both the overall flatness and local variation in flatness need to be calibrated on a surface plate. Calibration is done by checking conformance of the surface plate to the two different tolerance values. If necessary, adjustments to the surface plate flatness – typically onsite re-lapping – can be done by those with the required skills and tools.

The overall flatness is often checked with a laser interferometer, autocollimator, electronic levels, or master straightedge and indicator. For all of these methods, a series of measurement lines across the surface plate are made and then the lines are combined into a three dimensional analysis of the overall flatness.

The local variation in flatness, or repeat reading, is typically checked using what is called a repeat reading gage. This measuring instrument has a small three-point base connected to a pivoting section with a fourth contact point. An indicator is used to measure the vertical movement of the fourth point relative to the base. The repeat reading gage is manually swept around the surface plate, and the measured local variation in flatness is the range of the indicator movement.

Tolerances for Common Size Granite Surface Plates in Accordance to ASME B89.3.7-2013

Rectangular Surface Plate		Flatness Tolerances (µin.)					
		Grade AA		Grade A		Grade B	
Width (in.)	Length (in.)	Local Flatness	Overall Flatness	Local Flatness	Overall Flatness	Local Flatness	Overall Flatness
12	12	35	50	60	100	110	200
12	18	35	50	60	100	110	200
18	18	35	50	60	100	110	200
18	24	35	80	60	160	110	320
24	24	45	80	70	160	120	320
24	36	45	100	70	200	120	400
24	48	45	150	70	300	120	600
30	48	45	180	70	360	120	720
36	36	45	150	70	300	120	600
36	48	45	200	70	400	120	800
36	60	60	250	80	500	160	1000
36	72	60	300	80	600	160	1200
48	48	60	200	80	400	160	800
48	60	60	300	80	600	160	1200
48	72	60	350	80	700	160	1400
48	96	75	500	100	1000	200	2000
48	120	90	700	120	1400	240	2800
60	120	90	750	120	1500	240	3000
72	96	90	600	120	1200	240	2400
72	144	100	1100	140	2200	280	4400

▪ The decision rule that applies for statements of conformity to these specifications, as stated in ASME B89.3.7-2013, is Simple Acceptance with a test uncertainty ratio, TUR ≥ 4 for both Grade A and Grade B,

and TUR ≥ 2 for Grade AA.
▪ Except for some minor rounding differences, the tolerance values from GGG-P-463c are identical to these ASME B89.3.7 values.
▪ Metric values also available. Please consult ASME B89.3.7 for further information.

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