DOX CALIBRATION ... We Set The Standard!℠

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No 1887.01

Is there an industry standard for surface plate accuracy?

Most manufacturers use Federal Specification GGG-P-463c (Granite Surface Plates) as a basis for their specifications. A new replacement specification (ASME B-89.3.7) is nearing publication at present, but it will incorporate most elements of the current specification.

Copies of GGG-P-463c can be obtained from:

Federal Supply Service Bureau - Specification Section
Suite 8100 - 470 E. L'Enfant Plaza Southwest
Washington, DC 20407

Federal Specification GGG-P-463c for Granite Surface Plates: The current industry standards for granite surface plates. This specification covers all critical aspects of precision granite surface plates, including: Material properties, dimensional tolerances, acceptable methods of calibration, grades of accuracy, and flatness tolerances for each, surface texture, support points, packaging, certification, etc. All of our products are manufactured and certified to meet or exceed the requirements of this specification unless the customer specifically requests otherwise.

Flatness: Flatness, as defined by Federal Specification GGG-P-463c is: All points on the surface lie between two parallel planes, separated by 'X' distance, where 'X' is the overall flatness tolerance. (paraphrased from para. 3.3.4) This is a unilateral tolerance, not a plus/minus tolerance. Occasionally, flatness will be defined as: deviation from a mean plane. Tolerances stated in this way are plus & minus, as opposed to unilateral. GGG-P-463c:

Which is more important: flatness or repeat measurements?

Both are critical to insure an accurate surface. As stated above, a flatness specification alone is not sufficient to guarantee measurement accuracy. Take as an example, a 36 X 48 Inspection Grade A surface plate, which meets ONLY the flatness specification of .000300" If the piece being checked bridges several peaks, and the gage being used is in a low spot, the measurement error could be .000300"! Actually, it can be much higher, as the gage could be resting on the slope of an incline.

Errors of .000600"-.000800" are possible, depending upon the severity of the slope, and the arm length of the gage being used. If this plate had a Repeat Measurement specification of .000050"F.I.R. then the measurement error would be less than .000050" regardless of where the measurement is taken on the plate. Another problem, which usually arises when an untrained technician attempts to resurface a plate on-site, is the use of Repeat Measurements alone to certify a plate.

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The instruments which are used to verify repeatability are NOT designed to check flatness. When set to zero on a perfectly curved surface will continue to read zero, whether that surface is perfectly flat, or perfectly concave or convex 1/2"! They simply verify the uniformity of the surface, not the flatness. One instrument used for the standard repeat reading gage used in the industry today, is called the Repeat-o-Meter. Two different instruments are required to certify a plate for flatness and for repeatability. For flatness, an autocollimator, laser, differential levels, or a Planekator are recommended. For repeatability, a Repeat-o-Meter, or a height gage with a five inch arm can be used. Only a plate which meets both the flatness specification AND the repeat measurement specification truly meets the requirements of Federal Specification GGG-P-463c.

Repeat Measurements: (Also: Repeatability) The second part of the accuracy specification for surface plates. The repeat measurement specification insures that errors in measurement due to surface variations are held within acceptable limits, regardless of where they are taken on the surface of a plate.

What does 'Repeat Measurement' mean? Isn't it the same as flatness?

The Repeat Measurement specification states that a measurement taken anywhere on the surface of a plate will repeat within the stated tolerance. This is NOT the same as flatness. The flatness specification state that all points on the surface shall lie between two parallel planes separated by "X" distance, where "X" is the flatness tolerance.

The flatness tolerance alone does not guarantee that accurate measurements can be taken on a plate, since the surface can consist of peaks and low spots equal to the full flatness tolerance. If the piece being checked bridges several peaks, and the gage rests in a low spot, then the measurement will have an error equal to the full flatness tolerance of the plate. If the gage rests on a slope, the error can be even greater than the full flatness tolerance!

The Repeat Measurement specification guarantees that measurement errors due to waviness of the surface are limited to the much tighter Repeat Measurement tolerance. Because of the difficulty in producing a plate which meets both specifications, which guarantees that measurements will repeat within .000025"F.I.R. for Laboratory Grade AA, .000050"F.I.R. for Inspection Grade A, and .000100"F.I.R. for Tool Room Grade B.

What are the three grades of accuracy, and how are they defined?

The three standard grades of accuracy defined by the Federal Specification are:

(Tool Room) Grade B, (Inspection) Grade A, & (Laboratory) Grade AA. The flatness tolerances for these grades are defined by the following formula:

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- *Laboratory Grade AA = (40 + diagonal squared/25) x .000001" (unilateral)*
- *Inspection Grade A = Laboratory Grade AA x 2*
- *Tool Room Grade B = Laboratory Grade AA x 4.*

For standard sized surface plates, we guarantee flatness tolerances which exceed the requirements of this specification. In addition, Federal Specification GGG-P-463c deals with such issues as: repeat measurement accuracy material properties of surface plate granites, surface finish, support point location, stiffness, acceptable methods of inspection, installation of threaded inserts, etc.

All mfg's granite surface plates and granite inspection plates should meet or exceed all of the requirements set forth in this specification. At present, there is no defining specification for granite angle plates, parallels, or master squares.

How should my surface plate be supported? Does it need to be level?

To answer the second question first, if the plate is properly supported, precise leveling is only necessary if your application calls for it. Leveling is not necessary to maintain the accuracy of a properly supported plate. A surface plate should be supported at 3 points, ideally located 20% of the length in from the ends of the plate.

Two supports should be located 20% of the width in from the long sides, and the remaining support should be centered. Only 3 points can rest solidly on anything but a precision surface.

The plate should be supported at these points during production, and it should be supported only at these three points while in use. Attempting to support the plate at more than three points will cause the plate to receive its support from various combinations of three points, which will not be the same 3 points on which it was supported during production. This will introduce errors as the plate deflects to conform to the new support arrangement. Correctly constructed steel stands have support beams designed to line up with the proper support points.

Many manufacturers and from we can determine, all imported brands will obtain and guarantee the much looser Federal Specification tolerances. Many of the low value or budget plates available in the market today will not guarantee repeat measurements at all. A manufacturer who does not guarantee repeat measurements is NOT producing plates which meet the requirements of Federal Specification GGG-P-463c.

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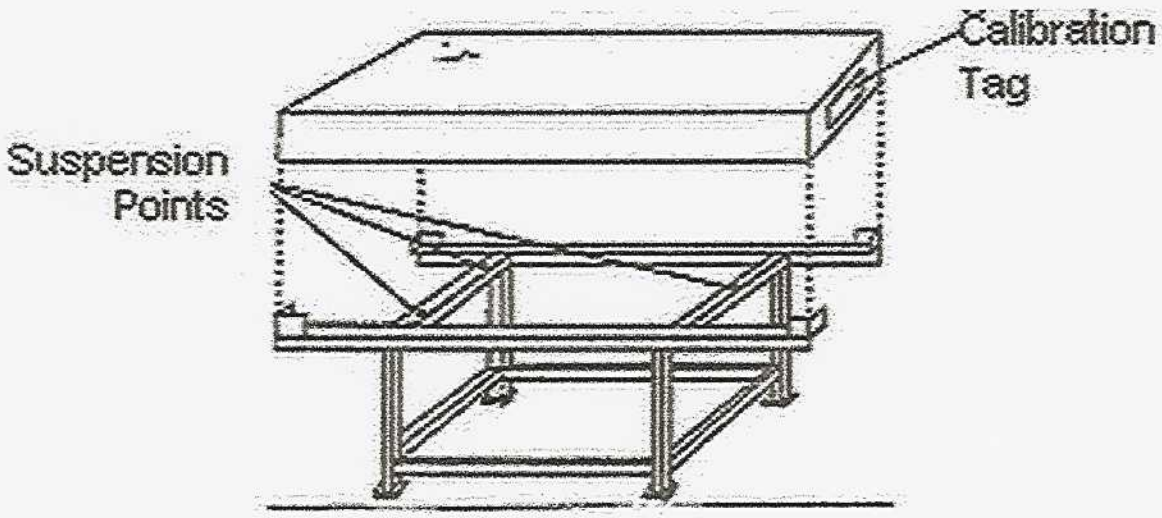

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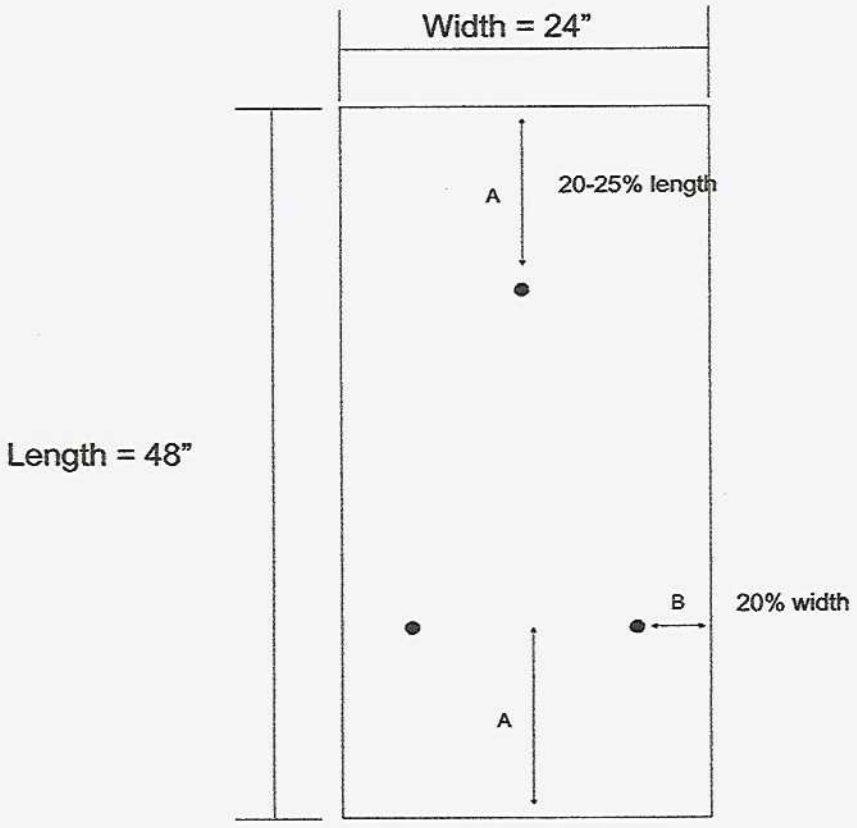

A = .25 x 48 = 12.0"

B = .20 x 24 = 4.6""

Q 6.4 Can diabase surface plates be used accurately at other than Gage Laboratory temperature?

A. Yes, if all necessary conditions are met. However, these conditions are difficult to retain while temperatures are constantly changing. A surface plate will be accurate at any temperature normally encountered, providing the plate IS THE SAME TEMPERATURE OVER THE ENTIRE SURFACE, and has the same gradient from top to bottom as when inspected. This condition is often easiest met by maintaining Gage Laboratory controlled temperature. Temporary distortions due to temperature changes may be minimized by observing the following:

1. Support surface plate on an open frame-work stand, so that room air may circulate freely all about it. Do not use on an insulated bench top.
2. Avoid drafts of varying temperature which strike part of the plate.
3. Shield from direct sunlight or other source of radiant heat. It has been found that the radiant heat from a two-tube 4 foot fluoresent light located 5 feet above a 4 ft. x 6 ft. surface plate caused the plate to change toward convex .000100 in 6 feet.
4. Clean with waterless paste cleaner to eliminate chilling of the surface due to liquid evaporation.
5. The heat conductivity of granite is very slow. If plate has been subjected to uneven temperature, allow plenty of time for it to normalize. Days -- or even weeks -- for large plates under extreme conditions.

7 Resurfacing

Q 7.1 When should a surface plate be resurfaced?

A. Before, not after, a job has been spoiled. The surest way is to check the surface regularly with a Rahn Repeat-O-Meter or measure a gage block with height gage all over the surface. Any variation in reading is a measurement error due to the plate.

Apply the rule of 1 to 10. Not more than 1/10 the blue print tolerance should be lost due to measurement errors.

If your Blue Print Tolerance is:	Measurements must Repeat within:
.010"	.001"
.005"	.0005"
.001"	.0001"
.0005"	.00005"
.0002"	.00002"

If resurfacing is necessary specify:

Tool Room Grade – 100 millionths Repeat Measurement Guarantee
Inspection Grade – 50 millionths Repeat Measurement Guarantee
Laboratory Grade – 25 millionths Repeat Measurement Guarantee

Once or twice a year the plate should be checked for flatness with a Rahn Planekator or Autocollimator.

Q 7.2 Will cast iron surface plates, capped with a thi granite top, give satisfactory results?

A. No. The cast iron plate will provide adequate suppo for a thin granite top if solidly bonded. However, th combination will bow greatly due to changes in temperatur Granite has coefficient of thermal expansion 3.5 millionth inches/inch/1°F. Cast iron has coefficient of thermal ex pansion of 6 millionths inches/in/1°F. If room temperatur change 1°F. from the temperature at which bonded,

36" granite will elongate 108 millionths
36" cast iron will elongate 216 millionths

With a 6" total thickness, this one degree temperatur change will bow the plate 81 millionths. If the plate wa bonded at 70°F., it will become .000810" concave at 80°F .001620" concave at 90° and .002430 at 100°F.

These are temperatures that will be encountered any place that does not have gage lab controlled temperature If a surface plate manufacturer does not know this basi fact of surface plates, he probably may do the bonding a almost any temperature and may also introduce othe stresses.

8 Miscellaneous

Q 8.1 How should a surface plate be supported?

A. At only 3 points, preferably located 1/5 the length and width from the ends and sides. Only 3 support points can rest solidly on anything other than a precision surface. The surface should be supported only at these three points while being lapped, and it should be supported only at the same 3 points when being used. Any attempt to use more than 3 points will cause the plate to receive its support on various combinations of three points, which probably will not be the same 3 points at which it was supported while being lapped, thus causing errors.

Attempts to build up a multiple support with a system of levers, starting from a 3 point base, only causes the surface plate to bend more under a given load. A load on the plate, directly over one end of a lever, will cause the opposite end of the lever to exert an upward thrust on the plate. Thus the plate will have upward and downward forces exerted at opposite ends of the lever. This causes greater bending than would occur if the plate rested on only three supports.

If greater stiffness is required in a surface plate, the easiest and most economical method is to increase the thickness. A 26% increase in thickness will double the stiffness while increasing the cost less than 10%.

Diabase is three times as stiff as any granite. Granite should be 1.44 times as thick as diabase in order to be equally stiff.

Q 8.2 What is the best way to clean a granite surface plate?

A. Any method is satisfactory which will remove dirt an not leave a residue film to plug the tiny 6 to 12 millionths air grooves in the surface. Several kinds of dirt plug these grooves.

3 POINT SUPPORT SYSTEM

A) This depends on how the plate is being used. If possible, we recommend cleaning the plate at the beginning of the day (or workshift) and again at the end. If the plate becomes soiled, particularly with oily or sticky fluids, it should probably be cleaned immediately.

The choice of cleaning solutions is important. If a volatile solvent is used (acetone, lacquer thinner, alcohol, etc.) the evaporation will chill the surface, and distort it. In this case, it is necessary to allow the plate to normalize before using it, or measurement errors will occur.

The amount of time required for the plate to normalize will vary with the size of the plate, and the amount of chilling. An hour should be sufficient for smaller plates. Two hours may be needed for larger plates. If a water-based cleaner is used, there will also be some evaporative chilling.

The plate will also retain the water, and this could cause rusting of metal parts in contact with the surface. Some cleaners will also leave a sticky residue after they dry, which will trap airborne dust, and actually increase wear, rather than decreasing it.

The best cleaning agent for a granite surface plate is a non-water based paste cleaner, such as Rahn Waterless Surface Plate Cleaner (available in 32oz jars). This type of cleaner does not chill or distort the plate. It will not rust metal parts, leaves no sticky residue, and it will deep clean the plate by floating small abrasive particles out of the pores of the stone.

Q16) How should my surface plate be supported? Does it need to be level?

A) To answer the second question first, if the plate is properly supported, precise leveling is only necessary if your application calls for it. Leveling is not necessary to maintain the accuracy of a properly supported plate. A surface plate should be supported at 3 points, ideally located 20% of the length in from the ends of the plate.

Two supports should be located 20% of the width in from the long sides, and the remaining support should be centered. Only 3 points can rest solidly on anything but a precision surface.

The plate should be supported at these points during production, and it should be supported only at these three points while in use. Attempting to support the plate at more than three points will cause the plate to receive its support from various combinations of three points, which will not be the same 3 points on which it was supported during production. This will introduce errors as the plate deflects to conform to the new support arrangement. Rahn welded steel stands have support beams designed to line up with the proper support points.

Q17) Can granite surface plates be relapped on-site?

A) Yes, if they are not too badly worn. Generally, if a plate is within .001" of the required tolerance, it can be resurfaced on-site. If a plate is worn to the point where it is more than .001" out of tolerance, or if it is badly pitted or nicked, then it will need to be sent to the factory for grinding prior to relapping.

Great care should be exercised in selecting an on-site calibration and resurfacing technician. In recent years, the number of individuals and companies offering this service has increased dramatically. Many are poorly trained, and have little or no understanding of the instruments they are using, or the techniques necessary to achieve an accurate surface. Our technicians have decades of experience, backed by our own 50+ year reputation as the industry leader in top quality surface plates.

Before you allow your plates to be resurfaced or calibrated by an outside source, we suggest that you ask for at least 3-5 references, and that you check those references. If at all possible, ask for a

Federal Spec.
GGG-P-463a

3.2.3 Supports. Unless otherwise specified, support of the surface plate shall be by three fixed feet, located according to figures 5 and 6 to support the work surface properly, and to minimize sag and warp. When the three fixed supports have special requirements due to their location, abnormal load and/or vibration conditions, the supports and their locations shall be specified on the purchase order (see 6.2(e) and appendix 40).

3.2.3.1 Rectangular plates. The support pads shall be located no less than one-fifth or more than one-fourth of the length and width in from the ends and sides, respectively, with the exception that the single pad at one end shall be located in the center (see figure 5).

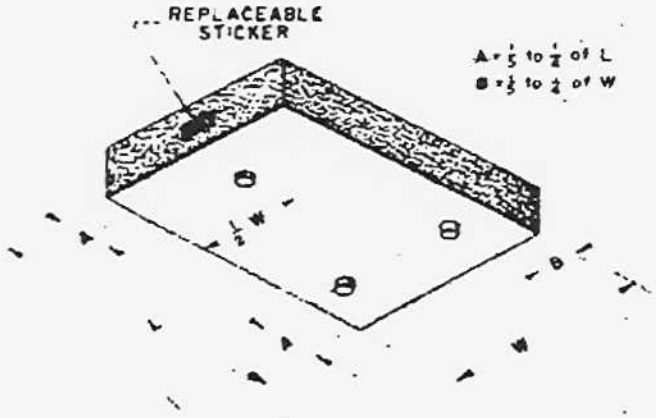

FIGURE 5. Support layout for rectangular surface plate.

3.2.3.2 Round plates. They shall be located at three equally spaced positions on a circle with a radius of approximately 0.7 radius of the plate measured from the center of the base surface (see figure 6).

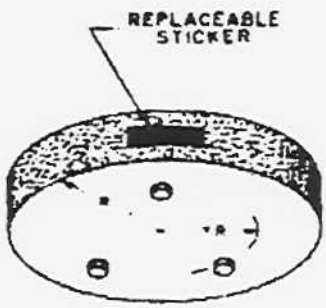

FIGURE 6. Support layout for round surface plate.