Scale Factor & Datum Talking Points

1. **Scale factor**: Pratt & Whitney laser-based instruments determine displacement by multiplying laser interferometer counts times the nominal laser wavelength (standard temperature, pressure, and humidity) times a scale factor. The instrument automatically determines this scale factor by using one of two possible methods. The first (preferred) method is two-point calibration, which uses two master gage blocks to determine a datum (reference point) and the scale factor. The second method (environmental) is to enter room temperature, material temperature, air pressure, and humidity data into the instrument, which then calculates a scale factor. Since the instrument scale is laser-based, changes in room temperature, pressure, or humidity affect the instrument scale.
2. **Datum**: A datum is a reference point typically set by using a master artifact similar to the artifact you are planning to measure. Temperature or force changes in the instrument components connecting the laser to the artifact (anvils or probes, for example) will cause a datum shift (but not a scale change).
3. Cardinal Points:
    a. The datum and scale factor are <u>different</u> concepts but <u>both</u> must be set properly to obtain adequate results.
    b. *Setting a scale factor* is also known as *mastering* or *calibrating* the machine.

PRATT & WHITNEY®
MEASUREMENT SYSTEMS, INC.
66 Douglas Street
Bloomfield, CT 06002-3619

Sales: 1.800.371.7174
Support: 1.860.286.8181
Fax: 1.860.286.7878

WWW.PRATTANDWHITNEY.COM

c. In effect, when you set a scale factor, you've scaled a portion of the total scale[1]. On Pratt & Whitney laser and glass-scale machines the scaled length is equal to the difference between the first and second gage blocks used to set the scale factor.

d. Machines requiring periodic laser scale factor readjustment during operation are known as *calibrate-before-use* machines. Pratt & Whitney recommends that a Product Specialist (Field Service Department[2]) perform calendar preventative maintenance (PM) checks[3] at an interval determined by the customer.

e. The first point (smallest gage block) of a two-point calibration serves double duty as a default datum.

f. Datum shift results from thermal expansion of the machine or mechanical re-positioning of fingers, anvils or contact force.

g. Resetting the datum does not change the scale factor; it shifts it, because the low end of the scale factor is always "anchored" to the datum.

h. Here are some examples:

    i. Perform a two-point calibration with 0.1-inch & 4.0-inch gage blocks. The scaled length is 3.9-inches and the (default) datum is 0.1-inches. You should measure from 0.1-inches to 4.0-inches.

    ii. Now, with a 3.0-inch gage block, reset the datum. Your range of measurement is from the datum to the upper limit of the scaled length, i.e., 3.0 to 6.9-inches.

    iii. Now reset the datum with a 2.0-inch master ring gage. Your range of measurement is from the datum to the upper limit of the scaled length, i.e., ring gages from 2.0 to 5.9-inches.

[1] Call this the *scaled length.*
[2] Call 1.800.371.7174 X230.
[3] Yearly PM checks are the most common.

i. For best results keep your measurements as close to the datum as practical and always keep your measurements within the range of the scaled length.

4. Rules of thumb:

j. Reset the two-point calibration hourly until you've grown accustomed to the *system*, i.e. the machine in your environment.

k. For laser-based machines, other than the Laser Measuring Machine or the LabMaster Standard utilizing the corner cube accessory, a typical two-point calibration is performed using a 0.1-inch and 4.0-inch gage block with the bi-directional probes (point-contact) in establishing a scale factor.

l. Always measure up from the datum to the upper limit of the scaled length.

m. For a suspect reading first check the datum. If off, reset.

n. Check and reset the datum as often as necessary. In particular:

i. Check & reset for thermal drift, i.e. if the base of the machine expands or contracts due to temperature shifts.

ii. Re-set the datum if you change or re-position the fingers, anvils or probe tip.

iii. When using the bi-directional fingers on the LabMaster Universal and Universal Supermicrometer, reset the datum when you switch from internal measurement, e.g. ring gages, to external measurement, e.g. gage blocks, pins, etc. and vice versa.

o. Best Uncertainty- Our recommendation for the scale factor is to use masters that result in the lowest ppm (µin/in) scale factor uncertainty. For larger gages we recommend getting gage blocks or ball bars that are within a few inches of the size of the artifact you wish to measure. Measurement uncertainty is the uncertainty of the datum plus the product of the scale factor uncertainty times the distance from the nearest datum. Please see Appendix A in the Labmaster User's Manual.