Gage Accuracy Runs Hot and Cold
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"It takes a while to warm up in the morning, but after that, it runs great." I swear I've heard machinists say this of their gages, as if those instruments were like car engines with 50-weight motor oil and cold intake manifolds.

What's really happening, of course, is that the machinist arrives at work, takes his gage and master out of a controlled environment, masters the gage and then gets to work. As he handles it, the gage begins to warm up—which is not to say that its moving parts move more freely, but instead, that the gage itself expands. Depending on where he keeps his master, and whether or not he re-masters regularly, he will find himself "chasing the reading," possibly for hours, until everything reaches equilibrium.

Thermal effects are among the most pervasive sources of gaging error. Dirt, as a gaging problem, is either there, or it isn't. But everything has a temperature—even properly calibrated gages and masters. The problem arises from the fact that everything else has a temperature too, including the air in the room, the workpiece, the electric lighting overhead, and the operator's fingers. Any one of these "environmental" factors can influence the reading.

Why is temperature such a critical concern? Because most materials expand with heat, and they do so at differing rates. For every 10°F rise in temperature, an inch of steel expands by 60 millionths. "Not to worry," you might say, "I am only working to 'tenths'." But aluminum expands at more than twice that rate, and tungsten carbide at about half. Now, what happens to your reading if you are trying to measure a 2-inch aluminum workpiece with a steel-framed snap gage and tungsten carbide contacts, after the workshop has just warmed up by 7 degrees? And by the way, did that workpiece just come off the machine, and how hot is it?

Beats me, too. That's why it's critical to keep the gage, the master, and the workpiece all at the same temperature, and take pains to keep them there.

That means keeping an eye on many factors. Don't put your master away like some sacred object. Gage and master must be kept together, to ensure that they "grow" in tandem and to permit frequent re-mastering. Workpieces must have sufficient time to reach ambient temperature after machining, or after being moved from room to room. The operator should avoid handling the gage, master and workpiece more than absolutely necessary.

Care must be taken that sources of heat and cold in the room do not intrude on the process. Incandescent lighting, heat and air conditioner ducts, even a shaft of direct sunlight through a window can alter a whole series of measurements. Keep things at the same "altitude" in the room, to avoid the effects of temperature stratification.

As tolerances tighten, additional measures become necessary. Workpieces should be staged on a heat sink beside the gage and should be handled with forceps or gloves. A Plexiglas shield may be required to protect the gage from the operator's breath. (The heat, that is, not the effects of the sardine sandwich he had for lunch.)

For accurate gaging, be aware of possible sources of thermal "contamination" to the measurement process. While it may not be possible to isolate your gaging process in its own perfectly controlled environment, at least take precautions to minimize the effects of temperature variation on your gages, masters and workpieces.

Thermal sources of error are a major cause of gage performance degradation. Typical thermal sources are: (1) radiant heat from illuminating sources; (2) conductive heat (e.g. operator touching workpiece); (3) convection and drafts from heating and cooling systems; and (4) room temperature gradients.