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How Accurate Is Your Kestrel®?

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> For suppression and prescribed fire operations, accurate RH information can be critical.

Since the late 1950s, when the belt weather kit was first being developed (USDA Forest Service 1959), firefighters have been using the sling psychrometers from the kits to measure relative humidity on the fire line. Because humidity has such a great effect on fire behavior, knowing the relative humidity and how it is changing over time is a critical piece of information for any wildland firefighter. With the advent of 21st century technology, the sling psychrometer is gradually being replaced by digital hand-held weather meters, such as the Kestrel®.

Several years ago, while teaching at a wildland fire investigation training program, I heard from several students and a fellow instructor that their Kestrel® hand-held weather instruments were giving consistently low relative humidity (RH) readings. The instructor told me that any time he got a RH reading on his Kestrel® that was below 25 percent, he simply added 6 or 7 percent to get the "correct" reading. That practice struck me as inconsistent with good scientific data collection, so I thought I should test the accuracy of the Kestrel® myself.

Over the rest of that spring and summer, whenever I had the opportunity and the weather conditions were right, I'd check my brand new Kestrel® 3000 against my trusted (circa 1980) fire-belt weather kit sling psychrometer. Sure enough, when the sling psychrometer reading was 22 percent RH, the Kestrel® would show 16 or 17 percent RH. I checked the instructions that came with the Kestrel® for clarification: they said that the error rate for the RH sensor was ± 3 percent between 5 and 95 percent RH, so the Kestrel® readings should not be off more than 3 percent of the actual RH. Mine consistently gave an RH of 5 to 6 percent below my sling psychrometer. I also was hearing more reports of "Kestrel® errors": a prescribed fire manager in the Southwest refused to use the Kestrel® for weather observations because it consistently pushed him out of prescription conditions, and a fire behavior analyst in the Pacific Northwest refused to use the Kestrel® because it always read lower than his sling psychrometer. My initial reaction was the same as everyone else: the Kestrel®'s readings must be wrong. What could be causing this error? Was it a problem inherent to the Kestrel® RH sensor, was it a calibration problem, or were we, the users, doing something incorrectly?

My first thought was that, if this was simply random error in the

The Kestrel hand-held weather instrument (left) and a standard sling psychrometer (right).

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Kestrel® sensor, it should be just that: random. If this was the case, sometimes the Kestrel® readings should be above the sling psychrometer and sometimes below; but the readings I and other users were getting were consistently below those of the sling psychrometer. That experience seemed to argue against random error.

In 2000, the Forest Service Missoula Technology and Development Center (MTDC) conducted an evaluation of eight different hand-held weather instruments (Lemon and Mangan 2000). One of the instruments tested was the Kestrel® 3000. Although the Kestrel® gave the most accurate RH readings of any of the hand-held hygrometers in the evaluation, the Kestrel®'s readings were consistently 4 percent lower than the established standard. In fact, the summary table in MTDC paper shows that all of the hygrometers tested gave RH readings lower than the "standard." What "standard" did the MTDC authors use for comparison to the hand-held instruments? It was a sling psychrometer from a belt weather kit.

I called the manufacturers of the Kestrel®, Nielsen-Kellerman Company, and began a dialog with them that stretched over several months. When I first described the problem that we were experiencing, the Kestrel® representatives were polite but firm; their instruments, when properly calibrated, were accurate within the specifications outlined in their literature. This, of course, raised the next question: Was my Kestrel® correctly calibrated? My instrument was less than a year old, but I sent it back to Nielsen-Kellerman and they rechecked the calibration. The tested accuracy was ±0.4 percent, or less at the two reference RHs, well within the published specifications for the instrument.

Then I took the next step. I did an Internet search for scientific instrument testing and calibration labs. These are the type of labs that calibrate instruments for other government, industrial, and forensics laboratories. All of their work is certified to the highest engineering and scientific standards. I selected one and sent them my Kestrel®. I requested that they check the accuracy of the Kestrel® at three different RHs: 35, 25, and 15 percent.

> Could the sling psychrometer that we all have been using for so many years be inaccurate?

Within a week, I had the answer. The Kestrel® gave exactly the same RH readings as the sophisticated laboratory test equipment at the three test points.

Now comes the hard part. If the Kestrel® readings are correct, then the error must be in the sling psychrometer readings. Could the sling psychrometer that we all have been using for so many years be inaccurate by that much? Yes, I believe that it can, and here's why.

First, most of the RH observations taken on the fire-line are made with a sling psychrometer from a fire-belt weather kit with 5-inch thermometers. The best information I can get from distributors is that the accuracy for those thermometers is, at the very best, ±1 °F (±0.55 °C). If the wet bulb depression is off by 1 °F, that could easily change the RH reading by 3 or 4 percent. For example, given a dry bulb temperature of 75 °F (23.8 °C) and a wet bulb temperature of 53 °F (11.6 °C), the RH is 21 percent at 1,900 to 3,600 feet (580 to 1,100 m) elevation, according to the U.S. Department of Commerce reference tables. However, if the thermometer is high by 1 °F, then the RH reading would rise to 24 percent, a potentially significant difference.

Second, most of the "operator induced errors" lead to higher, not lower, wet bulb temperatures—or, in other words, less of a wet bulb temperature depression. Examples of these "operator errors" are: (1) not slinging the thermometers long enough to get complete wet bulb depression, (2) reading the wet bulb temperature after it has already started to recover, (3) using dirty water, and (4) having a dirty wick, which slows evaporation and results in higher wet bulb temperatures. All of these errors can cause sling psychrometer readings that result in erroneous values higher than the actual RH.

Finally, there can be errors in reading the tables or using the incorrect table for a given elevation; an error eliminated by the direct digital reading from the Kestrel®.

So why, given all the potential for error with the sling psychrometers, do we believe their results before we believe the Kestrel®? I think it is because the sling psychrometer is the "technology" that we know. It was the best and, in most cases, the only information we once had, so we all assumed that it was correct and had no "error rate." Out in the woods, we think we know what 25 percent RH "feels like," and when the Kestrel® indicates that the RH is actually 19 percent, our response is "No, it can't be that dry!" The problem is, I believe, that the actual RH has been 19 percent all along; we just believed it was 25 percent because that was the reading we got from our sling psychrometers.

Another complicating factor, now, is that we are using a mixture of technologies: sling psychrometers of varying accuracy, hygrothermographs, hand-held instruments (e.g., Kestrel®s and others), and remote automated weather station (RAWS) sensor readings. All of these various instrument have differing degrees of accuracy, which may result in conflicting readings.

So why is this of any great importance? For me, as a fire investigator, I can eliminate or include certain categories of fire causes within fairly specific RH ranges. That's important, but it's not life-threatening. For suppression and prescribed fire operations, however, accurate RH information can be critical. Inaccurate information can have potentially tragic consequences in terms of escaped fires, resource damage, or loss of life and property.

Finally, the level of confusion in the field regarding the accuracy of the Kestrel® RH readings needs to be addressed. A definitive test to establish the accuracy of the Kestrel® (because of its increasingly universal usage) versus that of the sling psychrometer should be undertaken. It would be a major step toward reducing confusion and dispelling misinformation.

Much of the information presented here is anecdotal but, I believe, useful. Research with a sample size of one can hardly be called compelling scientific evidence, but it has convinced me that, given a choice between RH observations from a calibrated Kestrel® and a sling psychrometer from a belt weather kit, I'm putting my trust in the Kestrel®.

References

Lemon, G.; Mangan, R. 2000. Evaluating Digital Meters for Fire Weather Observations. Fire Tech Tips 0051-2315-MTDC. Missoula, MT: USDA Forest Service, Missoula Technology and Development Center. 8 p.

USDA Forest Service. 1959. Belt Weather Kit. Fire Control Notes 20(4): 122–123. ■

Success Stories Wanted!

We'd like to know how your work has been going! Provide us with your success stories within the State fire program or from your individual fire department. Let us know how the State Fire Assistance (SFA), Volunteer Fire Assistance (VFA), the Federal Excess Personal Property (FEPP) program, or the Firefighter Property (FFP) program has benefited your agency. Feature articles should be up to about 2,000 words in length; short items of up to 200 words.

Submit articles and photographs as electronic files by email or through traditional or express mail to:

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