Fire Management Tech Tips

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ELECTRONIC WEATHER METERS

by
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HIGHLIGHTS

- **Electronic weather meters provide numerous benefits over the belt weather kit, including greater ease of use, accuracy, data storage, and reduced weight.**
- **Most electronic meters are calibrated to industry-accepted standards and can eliminate errors that occur with traditional instruments.**
- **Suggested features for wildland fire weather meters are discussed, and technical details of several commercially available models are provided.**

INTRODUCTION

For decades, the belt weather kit has been an indispensable tool for fire crews and fire weather analysts. In the hands of a skilled observer, the kit provides accurate and repeatable measurements of wind, temperature, and relative humidity. Despite its strengths, the belt weather kit does have drawbacks. The observer must use several instruments to obtain the required data, and some, such as the sling psychrometer, can present pitfalls for inexperienced users. The kit is bulky and adds to the already demanding load carried by the wildland firefighter. Advances in measurement technologies over the past decade have led to the development of all-in-one digital instruments that provide accurate meteorological data. Electronic weather kits provide the opportunity for weather observers to collect data with an easy-to-use and lightweight device. The purpose of this Tech Tip is to introduce the reader to digital weather meters. Instrument features, accuracy, and applicability to the fire environment will be discussed.

WHAT ARE WE MEASURING?

Before considering the benefits and disadvantages of electronic weather devices, a brief discussion of important weather factors is necessary. The basic measurement principles of devices in the belt weather kit also will be introduced.

Wind

Accurate wind measurements are critical in the wildland and prescribed fire environment. Changes in wind speed and/or direction may indicate a significant change in weather, which could require adjustments to fireline tactics. Knowledge of wind conditions also is important for air operations (helicopters, airtankers, and smokejumpers).

The belt weather kit features a simple analog wind meter (anemometer) (figure 1). The user faces the meter into the prevailing wind (a compass is used to determine wind direction). Oncoming air enters a calibrated hole, pressurizing the inner tube and causing

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an indicator ball to rise. The height of the ball indicates the speed of the wind, as read on a placard on the front of the meter. Measurement errors can occur if the user is not directly perpendicular to the prevailing wind. Also, the meter must be cleaned periodically to prevent debris buildup, which could affect calibration. Readings from the meter cannot be saved, so the observer must record the wind speed once a steady reading has been achieved.

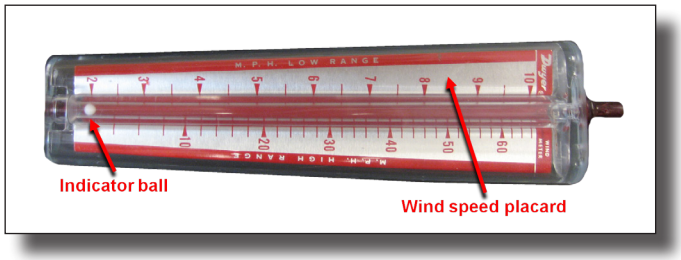

Figure 1—Anemometer from belt weather kit, for measurement of wind speed.

Temperature and Relative Humidity

Both temperature and relative humidity (RH) affect fire behavior. Hot and dry conditions aid fire spread by preheating and removing moisture from fuels, often leading to dangerous and unpredictable conditions.

The belt weather kit uses a sling psychrometer to measure both temperature and RH (figure 2). The psychrometer consists of two liquid-in-glass thermometers. The first, called the dry-bulb, is simply a traditional thermometer, which can be used to determine the air temperature. The second thermometer, the wet-bulb, is covered with a sheath (called a wick), which is saturated with distilled water. The psychrometer is "slung" by the user to promote evaporation from the wick. As water evaporates, heat is carried away with it, causing the temperature indicated by the wet-bulb thermometer to be less than that of the dry-bulb thermometer. By relating the wet- and dry-bulb temperatures to the thermodynamic properties of moist air, the RH can be obtained. This information is obtained using tables or slide rules provided with the belt weather kit. Again, these readings cannot be saved, so they must be recorded immediately after being observed.

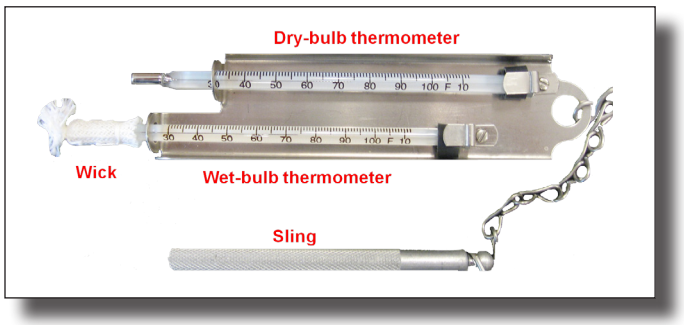

Figure 2—Sling psychrometer from the belt weather kit. Used for measurement of temperature and RH.

ELECTRONIC METERS—FEATURES, ADVANTAGES, AND DISADVANTAGES

Digital meters, which perform all functions of the belt weather kit in a single device, are readily available from a number of manufacturers (figure 3). Although these meters measure the same properties as the belt weather kit, most do so using different methods.

Wind

Most electronic weather meters use a magnetized impeller to determine wind speed. Similar to a pinwheel, the impeller rotates in response to forces imparted by the wind. As the impeller rotates, it creates a magnetic field, which is sensed by the computer and translated to wind speed. As with the wind meter in the belt weather kit, the observer must be directly in line with the prevailing wind to obtain an accurate reading.

Temperature

A majority of digital weather meters use thermistors to determine air temperature. Thermistors are devices whose electrical resistance changes with temperature. By measuring the resistance of the thermistor, the air temperature can be determined.

Figure 3—Nielsen Kellerman Kestrel 4000 electronic weather meter.

Relative Humidity (RH)

Unlike the belt weather kit, electronic weather meters do not use wet- and dry-bulb thermometers to determine RH. Rather, RH is measured directly, using devices whose electrical properties change based on the amount of water vapor in the air. This method is advantageous over the traditional sling psychrometer because the observer does not have to use thermometers and RH tables or slide rules.

INSTRUMENT ACCURACY: BELT WEATHER KIT VERSUS ELECTRONIC METERS

When making weather observations, accuracy is of primary concern. Inaccurate information compromises firefighter safety and hinders fireline and planning activities. Feedback received by firefighters currently using electronic meters indicates a strong lack of confidence in the RH data they provide. The RH values from electronic meters often disagree with the sling psychrometer by as much as 20 percent. However, this does not necessarily mean the electronic device is in error! Both types of devices have sources of error that affect their accuracy (figure 4).

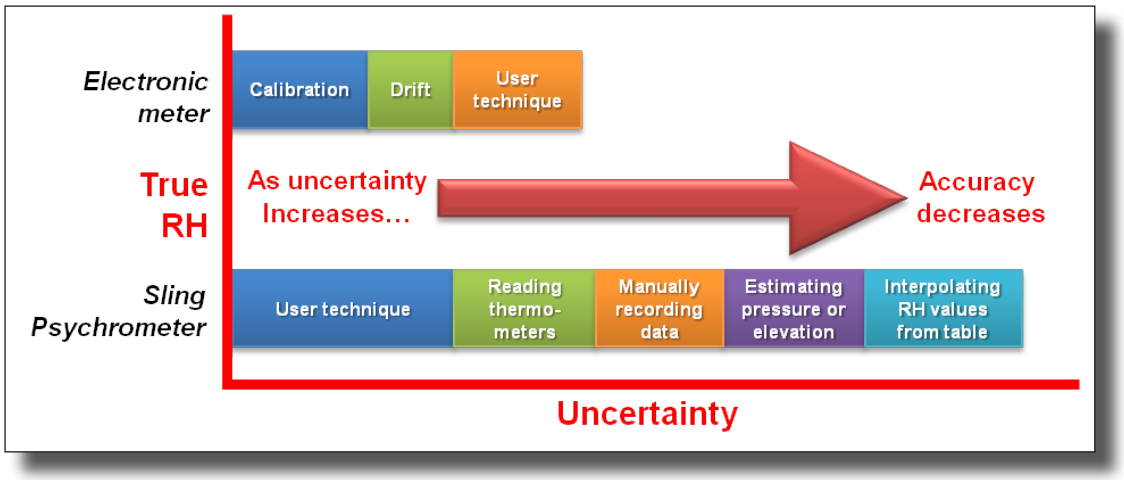

Figure 4—Sources of uncertainty in relative humidity measurement.

Electronic weather meters are calibrated to a known standard at the time of manufacture. Since no instrument is perfect, the manufacturer guarantees the accuracy within a percentage of the standard (for RH, typically +/- 3 to 5 percent accuracy within 5 to 95 percent RH). An additional source of error, calibration drift, occurs with all electronic devices over time. Drift is typically minimal, and can be corrected by periodically recalibrating in the field or at the manufacturer.

Though the sling psychrometer does not have calibration issues, it can present significant sources of error. When taking measurements, the user must sling the device for long enough to ensure the wet-bulb temperature has reached a true minimum. The cleanliness of water used also could affect evaporation characteristics, resulting in incorrect wet-bulb temperatures. Even when used properly, accurate readings from the sling psychrometer can be difficult to obtain. The small graduations on psychrometer thermometers only allow for a measurement accuracy of +/- 0.5 °F, at best. An error of 1 °F in reading the wet- and dry-bulb temperatures can lead to a 5 to 10 percent error in RH. In addition, the instrument also requires the user to know the barometric pressure or elevation of the measurement site. Since weather kit tables only provide data for specific barometric pressures, significant error may be incurred when converting the wet- and dry-bulb temperatures to RH.

ADVANTAGES OF ELECTRONIC METERS

1. **User display:** The liquid crystal display (LCD), common to digital meters, are easy to see and reduce the possibility for errors in reading data. Some meters can display multiple types of data simultaneously on a single screen (for example, temperature, wind speed, and RH), simplifying the data collection process. Some meters feature a backlight, which makes the display visible during night operations.
2. **Real-time data, trends, and averages:** All electronic weather meters display real-time data. However, some models also allow the user to view averaged data over any specified interval. In wildland firefighting, weather trends are often more important than instantaneous or average measurements. Many meters can display trends graphically over any desired time span, from minutes to days.
3. **Data transfer and storage:** A major advantage of digital weather meters is the ability to store information for future reference. Some devices allow the user to export this data to a personal computer (PC) or personal data assistant (PDA) using universal serial bus (USB) or wireless technology.
4. **Size and weight:** Electronic weather meters are designed to fit in a pocket or belt holster so they will not interfere with most firefighting activities and equipment. Most weigh only a few ounces and use lightweight batteries.

DISADVANTAGES OF ELECTRONIC METERS

1. **Environment:** The wildland fire environment is unforgiving for electronics. Heat, dirt, smoke, and water are all common, and could result in severe damage to the device. Care must be taken to ensure measurement probes are unobstructed by dirt or debris. Rough handling could damage internal and external components. Weather meters must be treated with the same level of care as radios and other electronic devices.
2. **Batteries:** The requirement for electrical power also is a disadvantage over the belt weather kit. The observer must carry spare batteries to ensure that the meter will be operational when needed. However, most operate using common, lightweight batteries that are easily obtained and carried.
3. **Calibration:** During fire season, crews do not have the time to coordinate with the manufacturer to recalibrate weather meters. As mentioned above, calibration drift is typically minimal. However, if the devices are repeatedly dropped or exposed to harsh environments, they may require more frequent adjustment. To address this issue, several manufacturers offer do-it-yourself kits, which allow instruments to be recalibrated in the field.
4. **Cost:** The cost of most quality electronic weather meters is greater than that of the belt weather kit. As of 2011, a standard belt weather kit costs approximately $120, while an electronic device with the same features may cost in excess of $200. However, given the simplicity of use and high fidelity of data obtained, many users will find the added cost to be an acceptable tradeoff.

WEATHER METERS: COMPARISON OF FEATURES AND SUGGESTIONS

Several manufacturers offer products that are appropriate for the fire environment. A comparison of several commercially available models is listed in table 1.

Table 1—Features of several commercially available weather meters

Product Name	Wind Speed	Wind Direction	Max Gust	Crosswind	Headwind/Tailwind	Average Wind Speed	Dry Bulb Temperature	Wet Bulb Temperature	Relative Humidity	Wind Chill	Heat Index	Dewpoint	Barometric Pressure	Barometric Pressure Trend	Pressure Altitude	Density Altitude	Comprehensive Data Storage	Bluetooth Capability	Compass	Backlight	Battery	Approximate Retail Cost
Nielsen-Kellerman																						
Kestrel 3000 Wind Meter	•		•			•	•		•	•	•	•								•	CR2032	$149.00
Kestrel 3500 Wind Meter	•		•			•	•	•	•	•	•	•	•	•						•	CR2032	$194.00
Kestrel 4000 Wind Meter	•		•			•	•	•	•	•	•	•	•	•	•	•	•			•	AAA	$354.00
Kestrel 4500 Wind Meter	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	AAA	$399.00
Speedtech (WeatherHawk)																						
SM-19 Skymate WindMeter	•		•			•	•		•	•		•									CR2032	$166.00
SM-28 Skymate WindMeter	•		•			•	•		•	•	•	•	•	•							CR2032	$200.00
WM-300 WindMate	•	•	•	•	•	•	•	•	•	•		•							•	•	CR2032	$200.00
WM-350 WindMate	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•		•	•	CR2032	$300.00
Brunton																						
Pro	•		•			•	•		•	•	•	•	•	•	•		•				CR2032	$204.00

What Features Do I Need?

The weather meter chosen should, at a minimum, perform the functions of the belt weather kit. Other features provide additional data and convenience, but at an added cost. Feature preference is up to the individual user, but the specifics of the ideal wildland fire weather meter are given in table 2. This table is based on feedback from a number of firefighters and support personnel.

Table 2—Suggested capabilities for electronic weather meters.

Capability	Must have	Like to have
Wind speed	X	
Dry bulb (air) temperature	X	
Relative humidity	X	
Ability to show averages	X	
Ability to show trends	X	
Barometric pressure		X
Wind direction		X
Dewpoint		X
Wind chill		X
Heat index		X
Pressure altitude		X
Density altitude		X
Data downloadable to PC		X
User or self-calibration		X

Accuracy and Calibration

Manufacturers under consideration must provide information on the instrument's accuracy. Typically, the manufacturer will provide two key pieces of information:

1. The accuracy of the device for each type of measurement, either expressed as a percentage or as a plus/minus value (i.e., for temperature, h+/- 3 percent or +/- 1.5 °F).
2. The range of measurement throughout which the specified accuracy applies (i.e., for humidity, +/- 3 percent accuracy from 5 percent to 95 percent RH).

For wildland and prescribed fire use, instruments with reported accuracies of +/- 5 percent or less are recommended. Devices should have a factory calibration that is traceable to an independent standards organization, such as the National Institute for Standards and Technology (NIST). Most reputable manufacturers can provide a certificate of conformance upon purchase. Remember, the accuracy of the instrument may come into question if the data is used in agency or legal investigations. Having a device that is traceable to accepted industry standards will eliminate questions about its capabilities. ***Products that are not traceable to accepted industry standards are not recommended for purchase.***

Maintenance of calibration also is a concern. As mentioned previously, all instruments will lose calibration over time due to environmental and electronic factors. Ask the manufacturer about suggested calibration intervals based on conditions in the fire environment. Products should, at a minimum, maintain reasonable accuracy (within 3 percent of original calibration) through one season of fire use. During the off season, meters can be sent to the factory for recalibration and refurbishment (if necessary), though this can be costly and inconvenient. A more economic solution is the do-it-yourself kits provided by several manufacturers. These kits are simple to use and can even be taken to the field if necessary.

CONCLUSION

Electronic weather meters provide an acceptable alternative to the traditional belt weather kit. They allow the observer to measure all desired meteorological properties using a single device, as well as view trends, averages, and historical data. Quality electronic meters are calibrated to accepted industry standards and eliminate many of the potential errors encountered when using traditional instruments. However, they do have disadvantages that must be considered before deciding to implement them as the primary tool for weather observation. Instrument accuracy and durability are critical in the fire environment. Any device under consideration should be traceable to industry-accepted standards, and should be able to withstand the demanding conditions faced by wildland firefighters.

Table 3—Contact information for electronic weather meter manufacturers listed in table 1

Nielsen Kellerman
<http://www.kestrelmeters.com>
800-891-8493

WeatherHawk (Speedtech)
<http://www.weatherhawk.com>
866-670-5982

Brunton
<http://www.bruntonoutdoor.com>
800-443-4871

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USDA Forest Service and U.S. Department of the Interior, Bureau of Land Management employees also can view videos, CDs, and National Technology and Development Center's individual project pages on their internal computer network at <http://fsweb.sdtdc.wo.fs.fed.us/>.

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