Fire Management Tech Tips

United States Department of Agriculture
Forest Service

National Technology & Development Program

September 2007

5100 0751 1306—SDTDC

Evaluation of Fuel-Sample Containers

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Introduction

This publication provides information to fuels and fire management personnel on three containers available for storing and transporting fuel-moisture samples. The U.S. Department of Agriculture Forest Service, San Dimas Technology and Development Center and Pacific Southwest Research Stations Forest Fire Laboratory in Riverside, CA, evaluated three containers that are most often used during field collection of fuel-moisture samples.

- One-quart paint can.
- Thirty-two-ounce polypropylene (Nalgene) plastic bottle.
- One-quart self-sealing plastic freezer bag (7 inch by 8 inch by 2.7-mil thick).

Evaluations were conducted at the Riverside Forest Fire Laboratory to determine which fuel-sample container is the most efficient for sample transportation and maintains sample moisture content from the collection site to the processing area.

History

Within forest management areas, drought, pine-beetle infestations, overgrown vegetation (fuels), and extensive tree mortality have created a great concern for fire and fuels managers and private citizens. These conditions create dry and abundant fuels that can support catastrophic wildland fires.

Presently, there are no agency-mandated protocols or standards for the collection of live and dead fuel-moisture samples, or the appropriate type of equipment and tools to use, only recommendations. The 2000 National Fire Plan addressed five key points:

- Firefighting.
- Rehabilitation.
- Hazardous fuels reduction.
- Community assistance.
- Accountability.

These key points sanction hazardous fuel-reduction projects carried out on Federal lands through the Healthy Forest Restoration Act. This act authorizes various methods to reduce hazardous fuel, including prescribed fire, wildland fire use, and mechanical methods. In order to implement any of the new policies or regulations, there needs to be a foundation and standardization of fuel-moisture data collection understanding and protocols. Within fire suppression, prevention, fuels, and vegetation management program areas, there have been attempts to formally improve the collecting, recording, and disseminating of fuel-moisture information. With a formalized consistent collection protocol, improved fuel-moisture data may provide added support for:

- Additional firefighter safety.
- Better estimation/prediction of fire behavior during wildland and project fires.
- Sound preparation and timing of fuel-reduction projects.

This evaluation, in support of the fire and fuels community, provides information on the equipment available that helps ensure accurate fuel-mositure collection in order to obtain the most precise data.

Evaluation

The main objective of this evaluation was to determine if there is a significant difference in the moisture-holding capacity of three containers used to collect fuel-moisture samples. Another objective was to determine if there were significant differences between using coolers or fire packs when transporting fuel-moisture samples. Dry coolers and green fire bags commonly are used when transporting fuel samples from the field.

A study was designed to address these two objectives simultaneously and was repeated for hot and cool conditions. The hot condition was achieved by running the tests in a greenhouse during the summer where temperatures ranged between 100 and 131 degrees Fahrenheit (°F) (38 and 55 degrees Celsius) (°C). To reduce exposure to these high temperatures, the time needed by the teams to make a complete set of measurements was kept to a minimum. Safety precautions were taken to meet Forest Service Handbook (FSH) requirements for working under these conditions. The same study was conducted inside an air-conditioned laboratory where temperatures ranged between 62 and 75 °F (17 and 24 °C). Each test was repeated three times. The objective was to determine how well the three containers maintained the moisture content of similar fuel samples under the two different temperatures over time. To reduce possible influence of sample-material variability found in natural fuels, the following materials were used to represent the different fuel-size classes (figure 1):

- 1-hour - Aspen excelsior.
- 10-hour - Pine dowels, ¼-inch diameter.
- 100-hour - Lodgepole-pine posts, 3 inches in diameter.

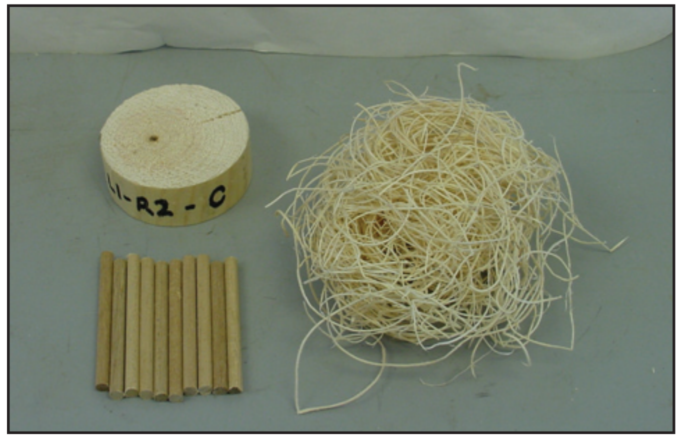

Figure 1—Fuel-size class samples.

Sample materials were cut into like-size pieces. The excelsior samples were formed into hand-size clumps. The dowels were cut to 3-inch lengths and 10 pieces constituted a sample. The pine posts were cut into 1-inch slices or cookies and each slice was considered a sample. Since all fuels samples were dried and cured material, the samples were submerged completely in water for 67 hours to ensure measurable moisture content changes.

After soaking, the samples were placed in an environmental chamber for 24 hours to stabilize the surface moisture. Due to the arrangement of the material inside the chamber, the excelsior samples were processed first, followed by the dowels, and then the cookies. Sample processing was done in a set order to produce three sets of samples per test.

Each sample, once sealed in a container, was weighed before being placed in the cooler, fire bag, or oven. A cooler and fire bag were designated for each fuel size class for a total of six transport containers (three coolers and three fire bags). The sample material (excelsior, dowels, and cookie) was placed in two cans; one for the cooler, and one for the fire bag. The process was repeated for the bottles and the plastic bags. (This process was repeated three times for a total of nine samples in the cooler and nine samples in the fire bag.) Each time a set was completed for the three containers, two additional samples were placed in bottles to determine the actual moisture content of the samples (control samples). There were a total of 18 control samples for each fuel size class. This entire process (soaking, sample processing, weighing, and drying) was done three times to produce three complete replications. Each replication consisted of a total of 72 samples.

Initially, each sample in each transport container was weighed every 30 minutes, but it became evident that the changes were too slight to warrant the short interval and the samples were then weighed hourly. An electronic balance was used to weigh the samples and the calibration was checked on a regular basis.

To determine the original moisture content of the soaking process, the 18 moisture-content samples were placed in a convection oven and dried at 203 °F (95 ºC) until there was no more weight loss from drying. After the last weighing measurement, all samples in the transport containers were dried to determine their final moisture content. The plastic self-sealing bag sample material had to be transferred to a bottle in order to be dried and each was weighed again in the new container. All fuel moisture content percentages (%FMC) are based on the oven dry weight and were determined by the standard equation:

%FMC = (net wet weight – net dry weigh)/net dry weight × 100

Discussion

The values used in the analysis were the difference between the initial and the final moisture content of the individual samples. To test the difference between the sample transport containers (fire bags and coolers), the change between the initial and final moisture contents were divided by the number of hours. There was no significant difference between the hourly changes of moisture content for the fire bag and cooler transport containers for all fuel size classes (*P*-value = 0.0000) except for the 1-hour size class (excelsior) tested under the low ambient conditions (fire bag *P*-value = 0.0160 and cooler *P*-value = 0.0255). These samples had the highest moisture content at the start of the test and this may have influenced the results. Another possible influence could be the transfer of material to the drying container or the combination of these influences.

Table 1 shows that there is a consistent and slightly significant larger loss of sample moisture content using the self-sealing plastic bags. This is most pronounced under higher ambient temperatures. Two issues were noted using this container. The first was that the sample had to be transferred to a container that could be placed in the drying oven, which could result in loss of sample material and additional exposure to drier or wetter air that could affect the moisture content of the sample (mostly affecting the small size class fuels). Secondly, there is potentially a significant amount of condensation on the interior walls of the bag, which would not be included as the moisture content of the sample potentially leading to a false lower estimate of the moisture content of that sample. The larger fuels used did not have these problems but it is conceivable that natural fuels in the larger size classes could have these issues since they can be at various stages of decay.

Generally, the polypropylene bottles maintained the moisture content of the samples longer and more often, especially during the higher-ambient-temperature tests. In some situations the can container was comparable and slightly better and could go directly into the oven for drying. The self-sealing bag was consistently not as reliable and required the transfer of the sample material to a drying container. The cans need to be checked for degradation (rust, dents, or poor seals) on a regular basis and require special tools (hammer, piece of wood to seal them, and a paint can “key” to open properly) to keep them a viable fuel sample container.

Recommendations

Fuel moisture is a critical factor when making management decisions regarding wildland fire and management prescribed fire projects. We have evaluated three containers that commonly are used to collect fuel moisture content data and to develop area drying trends. All three containers can be used effectively for collecting this type of information but the high-temperature polypropylene bottle surpasses the self-sealing plastic bag and paint can in sustaining the moisture content of the sample material over time and ease of use. The high-temperature polypropylene bottles have been known to be used for 10-years or more under these drying conditions before they begin to show structural or sealing degradation. Both the can and the bottle can be weighed and directly placed in the drying oven while the sample in the self-sealing plastic bag requires that the sample to be transferred to a sealable drying container prior to being weighed and dried. This adds additional time to the process and still requires one of these other containers. The higher individual cost of the polypropylene bottle outweighs the shortcoming of the other two containers and therefore is the recommended container for moisture content sampling.

Time is a critical factor to field personnel who are collecting this information. The process needs to be easy but accurate in order for field personnel to take on this task. If the process is too complicated or time consuming, other assignments will take priority and this information will not be collected and used. Everything relates back to the importance of this information in relation to firefighter safety, good sound decisions being made by managers, and having the necessary drying trend information for upcoming fire seasons.

Table 1. Mean change in percent moisture content of samples kept in different containers (bottles, cans, or bags) after 29 hours.

High Ambient Temperature—100 to 131 °F (38 to 55 °C)

Containers Stored in Fire Bag			
Type of Container	Excelsior	10-hour	100-hour
Polypropylene bottle	0.27%	0.32%	0.04%
Paint can	1.10%	1.48%	0.39%
Self-sealing freezer bag	4.10%	3.82%	1.17%
Containers Stored in Cooler			
Type of Container	Excelsior	10-hour	100-hour
Polypropylene bottle	0.03%	0.30%	0.04%
Paint can	1.13%	1.46%	0.32%
Self-sealing freezer bag	3.19%	2.91%	0.84%

Half of the samples were kept either in a green fire bag or in a cooler. (figure 2 and 3)

Table 1 (conttinued)

Low Ambient Temperature—62 to 75 °F (17 to 24 °C)

Containers Stored in Fire Bag			
Type of Container	Excelsior	10-hour	100-hour
Polypropylene bottle	0.12%	0.09%	0.03%
Paint can	0.09%	0.17%	0.04%
Self-sealing freezer bag	0.28%	0.37%	0.10%
Containers Stored in Cooler			
Type of Container	Excelsior	10-hour	100-hour
Polypropylene bottle	0.08%	0.19%	0.04%
Paint can	0.07%	0.22%	0.06%
Self-sealing freezer bag	0.42%	0.32%	0.09%

Figure 2. Samples in green fire bag.

Figure 3. Samples in cooler.

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SDTDC staff thanks Bea Day, assistant forest fire management officer, Tonto National Forest, Southwestern Region, and Tom Brand, division chief/fuels management, Cleveland National Forest, Pacific Southwest Region, for their review of this publication.

In addition, SDTDC staff would like to recognize the following personnel at the Pacific Southwest Research Station, Riverside Forest Fire Laboratory, Riverside, CA, for their invaluable work: Jim Baldwin and Jose Sanchez, mathematical statisticians; Gloria Burke, forestry technician; Bonni Corcoran, biological technician; and Anna Arias, biological aid.

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