



## Hydration Strategies for Firefighters

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**W**ildland firefighting is arduous work. Shifts are long, often on steep terrain and at higher elevations. The weather is usually hot and dry, and the fire increases exposure to heat. When hard work is performed in a hot environment, blood is sent to the skin to cool the body, primarily through evaporation of sweat (figure 1). Sweat is a combination of water and electrolytes.

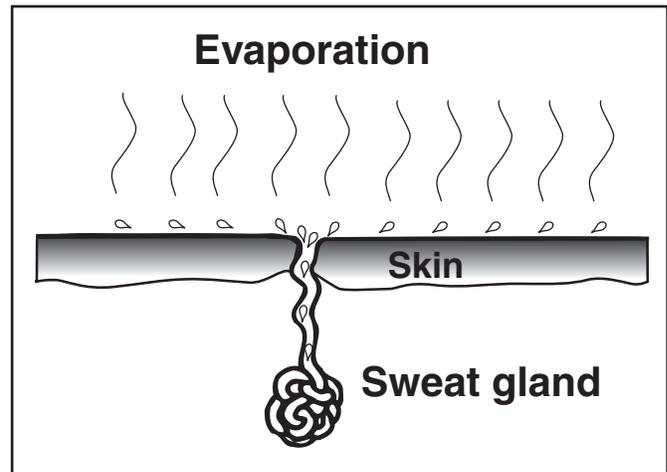
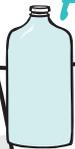


Figure 1—The evaporation of sweat cools our bodies.

### Highlights...



- Wildland firefighters need to drink at least 1 quart of fluid per hour during hard work.
- Studies have shown that firefighters stayed hydrated whether they used water bottles or the newer sipping hydration systems with a reservoir and a drinking tube.
- Water bottles and sipping hydration systems require regular cleaning to remove microbial films.
- Carbohydrate/electrolyte sports drinks should be stored in water bottles because water bottles are easier to clean regularly than sipping hydration systems.

As sweating continues, often at a rate of more than 1 quart per hour, the body loses a lot of fluid. The heart and circulatory function and the ability to work can be affected. If fluids are not replaced, the process that regulates body temperature begins to fail. Work becomes impossible and the possibility of life-threatening heat stroke increases dramatically.

Studies of wildland firefighters indicate that fire suppression activities generate about 7.5 calories of heat for each minute worked, more than 400 calories an hour. Additional heat (about 180 calories per hour) comes from the environment and the fire.



Complete evaporation of 1 liter of sweat removes 580 calories of heat. That means a firefighter needs to evaporate about 1 liter (1.06 quarts) of sweat for each hour of hard work.

These fluids must be replaced. The U.S. Army and the American College of Sports Medicine recommend that you consume 1 liter of fluid every hour of hard work to maintain blood volume and to enhance your ability to lose heat by sweating. Because Forest Service water bottles are 1 quart, we'll round the recommendation to 1 quart of fluid per hour. That means drinking (figure 2) before, during, and after work.

Maintaining hydration requires that firefighters understand their own fluid loss. Water and electrolytes must be properly replaced, for example with water and sports drinks. Consumption of too little water can lead to dehydration while consumption of far too much water can lead to serious illness or death.



Figure 2—Wildland firefighters should drink 1 quart of fluid for every hour of hard work.

## Personal Drinking Systems

Water bottles have been a fixture on firelines since they replaced canteens. However, sipping hydration systems (figure 3) have become more common as companies produce models appropriate for wildland firefighters and their line gear. During the 2006 fire season, the Missoula Technology and Development Center (MTDC) and the University of Montana (UM) Human Performance Laboratory conducted a field study comparing water bottles and sipping hydration systems. Firefighters using the two systems showed no differences in hydration status or work output. The benefits and drawbacks listed in table 1 were mentioned by firefighters during the study.



Figure 3—A typical sipping hydration system.

Table 1—The benefits and drawbacks of water bottles compared to sipping hydration systems.

<b>Water Bottles</b>	
<b>Benefits</b>	It's easy to see how much water has been consumed.
	If one bottle breaks, others may still hold water.
	Sports drinks can be added to just one bottle.
	Bottles are easy to clean.
<b>Drawbacks</b>	Bottles may be hard to reach without stopping work.
	Lids can break.
<b>Sipping Hydration Systems</b>	
<b>Benefits</b>	Fluid is readily available
	It's easy to take frequent sips.
	Newer models are easy to use with line gear.
	Water stays slightly cooler.
<b>Drawbacks</b>	If the hose, mouthpiece, or reservoir breaks, all the fluid can be lost.
	Systems are difficult to clean, especially the hose.

### Polycarbonate Water Bottles

Recent studies have shown that water bottles made from polycarbonate plastics can release a potentially harmful chemical. This chemical, bisphenol-A, helped keep the bottles from shattering. Bisphenol-A has been linked to birth defects, some cancers, and developmental abnormalities in animals.

Current standard issue Forest Service water bottles do not contain bisphenol-A. Many companies are discontinuing the use of plastic containing bisphenol-A for water bottles.

## Cleaning Strategies

An MTDC-UM study of the general sanitary conditions of wildland firefighters' personal drinking systems found that most sipping hydration systems had never been cleaned. Over time, the insides of water bottles and the reservoirs and drinking tubes (figure 4) of sipping hydration systems develop a microbial film. The addition of sports drinks increases the likelihood that a microbial film will form. The microbial film is not necessarily hazardous, but it is likely to give the water an unpleasant taste. The microbes in this film have the potential to cause allergic responses or illness. Firefighters' drinking systems should be cleaned regularly to prevent problems.

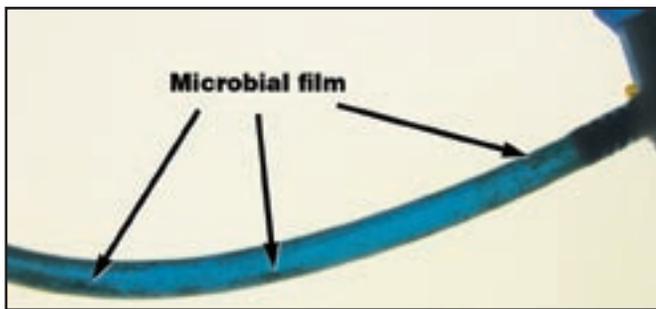


Figure 4—The tubes of sipping hydration systems can develop a microbial film if they are not cleaned regularly.

## Soaps and Tablets

Dish soap or mild bleach solution can be used to clean personal drinking systems. Bleach could shorten the life of the system and may leave an unpleasant taste.

Studies have evaluated the effectiveness of chlorine dioxide water purification tablets for cleaning a sipping hydration system's reservoir and drinking tube. After 4 hours of cleaning, studies showed that the microbial level dropped below detectable levels. The tablets do not require the system to be flushed after cleaning because the tablets create potable water.

Camelbak (<http://www.camelbak.com>) also has cleaning tablets that generate chlorine dioxide. The tablets are soaked in the system for 5 minutes. Then the system is rinsed and dried.

## Cleaning Kits

Cleaning kits by Camelbak use a different approach. These kits include brushes and frames. The brushes are used to scrub the walls of drinking systems, especially harder to reach areas, such as the tubes in sipping hydration systems. The frames allow the reservoir to dry out more quickly after use and cleaning.

## Hydration Strategies

**Before Work**—Drink 1 to 2 cups of juice or water. Eat small amounts of salty foods to stimulate thirst.

**During Work**—Take several fluid breaks every hour, drinking at least 1 quart of fluid each hour during hard work in the heat. Firefighters should drink as much as possible during the lunch break. Water is the body's greatest need during work in the heat. Studies show that workers drink more when lightly flavored beverages are available. Providing a portion of fluid replacement with sports drinks will help firefighters retain fluids and maintain energy and electrolyte levels. The carbohydrate in sports drinks also helps to maintain immune function

and mental performance. The sodium in sports drinks reduces urinary water loss.

**After Work**—Continue drinking to replace fluid losses. Thirst underestimates fluid needs, so firefighters should drink more than they think they need. Rehydration is enhanced when fluids or foods contain sodium and potassium. These electrolytes replace those lost in sweat. Sodium also stimulates thirst. Including some protein may help muscles recover from hard work.

## MTDC Recommendations

To maintain hydration:

- Firefighters may use water bottles, a sipping hydration system, or a combination of both. Studies showed no differences in hydration status based on the personal drinking system firefighters used.
- Firefighters should drink small amounts of fluid every 15 to 20 minutes. About one-third to one-half of the fluid consumed during each shift should be a sports drink.
- Firefighters may benefit from a combination of personal drinking systems, using water bottles for sports drinks (figure 5) and sipping hydration systems for water. Do not use sports drinks in hydration systems because of difficulty in cleaning the tubes.
- Firefighters should rinse personal drinking systems after each use and clean them after each assignment.



Figure 5—About one-third to one-half of the fluid firefighters consume should be sports drinks that provide electrolytes and carbohydrates.

- Firefighters should not share water bottles except during emergencies.
- Firefighters should monitor their hydration status during an assignment by paying attention to:
  - » Urine color—Pale yellow or wheat color is normal. A lighter color is a sign of overhydration. Dark yellow or brown urine is a sign of dehydration.
  - » Body weight—You should not lose more than 2 percent of your body weight during an assignment.

For additional information on hydration, consult the MTDC report “Fitness and Work Capacity: 2008 Edition” (0851–2815–MTDC) to be published late in 2009.

## About the Authors

**Joe Domitrovich** is an exercise physiologist at MTDC. His work includes hydration, nutrition, employee health, stress, and fitness testing. Domitrovich also is a wildland firefighter. He received a bachelor's degree in kinesiology at Cal Poly San Luis Obispo in California and a master's degree in exercise physiology at the University of Montana, where he is completing an interdisciplinary studies Ph.D. with an emphasis in exercise science.

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## Library Card

Domitrovich, Joe; Sharkey, Brian. 2008. Hydration strategies for firefighters. Tech Tip 0851-2324-MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 6 p.

This tech tip discusses the importance of firefighters drinking 1 quart of water per hour to stay hydrated during hard work. Recent research has shown that firefighters stayed hydrated and worked effectively whether they used water bottles or the newer sipping hydration systems with reservoirs and drinking tubes. Both water bottles and sipping hydration systems require periodic cleaning to remove microbial films. About one-third to half of the fluids firefighters drink each day should be carbohydrate/electrolyte sports drinks. These flavored drinks help firefighters consume enough fluid to stay hydrated and replace electrolytes lost in sweat and urine. Sports drinks are best stored in water bottles that are easier to clean regularly than the sipping hydration systems.

**Keywords:** Camelbak, cleaning, dehydration, drinking systems, microbes, sipping hydration systems, water bottles

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