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Camping Stoves

By Trevor Smith

For generations, campers had to learn the art of building a fire from sticks and kindling, but now they face the challenge of mastering the technology of stoves. In some ways, I'm saddened by the change. In the past, as the sky darkened, campers sat in the orange glow of a wood fire and retold the adventures of the day while a sooty pot bubbled and the aroma of the food blended with the wood smoke. The comforting smell was one of the rewards of camping.

But campfires leave scars on the ground and add to the risk of forest fires. In today's climate of concern about the environment, many campgrounds and most national parks and forests don't permit open fires. If you are going to enjoy the outdoors, you must learn to use modern stoves.

Starts with fuel

A good camping stove should be safe, small, lightweight, easy to start, and give a lot of heat from a small amount of fuel. But there are so many different kinds of stoves—where should you start? You can understand the different stoves if you look at the properties of the fuels. The fuel should be easy to ignite, easily transported from the stove's storage tank to the burner, resist flare-ups or explosions, give high heat output per kilogram, and be easily extinguished. The properties of the fuel affect the design, operating characteristics, and safety of the stove.

For many years, the most popular stove fuel in North America has been white gasoline, sometimes called camping fuel or Coleman fuel. This is similar to automobile gasoline but is more highly refined and free of additives. White gasoline is quite volatile. This means that it vaporizes easily and is therefore easy to ignite. (In any stove, it's the vapor that burns, so the fuel must first change from liquid to vapor.)

However, because it is a volatile liquid, campers must use and store this fuel with great caution. Like automobile gasoline, any spilled fuel can be easily ignited and, if the spill is in an enclosed space, an explosion can result. In the rest of the world, kerosene is a more popular fuel than gasoline. Kerosene is less volatile than gasoline, and this makes accidents less likely.

Gasoline and kerosene are derived from petroleum, which is a mixture of hundreds of hydrocarbons, compounds that contain only hydrogen and carbon. When hydrocarbons are burned in air, the hydrogen is oxidized to water, the carbon is oxidized to carbon dioxide, and heat is released. Heptane is a typical gasoline molecule (one of hundreds) and it burns like this:

$$C_7H_{16} + O_2 \Rightarrow H_2O + CO_2 + \text{heat}$$

Because white gas and kerosene are both liquids, a large quantity can easily be stored in a simple metal container. Both heat very efficiently (see side bar, Heating Efficiency).

Under pressure

Propane and isobutane (usually called just butane) are also popular fuels (see Figure 1). However, at room temperature and pressure these compounds are gases. Suppliers compress these fuels to liquify them, then store them in sealed containers to keep them in the liquid state at room temperature.

Propane is the more volatile of the two, so more pressure is required to keep it liquid. The result is that propane and butane must be stored in sturdy tanks—somewhat heavier than gasoline containers—equipped with special valves. If one of these tanks were inadvertently opened, the liquid would boil at room temperature and all the fuel would quickly escape.

Butane has a heating efficiency similar to that of propane, but is less volatile and can therefore be stored at lower pressures and packaged in thin, lightweight tanks (see Figure 1). The biggest disadvantage of butane is its higher boiling point, compared with propane, which means that butane does not vaporize well at low temperatures (see Figure 2). Consequently, the most popular brand of butane fuel (GAZ) actually contains a mixture of isobutane and propane. Wise backpackers who expect frosty mornings keep their fuel cartridge in their sleeping bags overnight.

Alcohol

The only nonpetroleum product that is used in portable stoves is ethyl alcohol, or ethanol (Figure 3). Alcohol is less efficient at heating than any of the petroleum products (see box Heating Efficiency) but it scores well for safety, because it mixes readily with water. If some alcohol is accidently spilled and lighted, a small amount of water will dilute the fuel and extinguish the fire, which is why alcohol stoves are favored by sailors.

A boat is just about the only place you can still find stoves that burn alcohol. Think of the advantages and disadvantages this way: if you have a fire on a boat you can't run to safety, but there is plenty of water around.

The most popular fuel for cooking aboard boats is propane, but not the cartridge-fueled stoves seen in campgrounds. On a boat the stove is located in the cabin; the pressurized tank of propane is installed outside the cabin. A hose feeds the stove vapor from the tank's head space, and a detector is often put in the cabin to warn of fuel leaks. A fuel leak anywhere can lead to a fire, but a fuel leak in a closed cabin can lead to accumulation of a large amount of fuel vapor. If the air/fuel mixture is ignited, the boat will be instantly destroyed in the resulting explosion.

Stove safety

There are several things you can do to make sure your stove operates safely and your outdoor enjoyment is not spoiled by an accident.

Don't lean over a lighted stove to check the stew, even if the stove seems to be operating perfectly. Unexpected flare-ups can occur.

Don't use a big pot on a small stove. It is often hard to find level ground, and the heavy pot may tip the stove over. A big pot may also reflect too much heat down to the tank and cause the fuel to overheat.

Respect the wind. Because small stoves can be vulnerable to breezes, and could tip over, many come with windshields. But don't shield the stove too closely; some air circulation is necessary to keep the fuel tank cool.

Don't cook in a tent. In addition to the risk of fire, there is the question of suffocation. A stove can quickly use up the oxygen in a small space. Worse, as the oxygen supply decreases, combustion becomes less efficient and the stove will give off less carbon dioxide (CO_2) and more carbon monoxide (CO), which is colorless, odorless, and very poisonous.

Watch the fuel too. If you give all your attention to the stove, you could leave the cap off the container of spare fuel and kick it over.

Read the instructions. Memorize them. Then don't be nervous, remember that you are in charge of the stove.

Don't take a new stove on a trip. Practice in your back yard until you're comfortable with it. If you have any difficulty, talk to the salesperson or call the manufacturer. When you go on a trip, cooking with your stove should be as routine as brushing your teeth.

The days of the romantic campfire are passing. But I've come to think of the roar of my compact white gasoline stove as a friendly sound at the end of a long day on the trail. When I shut it off the quality of the silence of the wilderness seems to be enhanced in a way that tells me that the new ways are good, too.

SIDE BARS

Heating efficiency

One of the most important properties of a fuel is the amount of heat produced when it is burned. When a compound is burned with enough oxygen to convert all the carbon into carbon dioxide and all the hydrogen into water, then the heat produced is called the "heat of combustion." There are a number of different units that describe the heat of combustion. Most outdoor stove users are concerned mainly with how much heat their fuel will give out for a given weight or volume. The more heat produced, the more efficient the fuel is for cooking. The table shows some values for the heats of combustion of the fuels described in the article, calculated in thousands of joules per gram, kJ/g. Approximately 330 kJ of heat is required to heat a liter of water (slightly more than a quart) from room temperature to boiling.

From tank to burner

Every camping stove stores fuel in a tank, and the designer of the stove must figure a way to move the fuel, a little at a time, to the burner. For the propane and butane stoves, this is easy because the fuel is stored under pressure and comes out on its own as soon as the valve is opened. The vapor is fed from the cartridge head space through a nozzle and a valve to the burner. All you have to do is open the valve and light the burner (Figure 4).

Stoves fueled by white gasoline are a bit more complicated to start because the fuel is unpressurized and has no tendency to leave the tank. When starting the classic Coleman two-burner picnic stove you must use the hand pump to force air into the tank head space. The compressed air then forces the liquid fuel (solid color) through the "generator tube" where heat from the burner turns the gasoline to vapor (tint). The vapor flows from a tiny jet at the end of the tube where it mixes with air to form a combustible mixture (tinted dots) which enters the burner (Figure 5).

When the stove has been operating for some time, the fuel level in the tank drops, the pressure in the head space decreases, and the fuel flows more slowly. This means that, when the flame under your pancakes gets low, it's time to pump up the tank again.

CAPTIONS

Instead of gathering this much firewood to cook each meal, backpackers can carry the MSR Whisper Lite stove. With enough gasoline fuel for 10-13 meals, you'll carry only 1 kg. When the fuel tank is removed, the 340-g stove collapses to the size of a coffee mug.

Figure 1. Propane, C_3H_8, and isobutane, C_4H_{10}, are popular hydrocarbon fuels that burn cleanly and produce a lot of heat. A "full" tank of propane or butane is not completely full—some of the volume is used for the "head space" where vapor is collected before it is transported to the stove. Because butane (formal chemical name, isobutane) has lower vapor pressure than propane, it can be packaged in thinner, lighter tanks.

Figure 2. Many campers feel that stoves fueled by propane or butane are the easiest to use—unless it turns very cold. Inside the fuel tanks, propane and butane (technically, isobutane) are stored in the liquid state and must vaporize to reach the burner. But the vapor pressure (the pressure of the vapor in the tank when it is in equilibrium with the liquid) decreases as the temperature drops, causing the vapor to be pushed from the tank less forcefully. At -12 °C most propane stoves operate very slowly. A butane stove may stop completely because the pressure of the fuel is no longer greater than the pressure of the atmosphere (dotted line) and, therefore, the fuel vapor will not leave the tank. The manufacturer may mix the isobutane with some propane to make the fuel work better when cold. At 22 °C both propane and isobutane have more than enough pressure to perform well.

Figure 3. Ethyl alcohol may be manufactured from natural gas or fermented from carbohydrates, such as corn. Because the molecule already contains an oxygen atom, when it is burned with oxygen it delivers less heat than hydrocarbon fuels.

BIOGRAPHY

Trevor Smith has hiked to the bottom of the Grand Canyon, to the top of Mt. Washington, and to many places between. A chemist, now retired from industrial research, he writes in Kensington, MD.